Report from Pulling Tests with Used Lashing Equipment

Pilot test performed at Ro-Ro International in Gothenburg 2009-01-16, Main tests performed at Forankra in Vårgårda 2009-04-15 and at Ro-Ro International in Gothenburg 2009-04-16

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1 Introduction

MariTerm AB has on behalf of the Swedish Transport Agency – Maritime Department performed a study by pulling used lashing equipment to break in order to find out at which level of wearing and damage lashing equipment has to be scraped. A pilot study was carried out at the site of Ro-Ro International AB in Gothenburg 2009-01-16 and main tests were carried out at the site of Forankra in Vårgårda 2009-04-15 and at the site of Ro-Ro International AB in Gothenburg 2009-04-16. Additional tests with Tor Lines trailer lashings were carried out at RoRo International 2009-04-29 and with provoked edge damages on new equipment at Forankra 2009-08-12 and 13.

The initiative to the tests was initially taken by the Swedish Coast Guard together with the lashing manufacturer Forankra AB. The interest was soon spread to other parties and also ship owners, forwarders and hauliers have participated in and contributed to the tests together with the authorities.

The result of the tests is intended to be used by controlling authorities as well as basis for instructions in cargo securing manuals and training documents.

The ship owners and forwarders participating in the study have supplied the lashing material without costs under the conditions that they are allowed to use the result. It should be pointed out that a significant part of the lashings supplied by the ship owners and forwarders were lashings that had been rejected due to the ship owners and forwarders internal procedures for inspection and maintenance of cargo securing devices. The Swedish Coast Guard has additionally bought a large number of “normal” 50 mm “4-tons” web lashings, which have been given to lorry drivers as replacement for worn equipment collected by the Coast Guard during inspections.

The lashing manufacturers have put their resources at disposal also on condition that they will be allowed to use the results of the study.

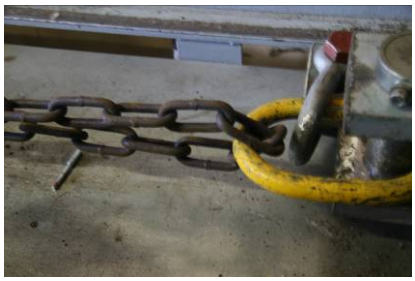
It has been a very co-operative spirit in the project and all parties have shared a common aim – to obtain safe and realistic instructions for the scrapping of lashing equipment.

2 Conclusions and recommendations

It can generally be concluded that used chain lashings have a much larger safety level than used web lashings. Chain lashings are not influenced by wear and tear and as long as lashings with deformed parts (links and hooks) are scrapped or repaired the chains do more or less keep the strength from when they are new.

In the tests it has been noted that the lever tensioner is a weak point for the chain lashings. Even if the strength of the lever tensioners is within the allowed limits, the complete chain lashings often broke at the tensioner. It is proposed to investigate if turnbuckles have a better remaining strength than lever tensioners or in which way the strength of lever tensioners could be improved.

A 11 mm chain drawn around a round bar with a diameter of about 25 mm showed surprisingly full strength, and it could thus be concluded that it is allowed to use chains around lashing fittings as on the photo. It shall, however, be noted that the link will be deformed and has to be replaced if the force in the lashing becomes large.



Age showed little influence on the remaining strength of web lashings made of polyester (PES).

Dirt level showed large influence on the remaining strength of web lashings and the tests showed that especially heavier web lashing (12 ton and upward) are strongly influenced by the dirt level. It should though be noted that the overall level of dirtiness of the heavier web lashings were more severe than the overall level of dirtiness of the lower capacity web lashings.

Only very few web lashings made of Polypropylene (PP) were tested. The ones tested showed a considerable reduction in strength even though they showed no damages and it was concluded that this type of material is influenced by the age.

For a majority of the tested heavy web lashings, the webbing broke at the hook or winch and not at the damages.

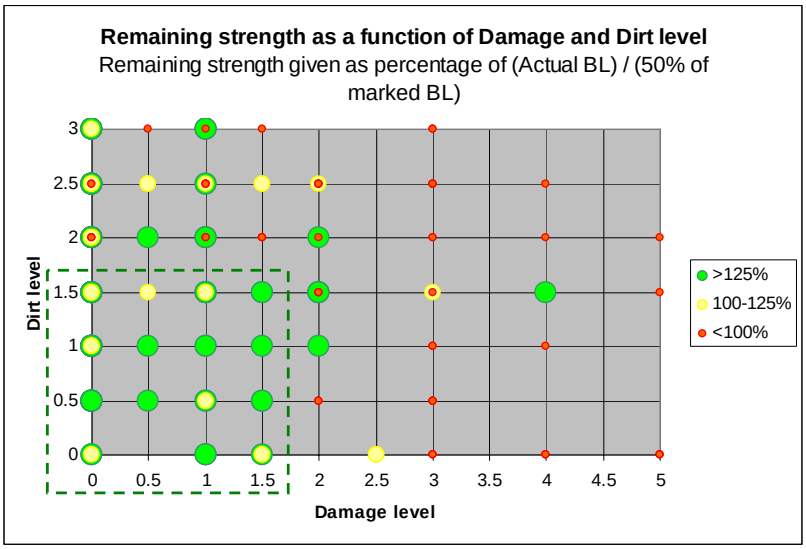
Most of the tested web lashings, even those which were undamaged, showed significant reduction in the remaining breaking strength in relation to the specified breaking strength for new equipment.

Some new heavy web lashings with specified strength 14 ton were tested with negative result. Also two new lever tensioner for 11 mm chain were tested and non of them reached the specified breaking strength.

Based on the tests, it has been concluded that the remaining strength of web lashings is influenced both by the dirt level and the damage level. The damages were in general classified from 0 – 3 with some sever damaged classified as 4 or 5. The dirt level was classified from 0 - 3.

The remaining strength in the lashings was put in relation to the limit allowed according to rules and regulations. For road transport the acceptable limit is LC (Lashing Capacity) and for sea transport the acceptable limit is MSL (Maximum Securing Load), which corresponds to 50% of the breaking load for new equipment.

The results are very diverging and small damages had in some cases large influence on the remaining strength while large damages in other cases showed little influence on the strength. However, by combining the damage level and the dirt level as shown in the diagram below acceptable and non acceptable levels of dirtiness and damages were found.



Based on the results from the tests by the used web lashings the following was concluded:

- Acceptable dirt level for web lashings is 0 – 1,5
- Acceptable damage level for web lashings is 0 – 1,5

Example of acceptable and non acceptable dirt and damage levels can be found in chapter 11 below.

Also provoked edge damages on new web lashing equipment showed that already small damages strongly influence on the remaining strength. The same thing applies to knots, which never can be accepted.

The strength in the webbing in web lashings is not influenced by twisted lashings, however has some pulse tests carried out for car lashings by RoRo International showed that tensioners may be influenced if the webbing is twisted.

Also the webbing on the tensioner side of web lashings showed large reduction in remaining strength even if the margin to the acceptable limit was larger than for the loose end.

2.1 Recommendations

When it comes to instructions for scrapping of lashing equipment the following is recommended:

- Chain lashings should be scrapped or repaired if any part is visibly damaged.
- Steel parts in web lashings should be scrapped or repaired if any part is visibly damaged.
- Webbing in web lashings made of polyester PES should be scrapped and replaced if:

  - the damage level of any damage is larger than 1,5 or if
  - the dirt level is larger than 1,5

  For details of different dirt and damage levels see chapter 11 below.

  Web lashings made of polypropylene PP should in addition be scrapped if web fibres are bleached by the sun and by that has become dry, crispy and scratchy.
- The requirement in chapter 2 §5 of the Swedish national regulation 2008:4, that undamaged equipment of satisfactory quality only may be used for cargo securing, should be changed according to the findings in this study.
- More extensive tests should be required for new equipment and the tests should now and then be audited by authorities.

3 Attendance at the tests

Among others the persons mentioned below attended the tests.

3.1 Pilot tests at Ro-Ro Int. in Gothenburg 2009-01-29

Swedish Transport Agency	Johan Lindgren	
The Swedish Coast Guard	Anders Melander	Anders Håkansson (partly)
	Anders Wibaeus	Mia Kåmark (partly)
	Anders Udén (partly)	
Wallenius Wilhelmsen Lines	Ove Moring	
DFDS Tor Line AB	Evan Johansson	Martin Larsson
Finnlines OY	Mikko Hänninen	Anders Hamming (partly)
Sveriges Åkeriföretag	Mårten Johansson	
Svensk Åkeritidning	Frans Johansson	
MariTerm AB	Peter Andersson	Juraj Jagelcak (University of Zilina)
Forankra AB	Fredrik Hildingsson	Staffan Bengtsson
RoRo International AB	Thor Maugesten	Ivan
	Mikael Lindahl	

3.2 Main tests at Forankra in Vårgårda 2009-04-15

Swedish Transport Agency	Johan Lindgren	Tore Dahl
	Patrik Granstam	Caroline Petrini
The Swedish Coast Guard	Jimmy Leijonfalk	Sabina H (Partly)
	Anders Melander	Jesper B (Partly)
	Karoline M (Partly)	
MariTerm AB	Peter Andersson	
Forankra ABT AB	Fredrik Hildingsson	Lena Gustavsson
	Staffan Bengtsson	Urban Jönsson
	Ulf Carlsson	Michael Nilsson
	Tony Ekstrand	
Geodis Wilson Sweden AB	Conny Blysell	
DHL	Olle Bernstaf	
Schenker	Rustan Eliasson	Hans Carlheim
Green Cargo	Stanley Öberg	Roger Leandersson
The Traffic Police in Gothenburg	Mattias Gramsby	Lars P. Ekblad

3.3 Main tests at RoRo Int. in Gothenburg 2009-04-16

Swedish Transport Agency	Johan Lindgren	Tore Dahl
The Swedish Cost Guard	Jimmy Leijonfalk	Anders Melander
Wallenius Wilhelmsen Logistics	Ove Moring	Tomas Larsson
DFDS Tor Line AB	Evan Johansson	Martin Larsson
Finnlines Plc	Markku Seppälä	
MariTerm AB	Peter Andersson	
Forankra ABT AB	Tony Ekstrand	Michael Nilsson
	Urban Jönsson	
RoRo International AB	Thor Maugesten	Ivan
	Mikael Lindahl	
TT-Line AB	Sven Nilsson	Johan Ullenby
Geodis Wilson Swedan AB	Conny Blysell	
Scandlines AB	Patrik Dahl	

4 Pulling test machines

At Forankra in Vårgårda a vertical pulling machine is used and at RoRo International a heavy horizontal machine is installed.

4.1 Vertical pulling machine at Forankra in Vårgårda

Parameters: see Annex A

Test pull machine at Forankra

The pulling machine was calibrated 2008-02-04.

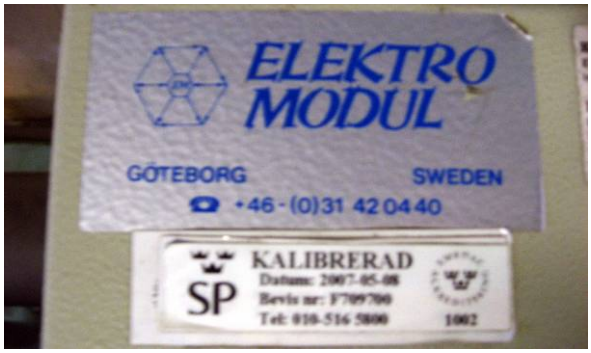
Test machine with the calibration marking

4.2 Horizontal pulling machine at Ro-Ro Int. in Gothenburg

Parameters: see Annex A

Test pull machine at Ro-Ro International

The pulling machine was calibrated 2007-05-08.



Test machine with the calibration marking

5 Tested lashings

During the tests both lashing equipment normally used for securing of cargo on vehicles as well as maritime equipment used for securing of cargo onboard vessels were tested.

Most of the equipment tested was scrapped by the ship owners and forwarders and was no longer in use. The different types of equipment used in the tests are described below.

5.1 "Normal" 50 mm "4-tons" Web lashings

At the tests a large number of "normal" 50 mm web lashings were tested. This equipment had been collected by the Swedish Coast Guard during inspections. The collected equipment was replaced by new equipment.

Equipment scrapped by Schenker and DHL was also tested.

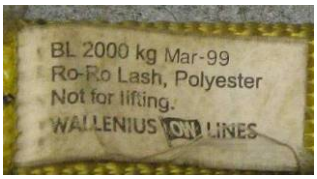
Web lashings

- the web lashings were of different age and conditions with wearing, edge and fibre damages
- in the pilot study some lashings were of unknown minimum breaking load (MBL) without or with unreadable identification tags. In the main study only marked lashings were tested
- material: polyester (PES) and some polypropylene (PP)
- MBL – 4 to 5 ton

5.2 Car lashings provided by Wallenius Wilhelmsen Lines

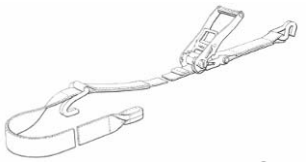
Car lashings
The Car lashing equipment was collected on board of Wallenius Wilhelmsen Lines' Ro-Ro vessels. The lashings consist of web lashing with a buckle tensioner.

Material: PES
MBL = 2 tons, MSL = 1 ton
Manufacturer: Ro-Ro Int.



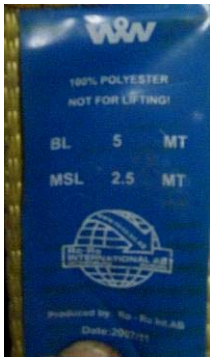
Car lashing - W&W

5.3 Rollashings provided by Wallenius Wilhelmsen Lines



Rollashings

The Rollashings were collected on board of Wallenius Wilhelmsen Lines' Ro-Ro vessels. The lashings consist of web lashing with a ratchet tensioner.



Material: PES
MBL = 5 tons
MSL = 2,5 tons
Manufacturer: Ro-Ro Int.

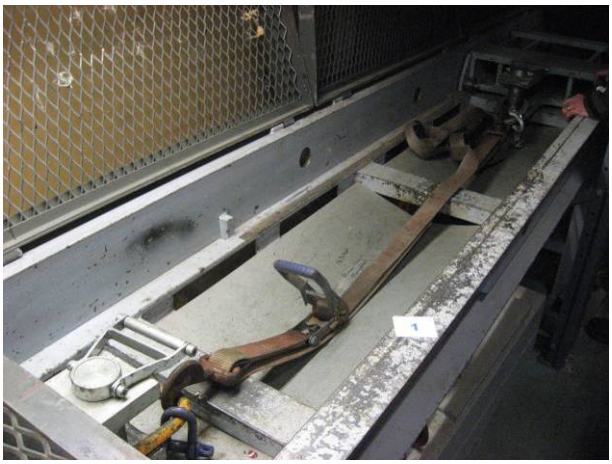
Rollash - W&W

5.4 Lashings from Finnlines, Scandlines and TT-Line

Trailer web lashings

The trailer lashings were collected on board Finnlines, Scandlines and TT-Lines vessels. The used lashings consist of double web lashing with a ratchet tensioner and hooks in both ends. The lashings were of different makes and slightly different .

Material: PES
MBL = 12 tons (some 14 ton)
MSL = 6 tons
Manufacturer: Scan Unit, Load Lock and Ro-Ro International.



Trailer web lashing

5.5 Chain lashings provided by Wallenius Wilhelmsen Lines

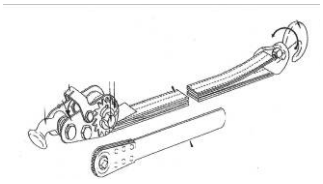
Chain lashings

The chains were collected on board of Wallenius Wilhelmsen Lines' Ro-Ro vessels. The used lashings consist of steel chain. The chains were tested with new, used or no lever tensioner.

Material: Steel – 11 mm, Class 8 (grade 80)
MBL = 15 tons
MSL = 7,5 tons
Manufacturer: Orsa Link AB
Supplier: Ro-Ro Int.

Chain lashing – W&W

5.6 Trailer web lashing provided by DFDS Tor Line



Trailer web lashings

The trailer lashings were collected on board of DFDS Tor Lines' Ro-Ro vessels in Gothenburg. The used lashings consist of four doubled web lashings with a heavy ratchet tensioner and hook in one end and an elephant foot in the other end. The lashings were collected on different vessels and decks including some from weather deck.

Material: PES
MBL = 20 tons, MSL = 10 tons
Manufacturer: Ro-Ro Int.

Trailer web lashing – DFDS Tor Line

6 Lashing properties and performance

6.1 Marking and properties of webbing material according to standard EN 12195-2

Web lashings can consist of the following material types:

PES - Polyester webbing – blue tag
PA - Polyamid webbing – green tag
PP - Polypropylene webbing – brown tag

PES webbing
Polyester is resistant to mineral acids but is attacked by alkalis.

PA webbing
Polyamides are virtually immune to the effects of alkalis. However, they are attacked by mineral acids.

PP webbing
Polypropylene is little affected by acids and alkalis and is suitable for applications where high resistance to chemicals (other than certain organic solvents) is required.

Web lashings complying with EN 12195-2 are suitable for use in the following temperature ranges:

– 40 °C to + 80 °C	for polypropylene (PP);
– 40 °C to + 100 °C	for polyamide (PA);
– 40 °C to + 120 °C	for polyester (PES).

These ranges may vary in a chemical environment. In that case the advice of the manufacturer or supplier shall be sought. Changing the environmental temperature during transport may affect the forces in the web lashing.

6.2 Types of web lashing damages

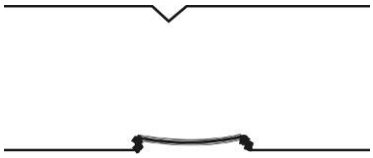
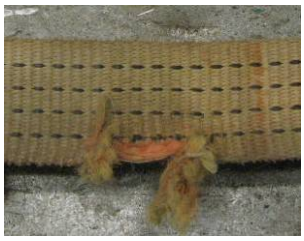
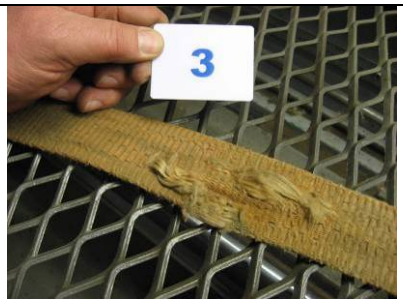
According to the EN 12195-2 Annex B web lashings shall be rejected or returned to the manufacturer for repair if they show any signs of damage.

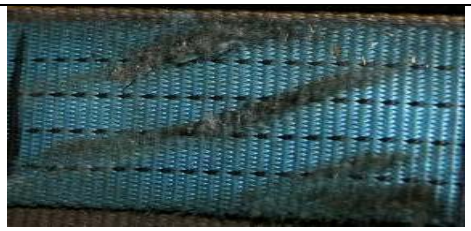
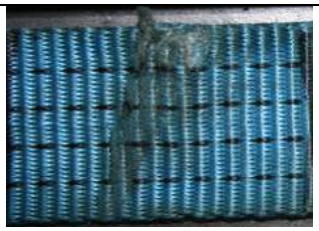
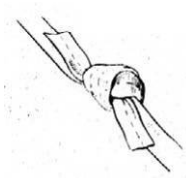
The following criteria are considered to be signs of damage:

- Only web lashings bearing identification labels shall be repaired;
- If there is any accidental contact with chemical products, a web lashing shall be removed from service and the manufacturer or supplier shall be consulted;
- for web lashings (to be rejected): tears, cuts, nicks and breaks in load bearing fibres and retaining stitches; deformations resulting from exposure to heat;

- for end fittings and tensioning devices: deformations, splits, pronounced signs of wear, signs of corrosion.

Below different types of web lashing damages are described:

Type of damage	Examples
ED – Edge damage; cut of fibres on the side of the webbing 	  
CU – Cut damage; cut mainly of longitudinal fibres on the surface 	  
BR – Break damage; compression of the webbing by high pressure 	
TE – Tear damage; mainly damage of transverse fibres 	   

FD - Wear at lashing fittings	 
B/C – Burn or chemical damage	
WE – Wear damage, damages caused by friction	 
DL – Dirt level	
KN - Knot 	

The damages were before the tests ranked from 0 – 3. The scale could in exceptional case be extended to 4 and even 5 for extremely damaged equipment.

Examples of different levels of the different damage types as well as different levels of dirtiness is shown in chapter 11 below,

7 Methodology for performing the main tests

For the main test the following types and approximate number of lashings were collected.

- Normal 50-mm web lashings – 150 pcs
- 12 tons trailer lashings – 40 pcs
- 20 tons trailer lashings (Tor Line type) – 30 pcs
- Car lashings (WW type) – 15 pcs
- Rollashes (WW type) – 15 pcs
- Chains (WW type) – 15 pcs

Most lashings were complete with tensioner. As far as possible lashings with mark tag only had been collected.

As far as possible lashings with different types of damages had been collected.

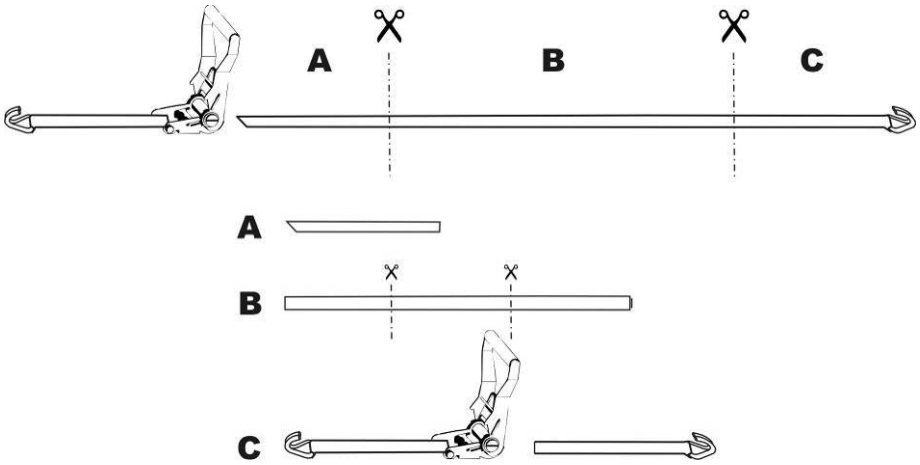
50-mm lashings were brought or delivered to Forankra in Vårgårda and all other types of lashings were brought or delivered to Ro-Ro International in Gothenburg.

Upon testing the 50 mm lashings several tests were performed with each lashing according the description and sketch below.

Part A…test of the least worn part of the webbing, normally the outer end of the loose end

Part B…tests of different damages which occurred on the webbing

Part C…test of the last part of the loose end with hook



Separate tests were carried out with some of the ratchets.

For the maritime equipment one test only per lashing was performed, and each lashing was tested from hook to hook.

8 Results

All details from the tests are presented in the following annexes in separate documents:

Annex B – results from the pilot study
Annex C – results of tests of 50mm web lashings in the main study
Annex D – results of maritime lashings in the main study
Annex E – photos from the tests of 50mm web lashings in the main study
Annex F – photos from the tests of maritime lashings in the main study

In the annexes the following parameters are, as far as possible, given for each lashing that was tested:

- Test number: Internal number for identification
- Make, S_{TF} and Material: Information from the marking tag if available
- Marked BL (Break Load): From marking tag or stripes, normally in ton
- Marked LC (Lashing Capacity): From the marking tag, normally in daN
- Dirt level: A scale from 0 – 3
- Damage type according to the description above
- Damage level: A scale from 0 – 3 sometimes extended for very worn lashings
- Photo before and if available after the test
- Note: If available
- Break load: The remaining breaking strength in daN
- Break/LC: The relation between remaining strength and LC in %
- Break/0.5BL: The relation between remaining strength and 50% of the marked break load (BL) in %
- Manufacturing date

The cells in the left column are marked as follows:

Green	When remaining strength / 0.5BL > 125%
Yellow	When 125% > remaining strength / 0.5BL > 100%
Red	When remaining strength / 0.5BL < 100%

Below diagrams are shown in which the different damage types have been plotted. For most of the damage types photos showing the following are also presented:

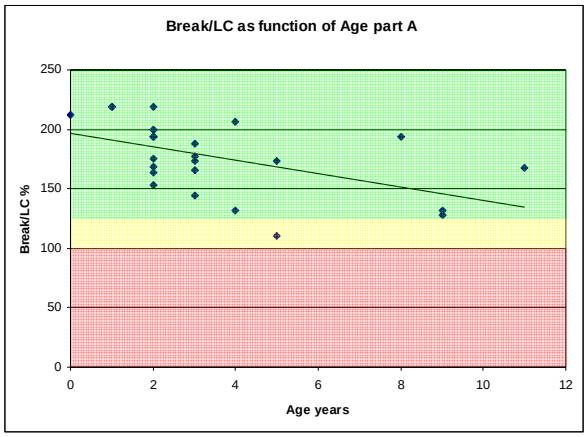
- Acceptable damage
- Non acceptable damage

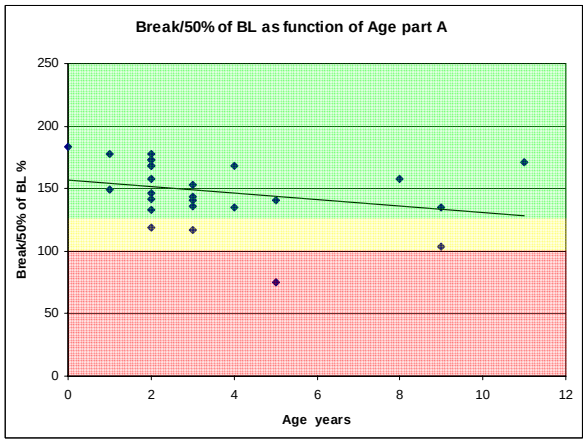
9 Results of tests with 50 mm web lashings

9.1 Remaining strength as function of Age

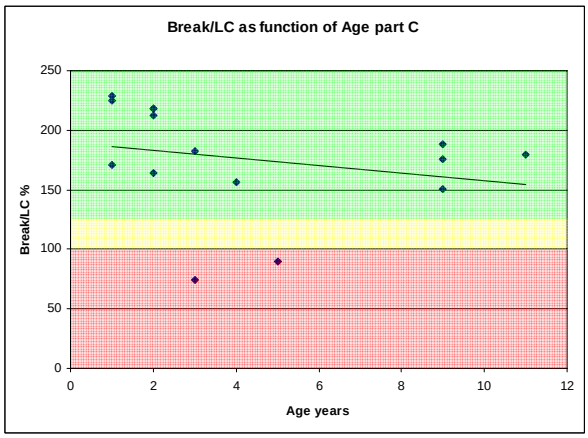
In the diagrams below the Break strength/LC as well as the Break strength/0,5 BL are shown. The first relation is valid for road transport while the second is used for sea transports.

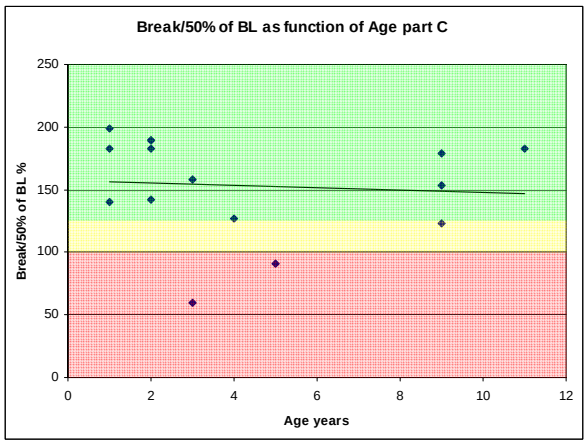
The remaining strength is shown as function of the age. Only lashings without damages are shown in the diagrams.





Remaining strength as function of age for undamaged lashings part A





Remaining strength as function of age for undamaged lashings part C

From the diagram it can be seen that the age has little influence on the remaining strength of the lashings as long as they show no damages. It can, however, also be noted that there is a large spread of the results and in some cases the remaining strength has dropped considerably also in these undamaged lashings.

Table of remaining strength as function of age for undamaged lashings part A

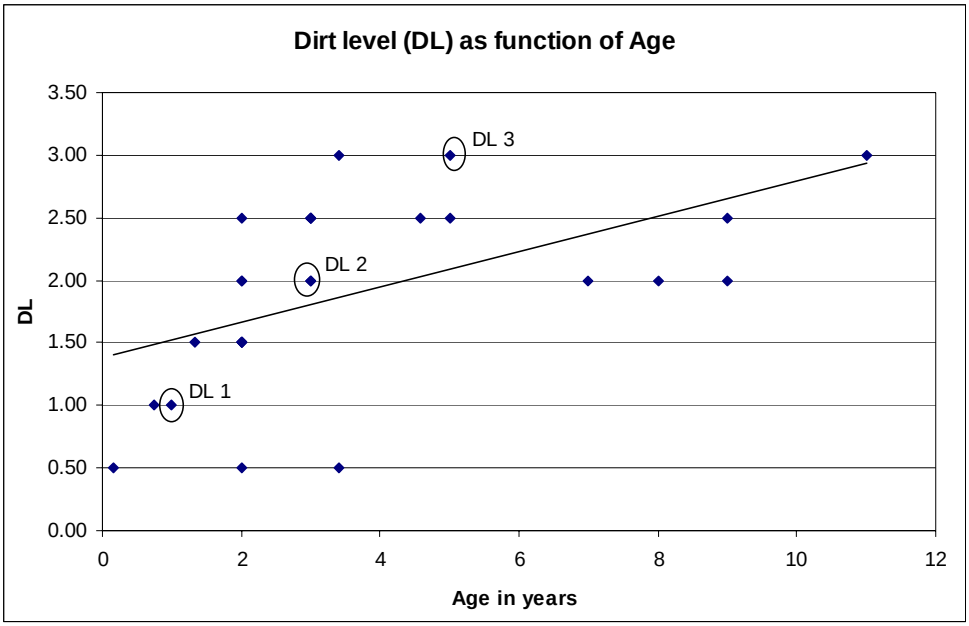
Test no	Break/LC %	Break/0.5 BL %	Age years
00.A	200	173	2
01.A	228	186	1
02.A	219	178	1
04.A	194	168	2
05.A	206	168	4
06.A	168	171	11
07.A	132	135	4
08.A	153	133	2
09.A	200	173	2
11.A	188	153	3
12.A	177	144	3
13.A	128	104	9
14.A	173	141	4
15.A	194	168	2
16.A	164	142	2
17.A	175	119	2
18.A	166	136	3
19.A	194	158	8
20.A	219	178	2
21.A	169	146	2
24.A	173	141	5
25.A	144	117	3
26.A	219	149	1
27.2A	212	183	0
27.A	194	158	2
28.A	132	135	9
31.A	110	75	5

Table of remaining strength as function of age for undamaged lashings part C

Test no	Break/LC %	Break/0.5 BL %	Age years
01.C	225	183	1
02.C	171	140	1
06.C	180	183	11
07.C	90	91	5
08.C	218	189	2
11.C	182	158	3
13.C	151	123	9
14.C	156	127	4
15.C	212	183	2
16.C	218	189	2
19.C	188	153	9
21.C	164	142	2
27.2C	229	199	1
28.C	176	179	9

9.2 Dirt level as function of Age

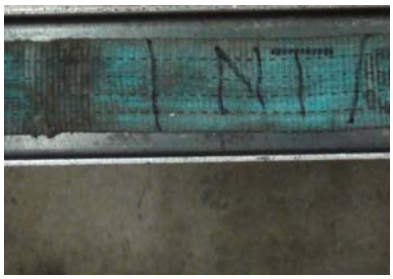
Initially the dirt level (DL) was not noted for the 50 mm web lashings tested in Vårgårda. During the tests in Gothenburg it was found that the dirt level has a large influence on the remaining strength of web lashings. After the tests all the tested lashings were collected and marked and it was thus possible to afterwards rank also the 50 mm web lashings in a dirt level degree from 0 – clean to 3 – very dirty, see photos below. In the diagram below the dirt level as function of the age of the lashing is shown.



27 out of 30 tested lashings are represented in the diagram. Some of the tests have the same parameters and are thus covering each other

DL 1 *DL 2* *DL 3*

01.A; Dirty only at surface



25.A; Dirty and worn

23.A; Very dirty and swollen

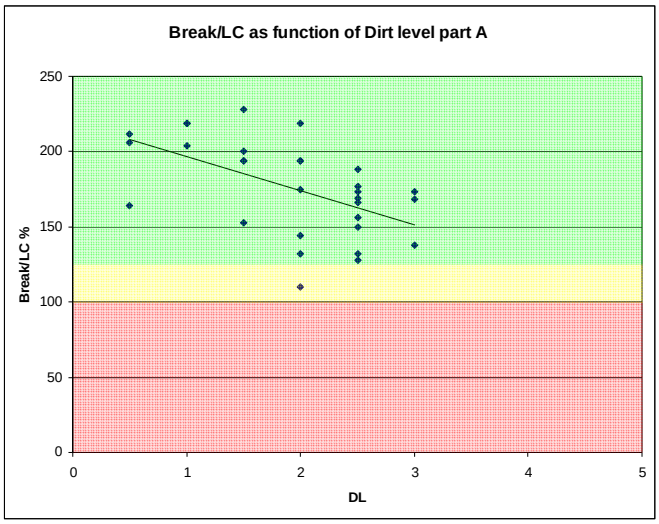
From the diagram above it can be seen that there is a correlation between the dirt level and the age even if it is not obvious. It should though be noted that the dirtiness of these web lashings were less than the heavy maritime web lashings.

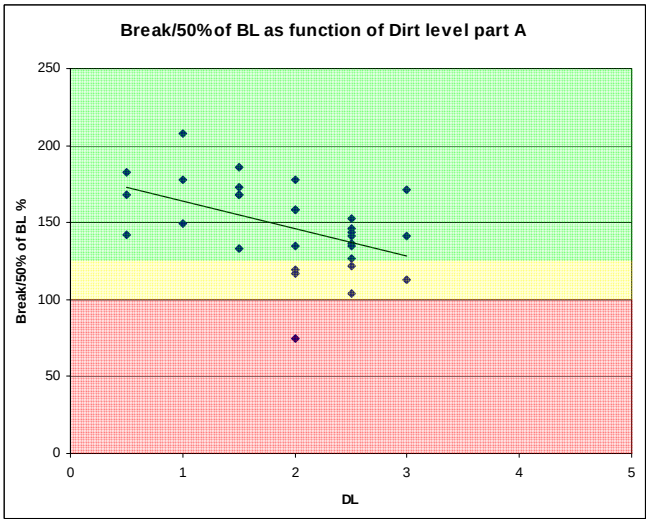
Table of dirt level as function of age

Test no	DL	Age years
01.A	1,50	1
02.A	1,00	1
04.A	1,50	2
05.A	0,50	3
06.A	3,00	11
07.A	2,50	5
08.A	1,50	2
09.A	1,50	2
11.A	2,50	3
12.A	2,50	3
13.A	2,50	9
14.A	3,00	3
15.A	1,50	2
16.A	0,50	2
17.A	2,00	2
18.A	2,50	3
19.A	2,00	7
20.A	2,00	2
21.A	2,50	2
23.A	3,00	5
24.A	2,50	5
25.A	2,00	3
26.A	1,00	1
27.A	2,00	3
27.2A	0,50	0
28.A	2,00	9
31.A	2,00	8

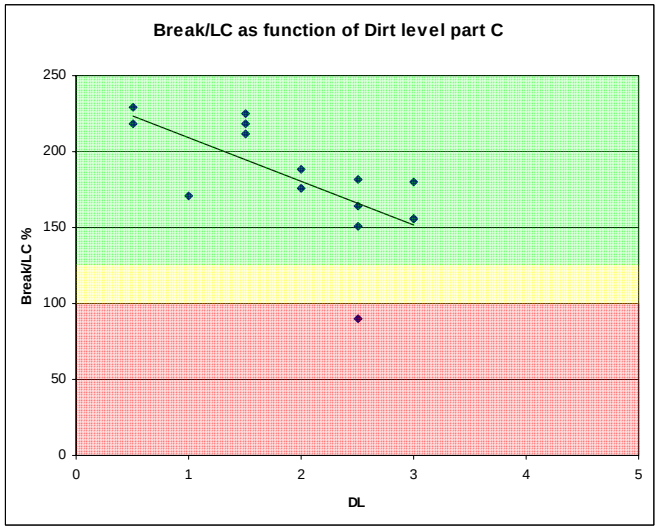
9.3 Remaining strength as function of Dirt level

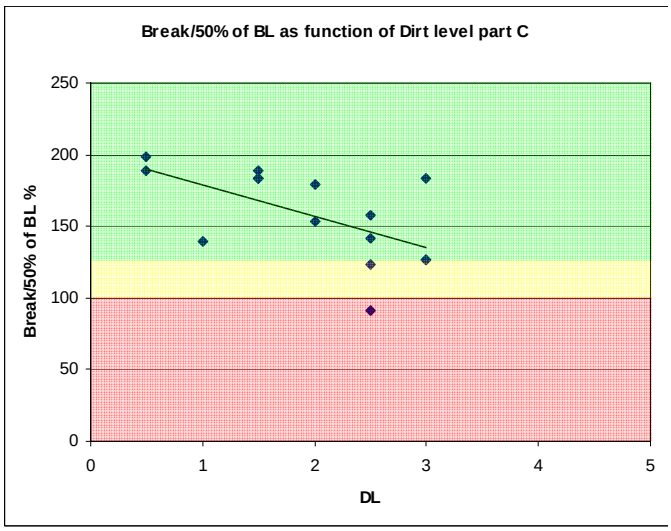
Separate diagrams are shown for part A, the least worn part of the webbing and part C the most worn part. Only lashings that did not break in any damage are represented in the diagrams.





Results of tests with part A, the least worn part of the lashings





Results of tests with the part C, the most worn part of the lashings

From the diagrams it can be clearly seen that there is an obvious correlation between the remaining strength and the dirt level. It can also be noted that dirt itself without additional damages seldom is a reason for condemning this type of lashings.

As it is the same lashings shown in the left and the right diagrams more results are found in the yellow and red parts in the right diagrams as a larger force is allowed in the lashings during sea transport than during road transport. This also shows that for sea transports the scrapping tolerance must be stricter.

Table of remaining strength as function of dirt level part A

Test no	DL	Break/LC %	Break/50% of BL
01.A	1,5	228	186
02.A	1,0	219	178
03.A	2,5	150	122
04.A	1,5	194	168
05.A	0,5	206	168
06.A	3,0	168	171
07.A	2,5	132	135
08.A	1,5	153	133
09.A	1,5	200	173
10.A	2,5	156	127
11.A	2,5	188	153
12.A	2,5	177	144
13.A	2,5	128	104
14.A	3,0	173	141
15.A	1,5	194	168
16.A	0,5	164	142
17.A	2,0	175	119
18.A	2,5	166	136
19.A	2,0	194	158
20.A	2,0	219	178
21.A	2,5	169	146
22.A	1,0	204	208
23.A	3,0	138	113
24.A	2,5	173	141
25.A	2,0	144	117
26.A	1,0	219	149
27.A	2,0	194	158
27.2A	0,5	212	183
28.A	2,0	132	135
31.A	2,0	110	75

Table of remaining strength as function of dirt level part C

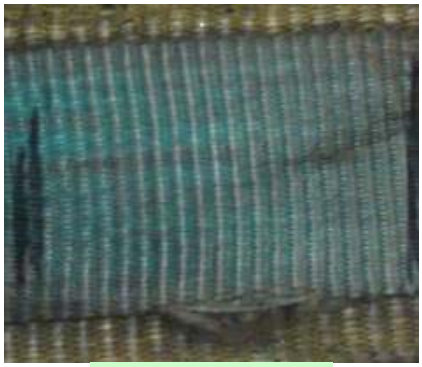
Test no	DL	Break/LC %	Break/50% of BL
01.C	1,5	225	183
02.C	1,0	171	140
06.C	3,0	180	183
07.C	2,5	90	91
08.C	1,5	218	189
11.C	2,5	182	158
13.C	2,5	151	123
14.C	3,0	156	127
15.C	1,5	212	183
16.C	0,5	218	189
19.C	2,0	188	153
21.C	2,5	164	142
27.2C	0,5	229	199
28.C	2,0	176	179
30.C	3,0	156	127

9.4 Damages

Below the remaining strength as function of different types and levels of damages is shown.

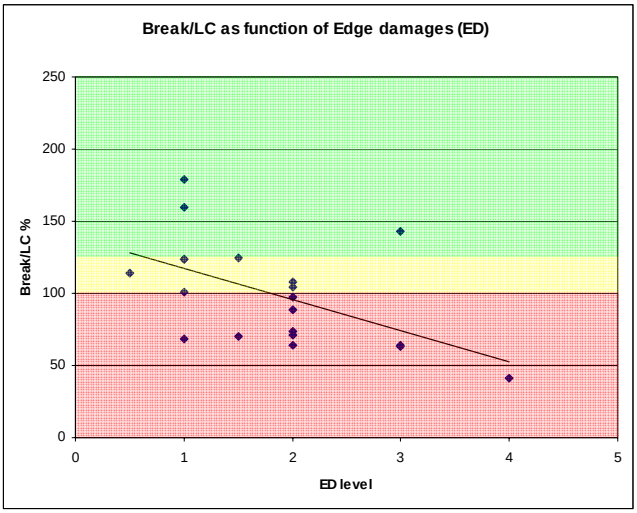
9.4.1 Edge damages

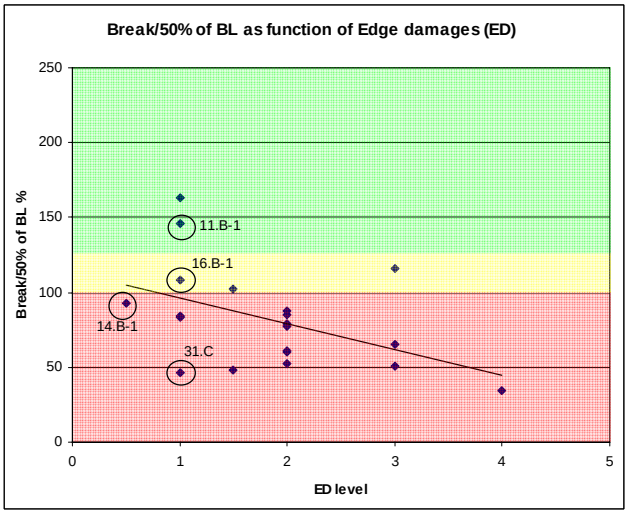
Acceptable damages



11.B-1 146% of MSL

16.B-1 108% of MSL





Remaining strength as function of the level of edge damages

Non acceptable damages

14.B-1 93% of MSL

31.C 46% of MSL

These tests show that also a very small edge damage reduces the remaining strength to unacceptable levels. Only very few of the tests were in or above the yellow part of the diagram.

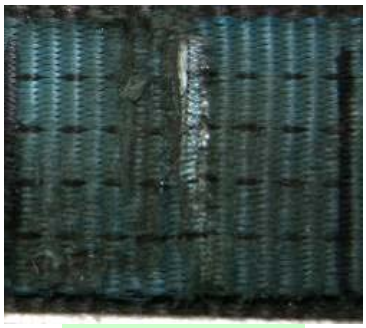
Lashing 14 had a dirt level of 3, but part A of the lashing showed acceptable remaining strength (173 and 141% respectively). The very small edge damage classified as 0,5 only in 14.B-1 made the lashing break at an unacceptable level (114 and 93%).

Table of remaining strength as function of the level of edge damages

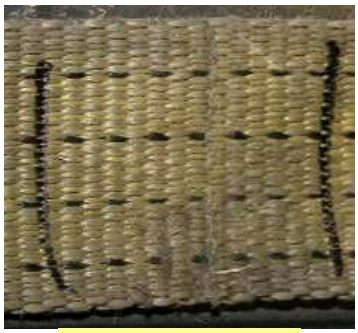
Test no	ED level	Break/LC %	Break/0.5 BL %
14.B-1	0,5	114	93
11.B-1	1,0	179	146
06.B-1	1,0	160	163
16.B-1	1,0	124	108
17.C	1,0	124	84
14.B-2	1,0	101	83
31.C	1,0	68	46
24.B-2	1,5	125	102
17.B-1	1,5	70	48
10.B-1	2,0	108	88
05.B-2	2,0	104	85
18.B-1	2,0	97	79
04.B-3	2,0	89	77
12.C	2,0	74	60
08.B-1	2,0	71	61
13.B-2	2,0	64	52
01.B-1	3,0	143	116
07.B-1	3,0	64	65
02.B-1	3,0	63	51
03.B-2	4,0	41	34

9.4.2 Cut damages

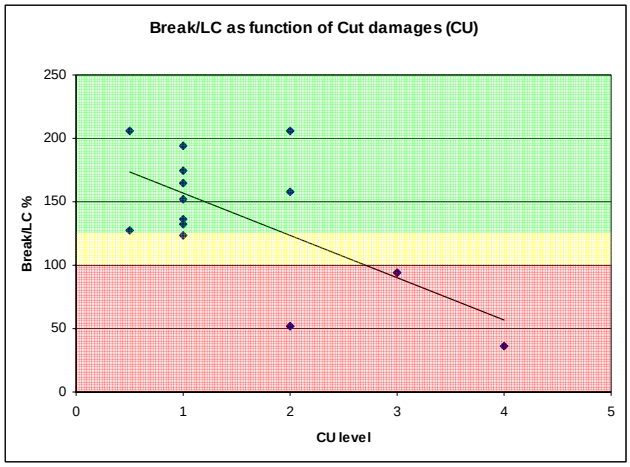
Acceptable damages

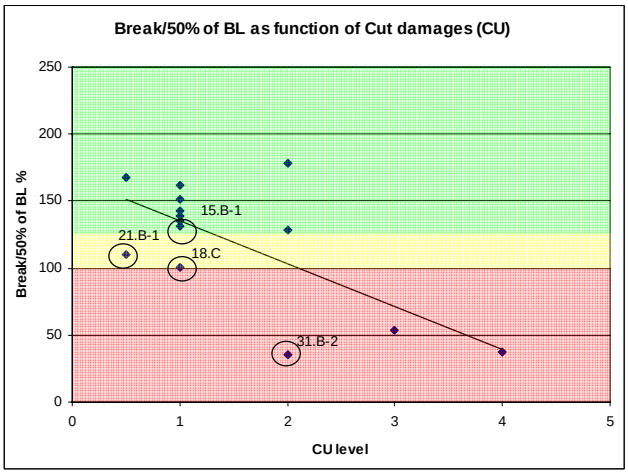


15.B-1 131% of MSL



21.B-1 110% of MSL





Remaining strength as function of the level of cut damages

Non acceptable damages

18.C 101% of MSL

31.B-2 35% of MSL

Also for cut damages there seems to be a correlation between the remaining strength and the degree of damage. Test 18.C shows that also small cut damages (level 1) can reduce the remaining strength to unacceptable levels.

Table of remaining strength as function of the level of cut damages

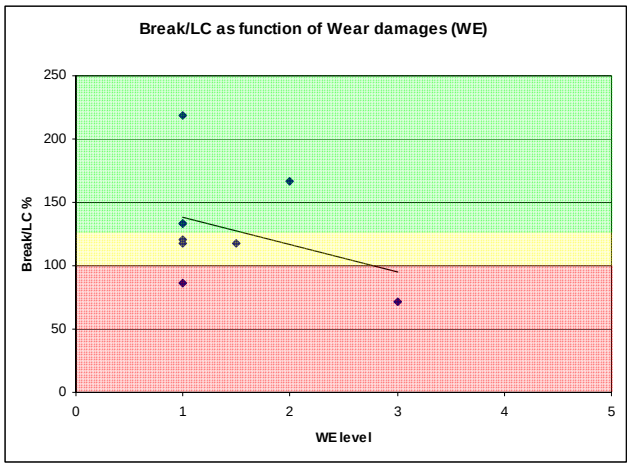
Test no	CU level	Break/LC %	Break/0.5 BL %
20.C	0,5	206	168
21.B-1	0,5	127	110
00.B-2	1,0	194	162
04.B-2	1,0	175	151
07.B-2	1,0	136	139
08.B-2	1,0	165	143
15.B-1	1,0	152	131
18.C	1,0	124	101
28.B-2	1,0	132	135
04.B-1	2,0	206	178
20.B-1	2,0	158	128
31.B-2	2,0	52	35
26.B-1	3,0	94	54
22.C	4,0	36	37

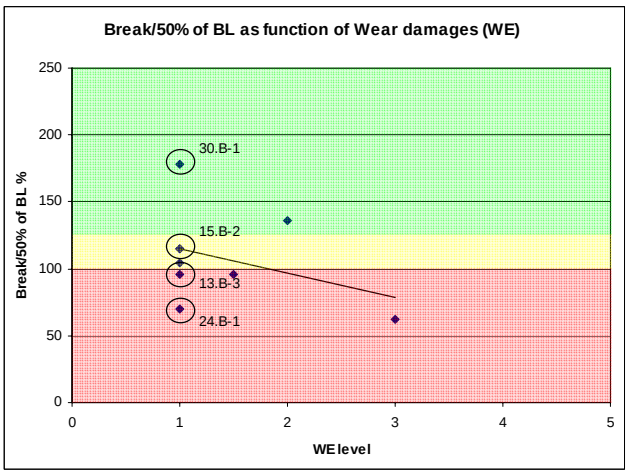
9.4.3 Wear damages

Acceptable damages

30.B-1 178% of MSL

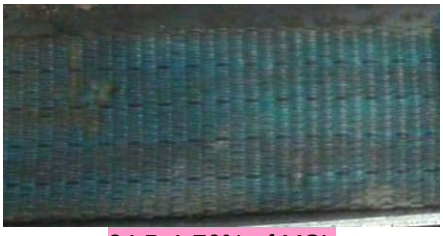
15.B-2 115% of MSL





Remaining strength as function of the level of wear damages

Non acceptable damages



24.B-1 70% of MSL

13.B-3 96% of MSL

Only very few of the wear damaged lashings showed acceptable remaining strength. Test 24.B-1 shows that also a very small wear damage (level 1) made the lashing break at an unacceptable level.

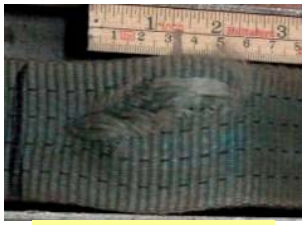
Table of remaining strength as function of the level of wear damages

Test no	WE level	Break/LC %	Break/0.5 BL %
24.B-1	1,0	86	70
13.B-3	1,0	118	96
16.B-2	1,0	121	104
15.B-2	1,0	133	115
15.B-3	1,0	133	115
30.B-1	1,0	219	178
27.B-1	1,5	118	96
05.B-1	2,0	167	136
00.B-1	3,0	72	62

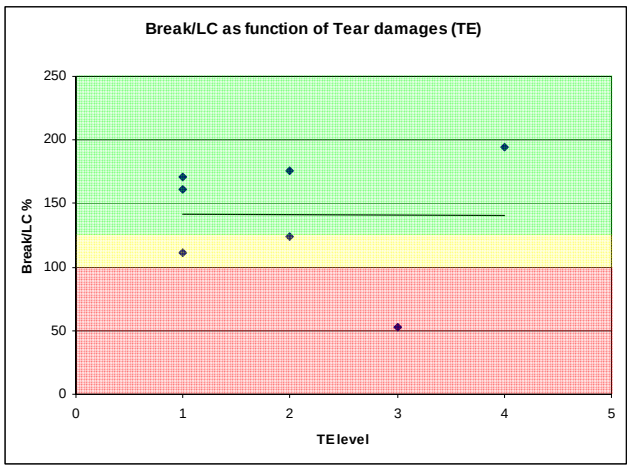
9.4.4 Tear damages

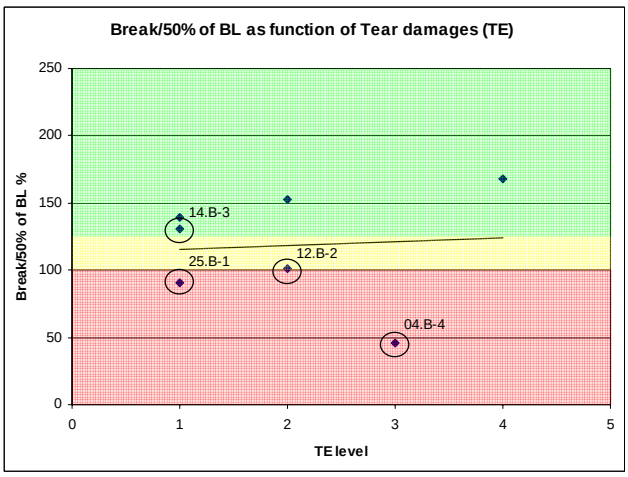
Acceptable damages

14.B-3 131% of MSL



12.B-2 101% of MSL





Remaining strength as function of the level of tear damages

Non acceptable damages

25.B-1 95% of MSL

04.B-4 46% of MSL

The tests show that there is no correlation between the remaining strength and the level of tear damage. A very large tear can have low influence on the remaining strength while a small damage as in 25.B-1 can have a significant influence.

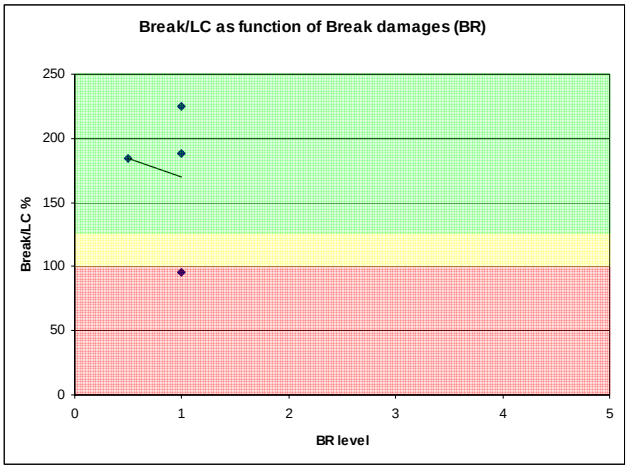
Table of remaining strength as function of the level of tear damages

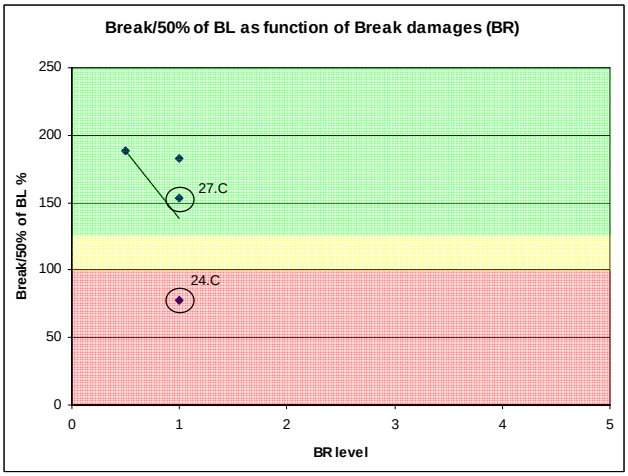
Test no	TE level	Break/LC %	Break/0.5 BL %
03.B-1	1,0	171	139
14.B-3	1,0	161	131
25.B-1	1,0	111	91
09.B-2	2,0	176	153
12.B-2	2,0	124	101
04.B-4	3,0	53	46
09.B-1	4,0	194	168

9.4.5 Break damages

Acceptable damages

27.C 153% of MSL





Remaining strength as function of the level of break damages

Non acceptable damages

24.C 78% of MSL

Only very few of the tested lashings had break damages and there is no obvious correlation between the remaining strength and the level of damage. Test 24.C shows that also a limited damage can give a large reduction in remaining strength.

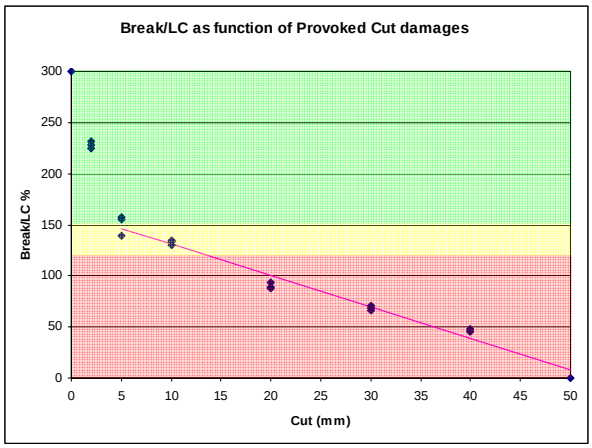
Table of remaining strength as function of the level of break damages

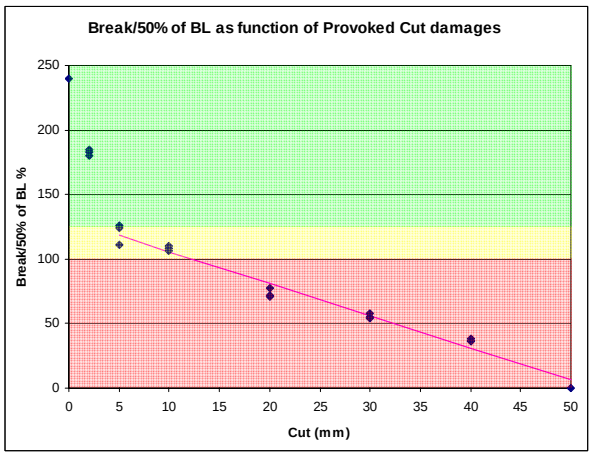
Test no	BR level	Break/LC %	Break/0.5 BL %
22.B-1	0,5	184	188
19.B-1	1,0	225	183
24.C	1,0	96	78
27.C	1,0	188	153

9.5 Provoked damages

Tests of provoked damages (edge and knots) were carried out with new equipment.

9.5.1 Provoked edge damages



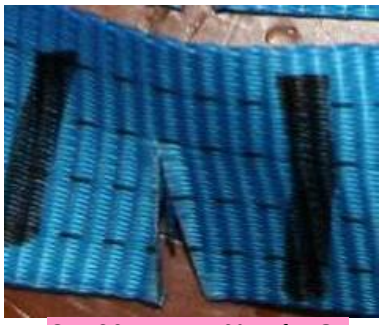


Remaining strength as function of provoked edge damages

Damages

Cut 10 mm ~ 108% of MSL

Cut 20 mm ~ 73% of MSL



Cut 30 mm ~ 56% of MSL

There is an obvious correlations between the level of edge damage and the remaining strength. Also a limited edge cut of 5 mm had large influence on the strength as can be seen. Three tests were carried out for each level of cut and all tests showed more or less identical results, see results of the tests 34 in annex C.

9.5.2 Knots

Loops made of bowline (pålstek) as well as a simple over hand loop (överhandsknop) were tested. Also here three tests were carried out with each type of knot.

Bowline 33.B-1

Overhand knot 35.ÖE-1

As can be seen in annex C from the tests 33, the simple overhand knot loop showed a larger strength than the bowline loop. In both cases the strength was considerably reduced and the remaining strength was between 50 – 60% of the lashing without knot. Similar results were obtained with loops on used lashing equipment as can be seen in tests 32 in annex C, but the remaining strength was much less than for the new lashings.

Knot on used lashing 11.B-2

Knot on used lashing 18.B-2

All types of knots on used lashings are reducing the remaining strength considerably and can not be accepted.

9.5.3 Twisted lashings

Tests were carried out with twisted lashings, and as can be seen for tests 36 in annex C, twisting has limited influence on the remaining strength of the lashing. It has, however, been pointed out that pulse tests carried out on car lashings by RoRo International have showed that twisted lashings may influence on the strength of the tensioner.

9.6 Tests with ratchet tensioners

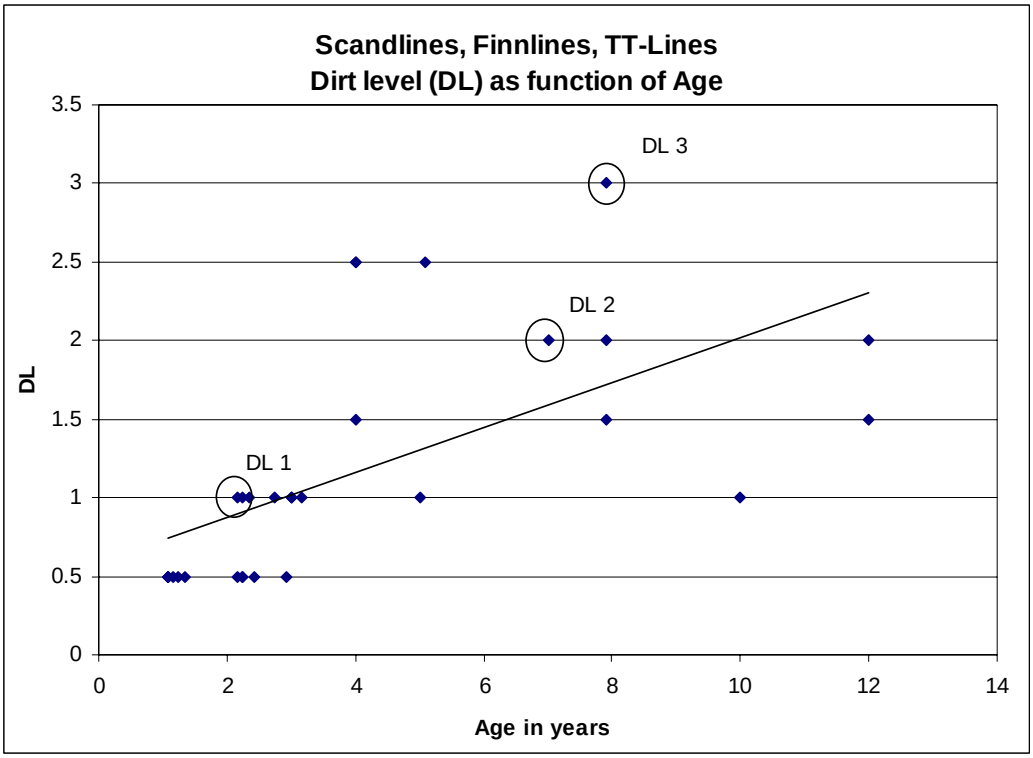
The ratchet tensioners were tested with new strong loose ends in order to find the remaining strength of the ratchet part. As the webbing is double on the ratchet end it had been expected that these parts

should show larger remaining strength than the loose ends. They also did as can be seen in tests 37 – 42 in annex C, but still the strength had been reduced in relation to new webbing.

10 Results of tests with maritime lashings

Below the tests with the maritime lashing equipment are presented.

10.1 Dirt level as function of Age



30 out of 34 tests are represented in the diagram. The other 4 were without known manufacturing date. Some of the tests have the same parameters and cover each other.

In the photos below example of different dirt levels (DL) are shown. Please note that the overall level of dirtiness were higher for the maritime trailer lashings than for the other types of web lashings and the grading of the different types should therefore not be compared to each other.

23 DL 1 - Dirty mainly at surface

17 DL 2 - Dirty and somewhat swollen

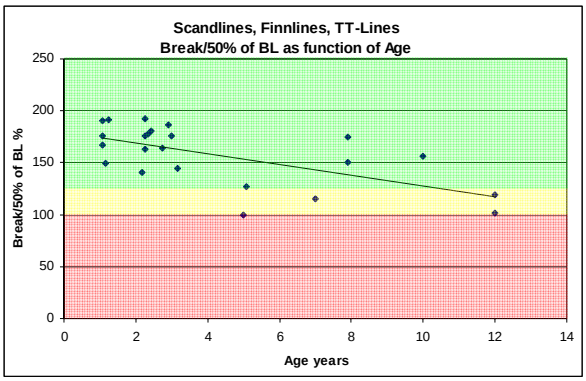
42 DL 3 - Dirty and swollen

The lashings from Tor Line were not marked with manufacturing date and are thus not included in the diagram. As for the 50 mm web lashings there is an obvious correlation between the dirt level and the age.

Table of dirt level as function of age – Scandlines, Finnlines, TT- Lines

Test no	DL	Age
16	1,0	10
17	2,0	7
18	1,0	5
19	2,5	5
20	1,0	3
21	1,0	3
22	1,0	3
23	1,0	2
24	0,5	2
25	0,5	1
26	0,5	1
27	1,0	3
28	0,5	3
29	0,5	2
30	1,0	2
31	1,0	2
32	0,5	2
33	0,5	2
34	0,5	1
35	0,5	1
36	0,5	1
37	0,5	1
38	1,5	12
39	2,0	12
40	2,0	8
41	1,5	8
42	3,0	8
43	2,5	4
44	1,5	4
45	2,5	4

10.2 Remaining strength as function of Age



Only lashings that did not break in any damage are represented in the diagram.

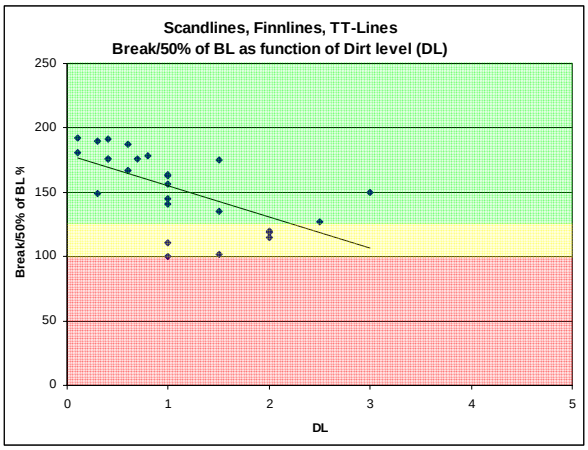
The Tor Line lashings are not represented in the diagram because of lacking manufacturing date.

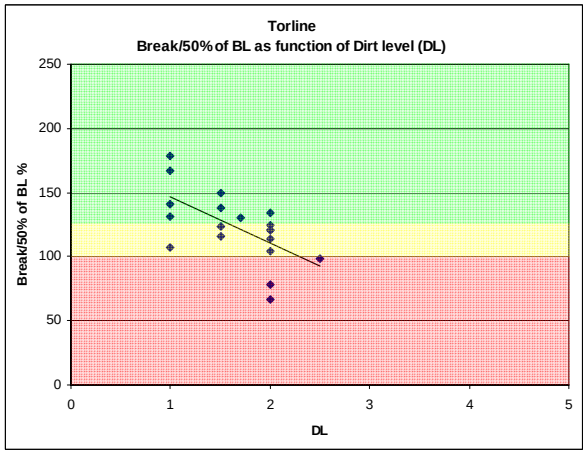
As can be seen from the diagram the age itself has low influence on the remaining strength as long as the lashings are undamaged.

Table of remaining strength as function of age – Scandlines, Finnlines, TT- Lines

Test no	Break/0.5 BL%	Age years
16	156	10
17	115	7
18	100	5
19	127	5
20	145	3
22	164	3
23	141	2
26	149	1
27	176	3
28	187	3
29	181	2
30	163	2
31	178	2
32	192	2
33	176	2
34	190	1
35	191	1
36	176	1
37	167	1
38	102	12
39	119	12
41	175	8
42	150	8

10.3 Remaining strength as function of Dirt level





Remaining strength as function of dirt level

Only the lashings that did not break in any noted damage are represented in the diagrams above. From the tests it can be concluded that the dirt level has an obvious influence on the remaining strength. The influence of dirt seems to be larger for the heavy (20-tons) Tor Line lashings.

Table of remaining strength as function of dirt level – Scandlines, Finnlines, TT- Lines

Test no	DL	Break/0.5 BL%
13	1,5	135
14	1,0	111
16	1,0	156
17	2,0	115
18	1,0	100
19	2,5	127
20	1,0	145
22	1,0	164
23	1,0	141
26	0,3	149
27	0,7	176
28	0,6	187
29	0,1	181
30	1,0	163
31	0,8	178
32	0,1	192
33	0,4	176
34	0,3	190
35	0,4	191
36	0,4	176
37	0,6	167
38	1,5	102
39	2,0	119
41	1,5	175
42	3	150
46	2	120

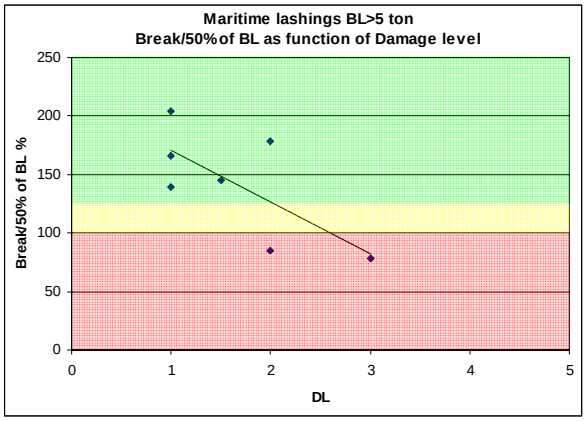
Table of remaining strength as function of dirt level – Tor Lines

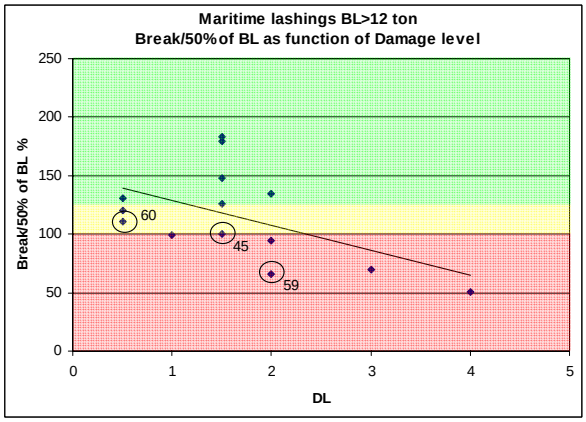
Test no	DL	Break/0.5 BL%
63	2,0	114
65	2,0	125
67	1,0	141
68	1,0	131
72	2,0	121
73	2,5	98
74	2,0	104
75	1,0	107
77	1,7	130
80	1,5	138
81	2,0	121
82	1,5	116
83	2	67
K1	1,0	179
K2	2,0	78
K3	1,0	167
K4	1,5	124
K5	2,0	134
K7	1,5	150

10.4 Remaining strength as function of Damage level

Acceptable damages

60 111% of MSL





Strength as function of damage level

Non acceptable damages

45 100% of MSL

59 66% of MSL

Too few tests were carried out to make separate diagrams of different damage types. Only lashings that broke in damages are represented in the diagram above .

For most lashings the webbing broke at the winch or at the hook whether they had any damages or not.

Also for the maritime web lashings it can be noted that also limited damage levels have large influence on the remaining strength.

Table of strength as function of damage level - Maritime lashings BL<5 ton

Test no	Break/0.5 BL%	Damage level
2	139	1,0
3	78	3,0
4	85	2,0
8	166	1,0
9	178	2,0
10	204	1,0
11	145	1,5

Table of strength as function of damage level - Maritime lashings BL>12 ton

Test no	Break/0.5 BL%	Damage level
13	135	2,0
15	99	1,0
21	148	1,5
24	179	1,5
25	94	2,0
40	51	4,0
43	120	0,5
44	183	1,5
45	100	1,5
59	66	2,0
60	111	0,5
64	126	1,5
78	131	0,5
K6	70	3,0

10.5 Chain lashings

A number of used chain lashings were tested.

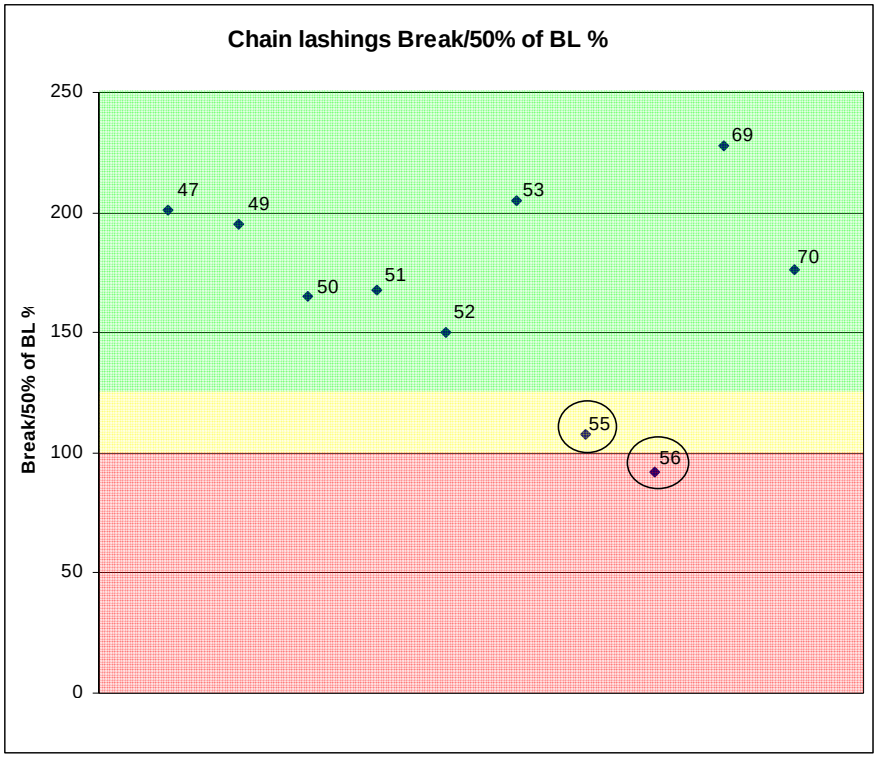
50 before

50 after

49 before

49 after

The chains were not marked by age, and the level of rust was not noted, which means that the remaining strength can not be plotted as a function on anything else but the test number.

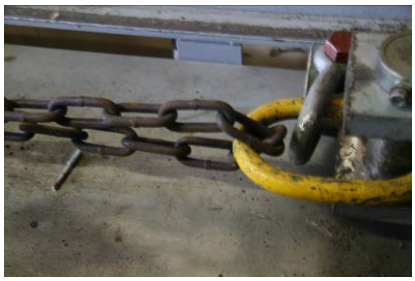


The remaining strength of all chain lashings except for number 55 and 56 is well above the allowed limit. Test number 55 and 56 had deformed links and broke in these, see below.

Deformed link in chain 55

Deformed link in chain 56

The tests showed that the weak point in the chain lashings is the tensioner which in many cases was the part that broke, see annex D. From the diagram it can be seen that a large number of the chains had the same strength as when new and in some cases the remaining strength was even larger than the specified strength for new equipment (results above 200%).

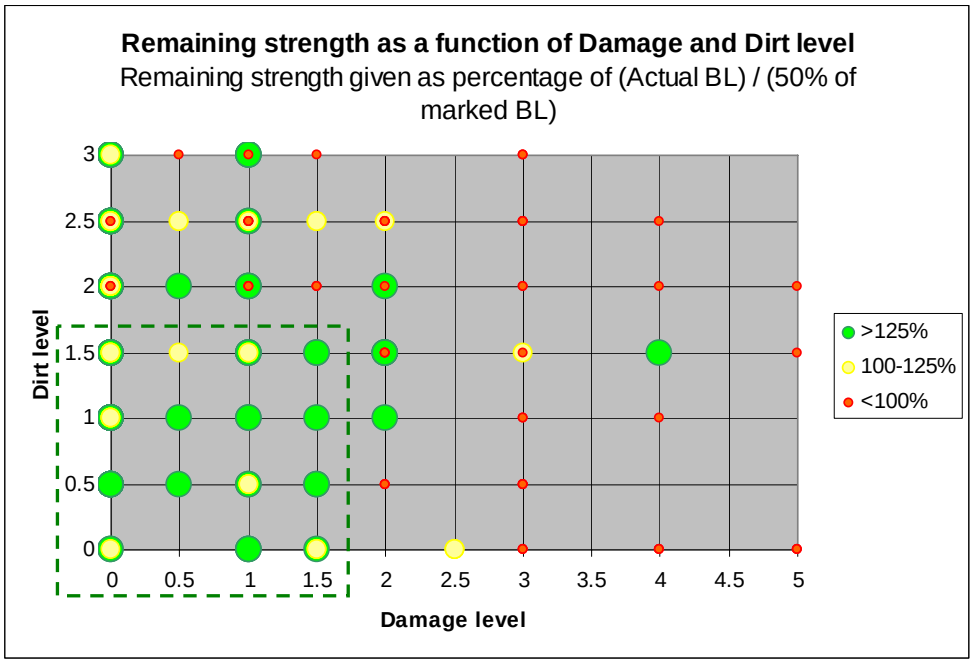


Test 69 with a 11 mm chain drawn around a ring with steel thickness 25 mm. The chain broke at 228 % of MSL.

As can be seen in test 69 with a chain drawn around a 25 mm round bar, this does not influence on the strength of the chain.

11 Acceptable damage and dirt levels for web lashings

In the diagram below, the results for all web lashings have been compiled into a comparative diagram which indicate the occurrence of lashing gear samples of acceptable as well as non acceptable condition as a function of both dirt and damage level.



Green circles in the diagram above, for example, indicate the occurrence of samples that showed a remaining strength of more than 125% of half the Break Load they were marked with.

Based on the diagram above, it can be concluded that lashings with a damage or dirt level above 1.5 should be removed from service. In the sections below, examples of different dirt and damage levels are shown.

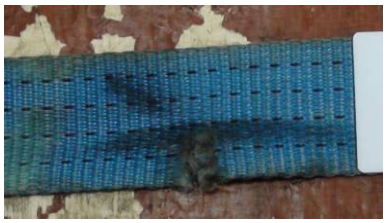
11.1 Examples of different dirt levels

Web lashings with dirt levels up to 1,5 is acceptable for use. Examples of different dirt levels are shown below.

Dirt level	50 mm web lashings		Maritime web lashings	
0,5		427		701
1		22A-1		656
1,5		444		856
2		27B-1		851
2,5		12B-1		652
3		14B-1		741

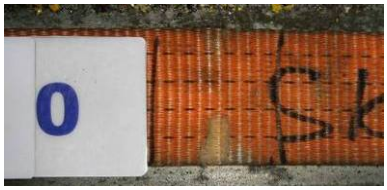
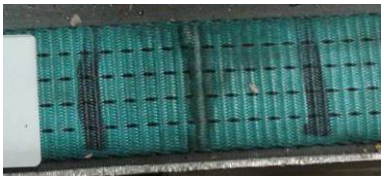
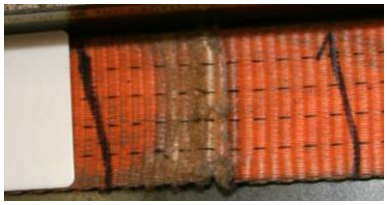
11.2 Examples of different levels of edge damages

Web lashings with edge damages up to 1,5 is acceptable for use. Examples of different damage levels are shown below.

Damage level	50 mm web lashings		Maritime web lashings	
0,5		14B-1		14
1		06B-1		624
1,5		24B-1		21-2
2		05B-1		577
3		02B-1		K6-1
4		03B-2		

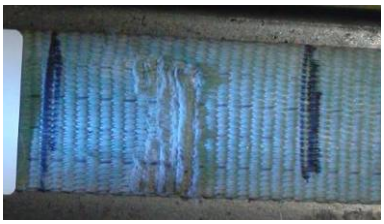
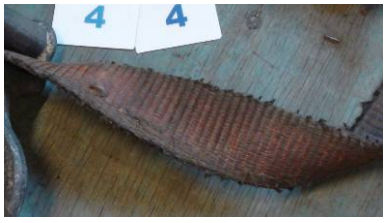
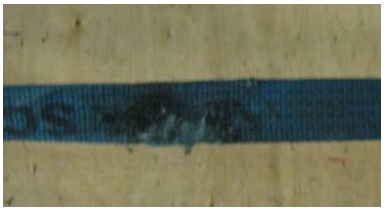
11.3 Examples of different levels of cut damages

Web lashings with cut damages up to 1,5 is acceptable for use. Examples of different damage levels are shown below.

Damage level	50 mm web lashings	Maritime web lashings
0,5	 20C	
1	 28B-2	
1,5		 65-2
2	 04B-1	
3	 26B-1	
4	 22C	 41-2
5	 31B-1	

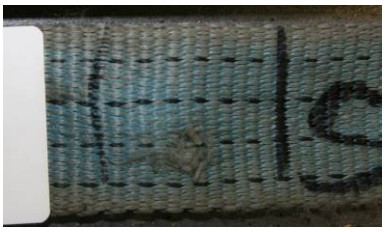
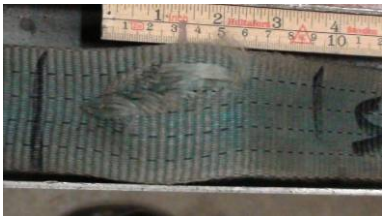
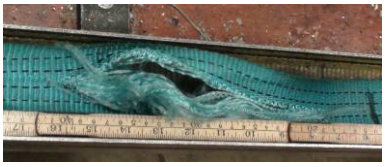
11.4 Examples of different levels of wear damages

Web lashings with wear damages up to 1,5 is acceptable for use. Examples of different damage levels are shown below.

Damage level	50 mm web lashings	Maritime web lashings
0,5		 16-2
1	 13B-3	 22-2
1,5	 27B-1	 44-3
2	 05B-1	
2,5		 83-2
3	 00B-1	

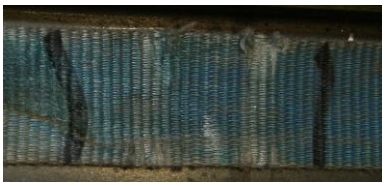
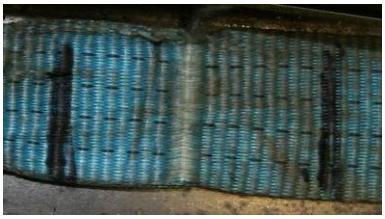
11.5 Examples of different levels of tear damages

Web lashings with tear damages up to 1,5 is acceptable for use. Examples of different damage levels are shown below.

Damage level	50 mm web lashings	Maritime web lashings
0,5		 31-2
1	 14B-3	 08
1,5		 20-2
2	 12B-2	
3	 04B-4	
4	 09B-1	

11.6 Examples of different levels of break damages

Web lashings with break damages up to 1,5 is acceptable for use. Examples of different damage levels are shown below.

Damage level	50 mm web lashings	Maritime web lashings
0,5	 22B-1	
1	 24C	 8
1,5	 27C	