Risk Potential of Safety Gears
Inspections with Tests Weights Show a Lack of Clearness!

Interlift 2015
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Introduction

- Thesis: Inspections with Test Weights Show a Lack of Clearness!
- Why and how are safety gears tested using weights?

- Why does a weight test only cover some of the safety gear's aspects?
  - What errors are sporadically made?
  - What are the principal errors made during testing?

- What can we do to avoid these errors?

Requirements to be met by safety gears

- Safety gears shall be able to safely decelerate a fully loaded car to a complete stop in a free fall situation (ropes broken)!

Exception: in North America acc. to enquiry 86-2 for A17.1 of March 11, 1987, type B safety gears shall be just able to decelerate the car to the allowable speed range of the buffer

- Depending on the standard different deceleration limits and/or slide distances need to be met

e.g. as per EN 81-1:2010-06, 9.8.4, between 0.2 g and 1.0 g for brake-type safety gears

Testing the safety gears

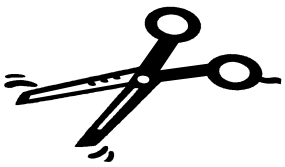
- Practically all over the world safety gears are tested at full load or overload when elevators are put into operation

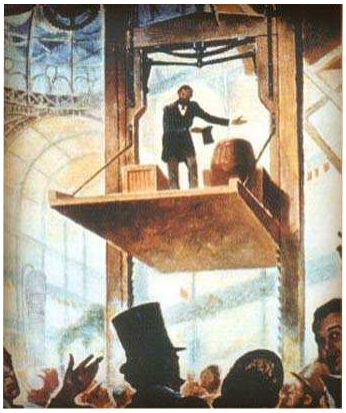
- Depending on the standard that is applied, safety gears are usually subjected to a recurrent inspection at regular intervals

Example:
In Europe usually every 2 years
In the USA and Canada every 5 years
…

Testing the safety gears using test weights

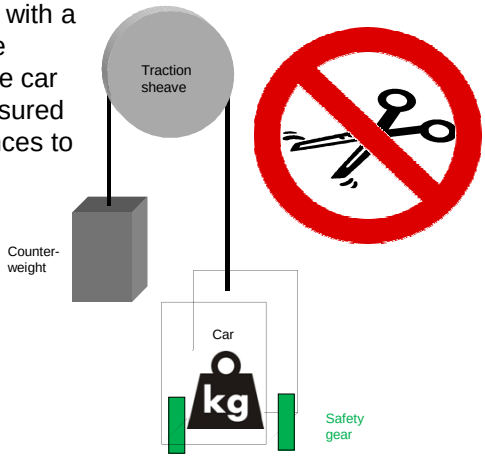
- Since Elisha Graves Otis made his demonstration with a really impressive free fall test at the 1854 world expo, suspension ropes are usually no longer cut to test safety gears





Testing the safety gears using test weights

- Instead the elevator is loaded with a rated load or overload and the safety gear is tripped when the car is going down to use the measured decelerations or sliding distances to make a test statement



Testing the safety gears using test weights

- One of the most important requirements to be met by safety gears is not tested:
  - A free fall test with failing ropes!
- Alternative test systems have already identified numerous elevators the safety gears of which would fail in a free fall test
- North America: failure of suspension means on at least 2 elevators in the last few years

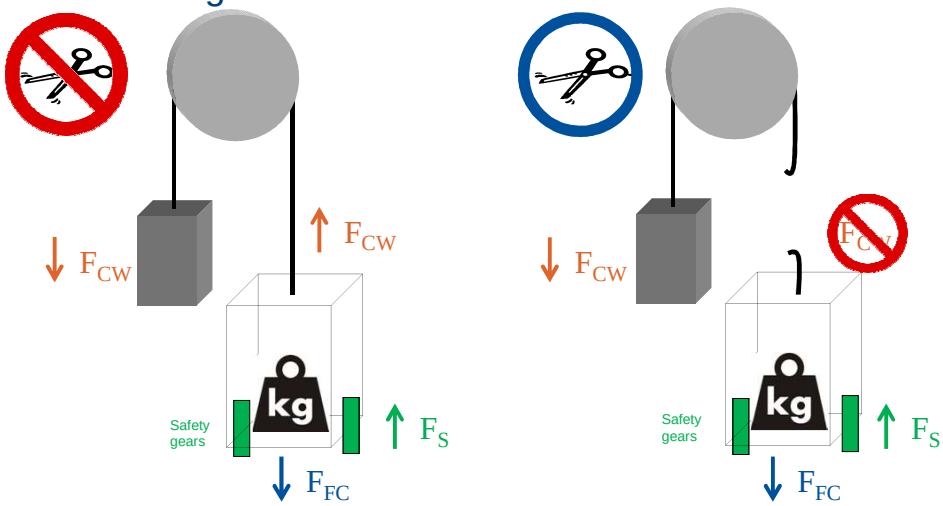
Testing the safety gears using test weights

- One of the most important requirements to be met by safety gears is not tested:
  - A free fall test with failing ropes!
- What is the difference between a safety gear test

with suspension ropes

in a free fall

Physical correlations during safety gear tests with weights



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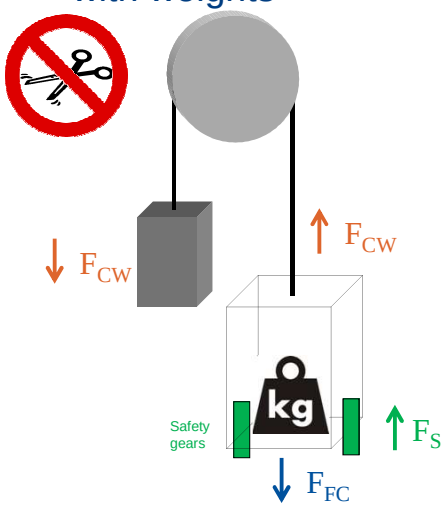
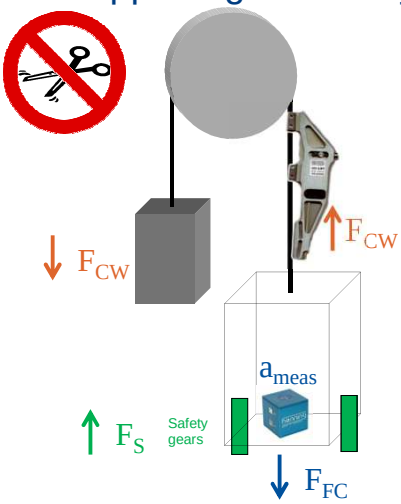


- During the test the car is not only decelerated by the safety gear but also by the counterweight (and any brakes etc. that are not kept released)
- The deceleration is the sum of the forces $F_S + F_{CW}$
- Force F_{CW} is an unknown in the test using loads. As long as it cannot be quantified, no test statement can be made for the worst case scenario with failed suspension means.

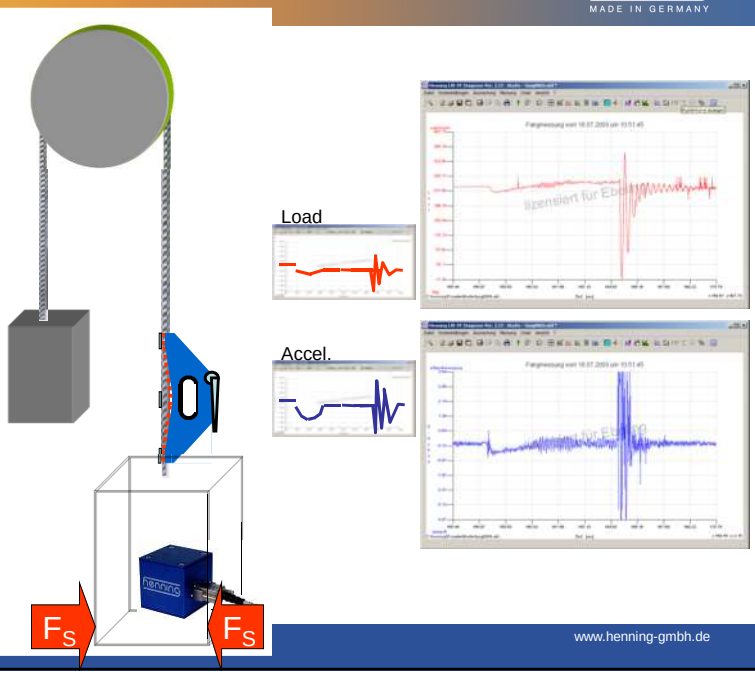
Tests used to quantify the counterweight force supporting the safety gear



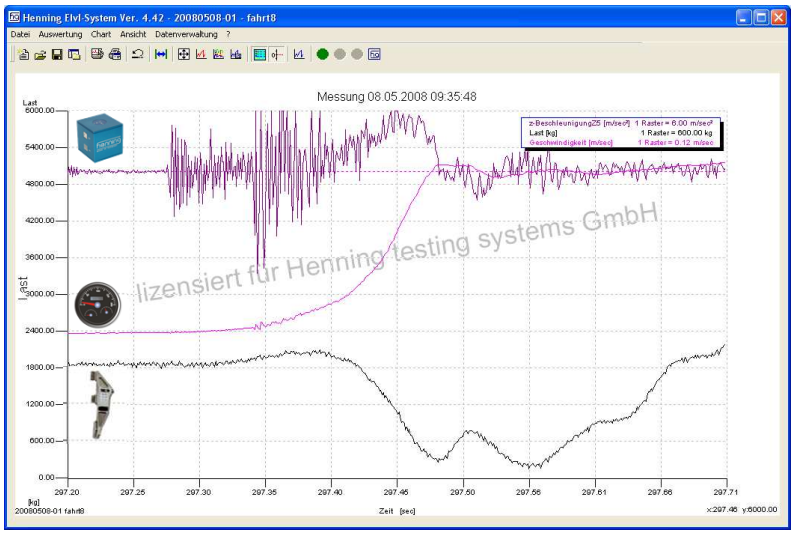
F_{CW} can be measured directly with rope sensors

$F_{FC} = a_{meas} \cdot m_{car}$

a_{meas} can be measured directly with an acceleration sensor.
m_{car} can be measured directly with a load sensor before starting the test.



Example 1: safety gear force measurement



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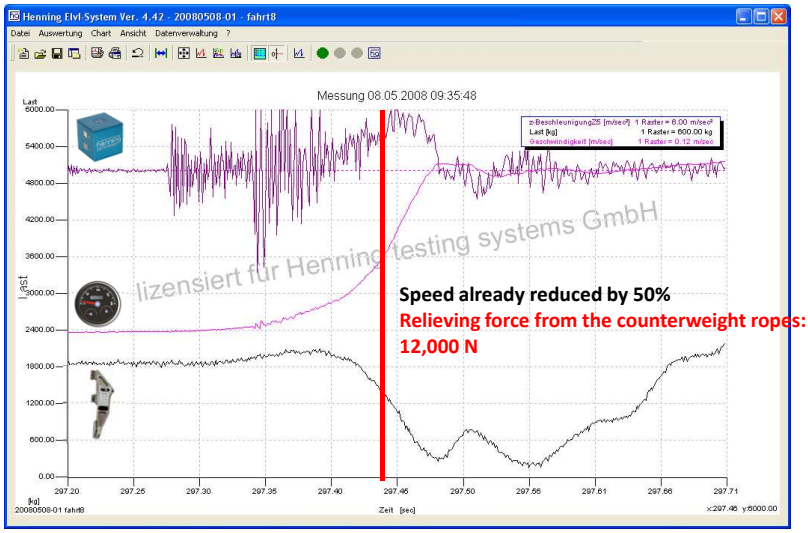

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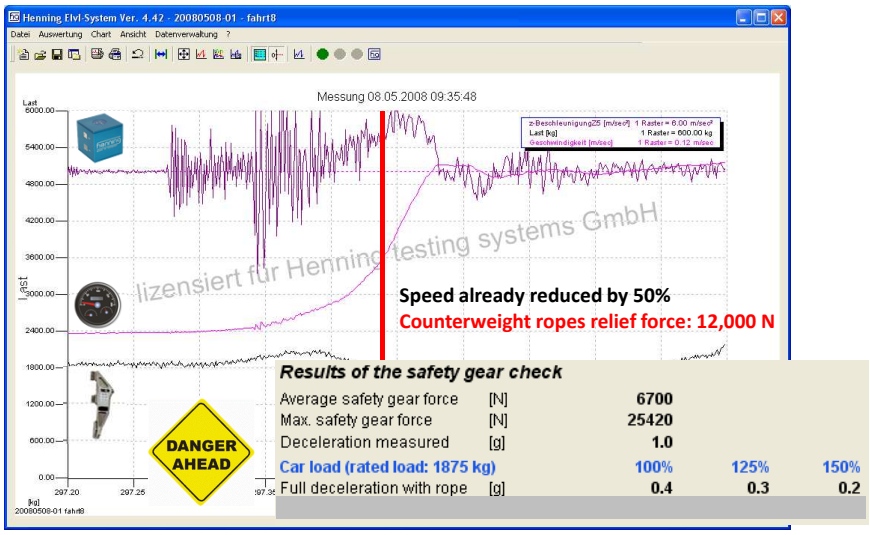
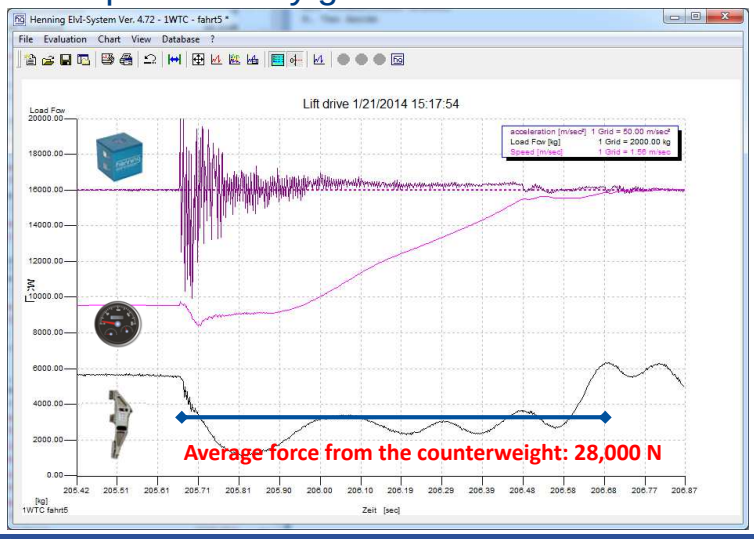


Results of the safety gear check

Average safety gear force	[N]	6700		
Max. safety gear force	[N]	25420		
Deceleration measured	[g]	1.0		
Car load (rated load: 1875 kg)		100%	125%	150%
Full deceleration with rope	[g]	0.4	0.3	0.2

Example 2: safety gear force measurement



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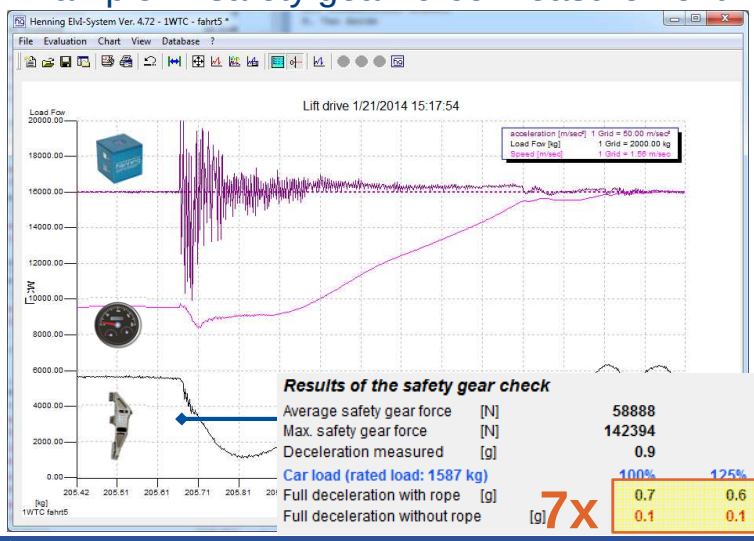


Results of the safety gear check

Average safety gear force	[N]	58888		
Max. safety gear force	[N]	142394		
Deceleration measured	[g]	0.9		
Car load (rated load: 1587 kg)		100%	125%	150%
Full deceleration with rope	[g]	0.7	0.6	0.6
Full deceleration without rope	[g]	0.1	0.1	0.0

7x

Faults made when testing safety gears with load

- Principal fault:
  The supporting force generated by the counterweight is not considered
- Usually safety gears are *type tested* worldwide. When properly installed, when free of wear and with the correct ambient conditions, a proper operation and efficiency should be possible.
- Sporadic faults:
  - Wrong car weights (especially following modernisations)
  - Wrong counterweight balancing (esp. following modernisations)
  - Defective safety gears (incorrectly adjusted, worn out, improperly installed, improperly dimensioned …)

Faults made when testing safety gears with load

- Principal fault is already included in the codes

The North American ASME A17.1-2010/CSA B44-10 code requires that certain stopping distances be met when testing loaded cars depending on the rated load, car weight and rated speed.
These are included in a table in the code.

Faults made when testing safety gears with load

- Example

Car weight:	2300 kg
Load:	1100 kg
Rated speed:	1.25 m/s
Tripping speed:	1:70 m/s

max. permissible sliding distance during the test: 675 mm (acc. to A17.1)

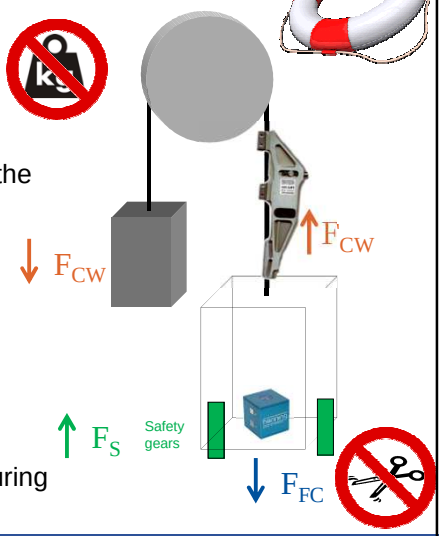
- This test verifies a deceleration force of 40 kN
- A free fall would require a deceleration force of 33 kN
- If the influence of the counterweight is only 22 % of the weight force of the fully loaded car, the safety gear would not be able to decelerate this elevator car!
- Random measurements (s. examples) verify an influence of approx. 50%

Alternative testing systems

- Electronic testing systems can warrant a safe inspection of safety gears when they consider the counterweight influences
- The first electronic testing system was developed nearly 25 years ago by the TÜV Süd, Germany.
- In the meantime other testing systems (e.g. Henning testing systems, TÜV Rheinland, TÜV Nord, etc.) exist.
- Since more than 20 years thousands of elevator systems in Germany are tested with such a system during recurrent inspections.
- Since September 2013 these systems are also used in the USA and Canada.

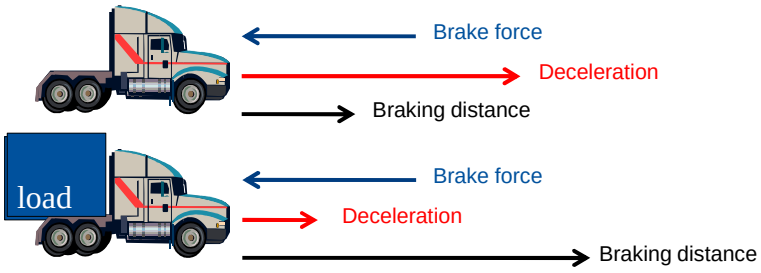
Alternative testing systems

- Do not need car testing loads
- Can take into account influences of the counterweight
- Produce quantified results
- Also test motor brakes, rope brakes, traction capabilities, etc.
- Reduce the load-dependent wear during testing



Basic principle for alternative testing systems

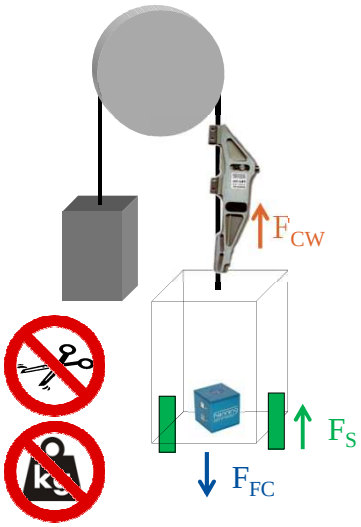
- Example: truck emergency brake with and without load



Brake force is identical, unaffected by initial speed and load!

If you know the brake force, you can calculate the braking distance and the deceleration referred to any load whatever. Also for ELEVATOR SAFETY GEARS!

Alternative testing systems



$F_{CW} + F_S = F_{FC}$

$F_S = F_{FC} - F_{CW}$

Test for worst case is passed, if

$F_S > (m_P + m_Q) \cdot g$

Worst case:

F_{CW} = min. = 0 (no ropes, free fall)

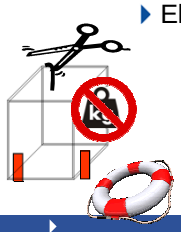
F_{FC} = max. = $(m_P + m_Q) \cdot g$ (max. load)

m_P weight of empty cabin
m_Q weight of load

Summary

- Practically all over the world safety gears of elevator systems are not inspected conform to requirements.

- Principal faults made in the tests and partially contained in the codes as well as sporadical system-related as well as service and assembly-related faults affect the usefulness of tests carried out with loads to substantiate the safe operation of safety gears.



- Electronic testing systems enable
  - physically correct tests of safety gears, machine brakes, emergency brakes and traction forces,
  - without the use of test weights,
  - and accounting for the important influence exerted by the counterweight.