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Mechanics and Maritime Sciences **Chalmers Railway Mechanics**

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67 pages

Swedish tests of block brake performance in winter conditions

Winter 2018-2019

Detailed analyses of experimental results

Summary

Data from the Swedish tests on LL brake blocks, performed April 2018, have been analysed in detail by merging tabulated data on brake cycles with measured data for the individual braking cycles. Measured data include train speed, pneumatic brake pressure, hanger link forces and some brake block temperatures.

The tests were performed in weather conditions that did not provide conditions with whirling snow and can for this reason be considered as trial runs for a larger experimental campaign to be launched during the winter 2019-2020.

The report details possible ways of assessing data acquired during winter testing. No conclusions presented.

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Contents

1. Background and Aim

The present study reports on a detailed assessment of data from the Swedish winter tests on cast iron and LL-type brake blocks as tested during some days in April 2019. The analyses are based on the data given in the test report[1] and the data files that were acquired during the tests[2]. To this end, data have been read into Matlab to allow for easy processing, structuring and visualization of results.

2. Method

Firstly, the nominal data, i.e. data according to the test plan, were read into Matlab from Excel sheets, providing the following useful data for individual brake cycles: date and time, initial speed of braking, braking pressure and outdoor temperature. In addition, comments are given on weather conditions regarding snow using UIC snow smoke index. After this, each individual brake cycle was identified in the time history data files by a procedure based on 1) finding the approximate time period using supplied time marks, and 2) to manually mark beginning and end of each brake cycle. The start of braking was identified as the time when the brake pressure starts to change and the end was identified as the time when the train was at full stop. For each identified brake cycle, the signals of the hanger link force transducers were put to zero just prior to the brake cycle, and the average force during braking[3] was calculated.

[1] N. Berglind, Brake performance tests of brake blocks in winter conditions, *ÅF Test Center*, Report No 6179083:01, 2019-05-02, 8 pp

[2] Nominal braking data in xlsx-format and time history data files in DeWeSoft-format and mat-format sent by N. Berglind, ÅF Test Center to Tore Vernersson on 2019-05-02

[3] The average value was calculated for the duration of the braking cycle for which the total braking force is higher than 10% of the maximum braking force during the considered cycle.

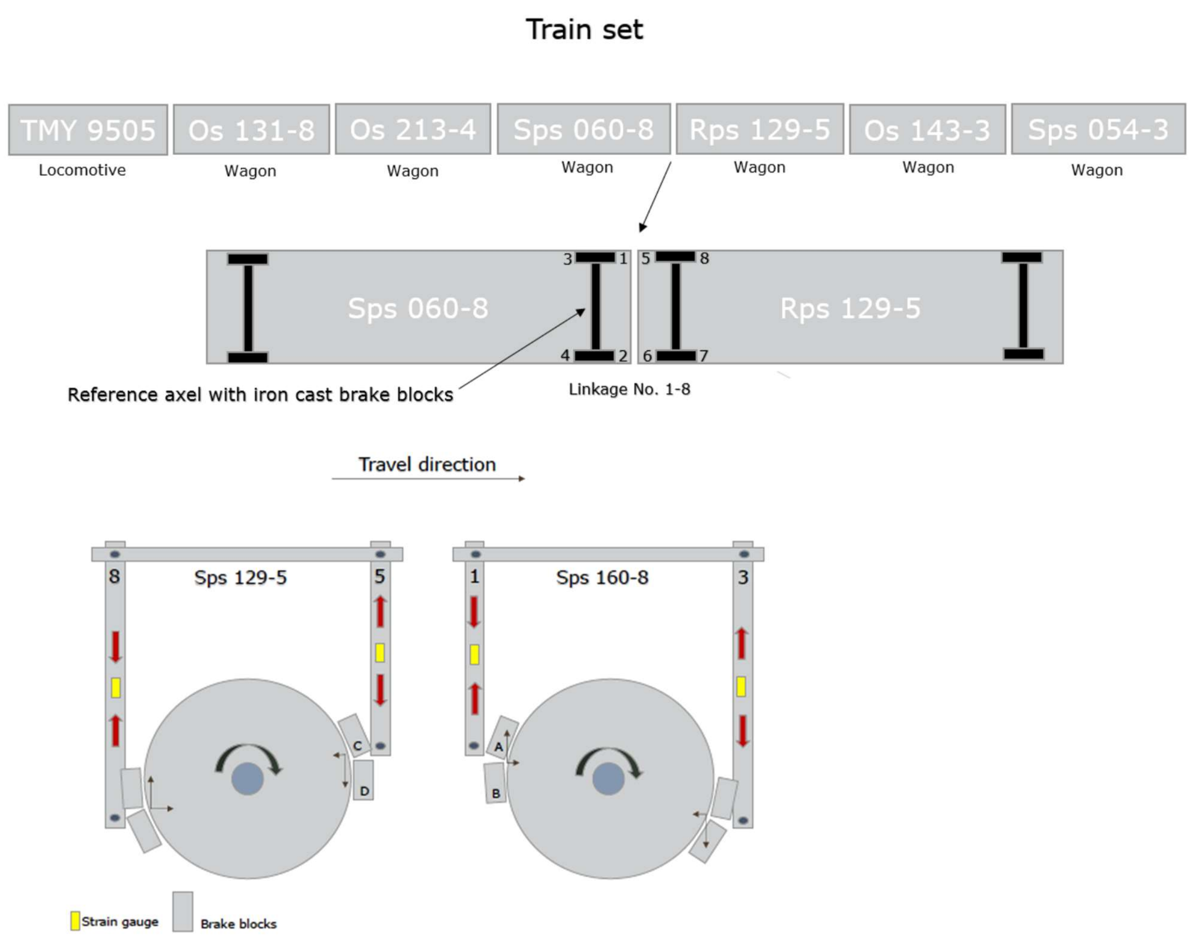


Figure 1 Sensor positions of hanger links in test train

3. Results and discussion

A total of 56 brake cycles could be identified, see Appendix A. Two of the cycles had indications of malfunctioning data acquisition and were removed from further analysis. The test wagons are going either forward or backward during different stages of the test campaign. For this reason, the hanger links that are in tension or compression varies during testing.

First, some general test data are compared. In Figure 2 the actual initial speeds are shown. The actual speeds should nominally be at three distinct levels (60 km/h, 80 km/h and 100 km/h), but the figure indicates a rather large spread in speeds. In Figure 3 the average[3] pressures are shown and also the peak pressure. Again there is a spread in the pressures values that have been produced. Noted is that the rise time for the brake pressure is slow, with about 10 s from onset of brakes until the full brake pressure is reached, see Appendix A. At lower speeds, there is a reduction in brake pressure. At the early phase of braking, there is sometimes a tendency for over-shooting the wanted pressure values, which is reflected by the peak pressure value in Figure 3. In Figure 4, the average and peak braking pressures for the two nominal pressure levels are presented as a function of nominal braking pressure. In addition, curve fitting has been performed and a linear trend line has been introduced in the graphs along with indications of the standard deviations from that line. The accuracy of both initial speeds and brake pressure variation will affect the train braking performance and limits for allowed variations at tests should be outlined for future tests.

The braking distance for each stop can be found by time integration of the measured speed history. In Figure 5, the calculated braking distances are presented separately for the two nominal pressure levels and the three nominal speeds. In the header of the subplots, the average braking distance are given along with the standard deviation. The standard deviation in the braking distance ranges from being about 7% of the mean braking distance up to about 16%. The higher percentages are found for the reduced braking pressure case at 1.2 bar, while lower ones are found for the full braking case at 1.5 bars.

An attempt has been made to assess the braking energy for all separate brake block inserts. Based on information on hanger link geometries and knowledge of coefficient of friction value, one can by use of a quasi-static equilibrium find relations between block-wheel contact force and hanger link force and also relations between block-wheel normal contact force and brake force provided by the rigging system. However, due to uncertainties in the geometry of the hanger link set-up, these efforts are left outside of the present report. Instead, an approximate measure of the brake energy has been calculated by integrating the time histories of the hanger link force multiplied by the train speed. It is chosen to present the total energy per wheel, see Figure 6 in which the cases for the two nominal braking pressures and three speeds are presented separately. It should be noted that values are given for two wheels having cast iron brake blocks and for one wheel having organic composite blocks (neglecting one wheel for the organic blocks since it had a broken force transducer). In Figure 7, the average values of the braking energies per wheel are presented along with the standard deviation.

The brake block temperatures at the end of each stop braking, as measured using thermocouples, are shown in Figure 8. The measured temperatures of the cast iron brake blocks can be seen to be substantially higher than the ones of the organic composite blocks.

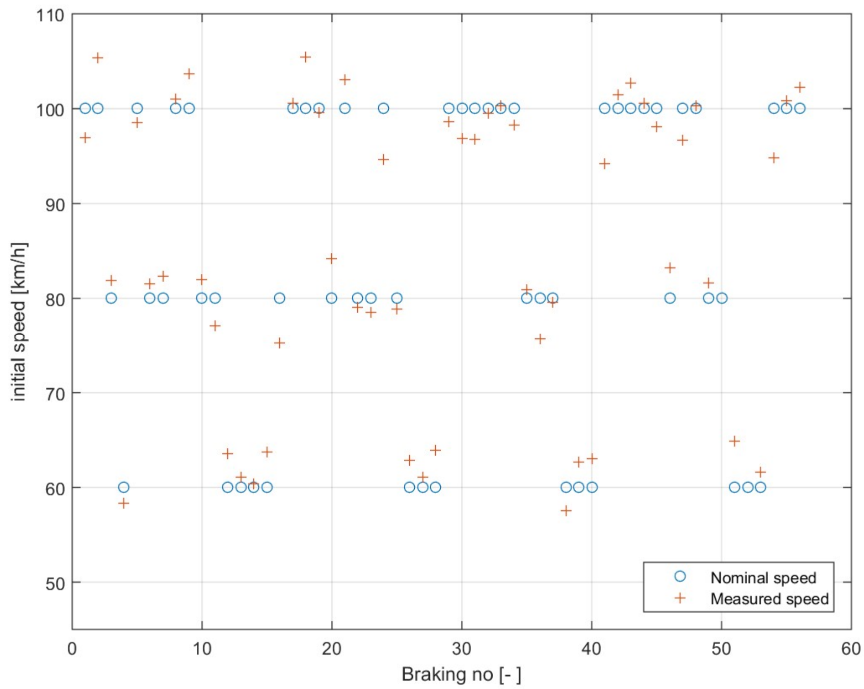


Figure 2 Actual initial test speed for the performed all 56 stop braking cycles.

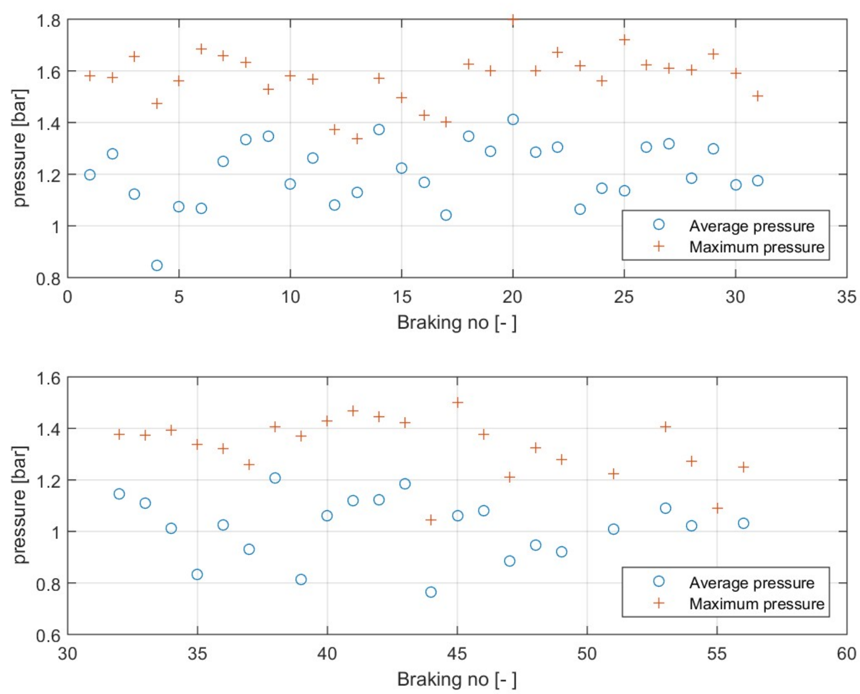


Figure 3 Actual brake pressures for the performed all 56 stop braking cycles. Average pressure (top) and maximum pressure during stop (bottom)

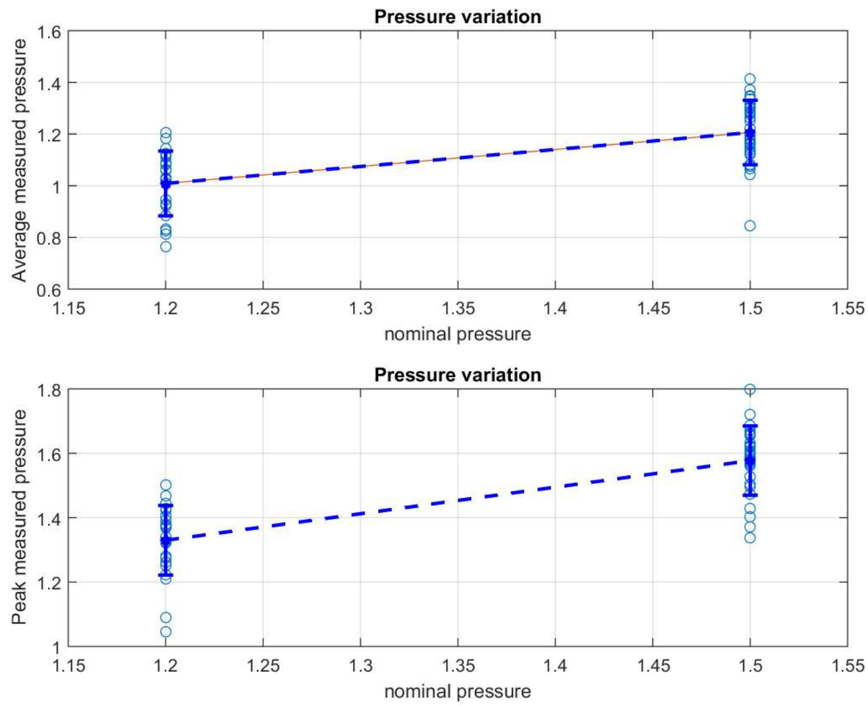


Figure 4 Actual braking pressures for the two nominal pressure levels. Top is average pressure and bottom is peak measured pressure. Average values are given along with error bars indicating the standard deviation of the values at each level.

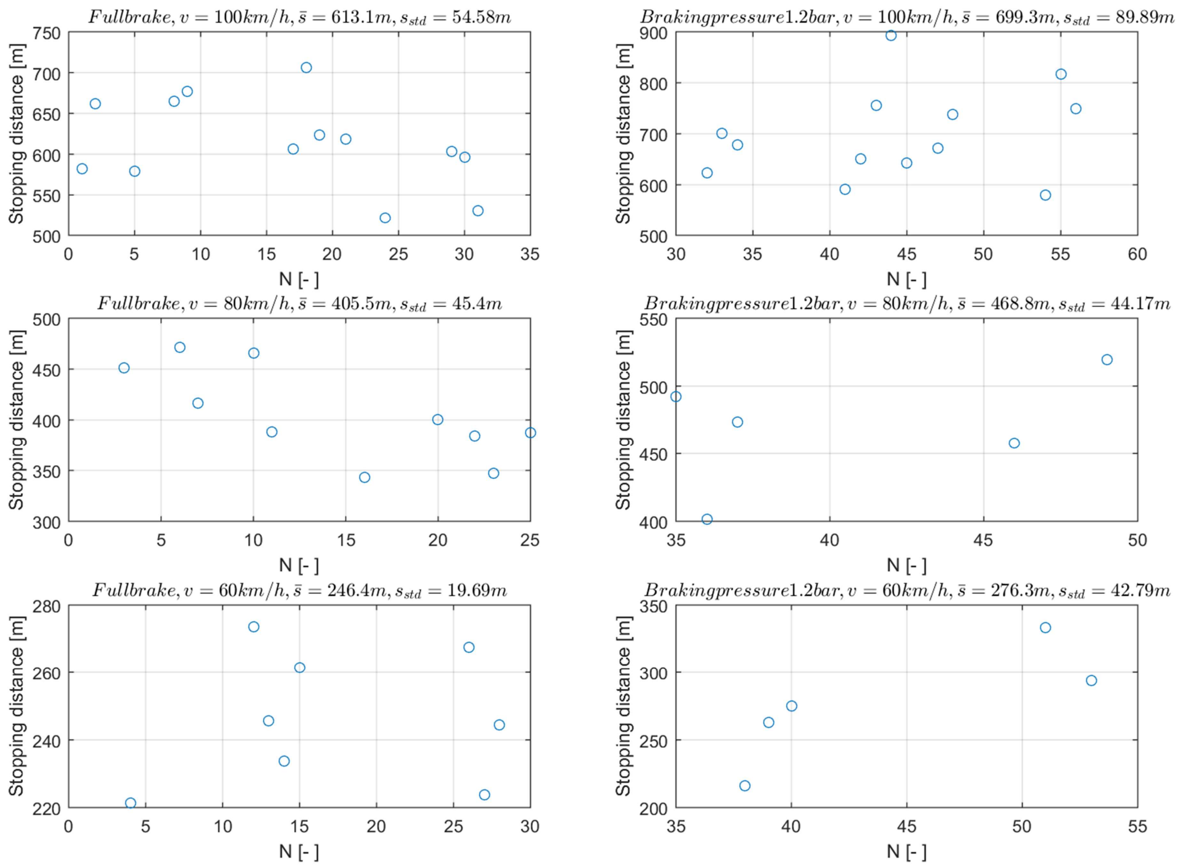


Figure 5 Calculated braking distances for the two nominal brake pressure levels and three nominal speeds. Left column is Full braking (1.5 bar) right column is reduced braking pressure 1.2 bars. Top row is stops from 100 km/h, middle row is from 80 km/h and bottom row is from 60 km/h.

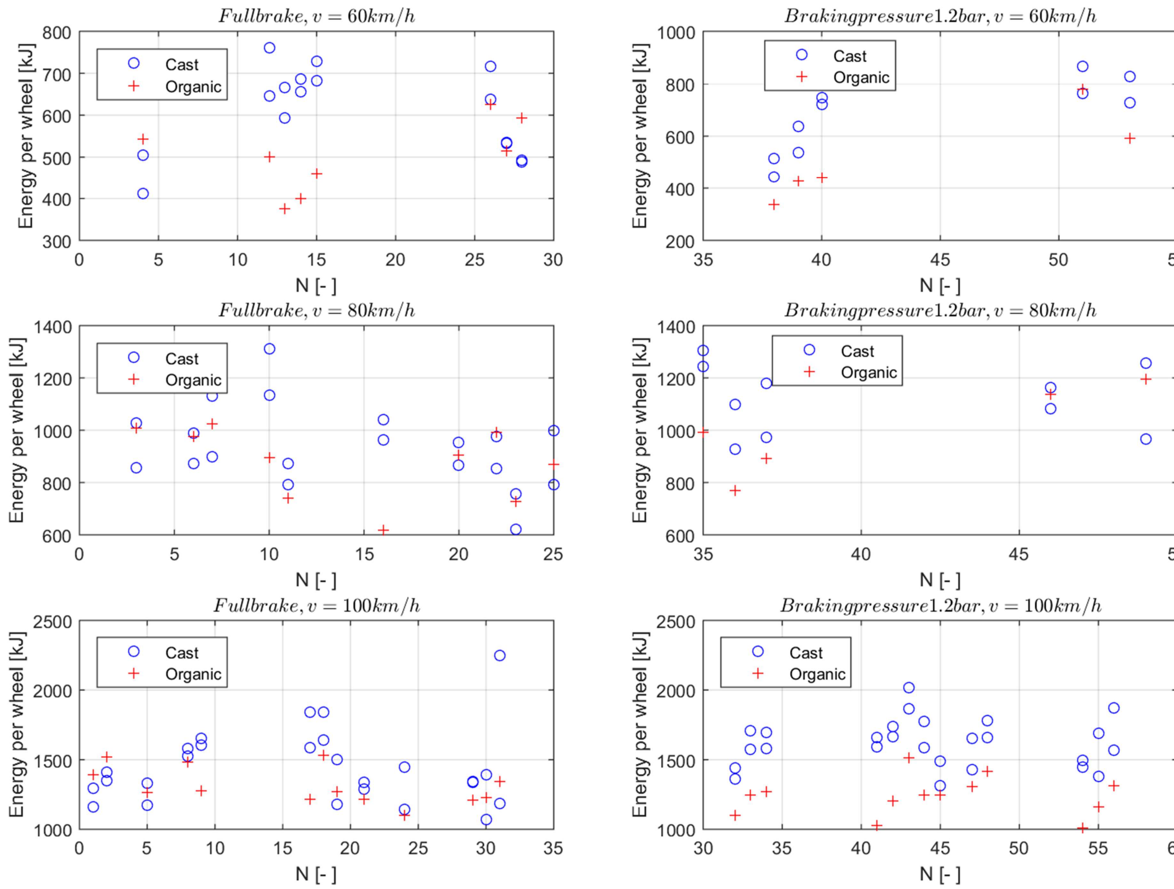


Figure 6 Calculated energy per wheel (assessed as total hanger link forces on wheel multiplied by speed) for the two nominal brake pressure levels and three nominal speeds. Left column is Full braking (1.5 bar) right column is reduced braking pressure 1.2 bars. Top row is stops from 60 km/h, middle row is from 80 km/h and bottom row is from 100 km/h. Values are given for two wheels having cast iron brake blocks and for one wheel having organic composite blocks (neglecting one wheel since it had a broken force transducer).

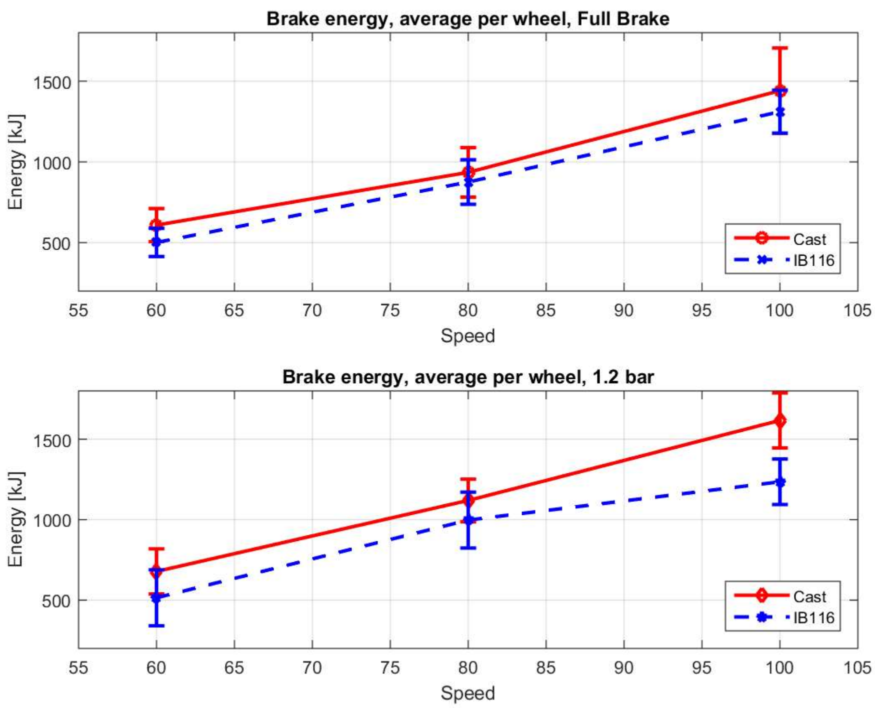


Figure 7 Calculated energy per wheel (assessed as total hanger link forces on wheel multiplied by speed) for the two nominal brake pressure levels as function of speed. Top is for Full braking (1.5 bar) and bottom is for reduced braking pressure 1.2 bars. Average values are given along with error bars indicating the standard deviation of the values at each level.

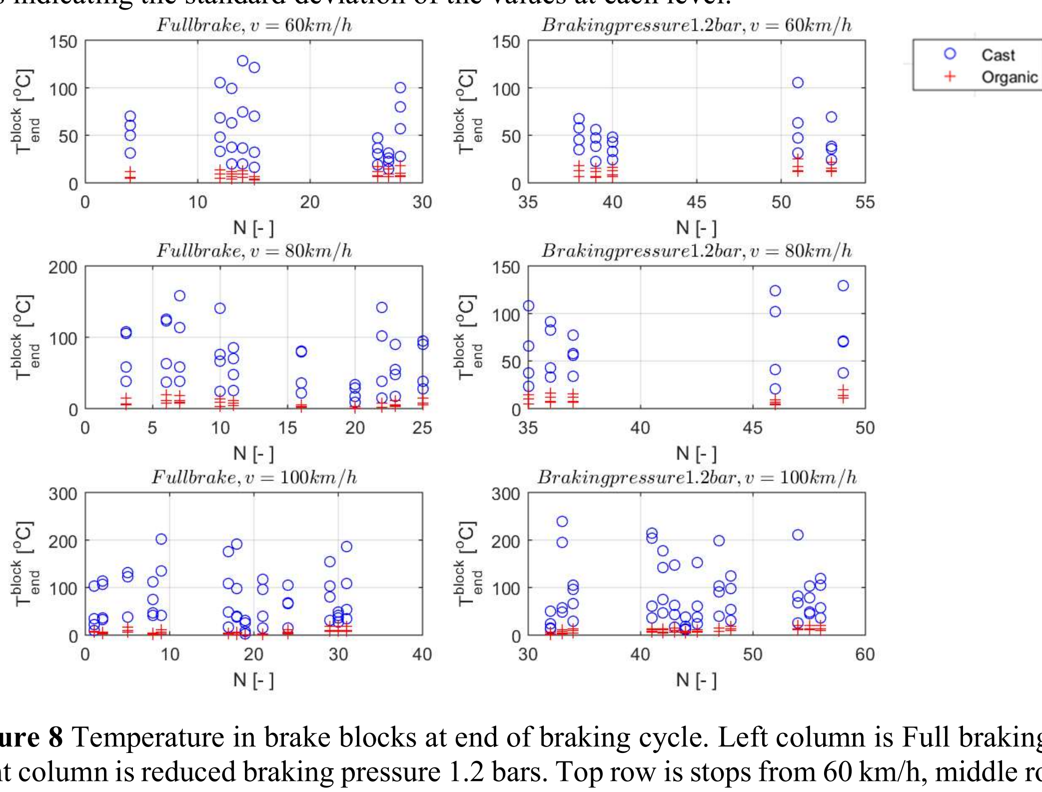


Figure 8 Temperature in brake blocks at end of braking cycle. Left column is Full braking (1.5 bar) right column is reduced braking pressure 1.2 bars. Top row is stops from 60 km/h, middle row is from 80 km/h and bottom row is from 100 km/h.

3.1. Hanger links in compression

In the assessment of the Swedish winter tests of 2018, it was found that the time delay until onset of the friction forces as indicated by the force in the hanger links in compression were often long. A histograms over results of time delay for cast iron blocks are given Figure 9, and for organic composite blocks in Figure 10. For the assessed tests, all friction forces for the cast iron blocks give time delays that are lower than 3 s whereas the organic composite blocks give time delays lower than 7 s, with a majority of the cycles having delays less than 5 s. The differences in time delays between the two block types is minor. One should note that the field tests were performed under conditions with no whirling snow.

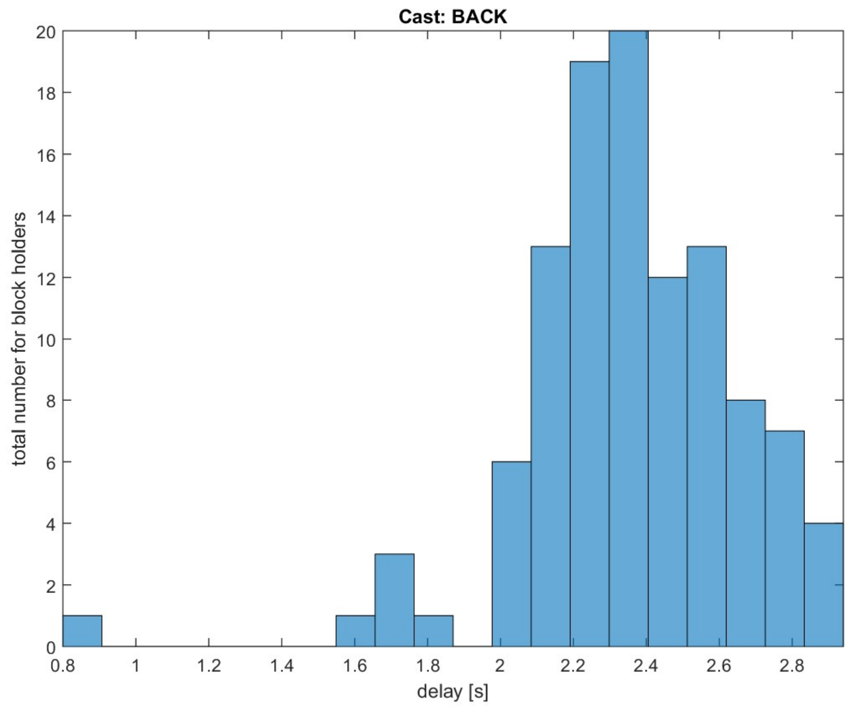


Figure 9 Histogram of number of brake cycles giving prescribed time delay from start of braking until onset of hanger link (friction) force for cast iron brake blocks

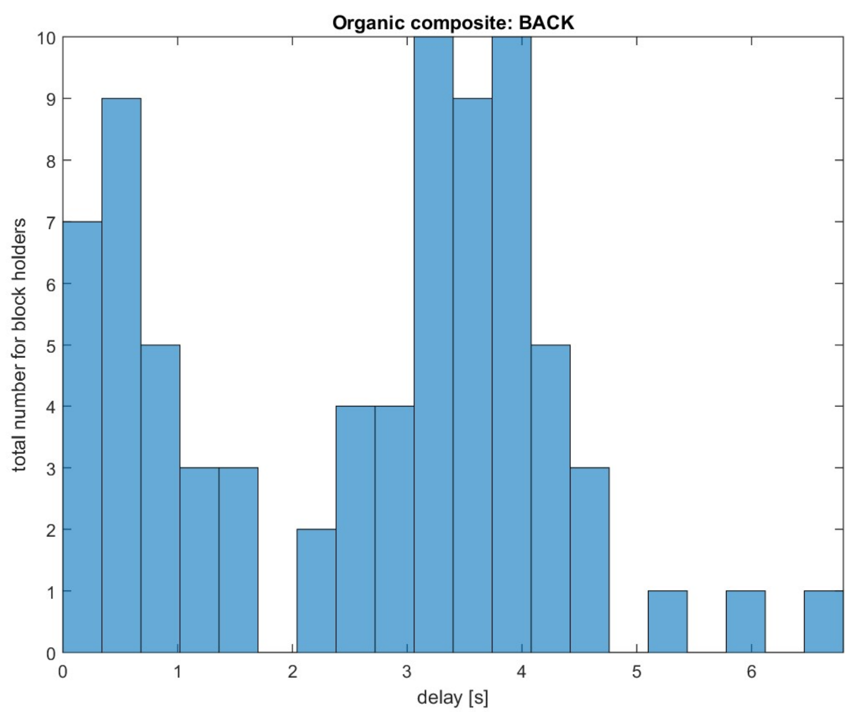
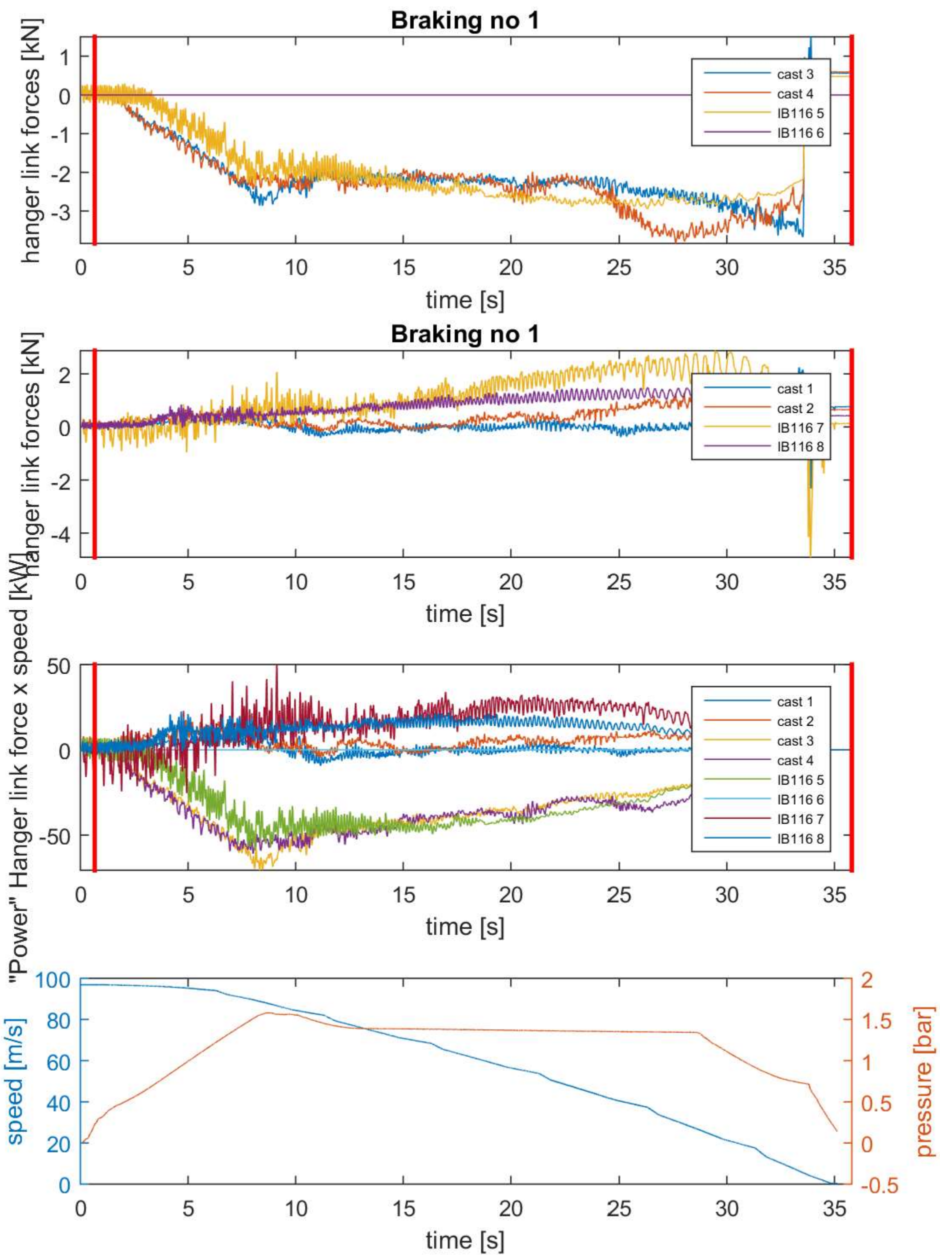


Figure 10 Histogram of number of brake cycles giving prescribed time delay from start of braking until onset of hanger link (friction) force for organic composite brake blocks.

Appendix A



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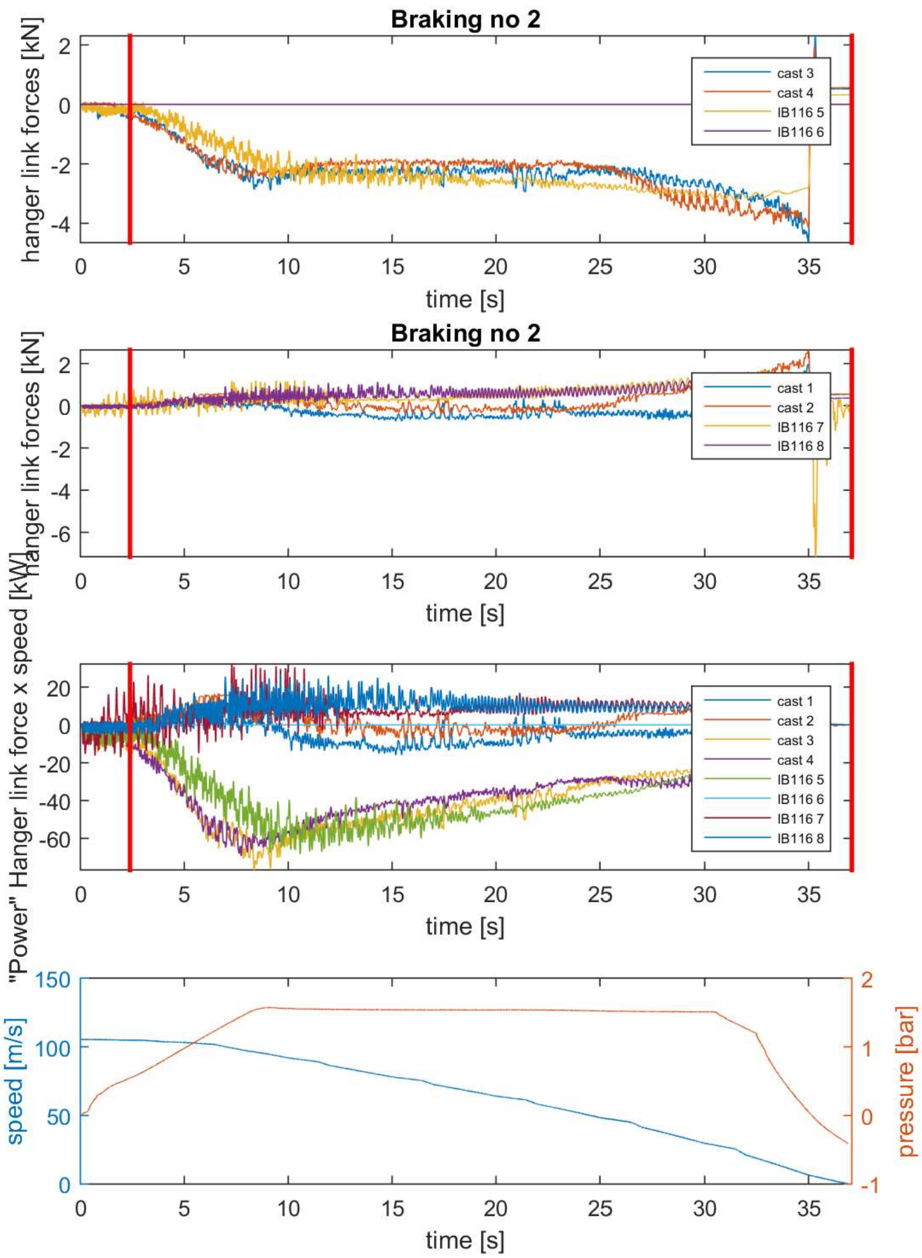
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 1
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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IB116 6
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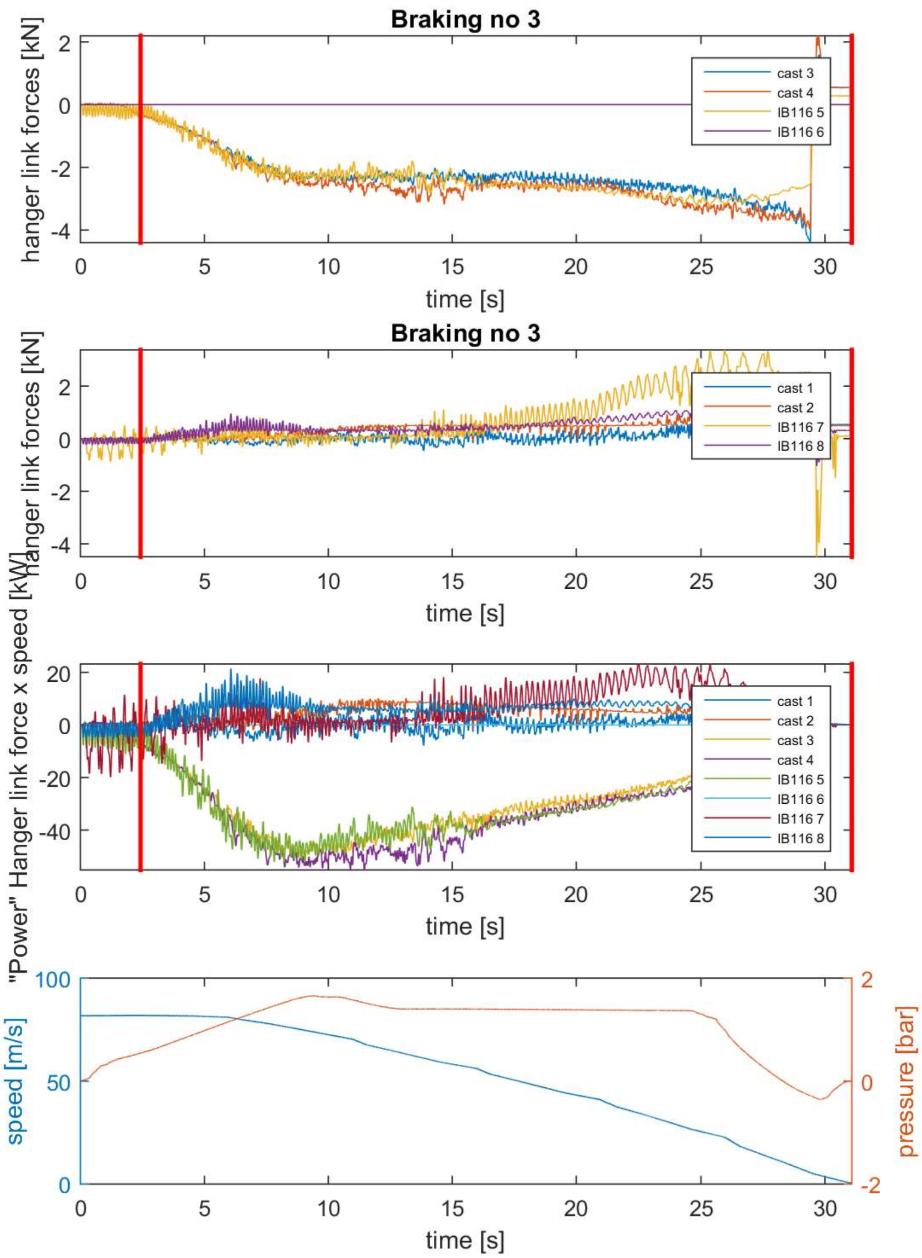
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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cast 4
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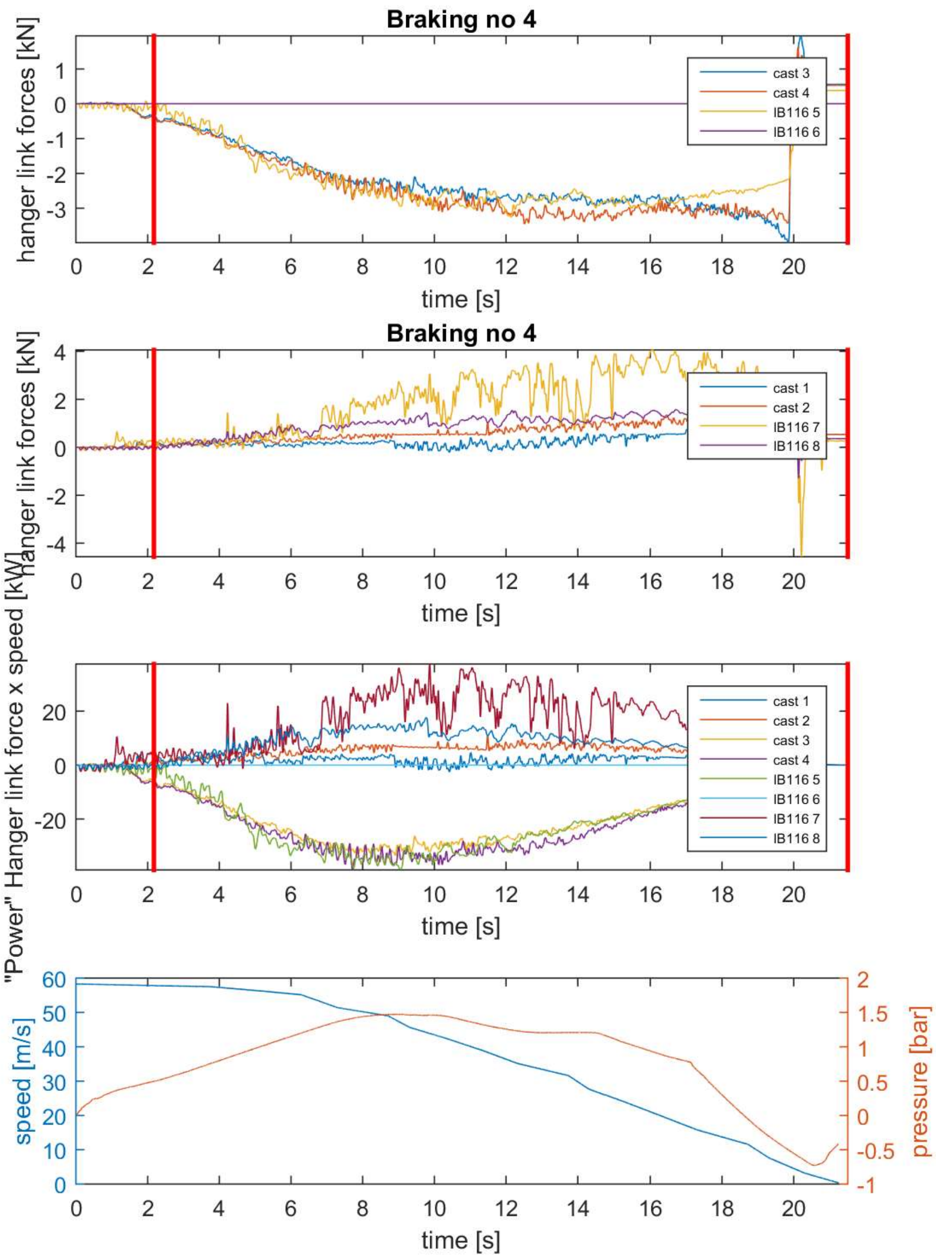
IB116 6
Braking no 3
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
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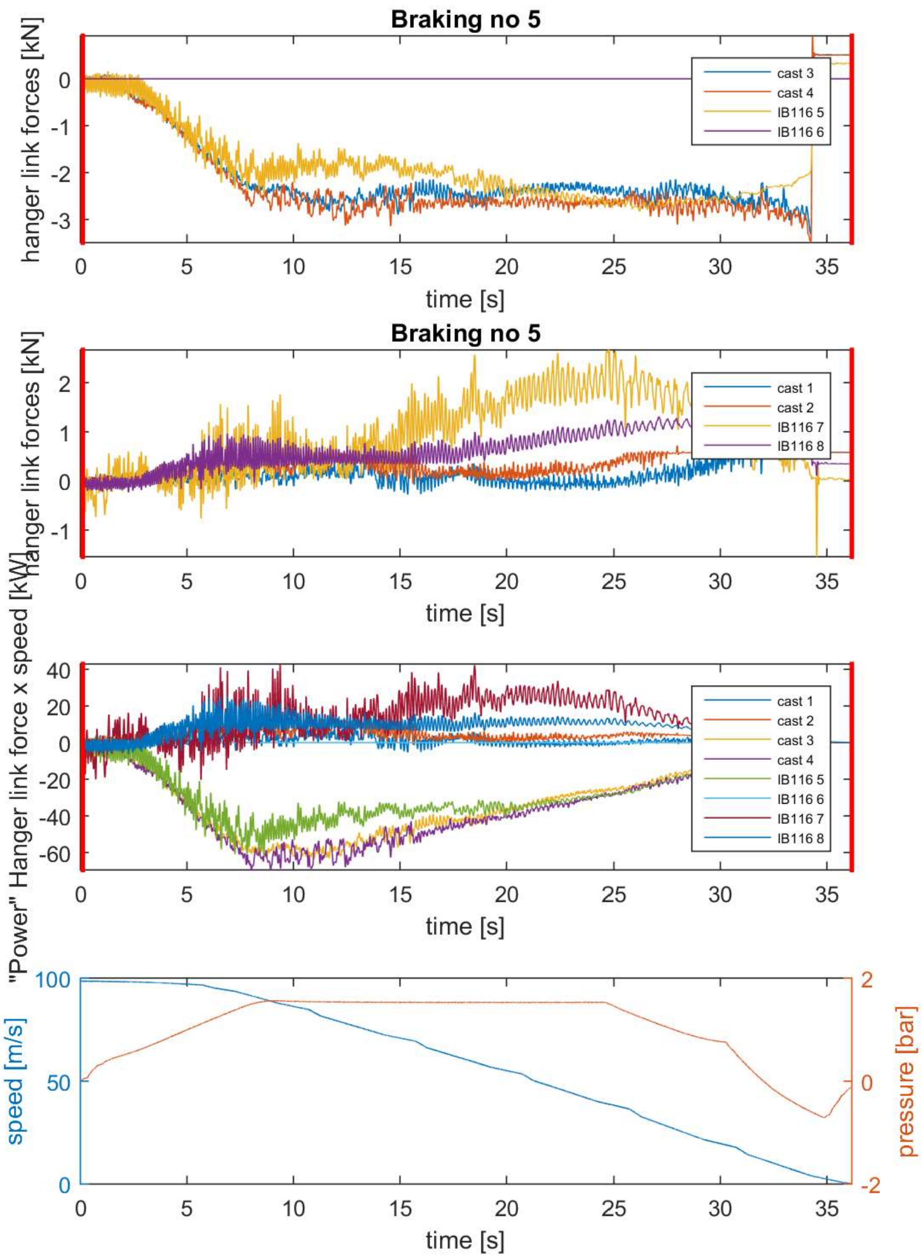
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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IB116 5
IB116 6
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cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
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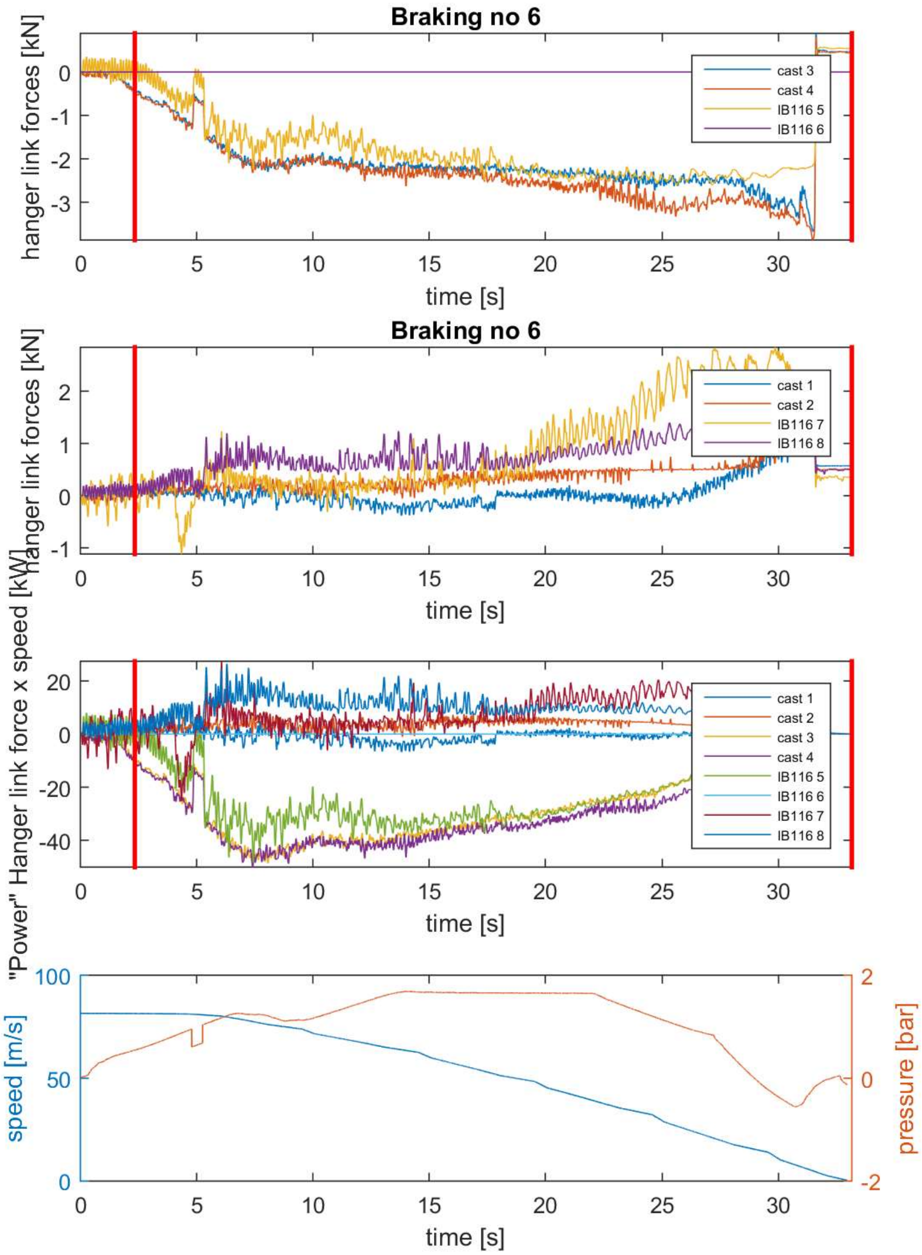
pressure [bar]
time [s]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time [s]
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hanger link forces [kN]
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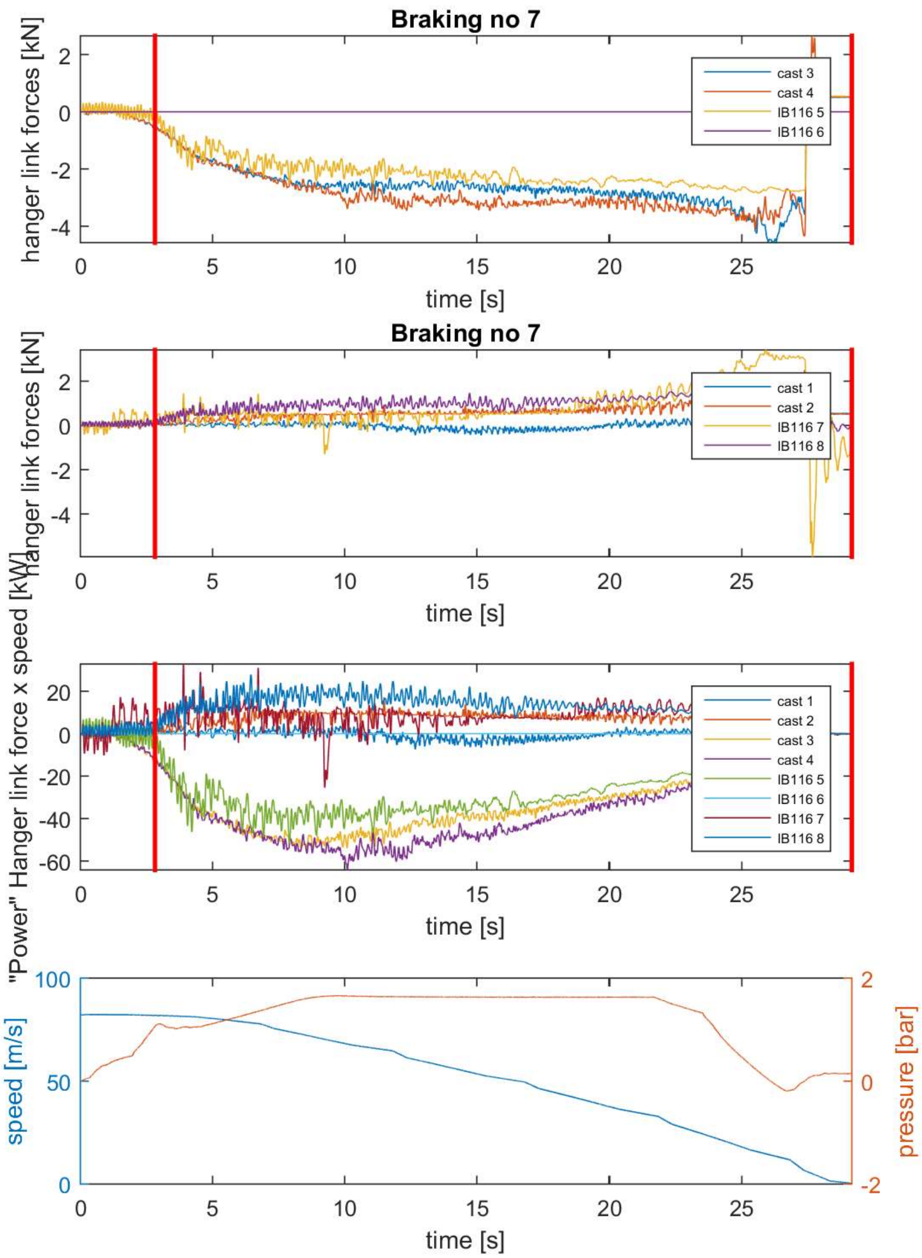
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]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cast 4
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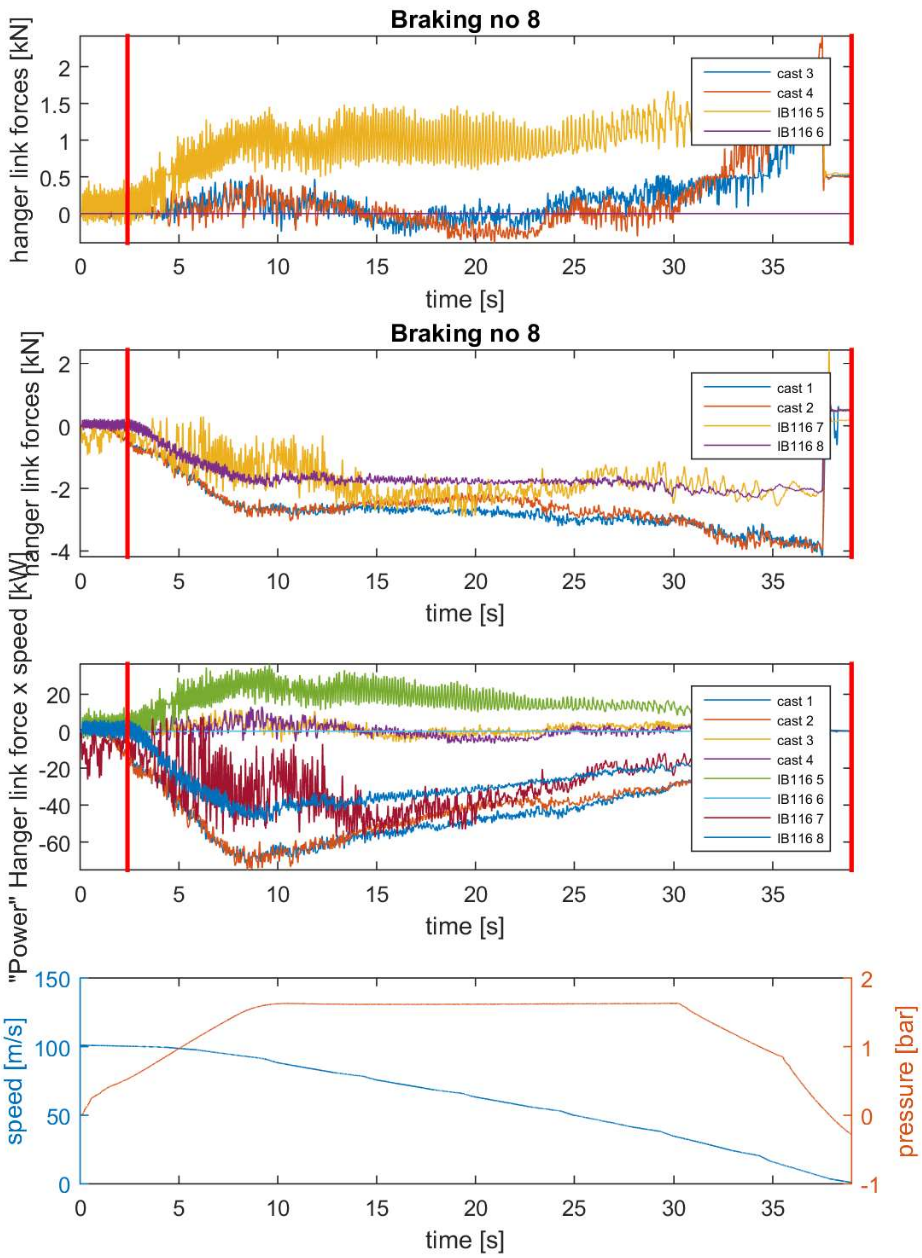
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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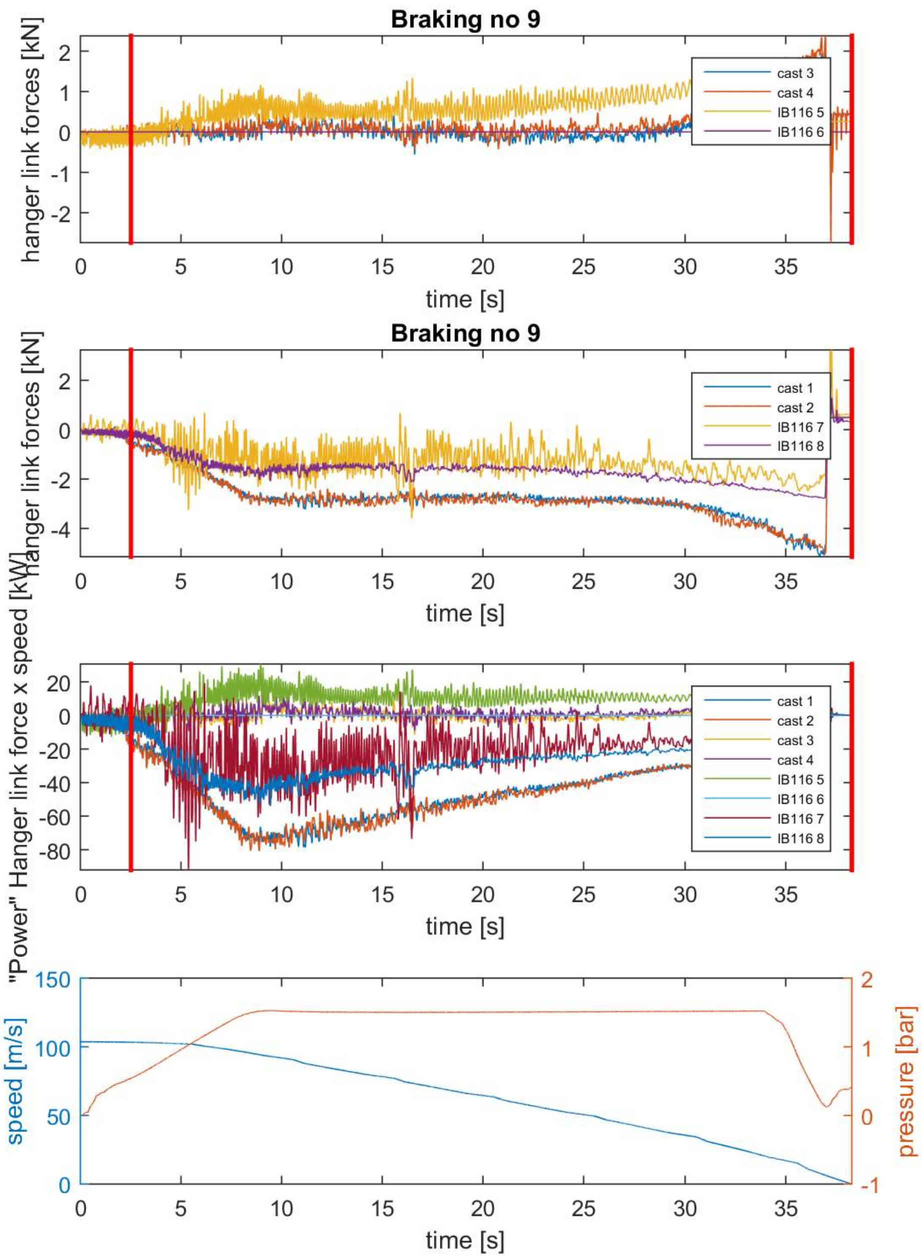
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]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cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
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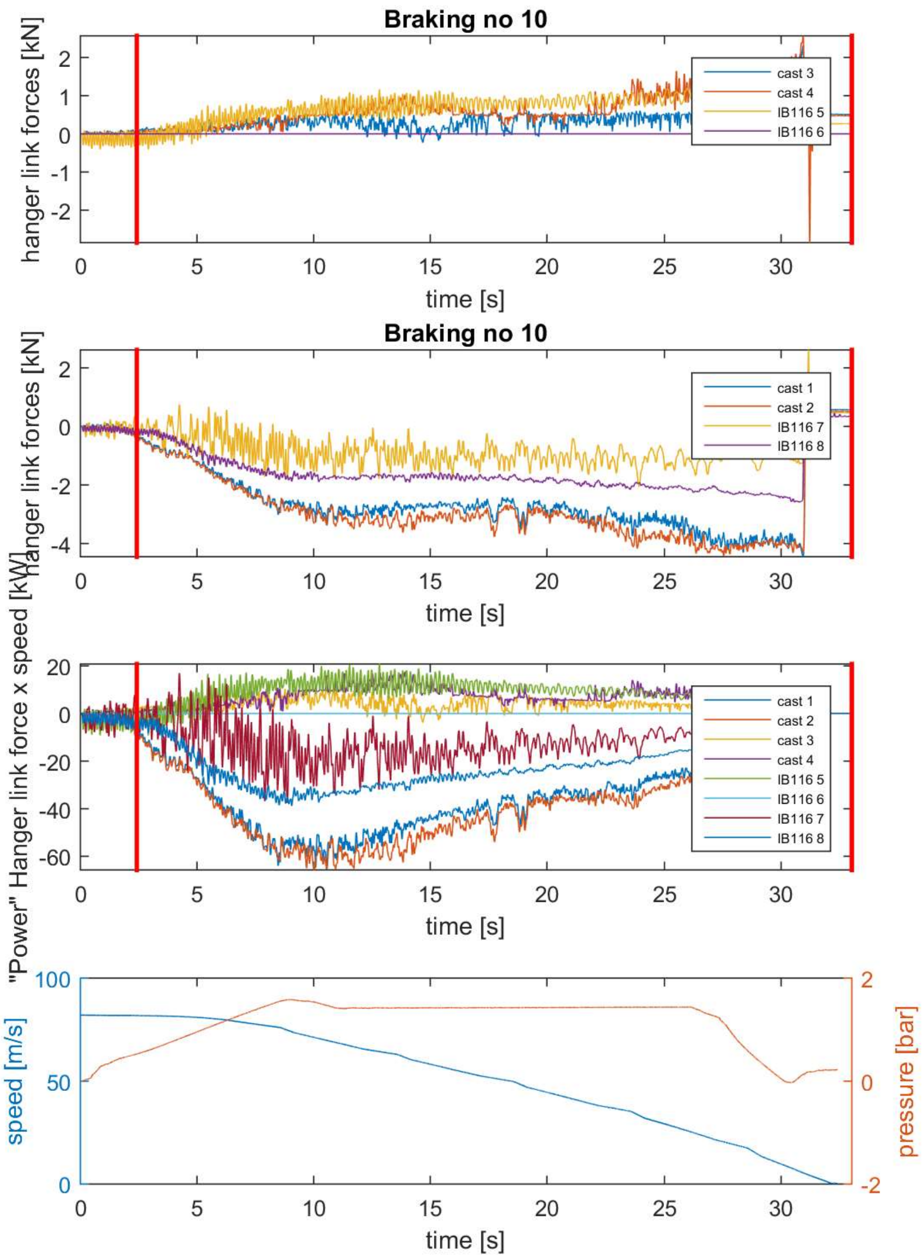
pressure [bar]
time [s]



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IB116 5
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time [s]
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cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
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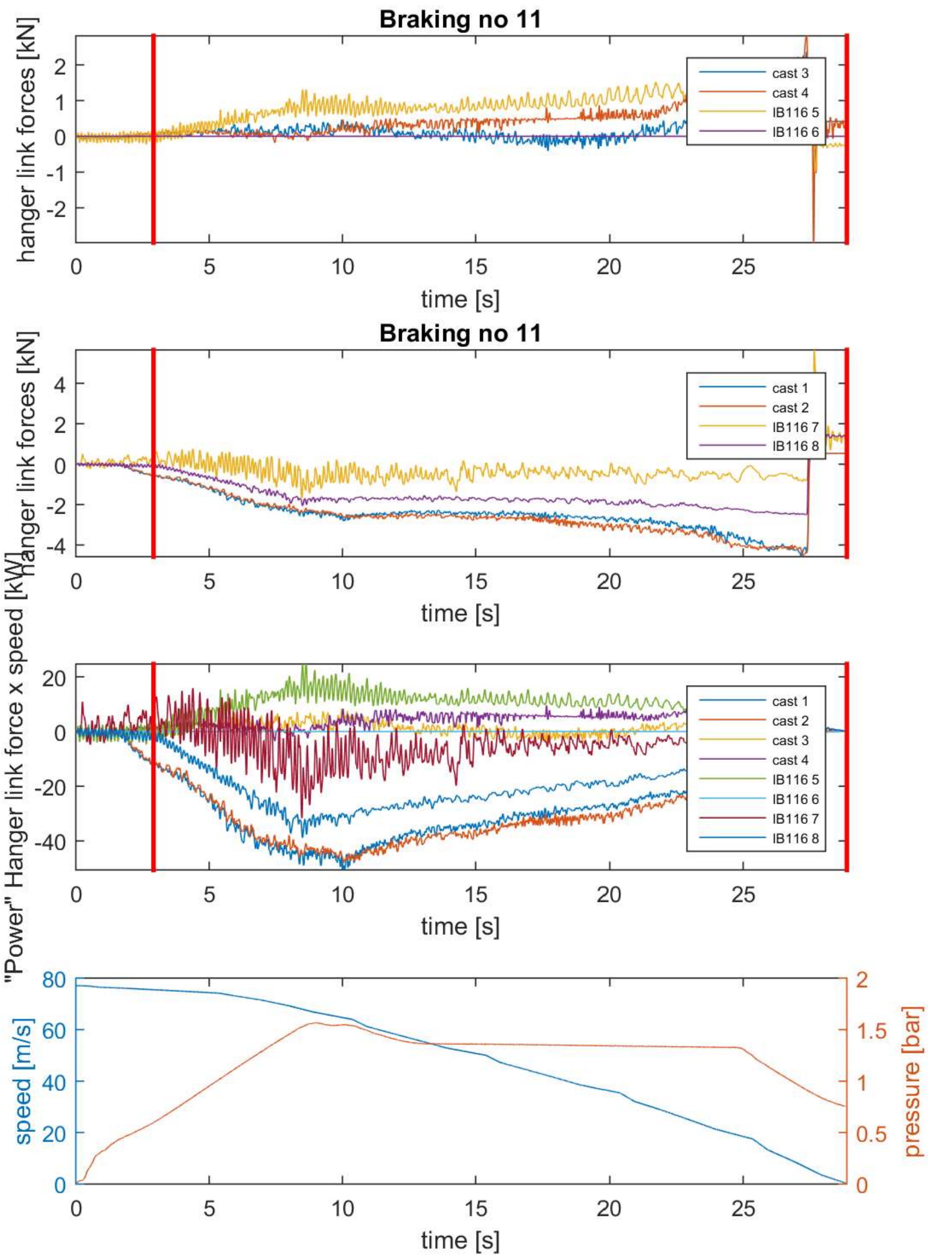
pressure [bar]
time [s]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cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
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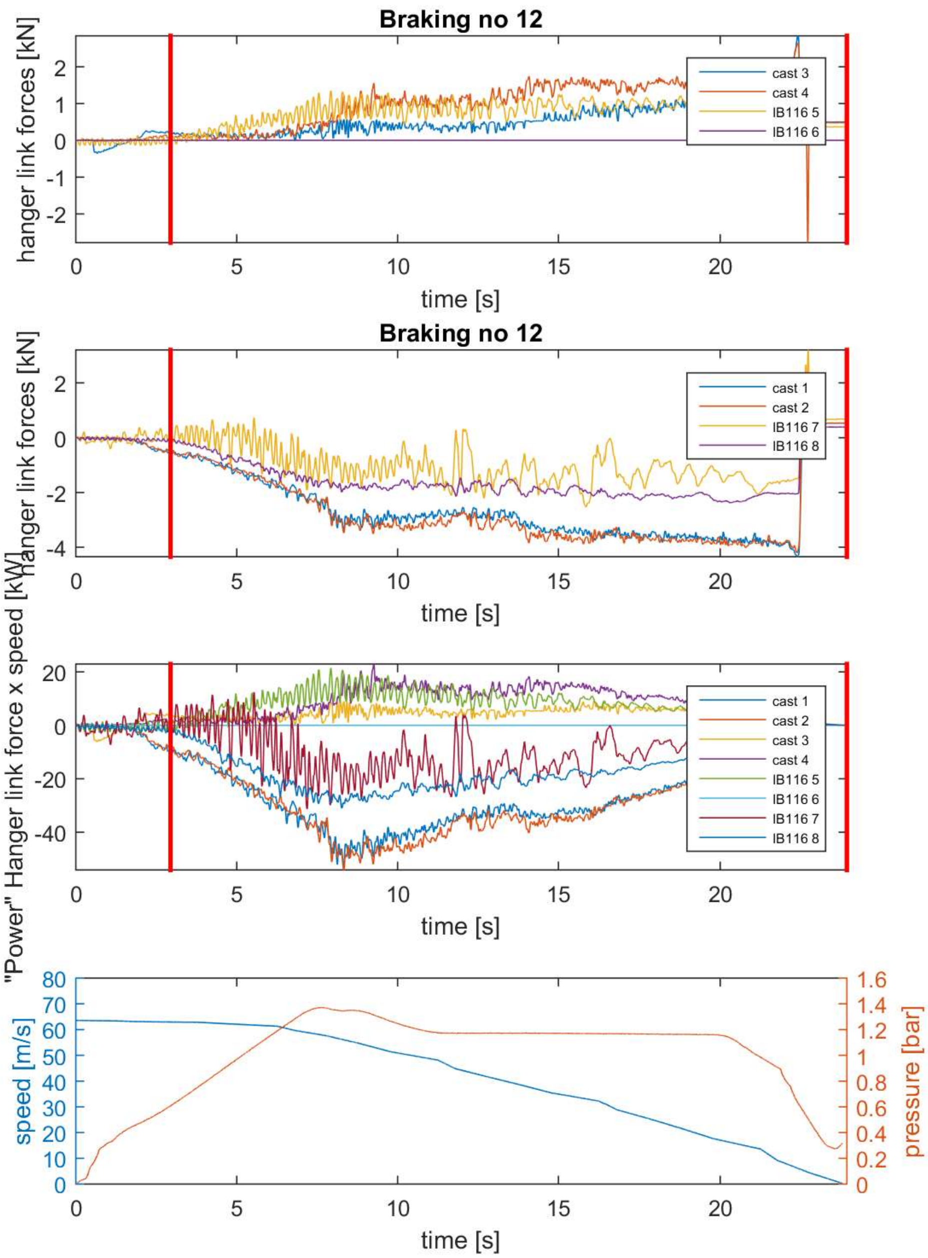
time [s]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cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
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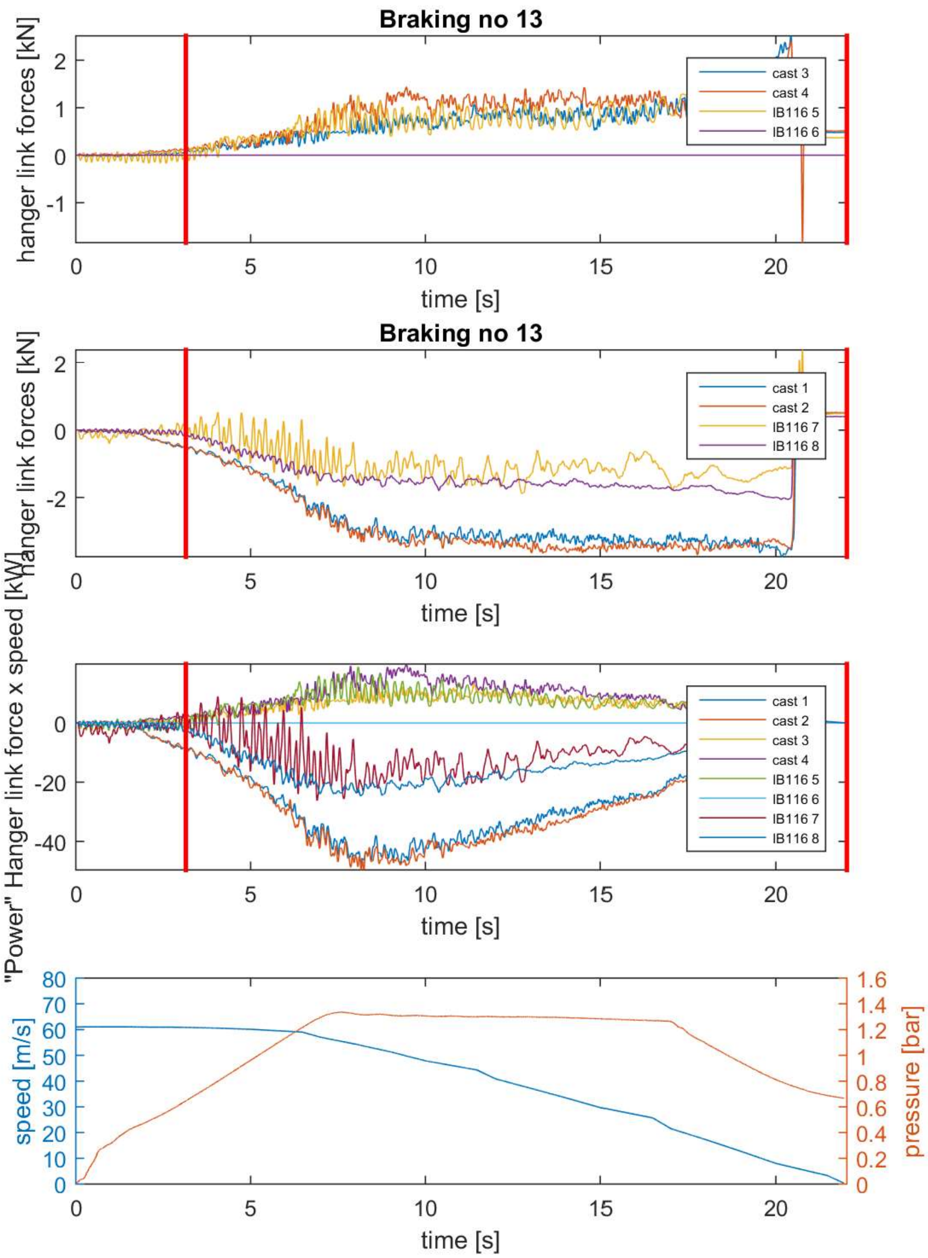
pressure [bar]
time [s]



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IB116 8
"Power" Hanger link force x speed [kW]
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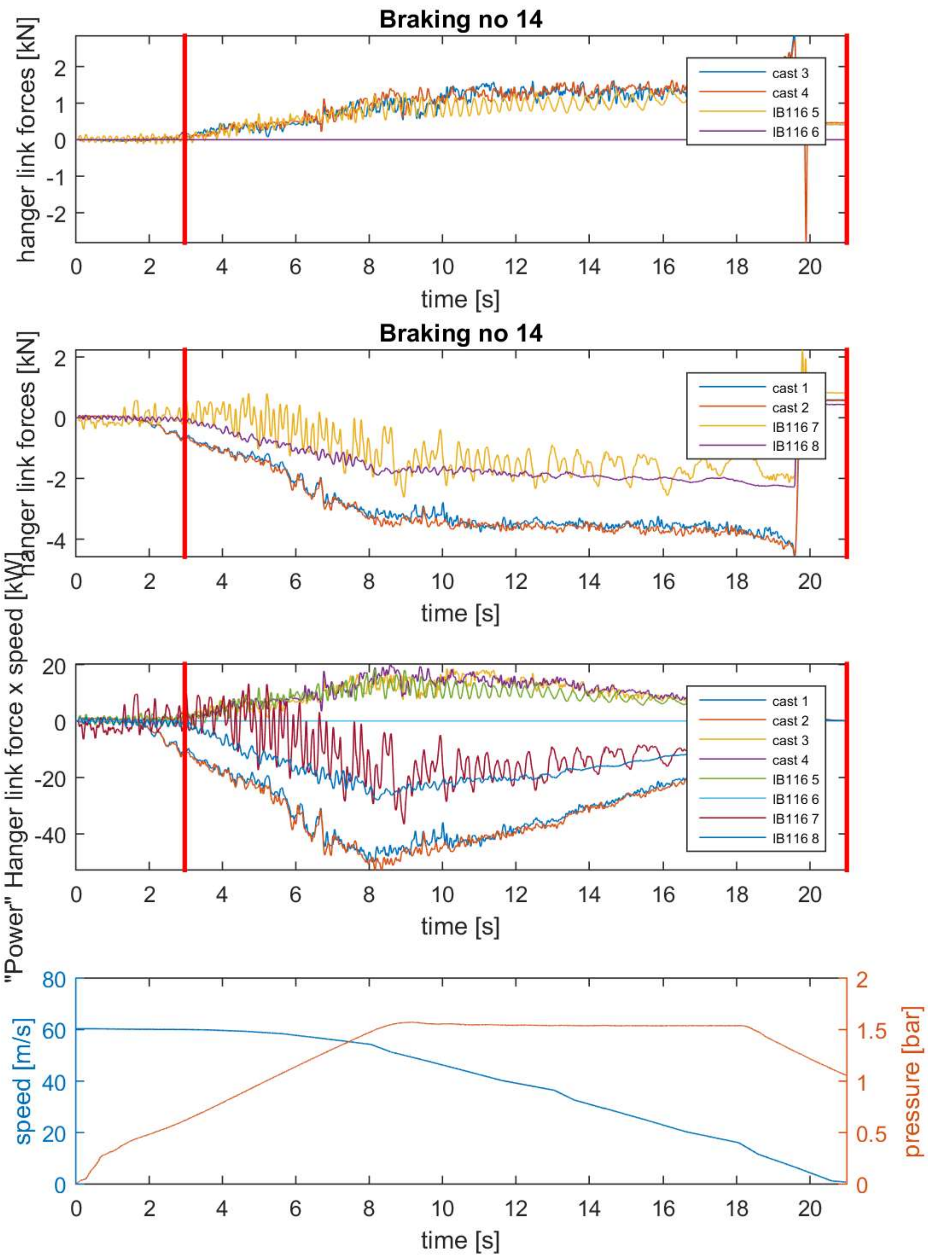
pressure [bar]
time [s]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IB116 8
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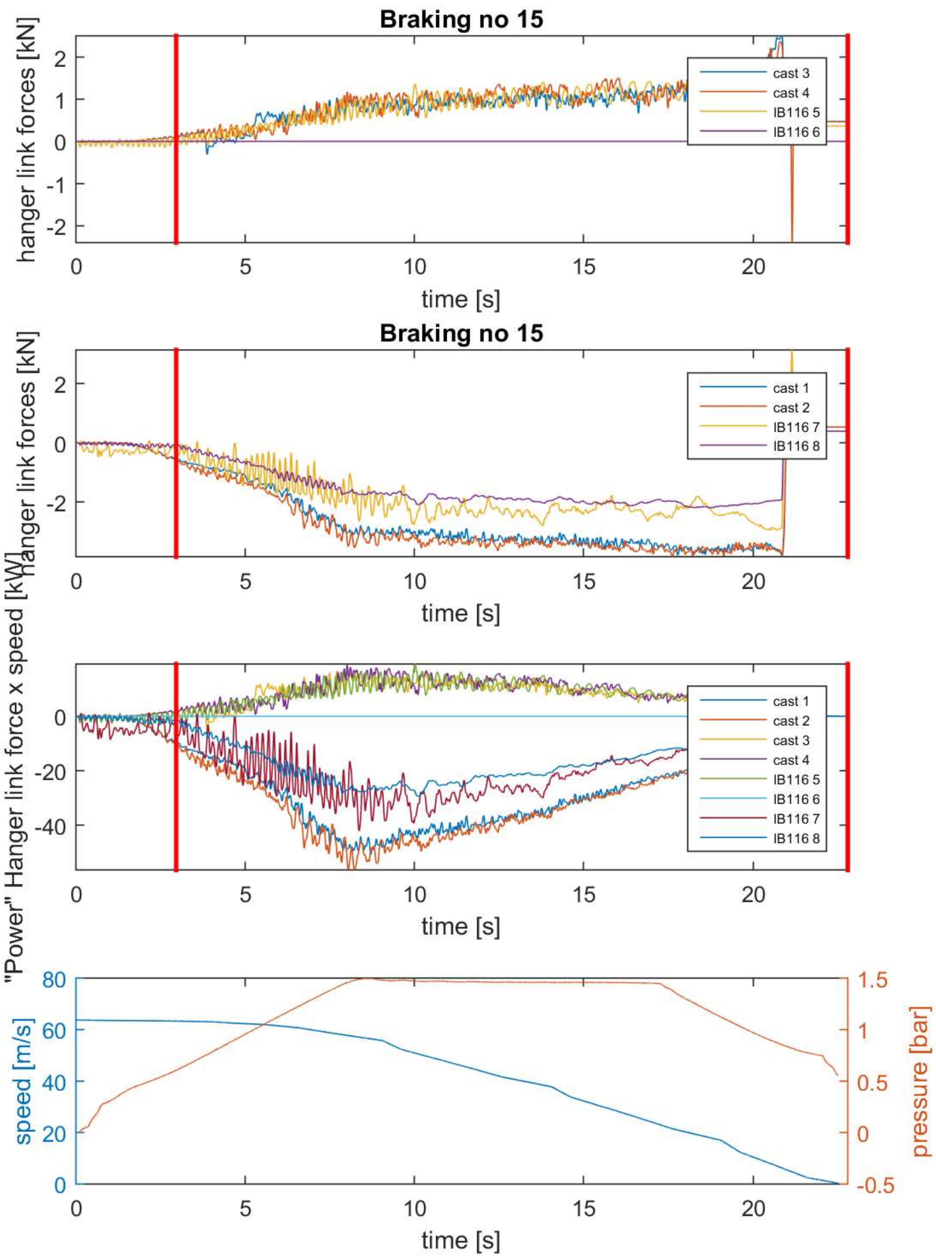
time [s]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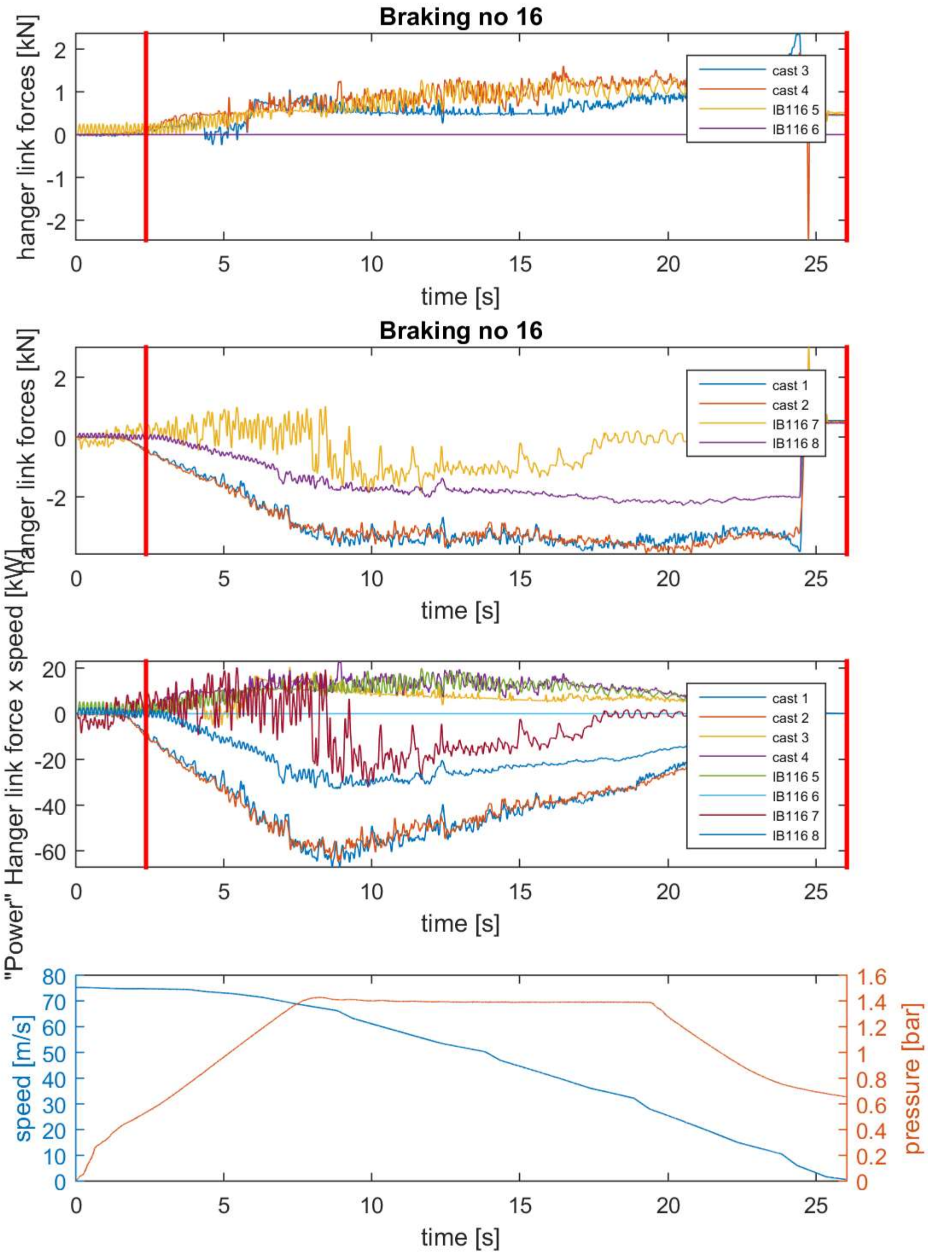
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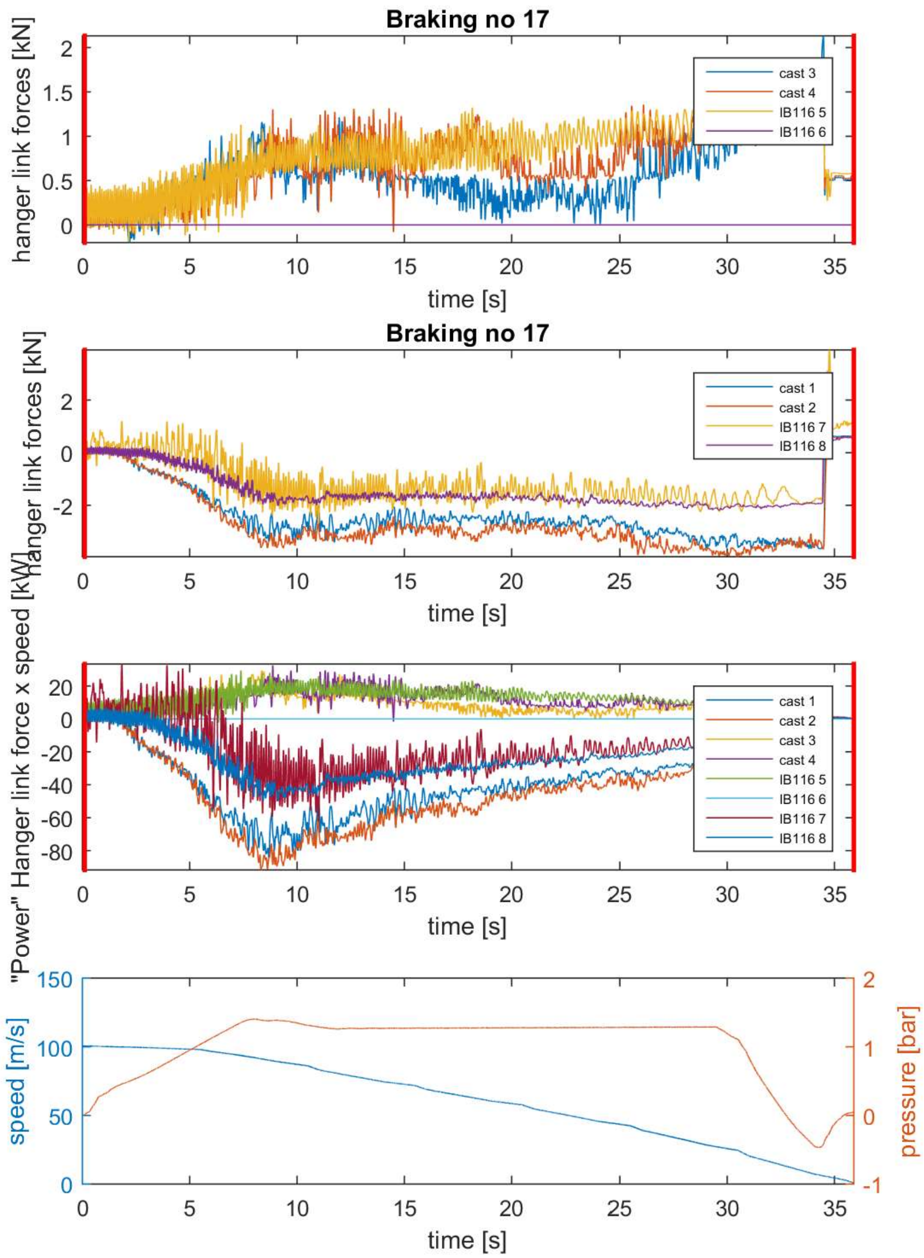
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speed [m/s]
pressure [bar]
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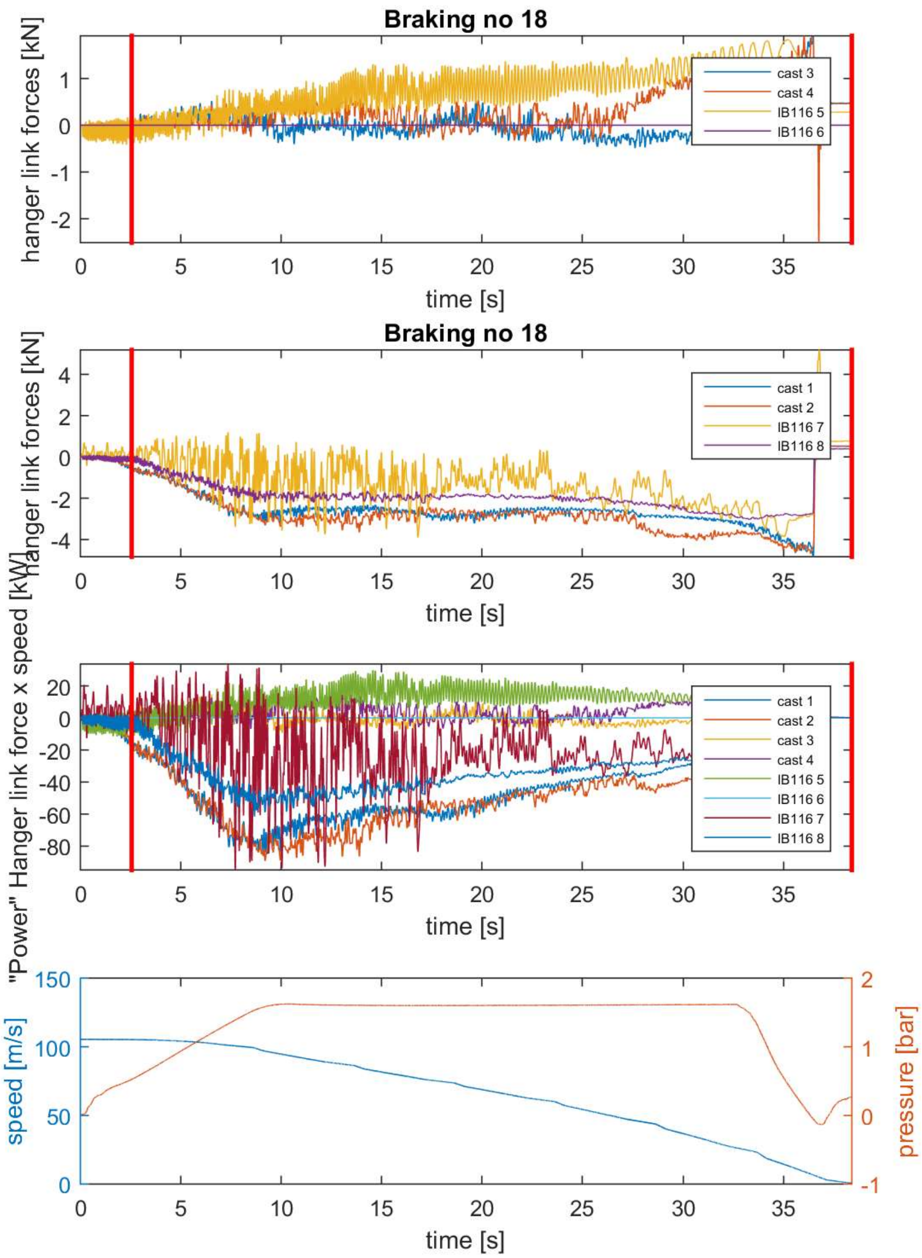

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cast 2
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IB116 8
"Power" Hanger link force x speed [kW]
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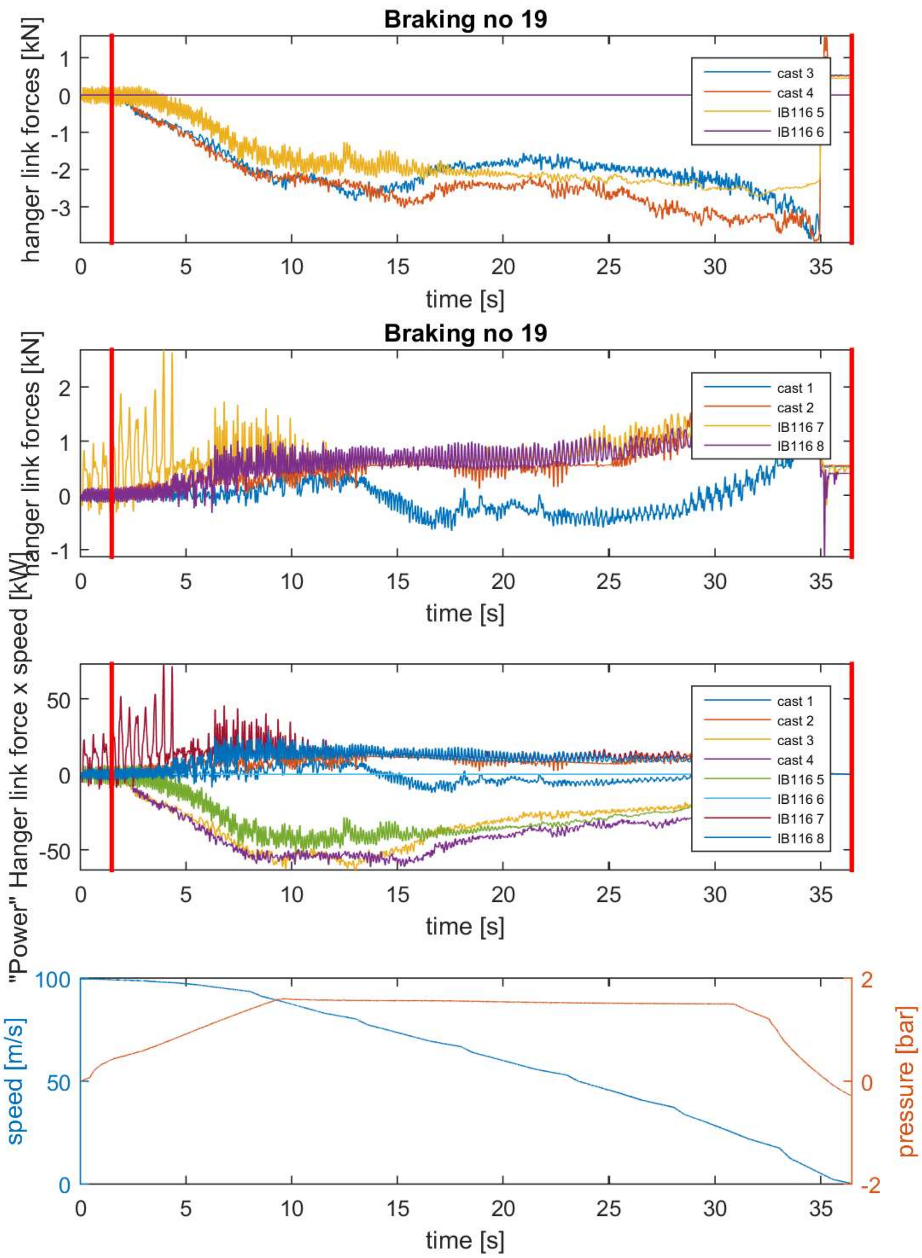
pressure [bar]
time [s]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cast 4
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cast 2
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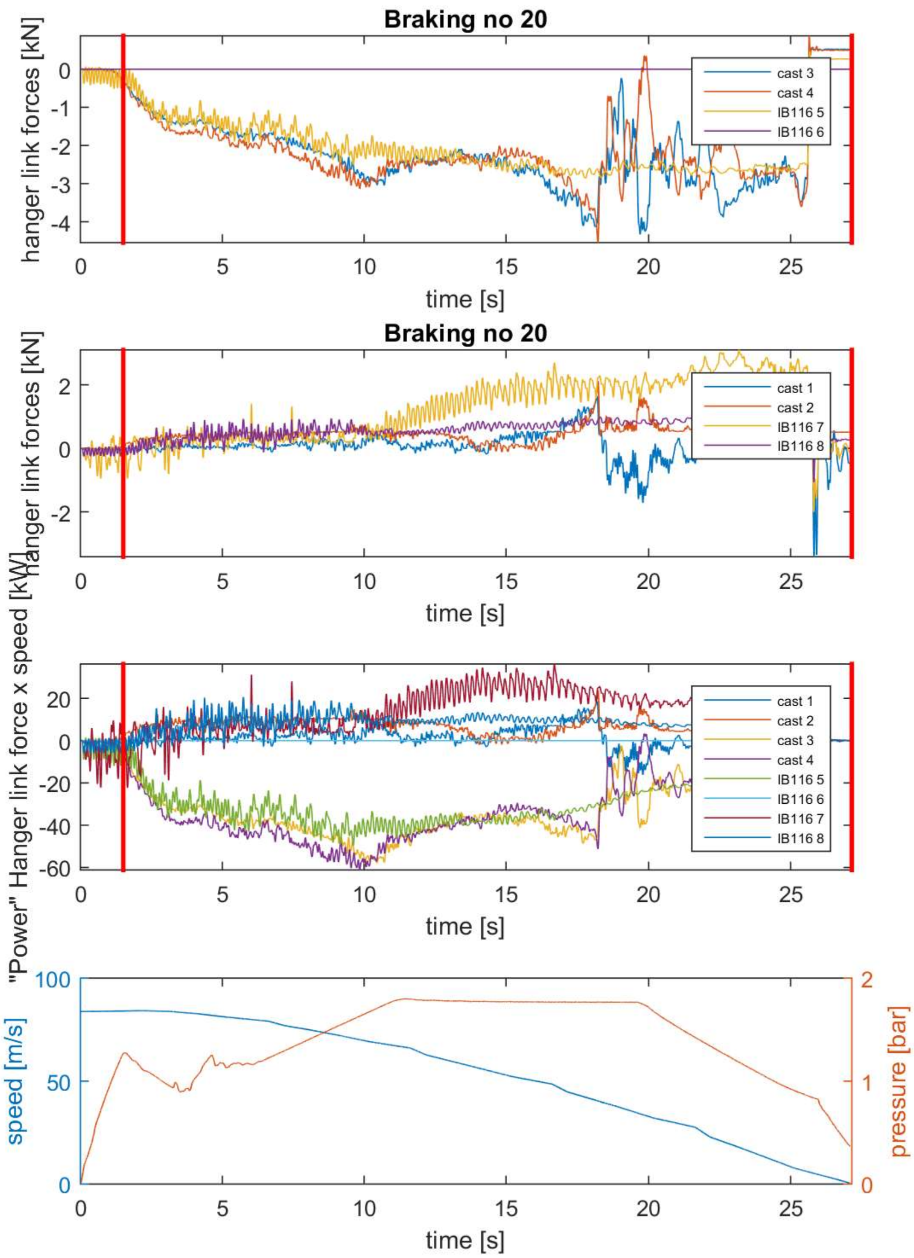
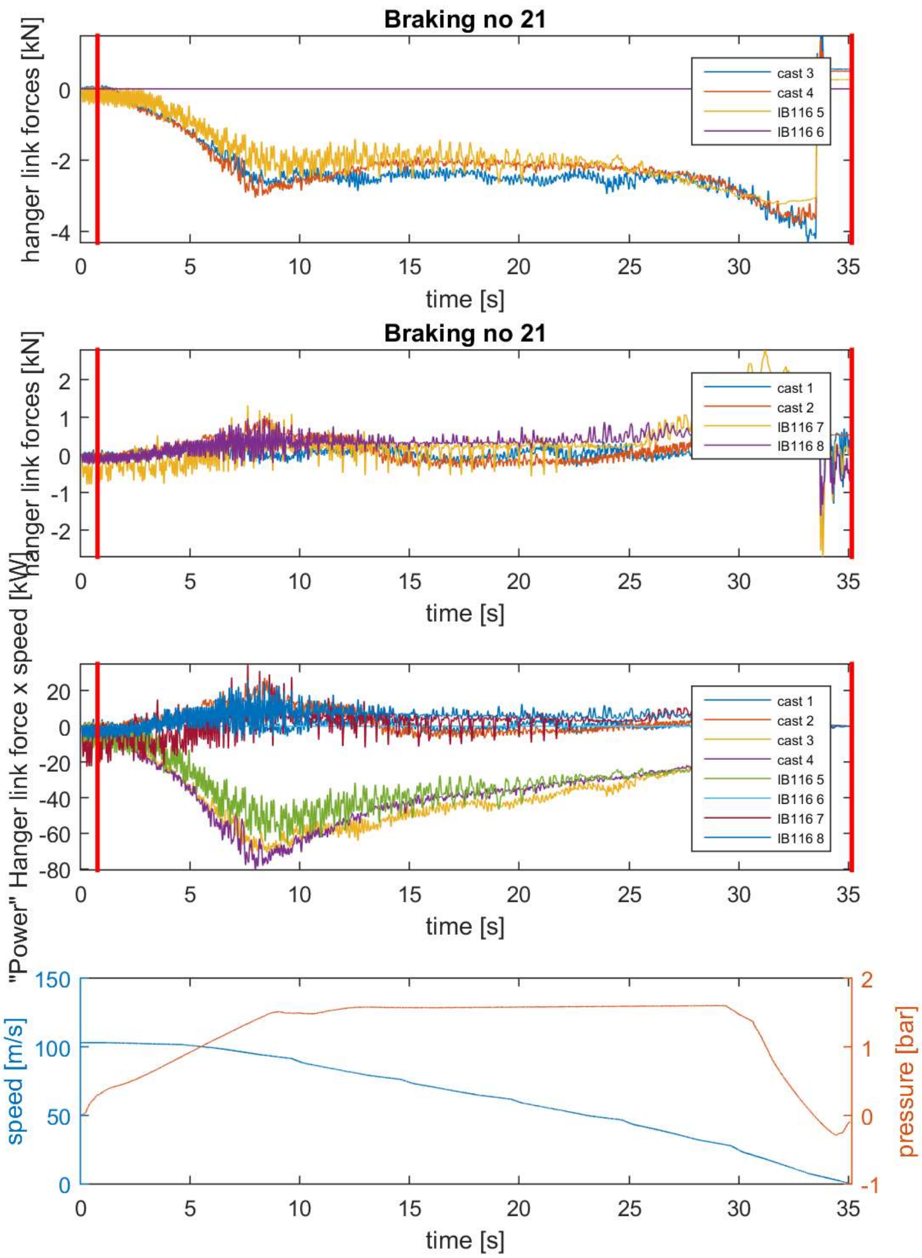
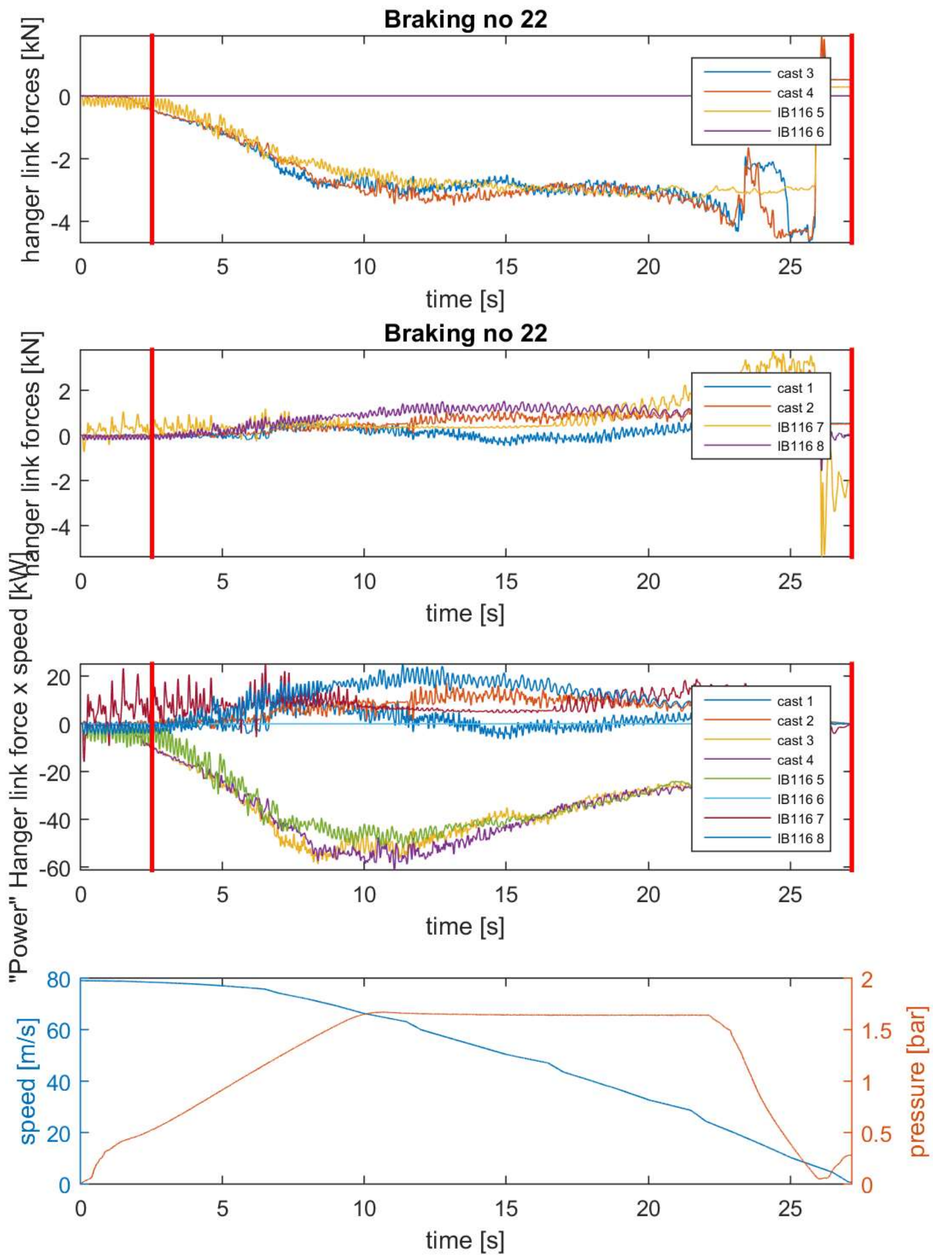
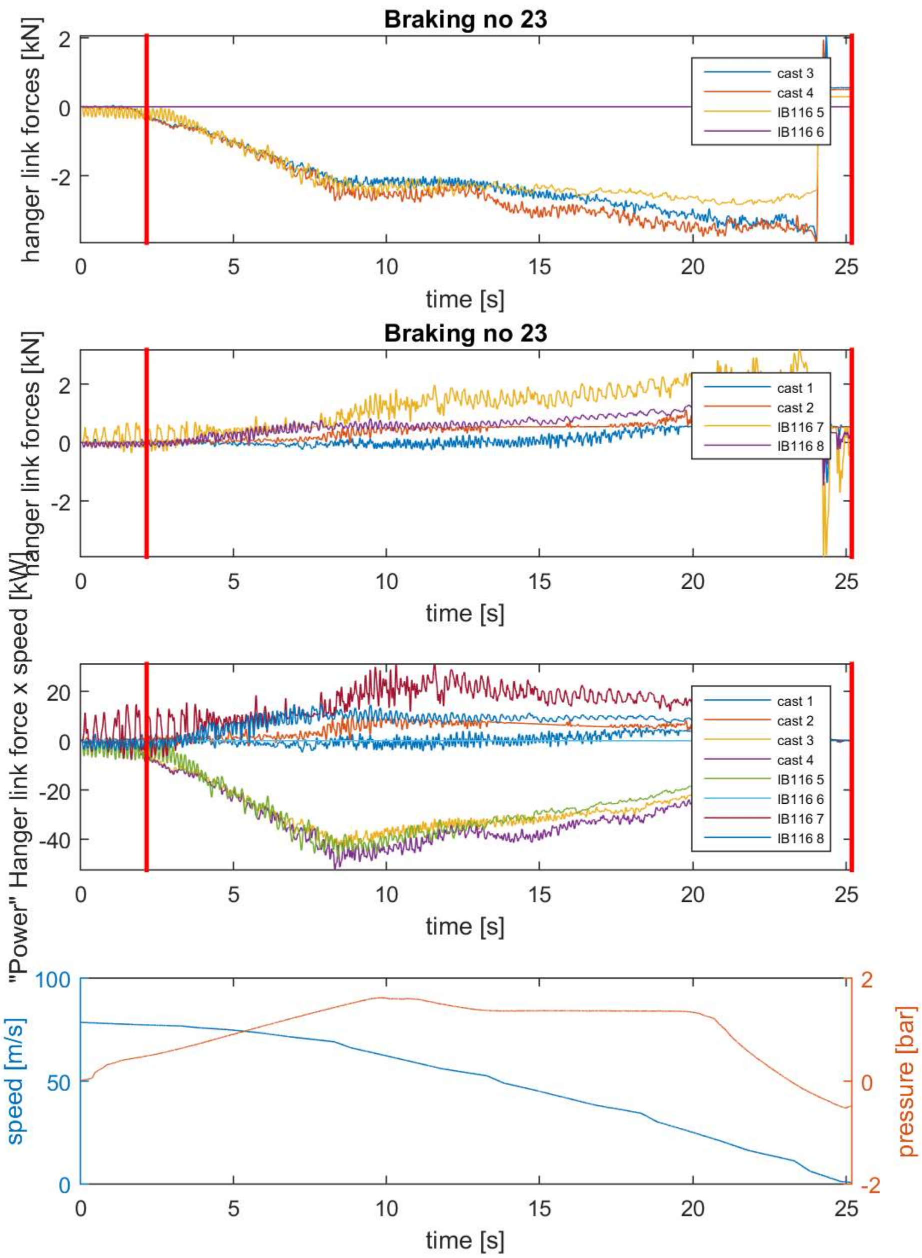
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

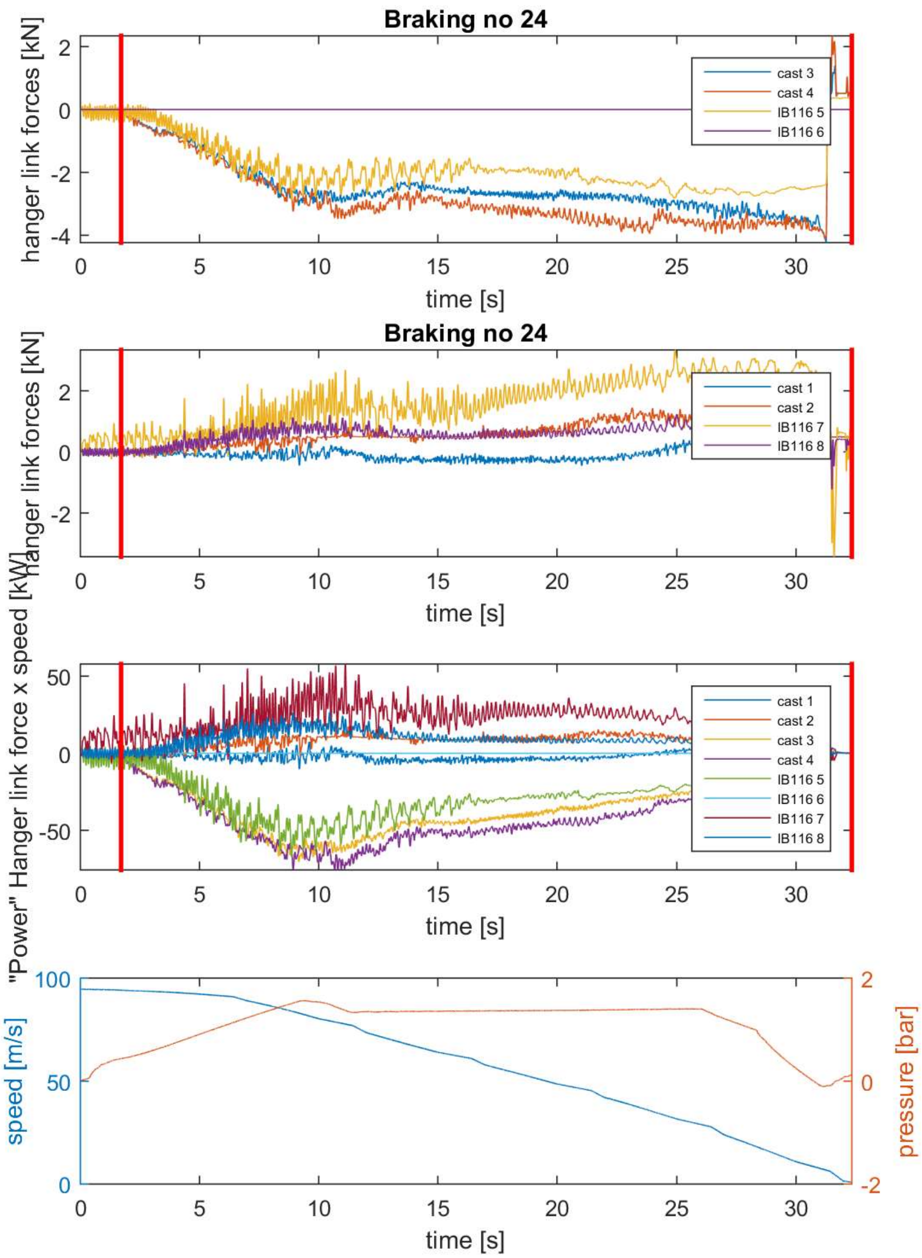

Braking no 20
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 20
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

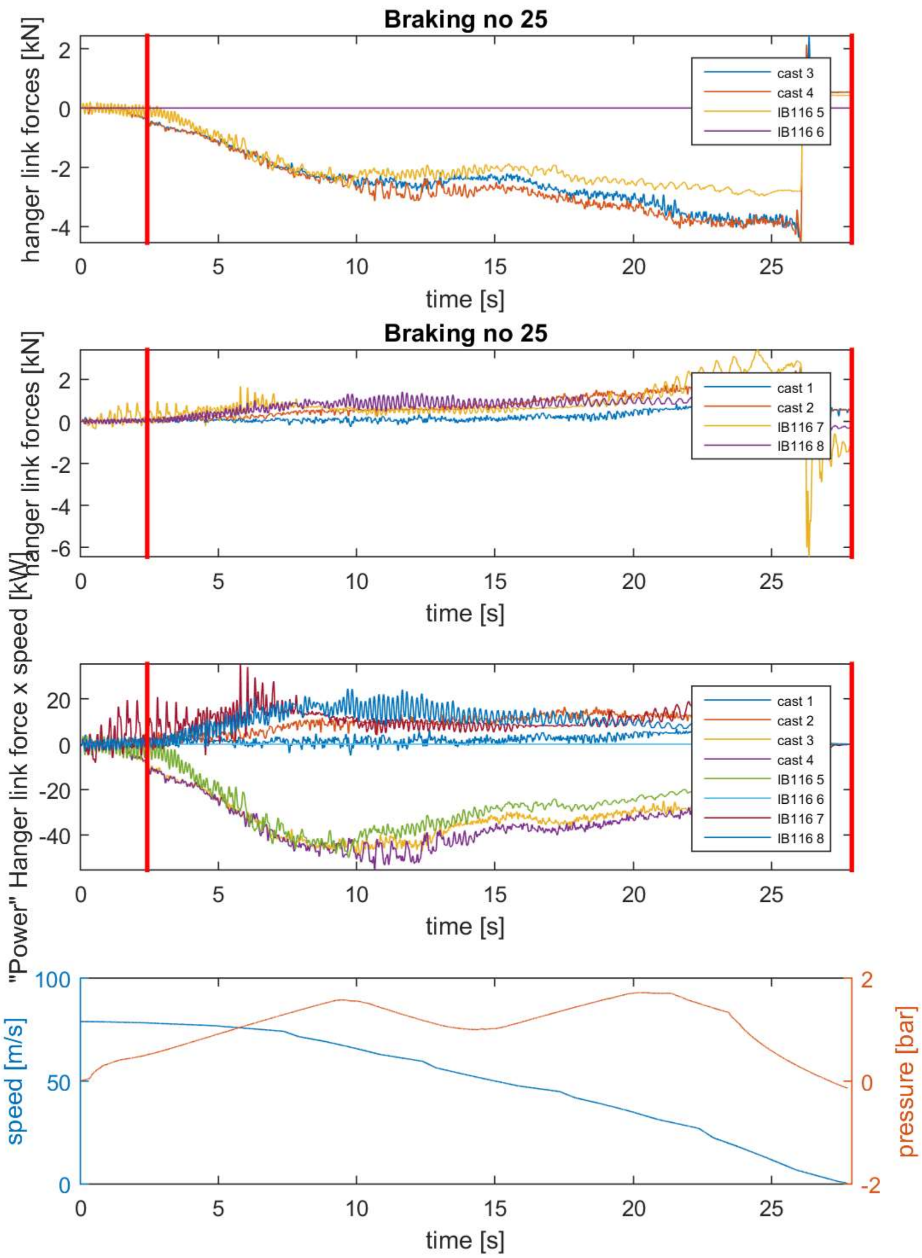

Braking no 21
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 21
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

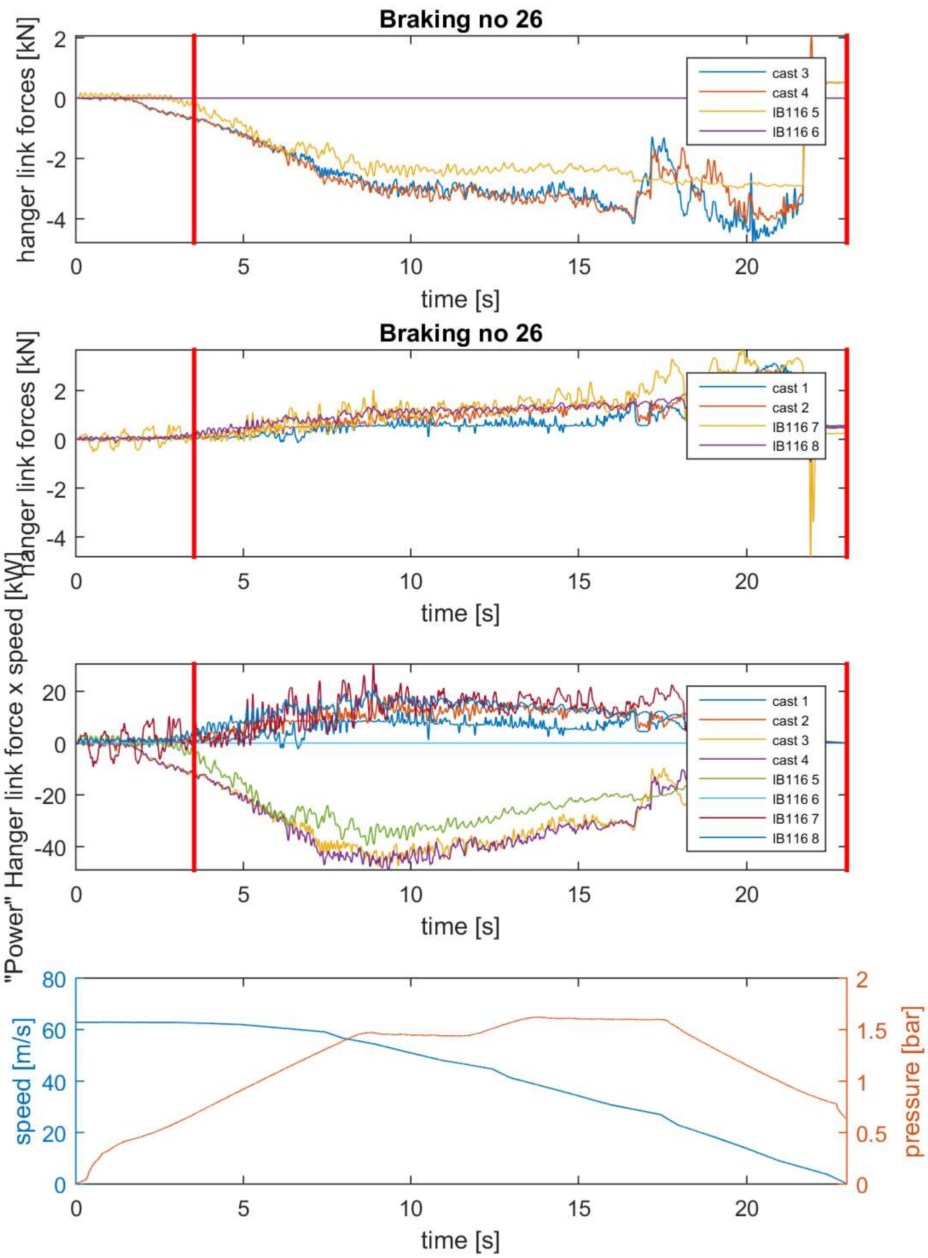


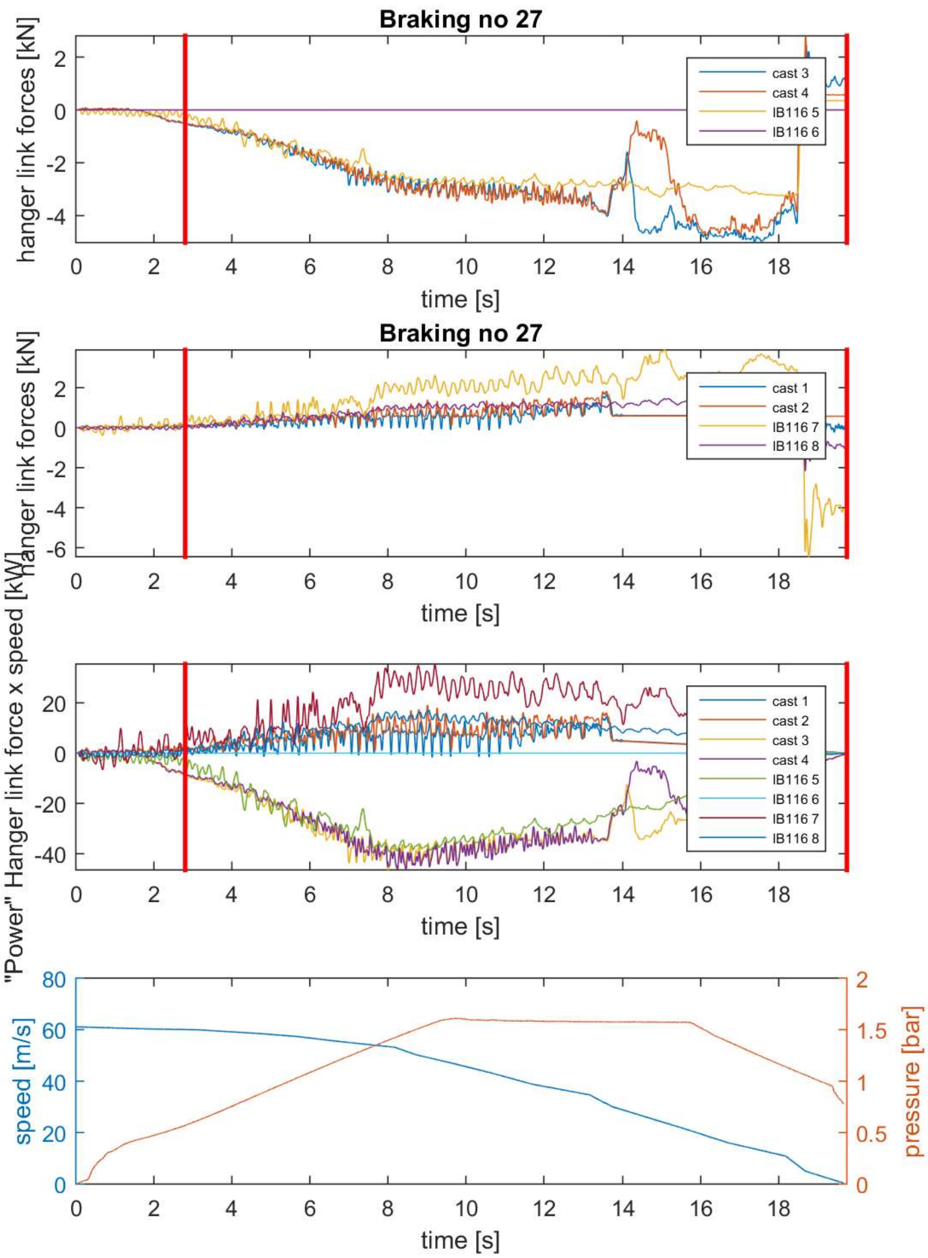
Braking no 22
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 22
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

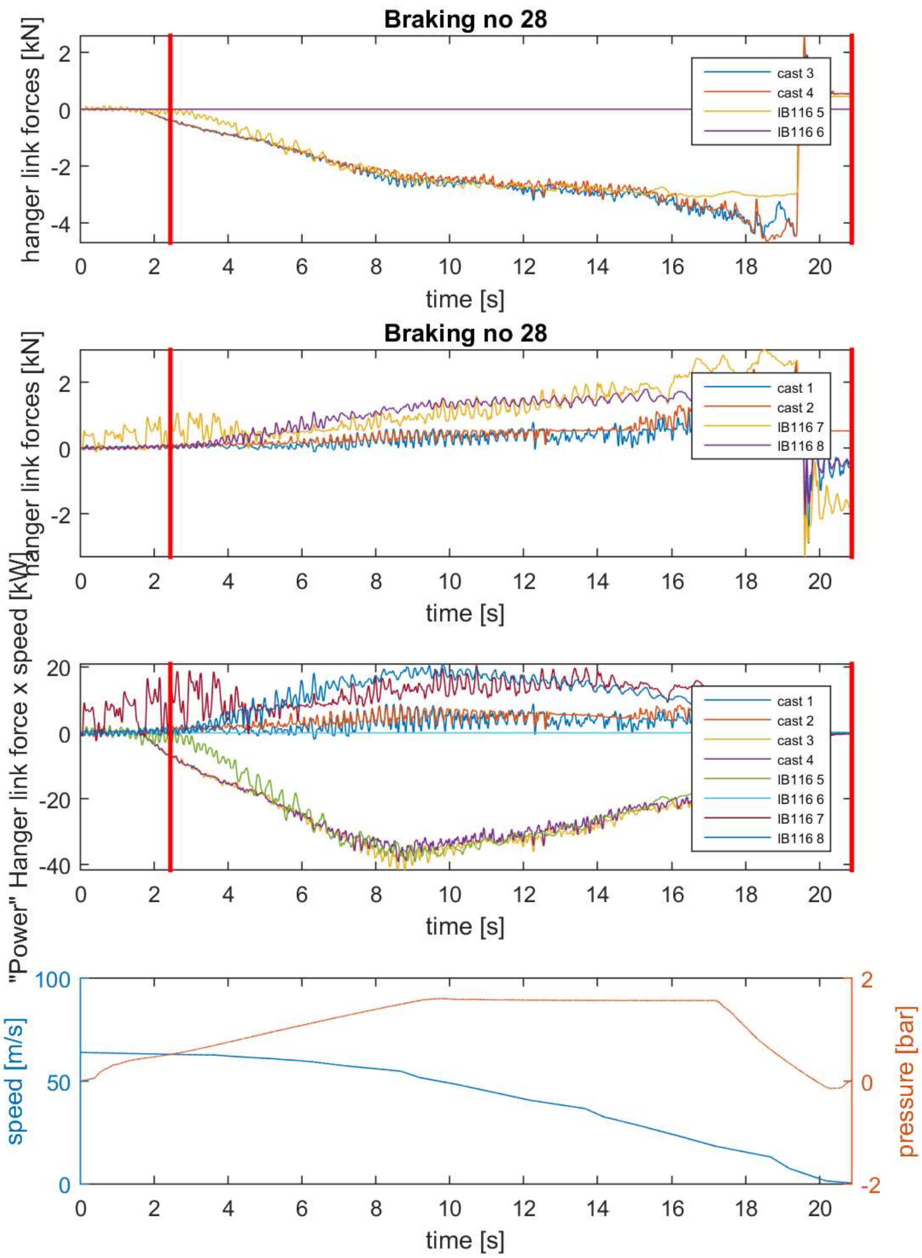

Braking no 23
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 23
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

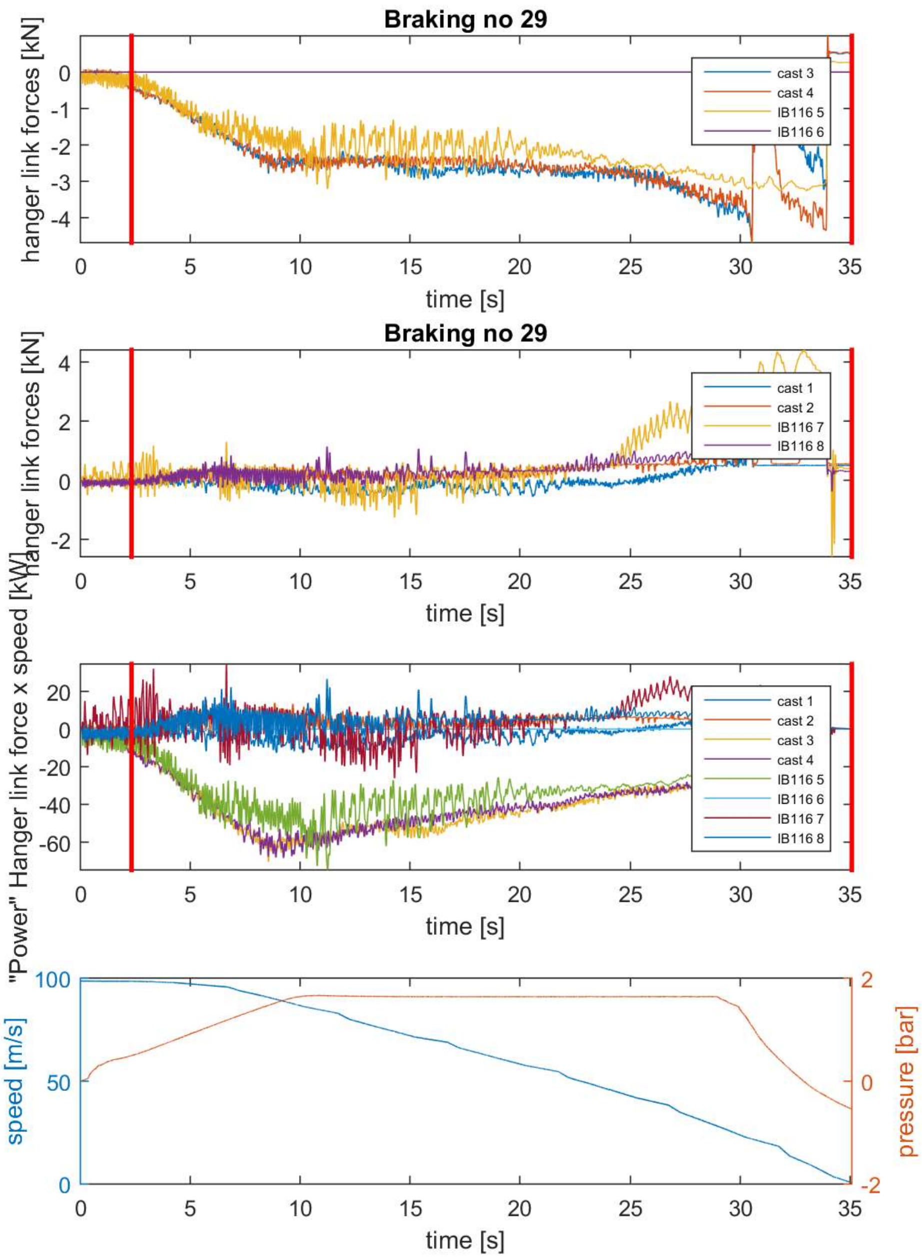

Braking no 24
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 24
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

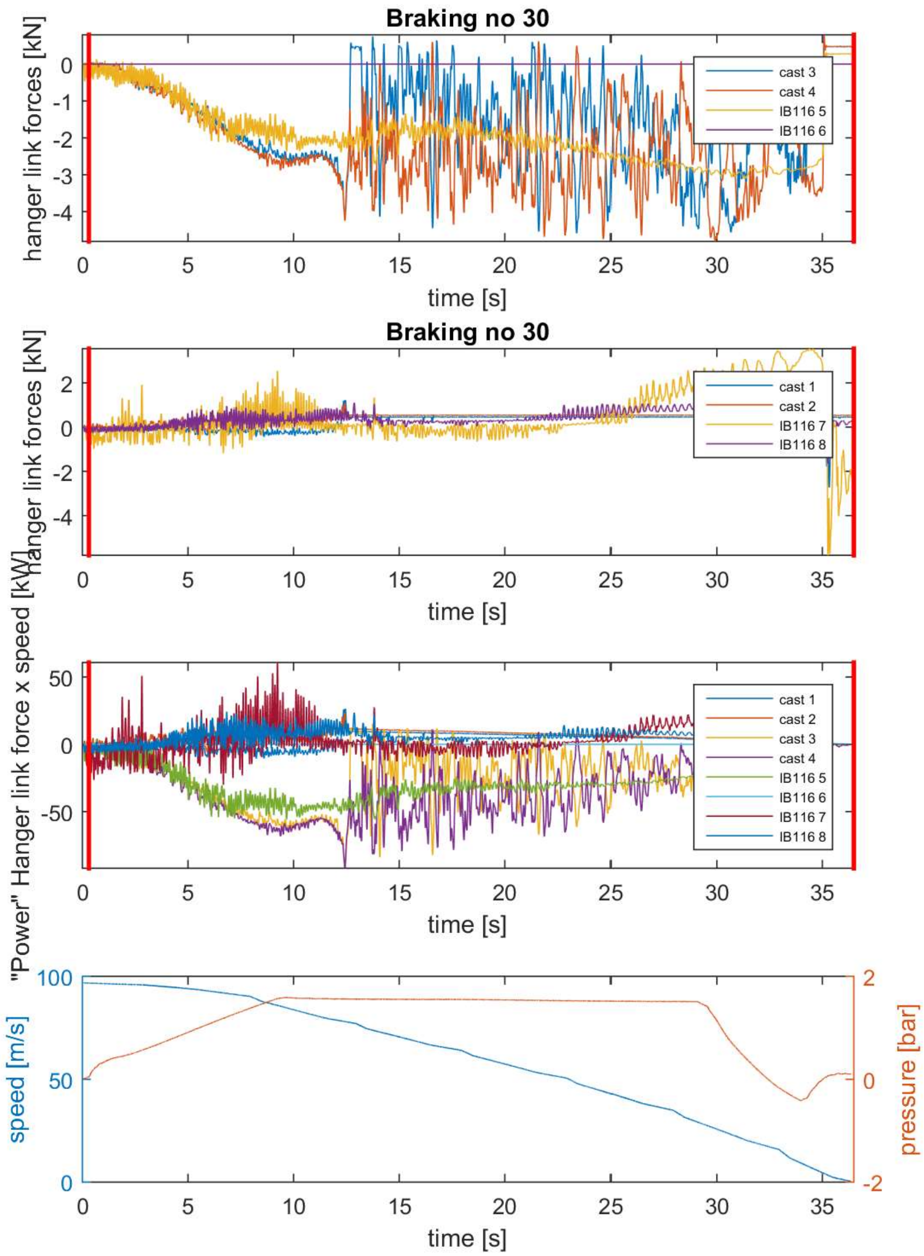

Braking no 25
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 25
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

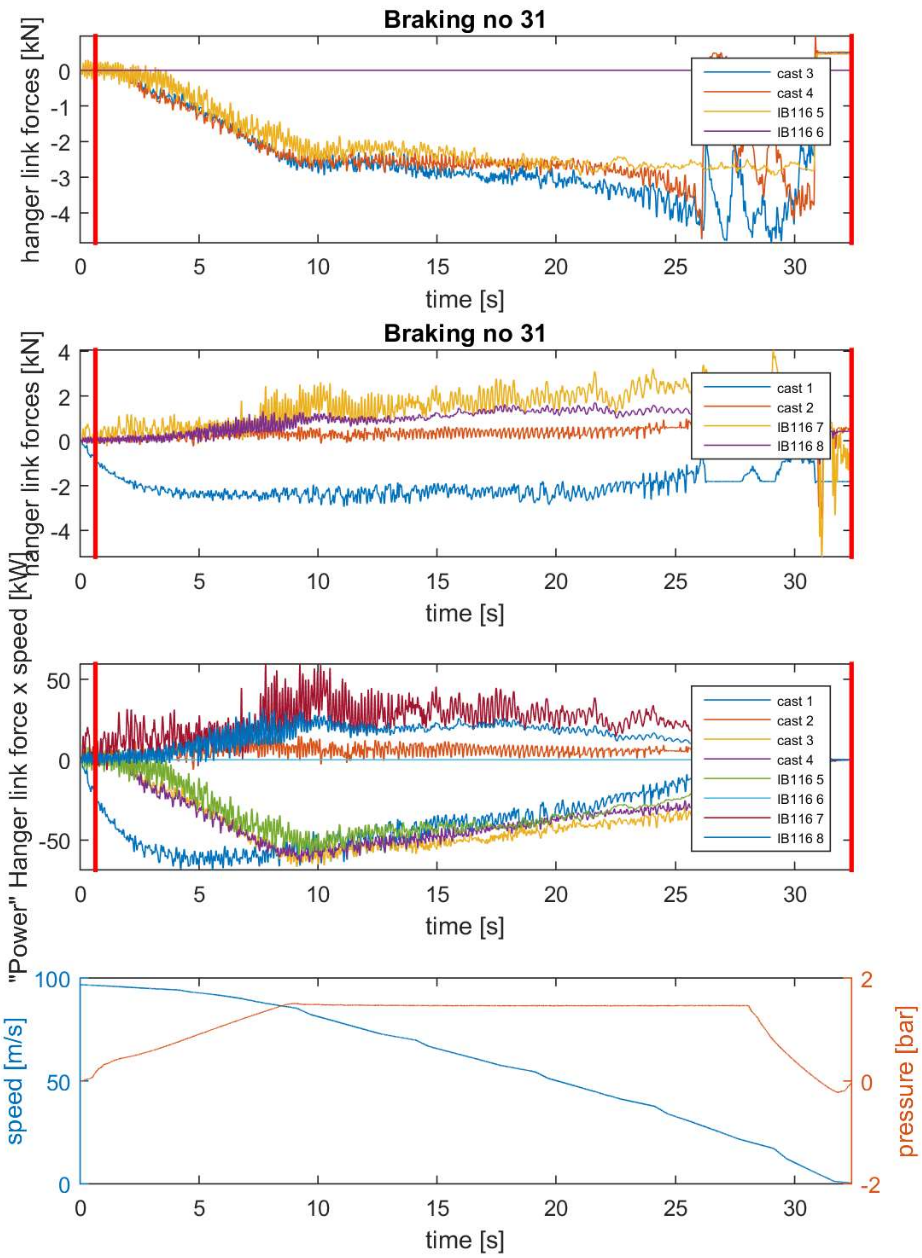

Braking no 26
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 26
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

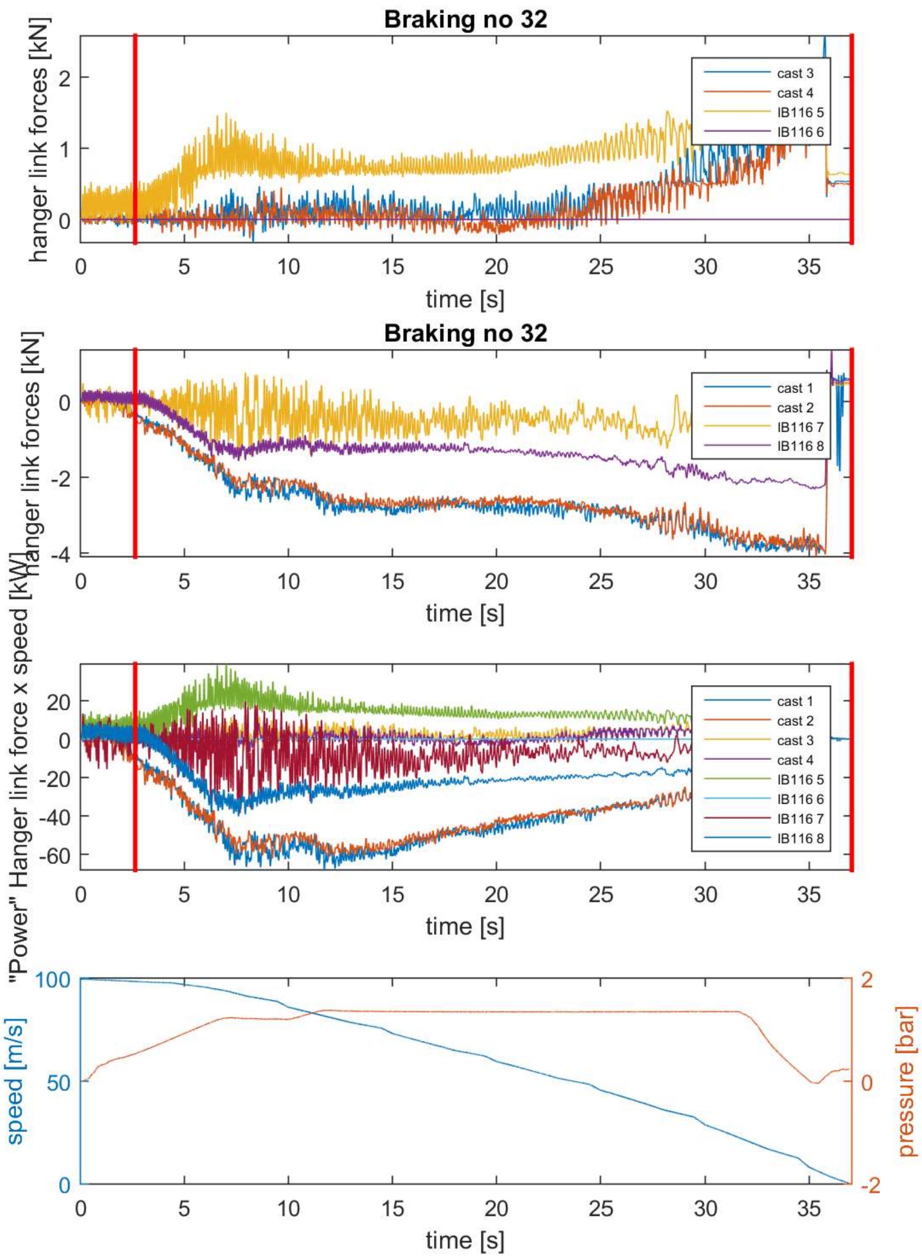

Braking no 27
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 27
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

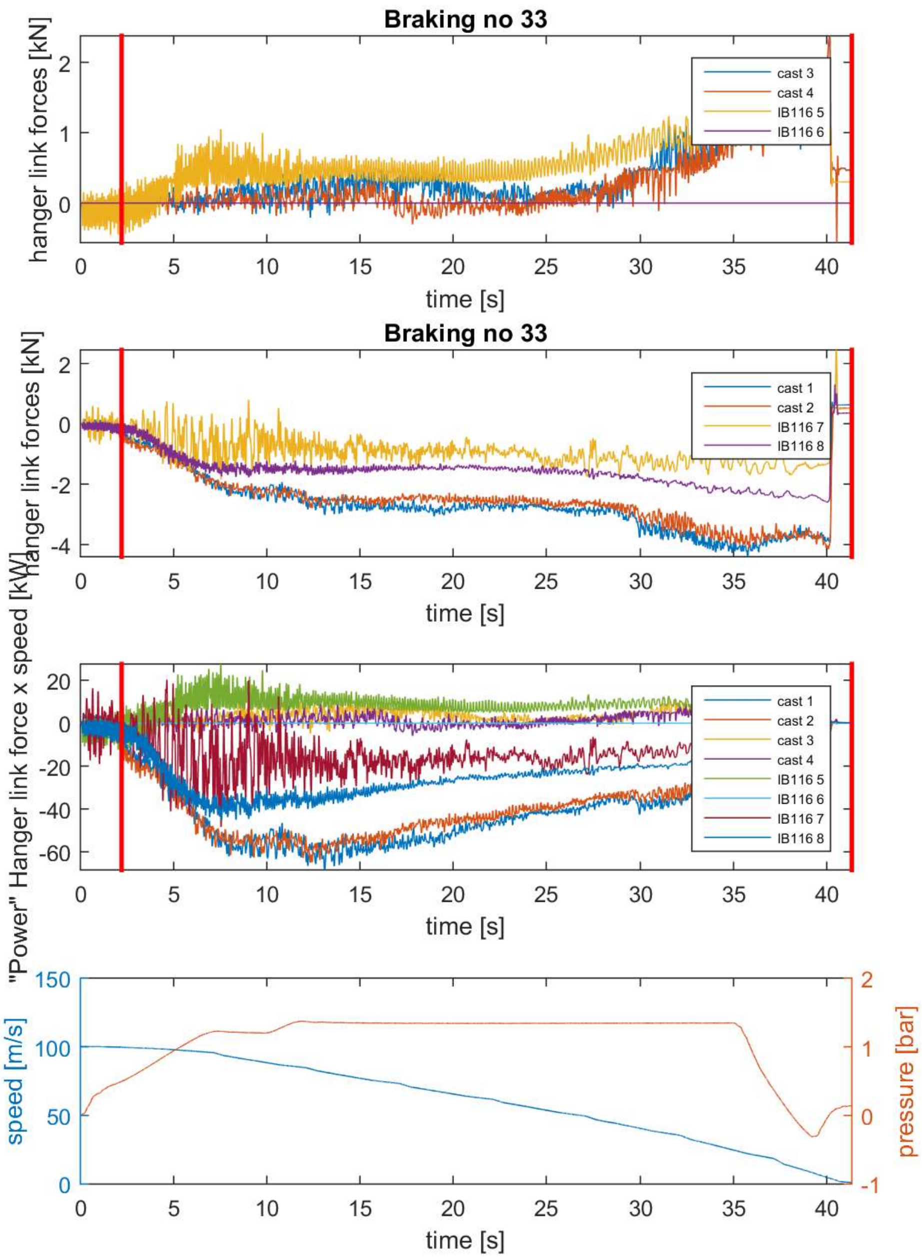

Braking no 28
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 28
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

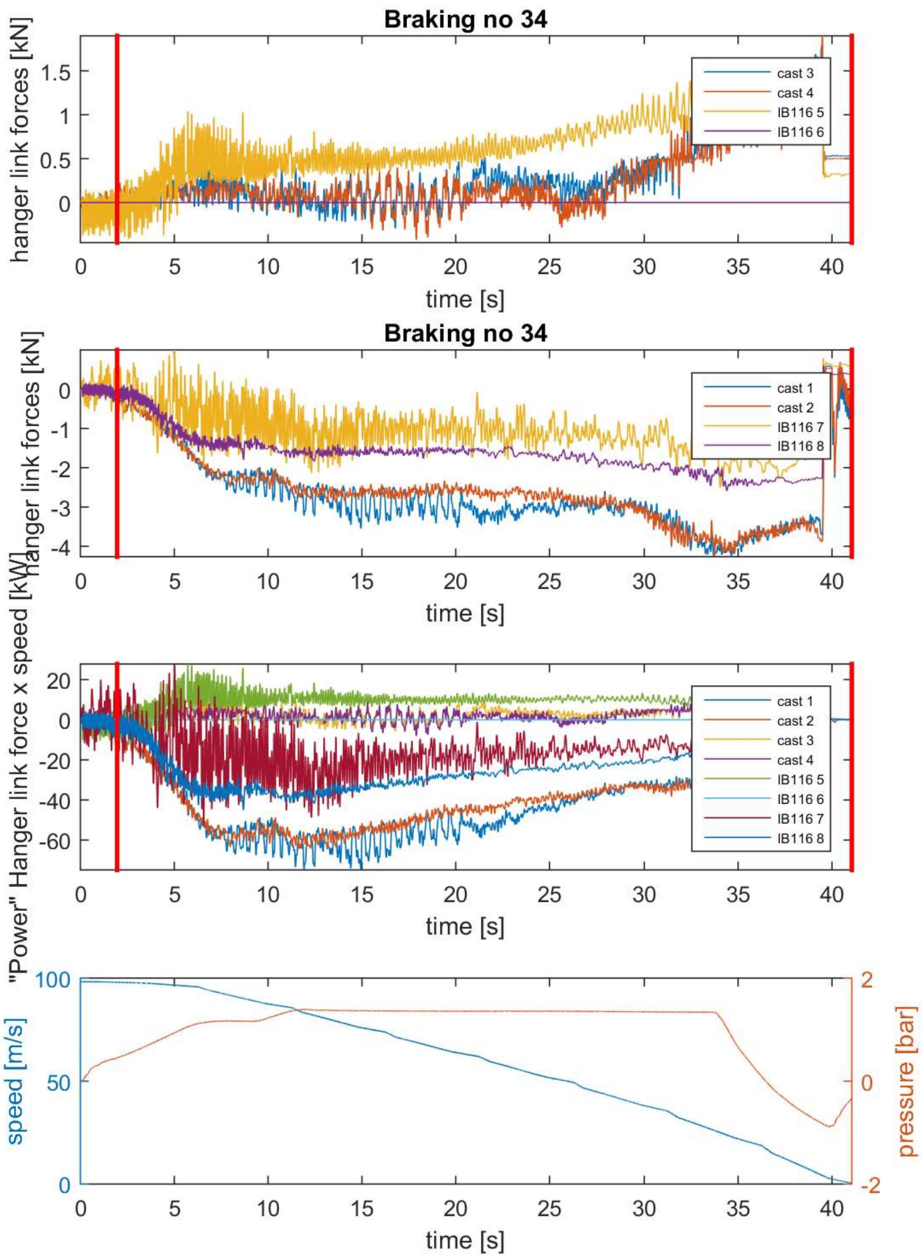

Braking no 29
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 29
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]


Braking no 30
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 30
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

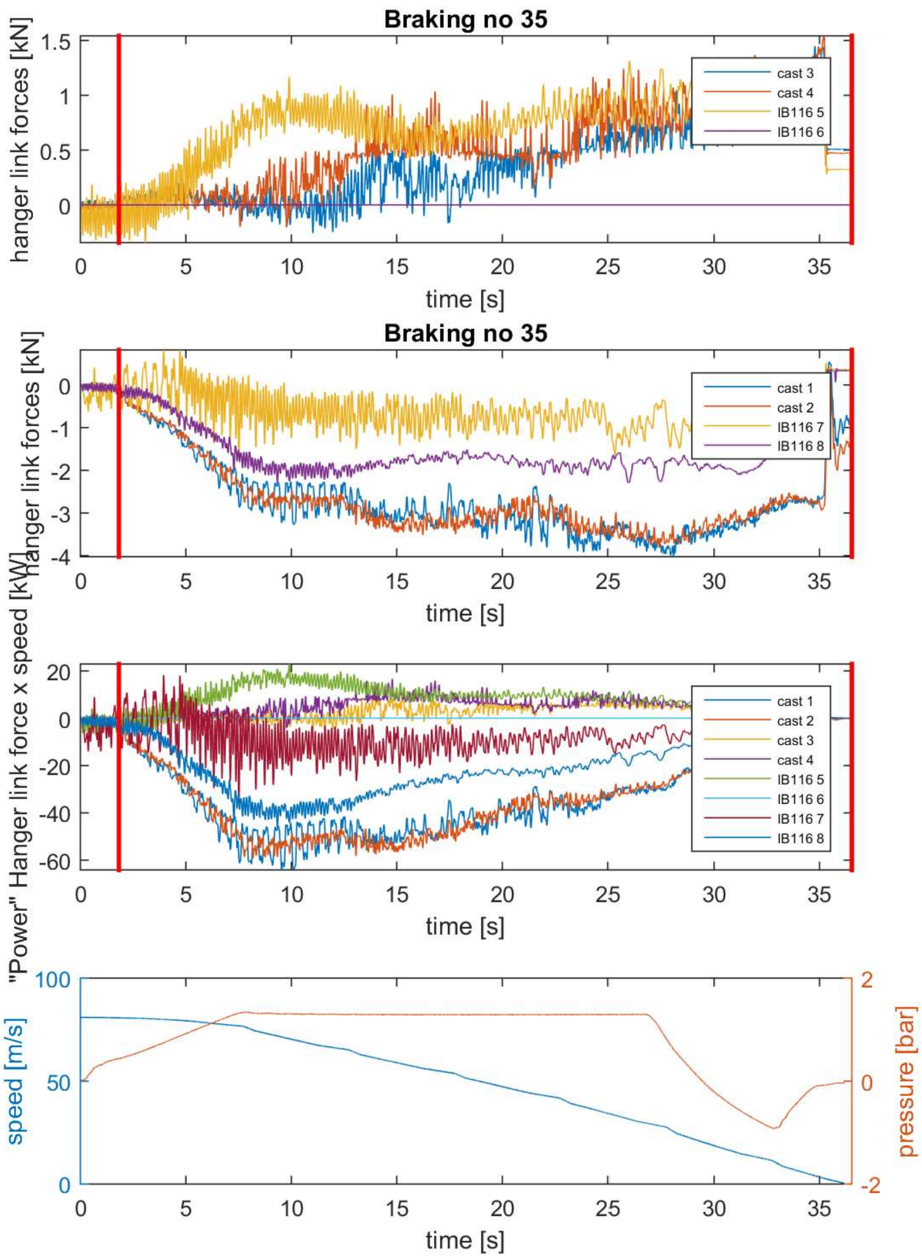

Braking no 31
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 31
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

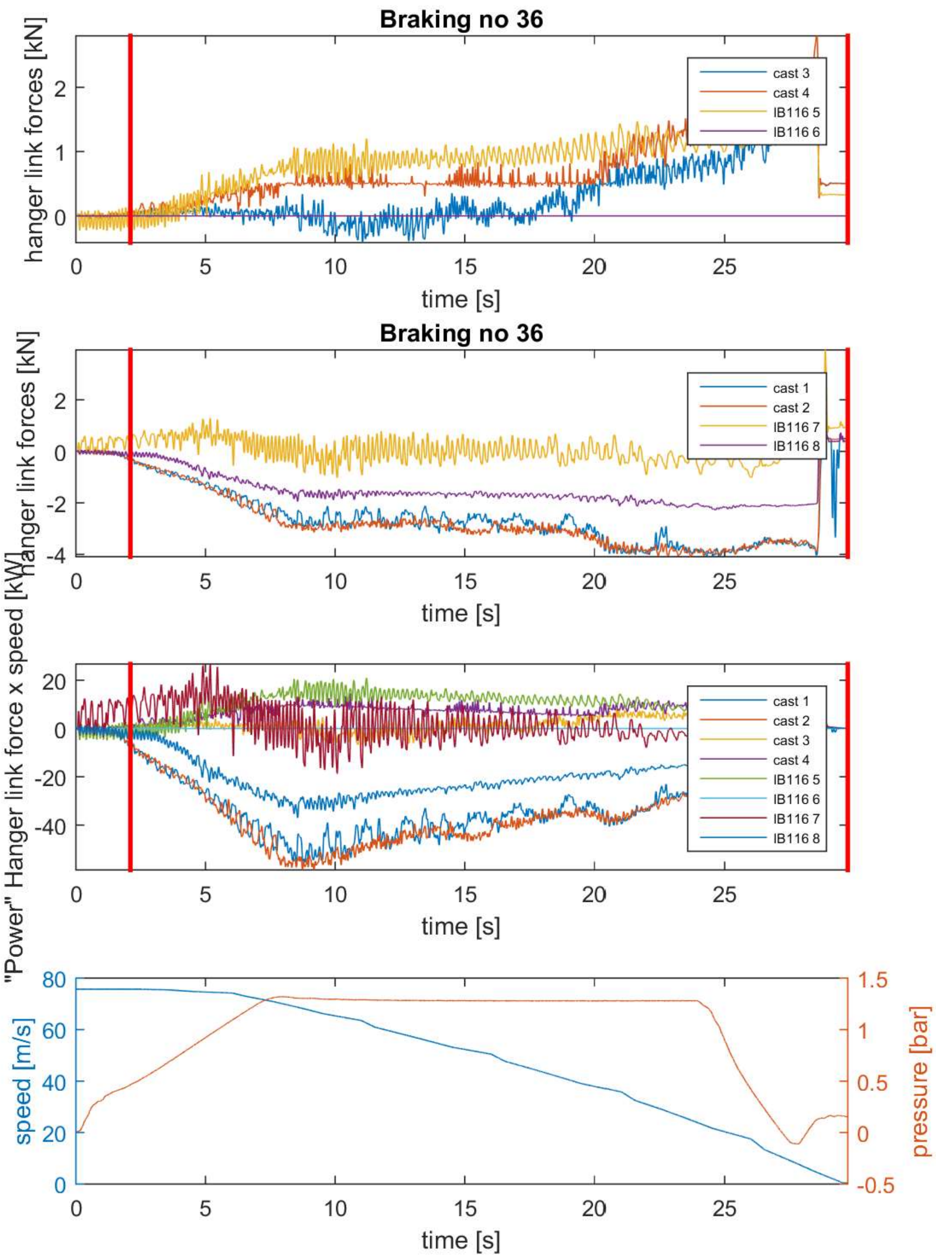

Braking no 32
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 32
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]


Braking no 33
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 33
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

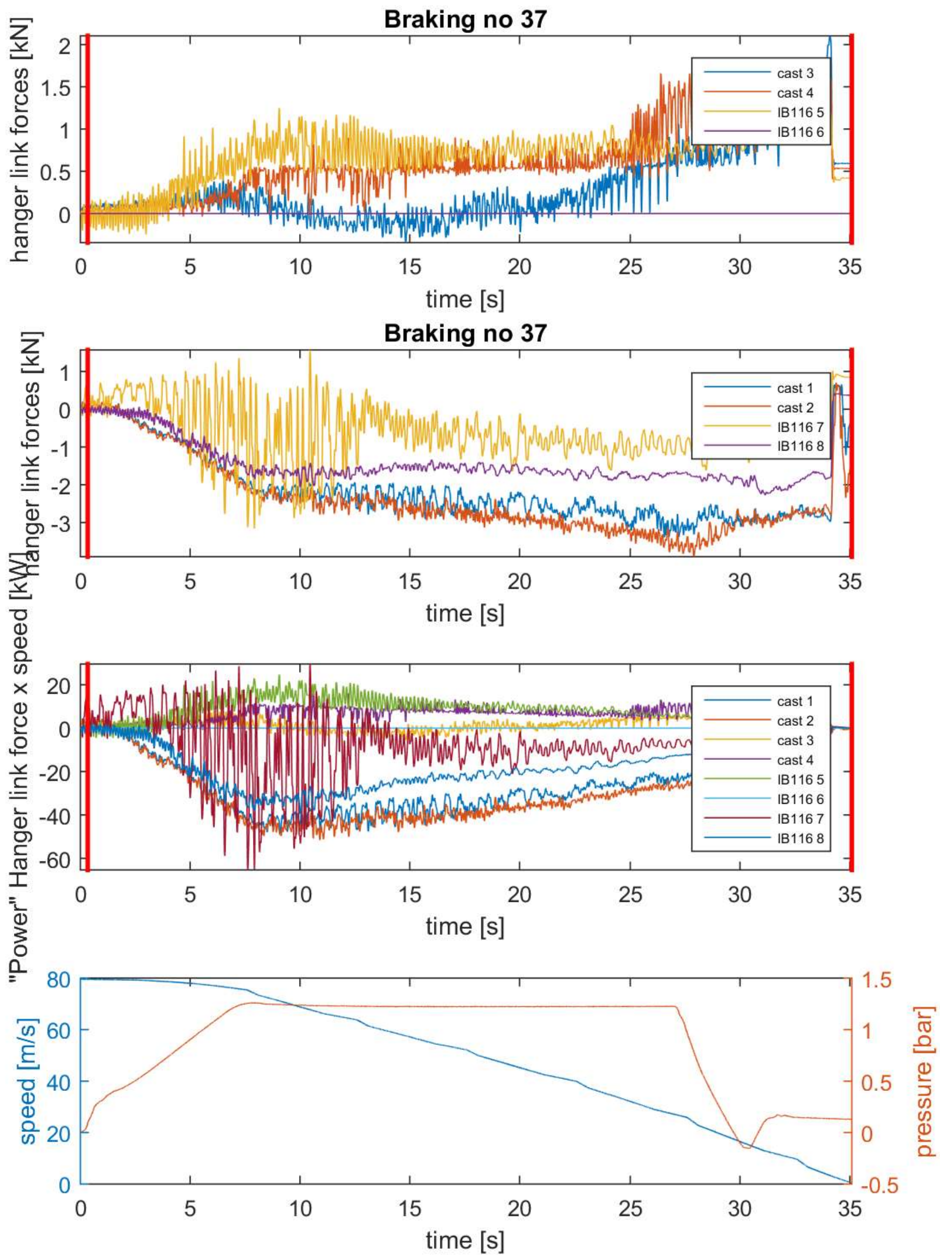


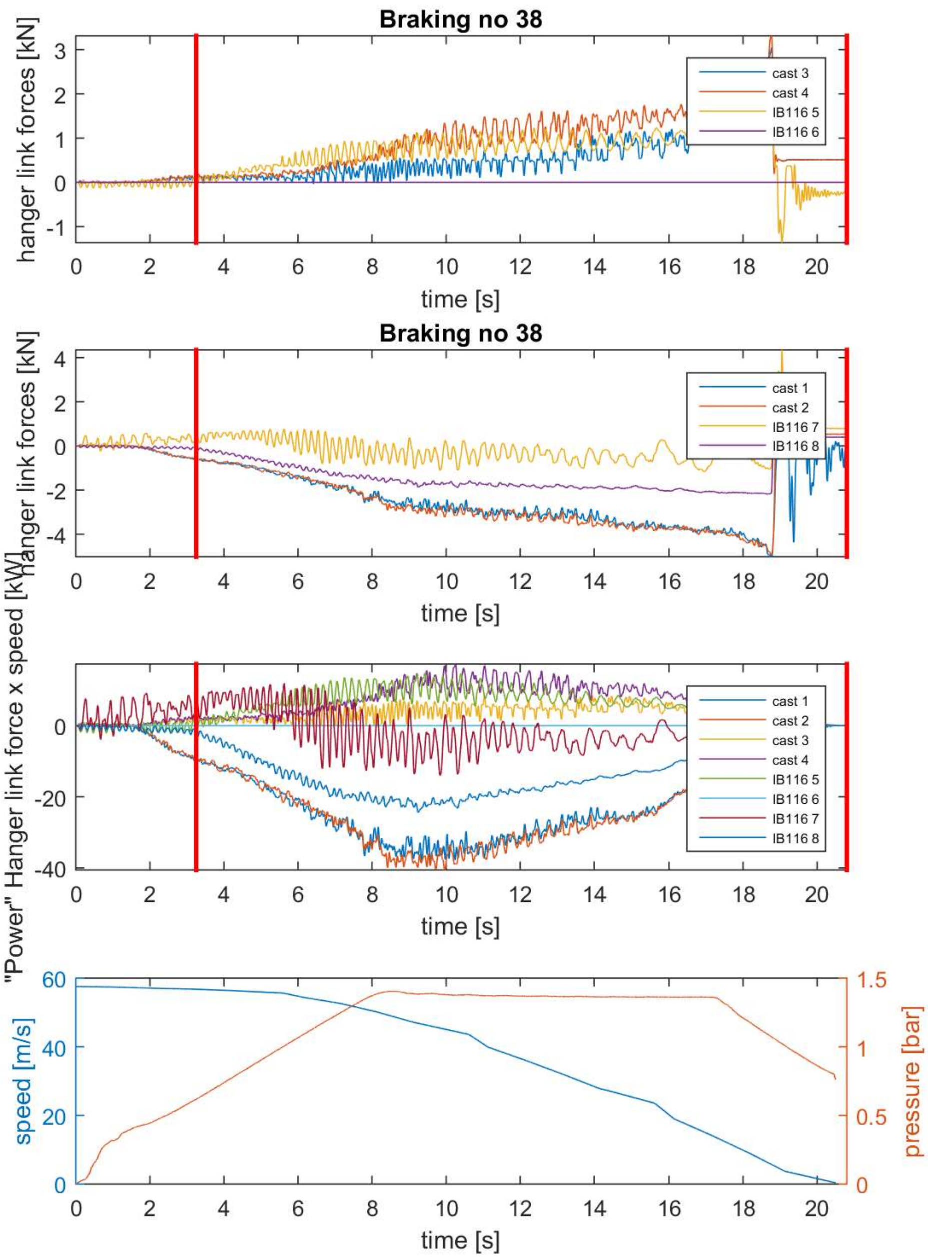
Braking no 34
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 34
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]


Braking no 35
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 35
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

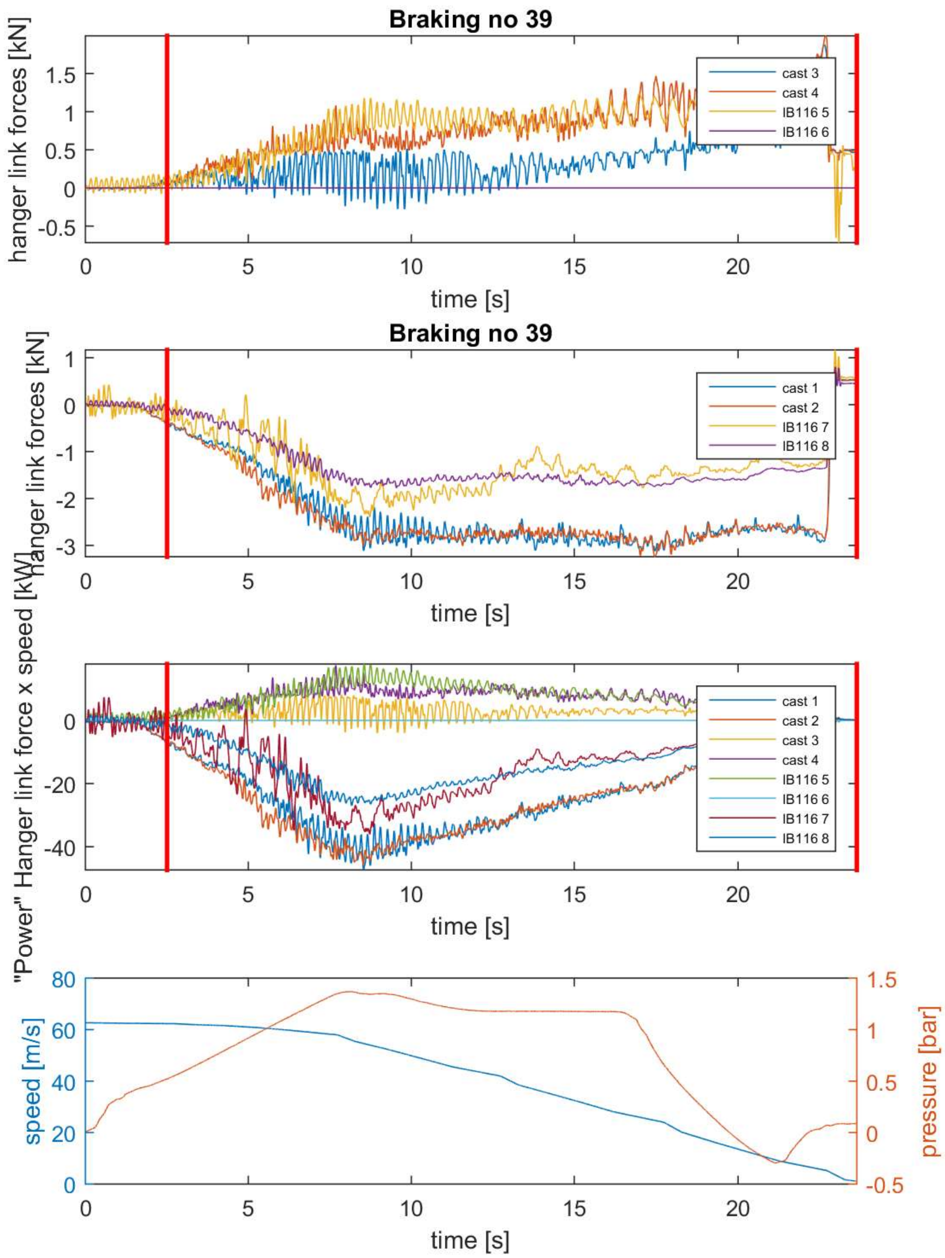


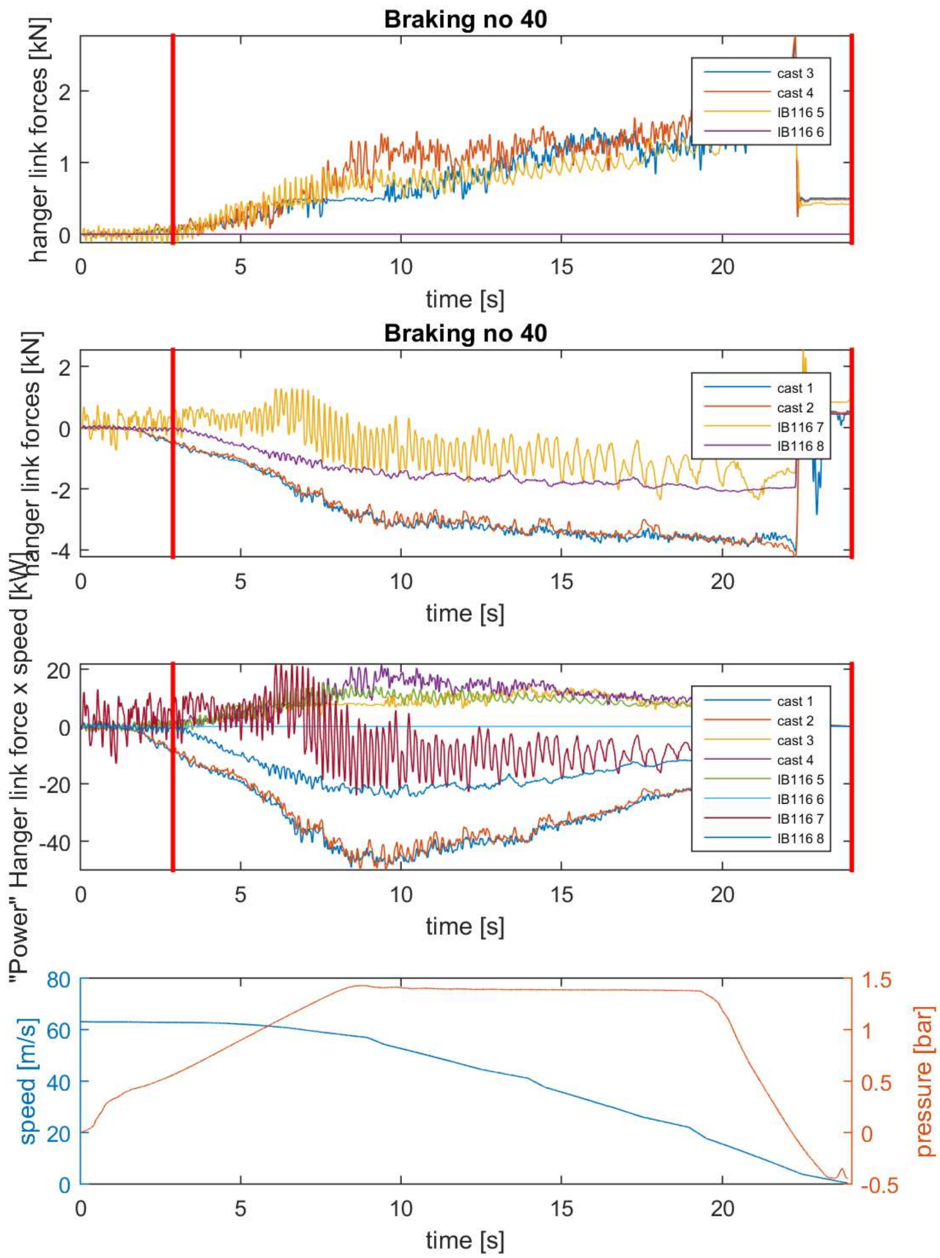
Braking no 36
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 36
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]


Braking no 37
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 37
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

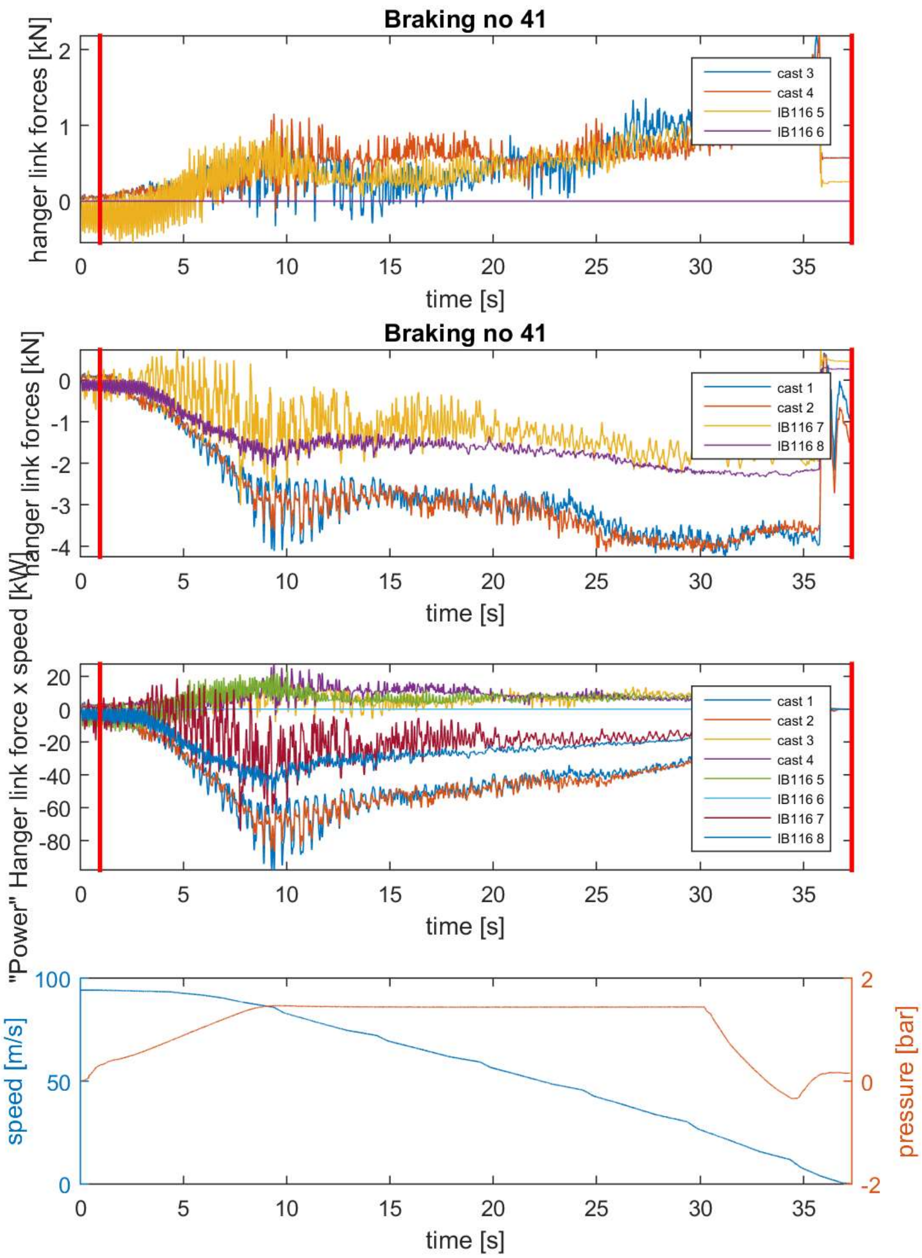


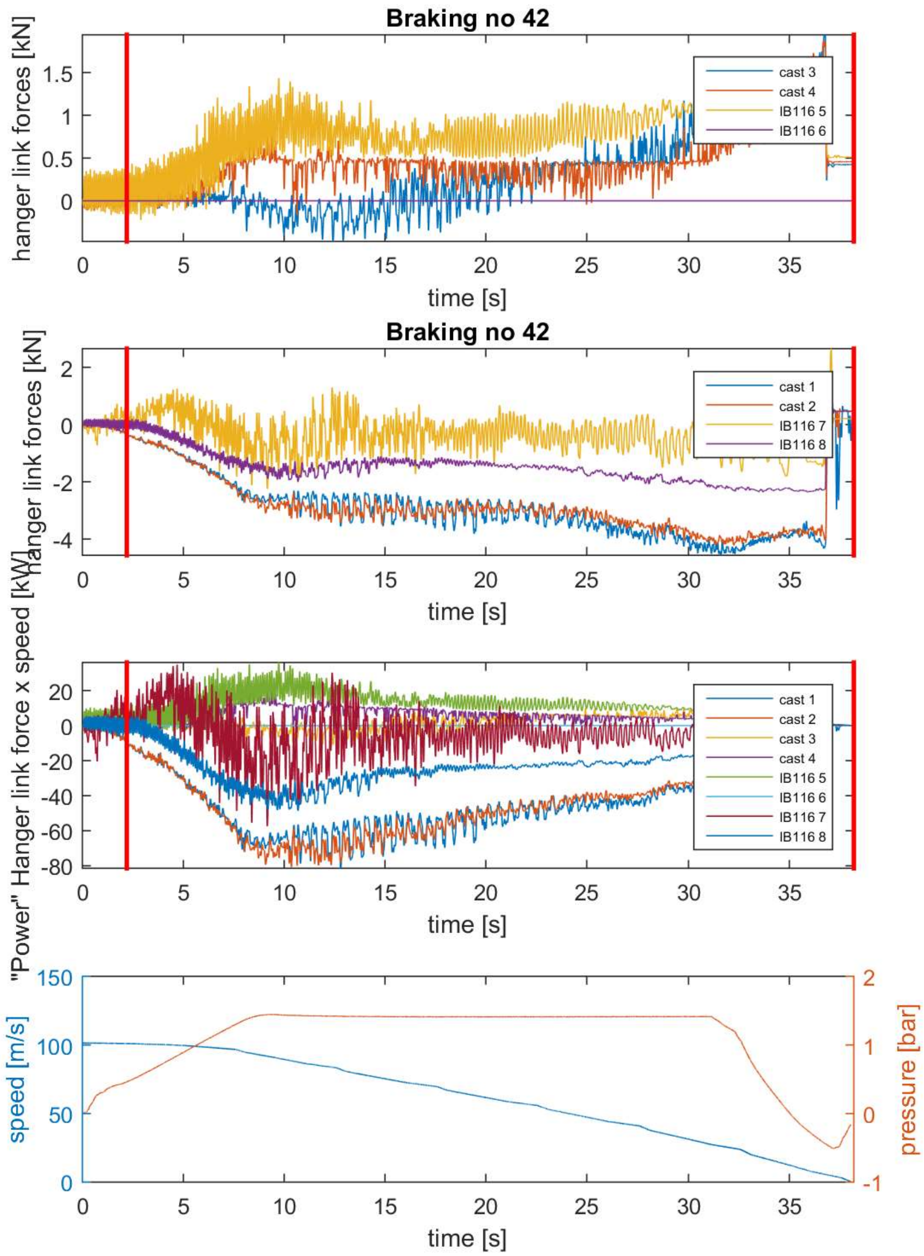
Braking no 38
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 38
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

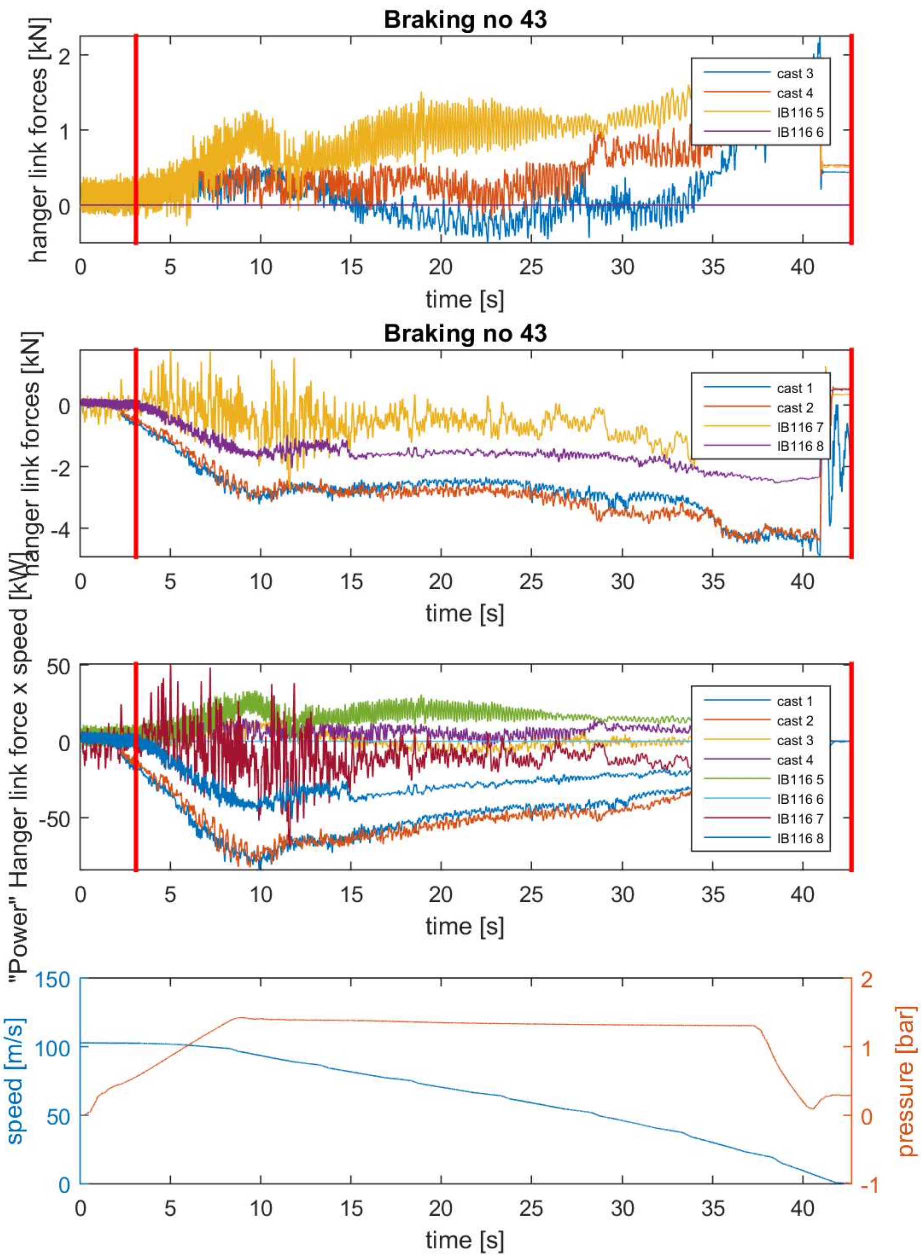

Braking no 39
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 39
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

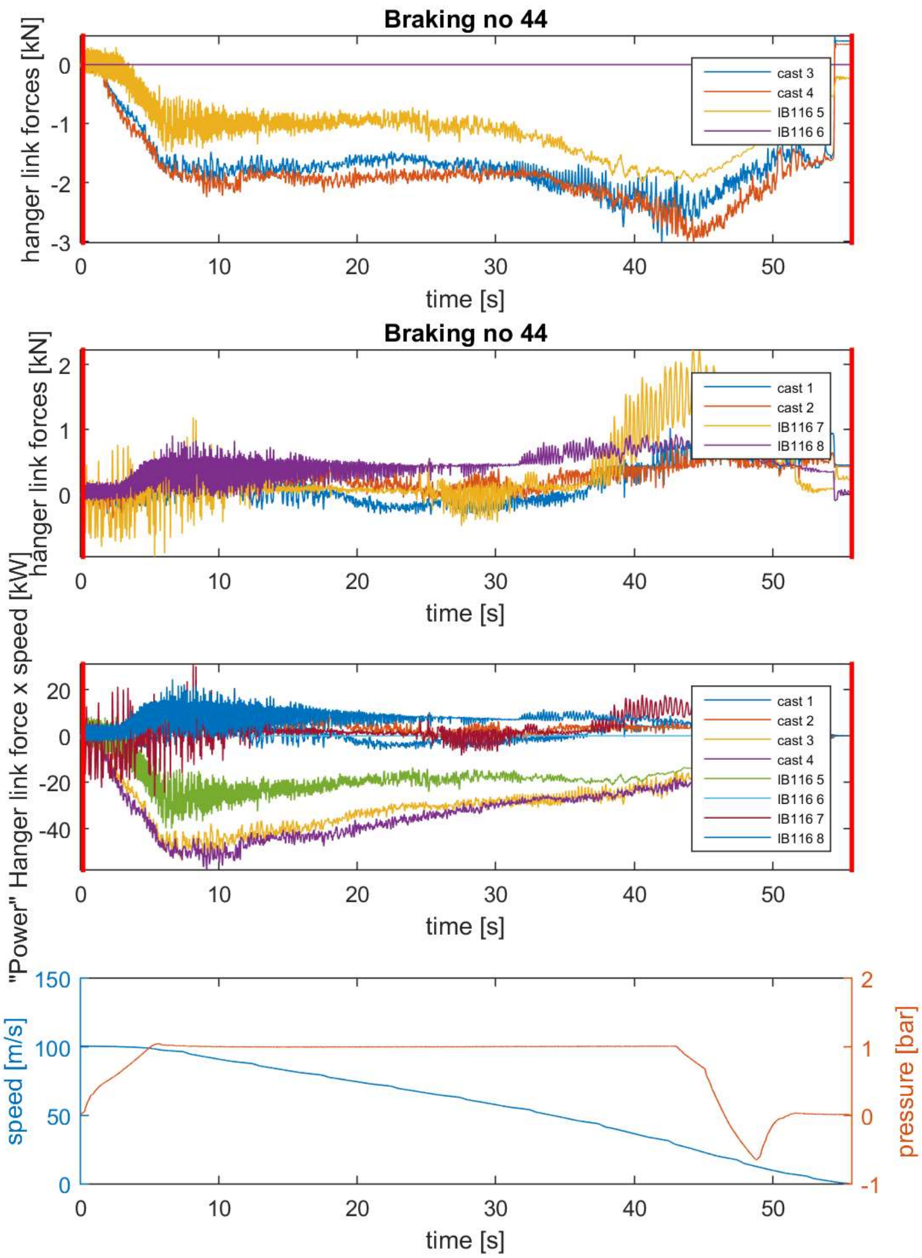


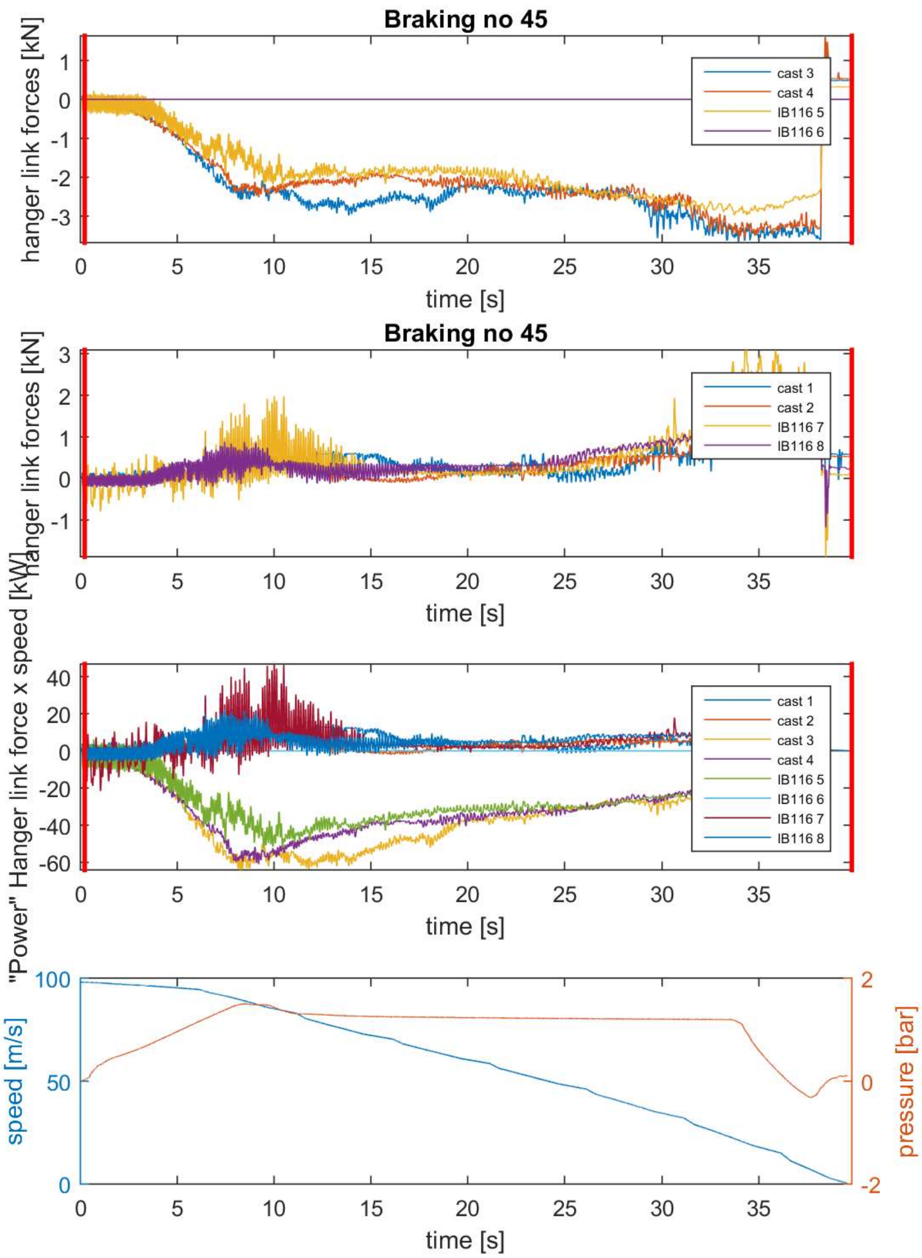
Braking no 40
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 40
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

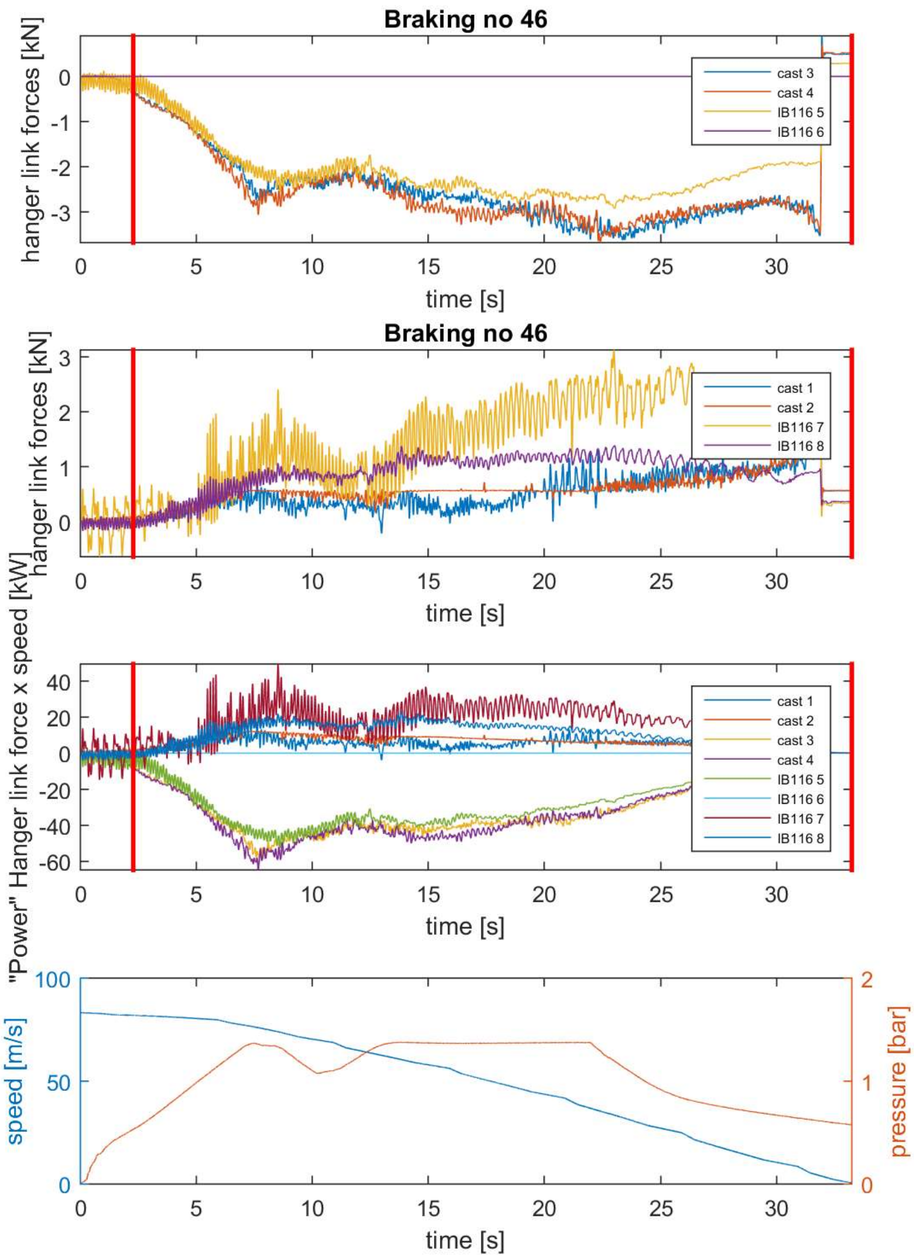

Braking no 41
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 41
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]


Braking no 42
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 42
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

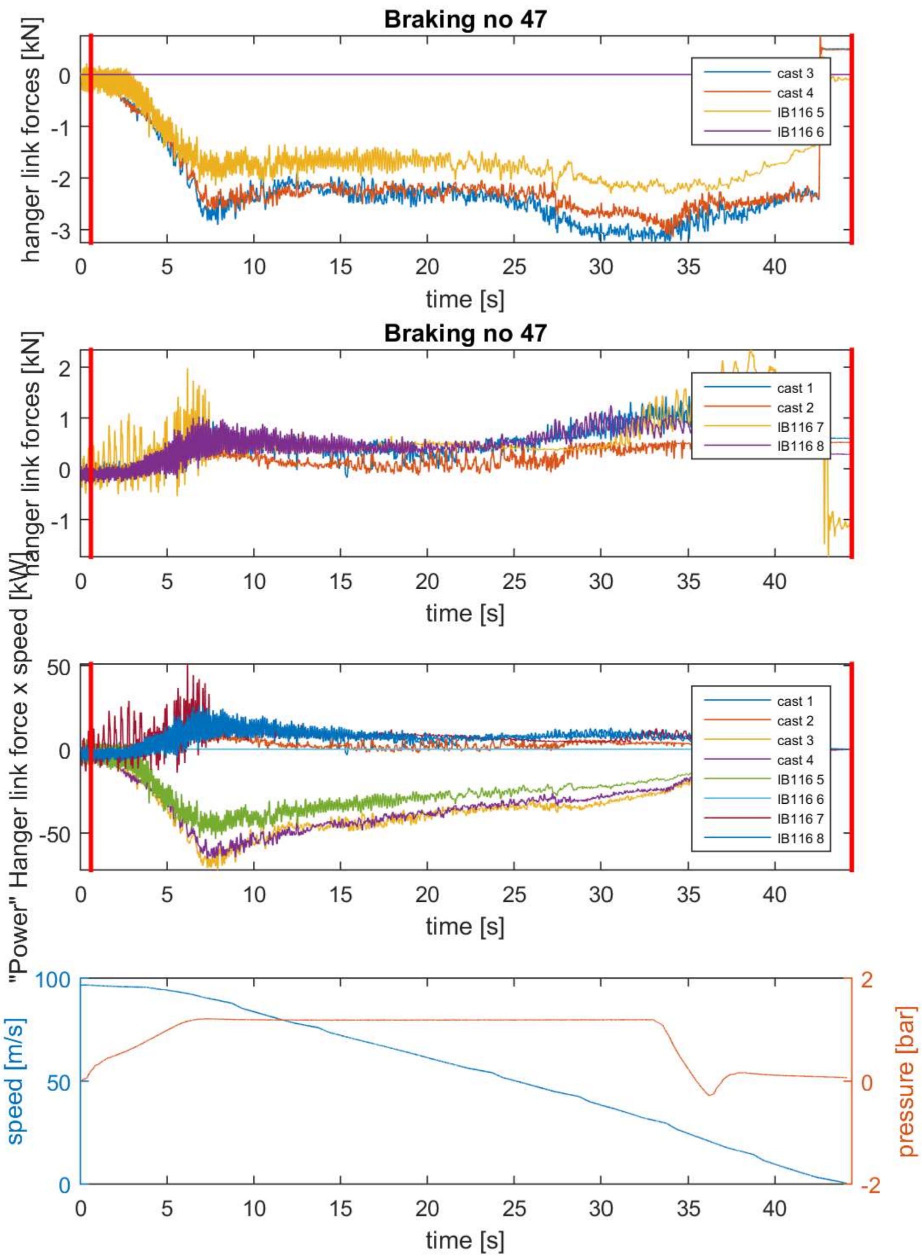

Braking no 43
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 43
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

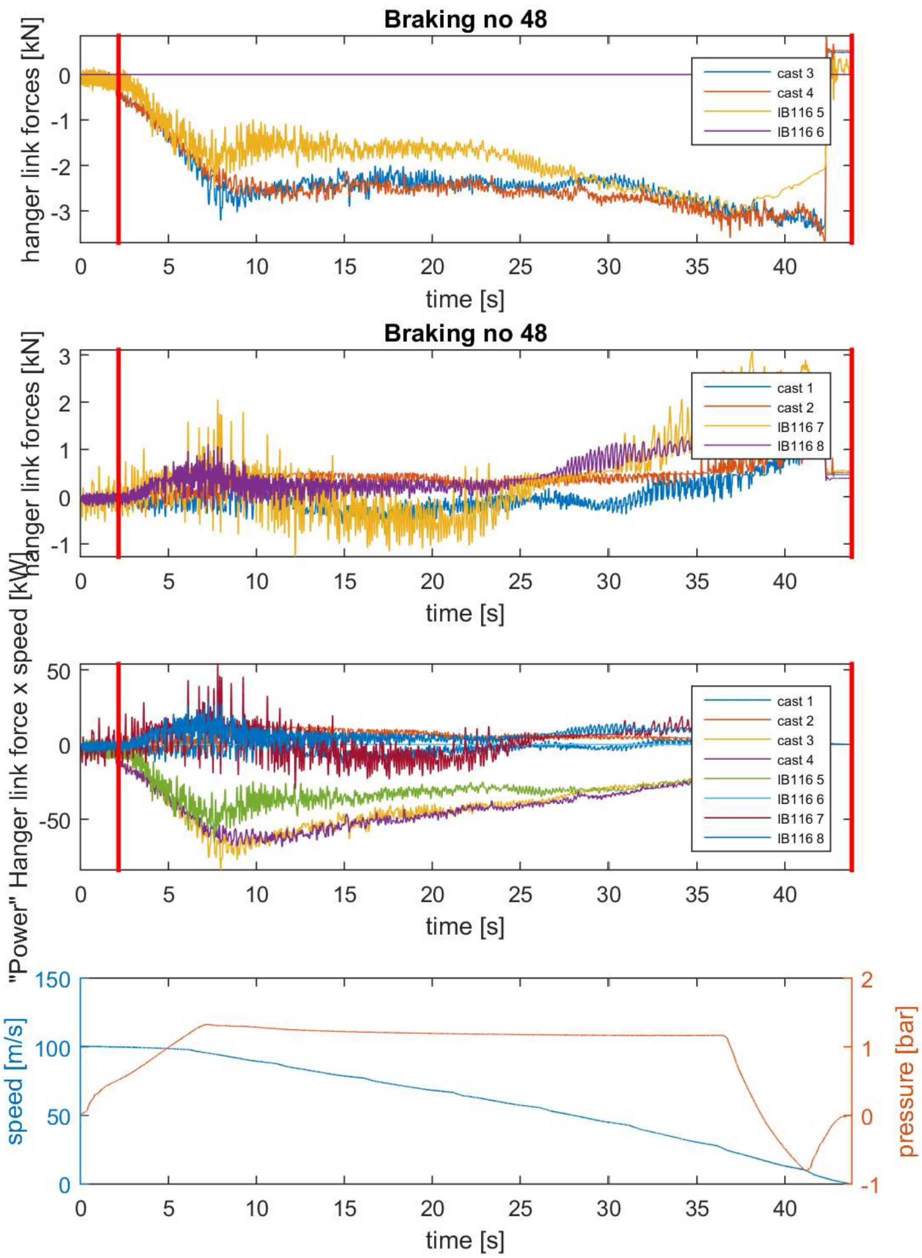

Braking no 44
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 44
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]

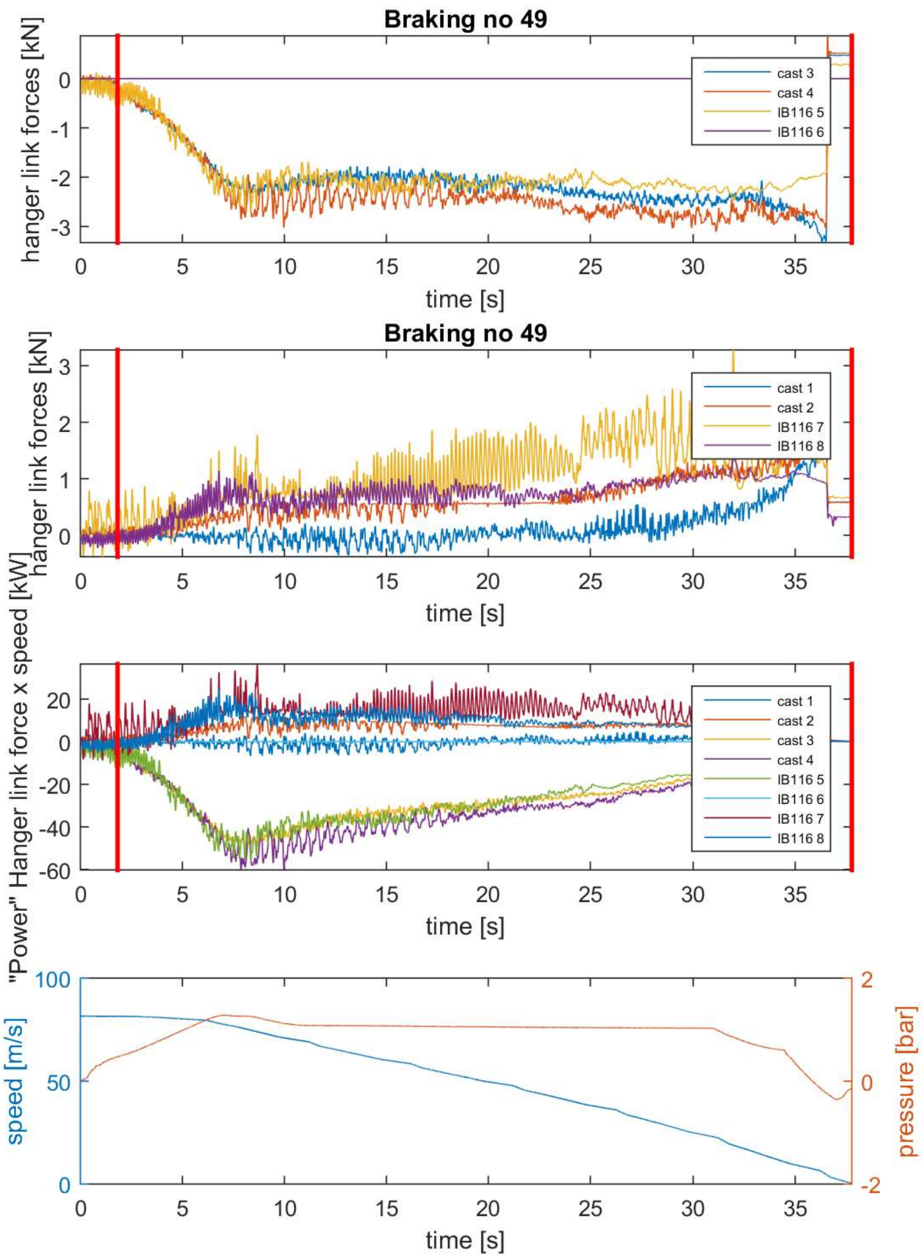

Braking no 45
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 45
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]



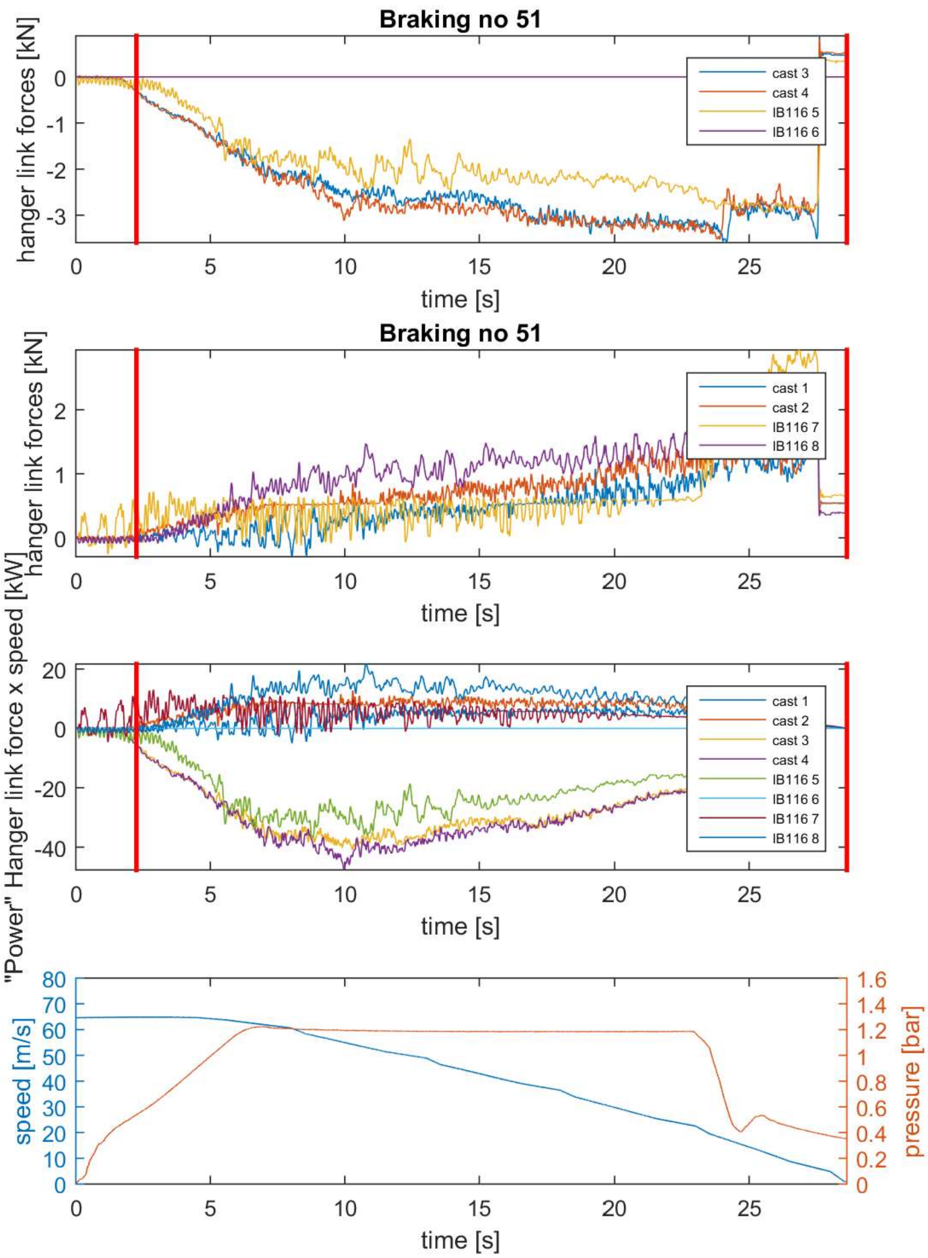
Braking no 46
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 46
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

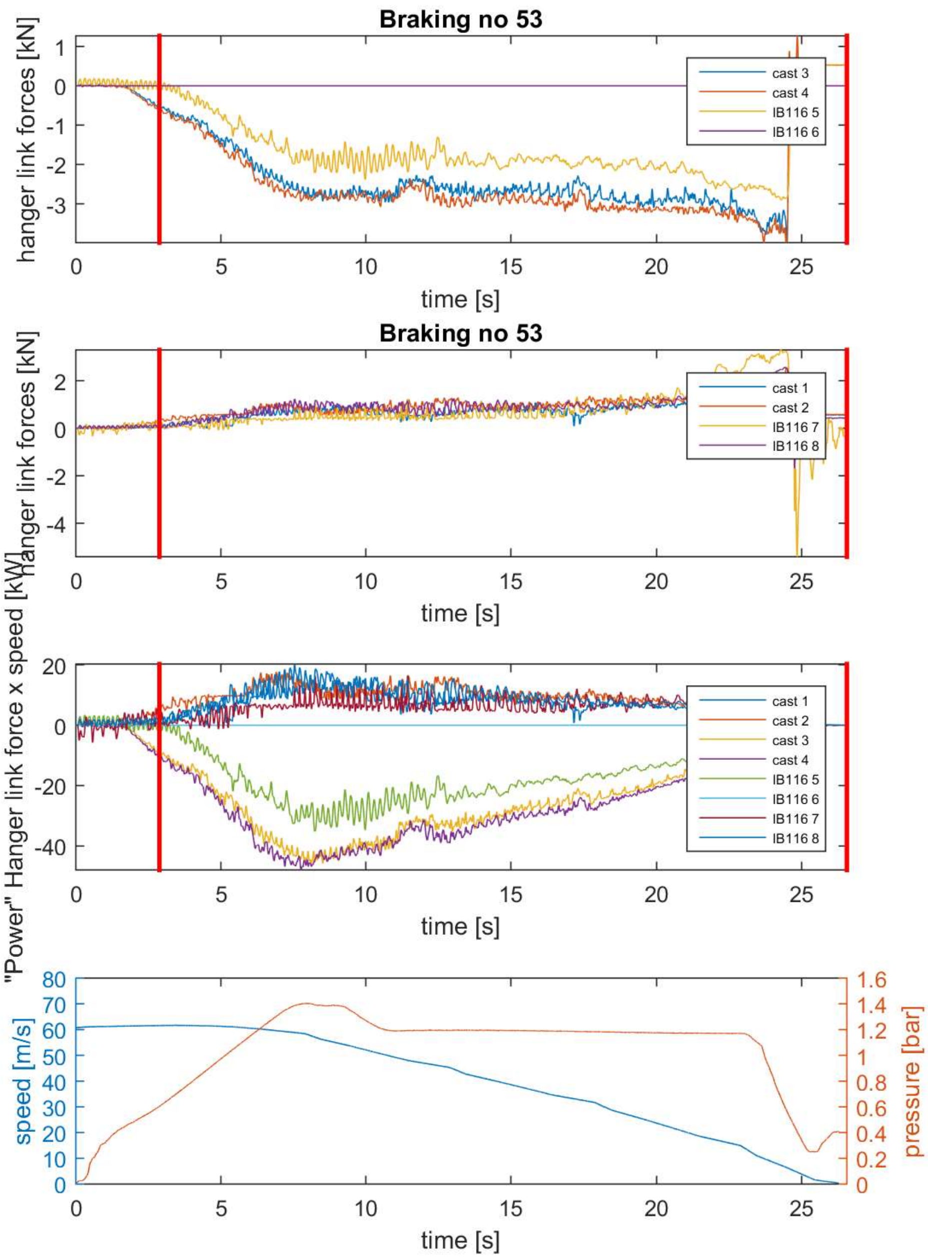

Braking no 47
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 47
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

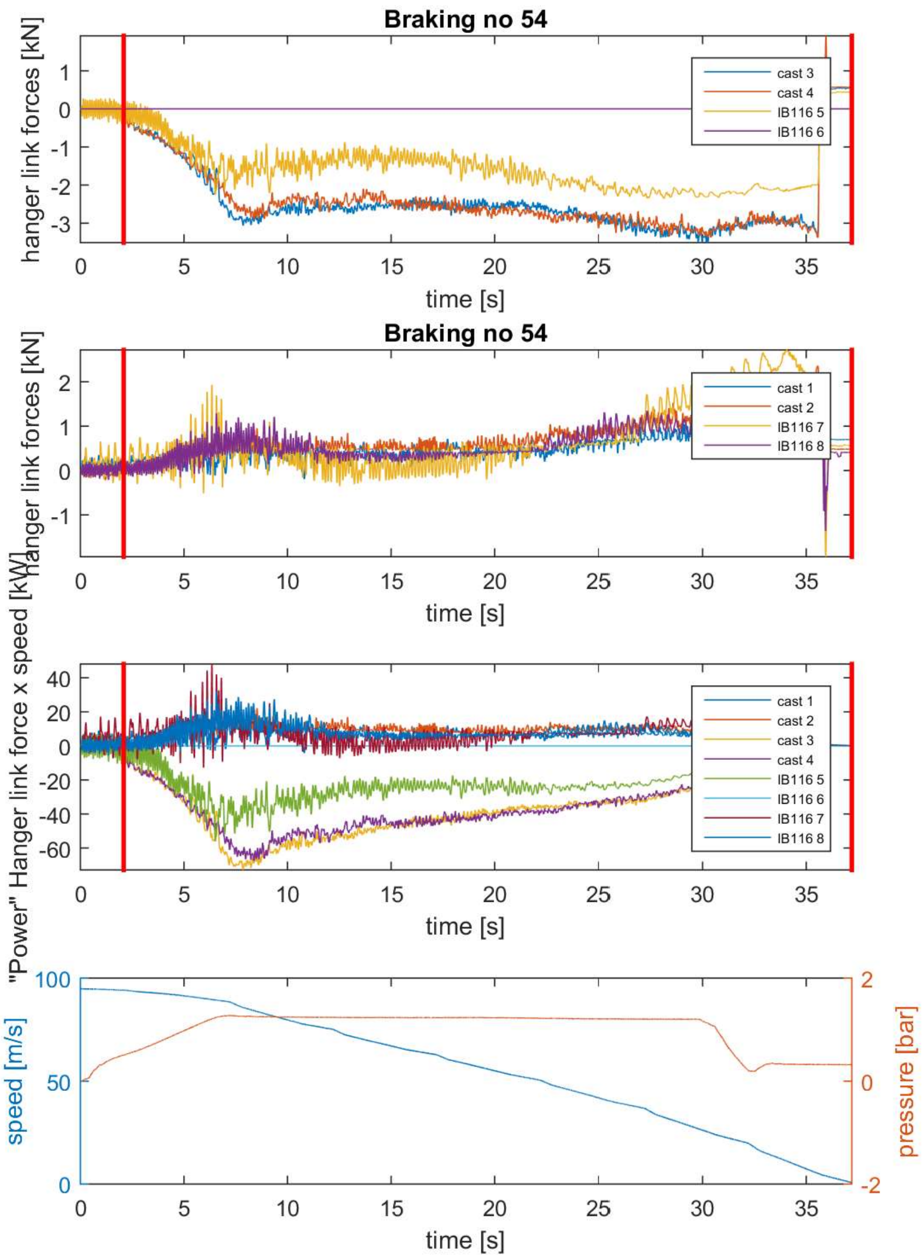

Braking no 48
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 48
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]



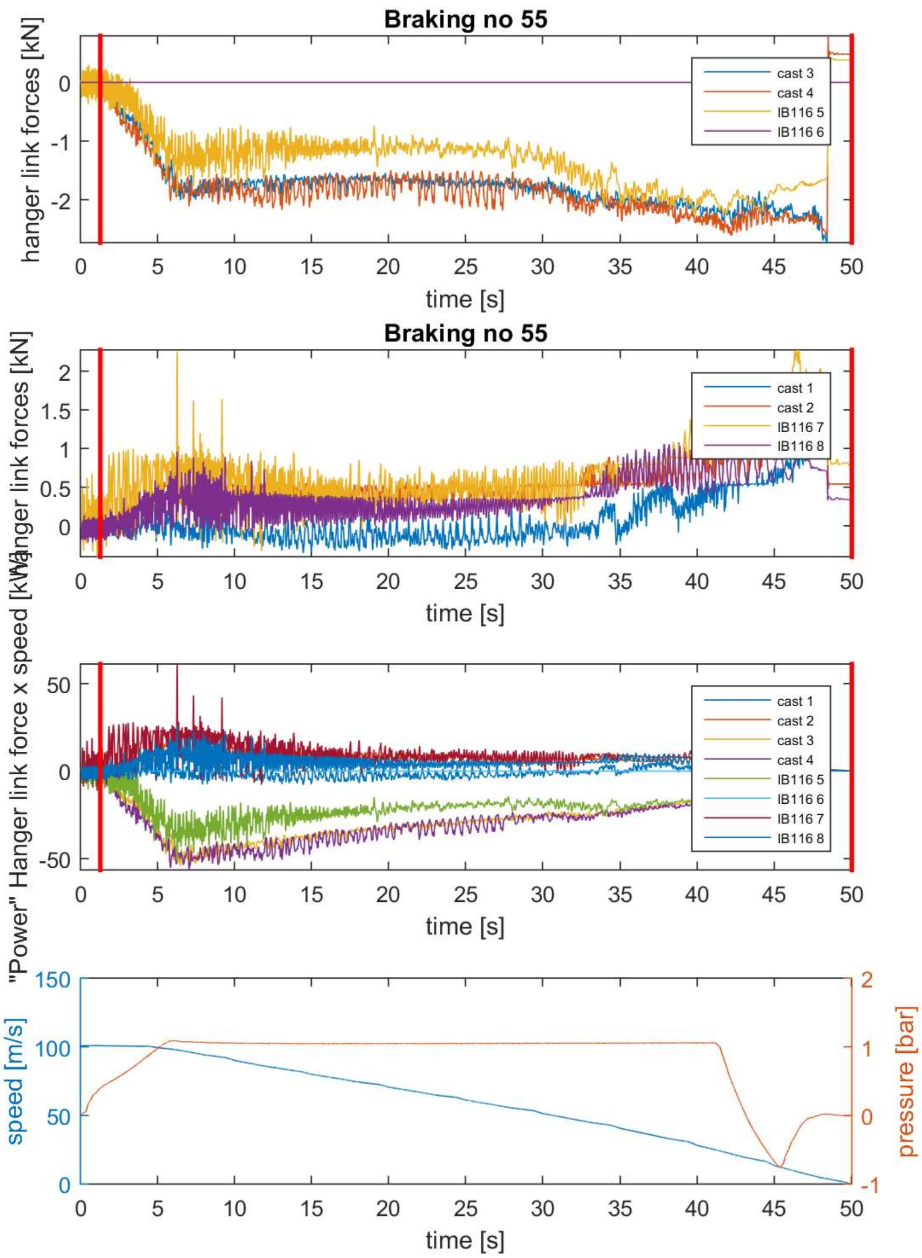
Braking no 49
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 49
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]

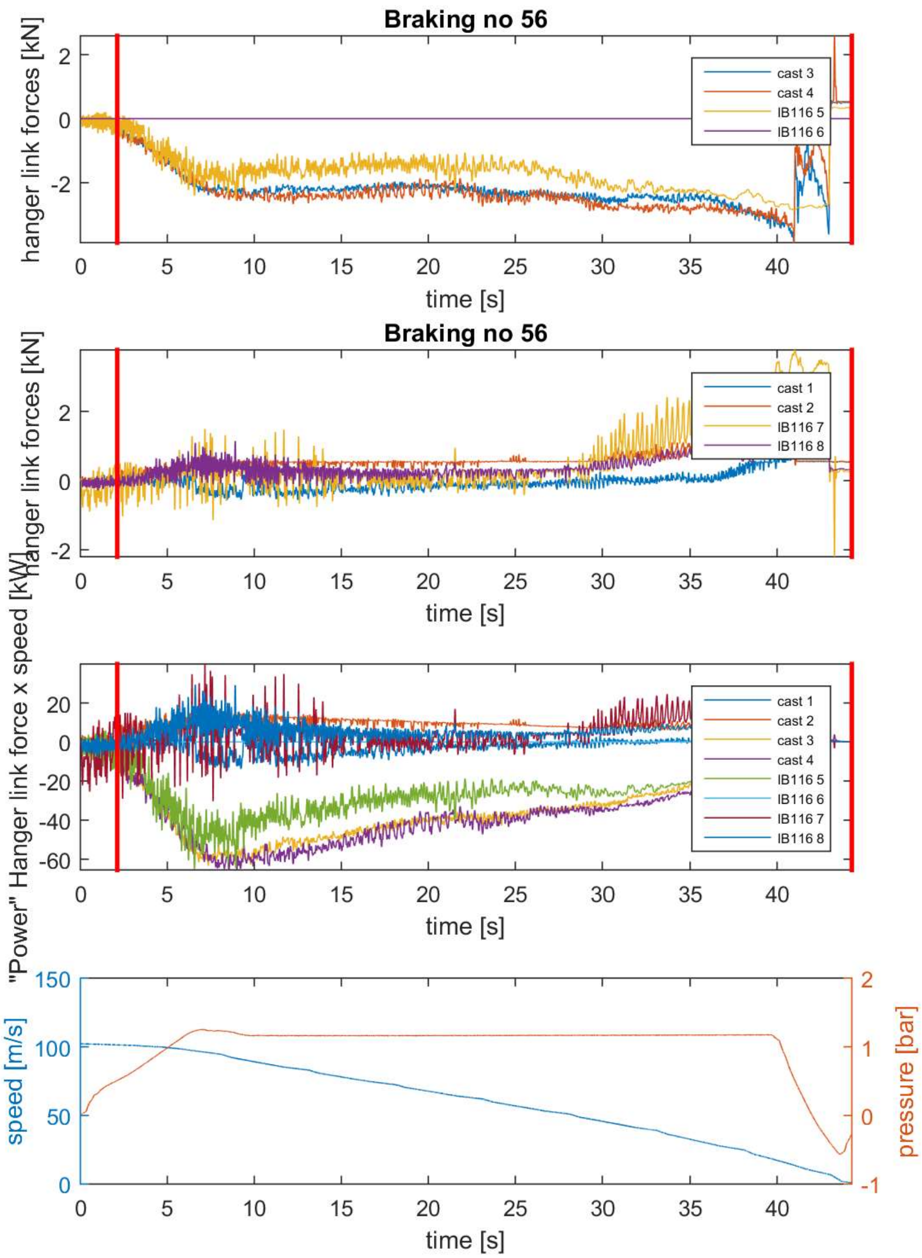

Braking no 51
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 51
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]


Braking no 53
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 53
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]



Braking no 54
hanger link forces [kN]
cast 3
cast 4
IB116 5
IB116 6
time [s]
Braking no 54
hanger link forces [kN]
cast 1
cast 2
IB116 7
IB116 8
time [s]
"Power" Hanger link force x speed [kW]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
time [s]
speed [m/s]
pressure [bar]
time [s]


Braking no 55
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 55
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]


Braking no 56
hanger link forces [kN]
time [s]
cast 3
cast 4
IB116 5
IB116 6
Braking no 56
hanger link forces [kN]
time [s]
cast 1
cast 2
IB116 7
IB116 8
"Power" Hanger link force x speed [kW]
time [s]
cast 1
cast 2
cast 3
cast 4
IB116 5
IB116 6
IB116 7
IB116 8
speed [m/s]
pressure [bar]
time [s]