COMPANY MAIN TOPIC [PRODUCT]

Rail Power Systems

TracFeed® CATMOS®

English

The validated Simulation Program

Made in Germany

TracFeed® CATMOS®
THE VALIDATED SIMULATION PROGRAM FOR DYNAMIC INTERACTION BETWEEN AN OVERHEAD CONTACT LINE AND PANTOGRAPH

A service from Rail Power Systems for your overhead contact line installation

The European Standard EN 50318:2002

The TracFeed® CATMOS® simulation program has been validated based on the following standard (English title):

EN 50318, Railway applications – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line. EN 50318 was approved on April 1, 2002.

This draft European Standard has been prepared under a mandate given to CENELEC by the European Commission and supports the Interoperability Directive 2008/57/EC. In this context, we explicitly refer to the Technical Specification for Interoperability relating to the energy subsystem (TSI Energy) of rail systems in the European Union. The Technical Specification for Interoperability relating to the energy subsystem was published in the Official Journal of the European Union L 356/179 (2014-12-12).

For the awarding of the EC design examination certificate for interoperable constituents of overhead contact line pursuant to TSI Energy according to module CH or CH1, there must be proof of observance of the criteria for the dynamic interaction between overhead contact line and pantograph (TSI Energy, chapter 6.1.4.1.). As a result, a simulation program is required which is validated pursuant to EN 50318:2002.

Inspection Body TSI

Rail Power System GmbH acts as a Type B inspection body according to EN ISO/IEC 17020. This body works as a subcontractor for the German Notified Body Eisenbahn-CERT and is certified by the same organisation. It performs its inspections according to EU directive 2008/57/EC, whose technical specifications for interoperability applies, among other things, to the interaction between overheard contact lines and pantographs.

Performance features

The optimisation and development of the running characteristics of overhead contact line systems using empirical measurements is very complex, time consuming and limits the number of variations. The results of such studies are also technically and economically unreliable due to the large number of environmental variables (e.g. wind and rain) and the inability to reproduce the effects of these variables.

With the TracFeed® CATMOS® simulation program, a large number of variations can be studied and optimised without excessive time and cost expenditure.

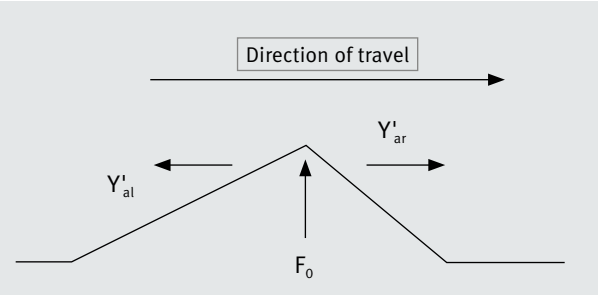
TracFeed® CATMOS® also allows very complex overhead contact line system designs to be studied for up to eight pantographs per train. The key performance features are as follows:

- Simulation of up to ten tension lengths with different tension forces for the catenary and contact wire
- Cross-catenary spans with cross-over rod and transverse stay cables
- Catenaries with stitch wires at supporting points and additional auxiliary catenary wire
- Eight different pantographs per train
- Pantograph models with up to eight degrees of freedom

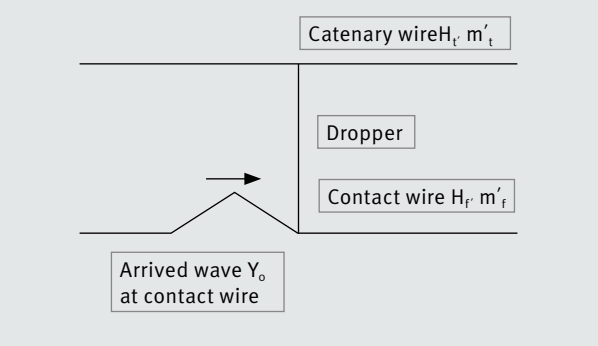
Mathematical base

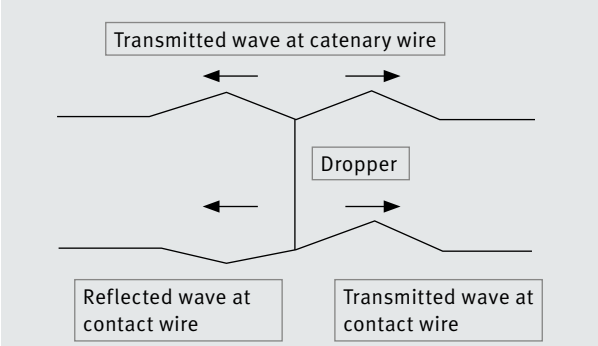
For the simulation of current collection of the overhead system it is necessary to create a mathematical model for the overhead contact line system and the pantographs.

As a result of the upward force of the pantograph, waves are created in the overhead contact line system. The d'Alembert method is used to determine wave travel.



By using this method, excellent simulation results are obtained, in which non-linear characteristics of the catenary, such as buckling of the droppers, is taken into account.





To determine the characteristics of the pantographs, 10 different simulation models are available. These simulation models are made up of discrete masses, springs and dampers. The masses are connected to each other by means of the springs and dampers. Pantographs with up to eight degrees of freedom can be simulated, with the rotational motion of the contact strip caused by the stagger of the contact wire taken into account for these models.

Analysis options

Using TracFeed® CATMOS® simulation techniques, quite extensive evaluation studies can be carried out. Evaluation options include:

- Statistical evaluation of the contact force
- Graphic display of the assembly state, the contact force and the movements of the pantograph
- Graphic display of the movement of selected points on the catenary
- Location and duration of arcing for each contact strip of a pantograph

Application of the simulation program

TracFeed® CATMOS® simulation techniques can be used for the following applications:

- Optimisation/simulation of existing overhead contact line systems
- Development of new overhead contact line systems
- Development/optimisation of special design and modifications to fixed installations
- Study/determination of assembly tolerances
- Increased speed on existing systems by using new pantographs
- Operation with multiple consecutive pantographs
- Development/optimisation of pantographs

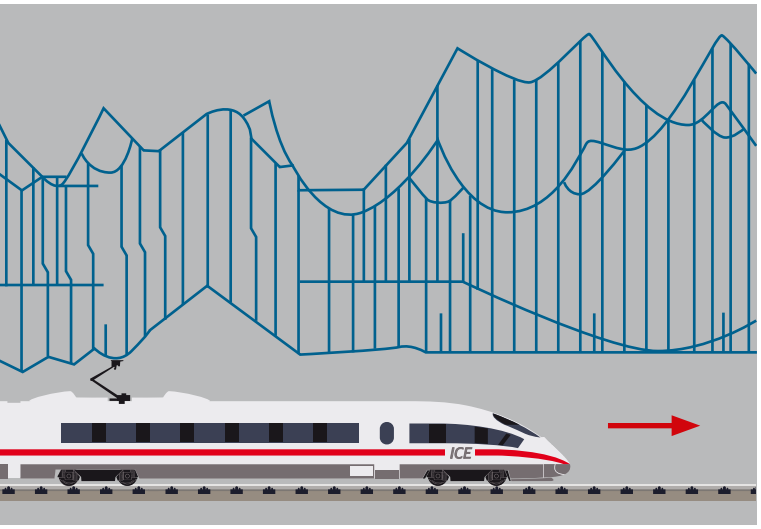
Steps of validation

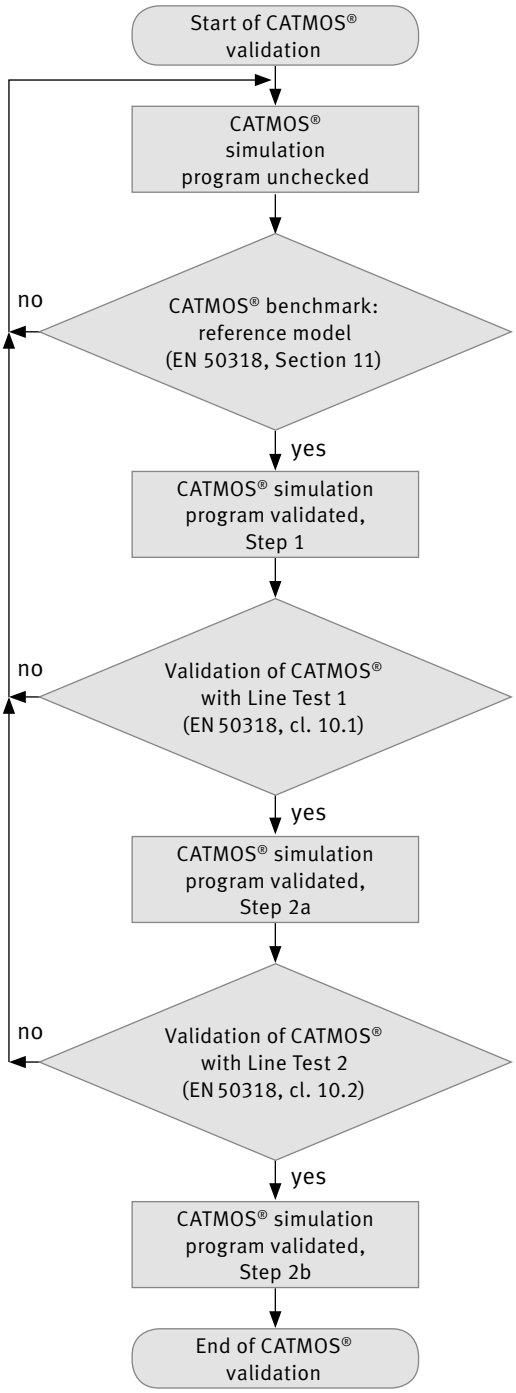
As required by the standard EN 50318:2002, Section 11, the first validation step of the simulation program TracFeed® CATMOS® must be a comparison with a reference model in order to verify the accuracy of the simulation. If the results are within the limit values set forth in EN 50318:2002, Table 2, then the simulation method can be used for the next validation step (comparison with line tests).

The next steps for the validation of the TracFeed® CATMOS® simulation program include the comparison of measuring values resulting from different line tests. For the validation with measuring values pursuant to EN 50318:2002, Section 10, measuring values from line tests must be made available that were determined by pantograph measurement systems according to EN 50317:2002.

For the comparison with Line Test 1, data from a test run on a Spanish high-speed line were made available.

The comparison with line test 2 was performed with data from a test run on a newly built Swiss line.





BENCHMARK WITH REFERENCE MODEL

The following table shows the admissible result ranges according to EN 50318:2002, Table 2, and also the results of the simulation performed by TracFeed® CATMOS®.

The simulation results are within the admissible result range, and thus fulfil the requirements of EN 50318:2002. As a result, the TracFeed® CATMOS® simulation program can be used for the next validation step (comparison with line tests) according to EN 50318:2002, Section 11.1.

Speed	250 km/h			300 km/h		
20 Hz frequency range	Range of results		Simulation	Range of results		Simulation
Medium contact force (Fm)	110 N	120 N	116.3 N	110 N	120 N	113 N
Medium contact force (Fm)	26 N	31 N	27.1 N	32 N	40 N	35 N
Statistical maximum of contact force	190 N	210 N	197.6 N	210 N	230 N	218 N
Statistical minimum of contact force	20 N	40 N	35 N	-5 N	20 N	8 N
Actual maximum of contact force	175 N	210 N	198.9 N	190 N	225 N	217.4 N
Actual minimum of contact force	50 N	75 N	72.2 N	30 N	55 N	37.3 N
Maximum uplift at support	48 mm	55 mm	51 mm	55 mm	65 mm	58 mm
Percentage of loss contact	0 %	0 %	0 %	0 %	0 %	0 %

Test Train of DB Systemtechnik GmbH during a Line Test

VALIDATION WITH MEASURED VALUES

Validation with measuring values requires measuring values from line tests according to EN 50318:2002, Section 10, which were determined with pantograph measurement systems according to EN 50317:2002. Comparison values between line test and simulation are listed below:

- Standard deviation of contact force σ,
- Maximum uplift at the support,
- Range between maximum and minimum vertical displacement of the point of contact.

The admissible deviations of the simulation results from the measuring values are set forth by EN 50318:2002, Table 1.

Comparison with line test 1

The deviations of the calculated and measured values of the contact forces, the uplift at the support point and the displacement at the overhead contact line are within the admissible range according to EN 50318:2002. Thus, in comparison with Line Test 1, the simulation program TracFeed® CATMOS® is validated.

Type of overhead contact line	Re250					Required accuracy as per EN 50318
Type of pantograph	DSA350EU					
Length of analysis section	1 km					
Speed	329.1 km/h					
Comparison with line test 1	Measurement		Simulation			
Pantograph (PA) no.	PA1	Percentage	PA1	Percentage	Deviation	
Standard deviation of contact force (σ)	32.3 N	100 %	30.5 N	94.3 %	- 5.7 %	± 20 %
Maximum uplift at support	5.3 cm	100 %	5.18 cm	98 %	- 2.3 %	± 20 %
Vertical displacement of the point of contact	6.11 cm	100 %	5.23 cm	85.6 %	- 14.4 %	± 20 %

Comparison with line test 2

The deviations of the calculated and measured values of the contact forces, the uplift at the support point and the displacement at the overhead contact line are within the admissible range according to EN 50318:2002. Thus, in comparison with Line Test 2, the simulation program TracFeed® CATMOS® is validated.

Comparison of selected curve progressions

The following graphic comparisons of selected curve progressions are not required by EN 50318:2002, therefore, they do not play any part in the validation of the simulation program TracFeed® CATMOS®. The graphics show the progression of measured and simulated values.

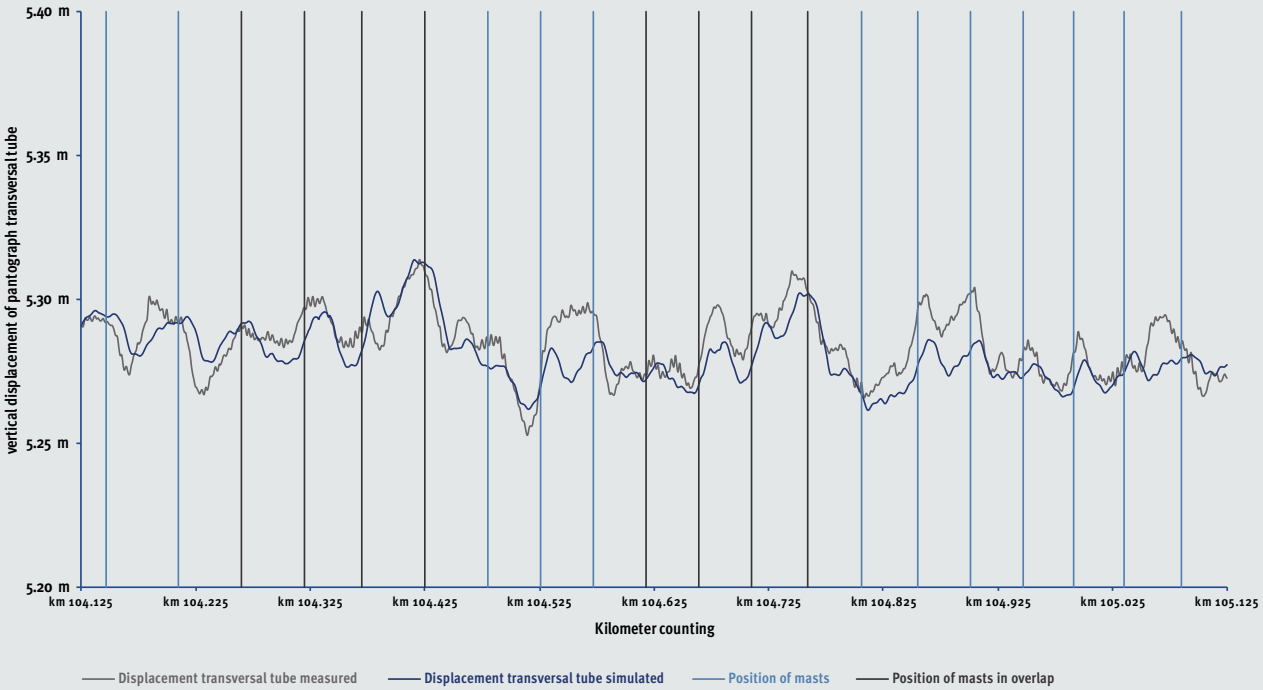
The comparisons of the curve progressions support the validation of the TracFeed® CATMOS® simulation program and demontrate its reliability.

Type of overhead contact line	Fl200T F+F					Required accuracy as per EN 50318
Type of pantograph	WBL85KCRC					
Length of analysis section	1 km					
Speed	220 km/h					
Comparison with line test 2	Measurement		Simulation			
Pantograph (PA) no.	PA1	Percentage	PA1	Percentage	Deviation	
Standard deviation of contact force (σ)	17.6 N	100 %	19.8 N	112.5 %	+ 12.5 %	± 20 %
Maximum uplift at support	9.0 cm	100 %	7.77 cm	86.3 %	- 13.7 %	± 20 %
Vertical displacement of the point of contact	8.5 cm	100 %	6.83 cm	80.4 %	- 19.6 %	± 20 %
Pantograph (PA) no.	PA2		PA2			
Standard deviation of contact force (σ)	26.0 N	100 %	27.6 N	106.2 %	+ 6.2 %	± 20 %
Maximum uplift at support	9.0 cm	100 %	8.21 cm	91.2 %	- 8.8 %	± 20 %
Vertical displacement of the point of contact	8.5 cm	100 %	9.29 cm	109.3 %	+ 9.3 %	± 20 %

The following diagram shows a quality comparison of the measured and simulated vertical displacement of the transverse tube of the pantograph.

Ankara–Konya, Turkey

Re250, DSA380EU, vertical displacement of pantograph transversal tube



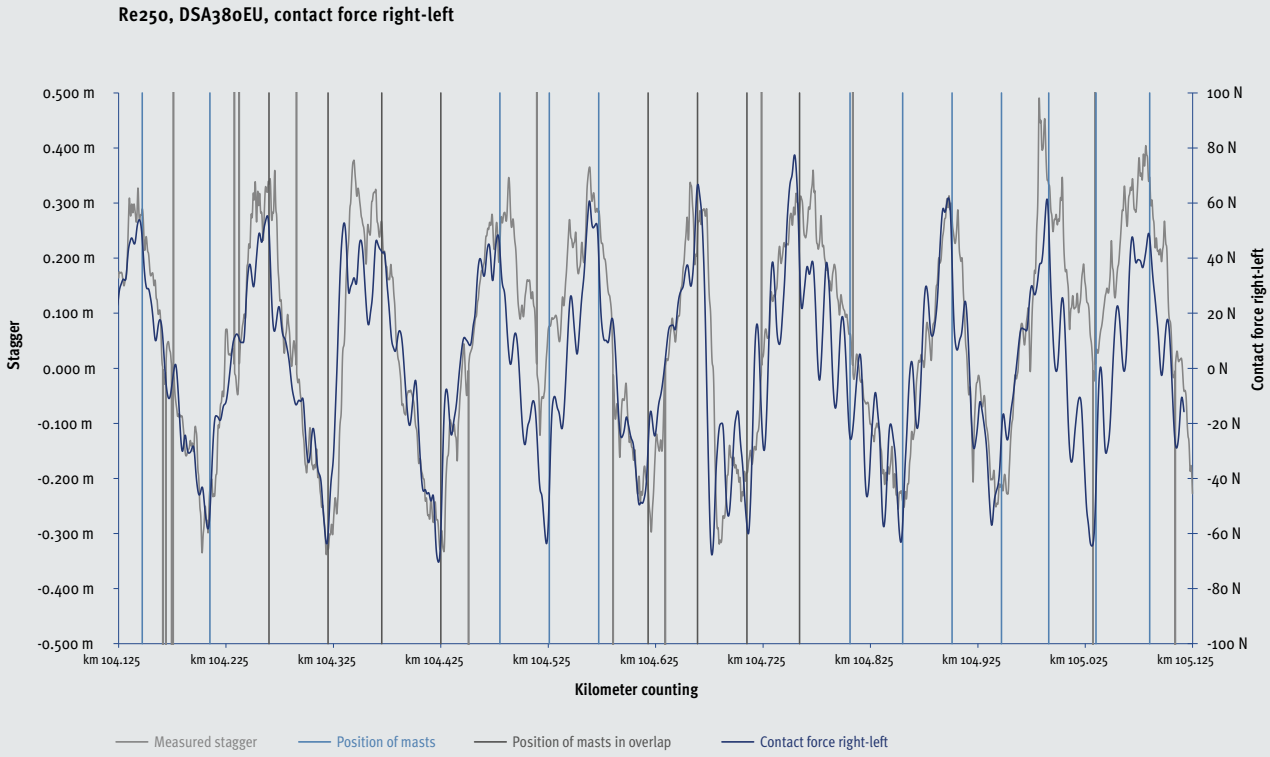
The diagram below shows depicts a quality comparison of the measured contact wire stagger and the simulated progression of the different sums of forces between the left and right load cells of the pantograph. Like the simulation, the pantograph measurement system determines the difference in values between the right and left load cells from the measured values of the individual load cells. First, the measurement setup is calibrated on a test stand. This permits the scaling of the contact wire stagger with one length unit. This is impossible for the simulated curve progression. As a result, this curve requires a second separate scaling of the Y axis.

Both curve progressions match well. For the measured curve, please keep in mind, that the track geometry defect, the lateral rolling of the car body and the pantograph are recorded but will not be corrected by the pantograph measurement system.

Quality system

Rail Power Systems has been certified according to EN ISO 9001:2008. This enables Rail Power Systems GmbH to run a certified quality management system with internal test procedures for sales, distribution of components, development, design, manufacturing and assembly of overhead contact lines and power supply / Railway tracks / net control systems / 50 Hz power supply / signaling including service and maintenance and large-scale projects. The quality management is applied to calculations with the simulation program TracFeed® CATMOS®.

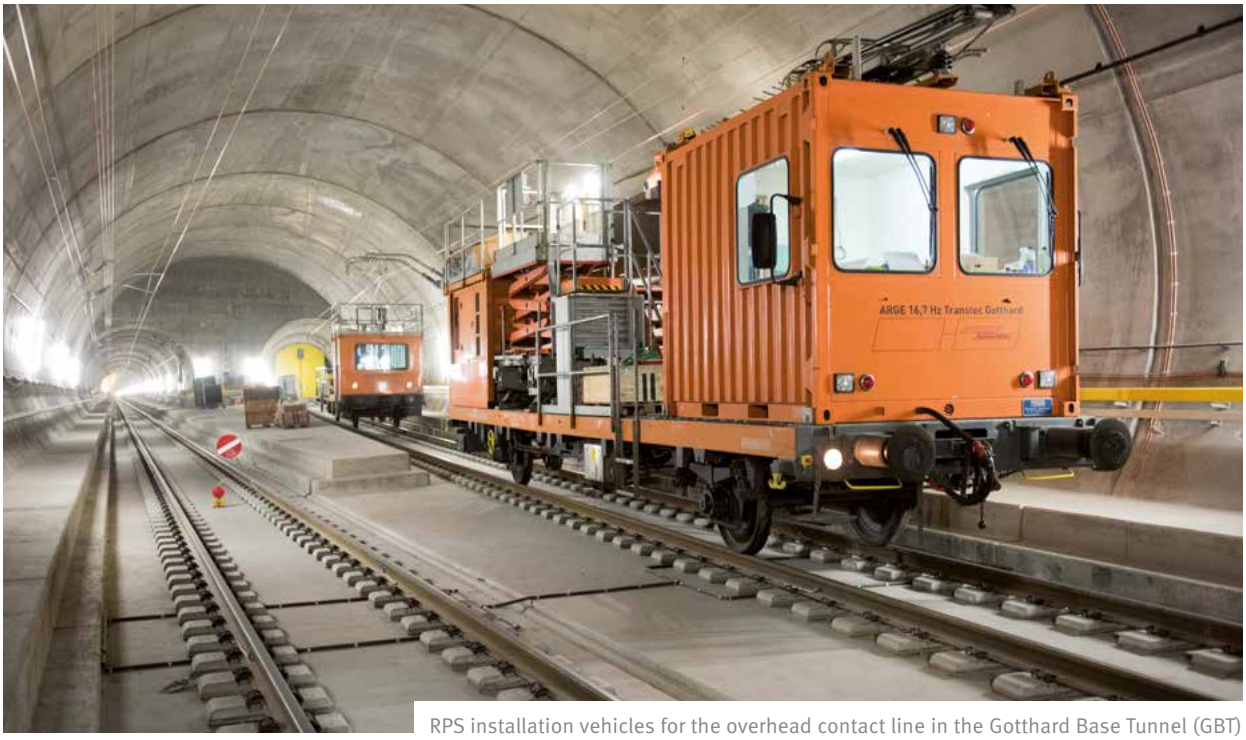
Furthermore, Rail Power Systems GmbH has been certified according to the OHSAS 18001:2007 – Occupational Health and Safety Assessment Series.



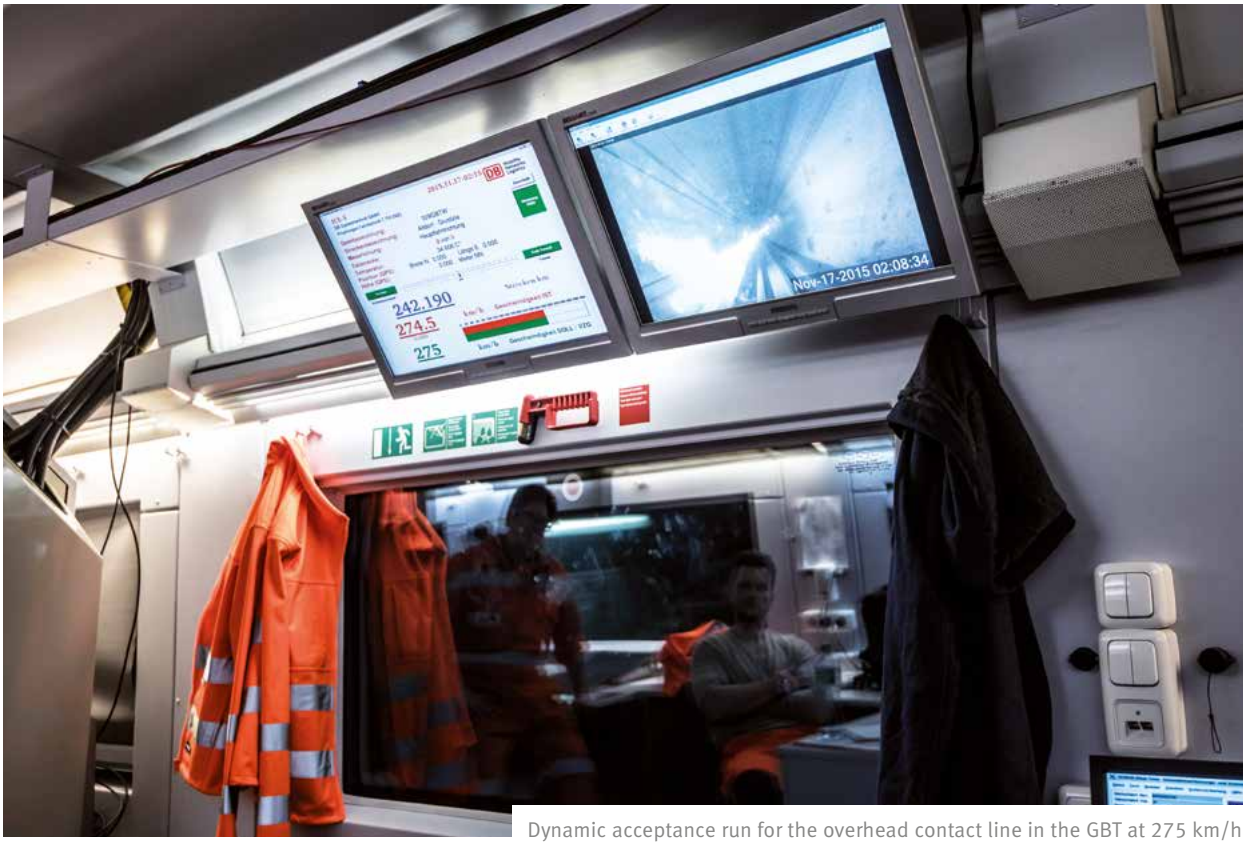
CONCLUSION

The validation of the TracFeed® CATMOS® simulation program was performed according to EN 50318:2002. The general requirements for a simulation program are in compliance with EN 50318:2002, Sections 6 to 9, whch are fulfilled by the TracFeed® CATMOS® simulation program. The required comparisons were completed with the reference model and two different line tests. The results of the simulation calculations for the set comparisons are within the admissible range of deviation according to EN 50318:2002, Tables 1 and 2. The TracFeed® CATMOS® simulation program is capable of providing all output values required by EN 50318:2002, Section 9. As a result, the TracFeed® CATMOS® simulation program is validated for simulations of the dynamic interaction between overhead contact line and pantograph.

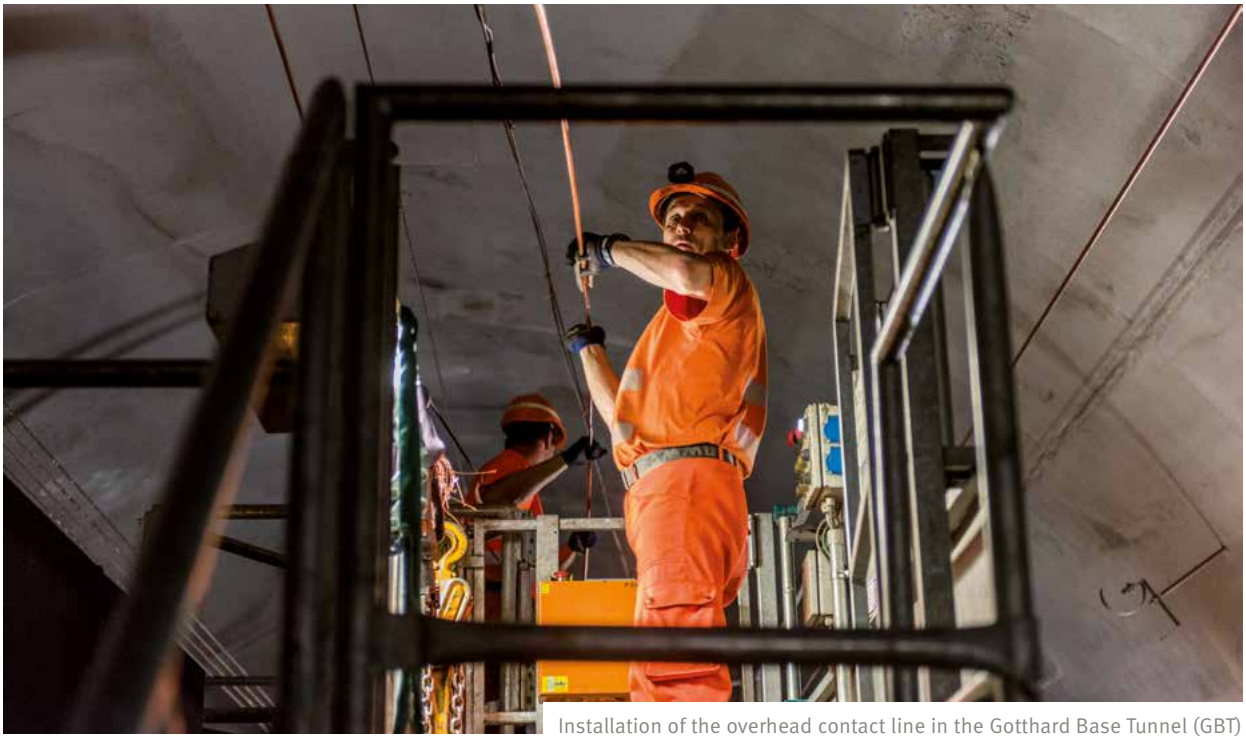
In addition, specific curve progressions selected from measurements from line tests and simulation were compared with the requirements of EN 50318:2002. The result of the visual comparison of curve progressions shows a good match. This verifies the reliability of the TracFeed® CATMOS® simulation program.



RPS installation vehicles for the overhead contact line in the Gotthard Base Tunnel (GBT)



Dynamic acceptance run for the overhead contact line in the GBT at 275 km/h



Installation of the overhead contact line in the Gotthard Base Tunnel (GBT)

RPS/EN/402/0916

The specifications set out in this document apply to popular applications. They do not represent performance limits. This means that divergent specifications may be attained in specific applications. The contractually agreed specifications alone shall apply. We reserve the right to effect technical modifications. TracFeed® and CATMOS® are registered trademarks of Rail Power Systems GmbH.

RAIL POWER SYSTEMS GMBH
Garmischer Straße 35 | 81373 Munich | Germany | T +49 89 41999-0 | F +49 89 41999-270 | info@rail-ps.com | www.rail-ps.com