Dynamic Catenary Monitoring DCM

Furrer+Frey®
Overhead contact lines

Dynamic Catenary Monitoring DCM

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For many decades, the main activities undertaken by Furrer+Frey have been the planning, construction and maintenance of overhead contact lines. Furrer+Frey follows clearly-defined quality assurance procedures. What was missing was an effective tool for checking the overhead contact line on completion of the work. It was only a matter of course, then, that Furrer+Frey should look for ways and means of satisfying both themselves and their customers that the requirements laid down had been met. These considerations led to the development of DCM or Dynamic Catenary Monitoring.

Furrer+Frey saw the increasing need for overhead contact line testing to determine the short, medium and long-term maintenance requirement as a further reason for developing the DCM system. DCM is intended for use by railway companies without their own measuring equipment, irrespective of gauge and operating voltage.

[1] — *DCM container on a Furrer+Frey standard gauge wagon on the BLS rail network*

[2] — *Measuring container on the Furrer+Frey meter gauge wagon in the MGB depot*

[3] — *DCM measuring container in the measurement train on the LGV Rhin-Rhône high-speed line*

References

The DCM measuring system has provided valuable assistance over many years to customers both within and outside Switzerland. These have included:

- The TGV high-speed line between Mulhouse and Dijon incl. 150 km of double track, stations and branch lines on behalf of TSO Caténaire for the French Rail Network (RFF)
- The TGV high-speed ‚Ligne du Haut Bugey' between Bourg-en-Bresse and Bellegarde. The unusual feature in this instance was the simultaneous measurement of a standard catenary system and an overhead conductor rail.
- The below ground station at the new Berlin Brandenburg International airport, completely equipped with overhead conductor rail, on behalf of BBRPS for Deutsche Bahn AG
- The recently installed overhead conductor rail in the Arlberg tunnel, on behalf of HC Electric for Austrian Federal Railways
- The new Engelberg tunnel, equipped with overhead conductor rail, for the Zentralbahn
- Brünig route between Interlaken and Lucerne

In total, approx. 1 340 km of overhead lines have been measured by the DCM system, divided up as follows:

Switzerland:	approx. 280 km
Germany:	approx. 100 km
Austria:	approx. 60 km
France:	approx. 900 km

The measuring container

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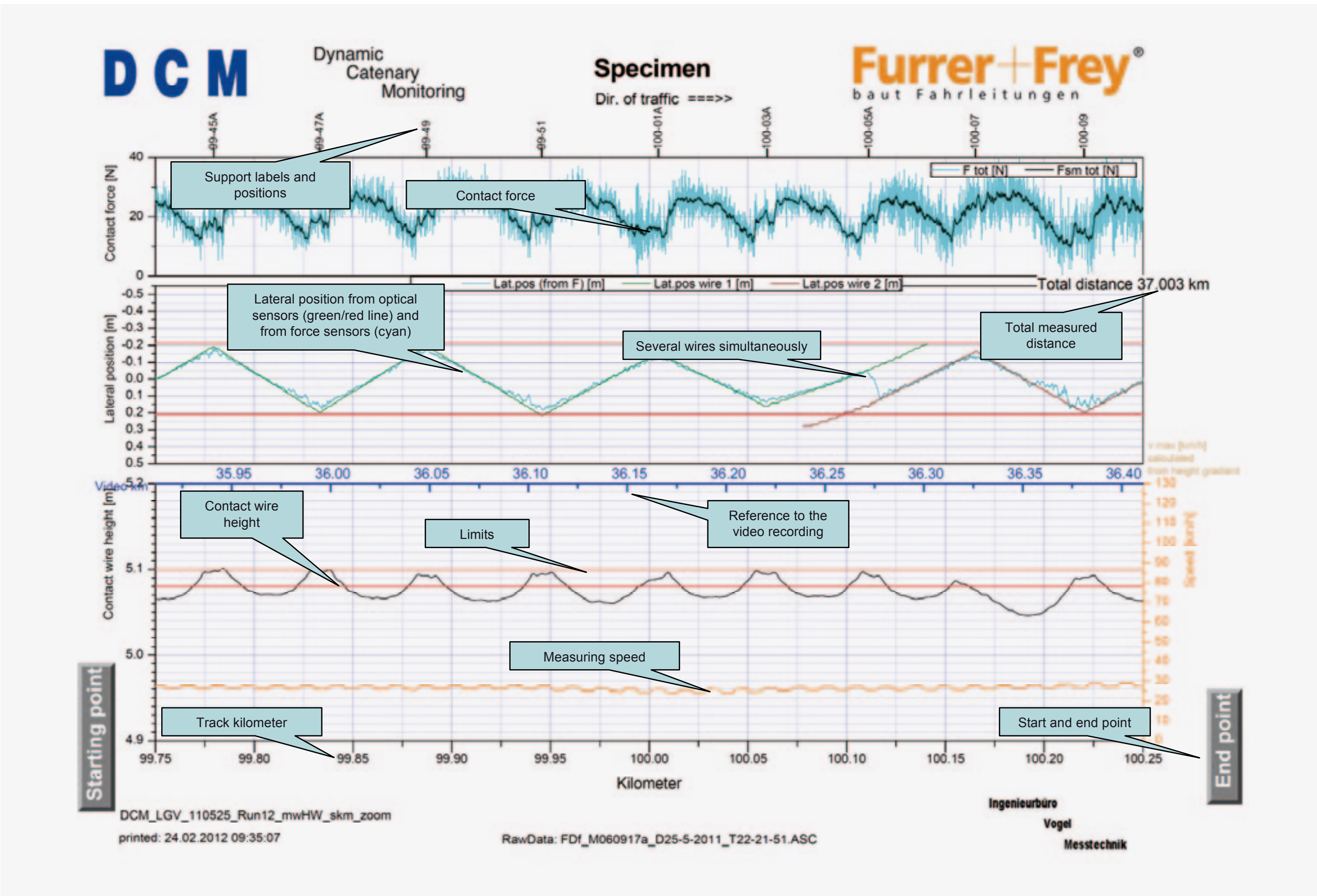

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The one-stop solution for recording overhead line geometry throughout the entire world. The measuring system is installed in a 20' ISO container and can be shipped by seafreight as well as moved by rail or truck to the required location. The system has also been licensed by Deutsche Bahn. The measuring container provides the following facilities:

- Separate measuring and pantograph cells
- 25kV insulation level: Measurements possible on all rail networks while the system is live
- Independent power and compressed air supply
- Heating and air conditioning system

[1] — *DCM container on a Furrer+Frey standard gauge wagon on the BLS rail network*

[2] — *DCM measuring container being loaded onto a customer's wagon at the TGV construction site station on the Rhin-Rhône LGV in Villersexel*

Once arrived at its destination, the measuring system is operational within three hours. Measuring is carried out using a single-arm pantograph (Schunk WBL 85) onto which a range of different pan heads can be installed. During the entire measuring run, the pantograph is filmed using a high-resolution industrial camera. The measurement data superimposed onto the video image allow the measuring run to be followed in real time on the screen in the measuring cell. After the measuring run, the video data can be handed to the customer on a DVD. In addition, a measurement carried out with the measuring container offers the following:

- Adjustable contact strip pressure
- Simultaneous detection of up to 4 contact wires
- Detection of twin contact wire
- Detection of support structures
- Detection of droppers
- Measurement of the contact wire lateral position using optical sensors
- Measurement of the contact wire lateral position using contact force sensors
- Measurement of the contact wire height using a draw wire
- Vehicle movement compensation (only if mounted on F+F's own wagon)

Before every measuring run, the measuring system is calibrated and a precise laser measuring device is used to reference it to a point chosen at will along the section of track. Every change made to the raw data during analysis is automatically recorded.

[3] — *View of the pantograph cell ready for transportation*

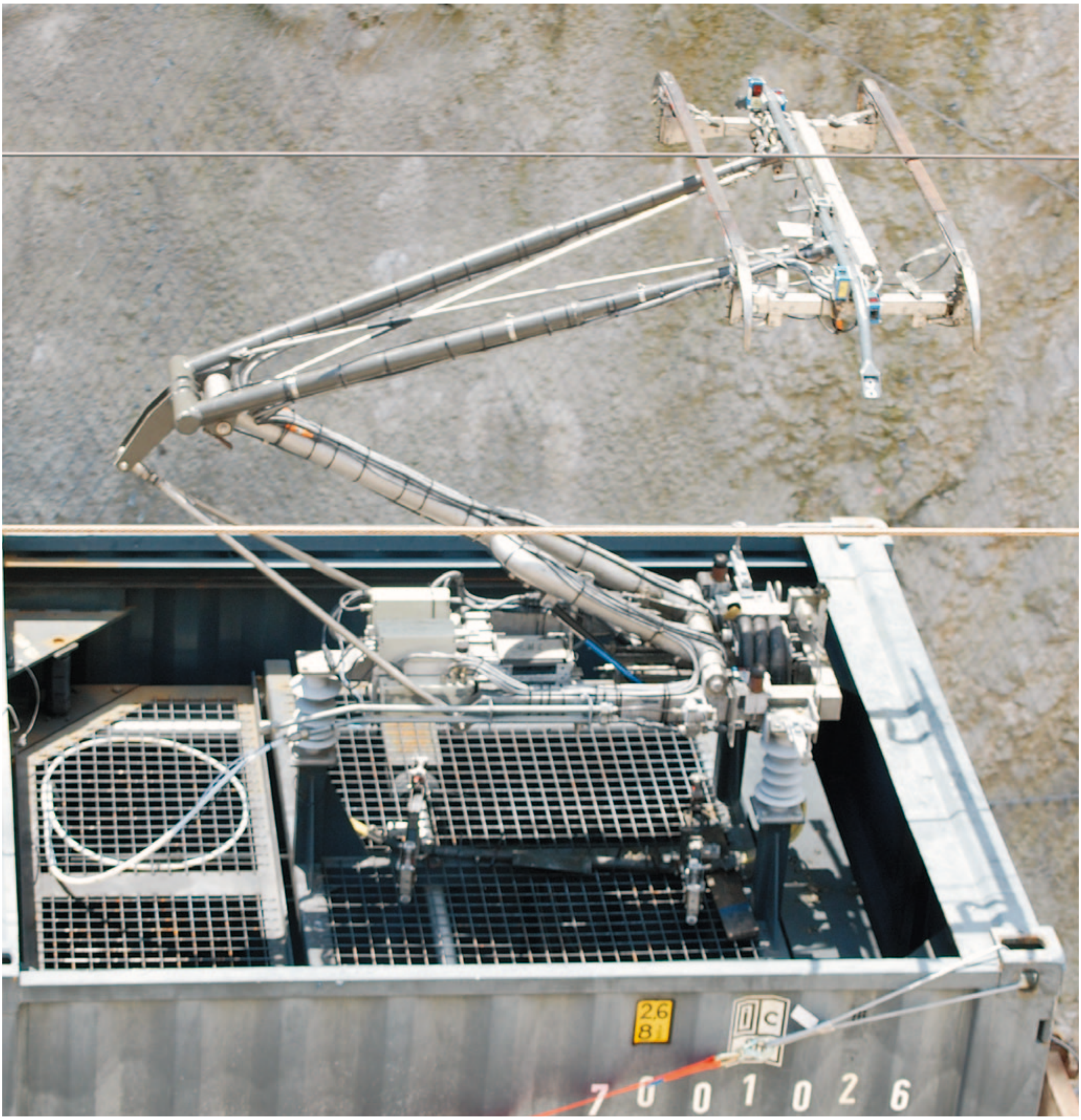
Analysis of the measurements is tailored to individual customers' wishes. Essentially, all the data recorded by the sensors is analysed. The following data can be depicted visually:

- Contact force pattern
- Lateral position, optical
- Lateral position, calculated from the force
- Contact wire height
- Vehicle speed
- Distance measured
- Positions and designations of support structures
- Droppers (position and number)
- Contact wire lift and rest position (two measuring runs at different contact pressures needed)
- GPS data (measuring points can be assigned to GPS points)
- Wind data
- Video kilometres (every measuring point can be uniquely assigned to one place in the video recording)
- Sagging at the centres
- Adherence to the minimum and maximum permissible contact wire height and lateral position
- Inclination in the contact wire rest position
- Inclination at the support points in the rest position
- Deviation of the rest position from the intended connecting line between the support points including pre-sag
- Relative elasticity compared with the adjacent support points

[4] — *Example of measurement graph*

In addition, customers can also be given all the analysed measurement data in the form of a text file (*.txt) or a comma separated value file (*.csv).

How does the DCM measure?



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Contact wire height

The distance between contact wire and the top of the rail is made up of different fixed values and a variable. The fixed values are validated at the start of each measuring assignment and adjusted if necessary. These fixed values are:

- Distance between top of rail and container floor
- Distance between container floor and lifting platform
- Distance between lifting platform and draw wire

As can be seen from the last of the points above, the height of the pantograph itself is measured with a draw wire. The last distance (and thus the only variable during the measuring run) is that between the upper edge of the contact strip and the draw wire sensor.

[1] — *View of the measuring pantograph during the measuring procedure*

Contact wire lateral position

Two different methods are available for determining the contact wire's lateral position; both have their advantages and disadvantages. The methods are:

- Lateral position measurement using force: Force sensors are attached to the left and right on the underside of both contact strips. The position of the contact wire can be calculated from the relationship between the left side and the right side forces and the dimensions of the contact strips.
- Lateral position measurement using optical sensors: An optical sensor unit is mounted between the contact strips to record regular pulses of light emitted by LEDs at approx. 4300 Hz. In this way, the adjoining sensors are also able to record several contact wires simultaneously as long as they are not too close together. This method allows a total of up to 4 wires to be recorded simultaneously.

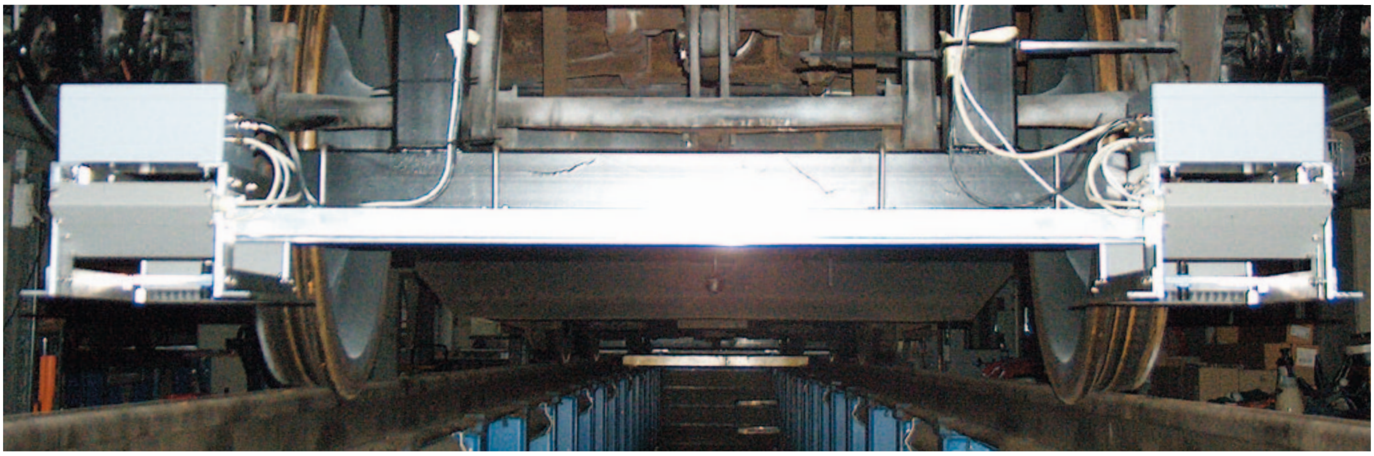
The advantage of force measurement is that contact force can also be measured at the same time; this is an important parameter especially as regards power transmission quality. Furthermore, the contact force allows the force patterns in particular areas such as the approaches to turnouts or when changing between wires to be understood so that any irregularities such as poorly adjusted section insulators and suchlike can be easily detected. However, the main drawback of force measurement is that it is precisely in these areas, where more than just a single wire is close to the contact strip, that the results only show that one wire which exerts a force on the contact strips or, if several wires simultaneously exert a force on the contact strips, then only the average lateral position of the two wires is shown. However, if the force measurement results are combined with the optical measurement results, a picture is obtained, not just of the lateral position patterns (and, in particular, of several wires simultaneously), but it is also possible to detect where the contact transition occurs.

Support structures

Several options are available for detecting support structures (or registration arms); if applied in combination during analysis of the results, they make it possible to determine the positions of all support structures:

- Detection by the optical sensor unit: Since the sensors detect, not just what is in contact with the contact strips, but also everything else up to 10cm above it, a response from all the sensors at a certain point is interpreted as a support structure.
- Detection by laser barriers: In addition to the optical sensor beams, the measuring pantograph has two laser sensors mounted on it (one on the left and one on the right) which point vertically upwards and which, as they pass by a support structure, generate an entry in the results at the appropriate place.
- Detection through the lateral position: During post-processing, in addition to the values above, the software also detects support structures based on the lateral position pattern. In places where the lateral position pattern clearly changes direction due to a support structure, the software automatically detects this for what it is.
- Detection by hand: Since the different types of overhead lines may cause all the above methods to fail, support structures can be inserted manually. This ensures that, in the end, all support structures are included in the results.

How does the DCM measure?



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Droppers

In addition to the laser sensors which point vertically upwards, two other laser sensors which point upwards at an angle are mounted on the measuring pantograph. If a dropper cable passes through this barrier, this is noted in the results. However, since also other overhead line components pass through this barrier (e.g. C-connectors, section insulators, etc.), including dropper data in the analysis is extremely time-consuming and is generally not carried out.

Compensating for wagon movement

In order to compensate for wagon movement which would inevitably produce false readings at high speeds, two of Furrer+Frey's own flat wagons (a standard gauge and a metre gauge flat wagon) have frames attached to their undersides onto which the above measuring equipment can be mounted. The compensation system consists of two spring deflection modules, which use ultrasound to measure the distance between wagon body and axle bearing, and of two rail modules which use a method similar to the optical lateral position measuring method to detect the position of the rail heads. This allows any tilting movement by the wagon as well as the track play to be compensated for in the calculations.

[1] — *The DCM rail measurement modules attached to the Furrer+Frey standard gauge wagon*

Speed and distance

The Furrer+Frey wagon mentioned in the section above is equipped with axle tachometers for measuring the travel signal which is needed to measure speed and distance.
For tasks on which a Furrer+Frey wagon cannot be employed, a radar tachometer, specially developed for rail applications, is available which can be mounted on the customer's wagon without too much difficulty.

[2] — *Measuring container on an RBS metre-gauge wagon*

Measurements

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Static measurement

Static and quasi-static measurements of the geometric situation of the contact wire can be carried out with the measuring container. For these measurements, the container can be mounted on any flat wagon whatsoever. For static measurement at speeds of between 5 km/h and 40 km/h*, the following accuracy can be assured:

- Height: ± 10 mm
- Lateral position: ± 12 mm
- Contact force: ± 2.0 N

* At speeds of between 10 km/h and 40 km/h, the above accuracy can only be maintained if F+F's own wagon is used because it is the only wagon equipped with the wagon movement compensation system. The dynamic measurement tolerances apply to higher speeds.

[1] — *Measuring container measuring the Ligne du Haut Bugey between Bellegarde and Bourg-en-Bresse*

Locomotive-mounted measuring pantograph

The DCM measuring system can also be removed from the measuring container and mounted on a customer's locomotive. However, this requires significantly more installation time and a corresponding degree of planning on site. Possible scenarios in which this might happen are:

- Dynamic measuring to assess power transmission quality (see section below)
- Measurements on routes where the container does not fit within the clearance gauge
- Measurements on tram routes or light urban rail systems

[2] — *BLS locomotive with pantograph modified for the DCM*

[3] — *Pantograph of a BLS locomotive modified for DCM measuring*

Dynamic measuring

The DCM measuring system can also be used to assess the power transmission quality. These measurements are made under operating conditions at line speed and thus at high velocities. If mounted on a customer's locomotive, the measurements can be made at speeds of up to 250 km/h. The pantograph is equipped with wind deflectors in order to correct the difference in contact force caused by the weight of the measuring system itself. The 230V power supply is provided by the locomotive's on-board energy supply which must be able to cover a power requirement of 1.5 kVA.
At speeds of up to 250 km/h, the following accuracy can be achieved:

- Height: ± 12 mm
- Lateral position: ± 18 mm
- Contact force: ± 4.0 N

Dynamic Catenary Monitoring DCM

Your partner for the design, delivery and construction of overhead contact lines.

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