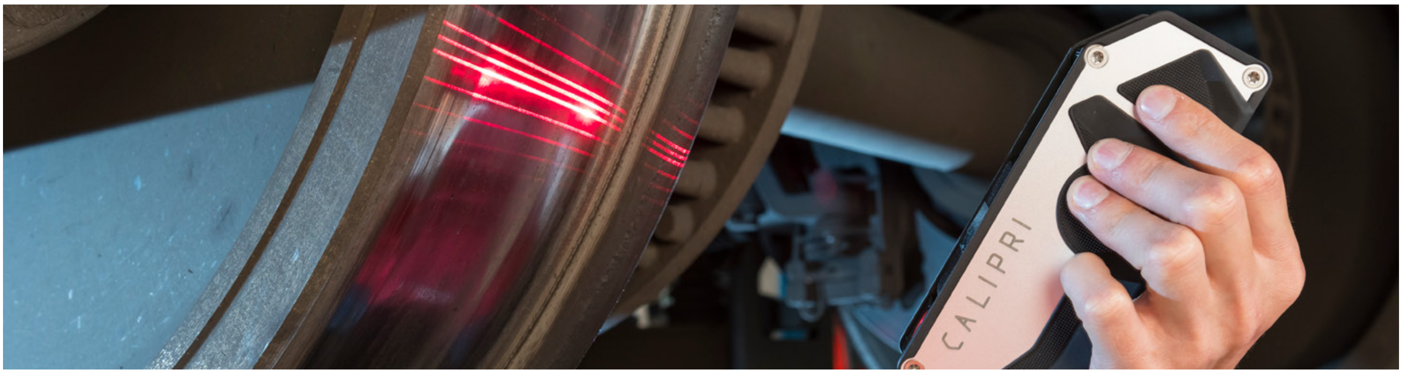
HEXAGON | NEXTSENSE

Equivalent Conicity – Determining One of the Most Important Safety Parameter in Railways



What do rolling stock or infrastructure maintenance engineers have in common with vehicle developers and derailing analysists? They all put a lot of weight on the parameter of equivalent conicity. Because this parameter is so relevant to safety, calculating equivalent conicity is quite complex. A powerful tool enters the game with the CALIPRI measurement module for equivalent conicity.

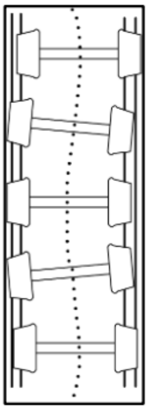
As unpleasant as the thought of a derailed train is, this potential thread is the driving force behind the calculation of equivalent conicity. To understand the parameter and interpret its value, there needs to be a basic understanding of how a train moves.

The Sinusoidal Motion

The train moves in a sinusoidal motion due to two characteristics of the wheel-rail interaction. First of all, the geometry of the wheel is a conical shape, although it is much more complex. As soon as the train is set in motion, this conical-like shape induces a sinusoidal motion pattern as shown in the drawing below.

This motion pattern requires a track gauge that is slightly broader than the back-to-back distance of the wheelsets – otherwise there would be no space for the wheelsets to move left and right. The importance of this way of moving forward becomes significant when thinking about taking a curve. Naturally one wheel – the outer wheel - will have to drive a longer distance, thus having to drive faster than the inner wheel with the shorter distance.

This effect, by the way, also occurs with cars. While a car makes use of the differential to balance the rotational speed of the wheels in a curve, a train makes use of the conical shaped wheels.



SINUSOIDAL MOTION
typical motion pattern

Equivalent Conicity

So, what exactly does the equivalent conicity (EC) parameter tell us? The name itself derives from the geometry of the wheel: the equivalent conicity defines to what extend the motion behaviour of a rail wheel equals a conical shape. In other words, the equivalent conicity tells us how fast the wheels are oscillating with a sinusoidal motion to the side.

As explained in our last article "**The role of the rail in the wheel-rail-interaction**", the touching point between wheel and rail is actually a very small point – in order to avoid too much friction and energy loss during movement. With the sinusoidal motion of the wheels, this touching point moves within a certain area of the wheels surface. Determining this touching point and its area of movement is one key statement of equivalent conicity.

Calculating Equivalent Conicity

The equivalent conicity is a crucial safety parameter and therefore is calculated based on two standards, namely UIC 519 und EN 15302. While calculation methods may vary between measurement systems, the key criteria stated in the norms always need to apply. Contrary to many other measurement systems on the market, the CALIPRI systems use non-linear differential equations instead of regression. Simply because this is more precise.

The underlying formula used in the CALIPRI measurement systems is called Klingel's formula. It describes the frequency with which a train moves left and right. Logically, the swinging frequency should be kept to a minimum. After all, a small frequency is characterised by a steady and stable train movement. Consequently, a low equivalent conicity value is desired. A high value, on the other hand, could indicate the danger of instable movement which in worst case can lead to a derailment. Especially for trains moving at a high speed, equivalent conicity has become a crucial parameter. In practice this means that the parameter can be used to determine a critical speed of a train at any location of a track (curve or straight).

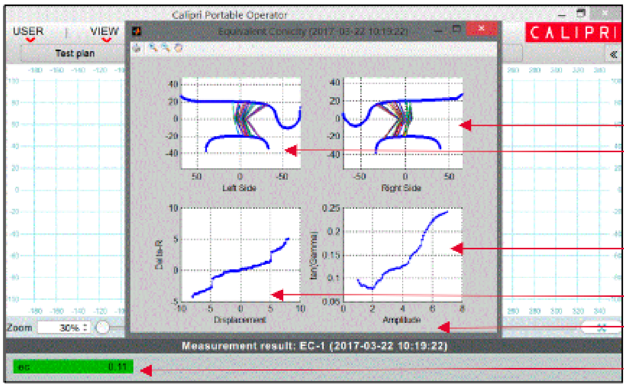
In order to determine the equivalent conicity with the CALIPRI handheld device, key parameters of rolling stock and infrastructure need to be at hand:

- Wheel profile (left and right
- Wheel diameter
- Back-to-back distance of wheels
- Rail profile (left and right)
- Track geometry
- Rail cant

The advantage of the CALIPRI system is that the underlying data can be a combination of currently recorded measurement data, previously collected and stored measurement data or reference data. E.g. a railway engineer in a train workshop can measure all rolling stock parameters and add the standard reference data for infrastructure. The same goes the other way around. It is also possible to work with reference data only, such as vehicle developers might do for example.

Interpreting the Data

Equivalent conicity is a very powerful parameter with a lot of informative value, given the person reading it is able to interpret the data. In general, it is preferable for the EC value to be small but never cross a certain lower threshold, because this again could cause a train to derail. A typical cause of an EC value that is too small would be a hollow tread of the wheel. On the other hand, minimum EC values are required for trains running through curves. The smaller the radii of the curves the higher is the required EC value.



CALIPRI MEASUREMENT MODULE „EQUIVALENTCONICITY"

But equivalent conicity is more than just a value, at least when it comes to the CALIPRI measurement system. Here the EC measurement module adds four graphs to the calculated value, giving extra data to interpret (see figure below).

The upper two graphs visualise the touching points between the wheel and the rail during movement (left graph showing the left wheel, right graph showing the right wheel). The graph in the lower left corner shows the wheel diameter difference between the left and the right wheel during the sinusoidal motion.

When the train stands still and centred within the track, this displacement is zero. The lower right graph puts the calculated EC value in relation to the actual amplitude of the movement within the track. Here the x-axis defines the wheel movement within the track in millimetres and the y-axis is the associated EC value.

A typical movement of the wheels within the track is 3 millimeters. At this Amplitude the according EC value in the figure below (green field) is is 0.11. Interpreting this value means: A wheel that moves about 3 millimeters left and right, equals a conical shape with an angle of tan(Gamma) = 0.11.

Conclusion

Whether operators work in infrastructure, rolling stock, vehicle development or as derailing analysts, the CALIPRI measurement module 'Equivalent Conicity' offers highly precise results for in-depth analysis of this crucial safety parameter.

e: sales@nextsense-worldwide.com
p: +43 316 23 24 00 - 0
w: nextsense-worldwide.com

Video: CALIPRI C42 Equivalent Conicity