UIC B 126/RP 43 (February 2013)

BRAKING QUESTIONS

Synthesis paper on the EuropeTrain operation with LL brake blocks - Final Report

- Management Summary -

INTERNATIONAL UNION
OF RAILWAYS

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Summary of conclusions

After over one year of preparation, the EuropeTrain project began in December 2010. After almost two years of service across Europe, operations came to an end in September 2012 with over 200,000 km mileage from 16 train runs. Final static and in line measurements for defining the running stability of some wagons were made up until the end of November 2012. This report summarizes the most important results in relation to the initial EuropeTrain objectives, which were

1. … to serve as a tool to accelerate finding a solution to the problem of falling equivalent conicity by:
   - validating the influence of a new block shape or block position on equivalent conicity, proposed by the “Study on Equivalent Conicity” group (UIC working group B 126.13C),
   - improving insight into equivalent conicity limit values and effects on running behaviour (UIC SET 4/TTI)

and

1. … to gather high quality field data on block and wheel wear with LL blocks (LCC) over the short term.

Train operation

The train operation was organised on the basis of 5 different Loops with very different climatic, topographic and operational conditions. Each Loop was covered at least twice. Severe winter and summer conditions were included, as were steep gradients and flat country.

Results demonstrated that the load for the brake system varied broadly through the different runs (energy input was different by about a factor of 5 between runs). The following figure shows some examples. As a result both block and wheel wear depend strongly on the load spectrum of the wagon in the different runs (i.e. topography, operations, loading status, design of the wagon, braked weight).

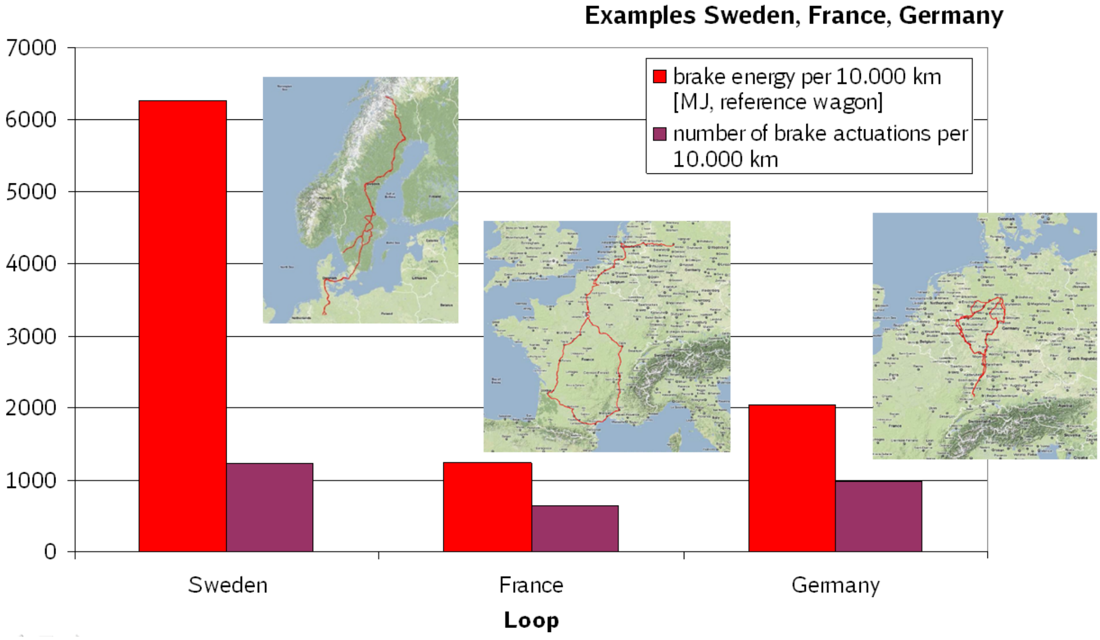

Figure 1: Different load spectra in Sweden, France and Germany (exemplary)

Validating the effect of a new block shape or block position on equivalent conicity

No significant influence of block shape on EC or on wheel wear patterns was observed. On Hbbilns wagons the brake block bedding-in period was found to be quite short in the test. After the first run, the profiles of the normal and machined brake blocks were already quite comparable and adapted to the wheel profile.

The EuropeTrain project did not reveal any significant influence on EC by modifying block position, both for C952-1 and for IB116* LL-brake blocks. Limited signs showed that inwardly displacing LL-blocks could produce some beneficial effect. The UIC B 126.13C working group therefore aims to perform further studies on EuropeTrain wheels (non-destructive and destructive investigations) to determine if sounder statistically based conclusions can be drawn about any potential small effect which may then be optimised. Results of this investigation will be reported in the final report of the UIC B 126.13C project. Based on the current insights it is clear that the use of inwardly displaced blocks will not be a solution for reasonable reduction in inspection and/or reprofiling intervals.

Development of equivalent conicity

Despite being unable to obtain evidence about the influence of the new block shape or position, EuropeTrain provided excellent insight into how equivalent conicity develops under the given test conditions. A reduction in nominal flange thickness, to obtain a wheel profile with a flange thickness less or equal to 30.5 mm (as it was already foreseen as a mandatory requirement in the Usage guideline) is important for successful operations with LL-blocks. All the following conclusions are drawn on this basis.

Figure 2 shows the overall development of equivalent conicity with IB116* and C952-1 in comparison with cast iron:

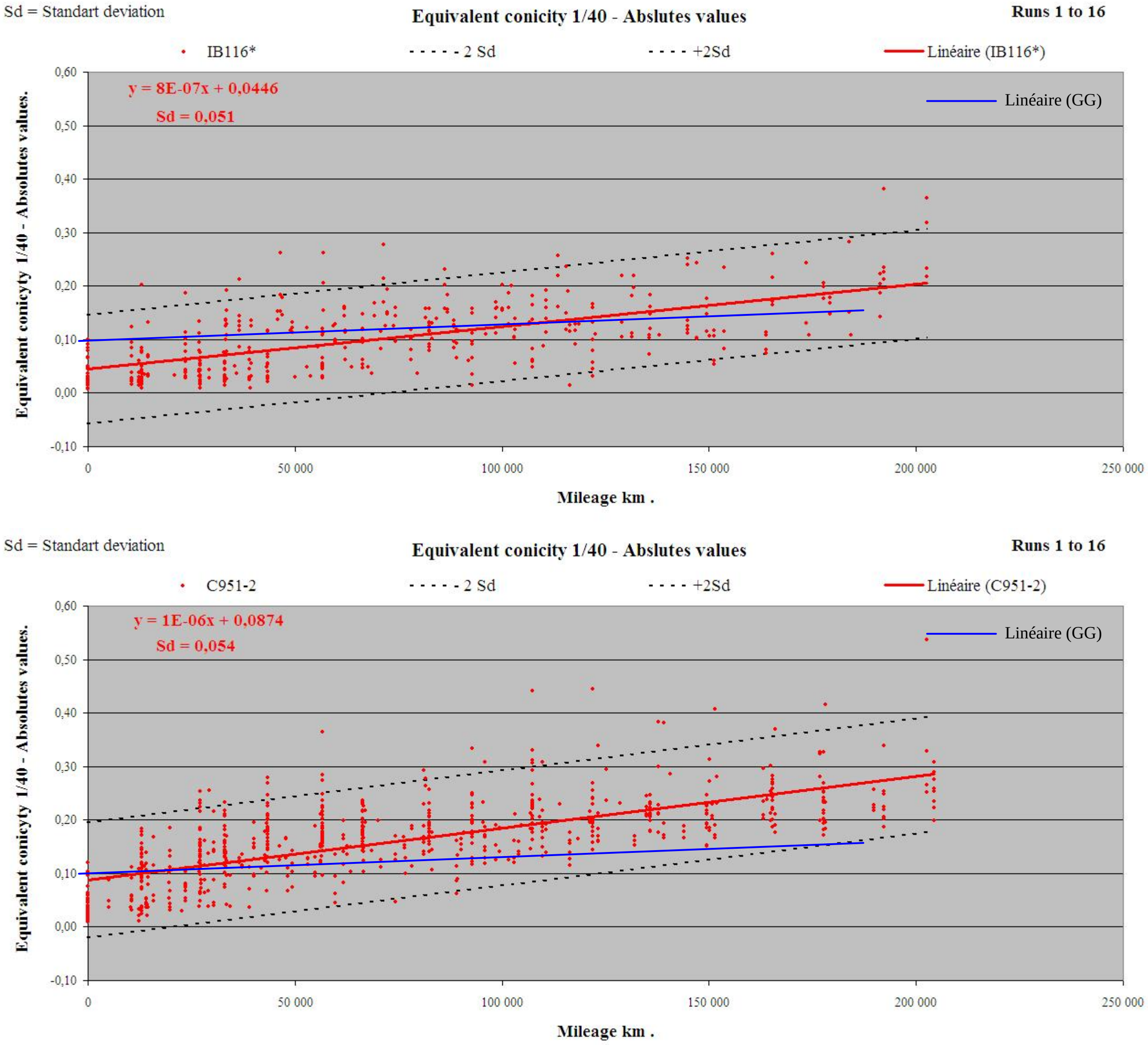

Figure 2: Overall development of equivalent conicity with IB116* and C952-1 compared to cast iron

The following observations can be derived from this analysis:

- Wagon type, loading history and specific conditions of each run had a significant influence on wheel wear and equivalent conicity.
- The P10 cast iron blocks produced the smallest increase in equivalent conicity per 100,000 km and appeared to be very “stable” (low dispersion, no important increase in a short mileage). With high mileage (> 100,000 km), there was almost no further increase in equivalent conicity. It seems that the evolution of equivalent conicity is an asymptote.
- The C952-1 blocks produce a faster increase in equivalent conicity than P10 cast iron blocks. The increase appears to be predictable with low dispersion between sequential measurements and different wagons. The increase of equivalent conicity remains linear, even for high mileage (no asymptote).
- On average, the use of IB116* blocks results in equivalent conicity growing somewhat faster than with P10 blocks but more slowly than with C952-1 blocks. The increase in equivalent conicity remains linear, even for high mileage (no asymptote). However the behaviour of wagons with IB116* is sometimes less predictable with high changes between sequential measurements and different wagons in some cases.

Since monitoring equivalent conicity would be very complicated and costly if part of normal operational inspections, a more practical parameter needed to be found. One possibility was general wheel wear measured through an increase in flange height. Since LL brake blocks induce higher wheel wear, monitoring flange height could also be useful for avoiding high equivalent conicity.

Even though the direct linear correlation between equivalent conicity and wheel wear shows a certain spread, EuropeTrain data clearly shows that the maximum equivalent conicity during the operation (mostly less than 0.4) corresponds with maximum wheel wear (less than 4 mm). So monitoring flange height can indeed serve as a suitable alternative to determine high equivalent conicity.

Another alternative could be to use hollow wear/ false flanges as an indicator for high equivalent conicities. Even though the overall values of hollow wear were very low during EuropeTrain operations, it can be seen that in some cases high equivalent conicity occurs along with false flanges. This means that these cases can be detected by measuring the false flange. Especially when a maximum false flange of 0.5 or 1.0 mm is used as a criterion (instead of today’s 2 mm; still needs to be checked for practicality in normal operation), wheelsets with high equivalent conicity can be detected – without the risk that wheelsets with low equivalent conicity being incorrectly rejected.

Conclusions of UIC Leaflet 518 tests and continuous datalogger measurements

The qualitative link between equivalent conicity and running stability reveals a decrease in stability when equivalent conicity increases. The quantitative link between EC and stability is not so well known, as stability is driven by plenty of other characteristics:

- bogie and suspension characteristics. The influence of this is emphasised by the fact that freight wagons have a large number of dispersions in these parameters, such as friction coefficient, spring heights, geometry of elements;
- loading of the wagon;
- adhesion coefficient between rail and wheel.

One of the main objectives of the EuropeTrain is to improve the knowledge of this quantitative link.

It can be determined that:

- equivalent conicity of 0.2 appears to be common on a rail inclination of 1/40 and this doesn't lead to freight wagon instability;
- the stability measurements during the runs and in the UIC Leaflet 518 tests showed that wagons with higher equivalent conicity show a different and undesirable running behaviour to that known from the existing in service behaviour (hunting behaviour with very high acceleration). However records showed that UIC Leaflet 518 safety limits were not exceeded when equivalent conicity was lower than 0.4 in association with running gear able to operate at 120 km/h;
- comparison of the running stability during runs with running stability during UIC Leaflet 518 tests has shown that (for the same wagon) the measured acceleration level during runs is lower than during the UIC Leaflet 518 tests. This proves that UIC Leaflet 518 tests have been able to simulate worst case conditions.

It is expected that different kinds of vehicles will have different levels of acceptable EC to ensure safe running behaviour.

Results of the first three UIC Leaflet 518 running tests (including all different wagon types used in the EuropeTrain) demonstrate, in sum, that the running behaviour of all tested wagons based on the existing contact conditions, comply with the safety limit values specified in UIC Leaflet 518 up to the maximum test speed of 120 km/h which means safety for running to an operating speed of v_{max} = 110 km/h (test speed - 10 %).

The results of the fourth UIC Leaflet 518 stability test show that the running behaviour of the tested wagon types Eas and Remms based on the existing contact conditions comply with the safety limit values specified in UIC Leaflet 518 up to a maximum operating speed of v_{max} = 120 km/h (test speed 132 km/h).

If the equivalent conicity is higher than 0.4 (real measured wheel profile linked with the theoretical rail UIC 60E1 with 1:40 inclination and a gauge of 1,435 mm) the measured acceleration levels are exceeding the accepted limit of the UIC Leaflet 518 in some parts of the line. The combination of worn wheels and worn rails results in principle in higher real equivalent conicity – partly higher than 0.8 in some sections depending on the track conditions.

It can be concluded for all EuropeTrain wagons, that an equivalent conicity of 0.4 (real measured wheel profile linked with the theoretical rail UIC 60E1 with 1:40 inclination and a gauge of 1,435 mm) is dynamically safe for an operating speed of 100 km/h. Safety is also proven for an operating speed of 120 km/h except for wagons with a bogie type Y25 with non-suspended side bearers.

Block and wheel wear

To fulfil the second main goal – gather high quality field data on block and wheel wear with LL blocks (LCC) in the short term and of high quality – brake block and wheel wear were monitored very closely throughout the project. Even though LCC is not defined precisely in this report, a large volume of data was collected which may serve as a very good basis for further LCC analyses.

Comment from SNCF and DB: Such assessment should be done and agreed inside UIC before summer 2013, as it is an important element for the viability of freight traffic in all Europe (to be ready for the study, EC will launch pretty soon this year).

The following observations can be made after analysis of results:

- Block wear in general was influenced mainly by the homogenous nature of the train (i.e. mix of cast iron and composite brake blocks).
- Both block and wheel wear depended strongly on the load spectrum of the wagon in the different runs (i.e. topography, loading status, design of the wagon, braked weight).
- The averaged overall block wear rates (empty and loaded, data from all runs and 204,000 km) are shown in Table 1.

Block wear rate [mm/10,000 km] and in % to CI							
CI empty	**CI loaded**	**C952-1 empty**	**C952-1 loaded**	**IB116* empty**	**IB116* loaded**	**IB116*-Combi empty**	**IB116*-Combi loaded**
2.14	8.00	0.82	1.70	1.31	4.11	0.86	4.92
100 %	100 %	38 %	21 %	61 %	51 %	40 %	62 %

Table 1 - Averaged overall brake block wear rates of EuropeTrain operation

- LL-blocks wear less than cast iron blocks. The sintered block C952-1 under loaded conditions only haad 21 % of cast iron block wear, whereas IB116* had 51 %.
- EuropeTrain data will be analysed further to produce more accurate calculations of block wear, corresponding to the different operator operating conditions, consequently, each operator will be able to adapt the data to their specific traffic needs and calculate their specific special LCC.
- The main parameters influencing the LCC of wheelsets are the wheel (tread) wear (caused by rolling contact between wheel/rail and by the application of the brakes), the reprofiling interval and the removal of wheel material due to the reprofiling process (cutting depth)
- The use of LL-blocks increases wheel wear rate. Wear rate strongly depends on the loading conditions of the wagon and varies strongly between runs and wagon type. The main wear rates determined over the whole duration of the project, expressed as change in flange height (ΔSh) are:

Wheel wear rate (ΔSh) [mm/100,000 km] and in % to CI							
CI empty	**CI loaded**	**C952-1 empty**	**C952-1 loaded**	**IB116* empty**	**IB116* loaded**	**IB116*-Combi empty**	**IB116*-Combi loaded**
0.7 100 %	**0.9 100 %**	**0.8 109 %**	**2.2 237 %**	**0.8 109 %**	**1.8 194 %**	**1.0 143 %**	**2.5 260 %**

Table 2 - Averaged overall wheel wear rates of EuropeTrain operation

- The average wheel wear (ΔSh) rate for all brake blocks and all loading condition was 1.35 mm / 100,000 km.
- Reprofiling intervals will differ for each brake block material and set of service conditions. In comparison with cast iron brake blocks in general a medial reduction of the reprofiling interval is expected, a detailed forecast is not possible. Based on the wheel wear rate a reprofiling interval for LL blocks of between 150,000 and 250,000 km is realistic.

- The average change in flange thickness for the different brake block types differed only marginally. All brake blocks, except C952-1, showed similar behaviour like cast iron brake blocks with a slight decrease in flange thickness. Based on these results the cutting depth during reprofiling will be on a comparable level. For C952-1 the cutting depth could be a little lower.

In sum, EuropeTrain data may serve as a basis for extending today's very restrictive inspection limit value of 0.23 and inspection intervals of 50,000/25,000 km.

Based on the results of EuropeTrain the project team will issue a proposal for the revision of the “Usage guideline for composite (LL) brake blocks” regarding wheel profile as an input into the UIC decision process within SET07 (Brakes), SET06 (Wheelsets), TTI-Group (Equivalent conicity) and the Rail System Forum (RSF).

Given the lack of data from this project for IB116*-Combi block material and the small noise abatement potential of below 10 dB(A), the project team decided to make its recommendation regarding the revision of the usage guidelines only for the two products tested intensively in the EuropeTrain:

C952-1 and IB116*