CER/EIM Position Paper
“Ballast Pick-up due to Aerodynamic Effects”

October 2015

Version 1.0

Introduction

Aerodynamic loads on the trackbed generated by the passing of trains at high speed may cause individual pieces of ballast to move and rise. While the kinetic energy transmitted to the individual pieces of ballast in this way is in itself low, it may cause the ballast to rise and collide with the rolling stock. These collisions can give rise to two undesirable consequences: damage to rolling stock and stones being thrown away from the track like projectiles. Therefore, the ballast pick-up phenomenon needs to be controlled in order to prevent these incidents, which occur at high speeds in some cases.

Detection and reporting of the phenomenon of ballast pick-up due to aerodynamic effects is relatively new since the deployment of the high speed railways in Europe is currently ongoing and the experience of operation at speeds above 250 km/h is only around thirty year. That is why the interface between the rolling stock and infrastructure in this respect is not fully covered by a commonly accepted standard throughout Europe.

In order to deal with this situation, there is a need to focus on two different open points. Each of these points should be independently applied in the respective subsystem at a distinct speed: in the INF TSI for line speeds of 200 km/h or greater, and its counterpart in the LOC&PAS TSI, which applies to units with design speeds greater than or equal to 190 km/h. The establishment of these open points implies that this phenomenon must be covered by national rules. At present, every Member State where trains may run at speeds over 190 km/h is tackling this issue according to their own criteria and safety is guaranteed for all at the current operational speeds. However, a technical harmonisation in this regard is just a matter of time.

It should be mentioned that there exist other factors that may cause ballast pick-up problems, e.g. snow and ice falling from train, which may also occur at speeds below 200 km/h. However, ballast pick-up due to factors other than aerodynamic effects will not be dealt with in this document.

This document sets out EIM's and CER's views that some principles should be respected in the regulatory treatment of this phenomenon.

Current status of standardisation

At the moment, rolling stock is the subsystem for which most progress has been made in order to set a standard to control the phenomenon of ballast pick-up. Annex A of EN 14067-4:2013 contains a procedure for full-scale tests regarding train-induced airflow on the track bed. Although, limit values and acceptance criteria for these tests are not defined.

Revision of the series EN 14067 follows the principle that rolling stock must be assessed according to its own aerodynamic parameters and regardless of infrastructure dependent phenomena.

EIM and CER are not against this approach, which facilitates the definition of repeatable conditions for the assessment of rolling stock within a single pre-established environment, providing that testing developed in this way allows for putting in place of controls that ensure safe and uneventful running of trains under all foreseeable operational conditions on real infrastructure.

Probabilistic approaches to the phenomenon

Movement of individual pieces of ballast on the track bed can be observed during the passage of trains under certain conditions at speeds as low as 200 km/h. Nevertheless, these movements along the track bed need to be wide enough in order to cause the ballast to rise. Additionally, the lifting of individual pieces of ballast does not always result in collisions as this requires a minimum height in order to reach the train. Hence, these collisions have been found to begin to occur at speeds of 250 km/h or greater. Furthermore, the collisions have no serious consequences in the vast majority of cases. Therefore, any approach to predict and control the phenomenon of ballast pick-up together with its effects will have a high degree of uncertainty. Probabilistic models are thus highly appropriate.

It is EIM and CER’s view that the consequences of impacts due to ballast pick-up have to be considered in the context of practical operational experience. It would be irrational to apply a speed restriction in order to eliminate or reduce the level of ballast pick-up. The reduction of the incident rate of impacts of ballast pieces until making them rare events seems a much more rational target rather than considering them as totally unacceptable incidents.

State of the art for infrastructure: mitigation measures

The primary control method to mitigate against ballast pick-up is by the rolling stock having suitable aerodynamic characteristics.

Notwithstanding the different approaches to cover the existing open point within each Member State, many common criteria can be seen given the limited flexibility to implement design modifications on infrastructure. The long lifespan of infrastructure elements and the high costs involved make the implementation of drastic changes, which would require tens of years in order to be effectively put in place, unrealistic. The most effective way to tackle this issue from the infrastructure side is the adoption of specific maintenance measures, which in most cases consist of lowering the ballast layer between the rails by 3-4 cm with respect to the top of the monoblock sleepers. This measure can also be easily implemented at the construction stage. The lowering of the ballast layer on tracks equipped with monoblock concrete sleepers remains a difficult maintenance task. Therefore, we consider that this debasement action should remain a recommended, rather than a mandatory prescription.

For tracks with bi-block sleepers, gluing ballast appears to be the best method of preventing this phenomenon when usual maintenance procedures are not sufficient.

If necessary the surrounding area of the track can be protected from projectile ballast, for example by using fencing in certain sensitive areas such as railway bridges crossing motorway or at stations.

It is worth mentioning that issues related to the phenomenon of ballast pick-up due to aerodynamic effects are rarely reported and thus it is the view of EIM and CER that the validity of the currently implemented maintenance measures should be regarded as proven by experience.

Additionally, incidents due to these phenomena in many cases involve inadequate maintenance. Ballast pick-up problems may be caused by stacking of ballast in certain points or holding of ballast on the top of sleepers due to an inadequate profiling of the ballast layer.

Special care is to be taken to avoid either stacking of ballast at any point along the track bed or holding of ballast on the top of sleepers. Both failures to fulfill the usual maintenance procedures of the IMs may cause issues related to the phenomenon of ballast pick-up at speeds below what are typical of high speed lines.

Conclusion

Specific measures in order to control the phenomenon of ballast pick-up are applied in every member state operating trains at high speed. It is EIM and CER's position that the experience obtained from operation all over Europe should be taken into account when laying down the specifications to control the phenomenon of ballast pick-up. Otherwise, the IMs would be forced to modify measures that have already been successfully implemented, assuming both the risks and the costs involved.

Hitherto, important improvements have been made to all the subsystems concerned. For infrastructure, specific maintenance measures as previously explained are in place in order to mitigate this phenomenon.

For rolling stock, manufacturers have made a great effort to enhance the aerodynamics of the undersides of trains despite the rest of the design constraints for running gears, braking systems, etc. It is important to note that a smooth underside profile of the vehicle body is not only essential for reducing ballast pick-up but also for minimising energy consumption due to the lesser resistance to motion. Thus, train underside aerodynamics is relevant for the overall performance of the rail system.

The above explained approach can be summed up into the following proposals:

The current sharing of responsibilities between subsystems in order to control the phenomenon of ballast pick-up should be respected. The authorisation of trains with a worse performance than those currently operating would imply breaking the current balance that ensures safety. In this state of affairs, innovation should be used in order to achieve a better functioning of the whole rail system and current performance should be regarded as a minimum since it has been proven to be attainable. In this respect, it must not be forgotten that trains designed for speeds over 300 km/h are currently operating at maximum speeds of around 300 km/h. More controls may be required in order to cover the operation of the aforementioned rolling stock at its maximum velocity given the high impact of speed on the phenomenon of ballast pick-up.

Proposal 1 – ROLLING STOCK

A reference limit for aerodynamic effects regarding the phenomenon of ballast pick-up should be established for rolling stock. Characteristic Reference Wind Curves as set out in the LOC&PAS TSI can be taken as an example of a similar procedure that can be successfully applied in issues related to aerodynamic effects.

New vehicles that do not fulfil this criterion should not be authorised.

The validity of the measures currently being applied in order to control the phenomenon of ballast pick-up should be recognised in order to avoid the risks associated in changing what is successfully working. Regulatory treatment of this phenomenon should take into account the existing constraints in order to develop and, especially, apply design modifications on infrastructure. It makes no sense to test the aerodynamic performance of a track design when there is no possibility to modify its essential features. Rolling stock should be tested in such a way that its ability to run safely and uneventfully on real infrastructure is proven.

The validity of the usual maintenance procedures of the IMs is proven for speeds up to 250 km/h.

Proposal 2 - INFRASTRUCTURE

No requirement is needed for infrastructure for speeds up to 250 km/h in order to control the phenomenon of ballast pick-up due to aerodynamic effects.

Measures currently applied on infrastructure in order to control the phenomenon of ballast pick-up due to aerodynamic effects for speeds in the excess of 250 km/h should be seen as TSI compliant.

Measures for effective design, construction and maintenance of ballast cross section are to be harmonised in the TSI, for example:

- Lowering of the ballast cross section, between the rails, for ballasted track with monoblock sleepers
- Maintenance procedures to avoid holding of ballast on the top of sleepers and fastenings.