Calibration of roller brake testers
transmission
and
use of reference brake force

Jorge Soria Galvarro
Senior Technical Adviser – Vehicle Regulations
SCANIA CV
Content

• This presentation is about the NVF initiative to investigate the measurement accuracy of the roller brake tester used for heavy vehicles.

• It summarizes some of the research carried out in this field in Scandinavia and suggests further steps to minimize the calibrations uncertainty of roller brakes testers.

• It also describes the method to evaluate heavy vehicles brake performance with roller brake testers using reference brake forces.

Measuring the accuracy of the roller brake testers

Investigations in Finland

In 1999, the Finnish Road Vehicle Administration initiated a project to improve the reliability and consistency of measurements and calculation done by roller brake testers of heavy vehicle brake systems.

The validation instrument was a heavy trailer with a measuring system for brake dynamometers.
Measuring the accuracy of the roller brake testers

Tests in Sweden

In 2005, BILPROVNINGEN in Sweden, carried out a field test together with CENTRIA from Finland using the measuring trailer.

The task was to measure all Bilproningens roller brake testers for heavy vehicles situated in the Stockholms area.

• The field test showed the same results as in Finland, that approximately 1/3 of the measured heavy vehicles roller brake testers have a measurement uncertainty higher than ± 5% of the braking force.

• The test results also showed the importance of the calibrations procedures for the roller sets.
Analyzing the calibration method for the roller brake testers

Thesis work at Bilprovningen

The analysis of the calibration procedure shows that the principal factor for uncertainty is the reduction in the roller diameter due to wear on the surface of the rollers.

The real diameter should be measured and included in the calculation program for the calibration instead of default values for new rollers. For example, some manufacturers recommend to change the roller sets when the diameter difference in the roller is larger than 1%.

The analysis also revealed that rounding the values used in the calibration program influence the results significantly. For example, gravitational force 9.81 m/s² was rounded to 10 m/s².
The investigation revealed that the total uncertainty in the calibration procedure for the roller brake tester was at a 95% confidence level, giving a total measurement uncertainty of $U = 164 \text{ N}$, which corresponds to approximately 1.6% uncertainty at normal operating roller brake test forces.
In order to have the total roller brake tester uncertainty, the total uncertainty of the transmission in the roller brake tester needs to be analyzed.

The factors of uncertainty are components of the transmissions such as the roller diameter, the lever length in the electrical motor and the gear ratio between the gearwheel and the roller radius. Totally 24 different factors.
Uncertainty Analysis for the roller brake tester

The main factors contributing to the uncertainty are:

- Factor u6: Uncertainty in the radius of the rollers.
  This factor contributes with an uncertainty of $u6 \times c6 = -55.4$ N to the total uncertainty reference force.

- Factor u9: Uncertainty in the lever arm length on the motor side respective to the gear ratio for the simulation force.
  This factor contributes with an uncertainty of $u9 \times c9 = 58.2$ N to the total uncertainty reference force.

- Factor u11: Uncertainty due to unknown gear ratio between the gearwheel and rollers radius.
  This factor contributes with an uncertainty of $u11 \times c11 = 77.6$ N to the total uncertainty reference force.

- Factor u21: Uncertainty due to force transducer hysteresis.
  This factor contributes with an uncertainty of $u21 \times c21 = 69.3$ N to the total uncertainty reference force.
Uncertainty Analysis for the roller brake tester

The total measurement uncertainty of the standard level is calculated and the different contributions are assumed to be independent of each other.

\[ u = \sqrt{(u_1 \cdot c_1)^2 + (u_2 \cdot c_2)^2 + \ldots + (u_{24} \cdot c_{24})^2} \]

Thus becomes \( u = 147 \) N at the standard level. In an expanded probability level corresponding to \( k = 2 \), or approximately a 95% confidence level, the total measurement uncertainty is then \( U = 294 \) N or 29.4 daN or 3% at a brake force of 1,000 daN.

The analysis of the total measurement uncertainty of the roller brake tester shows an uncertainty of 3% at normal operating load of 10 kN. This level is considered acceptable for this type of testing machinery.
Use of reference brake force

• The uncertainty analysis was focused on the contribution of the factors regarding calibration of the roller brake tester.

• There are, however, other factors that contribute to the uncertainty of the measuring results, such as the measurement procedures and how the measurement results are used to calculate brake performance.

• In order to standardize the measurement procedures the ISO 21069-1 was created and later on ISO 21995 for the use of reference values using a roller brake tester.
Use of reference brake force

• A simple summarization of the method is that the brake force is measured up to a fixed brake camber pressure and the brake force is then compared to the brake force given by the manufacture. The brake forces are declared from 1 bar up to 5 bars with an interval of 0.5 bars. The reference values are given for every tyre type and brake type (drum, disc) and brake chamber size (12” – 30”).

![Reference Brake Forces](image)
Conclusion

• the uncertainty analysis for the total measurement process for the roller brake test-er is around 3% at normal operating load of 10 kN. This level is considered acceptable for the total measurement uncertainty of the roller brake tester.

• The calibration procedure should also include:
  • To measure the actual diameter of the rollers and include it in the calibration program calculations.
  • Rounding the values used in the calibration programs should not be allowed
  • It is important that the roller brake tester is standardized according to ISO 21069-1 as base for the roller brake tester specifications in the Nordic countries.
Conclusion

• The calculation method for brake efficiency is important to harmonize in the Nordic countries, the use of the reference brake forces according to ISO 21995 could result in a more accurate and simpler method compared to today’s national calculation formulas.

• All this is also in line with directive 2009/40/EC.
Questions?