











cycle sections (Fig. 10). In the case of NO<sub>x</sub> and THC, the highest values were achieved in the urban and motorway sections. It is worth noting that in the urban section the maximum value of NO<sub>x</sub> road emissions was obtained, which could have been the result of the low conversion rate of the TWC catalytic converter, whose efficiency is closely related to the temperature of the exhaust gases. As mentioned earlier in the urban section, the degree of hybridization of the propulsion system was calculated to be almost 60%, which influenced the low temperature of the catalytic carrier in this test phase. Hence the dominant share of urban NO<sub>x</sub> emissions in the RDE test. Such a situation would not occur for a vehicle with a conventional drive system, powered with an SI engine. In the case of performing measurements in the RDE test for such a vehicle type, the largest NO<sub>x</sub> road emissions are expected to occur in the rural and motorway sections, as confirmed by other research results performed by the authors.

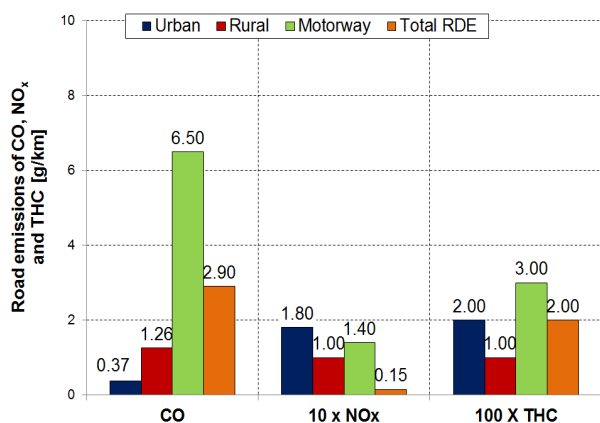


Fig. 10. Road emissions of CO, NO<sub>x</sub>, and THC in RDE test.

In order to compare the road emission obtained in the RDE test to the values listed in the Euro 6c norm, it was decided that the CF coefficient, constituting the ratio of the total emission from the RDE test to the limit values specified in the norm, needs to be determined. The CF coefficient for CO was 2.9, for NO<sub>x</sub> 2.5 and for THC 0.23 (Fig. 11). Therefore, since according to the norm that the CF coefficient for CO, NO<sub>x</sub> should not exceed 2.1, this condition was not met in any of the compounds considered.

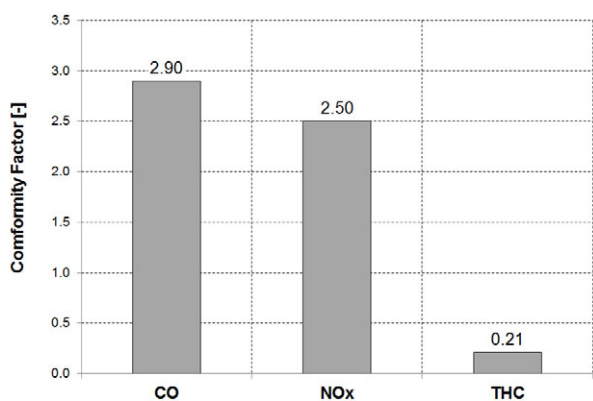


Fig. 11. Conformity factor (CF) of CO, NO<sub>x</sub>, and THC determined during RDE tests (all results).

When determining the CF coefficient according to the EMROAD method for CO and NO<sub>x</sub> road emissions, similar values were obtained as from the calculations made for the entire RDE test. Both compounds also did not meet the 2.1 limit value (Fig. 12).

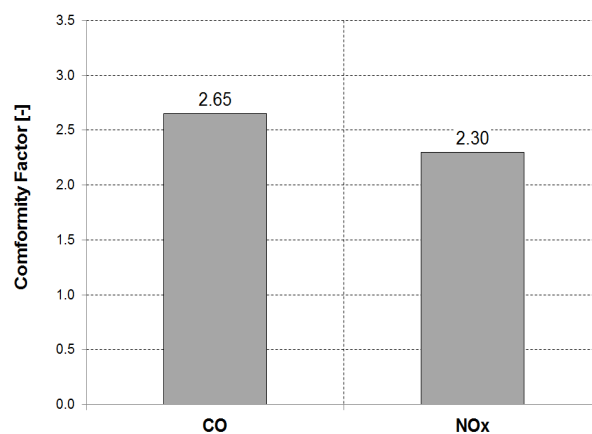


Fig. 12. Conformity factor (CF) of CO, NO<sub>x</sub>, determined during RDE tests (EMROAD procedure).

The last stage of the analysis of the obtained test results in the RDE test was the evaluation of the vehicle fuel consumption. The carbon balance method was used to achieve this, in which the road emissions of CO, THC and CO<sub>2</sub> are used to assess the fuel use. The values of the first two compounds were presented earlier, while the CO<sub>2</sub> road emissions were as follows:

- urban section – 174.6 g/km,
- rural section – 114.7 g/km
- motorway section – 180.9 g/km.
- total – 161 g/km.

The mean fuel consumption value for the whole RDE test was 6.42 dm<sup>3</sup>/100 km (Fig. 13). The smallest value was recorded in the rural phase, while the largest in the motorway phase.

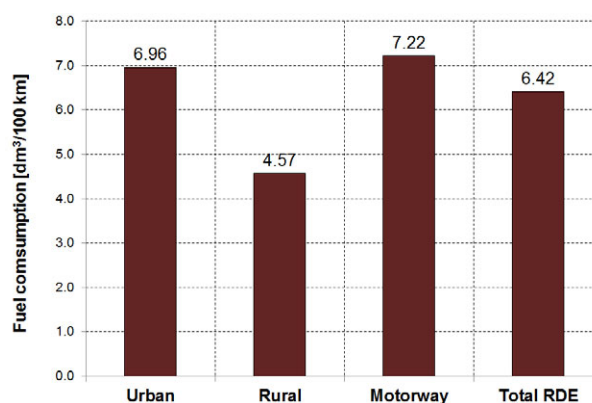


Fig. 13. Fuel consumption determined during RDE tests (all results)

## 6. Conclusion

The measurements carried out in the article confirmed the correct selection of the research route in the Poznań agglomeration for performing RDE tests. The creation of a test route in line with the requirements of the latest

emission standards is currently one of the most difficult aspects of this type of research. For this reason, it was assumed that the route will be referred to as the Poznań-RDE test route and on it the authors will perform RDE tests in accordance with the applicable procedures for PC and LDV category vehicles. For the tested vehicle, the degree of hybridization during the whole test was 46% and its highest value occurred in the urban and rural sections. In the motorway section, the electric motor propulsion of the hybrid drive system was not used. The high share of electric motor use in the urban section ended up limiting the conversion rate of the TWC catalytic converter, which in turn resulted in a very large value of NO<sub>x</sub> emission in this test section – it was higher than for the motorway section. The CF coefficients for CO and NO<sub>x</sub> determined both from the entire RDE test and the EMROAD method were larger than currently defined by the emission norms. For this reason, it is necessary to perform further RDE measurements for motor vehicles in the PC and LDV category in order to check the correctness of the definition of the CF factor by the legislator.

## References

1. K. Andrzejczak, J. Selech, *Transport Problems* **12**, 103-111 (2017), DOI: 10.20858/tp.2017.12.3.10.
2. J. Merkisz, M. Andrzejewski, A. Merkisz-Guranowska, I. Jacyna-Gołda, *Journal of KONES Powertrain and Transport* **21**, 219-226 (2014)
3. J. Merkisz, M. Idzior, J. Pielecha, W. Gis, *WIT Transactions on the Built Environment* **111**, 181-189 (2010), DOI: 10.2495/UT100171
4. J. Merkisz, P. Lijewski, P. Fuc, S. Weymann, *Eksploracja i Niezawodność – Maintenance and Reliability* **15**, 364-368 (2013)
5. J. Zak, R. Jachimowski, P. Golebiowski, *Transport Means – Proceedings of the International Conference*, 772-777 (2016)
6. J. Merkisz, J. Pielecha, *IOP Conference Series-Materials Science and Engineering* **148**, UNSP 012078 (2016), DOI: 10.1088/1757-899X/148/1/012078
7. J. Pielecha, J. Merkisz, J. Markowski, R. Jasinski, *E3S Web of Conferences* **10**, UNSP 00073 (2016), DOI: 10.1051/e3sconf/20161000073
8. J. Merkisz, J. Pielecha, W. Gis, *Proceedings of the Ninth Asia-Pacific International Symposium on Combustion and Energy Utilization*, 477-482 (2008)
9. J. Merkisz, M. Bajerlein, P. Daszkiewicz, *Lecture Notes in Information Technology* **13**, 106-113 (2012)
10. J. Merkisz, P. Lijewski, P. Fuc, S. Weymann, *Applied Engineering in Agriculture* **31**, 875-879 (2015), DOI: 10.13031/aea.31.11225
11. B. Kurc, *Journal of Solid state electrochemistry* **18**, 2035-2046 (2014), DOI: 10.1007/s10008-014-2451-x
12. D. Dolinski, E. Odachowska, *Accident Analysis and Prevention* **115**, 73-78 (2018), DOI: 10.1016/j.aap.2018.03.007
13. Commission Regulation (EC) 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, 2008
14. Commission Regulation (EC) 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, 2007
15. <http://gpsvisualizer.com> (access: 24.06. 2019)

The research was funded by European Union from European Regional Development Fund through the National Centre for Research and Development (Narodowe Centrum Badań i Rozwoju) – research project within the Smart Growth Programme (contract No. POIR.04.01.02-00-0002/18).

