



FUTURE CHALLENGES FOR MOTORCYCLE EMISSIONS CONTROL



EURO 5 COMPLETED - WHAT NEXT?

The motorcycle industry is entering the final stages of Euro 5 development for implementation early in 2021. Looking forward and drawing parallels to the development of future emissions legislation, for gasoline passenger cars, this paper will discuss motorcycle development challenges in meeting lower tailpipe emissions.

The EU is developing the next level of emissions legislation for passenger cars and heavy duty applications, called Euro 7. Euro 7 will incorporate lower limits for currently regulated emissions and additional control of currently unregulated emissions, Figure 1. There will also be a real world operation focus which is not currently required for motorcycles, as motorcycle currently use the WMTC to prove emissions control. Real world focus operation is called RDE (Real Driving Emissions).



Figure 1: Ricardo view of Euro 7 Scope



Figure 2 compares the current WMTC, which motorcycles have to meet the legislative limits over and an RDE cycle for motorcycles. This RDE cycle was developed from a passenger car operation and modified for harsher acceleration for motorcycles. The RDE has 3 phases, urban, rural and highway, where the urban phase is similar to the start of the WMTC.

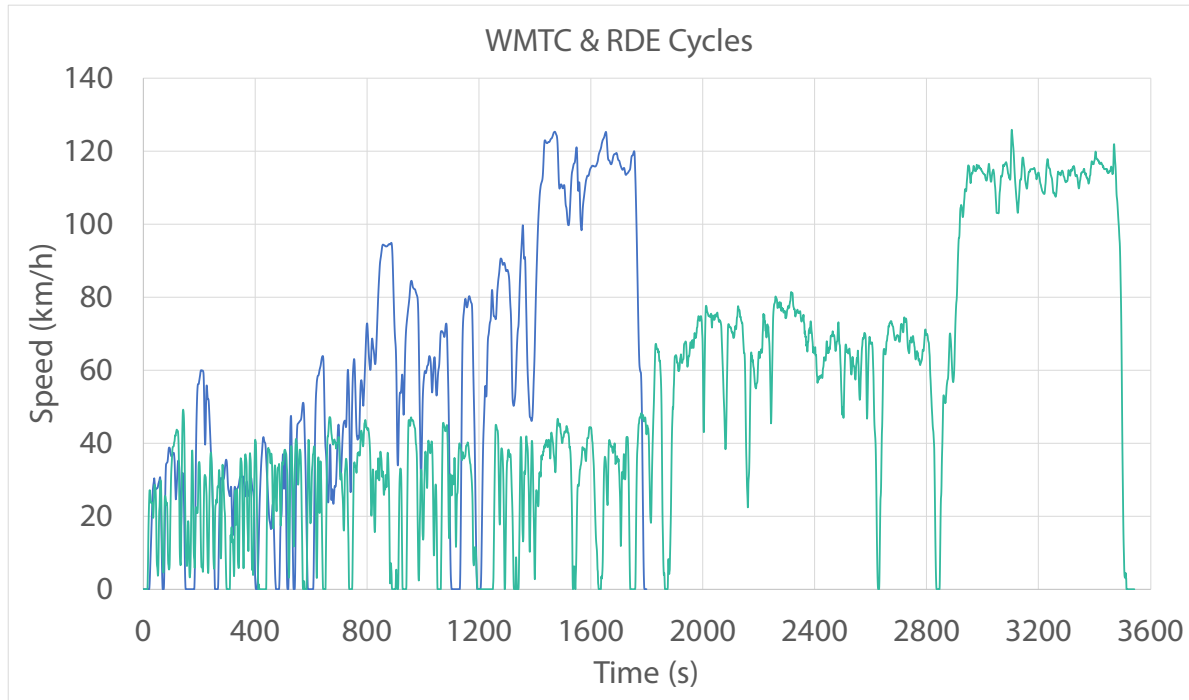


Figure 2: Comparison of WMTC and an RDE cycle for motorcycles

Table below shows the current gasoline passenger Euro 6 and motorcycle L-Category Euro 5 legislation. The gaseous emissions and PM are similar. However, there are currently no PN limits for motorcycles.

	Gasoline Passenger Car Euro 6 - WHTC	L- Category Motorcycle Euro 5 - WMTC
NOx (mg/km)	60	60
THC (mg/km)	100	100
NMHC (mg/km)	68	68
CO (mg/km)	1000	1000
PM (mg/km)	4.5	4.5
PN (#/km)	6x10 ¹¹	---

Table 1: Comparison of Euro 5 for motorcycles and Euro 6 for gasoline passenger cars





Figure 3 shows the Ricardo view on the passenger car Euro 7 timeframe, it is expected that the next level of motorcycle emissions will follow the passenger car schedule with a delay. It must also be noted that the current motorcycle Euro 5 emissions limits are the same as current Euro 6 gasoline passenger car limits (Table 1) but there is no current requirement to measure particle number or perform RDE testing.

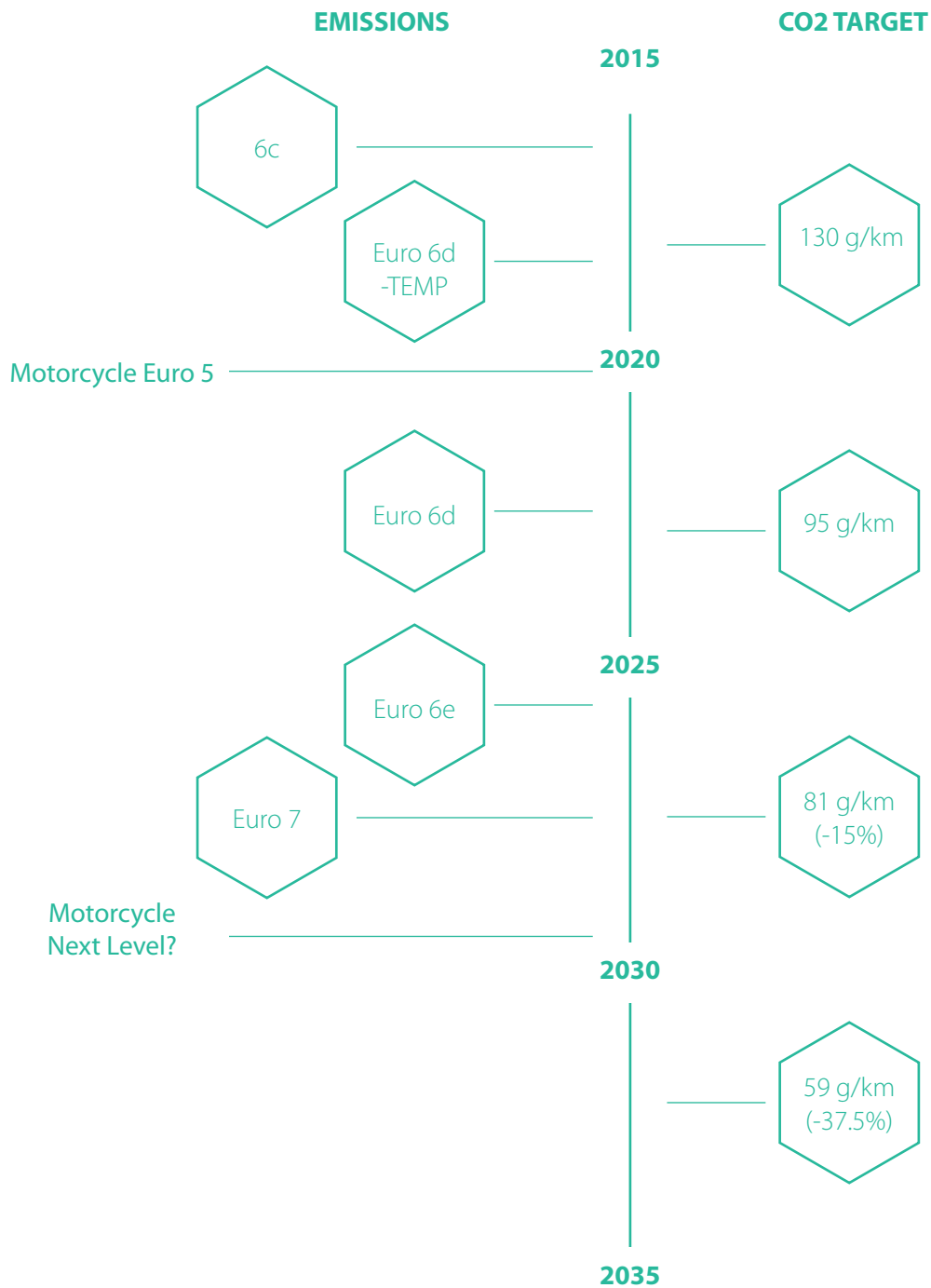


Figure 3: Ricardo view of the Euro 7 timeline





To understand future challenges, Ricardo tested a Euro 5 motorcycle over the WMTC and a modified RDE cycle for regulated and unregulated emissions. Figure 4, shows the results of the testing where the emissions are similar between the WMTC and RDE tests except for NO_x, where the emissions were ~4 times higher. Figure 5, shows the effective conformity factor (CF) which is the ratio of the emissions results from the RDE to the WMTC legislative limits. The CF is less than 1 for CO, THC and NMHC. However, the CF for NO_x is ~ 2, showing that the RDE emissions were twice the legal limit for NO_x over the WMTC.

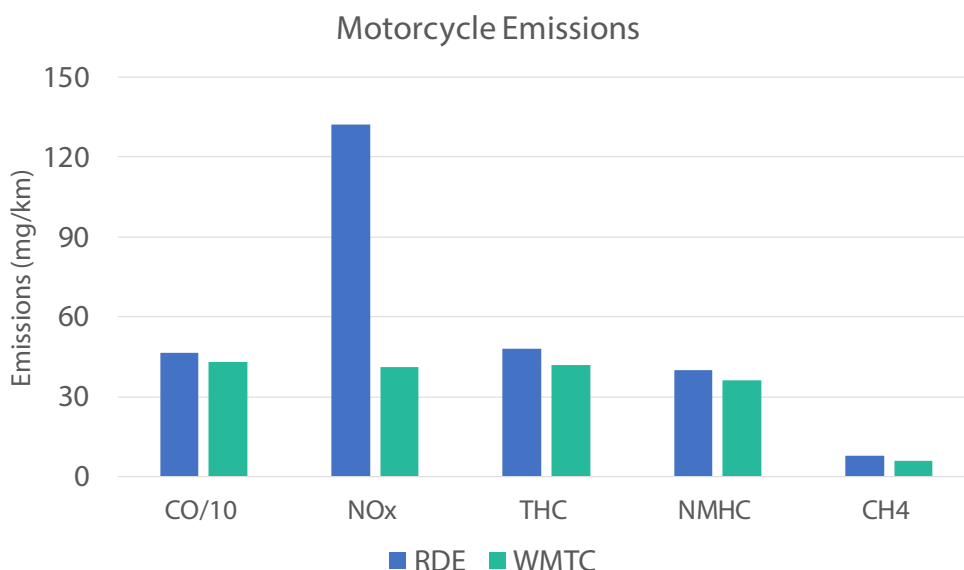


Figure 4: Motorcycle emission over WMTC & RDE

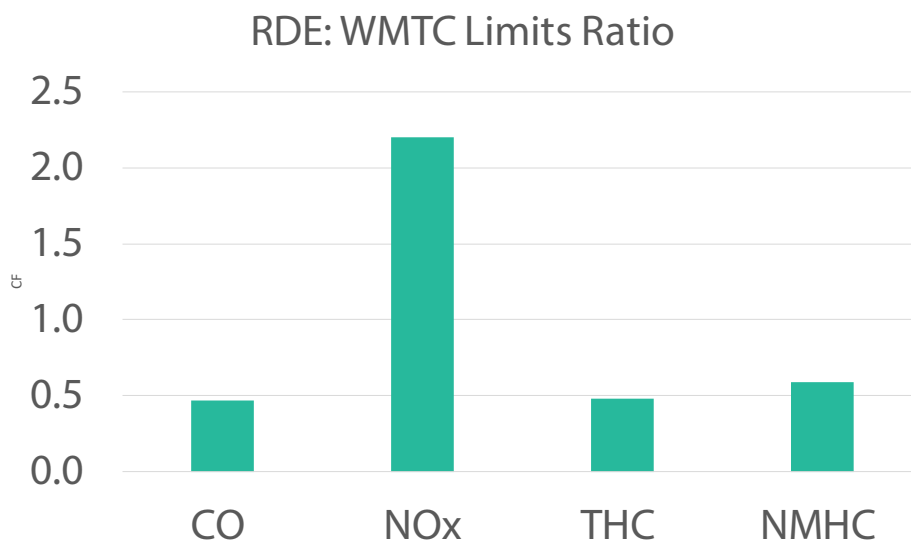


Figure 5: RDE CF

Particle number is currently regulated for gasoline direct injection (DI) engines at > 23 nm particle size and is expected to be updated to include > 10 nm particle size in the future. PN legislation for motorcycles is expected in the future at > 10nm. Figure 6 shows the PN emissions from the Euro 5 motorcycle measured at >23 nm and >10 nm. The particles >23nm are below the current Euro 6 gasoline DI PN limit of 6×10^{11} #/km. The >10nm particles are $> 1 \times 10^{12}$ #/km, higher than the current Euro 6 regulation for >23nm.

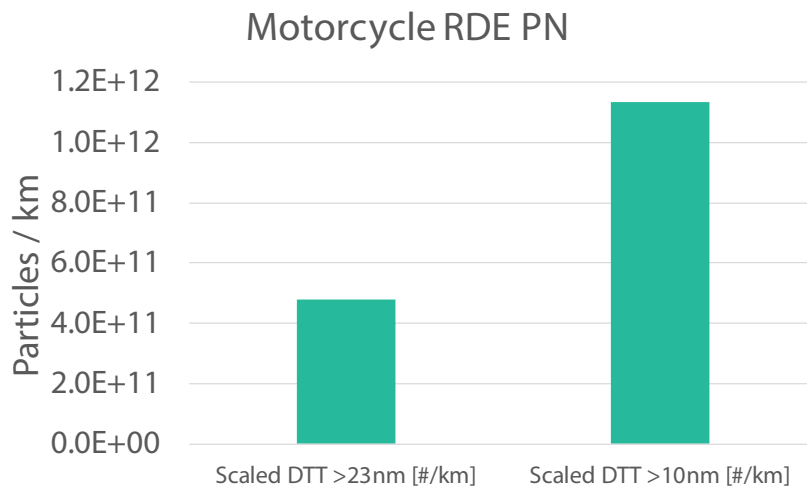


Figure 6: Motorcycle PN emissions

Emissions of NH_3 are expected to be regulated at Euro 7 for gasoline engines, hence NH_3 emissions were measured over the modified RDE cycle, Figure 7. The motorcycle NH_3 emissions are relatively controlled with less than 0.5g/RDE cycle, with the largest increase occurring over the harsh acceleration.

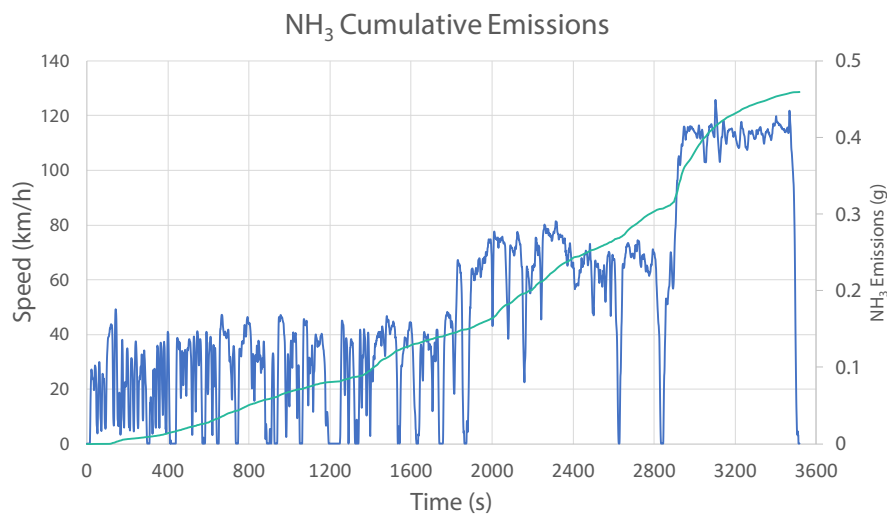


Figure 7: NH_3 emissions over the RDE cycle

In summary, Ricardo understands the challenges for development of current Euro 5 motorcycle to meet future emissions limits. The main challenges are NO_x and PN exhaust control. Enhanced NO_x control over the RDE can be achieved via increased catalyst volume and tighter lambda control. PN can be controlled via the application of an exhaust filter. Hence exhaust design and package availability are key to successfully meeting future emissions control for motorcycles, where Ricardo has significant experience and has achieved success.



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