Euro 7 exhaust **aftertreatment**

Looking into the near future of emissions requirements post-2027, compliance will require advanced material coatings and tighter engine controls, finds Toby Clark

Although the approaching Euro 7 emissions rules will mean sharp tightening of the current emissions limits, they are not meant to eliminate diesel vehicles. As the UK's Explanatory Memorandum (14598/22) on the new regulations puts it, "Limits for buses and lorries… are to become more stringent… to reflect the potential for existing technologies to further reduce emission levels."

The regulations come into force for cars and light commercial vehicles on 1 July 2025, but do not affect trucks, buses and coaches until 1 July 2027. And while the limits are not yet confirmed, they are not likely to change from the current proposals.

Euro 7, which does away with the distinction for light and heavy vehicles, and with it the roman numerals, means a dramatic reduction in NOx emissions, and a requirement that they be limited even during cold-start conditions. While the Euro VI limit was 400mg/kWh, the proposals are for 350mg/kWh cold, and just 90mg/kWh at normal running temperatures (see table, right). These limits need to be met across ambient temperatures from 0-35°C, with an 'extended' range of -10°C to 45°C in some applications.

Particulates emissions will be more strictly controlled. The proposals also include limits on formaldehyde and nitrous oxide (N_2O) emissions, as well as durability requirements and a requirement for on-board emissions monitoring.

"I believe that the timescale is achievable," says Dave Phillips, engineering director at exhaust specialist Eminox. "There are no new wholesale technologies that are going to be required to meet Euro 7. The SCR technologies and the oxidation catalyst technologies are already widely available. I expect those to carry over from Euro VI to Euro 7, just general technology development.

"There are modifications to current technologies: one would be the ability of the filter to trap particulates down to 10nm rather than 23nm. That does require a change in coating technology, or modification of existing technology."

Andy Walker, technology market insights director at catalyst and filter specialist Johnson Matthey, agrees: "Broadly speaking, it's going to be existing technology, but the development of that, so iterations of existing SCR." He points out that we are not going to see any return to EGR-only systems: "The beauty of SCR is you do get very high NOx conversion, which does allow you calibration flexibility towards superior fuel economy."

Dave Phillips adds: "Heavy EGR is not going to get anywhere near the targets. You'd lose all transient response; you'd fill the DPF extremely quickly and have no mechanism to keep up with the regeneration rate. So SCR is pretty much the only game in town."

"I think the particular challenge is obviously the low-temperature cycle performance," says Phillips, "and that's going to demand a couple of potential technologies, maybe in combination."

NON-EXHAUST EMISSIONS

Euro 7 will also cover emissions that don't come from the engine, in the form of particulates produced by the inevitable wear of the brakes, clutch and tyres. The most recent EU document, COM(2022) 586 final, says: "…by 2050, non-exhaust emissions will constitute up to 90% of all particles emitted by road transport, because exhaust particles will diminish due to vehicle electrification. Those non-exhaust emissions should therefore be measured and limited." It proposes that the European Commission prepare a report on tyre abrasion by the end of 2024, with an eye to setting limits.

STRATEGIES

A typical Euro VI system starts with the diesel oxidation catalyst (DOC), then the diesel particulate filter (DPF), and then the SCR unit. Observes Phillips: "You're waiting for the DOC and the DPF to heat up before you can start to dose and get the NOx reduction performance over the SCR." One possible solution for Euro 7 is pre-heating the SCR substrates themselves during low-temperature operation. This could be done electrically, using a pilot burn of fuel, or with an exothermic reaction from the DOC (although this would not work at the lowest temperatures).

But pre-heating may not be necessary. Instead, dual SCR modules

Pictured at a September 2022 event in Brussels is an ultra-low emission demonstrator vehicle developed by European trade body Association for Emissions Control by Catalyst (AECC) jointly with the International Platinum Group Metals Association (IPA)

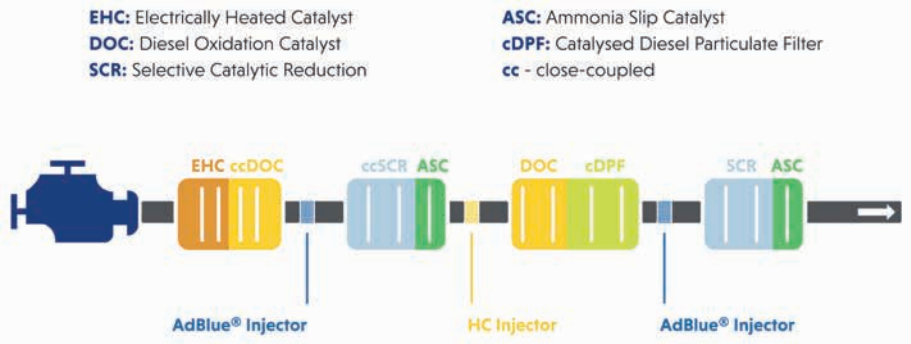
Euro VI	CO mg/kWh	THC mg/kWh	NMHC mg/kWh	CH_4 mg/kWh	NO_X mg/kWh	NH_3 ppm	PM mg/kWh	PN #/kWh
WHSC* (CI)	1,500	130			400	10	10	$8x10^{11}$
WHTC* (CI)	4,000	160			460	10	10	$6x10^{11}$
WHTC (PI)	4,000		160	500	460	10	10	$6x10^{11}$

*Source: ACEA Proposal for Euro VII (June 2021). *WHSC: worldwide harmonised steady state driving cycle. WHTC: worldwide harmonised transient driving cycle*

Euro 7 proposals	CO mg/kWh	NMOG mg	CH_4 mg/kWh	NO_X mg/kWh	NH_3 mg	PM mg/kWh	PN #/kWh	N_2O mg	HCHO mg
Cold emissions*	3,500	200	500	350	65	12	$5x10^{11}$	160	30
Hot emissions**	200	50	350	90	65	8	$2x10^{11}$	100	30
Short trips***	2,700	75	500	150	70	10	$3x10^{11}$	140	

Source: EU, Euro 7 Annex 1, 'Euro 7 emission limits' for M2, M3, N2 and N3 vehicles: www.is.gd/ocujoy

**Cold emissions refers to the 100th percentile of moving windows of 1 WHTC for vehicles*
***Hot emissions refers to the 90th percentile of moving windows of 1 WHTC for vehicles*
**** Emission budget for all trips less than 3xWHTC long*



could be used, with one of them 'close-coupled' to the engine – close to the turbo and perhaps even upstream of the DOC (pictured, right). "If the close-coupled SCR and the remainder of the system can be moved as close to the engine as possible, then you effectively remove the thermal mass in the system pre-catalyst, so more of the heat generated in the engine gets to the catalyst and heats it up."

Walker, of Johnson Matthey, agrees: "We expect to see… a close-coupled SCR system as well as an underfloor SCR system like we've seen in Euro VI. It gives the OEMs more flexibility and the ability to get higher overall NOx conversions, which also gives that additional degree of flexibility on engine calibration, which typically leads to better fuel efficiency."

These changes to engine architecture will come at a cost, of course: "The main challenge is going to be the DPF coating technology," says Phillips.

He adds that incorporating the extra hardware is going to be 'a packaging challenge', but "we're not expecting any wholesale increases in catalyst size over Euro VI. I think one of the biggest challenges with Euro 7 is going to be minimising the addition of control components and additional hardware that's required."

Still, he does not expect engine manufacturers to make wholesale changes to engine designs – no move towards V6 configurations, for instance – "mainly because of the cost of implementation; I'd expect us to build on existing technologies."

COST PREMIUM

The EU has estimated that the added purchase cost for Euro 7 will be around €2,600 (£2,257) for a truck. Phillips considers this to be 'probably realistic', taking into account the possible extra SCR dosing unit and catalyst, and the requirements for additional durability. "What we are expecting is probably greater serviceability for all components in the system. So where the DPF has been serviceable in the past, we would probably expect more of the catalyst to be serviceable as well, which will also push the costs up." In terms of the durability requirement, he says, "it allows components in the system to be replaced individually."

Adds Walker: "There will be better, or more robust, catalyst washcoats. And Euro 7 is looking at more detailed onboard monitoring [with] potentially over-the-air updates on the condition of the catalyst system."

But the initial cost is not the only issue: "Almost undoubtedly, like for like, there'll be an impact on fuel consumption," says Phillips. "Obviously the OEMs will be doing whatever they can to mitigate any back-pressure increases, so they'll be looking at different coating technologies, and how can they minimise restrictions through the system. But ultimately we're putting more catalyst volume in [and] potentially a heater element which is going to create a restriction as well – and that heater then needs to be powered, so that is also going to increase fuel consumption at certain points in the duty cycle."

Although Walker agrees, he adds: "Because of the freedom on engine calibration that the OEMs will have with the close-coupled SCR plus the underfloor SCR, we expect them to be able to mitigate the increase in back-pressure."

Will it possible to convert a Euro VI vehicle to comply with Euro 7? Walker says: "We see it as being next to impossible to do a cost-effective retrofit on these systems, because you need to do extensive calibration to get the optimum fuel efficiency." TE

THE OEMS' VIEW: JOIN UP EURO 7 AND ZERO-EMISSION STANDARDS

Euro 7 proposals have not been met with approval from truck OEM trade group ACEA, which published a critical report in March (*www.is.gd/ajixux*) about Europe's transport decarbonisation goals which were themselves released in February. It contends that they conflict with Euro 7 proposals.

ACEA writes: "The Euro 7 regulation for heavy-duty vehicles has been justified with unrealistically low assumptions about the required market uptake of zero-emission vehicles. While the Euro 7 regulation projects a share of new diesel-powered vehicles (including hybrids and PHEVs) of more than 41% in 2040, the CO_2 regulation would require manufacturers to register no more than 12% of new diesel-powered vehicles by 2040. These projections are obviously contradictory and lead to an unjustified level of stringency for Euro 7."

It adds that the stringency of Euro 7 levels should be revised "to a level which does not distort the huge efforts and investments that will have to be made in the context of the CO_2 regulation". Instead, the report refers back to ACEA's July 2021 proposals for a heavy-duty Euro VII regulation (which would maintain the distinction between light and heavy vehicle standards). By 2025/2026, compared to Euro VI, this would halve emissions of "key criteria pollutant emission limits (these will require R&D effort and hardware changes for new vehicles)". They include NOx and NMHC (non-methane volatile organic compounds). In addition, particulate matter (PM) limits would reduce from 10 to 8mg/kWh, and CO and PN limits would remain the same. The proposals also stipulate only minimal changes to the current test procedures, and no brake wear standards. -*Will Dalrymple*