NLB Corp.

The Leader in
Water Jet Productivity

Clean Power, Clean Air

How Tier 4 emission standards affect the water jet industry

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NLB Corp. has prepared this white paper to acquaint water jet users with the EPA's Tier 4 emissions standards and the issues associated with compliance, two important considerations in deciding when to invest in new equipment.

Introduction

For nearly two decades, the Environmental Protection Agency (EPA) has been tightening standards for the emission of harmful exhaust gases from diesel-powered equipment, such as high-pressure water jet units. Until January, 2015, these regulations applied only to new engines under 750 hp, but the latest rules (known as Tier 4) mandate lower emission levels from larger engines as well.

Until recently, the engines driving water jet units were not designed to meet these standards, but today engine manufacturers are adding new technology. While this adds cost to the engine (and, therefore, to the water jet unit it powers), it also improves fuel economy, which reduces operating expense. These savings offset a substantial portion of the investment.

EPA goal: near-zero emissions

Tier 4 standards are part of a national program by the EPA to reduce emissions from non-road diesel engines, a category that includes water jet pump units as well as excavators, generators, compressors, and a host of other equipment. These reductions are to be accomplished using the Best Available Control Technology, or BACT. Full details can be found at the EPA website, http://www.epa.gov/otaq/nonroad-diesel.htm. Essentially, the EPA wants non-road engines to have the same sort of advanced emission control technologies required of trucks and buses.

In 1996 the EPA announced that future emissions of nitrogen oxides (NOx) had to be limited to 10% of then-current levels and particulate matter (PM) emissions to 5%. (PM is the black soot or smoke in the exhaust of a diesel engine.) The agency estimated that its new standards would reduce NOx emissions by about a million tons per year by 2010… the equivalent of taking 35 million cars off the road. Reductions in carbon monoxide (CO) and non-methane hydrocarbon emissions (NMHC) were also mandated.

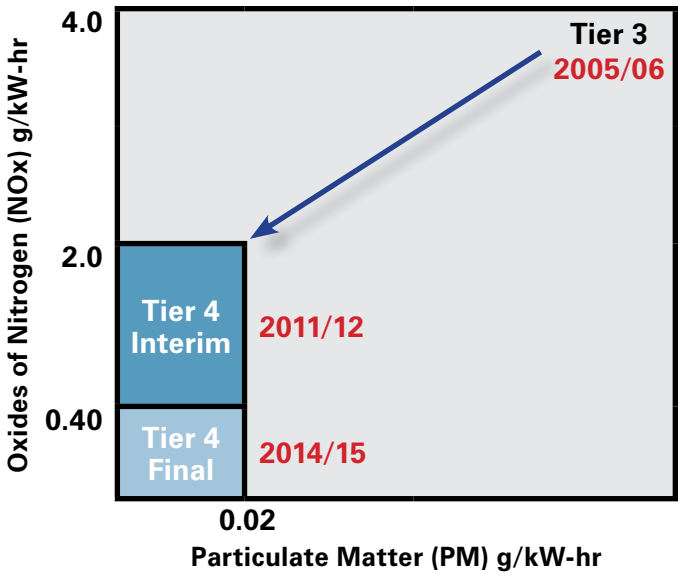
Recognizing that achieving these changes would not be simple (or inexpensive) for manufacturers, the EPA decided to phase them in. Diesel engines of 11 hp to 750 hp would have to reduce emission levels to a certain level (called Tier 1) by 2000, followed by progressively lower levels in 2006 (Tier 2), and 2008 (Tier 3).

An even stricter set of standards — Tier 4 — was established for engines above 750 hp. This was implemented in two stages, with Interim (Tier 4i) taking effect in 2011 and Final (Tier 4F) in January, 2015. Figures 1 and 2 detail these standards and the resulting 90% reduction in emissions.

Figure 1 *– Tier 4 emissions standards (all figures in g/kW-hr)*

	Tier 4i (752-1207 hp)	Tier 4F (>752-1207 hp)
On Jan. 1 of	2011	2015
NOx	3.50	0.67
HC	0.40	0.19
CO	3.50	3.50
PM	0.10	0.03

Figure 2 *– Emissions reduced by 90%, to near-zero*



The importance of compliance

Compliance with Tier 4F standards is now mandatory in areas that have not yet attained current EPA air quality standards, and in some areas that have. It is required by the California Air Resources Board (CARB) and written into bid specifications and site permits for DOT and public works projects in various states, including New Jersey, Pennsylvania and Massachusetts.

In addition, a growing number of companies — especially large, publicly-owned firms — are making environmental goals key elements of their business strategies. Dow Chemical Company and 3M, for example, now require that all diesel-powered equipment brought into their facilities (wherever they are) be Tier 4F-certified.

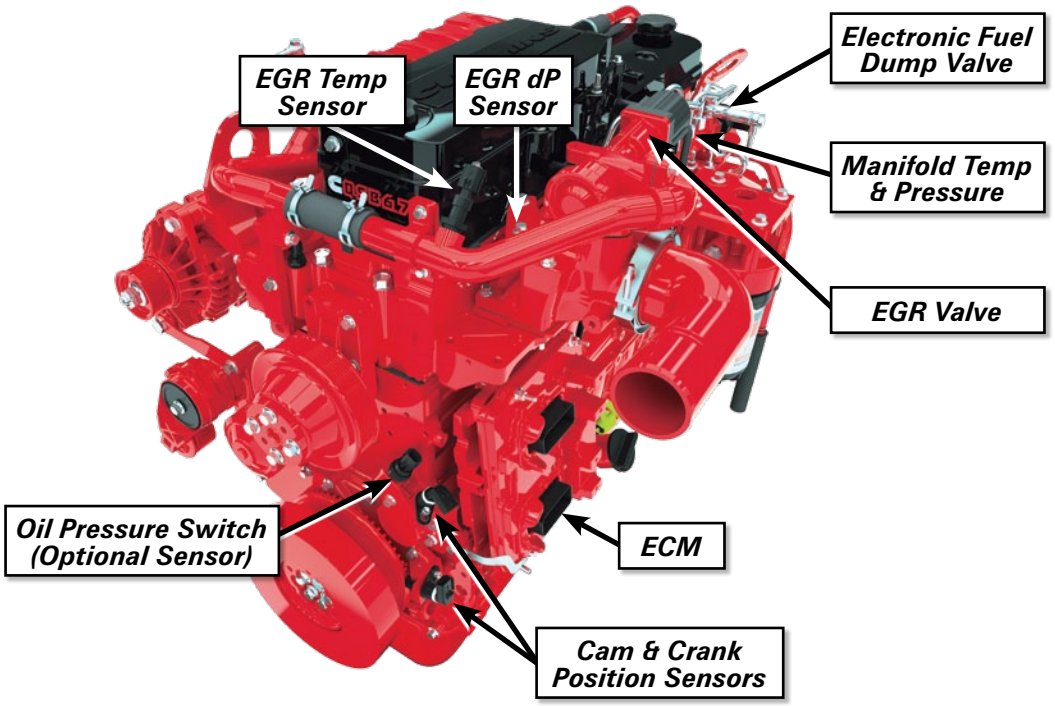
This puts water jet contractors whose equipment is not Tier 4F-compliant at risk of being shut out of projects. Furthermore, should they be caught using older, non-compliant equipment where it is not allowed, they can be liable for fines of $37,500 per violation, as well as the costs of litigation and lost time. Water jet users who want to be competitive in the future — or get ahead of competitors today — need to consider investing in new equipment.

Advanced engine technology

The two primary technologies that enable diesel engines to achieve Tier 4F emission levels are exhaust gas recirculation (EGR) and selective catalytic reduction (SCR). Some engines use a combination of the two.

EGR (Figure 3) refers to cooled exhaust gas recirculation, which recirculates some of the exhaust gases back to the combustion chamber. This has the dual effect of reducing the combustion temperature and reducing the formation of NOx. Large engines (like those used on stationary generator sets) may also have an exhaust pre-heater and Diesel Particulate Filter (DPF) to jumpstart the NOx conversion process. Together, they can heat the exhaust to 450°F in as little as nine minutes.

Figure 3 *– Diesel engine with EGR and ECM (image courtesy of Cummins Inc.)*

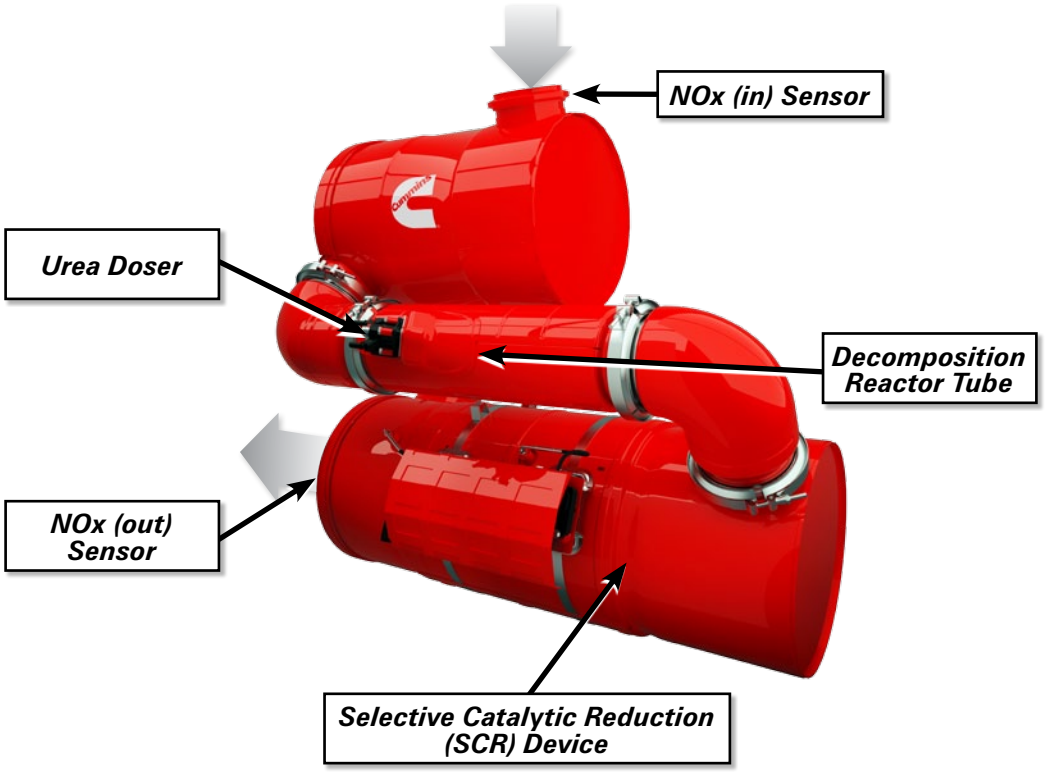


SCR (Figure 4), a technology widely used in Europe, is becoming more common in North America. It sprays diesel exhaust fluid (DEF), or aqueous urea, into the exhaust stream, where the urea reacts with the exhaust NOx. This reaction reduces NOx emissions to an average of less than 0.67 g/kW-hr. The DEF dosing system, supply and return tubing, and control and monitoring functions are all integrated into the engine's electronic controls.

Additional emissions controls are added to the exhaust system, where the traditional muffler is typically replaced by a catalytic converter or particulate filter.

Despite the additional technology, water jet units with Tier 4F-compliant engines operate much the same as older units. Displacement is more efficient (more torque at lower horsepower), and some users report better cold weather starting.

Figure 4 *– SCR after-treatment system (image courtesy of Cummins Inc.)*



Fluids, fuel efficiency and operating costs

Users should be aware of some differences, however. Tier 4F engines are designed to run on environmentally-friendly fluids, including:

- Ultra-low sulfur diesel fuel (ULSD), with sulfur content of no more than 15 ppm
- Low-ash oil meeting CES 20081 CJ-4, typically 15W-40 (this can also be used in older engines)
- Fully-formulated coolant, 50/50, meeting ASTM D6210
- Urea meeting ISO 22241-1, such as AdBlue DEF 32.5%

While these fluids cost more than those typically used in Tier 3 or Tier 4i engines, this expense is more than offset by the Tier 4F engine's greater fuel efficiency. Cummins Inc. has documented these savings for its QSB6.7 and QSL9 diesel engines, which are found in some water jet units manufactured by NLB Corp., a water jet industry leader.

Figure 5 shows (assuming 1,000 hours of operation) that fluid costs for Tier 4F engines are 6.3% less or 9.2% less than for Tier 3 engines of the same horsepower. This improvement comes from the Brake-Specific Fuel Consumption (BSFC), which indicates the load and rpm at which an

engine maximizes power from its fuel. For a 260 hp engine, a 3% reduction in BSFC — assuming prices of $4.10 per gallon for diesel fuel and $3.08 for urea — means an annual fluid cost of about $26,100. This represents a savings of about $2,650 vs. a Tier 3 engine.

That's just the beginning. Since Tier 4-compliant engines generate more torque with less horsepower, it is now practical to use water jet units with smaller engines for many jobs. For example (Figure 5 again), the lower fluid costs for a water jet unit with a 260 hp Tier4F engine instead of a 350 hp Tier 3 engine can ***save a user $12,400 a year***. Savings would be even greater for someone switching from a 350 hp engine with emission controls that predate Tier 3.

Payback periods depend on the user's particular circumstances, but 1,000 hours a year is a conservative figure (for many water jet users, 2,000 hours is more common) and units used more frequently will pay for themselves sooner.

Figure 5 – *Fluid Costs*

Tier 3 to 4F Fluid Operating Cost

	QSB6.7 260hp at 2500 (2200 Point)			QSL9 350hp at 2100 (2000 Point)		
	Tier 3	**Tier 4i**	**Tier 4F**	**Tier 3**	**Tier 4i**	**Tier 4F**
BSFC Improvement	Base	-5.0%	-3.0%	Base	-5.0%	-1.5%
BSFC (lb/hp-hr)	0.383	0.351	0.34	0.381	0.355	0.349
Load Factor .5 (Gal/Hr)	7.0	6.4	6.2	9.4	8.8	8.6
Urea Consumption (% fuel)			3%			3%
Diesel Price	$4.10	$4.10	$4.10	$4.10	$4.10	$4.10
Urea Price			$3.08			$3.08
Total Fuel Cost/1000 Hrs	$28,752	$26,350	$25,524	$38,502	$35,875	$35,269
Total Urea Cost/1000 Hrs			$574.29			$793.54
Total Fluid Cost/1000 Hrs	$28,752	$26,350	**$26,098**	**$38,502**	$35,875	$36,062
Savings vs Tier 4i			-1.0%			+0.5%
Savings vs Tier 3			-9.2%			-6.3%

Summary: the case for Tier 4 compliance

Water jet units that meet Tier 4F requirements deliver the cleanest water jet power ever, minimizing pollution and enhancing public health. But even without these "big picture" advantages, there are solid business reasons to use them:

1. better fuel economy and lower operating costs
2. opportunities to do jobs virtually anywhere
3. avoiding fines and legal costs for non-compliance
4. customer and public goodwill for reducing air pollution

Although immediate compliance with new regulations is usually the best long-term financial decision, a company's analysis must take many factors into consideration. NLB hopes the information presented here will make this task a little easier.

UltraGreen™

Proven technology from a water jet leader

NLB Corp. has been a water jet industry leader since producing its first high-pressure unit in 1971, and has earned a global reputation for quality and innovation. Nowhere is this leadership more clear than in the UltraGreen™ series of Tier 4F-compliant pump units, easily convertible to pressures as high as 40,000 psi.

Among the reasons to choose NLB and UltraGreen:

- more than 350 Tier 4i and Tier 4F units in operation… the most experience in the industry
- advanced after-treatment technology is integrated by the engine manufacturer, not an add-on
- available for sale or rent at all six NLB regional branches
- opportunities to "trade-in, trade-up" from older NLB units
- the industry's widest range (by far) of convertible pump units and specialized accessories
- standard-setting service, training and technical support

NLB Corp. *The Leader in Water Jet Productivity*

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