

## VERIFIED TECHNOLOGY LIST

The following table summarizes all the diesel retrofit technologies that both the US Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) have approved for use in engine retrofit programs.

*According to EPA's website, its Voluntary Diesel Retrofit Program signed a Memorandum of Agreement (MOA) with CARB for "the Coordination and Reciprocity in Diesel Retrofit Device Verification. The MOA establishes reciprocity in verifications of hardware or device-based retrofits, and further reinforces EPA's and ARB's commitment to cooperate on the evaluation of retrofit technologies. This agreement commits EPA and ARB to work toward accepting particulate matter (PM) and oxides of nitrogen (NOx) verification levels assigned by the other's verification programs. Additionally, as retrofit manufacturers initiate and conduct in-use testing, EPA and ARB agreed to coordinate this testing so data generated may satisfy the requirements of each program. This MOA is intended to expedite the verification and introduction of innovative emission reduction technologies. Additionally, this MOA should reduce the effort needed for retrofit technology manufacturers to complete verification. Additionally, as retrofit manufacturers initiate and conduct in-use testing, EPA and ARB agreed to coordinate this testing so data generated may satisfy the requirements of each program. This MOA is intended to expedite the verification and introduction of innovative emission reduction technologies. Additionally, this MOA should reduce the effort needed for retrofit technology manufacturers to complete verification."*

EPA verified technologies can be found at: <http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm>. CARB verified technologies can be found at: <http://www.arb.ca.gov/diesel/verdev/currentlyverifiedtech.htm>

Agency	PM Level (for CARB certified)	Manufacturer/Product Name	Technology Type	PM	NOx	CO	HC	Applicability
EPA		Various	Cetane Enhancers	n/a	0 to 5	n/a	n/a	Heavy Duty, Highway, 4 cycle, non-EGR-equipped
EPA		Clean Diesel Technologies, Inc.	Platinum Plus Fuel Borne Catalyst/Catalyzed Wire Mesh Filter (FBC/CWMF) System	55 to 76*	0 to 9*	50 to 66*	75 to 89*	Highway, medium-heavy duty, 4 cycle, model year 1991 - 2003, non-EGR, turbocharged or naturally aspirated
EPA		Donaldson	Series 6100 DOC & Spiracle (closed crankcase filtration system)	28 to 32*	n/a	31 to 34	42	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated
EPA		Clean Diesel Technologies, Inc.	Platinum Plus Purifier System (fuel borne catalyst plus DOC)	25 to 50	0 to 5	16 to 50	40 to 50	Highway, medium-heavy and heavy-heavy duty, 4 cycle, model year 1988 - 2003, turbocharged or naturally aspirated
EPA		Donaldson	Series 6000 DOC & Spiracle (closed crankcase filtration system)	25 to 33*	n/a	13 to 23	50 to 52	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated
EPA		Donaldson	Series 6100 DOC	20 to 26	n/a	38 to 41	49 to 66	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated
EPA		Lubrizol	PuriNOx Water emulsion fuel	16 to 58	9 to 20	-35 to 33	-30 to -120	Heavy Duty, Highway & Non-road, 2 & 4 cycle
EPA		Various	Biodiesel (1 to 100%)	0 to 47	0 to -10	0 to 47	0 to 67	Heavy Duty, Highway, 2 & 4 cycle
EPA		International Truck & Engine Corp.	Green Diesel Technology-Low NOx Calibration plus Diesel Oxidation Catalyst with Ultra Low Sulfur Diesel (ULSD)	0 to 10	25	10 to 20	50	Highway Light Heavy-Duty, 4-cycle, Navistar/International engines, model years 1999 - 2003 in the following families: XNVXH0444ANA, YNVXH0444ANB, 1NVXH0444ANB, 2NVXH0444ANB, 3NVXH0444ANB
EPA		Engine Control Systems	Purifier - Diesel Particulate Filter	90	n/a	75	85	Highway: Heavy Heavy-Duty, Medium Heavy-Duty; Urban Bus; 4 cycle; model years 1994 - 2003; turbocharged or naturally aspirated; non-EGR engines
EPA		Caterpillar, Inc.	Diesel Particulate Filter	89	na	90	93	Nonroad, 4-cycle, non-EGR equipped, model year 1996-2005, turbocharged engines with power ratings $130 \leq \text{KiloWatts} < 225$ ( $174.2 \leq \text{Horsepower} < 301.5$ )
EPA		Engelhard	DPX Catalyzed Diesel Particulate Filter	60	n/a	60	60	Highway, heavy-duty, 4 cycle, model year 1994 - 2002, turbocharged or naturally aspirated
EPA		Johnson Matthey	Continuously Regenerating Technology (CRT) Particulate Filter	60	n/a	60	60	Heavy Duty, Highway, 2 & 4 cycle, model year 1994 - 2002, turbocharged or naturally aspirated engines
EPA		Johnson Matthey	Catalyzed Continuously Regenerating Technology (CCRT) Particulate Filter	60	n/a	60	60	Highway, heavy-heavy, medium-heavy, light-heavy duty, urban bus, 4-cycle, non-EGR model year 1994 - 2003, turbocharged or naturally aspirated engines.
EPA		Engine Control Systems	AZ Purimuffler or AZ Purifier Diesel Oxidation Catalyst with Low Sulfur Diesel Fuel (30 ppm S max)	40	n/a	40	70	Highway Medium Heavy-duty, 4- cycle, model years 1991 - 2003 Cummins and Navistar/International engines originally manufactured without any aftertreatment which are turbocharged or naturally aspirated, non-EGR engines

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EPA		Engine Control Systems	AZ Purimuffler or AZ Purifier Diesel Oxidation Catalyst with Low Sulfur Diesel Fuel (30 ppm S max)	35	n/a	40	70	Highway Heavy Heavy-Duty, 4-cycle, model years 1991 - 1993 Cummins engines originally manufactured without exhaust aftertreatment which are turbocharged or naturally aspirated, non-EGR engines
EPA		Engelhard	CMX Catalyst Muffler	20	n/a	40	50	Heavy Duty, Highway, 2 cycle engines
EPA		Engelhard	CMX Catalyst Muffler	20	n/a	40	50	Heavy Duty, Highway, 4 cycle engines
EPA		Johnson Matthey	CEM™ Catalytic Exhaust Muffler and/or DCC™ Catalytic Converter	20	n/a	40	50	Highway, heavy-heavy, medium-heavy, light-heavy duty, non-urban bus, 4-cycle, non-EGR model year 1991 - 2003, turbocharged or naturally aspirated engines
EPA		Johnson Matthey	CEM Catalyst Muffler	20	n/a	40	50	Heavy Duty, Highway, 2 cycle engines
EPA		Caterpillar, Inc.	Catalyzed Converter/Muffler (CCM)	20	na	20	40	Highway, heavy-heavy and medium-heavy duty, 4-cycle, non-EGR, model year 1998 - 2003, turbocharged or naturally aspirated
EPA		Engine Control Systems	AZ Purimuffler AZ Purifier	20	n/a	40	50	Heavy Duty, Highway, 2 cycle engines
EPA		Engine Control Systems	AZ Purimuffler AZ Purifier	20	n/a	40	50	Heavy Duty, Highway, 4 cycle engines
CARB	Level 1	Extengine	DOC + SCR	25%	80%			1991-1995 Cummins 5.9 liter off-road; 15 ppm sulfur diesel or CARB diesel.
CARB	Level 1	Donaldson	DOC + crankcase filter	25%	N/A			1988-1990 on-road; 15 ppm sulfur diesel or CARB diesel.
CARB	Level 1	Donaldson	DOC + crankcase filter	25%	N/A			1991+ on-road/1996 + off-road port equipment; CARB diesel.
CARB	Level 1	Donaldson	DOC + crankcase filter	25%	N/A			1994+ on-road/1996 + off-road port equipment; 15 ppm sulfur diesel.
CARB	Level 1	Cleaire Flash and Match	DOC	25%	25%			1993+ on-road (limited - Cummins defeat device); 15 ppm sulfur diesel or CARB diesel.
CARB	Level 1	Donaldson	DOC	25%	N/A			1988-1990 on-road; 15 ppm sulfur diesel or CARB diesel.
CARB	Level 1	Donaldson	DOC	25%	N/A			1991+ on-road; 15 ppm sulfur diesel.
CARB	Level 1	Lubrizol ECS AZ Purifier & Purifmuffler	DOC	25%	N/A			1991-2003 Cummins and Navistar on-road; 15 ppm sulfur diesel. 1973-1993 DDC 2 stroke; CARB diesel. 1991-2002 certain model Cummins, DDC HDD 4 stroke; 15 ppm sulfur fuel.
CARB	Level 1	Lubrizol ECS AZ Purifier & Purifmuffler	DOC	25%	N/A			1996-2002 off-road; 15 ppm sulfur diesel
CARB	Level 2	Donaldson DFM DMF with/without Spiracle	Flow Through Filter	50%	N/A			1991-2002 on-road; 15 ppm sulfur diesel.
CARB	Level 2	Environmental Solutions Worldwide Particulate Reactor	Flow Through Filter	50%	N/A			1991-1993 on-road, CARB diesel.
CARB	Level 2	Rypos ADPF	DPF	50%	N/A			1996-2002 stationary engines; CARB diesel.
CARB	Level 2	Lubrizol AZ Purimuffler/Purifier	DOC + Alt Fuel	50%	20%			1996-2002 off-road; PuriNOx
CARB	Level 2	Lubrizol PuriNOx	Alternative Fuel	50%	15%			1988-2003 on-road.
CARB	Level 3	Cleaire Longview	Lean NOx Catalyst and DPF	85%	25%			1993-2003 model year on-road; 15 ppm sulfur diesel.

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CARB	Level 3	Johnson Matthey EGRT	EGR/DPF	85%	40%			2000 International DT-466, 2000 Cummins ISM 2001 Cummins ISB, 1998 - 2002 Cummins ISC, 2001 Cummins ISL, 2001 MY DDC - 50, and 2001 DDC - 60. on-road; 15 ppm sulfur diesel.
CARB	Level 3	Cleaire Flash and Catch CRT	DPF	85%	25%			1994+ on-road (limited - Cummins defeat device); 15 ppm sulfur diesel.
CARB	Level 3	Cleaire Flash and Catch DPX	DPF	85%	25%			1994+ on-road (limited - Cummins defeat device); 15 ppm sulfur diesel.
CARB	Level 3	Cleaire Horizon	DPF	85%	N/A			1994-2005 on-road; 15 ppm sulfur or CARB diesel.
CARB	Level 3	CleanAIR Systems PERMIT	DPF	85%	N/A			Stationary emergency generators; 15 ppm sulfur diesel.
CARB	Level 3	Donaldson	DPF	85%	N/A			1993-2004 on-road; 15 ppm sulfur diesel.
CARB	Level 3	International Truck and Engine Corporation DPX	DPF	85%	N/A			1994-2003 on-road Navistar (International); 15 ppm sulfur diesel.
CARB	Level 3	Johnson Matthey CRT	DPF	85%	N/A			1994-2006 on-road; 2002-2006 Cummins ISM and ISB with EGR; 15 ppm sulfur diesel or B20.
CARB	Level 3	Johnson Matthey CCRT	DPF	85%	N/A			1994-2006 on-road; 2002-2006 Cummins ISM and ISB with EGR; 15 ppm sulfur diesel.
CARB	Level 3	Lubrizol ECS Purifier	DPF	85%	N/A			1994-2003 on-road; 15 ppm sulfur diesel.
CARB	Level 3	Lubrizol ECS Unikat Combifilter	DPF	85%				1996-2004 off-road; 15 ppm sulfur diesel or carb diesel.

a - Total PM reduction figures reflect reductions from both tailpipe and crankcase emissions.

\* - These effectiveness figures are provisional values subject to change pending final review of the test data.

Note: For after-treatment devices the reductions are based on the installation of retrofits to engines that were originally produced without diesel oxidation catalysts or diesel particulate filters.