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Nett BlueMAX™ Selective Catalytic Reduction System

v3.1

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Introduction

Nitrogen oxides (NO_X), one of the most troublesome emissions from the diesel engine, is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. The main component of NO_X, nitric oxide (NO), is colorless and odorless. However, another component of NO_X, nitrogen dioxide (NO_2) along with particles in the air can often be seen as a reddish-brown layer over many urban areas.

Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NO_X are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.

NO_X emission reductions are needed because NO_X leads to formation of ozone and secondary particulate emissions (PM2.5) in the atmosphere. Ozone is a powerful oxidant, and exposure to ozone can result in reduced lung function, increased respiratory symptoms, increased airway hyper-reactivity, and increased airway inflammation. Exposure to ozone is also associated with premature death, hospitalization for cardiopulmonary causes, and emergency room visits for asthma.

Nett Technologies designed the BlueMAX™ SCR system to effectively control NO_X emissions from medium- and heavy-duty diesel engines in such applications as on-road, non-road and stationary. The exhaust temperatures needed for proper operation are typically encountered in most medium- and heavy-duty diesel engine applications. The Nett BlueMAX™ system typically provides a reduction in NO_X emissions in the range of 65 to 90% under transient diesel engine conditions and over 90% in steady-state operation.

What is Selective Catalytic Reduction?

Selective Catalytic Reduction—commonly referred to as "SCR"—is a proven technology capable of reducing diesel NO_X emissions using compounds such as ammonia or urea, which are injected upstream of the SCR catalyst. In urea-based systems, the injected urea solution evaporates in the hot exhaust gas and decomposes producing ammonia. Through catalytic reactions with ammonia, NO_X emissions are reduced to harmless products including nitrogen and water vapor. SCR was developed for and is well proven in industrial stationary applications. SCR technology was first applied in thermal power plants in Japan in the late

1970s, followed by widespread application in Europe since the mid-1980s. In the USA, SCR systems were introduced for gas turbines in the 1990s, with increasing potential for NO_X control from coal-fired powerplants. Additional SCR applications include plant and refinery heaters and boilers in the chemical processing industry, furnaces, coke ovens, as well as municipal waste plants and incinerators.

Urea-SCR has been selected by a number of manufacturers as the technology of choice for meeting the Euro V (2008) and the JP 2005 NO_X limits—both are 2.0 g/kWh—for heavy-duty truck and bus engines. The first commercial diesel truck applications were launched in 2004 by Nissan Diesel in Japan and in early 2005 by DaimlerChrysler in Europe.

SCR systems are also being developed in the USA in the context of the 2010 NO_X limit of 0.2 g/bhp-hr for heavy-duty engines, as well as the Tier 2 NO_X standards for light-duty vehicles. SCR remains the only proven catalyst technology capable of reducing diesel NO_X emissions to levels required by future diesel emission standards.

How the Nett BlueMAX™ SCR System Works

The Nett BlueMAX™ system is a urea-SCR system. NO_X is reduced over the SCR catalyst through chemical reactions with a reducing agent (urea). The urea solution is carried in an onboard tank and injected upstream of the SCR catalyst. The main components of the Nett BlueMAX™ system include the SCR catalytic converter, the urea dosing system (UDS), and the urea tank (Figure 1). The urea control strategy relies on a NO_X concentration measurement by a sensor positioned upstream of the SCR converter. Based on the NO_X sensor signal, in combination with an engine mass air flow sensor and temperature sensors, the necessary urea dosing rate is calculated by the control software.

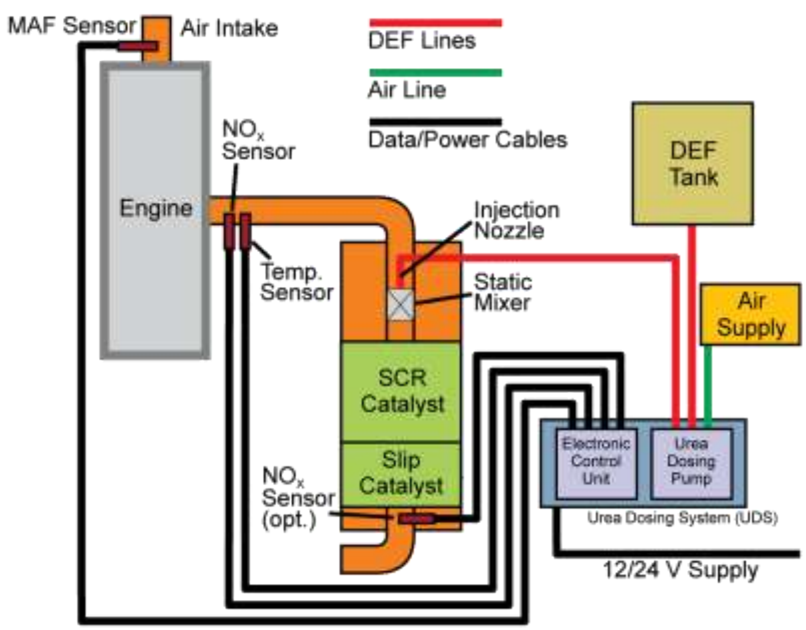

Figure 1. BlueMAX™ SCR System Schematic

The NO_X sensor-based strategy makes the system very suitable for retrofit applications. No time-consuming calibration (such as through engine mapping) is necessary, and the system can be installed on a wide range of diesel engines, including mechanical engines.

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Urea (in the form of a 32.5% water-based solution) is stored in the urea tank. From the tank, the necessary amount of urea is metered by a precise dosing pump. The urea solution is introduced to the exhaust pipe upstream of the SCR catalyst through an injection nozzle. Urea atomization is supported by compressed air supplied by a compressor.

SCR Catalyst Types

Selective catalytic reduction of NO_X with ammonia was first discovered over a platinum (Pt) catalyst. Two major groups of base metal SCR catalysts—vanadia and zeolite based—are widely used today, can operate at higher temperatures and have wider temperature windows, as illustrated in Figure 2.

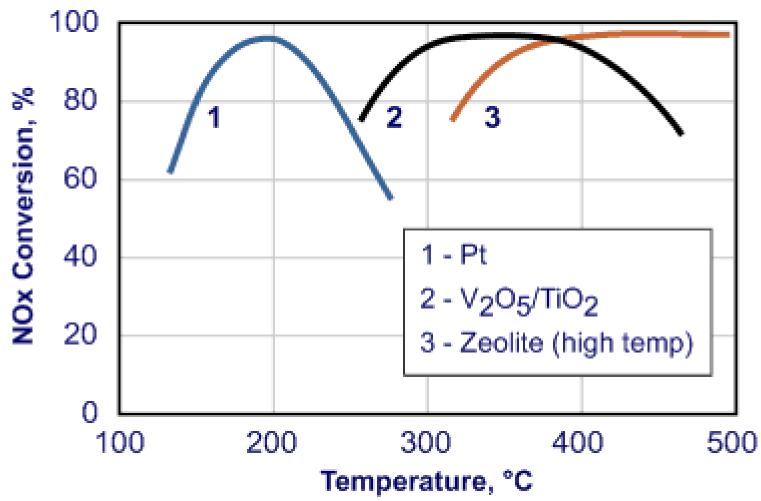

Figure 2. Operating Temperature Windows for Different SCR Catalysts

The Nett BlueMAX™ system employs a composite iron-substituted zeolite (high temp) catalyst. Porous ceramic honeycomb structures are coated with active catalyst material. The ceramic structure is the same material used universally in all automotive catalysts. It has superior mechanical strength and can withstand rapid increase changes in temperature during start-up and shutdown condition. The NO_X conversion efficiency continually increases with temperature.

Ammonia Slip Catalyst

The BlueMAX™ system includes an ammonia slip catalyst (oxidation catalyst) as a standard feature. The ammonia slip catalyst prevents the possibility that unreacted ammonia is released from the vehicle tailpipe. The catalyst consists of a metallic monolith honeycomb substrate coated with platinum group metal catalyst. The honeycomb structure with many small parallel channels presents a high catalytic contact area for the exhaust gases.

Due to the presence of an oxidation catalyst reductions in carbon monoxide (CO) and hydrocarbon (HC) emissions are achieved in addition to ammonia slip control. Typical conversion efficiencies for CO and HC are illustrated in Figure 3.

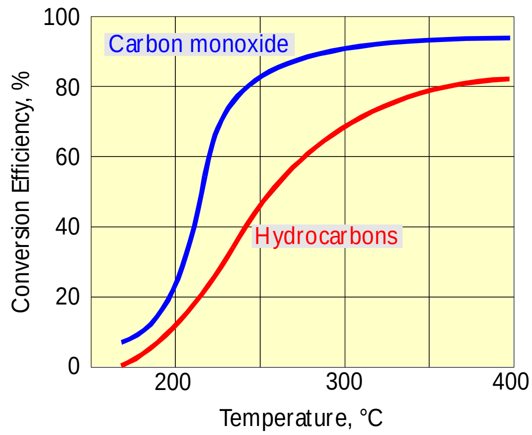

Figure 3. Conversion of CO and HC in Nett BlueMAX™ System

Urea Replenishment

The Nett BlueMAX™ system requires that aqueous urea solution (in the form of a 32.5% water-based solution) be carried in an on-board storage tank and that it is periodically replenished.

Urea consumption can vary from 1 - 5% (by vol.) relative to diesel fuel consumption (approximately 0.9%, relative to fuel consumption, of 32.5% urea solution is consumed per 1g/bhp-hr of NO_X that is reduced).

Standard Models and Sizing Charts

Standard models and sizing charts for the Nett BlueMAX™ system are listed in Table 1. Sizing for particular engines and applications should be consulted with our office before ordering.

Table 1 Nett® SCR Standard Models and Sizing Chart

Model	Max. Engine Power	
	kW	hp
GL5100	75	100
GL5200	110	150
GL5300	150	200
GL5400	185	250
GL5500	225	300
GL5600	260	350
GL5700	300	400
GL5800	335	450
GL5900	370	500

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Custom housing designs are available to fit any engine configuration. The Nett BlueMAX™ system can be supplied with a diesel particulate filter (DPF) for simultaneous NO_X and PM control. Based on the duty cycle, a passive or active DPF can be supplied. The passive DPF is installed upstream of the SCR catalyst while an active DPF is installed downstream the SCR catalyst.

Technical Specifications

Urea Dosing System

Urea Pump and Electronic Control Unit (ECU)

Mechanical Data	
Maximum capacity (l/h)	7.5
Air supply pressure (MPa)	0.6-1.2
Air consumption rate (l/min)	20-25
Working temperature (°C)	-40 to +85
Storage temperature (°C)	-40 to +85
Accuracy and repeatability	+/- 1%
Urea solution temperature (°C)	-5 to +50 (peak 85)
Maximum filter dimension for air and urea (microns)	100
Electrical Data	
System supply voltage (VDC)	24
Range of supply voltage (VDC)	9-32
Maximum current at 24 V (A)	7.6
Maximum power consumption (W)	150

Compressor

Mechanical Data	
Maximum pressure (MPa)	0.69
Air flow (l/min @0.7 MPa)	26.5
Max. ambient air temperature (°C)	40
Min. ambient start temperature (°C)	10
Electrical Data	
Motor rated power (hp)	1/3
Motor voltage (VDC)	24
Power at rated load (W)	440
Current at rated load (A)	18.5
Starting current (locked rotor, A)	122

Urea Tank

Capacity (liters)	25, 35, 45, 55, 65, 85, 100
Fluid	32.5% water based urea solution (according to DIN70 070)