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Operations Manual

Nett BlueMAX™ SCR System

V1.4

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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.

The process of urea decomposition is typically described by the following hydrolysis reaction:

$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$$

In practice, the decomposition of urea proceeds through two separate reactions, involving an isocyanic acid (HNCO) intermediate. In the first reaction, HNCO and one molecule of ammonia are formed by thermolysis of urea, followed by hydrolysis of the HNCO with the formation of second NH_3 molecule:

$$CO(NH_2)_2 \rightarrow NH_3 + HNCO$$

$$HNCO + H_2O \rightarrow NH_3 + CO_2$$

A possible alternative path of urea decomposition is a direct thermolysis with the formation of an $\cdot NH_2$ radical:

$$CO\,(NH_2)_2 \rightarrow 2\,\cdot NH_2 + CO$$

This thermal decomposition is confirmed by an evidenced formation of CO during SCR processes with urea. The $\cdot NH_2$ radical can then react with NO as follows:

$$\cdot NH_2 + NO \rightarrow N_2 + H_2O$$

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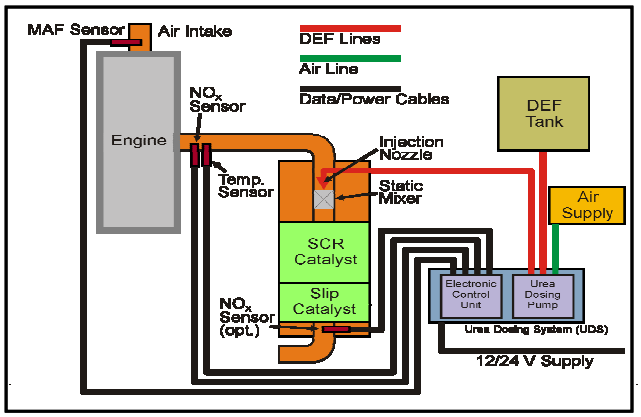
How the Nett BlueMAX™ System Works

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: Nett BlueMAX™ 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.

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.

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Urea Dosing System

Urea Pump and Electronic Control Unit (ECU)

Mechanical Data		
Maximum capacity	7.5 L/hr	1.98 gal/hr
Air supply pressure	0.6-1.2 MPa	87.02-174.05 psi
Air consumption rate	20-25 L/min	5.28-6.6 gal/min
Working temperature	-11 to +85 °C	12.2 to 185 °F
Storage temperature	-11 to +85 °C	12.2 to 185 °F
Accuracy and repeatability	+/- 1%	+/- 1%
Urea solution temperature	-5 to +50 °C (peak 85 °C)	23 to 122 °F (peak 185 °F)
Maximum filter dimension for air and urea (microns)	100	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 (BlueMAX™ 100 Models Only)

Mechanical Data		
Maximum pressure	0.69 MPa	100.08 psi
Air flow (l/min @0.7 MPa)	26.5 L/min @ 0.7 MPa	7 gal/min @ 101.5 psi
Max. ambient air temperature	40 °C	104 °F
Min. ambient start temperature	10 °C	50 °F
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
Urea Solution	32.5% water based urea solution (according to DIN70 070)

Nett BlueMAX™ System 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: Standard Models and Sizing Chart

Model		Max. Engine Power	
BlueMAX™ 100	**BlueMAX™ 200**	**kW**	**hp**
GL5100	GL5150	75	100
GL5200	GL5250	110	150
GL5300	GL5350	150	200
GL5400	GL5450	185	250
GL5500	GL5550	225	300
GL5600	GL5650	260	350
GL5700	GL5750	300	400
GL5800	GL5850	335	450
GL5900	GL5950	370	500
GL – BlueMAX™ SCR System			

Urea Replenishment and Consumption

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. Table 2 gives the specifications of aqueous urea solution for SCR application.

Table 2: Specifications of Urea Solution for SCR Application

Property	Unit	Siemens (1999)	DIN V 70070
Name		Aqueous urea solution	NO_x reduction additive AUS 32
Urea content	% wt.	32.5 ±0.5	31.8 – 33.3
Density at 20°C	g/cm^3	1.085[a]	1.0870 – 1.0920
pH		9 – 11	-
Appearance		Colorless	Colorless liquid†
Point of crystallization	°C/°F	-11/12.2	-11†/12.2†
Refractive index @20°C		-	1.3817 – 1.3840
Alkalinity as NH_3 (max.)	%	0.4	0.2
Carbonate as CO_2 (max.)	%	0.4	0.2
Biuret (max.)	%	0.4	0.3
Formaldehyde (max.)	mg/kg	-	10
Insolubles (max.)	mg/kg	-	20
Phosphate, PO_4 (max.)	mg/kg	-	0.5
Calcium (max.)	mg/kg	1[b]	0.5
Iron (max.)	mg/kg	-	0.5
Copper (max.)	mg/kg	-	0.2
Zinc (max.)	mg/kg	-	0.2
Chromium (max.)	mg/kg	-	0.2
Nickel (max.)	mg/kg	-	0.2
Magnesium (max.)	mg/kg	-	0.5
Sodium (max.)	mg/kg	-	0.5
Potassium (max.)	mg/kg	-	0.5
Viscosity (dynamic) @25°C	mPa·s	-	~1.4†
Thermal conductivity @25°C	W/mK	-	~0.570†
Specific heat @25°C	kJ/kgK	-	~3.40†
Surface tension (min.)	mN/m	-	65†

† informative only (not normative)
a – at 15°C
b – mg/dm^3

Source: DieselNet

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).

Urea Handling & Storage

Urea is a synthesized chemical that contains ammonia and carbon dioxide. In the solid form it contains the highest nitrogen content of any non-hazardous commercially produced material. Approximately 95% of all urea consumed in the U.S. is used as either an agricultural fertilizer (85%) or as a component of formaldehyde resin production (10%).

In general, urea is considered a non-hazardous and non-toxic material. As with all chemicals, urea should be treated with respect, caution and the proper personal protective equipment (PPE).

PPE should be used to protect against accidental contact with the product. The use of chemical resistant gloves and face shield are the recommended minimum.

Skin: Short term contact with skin causes no injury. Prolonged contact can cause a rash or minor irritation. Washing with soap and water is sufficient to clean the contacted area. Clothing that has been exposed should be removed as soon as possible. Clothing can be cleaned using a normal washing cycle.

Eye: Chemical goggles and/or face shield should be worn when handling urea solution to avoid accidental contact with eyes. Urea solution is somewhat basic which will cause short-lasting eye irritation. Any contact should be immediately flushed from the eye using standard eyewash procedures.

Please refer to the attached MSDS for further details and instructions on safe handling procedures.

According to DIN V 70070, urea solutions should be stored in tanks made of austenitic Cr-Ni or Cr-Ni-Mo steels (copper or galvanized steel tanks should not be used). To minimize urea crystallization and hydrolysis, the optimum storage temperature is 25°C.

Maintenance Requirements

As the equipment owner, you are responsible for performing the required maintenance described below on your Nett BlueMAX™ System. Nett Technologies recommends that you retain all maintenance records and receipts of maintenance expenses and urea purchases. If you do not keep your receipts or fail to perform recommended scheduled maintenance as listed below in Table 3, Nett Technologies may have grounds to deny warranty coverage.

The most important maintenance that can be carried out to keep the BlueMAX™ system operating properly is **engine maintenance**. Wear to engine valves or rings can cause high lube oil consumption. This oil will exit the engine through the exhaust system, and it can irreversibly deactivate the catalyst.

Table 3: Maintenance Requirements

#	Service Times	Action Required
1	Daily (while in operation)	• Observe urea alarm box (mounted on cab) for indicator codes • Report any alarms to Nett Technologies *See Troubleshooting section for Error Codes*
2	Every 100hrs/bi-weekly	• Drain air tank inlet filter by depressing spring loaded pin • Drain air tank
3	Every 250hrs/monthly	• Clean air compressor inlet filter
4	Every 500hrs/3 months	• Inspect urea injection nozzle and if necessary clean by soaking in tap water
5	Every 1000hrs/6 months	• Drain urea tank and flush using clean tap water • Inspect urea filter and clean using tap water
6	Every 1500 hrs/9 months	• Change compressor brushes at 1500 hrs of operation and at 800 hrs after

Note: Servicing should be done for which ever service time comes first (i.e. hours or monthly)

The following are step-by-step instructions for performing the scheduled maintenance services as mentioned in Table 3.

1) Daily Operations (While in Operation)

i. Locate the urea alarm box mounted on the vehicle cab (see Figure 2 below).
ii. Read error code display (outlined in Figure 2).
iii. Call Nett Technologies to report any error codes.
iv. Once the error has been rectified, the error code will disappear from the alarm box display.

Figure 2: Urea Alarm Box Display

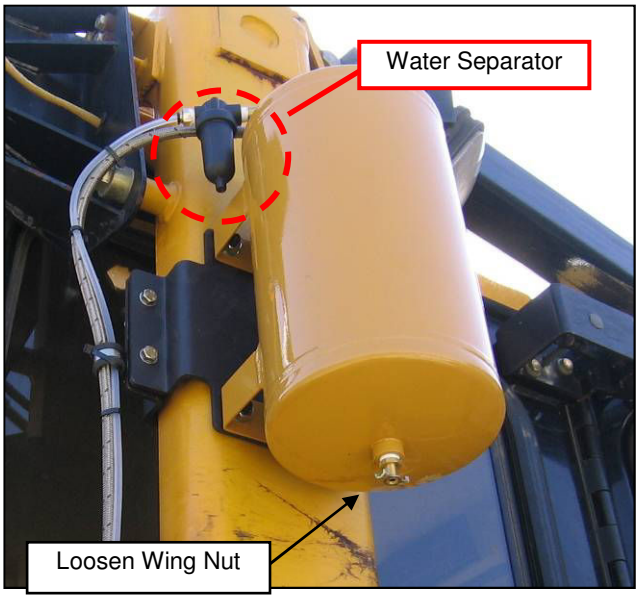
2) Every 100 Hours or Bi-Weekly

i. Locate the air tank on the vehicle.

ii. At the bottom of the air tank, locate the brass drain plug & wing nut fitting (outlined in Figure 3).

iii. Loosen the wing nut by approximately one half turn.

Figure 3: Air Tank Indicating Wing Nut and Water Separator Location



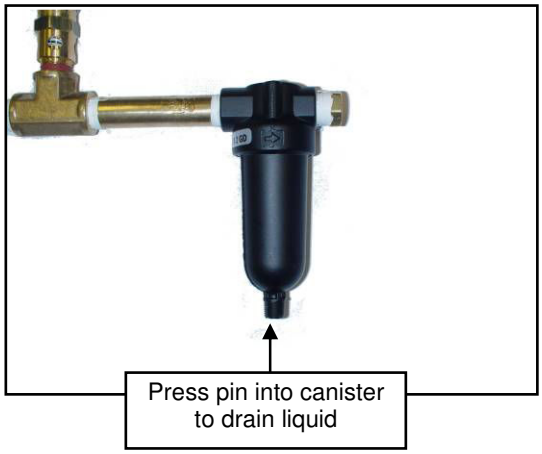
iv. Air will begin to drain once the wing nut has been loosened.

v. Once draining is complete, tighten the wing nut.

vi. Locate the Air Filter/Water Separator unit attached to the air tank inlet as shown in Figure 3.

vii. Drain water separator unit from air tank by depressing the spring loaded pin located at the bottom of the water separator canister. Remove any liquid collected (see Figure 4).

Figure 4: Drain Valve on Water Separator Unit

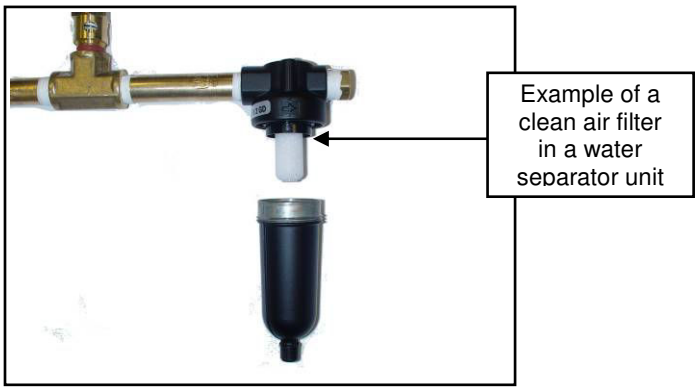


2) Every 100 Hours or Bi-Weekly continued…

viii. Unscrew the canister of the water separator unit to expose air filter.

ix. Check the condition of the air filter of the water separator unit. If air filter is dirty then replace it. See Figure 5 for reference.

Figure 5: Air Filter/Water Separator

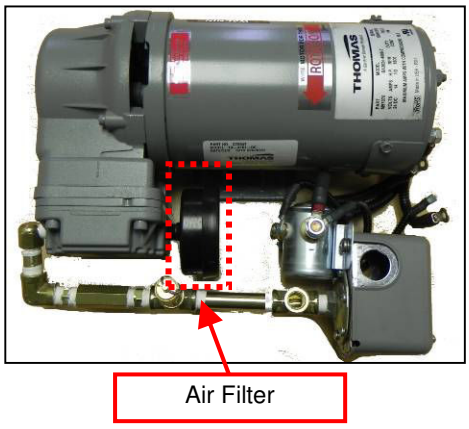


3) Every 250 Hours or Monthly

i. Locate the air filter assembly on the air compressor motor (see Figure 6).

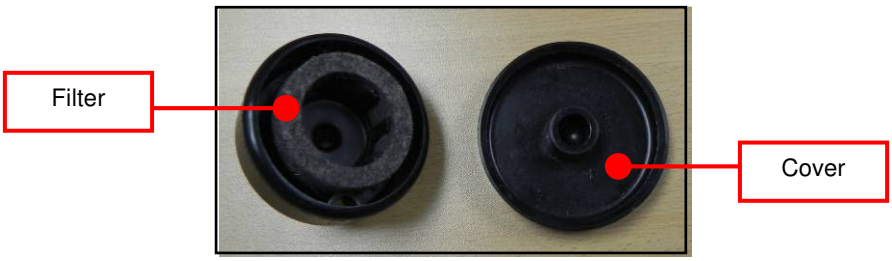
ii. Remove the air filter assembly by unscrewing it from the air compressor motor.

Figure 6: Air Compressor Motor



iii. Snap off the cover of the air filter assembly to expose the air filter as shown in Figure 7.

Figure 7: Air Filter Assembly



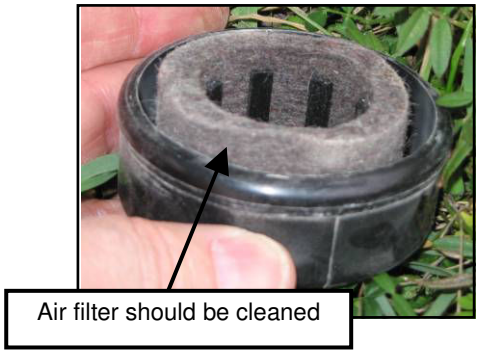
iv. Remove the air filter from within the assembly as shown in Figure 8.

Figure 8: Disassembled Air Filter Assembly

3) Every 250 Hours or Monthly continued…

v. Clean the air filter using compressed air using Figure 9 as a reference.

Figure 9: Dirty Air Filter



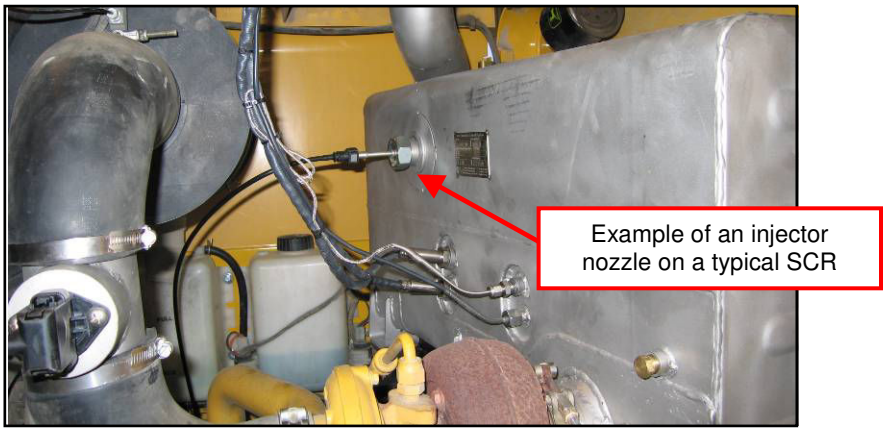
vi. Once the filter is clean, return it into the filter assembly, and secure it by re-installing the cover.

vii. Re-install the air filter assembly by threading it onto the air compressor motor.

4) Every 500 Hours or 3 Months

i. Locate the urea injection nozzle on the SCR unit as shown in Figure 10.

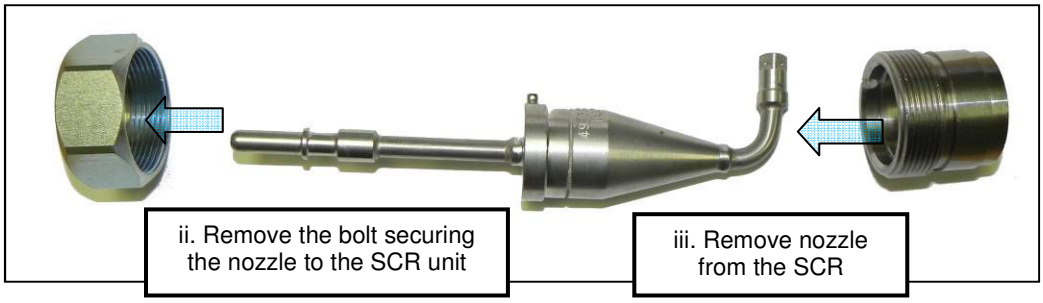
Figure 10: Typical SCR Installation



ii. Unscrew the bolt fastening the injection nozzle to the SCR unit.

iii. Remove the injection nozzle from the SCR unit as per Figure 11.

Figure 11: Injector Nozzle Assembly

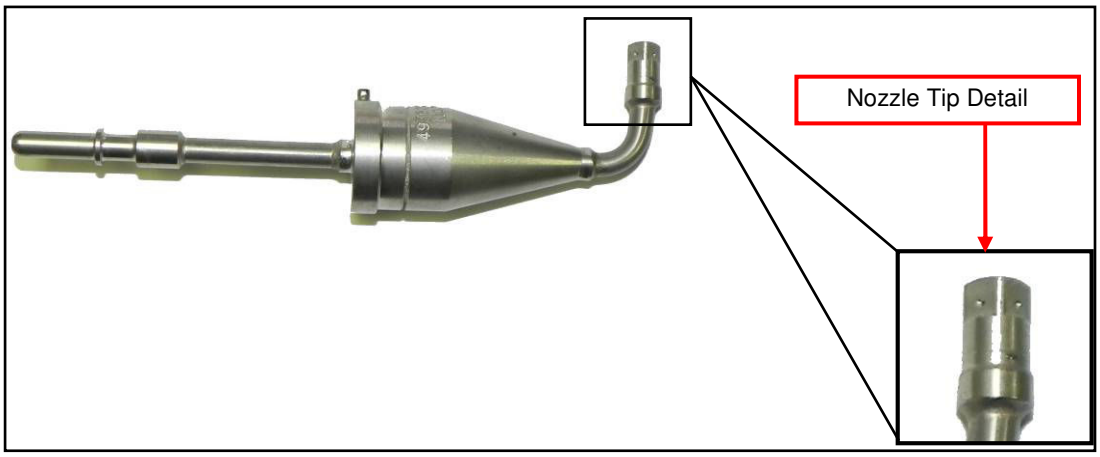


iv. Inspect the injector for urea build up (urea crystals) around the nozzle and within the four holes of the injector tip as shown in Figure 12.

v. If a build up exists, place injector nozzle in water to dissolve urea crystals. Note: Warmer/hotter water will dissolve urea crystals quickly.

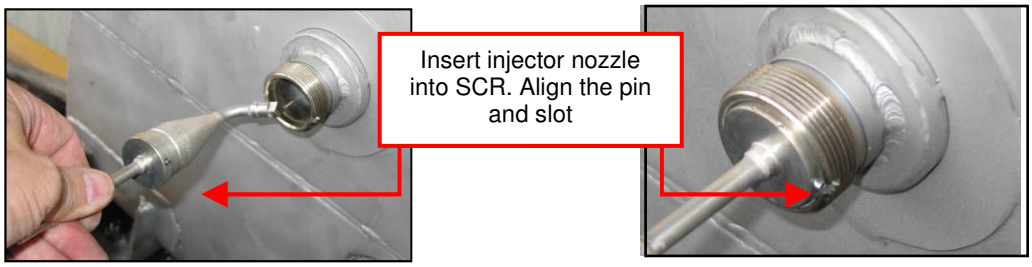
4) Every 500 Hours or 3 Months continued…

Figure 12: Injector Nozzle with Tip Detail



vi. Once the nozzle is cleaned, insert it into the SCR and fasten by tightening the bolt onto the injector port (see Figure 13). Be sure to align the nozzle pin with the slot on the injector port to ensure injection occurs in the exhaust flow direction.

Figure 13: Injector Nozzle Reassembly onto SCR

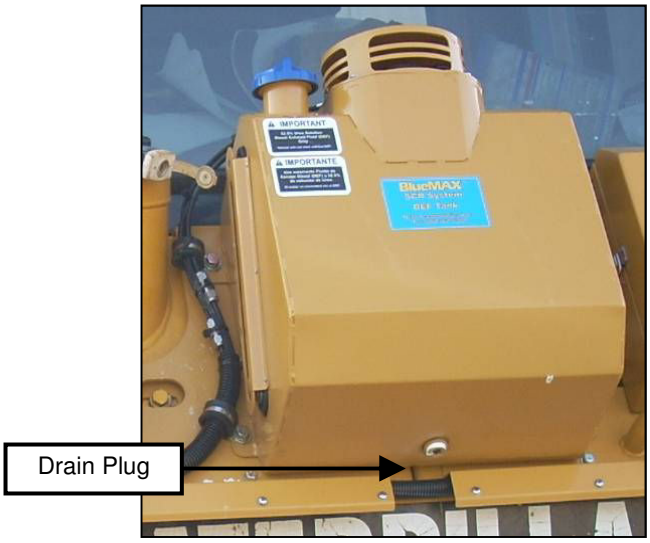


5) Every 1000 Hours or 6 Months

i. Locate the urea tank mounted on the vehicle.

ii. Drain urea by removing drain plug located at the bottom of the urea tank as shown in Figure 14. Use a clean container to collect urea to be re-used when refilling

Figure 14: Urea Tank



iii. Pour tap water into urea tank to flush out remaining urea solution.

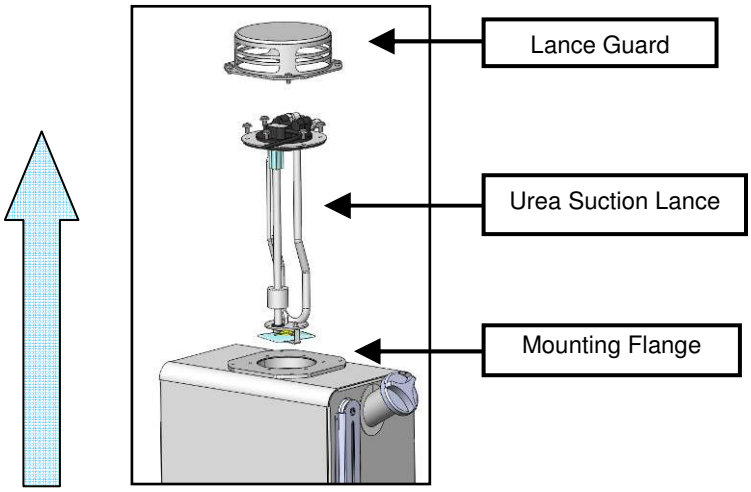
iv. Once drained out, flush again with tap water to ensure tank is flushed completely.

v. After flushing, reinstall the drain plug at the bottom of the urea tank.

vi. Re-fill the urea tank with urea solution.

vii. Remove the urea suction lance from the top of the urea tank by unscrewing the bolts securing it to the mounting flange as shown in Figure 15.

Figure 15: Urea Suction Lance Components



5) Every 1000 Hours or 6 Months continued…

viii. Check the urea filter located at the bottom of the urea suction lance to ensure it is not clogged with particles. See Figure 16 and 17 for location of filter.

Figure 16: Urea Suction Lance

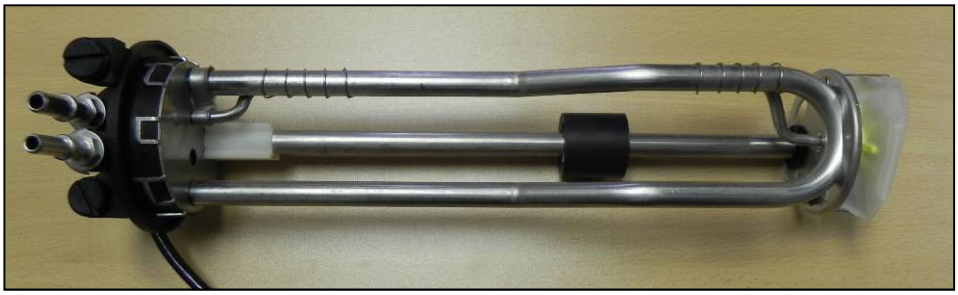
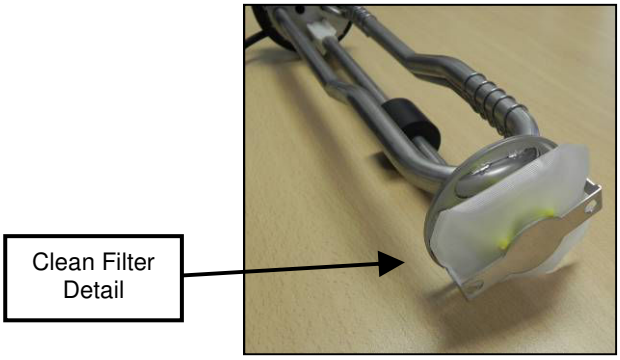


Figure 17: Urea Filter



ix. If the urea filter is clogged, it must be replaced.

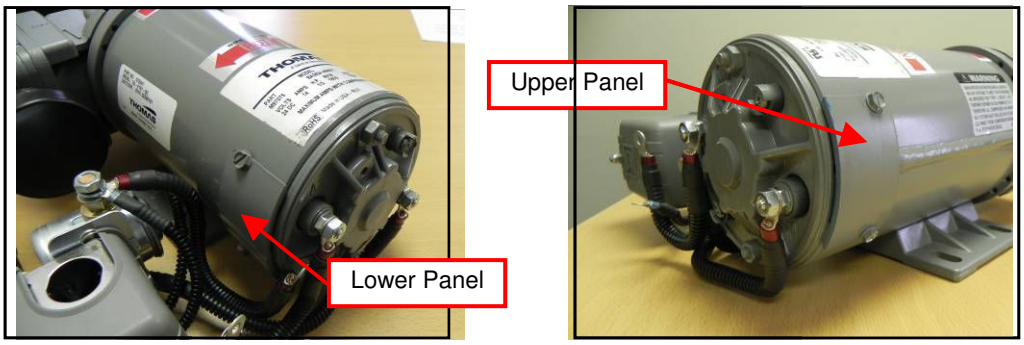
x. Re-insert the lance into the urea tank.

xi. Fasten the lance to the mounting flange using the original bolts.

6) Every 1500 Hours or 9 Months

i. Locate the two access panels for the brushes on either side of the air compressor housing as shown in Figure 18.

Figure 18: Panel Location on Air Compressor Motor

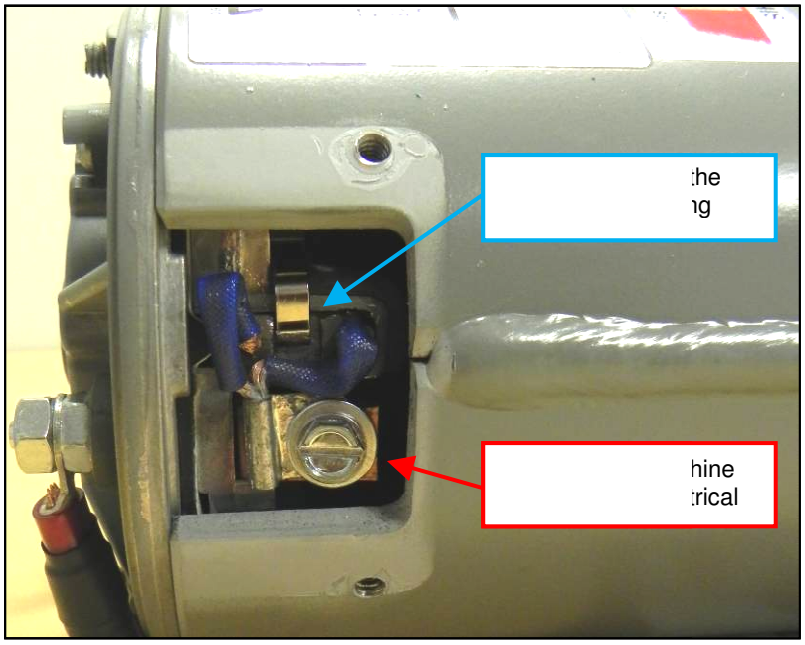


ii. Remove the access panels by unbolting (2 bolts/panel) from the compressor body.

iii. Remove the machine screw labeled in Figure 19 that attaches the motor brush lead wires to the copper electrical contact.

iv. Lift and disengage the retaining spring to allow for the removal of the motor brush (also labeled in Figure 19).

Figure 19: Interior of Access Panel



6) Every 1500 Hours or 9 Months continued…

v. Remove the worn brush and replace it with the new brush. Refer to Figure 20 for comparison.

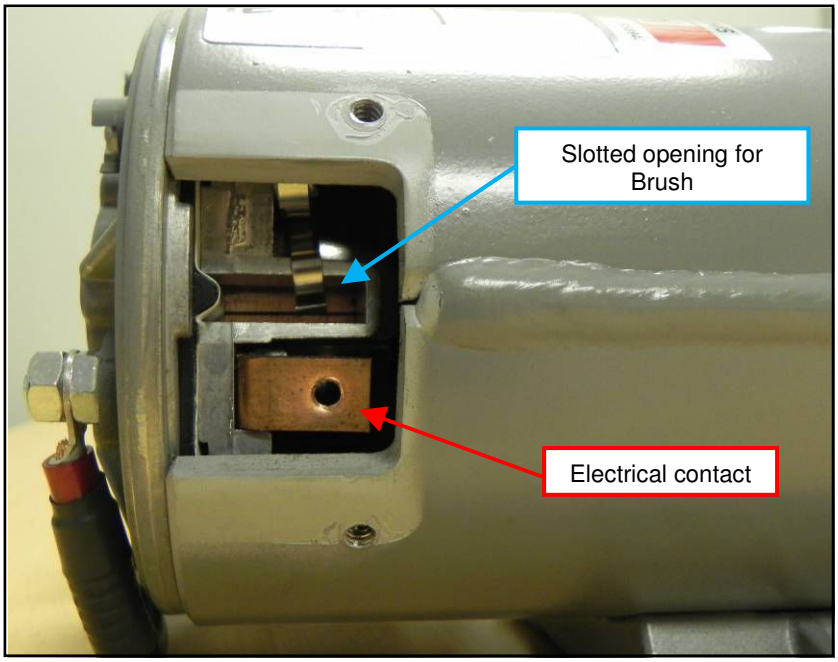
Figure 20: Comparison Between a New & Old Motor Brush

vi. Insert the motor brush back into the slotted opening, while holding the retaining spring so that it does not interfere. Refer to Figure 21.

vii. Release the retaining spring, returning it to its original position against the motor brush. Refer to Figure 21.

viii. Reattach the motor brush lead wires to the electrical contact; secure it with the original machine screw. Refer to Figure 21.

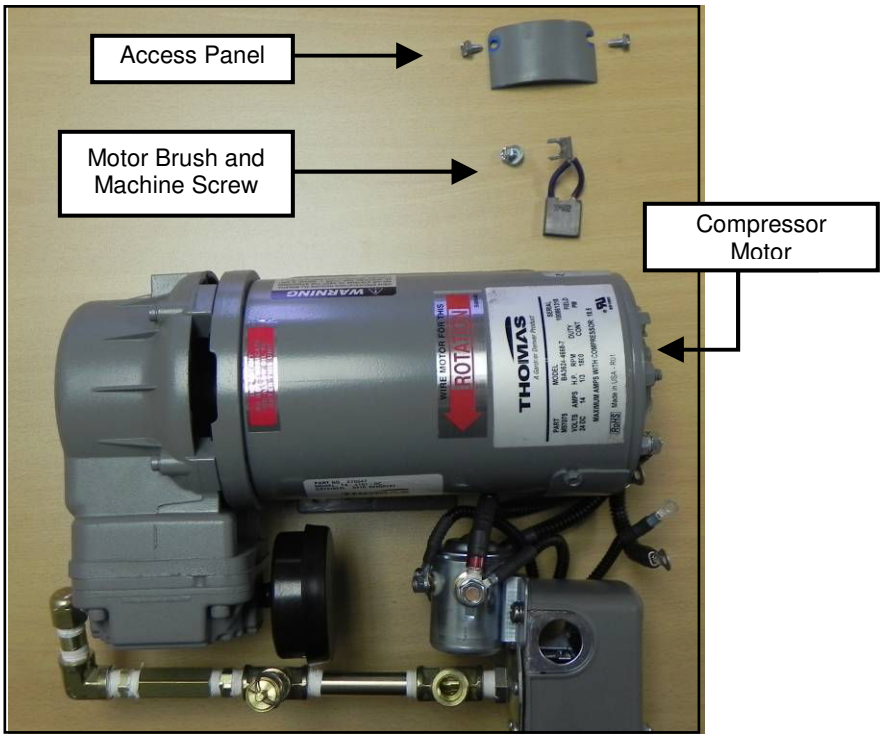
Figure 21: Interior of Access Panel without Brush and Spring



6) Every 1500 Hours or 9 Months continued…

ix. Reinstall the access panels to the air compressor body and tighten screws to secure (each component is outlined in Figure 22).

Figure 22: Components within Access Panel of Air Compressor Motor



Parts

Below is a table that lists the parts associated with the maintenance procedure. Included in the list are the corresponding part numbers and costs for reference.

Table 4: Part Identification & Cost

Part Name	Part Number
Digital Alarm Box	GP-00100-06-ALMBX-00010
Air Tank, 2 Gallon, Vertical	GP-00100-03-ARTNK-00010
Air Tank, 2 Gallon, Horizontal	GP-00100-03-ARTNK-00020
Air Water Separator Unit, ¼" NPT, 5um, inlet 300 psi, manual drain, metal bowl	GP-00100-03-FILTR-00010
Air Water Separator Filter	GP-00100—02-ARFLT-00020
Urea Injection Nozzle	GP-00100-06-IJNOZ-00010
Suction Lance Kit	GP-00100-05-SCNLC-00010
Urea Filter – Suction Lance Kit	GP-00100-11-FILTR-00010
Urea Tank Drain Valve, ½" NPT(M), hex socket	GP-00100-10-FTTNG-00160
Compressor Pump 12V	GP-00100-02-CMPSR-00012
Compressor Pump 24V	GP-00100-02-CMPSR-00024
Air Filter Assembly, Compressor Intake	GP-00100-02-FILTR-00010
Compressor Air Filter	GP-00100-02-ARFLT-00010
Motor Brushes & Springs (kit of 2)	GP-00100-11-MBRSH-00010

Please contact Nett Technologies for ordering parts.

Troubleshooting

The digital display of your Nett BlueMAX™ System will be activated when an OBD error is detected. The number displayed indicates the type of OBD error. Recommended action is as per table 4 below.

Table 5: Troubleshooting

OBD Error	Error Code	MIL	Urea	Comments
EEPROM	1	On	Off	Switch of power supply and restart after one minute. If problem persists, contact Nett.
Drive Unit	2	On	Off	Switch of power supply and restart after one minute. If problem persists, contact Nett.
NOX Sensor In	3	On	Off	Check the NOX sensor and its connections including relays and fuses. If problem exists contact Nett.
MAF Sensor	4	On	Off	Check the MAF sensor and its connections. If clogged, clean by blowing air.
Catalyst Temp. In	5	On	Off	Check the temperature sensor and its connections. If problem persists change temperature sensor.
Dosing Valve	7	On	Off	Dismount the urea in tube and inject clean water into the suction inlet to make the urea pump prime. If problem persists, contact Nett.
Internal Heater	10	On	Off	Contact Nett.
Pump Head Temp.	12	On	Off	Temperature is above + 85^0 C. Urea pump cannot work at this temperature.
Pump Frozen	13	On	Off	Temperature is below – 5^0 C. Allow few seconds after restart. If problem continues, contact Nett.
Blocked Nozzle	16	On	Off	Blocked injection line or nozzle. Use clean water to unblock the nozzle or the injection line. If problem persists, change injection line with nozzle.
Urea Level Sensor	17	On	Off	Check connections to urea lance. Check filter at bottom of lance.
Urea Tank Level – Full – Low – Empty	18 18 E	Off Off Off	Off On On	Refill urea tank.

OBD Error	Error Code	MIL	Urea	Comments
Air-Urea Detection	19	On	Off	No air or urea present. Check compressor fuse, air filter, connections and check air presence by removing tube. If there is no urea present OBD error 18 will appear. Check for presence of urea in tank and all connections for damage and/or leakages.
Return Line	20	On	Off	Contact Nett
Any Other Errors	Report to Nett			
No Power – Check fuses, power supply, main harness connection to urea dosing pump, and alarm box for OBD codes.				
Urea stalactite (white deposits) are visible at the exhaust pipe; report to Nett.				
When the system is first switched on, the MIL light appears and stays for 30 seconds indicating that the system is priming and not ready for use. The light disappears after 30 seconds. When the system is shut down, the system purges for 30 seconds before shutting down.				
IMPORTANT: DO NOT OPERATE THE EQUIPMENT WITH EMPTY UREA TANK; THE EQUIPMENT WILL NOT START. IF THE EQUIPMENT DOES NOT START EVEN WITH UREA AND AIR PRESENT CHECK ALL FUSES IN BLUEMAX COMPRESSOR AND DOSING UNIT.				