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**New Technology Research & Development Program
Grant Contract 582-5-65591-0011**

Task 1 Deliverable Report

The preparation of this report is based on work funded in part
by the State of Texas through a Grant from the
Texas Commission on Environmental Quality.

clēaire

ADVANCED EMISSION CONTROLS®

February 5, 2007

Ms. Katherine M. Williams
Grant Management and Monitoring Team
Air Quality Planning and Implementation Division
Texas Commission on Environmental Quality
Mail Code: 204
P.O. Box 13087
Austin, TX 78711-3087

RE: NTRD Contract No. 582-5-65591-0011

Dear Kate:

Please accept the enclosed submittal to replace the report Cleaire originally submitted to the TCEQ on April 18, 2005 to complete the Task 1 Scope-of-Work in the NTRD contract.

The original Lonestar constructed for this grant was installed on a refuse truck for the Department of Sanitation New York (DSNY). Unfortunately, the technician's camera was stolen at the New York airport with all the pictures of the installed Lonestar system. Since that time, the design of the Lonestar has changed with TCEQ's approval (a DPF replaced the particulate control module in the original design).

Photographs of the current design Lonestar constructed for this grant are included in the attached "Revised Report for Task 1: Construction of the Lonestar Systems." Operating data from these two systems (AC Transit bus #3023 and bus #3029) was submitted to the EPA in October 2006 and a copy was provided to the TCEQ.

Please contact me if you have any questions or would like additional information regarding this revised report for the completion of Task 1.

Sincerely,

(submitted via email)

William D. Binder, P.E.
Project Manager

Encl: Revised Report for Task 1

**Revised Report for Task 1:
Construction of the Lonestar Systems**

submitted by

Cleaire Advanced Emission Controls, LLC

for

**New Technology Research & Development Program
Grant Contract 582-5-65591-0011**

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by the State of Texas through a Grant from the
Texas Commission on Environmental Quality.

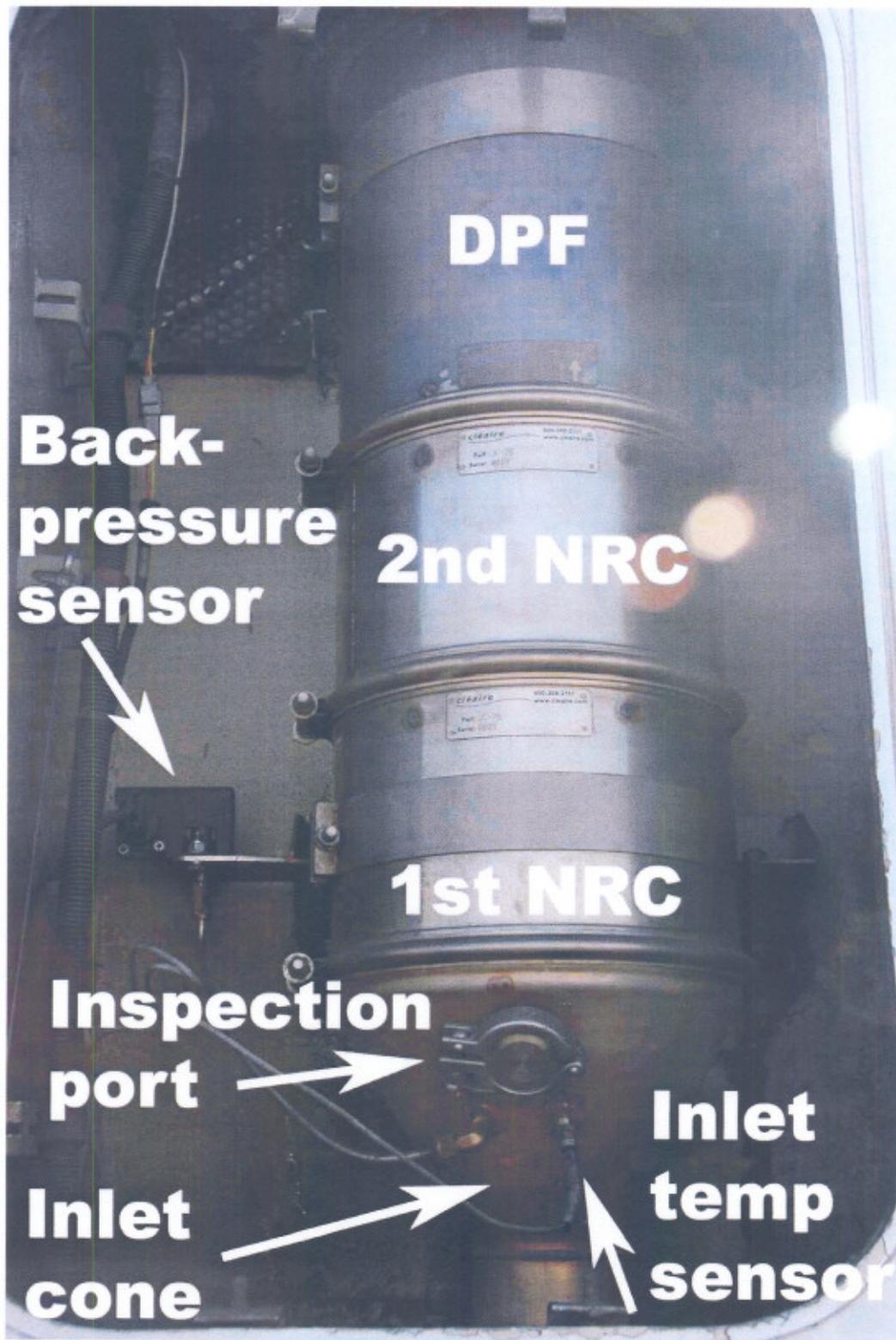


Lonestar system installed on AC Transit bus #3023

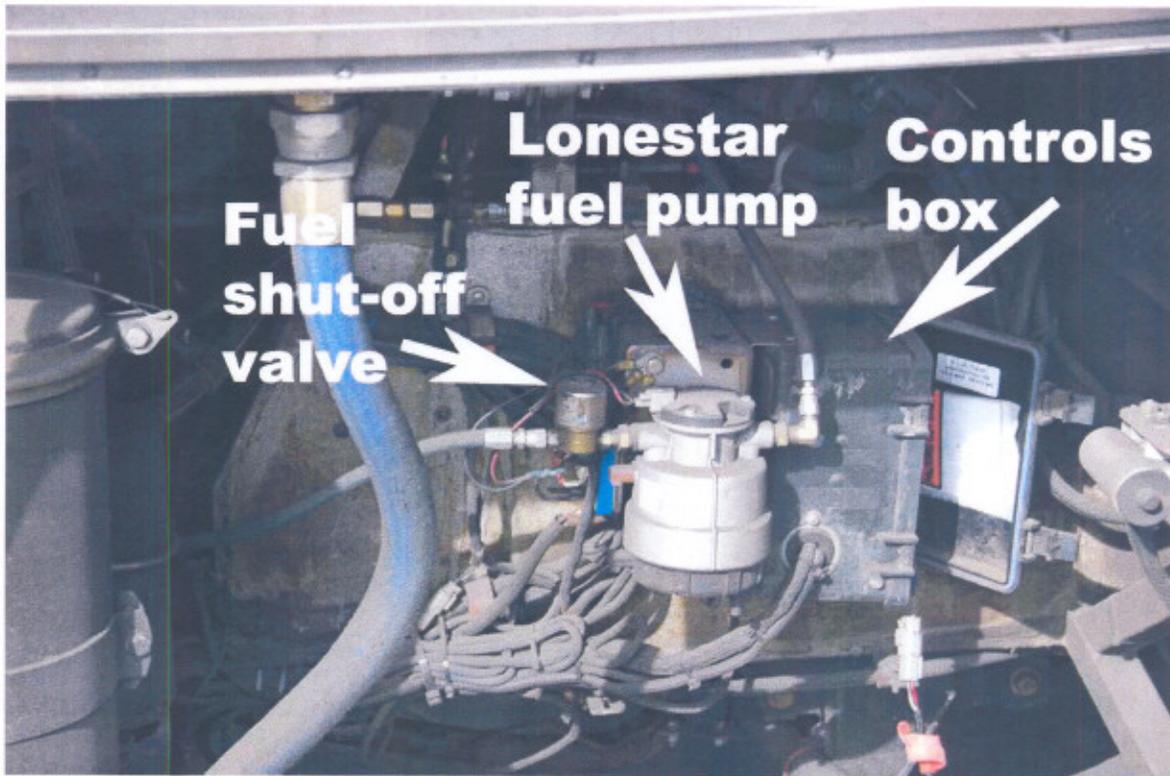


Lonestar system installed on AC Transit bus #3029

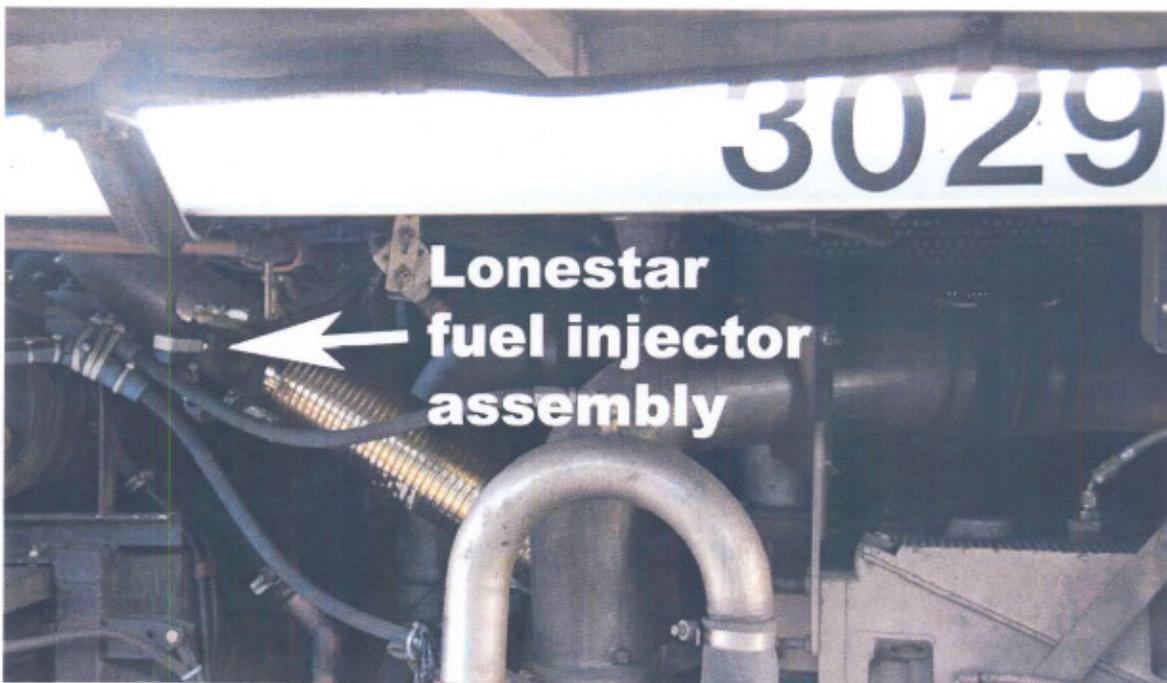
Note: the Lonestar systems are identical on each bus



Major components of Lonestar catalyst assembly and backpressure sensor



Note: the Controls Box contains the Claire MLC[®]



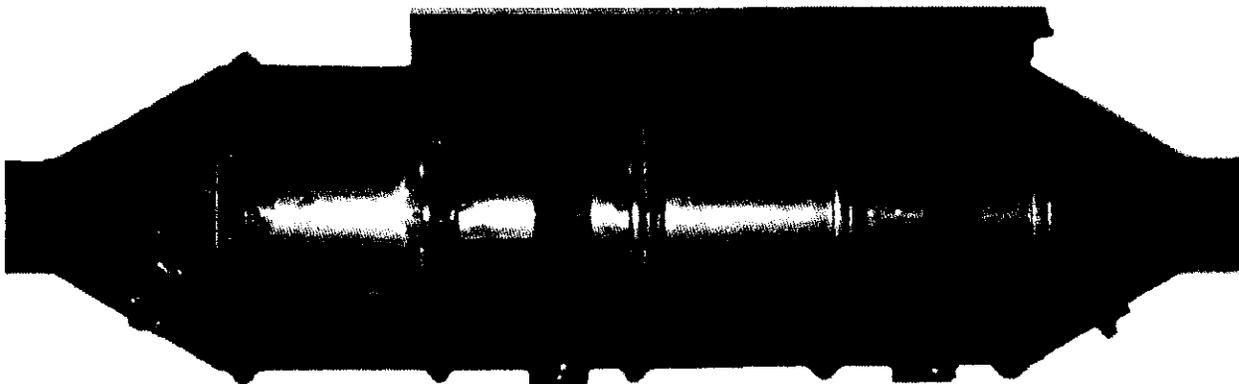
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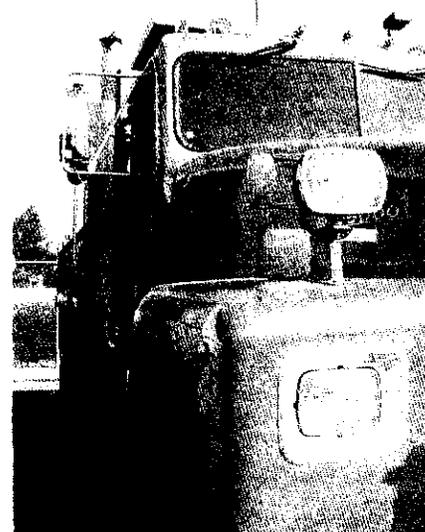
Lonestar™

Owner's Manual

9/21/05



U.S. Patent # 6,814,303 and patents pending



Cleaire Lonestar™ Owner's Manual
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I. INTRODUCTION

A. Cautions

- **Please study this manual and understand the requirements for the Cleaire Lonestar™ system before operating your vehicle.**
- **Be sure to use the appropriate diesel fuel specified for your system (see p. 9).**

The pictures and descriptions in this manual are for a typical Lonestar system. Some parts, components and configurations for your particular system may vary from those shown here depending on the vehicle and application.

The use of parts that are materially different than the verified retrofit parts or systems may void the verification and the warranty. ULSD or TxLED is required for verified systems.

The Cleaire Lonestar system is designed to operate automatically. The owner's obligations, routine observations and periodic maintenance requirements are described in this manual. Contact your distributor if you need further assistance.

B. Owner's Obligations

The installation of the Lonestar system is based on the owner's understanding that adding a new part to or altering an original part of a certified configuration could be considered a violation of the tampering prohibition of the Clean Air Act. The owner understands that the installation of the Lonestar will not violate tampering provisions of the Act, at the time of installation, because of the testing performed under the verification process and provided the owner adheres to all installation instructions and meets all operating and maintenance requirements for the Lonestar.

- **Events that require action by the owner or operator are given in the Owner's Obligations Chart (page 18).**
- **If any of these events occur, it is the owner's obligation to take the appropriate action; otherwise, failure to do so may invalidate the warranty.**

C. Installation

The Lonestar may only be installed by a Cleaire-authorized technician. The complete installation procedures are described in the "Longview, Alliance and Lonestar Installation Manual." Copies of the manual are available upon request from your distributor or Cleaire.

D. Contact Information

Contact your distributor for any sales or service support for your Lonestar system. For additional information, you may contact Cleaire at 800-308-2111 or see www.cleaire.com.

II. LONESTAR™ SYSTEM OVERVIEW

A. Features

The Lonestar system reduces oxides of nitrogen (NOx), particulate matter (PM), carbon monoxide (CO) and unburned hydrocarbons (HC) from the diesel engine exhaust. Features include:

- NOx reduction catalyst (NRC)
- Particulate control module (PCM)
- Cleaire MLC® (the “brains” of the system)
- Stainless steel construction
- Modular design to facilitate installation, service and maintenance
- Sound attenuation eliminating the need for a muffler or silencer

B. Catalyst Assembly

The catalyst assembly (Figure 1) is the core of the Lonestar system and it replaces the stock muffler. The catalyst assembly has some important features highlighted here and it is described in greater detail in the System Description section (§III, page 4).

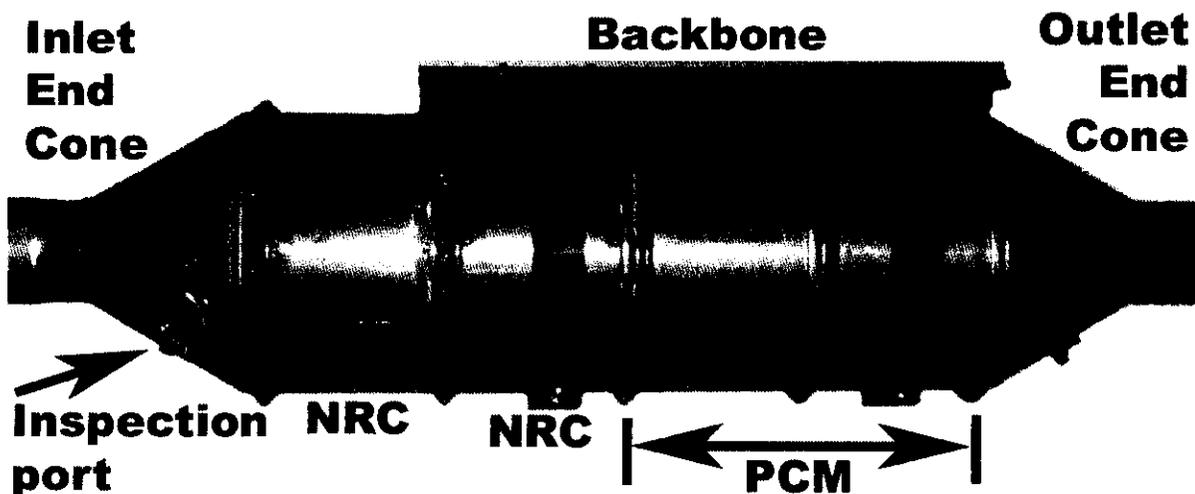


Figure 1. Catalyst Assembly (End cone configurations vary depending on vehicle).

Although the catalyst assembly replaces the stock muffler, it is important to note that the catalyst assembly is approximately twice the weight of a typical muffler. Cleaire provides a mounting assembly specifically designed for the Lonestar. The care and handling requirements for the catalyst assembly are as follows:

1. Do not drop or hammer.
2. Ensure that the mounting assembly, clamps, and straps are secure.
3. Protect from excessive vibration.
4. Protect from water intrusion.
5. Protect from accidental impacts.
6. Do not weld.

Caution:
Handle with care!

SAFETY WARNINGS:

- Do not touch the Lonestar catalyst assembly or tubing during or after operation. All surfaces can become hot and may cause burns. At times, the catalyst assembly (and especially the end cones) may be at a higher temperature than a muffler would be under the same engine conditions.
- The catalyst assembly stays hotter much longer than a stock muffler will after the engine is turned off.
- If it is necessary to move a hot catalyst module, use gloves and other appropriate precautions (as previously mentioned, it is much heavier than a muffler).

C. Acronyms

BP	backpressure
CARB	California Air Resources Board
CO	carbon monoxide
FIS	fuel injection system
HC	hydrocarbons
LED	light emitting diode
MLC®	the "brains" of the Lonestar® system
<i>MLinC</i>	the software program used to communicate with the MLC
NOx	nitrogen oxides
NRC	NOx reducing catalyst
PCM	particulate control module
PM	particulate matter (diesel soot)
TC	thermocouple
TxLED	Texas low emission diesel
ULSD	ultra-low sulfur diesel
VDC	volts direct current
VOC	volatile organic compound (regulatory term for hydrocarbon)

III. SYSTEM DESCRIPTION

A. Process Description

The Cleaire Lonestar system shown in (Figure 2) consists of three main subsystems: the catalyst assembly (Figure 1), the fuel delivery system (Figure 3), and the control system.

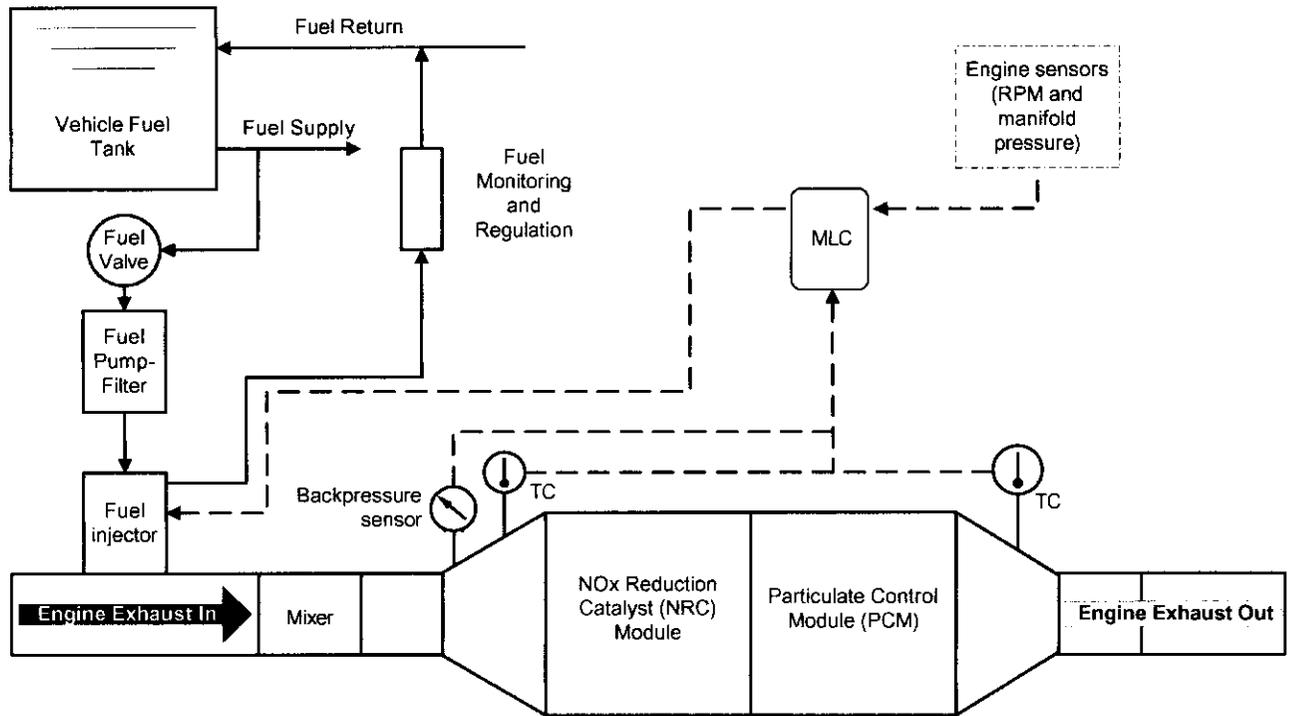


Figure 2. Cleaire Lonestar system.

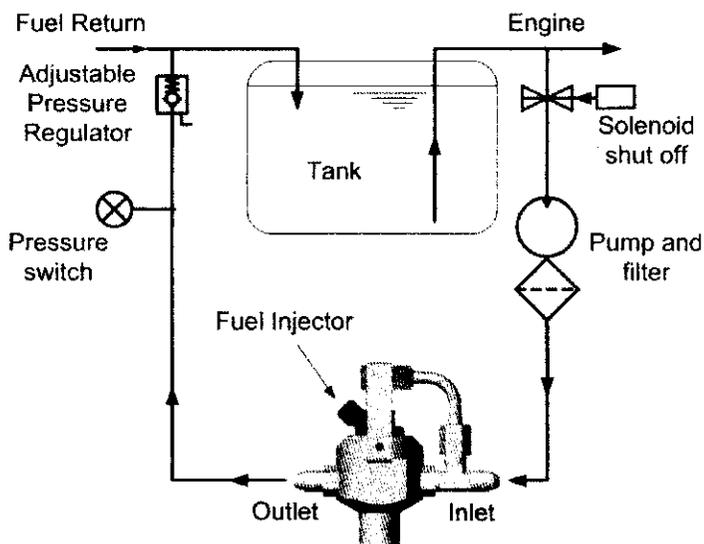


Figure 3. Fuel system flow diagram.

The MLC[®] monitors engine conditions, Lonestar system operation and controls the fuel addition. The injector adds fuel (Figure 3) at the rate dictated by the MLC in order to provide a reducing agent for the NRC. With the addition of diesel fuel to the engine exhaust by the fuel injector, the NRC reduces the NOx emissions to the atmosphere. The fuel addition also causes an increased exhaust gas temperature, thus enhancing the catalytic activity of the PCM. The PCM reduces the PM, HC (VOC) and CO emissions.

Fuel is drawn directly from the vehicle fuel supply system to ensure that it will not interfere with engine operation. A combination pump-filter pressurizes the fuel to the injector. (Note: the Lonestar fuel pump does not turn on until approximately 30 seconds after the engine starts.) The fuel injector is mounted in a fuel-cooled assembly attached to the exhaust tube upstream of the catalyst assembly. The fuel flow is monitored and regulated by the pressure switch, regulator-check valve, and shut-off solenoid valve.

The PCM partially filters the exhaust, which results in a backpressure on the engine. At times, the backpressure from the PCM (and Lonestar system as a whole) may be higher than the backpressure caused by a muffler (typically less than 40 inches of water (9.9 kPa) pressure). The actual amount of backpressure from the Lonestar varies instantaneously depending on the engine speed and load, soot load in the PCM, and ambient conditions.

The MLC reads the backpressure sensor and calculates the combined soot load in the PCM. If the backpressure limit (85 inches of water (21 kPa) pressure) is triggered, a message and some data will be written to a special portion of the MLC's memory for future download (note that this is permanent memory, erasable only by Cleaire-approved technicians). The MLC turns on the amber light to alert the vehicle owner to bring the system in for service (see Owner's Obligations Chart, page 18) if the soot load is above recommended limits. The constant monitoring by the backpressure sensor and MLC ensures that the backpressure is within safe limits and alerts the owner in time to take corrective action if necessary.

The MLC not only monitors the system and outputs warnings to the system user, but also continually logs operating data and records instances of unusual conditions.

B. Major Component Pictures

The major components of the Lonestar system are shown in this section (except the catalyst assembly, which is shown in Figure 1, page 2). For a description of how each component operates and its purpose for the overall system, see the Process Description section (§III.A, page 4).

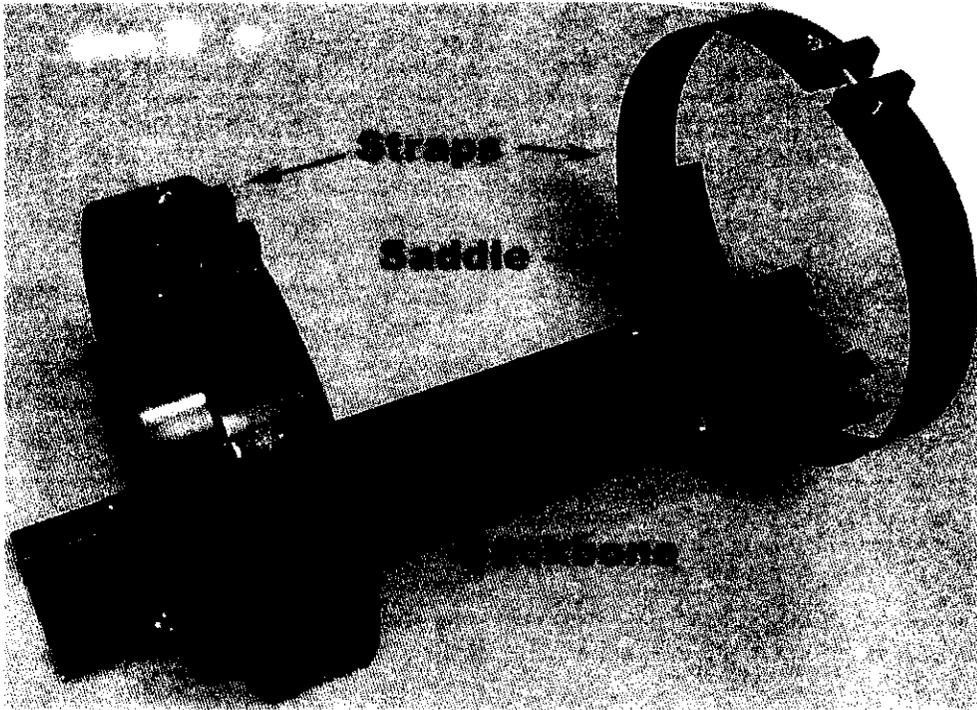


Figure 4. Mounting Assembly: backbone, saddles and straps.

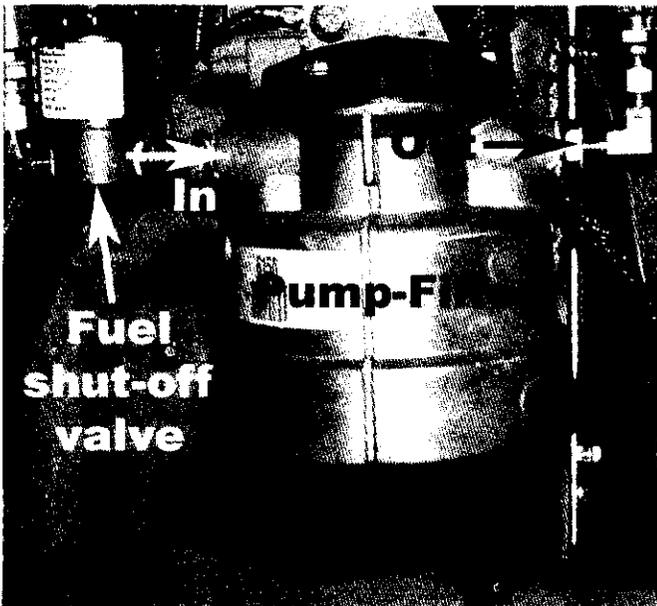


Figure 5. Fuel pump-filter and shut-off valve.

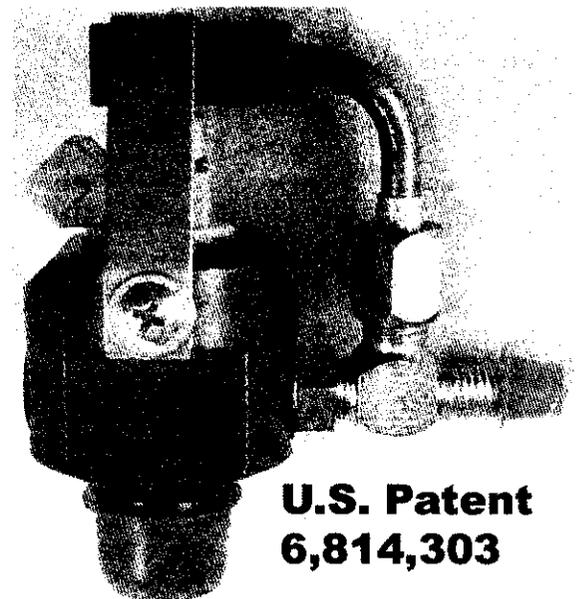


Figure 6. Fuel injector and mount.

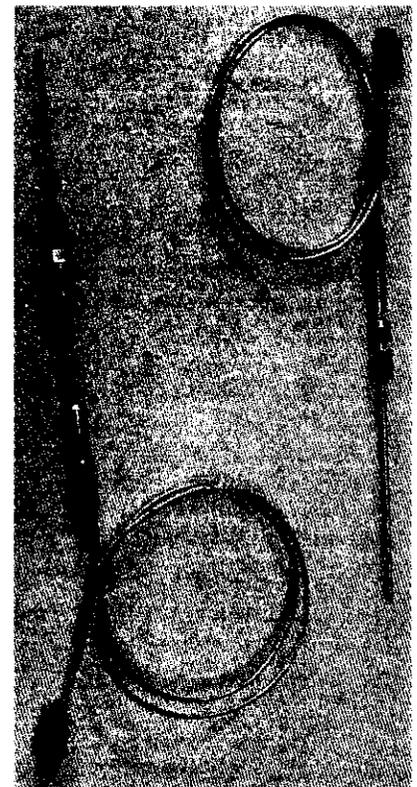
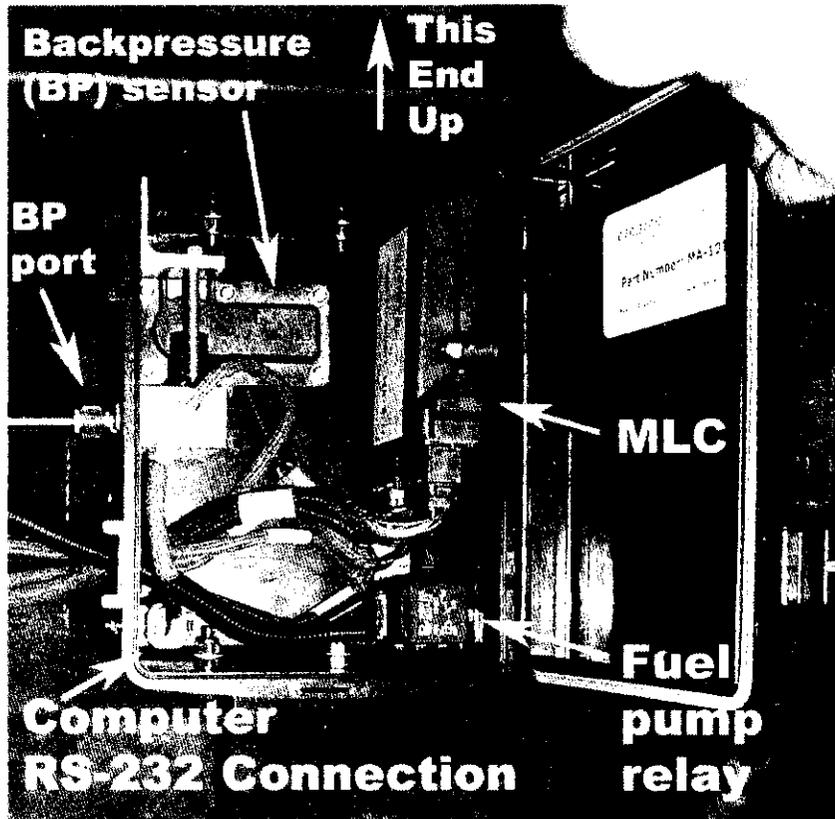


Figure 7. Controls box with MLC, BP sensor and pump relay.

Figure 8. Thermocouple.

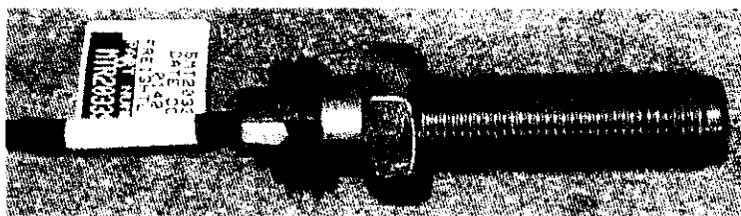


Figure 9. Engine speed sensor.



Figure 10. Manifold pressure sensor.

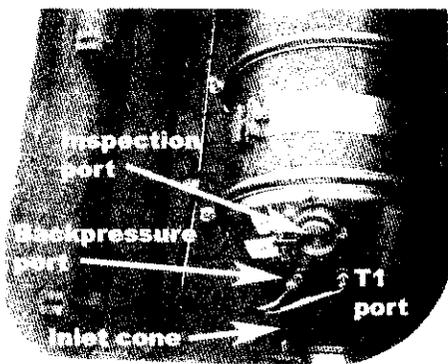


Figure 11. Inspection port.



Figure 12. Mixer

IV. OPERATIONS

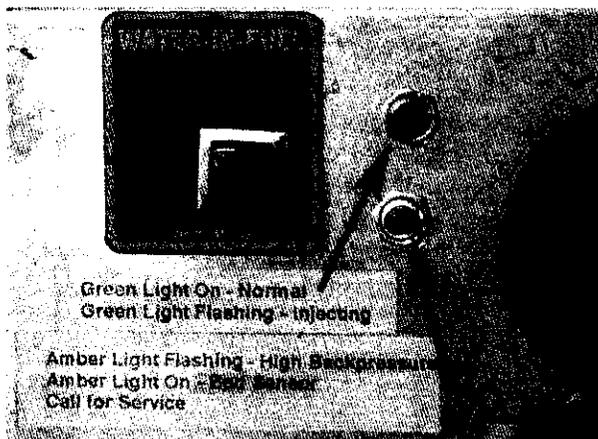
A. Observing the Lonestar System

The green light on indicates that the Lonestar system is operational. During normal operation, the amber light will be off. If the amber light comes on or blinks, contact a Cleaire-authorized technician as soon as practical. The indicator lights are described below. Refer to the Troubleshooting Table (page 13) if you suspect the system is not operating properly.

1. At a minimum, the operator should observe the green and amber lights upon engine start-up, operation and shut-down.
2. During engine operation, note any indications of unusual exhaust emissions or odor. Notify a Cleaire-authorized technician if any unusual odors or emissions are observed.
3. Periodically inspect the exhaust system for integrity. Note anything abnormal and make repairs as warranted. For vertical exhaust stacks, make sure the rain cap is in place and functioning properly. Contact a Cleaire-authorized technician as needed.
4. Periodically inspect the Lonestar fuel system for integrity. Note anything abnormal and make repairs as warranted. Contact a Cleaire-authorized technician as needed.

B. Indicator Lights

Amber and green indicator lights (Figure 13) alert the driver or vehicle service technician to the Lonestar system's operating condition. It is important that the operator and/or technician observes the lights on a regular basis and responds accordingly.



Note:

The location of the LEDs may vary depending on the vehicle.

Figure 13. Lonestar system indicator lights.

○ **Green Light – On:**

When the system power is on, the green light will be illuminated. The green light indicates a normal, healthy system (as long as the amber light is not on or blinking).

○ **Green Light – Off:**

If the green light is off, service (repair) is required. See the “Troubleshooting Table” (page 13) for possible causes and remedies.

- **Amber Light – Blinking:**

A blinking amber light indicates high backpressure. Maintenance is required.

A number of factors can cause this situation such as excessive idling or the engine producing excessive soot. These primary causes produce an overloaded PCM or soot accumulation on the NRC, which in turn cause high backpressure.

See the “Troubleshooting Table” (page 13) for possible causes and remedies.

If the amber light is still blinking after following the recommended procedures, then contact a Cleaire-authorized technician for maintenance.

- **Amber Light – On Solid:**

A solid amber light indicates a broken sensor, disconnected sensor or system fault.

Verify that all the wiring harness connections are properly attached. If the amber light stays on, have the system serviced as soon as possible. For some faults, the solid amber light can only be turned off through the service computer connection to the MLC.

The amber light will turn on solid for a few seconds after the engine starts. This allows the operator to confirm that the LED itself is good.

ATTENTION:

A solid or blinking amber light indicates that maintenance is required.

C. Monitoring the Fuel System

The operator should observe both the vehicle and Lonestar system for the following:

- **Fuel Leaks:**

Clearly, any fuel leak presents a safety concern warranting immediate action. The first step is to investigate and see if the problem can be resolved immediately and locally. In the event that special parts (that is, Lonestar system components) are at fault, then contact your distributor immediately for further assistance.

- **Fuel Consumption:**

Fuel consumption varies in accordance with the specific application, driving habits and other factors. Generally, the Lonestar system’s fuel consumption will be in the range of 3% to 5% or less of the engine’s fuel consumption. If you experience excessive fuel consumption, please contact the distributor.

- **Fuel Supply:**

The Lonestar system’s operation depends on a clean fuel supply. An integrated fuel pump-filter is part of the Lonestar fuel system. The fuel filter should be inspected and replaced if necessary during the Lonestar system’s preventative maintenance.

Be sure to use the correct grade of diesel fuel specified for your application. ULSD or TxLED is required for verified Lonestar applications. If your vehicle requires ULSD or TxLED, a label similar to Figure 14 should have been installed near the fuel tank.

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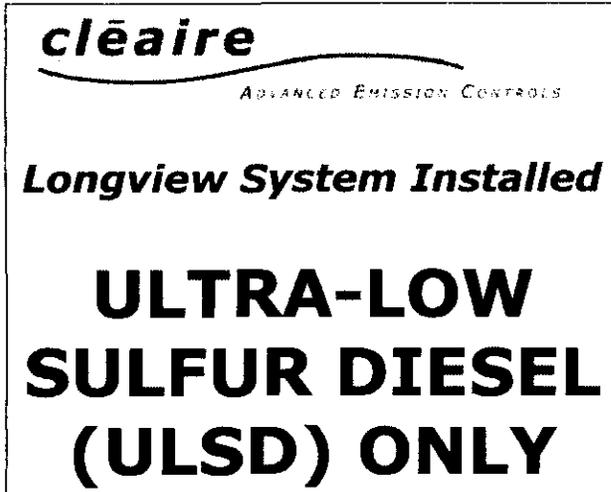


Figure 14. Example of ULSD Fuel Label (for a Longview system).

D. Conditions Resulting in Lonestar System Damage or Failure

The operator should be aware of conditions that could result in damage or failure of the catalyst assembly or Lonestar system. If any of these events occur, it is the owner's responsibility to contact their distributor immediately.

Mechanical damage can occur if any system component is mishandled or accidentally impacted. Internal damage to the catalyst assembly can occur from various forms of engine failure such as losing a turbo or head gasket. These events would cause foreign debris to enter the exhaust gas and then impact the catalyst assembly, likely causing some damage. Furthermore, losing a turbo or other major oil leak could result in excessively high temperatures in the catalyst and PCM. If the engine loses the turbo, the driver should pull off the road as soon as possible and shut the engine off.

It is important that oil consumption is within the engine manufacturer's specification for the proper operation and long-term performance of the Lonestar. If engine oil consumption exceeds the specification, the engine should be repaired immediately. Failure to do so may cause damage or excess emissions from the Lonestar and may void the warranty. Also, higher than normal oil consumption may lead to ash accumulation in the particulate control module, which might require maintenance.

Power washing the vehicle should not be a problem for the catalyst assembly or Lonestar system. Avoid pointing the high-power wash at any Lonestar system connectors. However, depending on the power washing technique, it may be possible to loosen an electrical connector. If a connector comes loose, the amber LED will light. If the amber light comes on, follow the procedures in the Troubleshooting Table (page 13).

For vertical stacks, be sure the rain cap is in place and functioning properly. It is important that water does not enter the exhaust pipe where it could migrate to the catalysts or PCM. Avoid low hanging branches or other obstacles that could knock off the rain cap.

V. MAINTENANCE AND REPAIR

Maintenance and repair of the Lonestar system must only be performed by a Cleaire-authorized technician. Preventative maintenance is required once a year (unlimited operating hours) or every 50,000 miles whichever comes first to maintain the product warranty. The cost of parts and labor for maintenance are not included in the purchase price of the Lonestar system.

A. Fuel Pump-Filter Maintenance

The integrated fuel pump-filter should be inspected during the scheduled maintenance. Cleaire recommends changing the fuel filter at that time or anytime the engine fuel filter is changed.

B. Catalyst Assembly and PCM Maintenance

In some cases, it may be necessary to clean the PCM module depending on the vehicle's driving cycle, soot output from the engine and the ash content of the diesel fuel and lube oil. If soot or ash accumulation in the PCM results in high backpressure, then the amber light will blink. In normal operation, the trapped soot will oxidize through thermal and catalytic means during the higher load portions of the driving cycle. The PCM allows for flow through of the exhaust gas so ash does not typically overload it.

If required, a Cleaire-authorized distributor can clean the PCM module. They also will ensure that the collected material (ash and soot) is properly disposed in accordance with all applicable Federal, State and local laws governing waste disposal.

The catalyst assembly is designed to process exhaust flow in only one direction. The order of the individual modules within the catalyst assembly is also critical for the proper operation of the Lonestar system. If any sections are disassembled for maintenance (or any other reason), be sure that they are reinstalled in their proper position and flow direction.

C. Exhaust Tubing and Components

All tubing connections between the engine and the catalyst assembly should be maintained in a gas-tight and leak-free manner. Also, all tubing between the engine and catalyst assembly must be maintained in good condition. This requirement includes any other components such as exhaust brakes. Aluminized mild steel in poor condition or excessively rusty tubing could flake off into the exhaust stream. If flaking occurs, the catalyst may plug, resulting in poorer emission performance and power loss. If any tubing is replaced, stainless steel tube is preferred. **It is the engine owner or operator's responsibility to ensure that all tubing in this critical area be maintained in good condition.**

D. Service Calls

The MLC® controls the green and amber indicator lights to provide system status as described in the Indicator Lights section (§IV.B, page 8). Not all conditions will be detected by the MLC® (for example, an accident that physically damages the catalyst assembly). Therefore, it is important for the driver and operator to observe the vehicle (see the Owner's Obligations Chart, page 18) and Lonestar operations in addition to watching the indicator lights. See the Operations section (§IV, page 8) for routine observations that the driver and/or owner should perform.

Upon any indication of a malfunction, contact a Cleaire-authorized technician promptly. Please be prepared with the following information:

1. Specific fault information or descriptions.
2. The part number and serial number of each catalyst module (see Figure 15).
3. The system label information (see Figure 16).

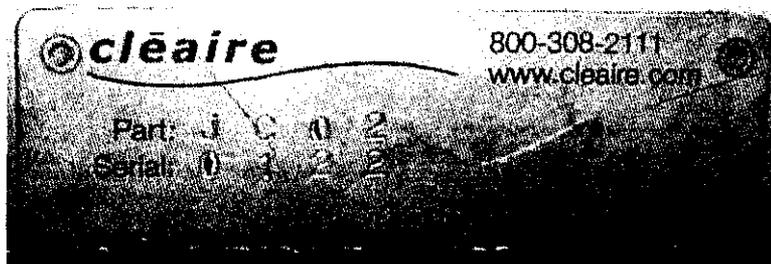


Figure 15. Cleaire Serial Plate.

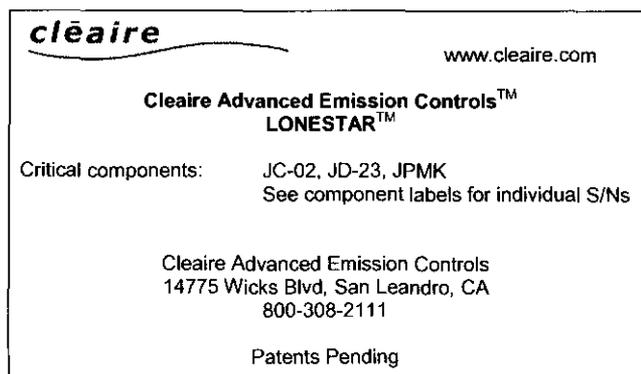


Figure 16. CARB-verified system label.

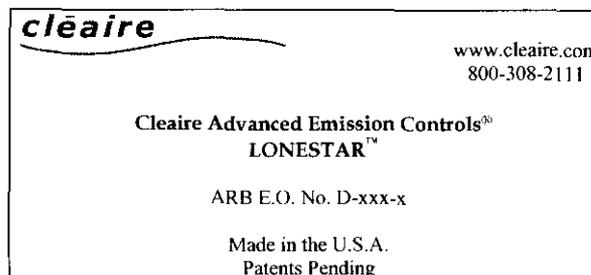


Figure 17. CARB EO system label.

E. Troubleshooting Table

Use the table below to diagnose and resolve potential Lonestar operating problems. Most abnormal conditions will require service or repair by a Cleaire-authorized technician.

Condition	Probable Cause	Remedy
1. Green LED - On	<ul style="list-style-type: none"> MLC® has power (desired condition) 	<ul style="list-style-type: none"> No action required. Operate & monitor normally.
2. Green LED - Off	<ul style="list-style-type: none"> No power or open fuse Bad LED Loss of MLC program (if amber on and green off) 	<ul style="list-style-type: none"> Check fuse, wires and power to the MLC®. Contact Cleaire-authorized technician for repair.
3. Amber LED blinks	<ul style="list-style-type: none"> High backpressure (overloaded PCM or soot accumulation on NRC) 	<ul style="list-style-type: none"> Follow the "Amber Light Blinking" guide (p. 14). Contact Cleaire-authorized technician for maintenance.
4. Amber LED on solid	<ul style="list-style-type: none"> Sensor connection loose Faulty sensor System malfunction Loss of MLC program (if amber on and green off) 	<ul style="list-style-type: none"> Check wiring connections. Contact Cleaire-authorized technician promptly. (system needs maintenance as soon as practical.)
5. Fuel drips or leaks	<ul style="list-style-type: none"> Loose connection(s) Fatigued O-ring Defective hose 	<ul style="list-style-type: none"> Tighten connection(s). Replace faulty parts. Contact Cleaire-authorized technician for repair.
6. Unusual odor or exhaust noises	<ul style="list-style-type: none"> Loose tubing connection(s) Loose clamp(s) Crack in exhaust tube Crack in catalyst assembly Loose injector mount 	<ul style="list-style-type: none"> Tighten connection(s). Replace damaged tube. Contact Cleaire-authorized technician for repair.
7. White smoke during startup	<ul style="list-style-type: none"> Normal condensation inside catalyst assembly 	<ul style="list-style-type: none"> No action required.
8. Light soot dusting in exhaust tube	<ul style="list-style-type: none"> Normal condition 	<ul style="list-style-type: none"> No action required.
9. Large amounts of white or black smoke during normal operations	<ul style="list-style-type: none"> MLC® power or signal loss Fuel injector malfunction Sensor failure PCM failure 	<ul style="list-style-type: none"> Contact Cleaire-authorized technician for repair.
10. Engine surges or has power loss	<ul style="list-style-type: none"> Engine malfunction Loose connection in Lonestar fuel system Soot accumulation on NRC or overloaded PCM (Amber light should have been blinking) 	<ul style="list-style-type: none"> Repair engine. Contact Cleaire-authorized technician for service.

F. Amber Light Blinking

A blinking amber light indicates high backpressure. High backpressure is usually the result of soot accumulation on the front of the NRC or an overloaded PCM.

The causes and remedies for soot accumulation on the NRC or an overloaded PCM are provided after the chart below. Follow Figure 18 to respond to a blinking amber light condition. The “Drive Hard Procedure” is explained after the chart.

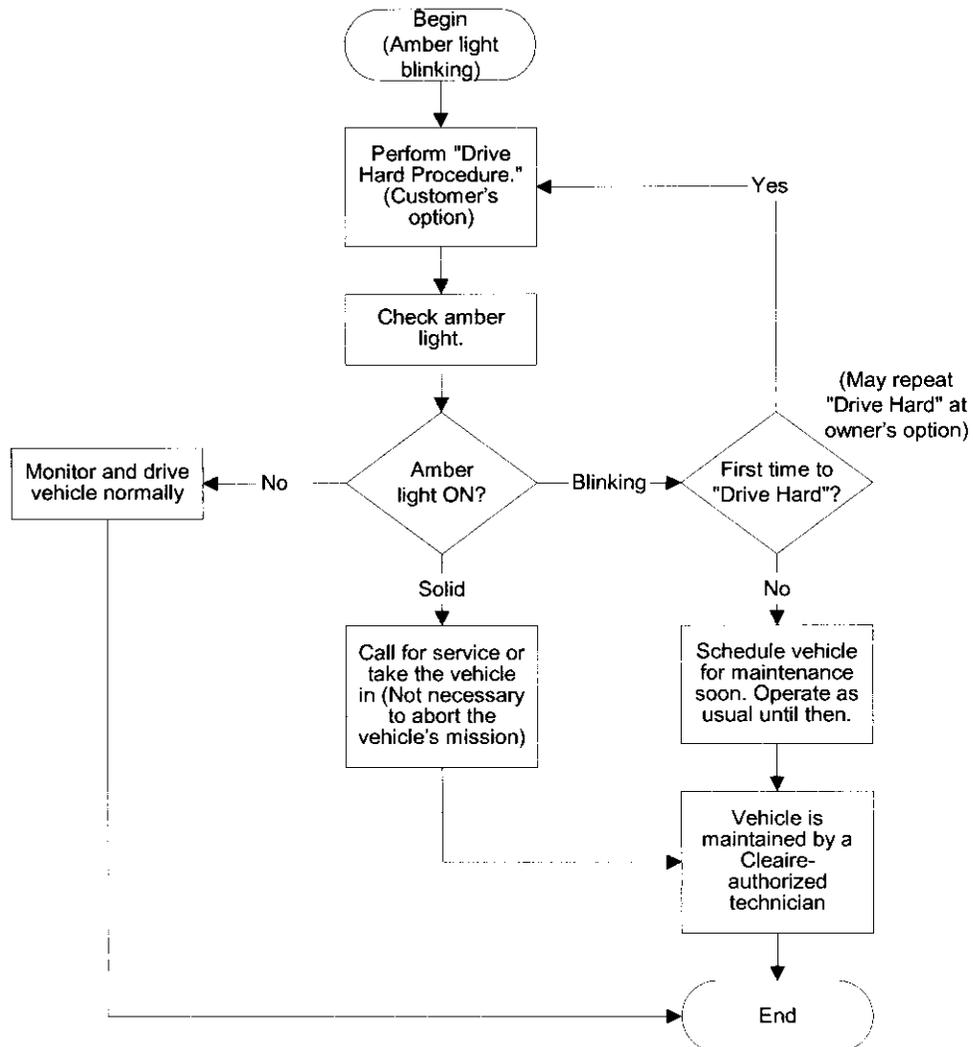


Figure 18. Blinking Amber Light Troubleshooting Process.

○ **Drive Hard Procedure**

The customer may perform this procedure at their option. If they do not want to do it, then they should schedule the vehicle for maintenance by a Cleaire-authorized technician as soon as practicable. The vehicle may be operated normally until the maintenance appointment.

Run the engine hard, under as much load as possible, for at least 30 to 45 minutes at sustained intervals. This operation may regenerate the PCM, and the light will reset itself. Check the light after the run and at the end of the day. If the amber light goes out, then operate normally from that time onward. If the light stays on, the customer may repeat this process at their option. If the amber light is still blinking after more than one "Drive Hard," then schedule the vehicle for maintenance by a Cleaire-authorized technician as soon as practicable. The operator may use the vehicle normally until the maintenance appointment.

ATTENTION:

***If the amber light turns on solid at anytime,
then the Lonestar will require maintenance by a Cleaire-authorized technician.***

- **PCM overloaded with soot or ash**

In some cases, driving the vehicle under load (Drive Hard Procedure) can regenerate a PCM overloaded with soot. Sometimes though, the high backpressure from the PCM is the result of ash loading in the PCM, which requires cleaning the PCM off of the vehicle.

If high backpressure from an overloaded PCM becomes repetitive, it might be that the engine is producing high levels of soot or the vehicle's duty cycle is relatively light. A light duty cycle causes the engine's average exhaust temperature to be too cold to regenerate the PCM consistently. Long idle times could also be the cause. Rotating the vehicle to a tougher duty cycle application or reducing idle time to a minimum may be sufficient to avoid repeat amber light events caused by a PCM overloaded with soot.

Another cause of a frequently overloaded PCM may be engine problems such as excessive oil consumption that result in a high rate of ash into the PCM. A Cleaire-authorized distributor can provide the PCM cleaning service to remove the ash.

Since engine problems may be the cause of the Lonestar amber light coming on, Cleaire recommends that the engine receive a thorough evaluation if the amber light does not turn off after performing the "Drive Hard Procedure."

- **Soot accumulation on the NRC**

Soot accumulation on the NRC face occurs on a small percentage of vehicles due to a variety of factors including engine age and condition, bad fuel injectors, driver habits, driving cycle and engine load.

If NRC soot accumulation has occurred, the Cleaire-authorized technician will be able to diagnose the condition and clean the NRC when the vehicle is brought in for maintenance according to Figure 18. The Cleaire-authorized distributor will be able to assist the customer in minimizing the impact of NRC soot accumulation on the vehicle's use and availability.

Since engine problems may be the cause of the excessive soot (and thus the amber light blinking), Cleaire recommends that the engine receive a thorough evaluation if soot accumulation is frequent.

G. Repair and Maintenance Clarifications

The warranty (page 19) includes a section titled “Owner’s Warranty Responsibility” which requires that the owner or operator is responsible for performing the required maintenance described in the Owner’s Manual. In addition to the required annual maintenance, the amber light is another indicator that maintenance is required.

ATTENTION:

A solid or blinking amber light indicates that maintenance is required.

Maintenance items such as cleaning an overloaded PCM or soot accumulation on an NRC (that are caused by engine or vehicle operating conditions) are not warrantable items. If a repair is required, it may be covered under the installation or product warranty depending on the cause. The table below provides a summary of service types (maintenance or repair) and what organization is responsible for the cost of the service.

Service Type (and subtype)		Definition/Example	Cost Responsibility
Maintenance	(unplanned)	High backpressure from NRC soot accumulation or overloaded PCM.	Owner
	(regularly planned)	High backpressure from NRC soot accumulation or overloaded PCM.	Owner
	(annual)	Change fuel pump filter, perform multi-step complete system check out.	Owner
Repair	(warrantable)	System or component fails in normal application.	Cleaire
	(non-warrantable)	System or component failed because it was misapplied or installed improperly.	Installer
	(non-warrantable)	System or component damaged through abuse, neglect, or misapplication. Warranty period has lapsed.	Owner

VI. SPECIFICATIONS

Lonestar System	
Lonestar System Total Weight	123 pounds
Catalyst Assembly Weight	98 pounds
Construction	304 Stainless Steel
Fuel Type (same as vehicle fuel)	ULSD, CARB diesel or TxLED
Fuel Consumption (maximum)	2.2 gallons/hour

Cleaire MLC®	
Model	Cleaire MLC®, Rev. 4E
Voltage	9 to 30 VDC (12 or 24 V recommended)
Real time clock	Battery-backed
Diagnostic and Programming I/O	9-pin DBF Serial (RS-232) (adapter from harness required)
Inputs	
Catalyst Assembly Inlet Temperature	Type K thermocouple, ungrounded
Catalyst Assembly Outlet Temperature	Type K thermocouple, ungrounded
Engine Tachometer (Frequency)	0.5 to 12 kHz
Engine Tachometer (Voltage)	3 – 30 VDC
Catalyst Assembly Backpressure	0 – 5 VDC
Engine Manifold Absolute Pressure	0 – 5 VDC
Fuel Pressure Switch	0 – 28.5 VDC
Outputs	
Fuel Pump Relay	12 VDC
Two Power Output Lines	5 VDC
Lonestar System Power On Indicator	Green LED (on)
Lonestar System Warning Indicator	Amber LED (on or blinking)
Pulse Width Modulation Channel	One

VII. OWNER'S OBLIGATIONS CHART

It is the owner or operator's obligation to take the appropriate action if any of these events or symptoms occurs. These actions are mandatory for proper system operation and for the warranty to remain in effect.

Event or Symptom	Owner's Action Item	Manual Section
Initial installation of Lonestar system.	Review this manual and pay close attention to each item in the "Operations" section.	"Operations" (page 8).
Blinking amber light. (high backpressure)	May perform the "Drive Hard Procedure" at the operator's option. Contact a Cleaire-authorized technician as needed.	"Indicator Lights" (page 8) and "Troubleshooting Table" (page 13).
Solid amber light. (bad sensor or system fault)	Contact a Cleaire-authorized technician as soon as possible.	"Indicator Lights" (page 8) and "Troubleshooting Table" (page 13).
Engine failure (such as turbo failure, injector failure, excess oil consumption, or leaky head gasket).	If the turbo fails, get off the road safely ASAP and shut the engine off. Contact a Cleaire-authorized technician immediately. (Lonestar catalysts or system components may be damaged from foreign material.)	"Conditions Resulting in Lonestar System Damage or Failure" (page 10).
Road debris or other object impacts Lonestar system or components.	Contact a Cleaire-authorized technician immediately since system components may be damaged, including hidden damage to internal catalyst components.	"Catalyst Assembly" (page 2) and "Conditions Resulting in Lonestar System Damage or Failure" (page 10).
Tubing or exhaust component (turbo or exhaust brake, for example) between the engine and the catalyst assembly is removed, replaced or in poor condition.	Ensure that the tubing or component is installed properly and that no debris could enter the exhaust stream. (Debris or foreign matter in the exhaust stream can damage the catalysts or system components. Also, exhaust leaks may result in poor system performance and safety hazards.)	"Exhaust Tubing and Components" (page 11).
For a vertical exhaust stack, the rain cap is knocked off or somehow missing.	Replace the rain cap immediately. If any water entered the exhaust pipe then contact the distributor immediately.	"Catalyst Assembly" (page 2) and "Conditions Resulting in Lonestar System Damage or Failure" (page 10).
Poor engine performance or power (if you suspect that the Lonestar is the cause).	Check engine functions first , then call the distributor if you suspect that the Lonestar is the cause.	"Operations" (page 8) and "Troubleshooting Table" (page 13).
Oil consumption is more than the engine manufacturer's specification.	Repair the engine so that oil consumption is within the manufacturer's specification.	"Conditions Resulting in Lonestar System Damage or Failure" (page 10).

VIII. WARRANTY

A. Product Warranty

YOUR WARRANTY RIGHTS AND OBLIGATIONS

Cleaire Advanced Emission Controls, LLC warrants the diesel emission control system in the application for which it is sold or leased to be free from defects in design, materials, workmanship, or operation of the diesel emission control system which cause the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706, and 2710, for the periods of time listed in Table 1, provided there has been no abuse, neglect, or improper maintenance of your diesel emission control system, vehicle or equipment, as specified in the owner's manuals. Where a warrantable condition exists, this warranty also covers the engine from damage caused by the diesel emission control system, subject to the same exclusions for abuse, neglect or improper maintenance of your vehicle or equipment. Please review your owner's manual for other warranty information. Your diesel emission control system may include a core part (e.g., particulate filter, diesel oxidation catalyst, selective catalytic reduction converter) as well as hoses, connectors, a backpressure monitor (if applicable), and other emission-related assemblies. Where a warrantable condition exists, Cleaire will repair or replace your diesel emission control system at no cost to you including diagnosis, parts, and labor.

Table 1. Warranty Period

Engine Type	Engine Size	Warranty Period
On-Road	Light heavy-duty, 70 to 170 hp, Gross Vehicle Weight Rating (GVWR) less than 19,500 lbs.	5 years or 60,000 miles
	Medium heavy-duty, 170 to 250 hp, GVWR from 19,500 lbs. to 33,000 lbs.	5 years or 100,000 miles
	Heavy heavy-duty, exceeds 250 hp, GVWR exceeds 33,000 lbs.	5 years or 150,000 miles
	Heavy heavy-duty, exceeds 250 hp, GVWR exceeds 33,000 lbs., and the truck is: 1. Typically driven over 100,000 miles per year, and 2. Has less than 300,000 miles on the odometer at the time of installation.	2 years, unlimited miles
Off-Road (includes portable engines) and Stationary	Under 25 hp, and for constant speed engines rated under 50 hp with rated speeds greater than or equal to 3,000 rpm	3 years or 1,600 hours
	At or above 25 hp and under 50 hp	4 years or 2,600 hours
	At or above 50 hp	5 years or 4,200 hours

WARRANTY COVERAGE

For an engine used in an application listed in Table 1, the warranty period will be the years or hours or miles of operation shown in Table 1, whichever occurs first. If any emission-related part of your diesel emission control system is defective in design, materials, workmanship, or operation of the diesel emission control system thus causing the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706, and 2710, within the warranty period, as defined above, Cleaire will repair or replace the diesel emission control system, including parts and labor.

In addition, Cleaire will replace or repair the engine components to the condition they were in prior to the failure, including parts and labor, for damage to the engine proximately caused by the verified diesel emission control strategy. This also includes those relevant diagnostic

expenses in the case in which a warranty claim is valid. Cleaire may, at its option, instead pay the fair market value of the engine prior to the time the failure occurs.

OWNER'S WARRANTY RESPONSIBILITY

As the vehicle, engine, or equipment owner, you are responsible for performing the required maintenance described in your owner's manual. Cleaire recommends that you retain all maintenance records and receipts for maintenance expenses for your vehicle, engine, or equipment, and diesel emission control system. If you do not keep your receipts or fail to perform all scheduled maintenance, Cleaire may have grounds to deny warranty coverage. You are responsible for presenting your vehicle, equipment, or engine, and diesel emission control system to a Cleaire-authorized dealer as soon as a problem is detected. The warranty repair or replacement should be completed in a reasonable amount of time, not to exceed 30 days. If a replacement is needed, this may be extended to 90 days should a replacement not be available, but must be performed as soon as a replacement becomes available.

If you have questions regarding your warranty rights and responsibilities, you should contact Cleaire at 1-800-308-2111 or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731, or (800) 363-7664, or electronic mail: helpline@arb.ca.gov.

B. Installation Warranty

YOUR WARRANTY RIGHTS AND OBLIGATIONS

The Cleaire-authorized installer warrants that the installation of the diesel emission control system is free from defects in workmanship or materials which cause the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706. The warranty period and the extent of the warranty coverage provided by the Cleaire-authorized installer is the same as the product warranty provided by Cleaire, and the same exclusions apply.

OWNER'S WARRANTY RESPONSIBILITY

As the vehicle, engine, or equipment owner, you are responsible for presenting your vehicle, engine, or equipment, and diesel emission control system to the Cleaire-authorized installer as soon as a problem with the installation is detected.

If you have questions regarding your warranty rights and responsibilities, you should contact a Cleaire-authorized dealer, or Cleaire at 1-800-308-2111, or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731, or (800) 363-7664, or electronic mail: helpline@arb.ca.gov.

C. Cleaire Warranty Clarifications (Which do not limit or modify the provisions of the above warranty in any way)

The warranty above is the sole warranty made by Cleaire Advanced Emission Controls, LLC. There are no other warranties, expressed or implied, or of merchantability or fitness for a particular purpose.

For the purpose of this warranty, abuse or neglect includes vehicle accidents, ignoring the Lonestar system indicator lights, blending lubricating oil with fuel, or any engine failure or condition that allows excess lubricating oil, coolant, contaminants or debris to enter the exhaust system. The owner shall not use any fuel additive or lube oil additive that is not approved for use in diesel engines equipped with catalytic mufflers.

Cleaire is not responsible for incidental or consequential damages, which include, but are not limited to fines, theft, vandalism, or collisions. The owner is responsible for incidental costs such as communication expenses, meals, and lodging incurred by owner or employees of owner as a result of a warrantable condition.

The verified diesel emission control system must be installed and serviced by Cleaire-authorized personnel. Installation or service by unauthorized personnel may result in a denial of warranty coverage.