



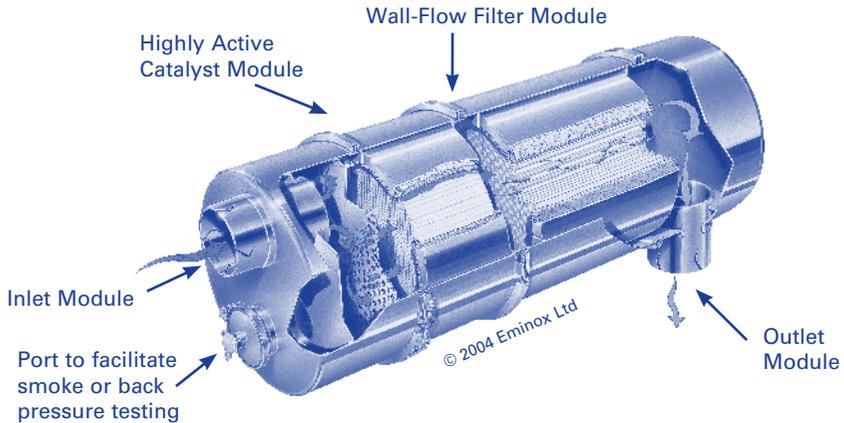
Operation & Maintenance Manual

Exhaust Engineering Excellence

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CRT® System Operation & Maintenance Manual



Introduction

Your CRT® system is a Continuously Regenerating Trap using novel patented technology which largely eliminates harmful pollutants from your diesel engine exhaust, in addition to providing the normal functions of a silencer system such as noise reduction. Typical reductions for some of the major pollutants are:

Particulate matter (PM) 75 to 95%
Hydrocarbons (HC) 75 to 95%
Carbon Monoxide (CO) 75 to 95%
Nitrogen Oxides (NOx) up to 10%

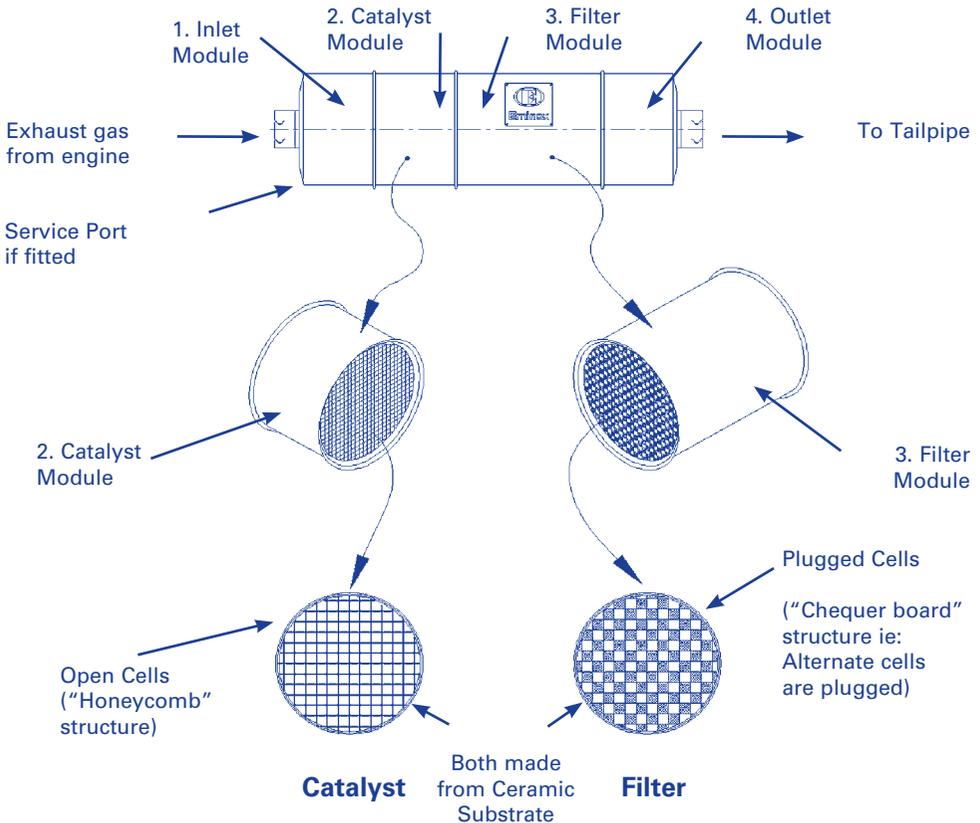
Your CRT® system contains a specially formulated, highly active Catalyst and a wall-flow ceramic filter housed in modular units. The patented chemical technology promotes self cleaning of the soot or particulate matter trapped within the ceramic wall flow filter. The efficiency of this process determines the service frequency.

Your CRT® system is housed in high grade stainless steel which protects the system from corrosion giving many years of useful service.

Section 1 - Technical Description & Identification of Parts

Your CRT® system is made up of four major parts illustrated in the diagram below:

1. Inlet Module
2. Catalyst Module
3. Filter Module
4. Outlet Module



Note:

1. In certain circumstances modules may be combined.
2. The Catalyst must always be positioned **upstream** of the Filter.

Section 2 - CRT® System Operation

CRT® System Operating Characteristics.

The essential characteristic of the CRT® system is to capture and oxidise the soot or particulate matter contained in diesel exhaust, commonly observed as smoke. The particulate matter is caught within the wall flow filter and then continuously oxidised, at typical exhaust gas temperatures, into harmless gas by the novel patented chemical technology.

Under normal operating conditions, with a properly maintained engine under typical loading, the soot component of diesel exhaust is oxidised harmlessly leaving only ash, mainly the incombustible residue of burnt engine oil. This accumulates very gradually in the Filter and should be removed by regular servicing.

In conditions of prolonged low engine loading however, for example when vehicles travel at slow speeds in urban conurbations or engines are used in a static utility role, the exhaust gas may not achieve a high enough temperature for the full oxidation of the soot. In these cases the Service Interval of the CRT® system must then be shortened in order to remove any accumulation of unburned soot and ash.

In the exceptional case, when engine soot output exceeds that specified by the manufacturer, faster soot (and ash) accumulation within the Filter can cause exhaust gas flow restriction and a corresponding increase in Back Pressure. In the extreme condition, when the Filter carries an undetected high concentration of soot, a relatively short period of high engine work output can cause a rapid rise of exhaust gas temperature. This can lead to spontaneous soot ignition and very high temperatures which can result in irreparable damage to the filter and the need for replacement.

The following conditions are essential for satisfactory CRT® system operation:

- Use only diesel fuel with sulphur content less than 50 ppm and conforming to EN590
- Do not use fuel additives other than those already incorporated in general commercial diesel fuel supplies
- Additionally the following biodiesel and water-diesel emulsion fuels are approved for use with CRT® technology
- Biodiesel
 - 30% Diester
 - Greenenergy Global Diesel, 5% biodiesel, 95% ULSD
 - Global Commodities UK Ltd, driveEco
 - Rix Biodiesel Ltd, Bioblend 5
 - Petroplus Marketing Ltd, Bio-plus
- Water-fuel emulsions
 - BP Aspira @ 10% demineralised water
 - Lubrizol PuriNOx™ @ 10% demineralised water

- The engine is properly maintained so that the level of smoke produced by the engine does not exceed the maximum limits set by the engine manufacturer. If this is not available then Eminox recommend:-

	E1 + E0		E2		E3	
	Pass	Fail	Pass	Fail	Pass	Fail
K	< 1.25	>= 1.25	< 1.0	>= 1.0	< 0.8	>= 0.8

- Eminox approve the use of E4 and E6 oil. Eminox recommend the use of E6 rated engine oils ahead of E4, because of their potential to extend catalyst life and the advantages of extended filter service intervals. Which ever oil is used, it is important to ensure that it is a low ash engine oil with a sulphur content of less than 7,000 ppm.
- Eminox recommend that oil consumption is monitored closely. It is important that oil consumption rates should not exceed engine manufacturer’s limits, typically less than 1 litre per 1,000km
- The vehicle must be serviced according to manufacturer’s recommendations in order to maintain the optimal engine performance, which the CRT® system is designed to be compatible with
- Repeated long periods of engine idling should be avoided. This can lower the engine temperature below that required for filter regeneration, causing soot to accumulate and block the filter

Warning.

The factors described in this Section have an effect on the life of the Catalyst. Under normal operating conditions where the engine is well maintained and the correct oil is used your Catalyst has been designed to last for the operating life of a vehicle. If these conditions have not been met it is possible that the Catalyst will require earlier replacement.

The activity level of the catalyst, contained in many diesel particulate filter systems, can also affect the frequency of filter servicing. We recommend that catalysts are checked after 5-6 years to ensure optimum system performance. We offer a catalyst testing service to check the activity level of the catalyst and advise on whether this could be affecting your system performance and servicing costs.

Aim of the Manual. The aim of the following Sections of this Manual is to set out CRT® service requirements which should avoid the extreme condition that leads to filter damage

Note: A Health and Safety risk assessment should be done **before** attempting to carry out work described in the following Sections of this Manual. To help with your Risk Assessment, material safety data sheets (MSDS) for both ash and soot are available from the Eminox Ltd website www.eminox.com.

Section 3 – Regular Maintenance Check

Caution: Before checking your CRT[®] system you should observe the requirements of your Health & Safety Risk Assessment.

Back Pressure. Exhaust Back Pressure (BP) rises as a CRT[®] system Filter accumulates ash and soot. BP checks at regular intervals can indicate the extent of this accumulation, and the point at which the Filter needs to be serviced, see Section 4.

BP should be measured when the:

- vehicle is stationary
- engine is as close to operating temperature as possible
- engine is run at max static rpm (the condition reached when the accelerator pedal is fully depressed with the transmission in neutral). Care must be taken if a Limiter is fitted to make allowance for an rpm that is lower than the standard set by the manufacturer see Section 4.

Record BP using:

- an Electronic Service Indicator (ESI) if this is fitted, see Section 5
- Eminox hand held Digital Pressure Gauge (Part Number QM1466) connected by a tube to the BP tapping point fitted to your system. This could be to a Schrader valve output located within the engine bay or at some other easily accessible position, or to the CRT[®] system Service Port (by removing the Allen screw).



Section 4 - CRT[®] System Service Intervals

Engine Duty Cycle. The efficiency of soot oxidation within the CRT[®] system increases with exhaust gas temperature. It follows that, if an engine has a low work output or idles for long periods, this may reduce effective regeneration and lead to soot accumulation and an earlier service requirement. Eminox therefore strongly recommends that a regular check of BP is maintained in order to guard against excess ash and soot accumulation due to operation in adverse conditions and/or deterioration in engine performance leading to high engine out smoke. Alternatively it is possible to identify categories of engine duty cycle which are listed below and can be used a guide.

A Guide to Service Interval Prediction.

Duty Cycle	Typical Example	Typical Service Interval
High and sustained workload	Long haul truck Intercity train or coach	Upto 1 year*
Variable engine work rate	All purpose delivery truck Bus operating in a mix of city and rural areas	Upto 1 year*
Low engine work rate	Bus operating in heavy traffic and congested city centres Waste refuse vehicles	Upto 6 months* Monitor back pressure at least once every 6 weeks

* or as indicated by the Electronic Service Indicator (ESI), whichever occurs first

Warning.

- Long periods of idle should be avoided. In a workshop environment this should be limited to 15 minutes per day.

The Interpretation of Back Pressure. BP varies with the maximum static rpm (which may have an rpm limiter fitted or reset as a matter of Fleet operating policy), and with engine temperature (where it is not possible to reach a normal operating level during a service). The **BP Limit** is the conservative figure that EminoX Ltd will provide for your engine configuration which can help to take account of these uncertainties. Best practice is to record BP readings under similar measurement conditions (see Section 2) at intervals of not more than 4 weeks. Interpretation may be assisted by plotting a graph of BP against time. When the **BP Limit** is reached the Filter must be serviced but a graph may assist with the detection of a rapid rise in BP which is a stronger indication that damage is likely to occur.

Warning.

- If the BP limit is reached within the CRT® system Service Interval it is likely that engine smoke has increased. (A condition that will be masked by the CRT® system). You must then check engine smoke output. If corrective action is not taken you will risk catastrophic failure of the Filter, and invalidation of any warranty cover. You may also experience a deterioration in engine performance.
- The measurement of engine out smoke is a gauge of engine performance, not an indication of the state of a CRT® system. Ideally, smoke readings should be taken with the CRT® system disconnected, with appropriate safeguards against fumes and noise.
- If you do not know what the manufacturer's smoke limits are for your engine then you should consult your engine supplier. Alternatively Eminox Ltd Recommends:-

	E1 + E0		E2		E3	
	Pass	Fail	Pass	Fail	Pass	Fail
K	< 1.25	>= 1.25	< 1.0	>= 1.0	< 0.8	>= 0.8

- If black smoke emerges from the tailpipe of the CRT this is a clear indication that the system is not working and should be thoroughly investigated.

Section 5 – Electronic Service Indicator (when fitted).

Operation. The Eminox Ltd Electronic Service Indicator (ESI) is a robust Back Pressure (BP) recording device normally fitted within an engine bay, or adjacent to it. It has two key elements; a pressure sensor connected by heat resistant tube to the CRT® system inlet (or upstream of the CRT® system), and a central processor unit (CPU) which continuously measures dynamic BP.



ESI Warning System. The ESI warning system consists of 3 coloured lights. Limits are set within the micro-processor by Eminox Ltd for a particular engine configuration and duty cycle. The ESI triggers the appropriate light illumination when a preset BP has been exceeded:

- Green.** System on, BP at acceptable levels
- Amber.** BP above acceptable levels. Filter will require servicing shortly. Check by recording BP at max static rpm.
- Red.** Filter requires an immediate service. The display also shows the BP in the format Cxxx and Mxxx where C = current value of BP, M = the maximum BP since the unit was last re-set and xxx = numerical value of BP in mbar. The display alternates between these two formats automatically whilst the unit is turned on.

BP Measurement at Max Static rpm. The ESI digital display may also be used to read a maximum BP when the vehicle is stationary (when the highest BP reading remains on display). It is possible therefore for one man to run the engine to max static rpm, allow the vehicle to return to idle (or stop the engine), then walk back to read max BP. This should be used as an independent check on the Amber and Red lights on the Warning System.

The CPU retains the BP trace history of the vehicle. This can be downloaded for analysis. Resetting the unit to carry out a max static rpm pressure reading does not erase this memory.



Section 6 - CRT® System Service Records.

The following information should be recorded on your vehicle check sheet at each service:

- Back Pressure before and after service (note that the engine must be warm at the time of measurement)
- Vehicle mileage
- Filter and Catalyst Serial Numbers
- Filter cleaning, method and date

Note: Eminox Ltd will require service records in order to investigate any warranty claim. Failure to provide service records will invalidate your warranty cover. A typical CRT® system Service Record Sheet can be obtained from the Eminox Ltd website www.eminox.com

Section 7 - Dismantling your CRT[®] System

Caution: Before dismantling your CRT[®] system you should observe the requirements of your Health & Safety Risk Assessment.

Note: Unless the Filter is already marked with the exhaust gas flow direction through the Filter, this should be marked on the outside of the casing before removal, unless it is to be returned to be reconditioned as an Eminox Ltd **Service Exchange Filter**.

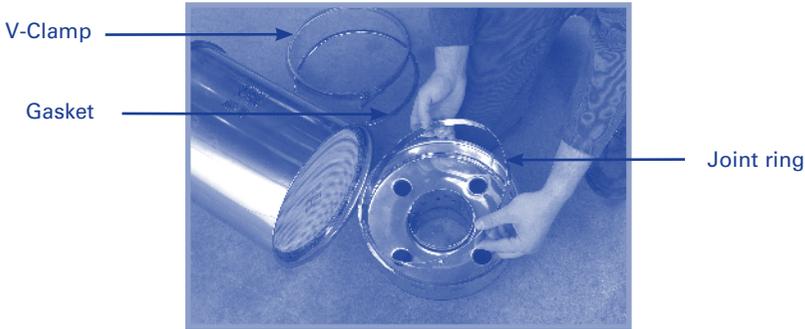


Your CRT[®] system may be removed as a complete unit by slackening Inlet Module and Outlet Module pipe retaining Band Clamps and dismantling the supporting brackets as necessary. Some installations like twin systems may require that one or more Modules be released first, in which case disconnect the V-Clamps and remove the CRT[®] system units individually.



When the Filter Module is to be removed for servicing or exchange it may be possible to release it as a single unit by disconnecting its V-Clamps and easing away the adjacent Modules and pipe work.

When the CRT[®] system is dismantled always inspect all parts for obvious external damage, particularly the flared end of all units which form together with the gaskets the gas tight joint beneath the V-Clamps. A significant dent in a Catalyst or Filter Module may well have damaged the ceramic substrate. Check for obvious signs of damage on the surfaces of the ceramic substrate. Any damaged Module **must** be replaced.

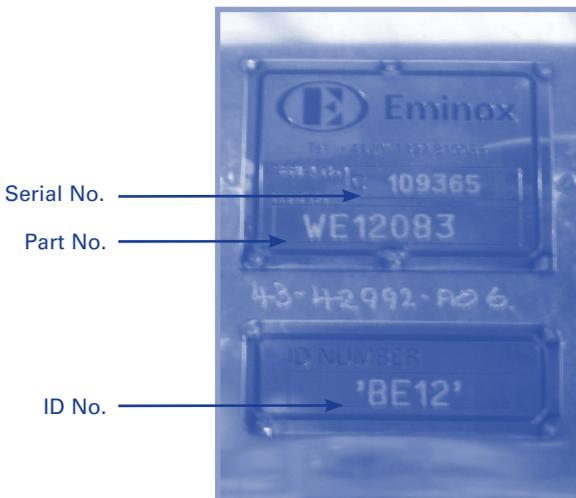


Section 8 - Re-assembling your CRT® System

Caution: Before re-assembling your CRT® system you should observe the requirements of your Health & Safety Risk Assessment.

Re-assemble your CRT® system in the reverse sequence using new gaskets and, if needed, new V-clamps. The Catalyst Module may be re-assembled in either direction and **must** be fitted upstream of the Filter. The Filter should be replaced so as to maintain the marked previous exhaust gas flow direction.

Note: It is recommended that the Filter Module is refitted with the CRT® system Serial No and ID No easily visible to the Vehicle and Operations Services Agency (VOSA) for the purposes of their Reduced Pollution Certificate (RPC) inspections.



The following torque settings should be applied. Note that it is essential not to over-tighten the clamps that provide the structural rigidity of the CRT® system as this can lead to in service failure which could have serious results.

- | | |
|---------------------------------------|-------|
| • CRT® system Band Clamps (pipe work) | 14 Nm |
| • CRT® system V-Clamps | 14 Nm |
| • Hi-Torque Clamps (heat shields) | 11 Nm |
| • Service Port Plug (if fitted) | 68 Nm |
| • Allen Screws | 20 Nm |

Following the replacement of the CRT® system and all exhaust pipes:

- Connect the garage exhaust extractor and start the engine.
- Allow the engine to reach normal operating temperature.
- Run at idle for five minutes, then gradually increase to full rpm. Then leave on tick over for 5 minutes before shutting off the engine. Remove the exhaust extractor unit and check the security of CRT® system and pipe work fixings making sure there are no leaks in the system.
- Check that any insulation fitted to the pipe-work is replaced and properly secured with a tight fitting to the pipe.

Please quote the CRT® system Serial Numbers when ordering spare parts.

Section 9 - Servicing the CRT® System Filter

Caution: Before servicing your Filter you should observe the requirements of your Health & Safety Risk Assessment.

The unique design of the Eminox CRT® and SCRT® systems mean that the filters are continuously regenerating, however, incombustible residues can still build up on the filter. Similarly FBC and FBC Active systems are designed to regenerate during use. For optimal performance, the filter needs periodic cleaning to remove incombustible ash and any excess soot. Failure to clean the filter can result in filter blockage, causing build up of soot and ultimately an exothermic reaction which will damage the filter.

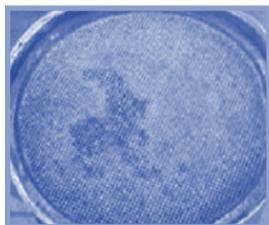
Eminox has developed a specialist cleaning process which rejuvenates the filter for the best possible performance. Filters are professionally reconditioned and their performance tested. This is backed by a 12 month warranty for reconditioned filters. The cleaning process helps maintain the service interval and improves the longevity of the filter.

A range of filter servicing packages are available, for details please visit www.eminox.com or contact us on +44(0)1427 810088

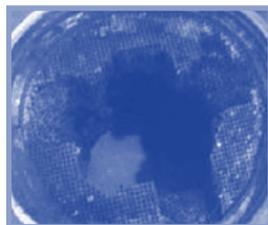
The environmental benefits of fitting an Eminox Systems are well established CRT® Systems significantly reduce exhaust emissions, including Carbon Monoxide, Hydrocarbons and Particulate Matter, FBC systems also reduce particulate matter, the SCRT® system additionally reduces Nitrogen Oxides. The environmental benefits have encouraged many operators to run green vehicles. A clean filter will ensure that the CRT® and SCRT® systems will continue to offer trouble free performance and carry on reducing harmful emissions.



Normal Appearance



Local Internal Damage



Extensive internal damage

Section 10 - Catalyst Maintenance

Caution: Before maintaining your Catalyst you should observe the requirements of your Health & Safety Risk Assessment.

When operating under Normal Conditions the Catalyst should not become clogged by soot. However, during a Filter service it is advisable to check the condition of the Catalyst and to dislodge any accumulated soot by using a soft brush. Inspect those visible surfaces of the Catalyst that are accessible (not always possible on the upstream side) to ensure that there is no surface cracking or pitting and that the ceramic substrate is secure within the high grade stainless steel housing. Should any defect be found, replace the Catalyst Module.

Section 11 – Warnings

The performance of your CRT® system and engine are linked. If the condition of either is allowed to deteriorate it will have a harmful effect upon the other. This can be avoided if the instructions in this Manual are followed. In particular, the following measures will minimise the chances of poor performance:

Never:

- Use jointing compound, gasket cement or such like on upstream exhaust connections. These may contain silicon (a catalyst poison) which can destroy your CRT® system
- Exceed the CRT® system **Service Interval**,
- Run the vehicle when the engine is generating excessively high smoke levels,
- Allow the engine oil consumption to exceed engine manufacturers limits,
- Overfill the engine with oil,
- Allow the engine to idle for long periods, and in a Workshop not more than 15 minutes continuously
- Allow any insulation material to become dislodged.

Always:

- Service the filter when a Back Pressure limit is reached or when a BP graph indicates a rapid rise
- Re-assemble a filter correctly with the marked or previous gas flow direction
- Use fuel with a sulphur content less than 50 ppm,
- Use fuels, fuel additives or alternative fuels which conform to EN590, or which are specifically approved by Eminox Ltd
- Use E4 or E6 oil. Eminox recommend the use of E6 rated engine oils ahead of E4, because of their potential to extend catalyst life and the advantages of extended filter service intervals. Which ever oil is used, it is important to ensure that it is a low ash engine oil with a sulphur content of less than 7,000 ppm.

Glossary of Terms

Term	Meaning
Ash	The incombustible particulate matter in the exhaust gas, mainly residues of components of the lubricating oil.
Back Pressure	The pressure above atmospheric within an exhaust system caused by flow resistance.
Band Clamps	Flat metal clamps which are used to connect your CRT® System to the exhaust pipes.
Catalyst	A ceramic substrate coated with precious metals to oxidise pollutants in the exhaust gas.
Catalyst Module	The metal housing containing the Catalyst.
Ceramic Substrate	A ceramic extrusion usually in the form of a cylinder with channels running its full length, used as the basis of both the Catalyst and Filter. The channels in the Catalyst are open at both ends. In the filter every other channel is blocked forming a chequer board effect. This forces the gas to flow through tiny pores in the walls of the channels preventing the passage of soot.
CRT® System	Continuously Regenerating Trap. A unique patented process which uses a Catalyst to convert some NOx into NO2. This oxidises or burns any soot which is collected on the walls of the filter at temperatures in excess of 250°C so cleaning the filter.
Filter	A extruded ceramic substrate used to trap Soot and Ash.
Filter Module	The metal housing containing the Filter.
Inlet Module	The metal housing into which the exhaust down pipe from the engine enters the CRT® System.
Maximum Static rpm	The rpm reached by the engine when the accelerator pedal is fully depressed with the vehicle stationary and the transmission in neutral (sometimes called 'max.static').
Outlet Module	The metal housing from which the exhaust exits your CRT® System.
Particulate Matter (PM)	PM is the solid content of Soot and Ash in the exhaust gas normally observed as dark or black smoke.
ppm	'Parts per million'. A measurement used to quantify very small amounts of a trace element within a larger overall substance.
Serial Number	A unique number etched onto a plate welded onto the outside of the Catalyst Module and the Filter Module used to record when either module was manufactured and fitted.
Service Port	An access port may be built into the Inlet Module of your CRT® System which contains a smaller threaded orifice to allow the connection of a tube to a Back Pressure gauge.
Smoke Reading	The visible and measurable opacity (blockage of light) of the exhaust gas. This is related to the amount of particulate matter emitted by the engine.
Soot	The combustible particulate matter in the exhaust gas created as part of the normal engine combustion process typically observed as smoke.
V-Clamps	The metal clamps with a V shaped cross section which are used to hold the four modules of your CRT® System together. They are also often used to connect the turbo charger to the engine and exhaust pipes.



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