



DIVISIONE -TERS® - ECOSYSTEM

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TERS® Presentation



TERS® Catalytic System
Clean Diesel!

We are in

EURO 5

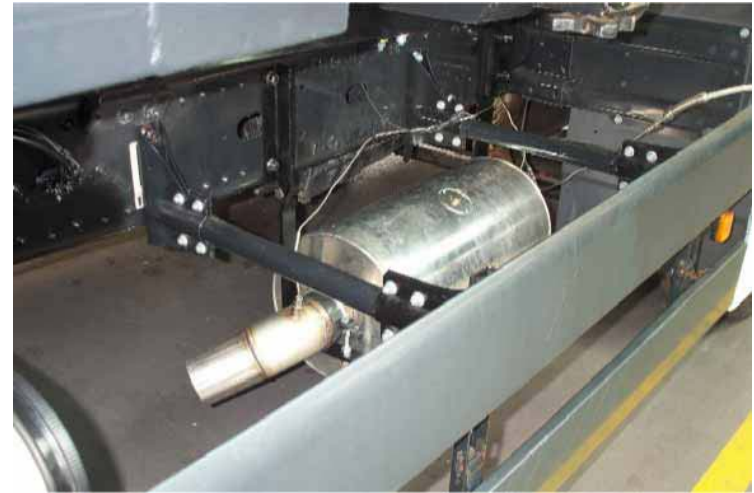
without **SCR** and **ADITIVES**

- ***TERS***[®] stands for “***T**otal **E**missions **R**eduction **S**ystem “*

- The working principle is based on the 99,9 % pure silica fibre applied with our own special technology that is obviously patented.
- The fibre is soaked of noble metals in order to make it catalysing with a procedure developed during long years of acquired experience from both laboratory and field tests.
- The main feature of ***TERS*** is to lead to 0,0 the carbon, the un-burnt hydrocarbon and the carbon monoxide also with few NO_x, by self producing the needed quantity of NO₂ in order to achieve the above mentioned results, never blocking and exclusively allowing the pass of the ashes got from the lubricant oils.
- Furthermore, thanks to the Brönsted acidity of the Si O₂ fiber, the catalysis begins at around 190°C, accordingly to the chemical reaction $\text{NO}_2 + \text{C} \rightarrow \text{NO} + \text{CO}$.
- This feature allows to recycle the exhausted gases in a sufficient quantity to reduce the NO_x over EURO 5 (Of course following our recycle specifications with EGR ***TERS***).
- The ***TERS***’ backpressure however remains under the actual automotive limits “within 150 mbar” in every operating situations, giving to the engine/manifold system the intrinsic reliability.
- This essential benefit, let the users to eliminate the maintenance and service costs. Moreover, the engine/***TERS*** system is independent and doesn’t require additives.

Content

- **TERS** System description
 - The system will be described with focus on its key elements
- **TERS** System story
 - From early studies in 1985 to the latest test results
- **TERS** System performances
 - Test results as regards as pollutants abatement
 - System inner function principle
 - Pros when compared to all other catalytic converters

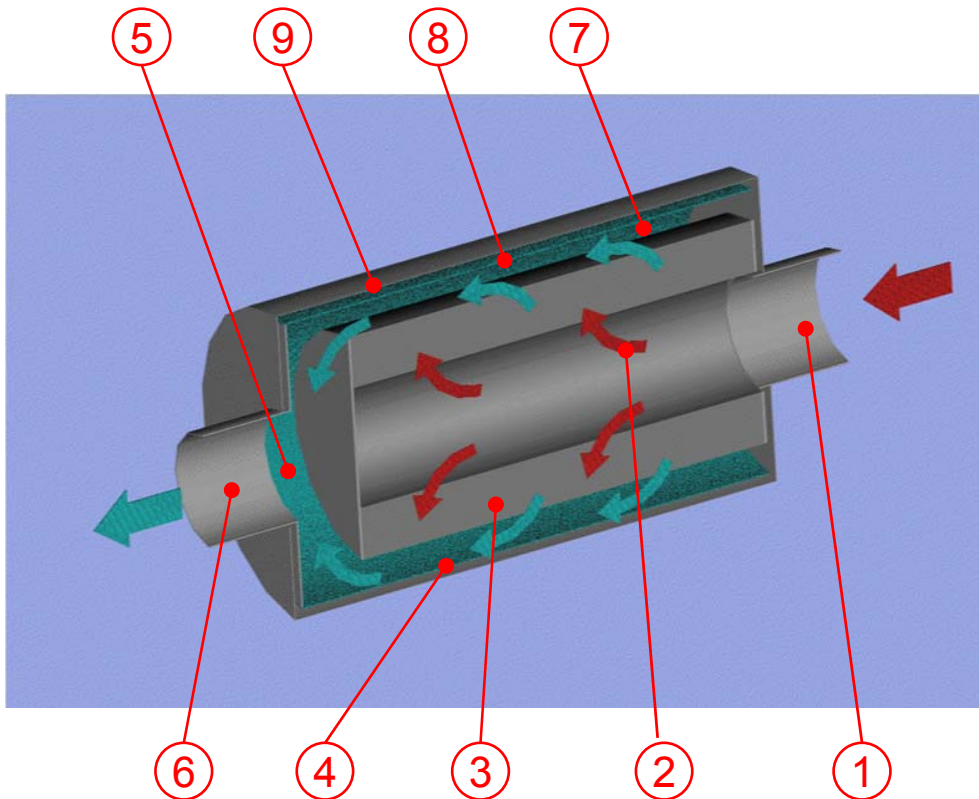


TERS® System Description

TERS is a catalytic converter system to be installed in diesel exhaust systems. Its main component is a *cartridge* made of quartz-silica fiber coated with precious metals.



TERS® System Description(I)

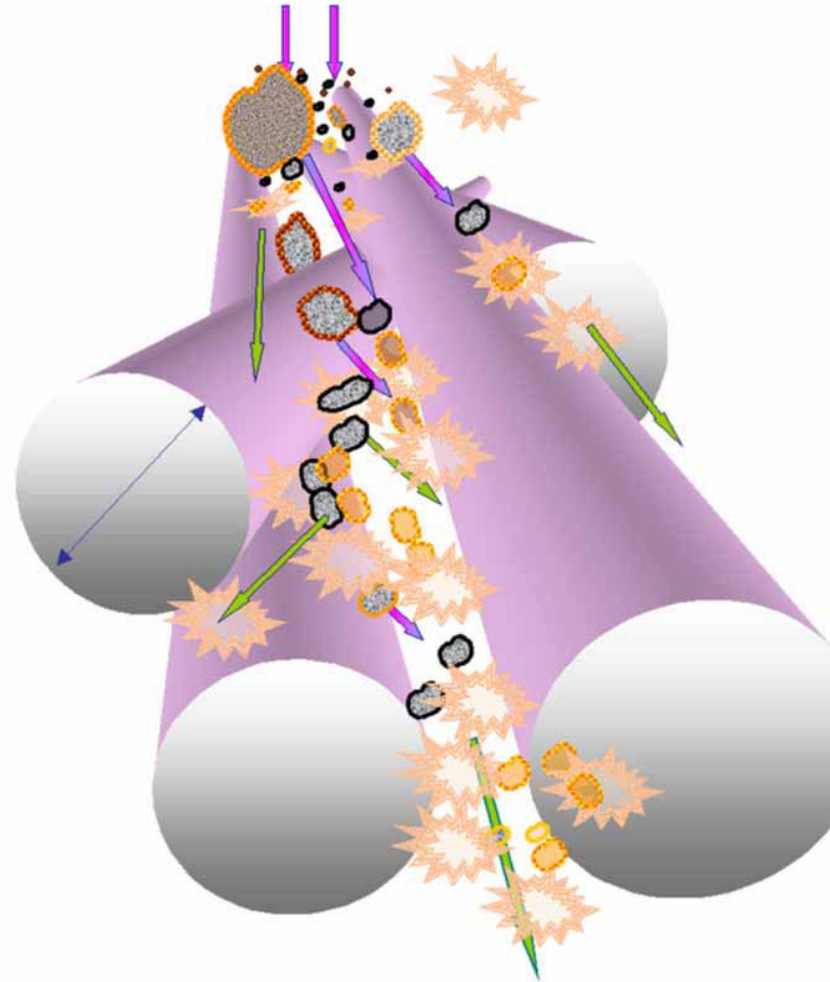


- 1) Inlet pipe
- 2) Expansion pre-chamber
- 3) **Cartridge**
- 4) Conveying chamber
- 5) Pre-release chamber
- 6) Outlet pipe
- 7) Inner shell
- 8) Insulation
- 9) Outer shell

Transit speed of exhaust gas through the cartridge is kept constant under any condition \Rightarrow system inner reliability
Insulation layer prevents condensate from freezing and allows fast light-off even in winter time. Moreover, it assures an adequate heat inertia that helps in keeping a high average temperature even under stop-and-go conditions

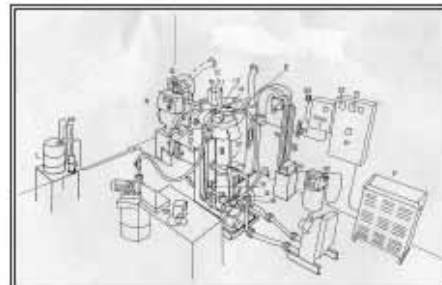
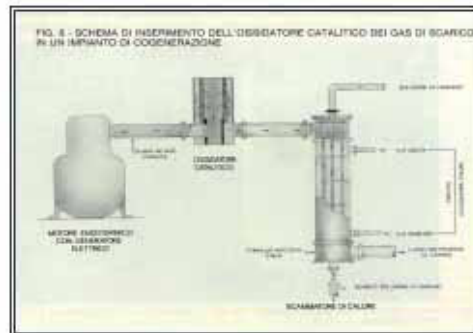
TERS® System Description (II)

- Quartz-silica fiber pure to 99.99%
 - Handling of this type of fiber is universally acknowledged as harmless
 - Fiber is made of filiform austenitic fabrics with a high elasticity
 - Fiber can barely swing due to exhaust gas flux \Rightarrow self-cleaning by a mechanical action
- Exclusive and patented process to coat the fiber with precious metals
 - Catalytic coating enables conversion even at very low temperatures ($\geq 200^{\circ}\text{C}$)



TERS® Technology History

- 1985: Completion of tests by a working group including SPACE -
- ENEA - Gilardini, Flexider department and RIP-Simonini - FIAT
- TTG on the experimental co-generation plant in Turin.
- The first ENEA (Alternative Energies National Board) patent
- originated from these tests.



TERS® Technology History

- 1989: Test results obtained by FIAT Engineering after 950 hours
- with an IVECO AIFO 8045 natural aspirated engine on a city bus.
- Fuel sulfur content : 500 ppm

- CO – 40%
- HC – 80%
- NOx – 1.4%
- PM – 50%
- SO2 – 67%
- SO3 + 27%



- From 1986 the TERS system has been installed on more than 500 urban buses, which have been running for at least 250.000 km between maintenance stops, even using high sulfur fuel (>3000 ppm) and without pre-oxidation catalysts.
- Tests have been performed in collaboration with the main Public Transport Companies, such as ATM (Turin), ATAC (Rome), AMT (Genoa), APAM (Mantua), APT (Pisa), ATESINA (Trento) and others.

TERS® *Technology History*

- 1993 Homologation for Diesel Train Locomotive ALN 663 (FIAT Ferroviaria Savigliano):
- smoke measurements with and without TERS catalytic converter

Engine equipped with TERS



Engine without TERS

TERS® Technology History

1999: TERS installed on MAN Euro2 bus in Nuremberg



***TERS®** Technology History*

- 2000: Multiple-cartridge TERS system for a 178 kW diesel engine



TERS® *Technology History*

- The TERS technology has been tested by Research Organizations such as:
 - **ENEA**
 - **C.S.R.P.A.D.** (Italy Ministry of Transport Motor Vehicles Research and Testing Center)
 - after functionality and ageing tests, authorized its use to OEMs with circular no. 540/4209 A022 of 24th Feb., 92
 - **CNR** of Neaples
 - **TÜV BAYERN**
 - **IP Italiana Petroli** in collaboration with **AMT** of Genoa and **ATM** of Turin
 - **AVL MTC, Haninge SWEDEN**

TERS® System Performances

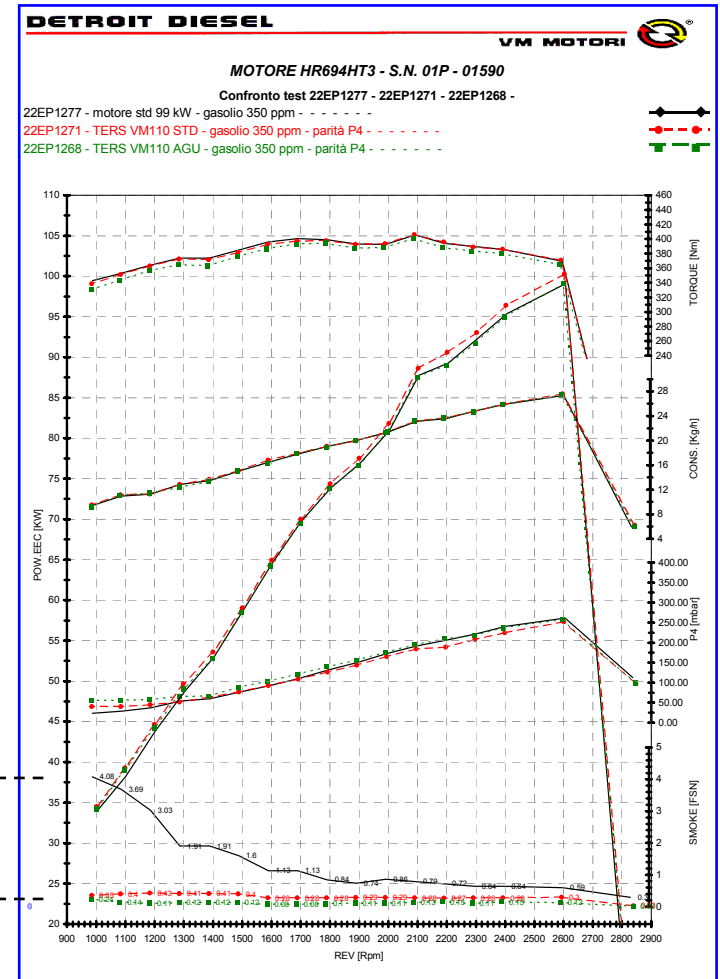
- CO, HC and carbonaceous PM reduction comparable to a honeycomb filter
- Nanoparticles reduction
- **TERS** requires low levels of NO_x in the exhaust (about 50% of traditional catalysts) to form NO₂
- TERS is capable of handling fuel sulphur levels up to 350 ppm
- Non-regulated pollutants reduction
 - Aldehydes, Polycyclic Aromatic Hydrocarbons (PAH)
- Carbonaceous PM conversion at **T ≥ 200°C**
- Much higher **regeneration speed** compared to a honeycomb filter
- Ash is not trapped ⇒ no filter clogging ⇒ **maintenance free**
- Back pressure less than a honeycomb filter
- Durability > 600 000 km on prototypes built up to now

TERS® System Performances

European Stationary Cycle (ESC)

	w/o <i>TERS</i>	w/ <i>TERS</i>	Euro5 limits
CO	0.65	0.00	1.5
HC	0.04	0.00	0.46
NOx	2.85	1.58	2.0
PM	0.115	0.004	0.02

Smoke



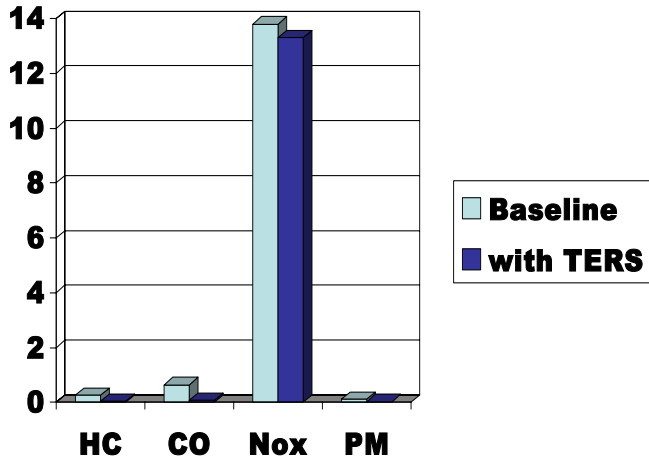
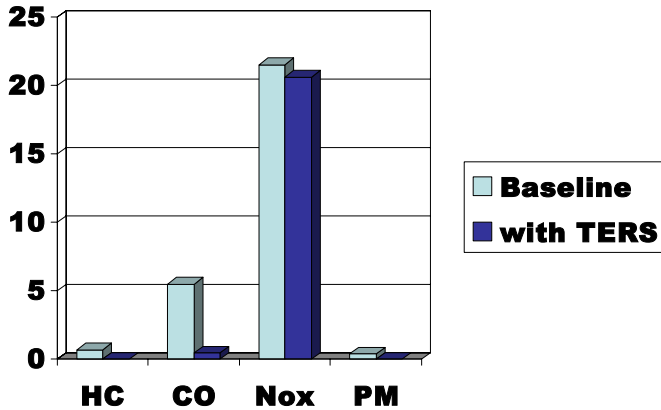
Swedish Enviromental zone Test performed by AVL MTC December 2003

Braunschweig

	HC	CO	NOx	PM
Baseline	0,26	0,65	13,8	0,11
With TERS	0,04	0,08	13,3	0,02

R49

	HC	CO	NOx	PM
Baseline	0,69	5,51	21,5	0,41
With TERS	0,00	0,46	20,6	0,02



TERS® In action

- FIAT Daily truck
- Ters 100 Kw
- Smoking Test with AVL Device



TERS® *In action*

- **MAN Truck 320 Kw**



TERS® In action

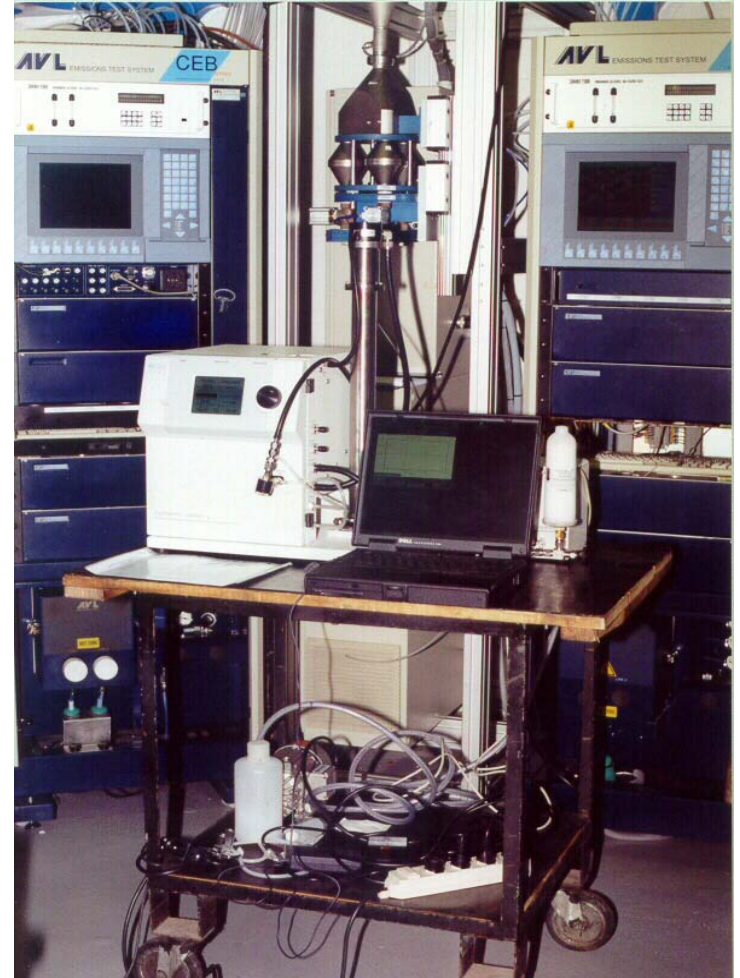
MAN Bus 190 Kw



Test on **TERS®** 90 Kw.
at
VM Motori Detroit Diesel



Test on *TERS*® 160 Kw.
at
VM Motori Detroit Diesel



Test on **TERS®** 190 Kw.

At

MAN Nutzfahrzeuge

Reparto Ricerche ed Esperienze Motori Diesel MTVV



MAN Declaration

- To SPACE Company Nuremberg, 11/22/2002
- **TERS system equipped with EGR filter: state of the art on November 2002**
- Since about one year, MAN DIESEL ENGINES TEST AND RESEARCH LABORATORY in Nuremberg has performed experimental tests on TERS system “designed by SPACE srl” functionality. From them, it has been noted that the system in object allows the carbon to be completely converted without accumulating carbon and ashes that could compromise the engine working.
- What we have written above is better highlighted by the following results obtained in the 13 MODES ESC cycle and in ETC cycle with an EURO 4 engine:
- CO = 0.00 g/kWh
- HC = 0.00 “
- NO_x = 2.80 “ (in ETC 3.30 g / kW h)
- PM = 3-4 mg / kW (in ETC 4 mg / kW h)
- The smokiness measured by AVL equipment in all working field is lower than 0.05 FSN (i.e. Filter Smoke Number, that is similar to BOSCH number). For the most part of 13 points in ESC test, the smokiness is not measurable, as the equipment gives 0.00 FSN results.
- Correspondingly, the relieves without TERS system gave the following results:
- CO = 0.65 g / kW h
- HC = 0.04 “
- NO_x = 2.85 “
- PM = 115 mg / kW h

- Follow MAN declaration
- The smokiness in 13 MODES was going from a minimum of 0.27 FSN to a maximum of 1.30 FSN. A peak of 2.45 FSN in the second MODE, due to a sudden change in engine loading fixed by test, is completely removed by TERS system.
- The system backpressure is max. 200 mbar with a 178 kW engine at max. power. It is determined by a TERS device downstream that has the task of increasing EGR degrees by the exhaust pipe section reduction. These values, that seem to become stable with the passing of time, are completely suitable for letting the working on vehicle.
- Specific consumptions are such as to give the possibility of keeping the known levels for EURO 3 engines.
- After having changed the engine setting and recycle accessory devices, other functional demonstrative test have been done under the fixed limits for EURO 5 level.
- In ESC test, the results become stable on the following values:
 - CO = 0.00 g / kWh
 - HC = 0.00 “
 - NO_x = 1.58 “
 - PM = 4-6 mg / kW
- Chemical analysis would demonstrate the ashes presence in exhaust gas measured on TERS system downstream. This confirms the system carbon particulate destruction function: avoiding the ashes accumulation coming from principally additives of engine oil, this system is not subject to obstruction coming from them.

- Follow MAN declaration
- Correspondingly, simultaneous smokiness relieves effected at TERS upstream allow to calculate the following carbon particulate value:
- $PMc = 183 \text{ mg / kW h}$
- Since for the engines used during the test the carbon particulate contribution at this smokiness level with a lack of Sulphur in the fuel ($S < 10 \text{ ppm}$) is about 95% of total, a result for the total particulate measured at TERS system upstream of about 195 mg / kW h can be expected.
- Smokiness values, in the 13 MODES used for the above calculation, were going from a minimum of 0.6 FSN to a maximum of 2.0 FSN, with the max. peak of 2.65 FSN in the second mode.
- The above procedure has been followed since the high smokiness levels have prevented to measure the correct particulate total mass using Microtrol's microtunnel normal filter equipment.
- In this case the noticed peak pressure at TERS system upstream is about 110 mbar too.
- .We are following an endurance test plan with an urban bus that can confirm the backpressure becomes stable on normal levels for the correct engine working.
- **MAN Nutzfahrzeuge**
- **MTVV Diesel engines test and research Dept.**

•MAN declaration to Italian Branch



Traduzione della lettera "Rußabscheidesystem von TERS"

MAN Veicoli Industriali S.p.A.
Filiale Autobus
Cort. Att. Sig. Velati
Via Razzaboni, 130
41100 MODENA

Nürnberg 29.01.03

Oggetto: sistema di separazione del particolato Sistema TERS della ditta SPACE

Su richiesta della ditta SPACE e tenendo conto dello stato della sperimentazione riguardante la marmitta silenziatrice catalitica Sistema TERS, diamo il nostro consenso alla sostituzione dei silenziatori di scarico e dei filtri per il particolato montati sui veicoli dotati di motori MAN a norma Euro 3 e precedenti, adibiti in Italia al trasporto pubblico sulle tratte urbane e interurbane, con il suindicato sistema. I reparti di vendita MAN sono autorizzati a trasmettere il presente documento alla ditta SPACE ed alle aziende di trasporto interessate. Detto consenso è vincolato alle seguenti condizioni:

Al produttore del sistema è fatto obbligo di assumersi la garanzia eventualmente richiesta dagli utenti riguardo la funzionalità del proprio silenziatore catalitico. Il costruttore dei motori (MAN Motorenwerk Nürnberg) non si fa carico dei danni occorsi durante periodi di garanzia ancora in corso e riconducibili a vizi funzionali del suddetto sistema.

La modifica dei veicoli deve essere preventivamente comunicata al reparto MTE, indicando il tipo di motore e la sua dotazione.

È fatto obbligo a chi lo effettua di eseguire la sostituzione del silenziatore di scarico a regola d'arte e secondo le direttive MAN per il montaggio di impianti di scarico.

La contropressione dei gas di scarico a monte della marmitta catalitica non deve superare i valori prescritti dalla MAN. Si raccomanda la sorveglianza della contropressione di scarico con indicazione ottica (spia o simile) al conducente per evitare il superamento di detti valori massimi.

Il costruttore del sistema è tenuto ad assicurare che la rumorosità del veicolo non superi i valori di omologazione.

Gli utenti e gestori dei veicoli devono essere istruiti riguardo i fluidi tecnici approvati (carburanti ed oli motore), in particolare tenendo conto delle raccomandazioni MAN per carburanti a basso tenore di zolfo (additivi).

MAN Nutzfahrzeuge

Werk Nürnberg

MTE , Dr. Held

MTV , v.Hoerner

11/16

4/4