

Tier 4 Emissions Overview

Volvo Construction Equipment



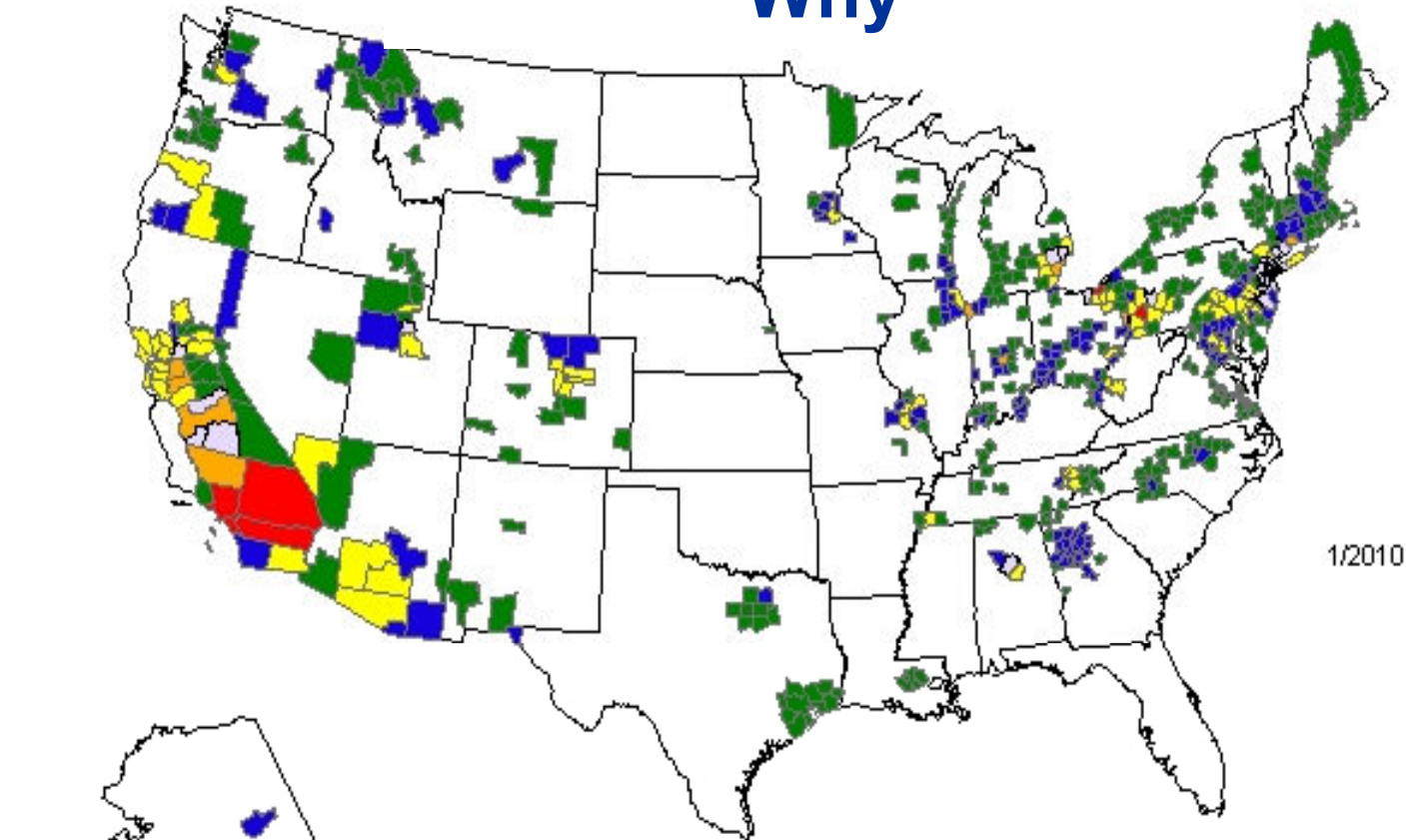
Improving Processes. Instilling Expertise.

Agenda

- Tier 4 Regulation Overview
 - Why
 - What is Tier 4
 - Where - World Impact
 - When
 - How - Technology of Tier 4
- Training
- Service
- Questions & Answers









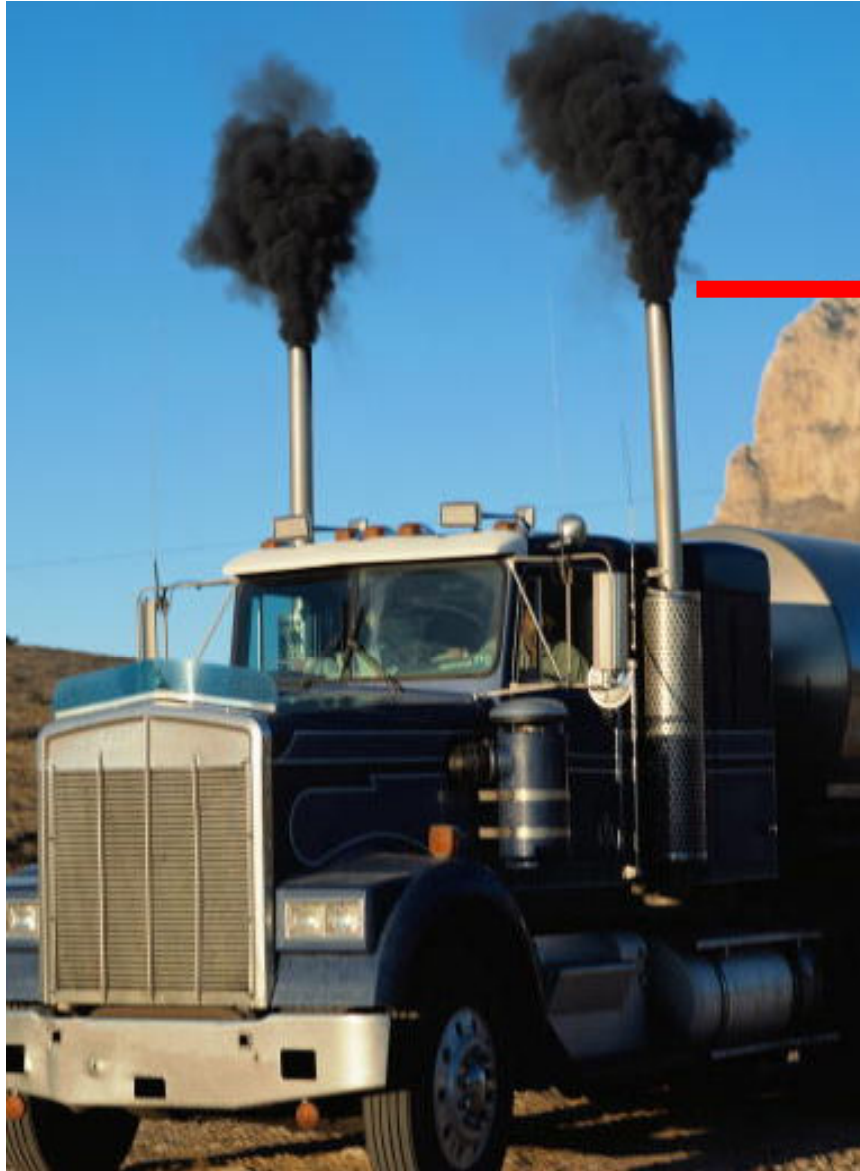
Why



1/2010

Legend **

-  County Designated Nonattainment or Maintenance for 6 NAAQS Pollutants
-  County Designated Nonattainment or Maintenance for 5 NAAQS Pollutants
-  County Designated Nonattainment or Maintenance for 4 NAAQS Pollutants
-  County Designated Nonattainment or Maintenance for 3 NAAQS Pollutants
-  County Designated Nonattainment or Maintenance for 2 NAAQS Pollutants
-  County Designated Nonattainment or Maintenance for 1 NAAQS Pollutants



Tier 4 Journey

PM, NO_x, CO, HC, CO₂, SO₂,
EU STAGE IIIB, EPA TIER 4 INTERIM,
BART, SCR, EGR, DPF, VGT

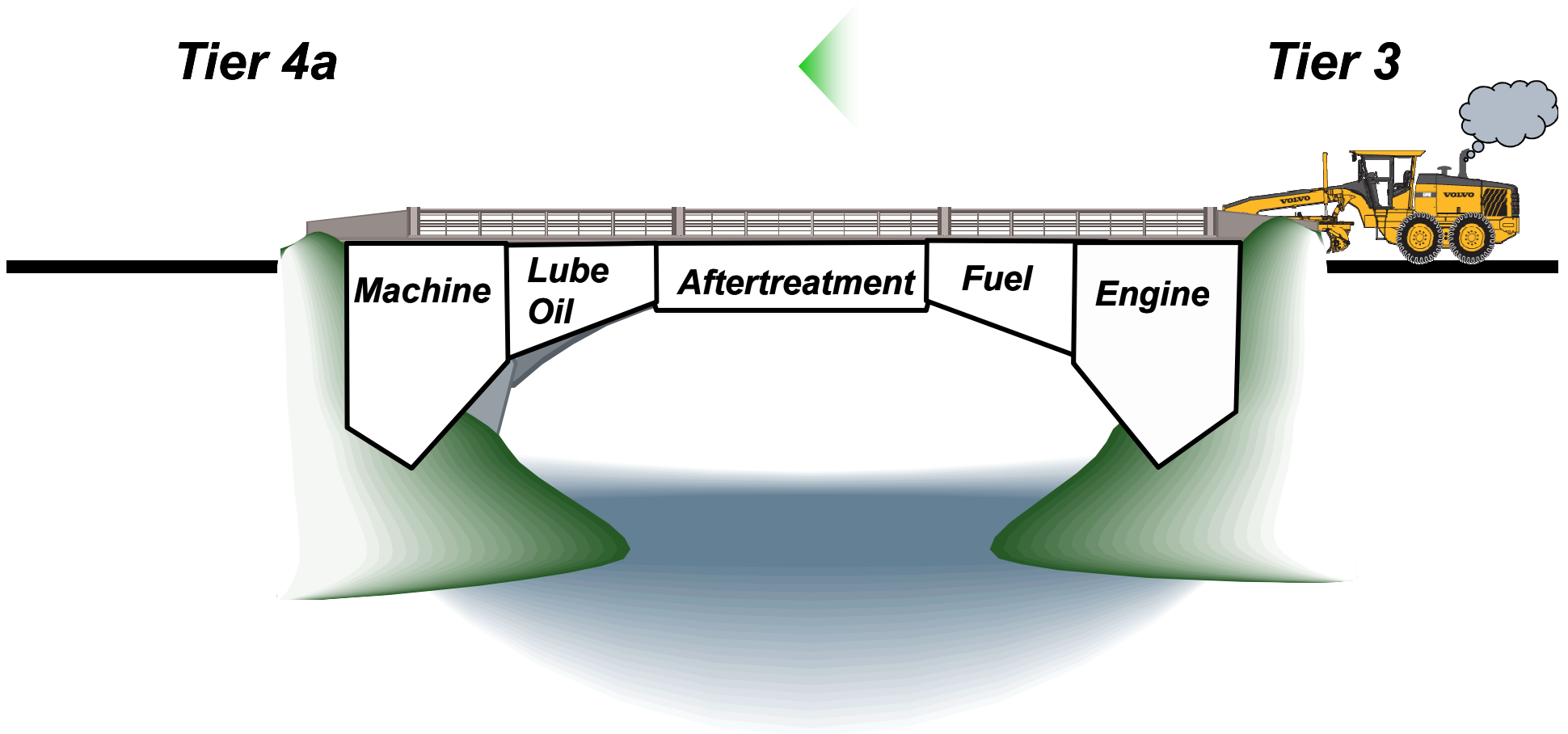
HOW WILL ALL THIS AFFECT YOUR BUSINESS?

Tier 4a Journey

Tier 4a requires a systems approach. All systems must be in place to have a successful product. Engines alone cannot meet the new emissions requirements.

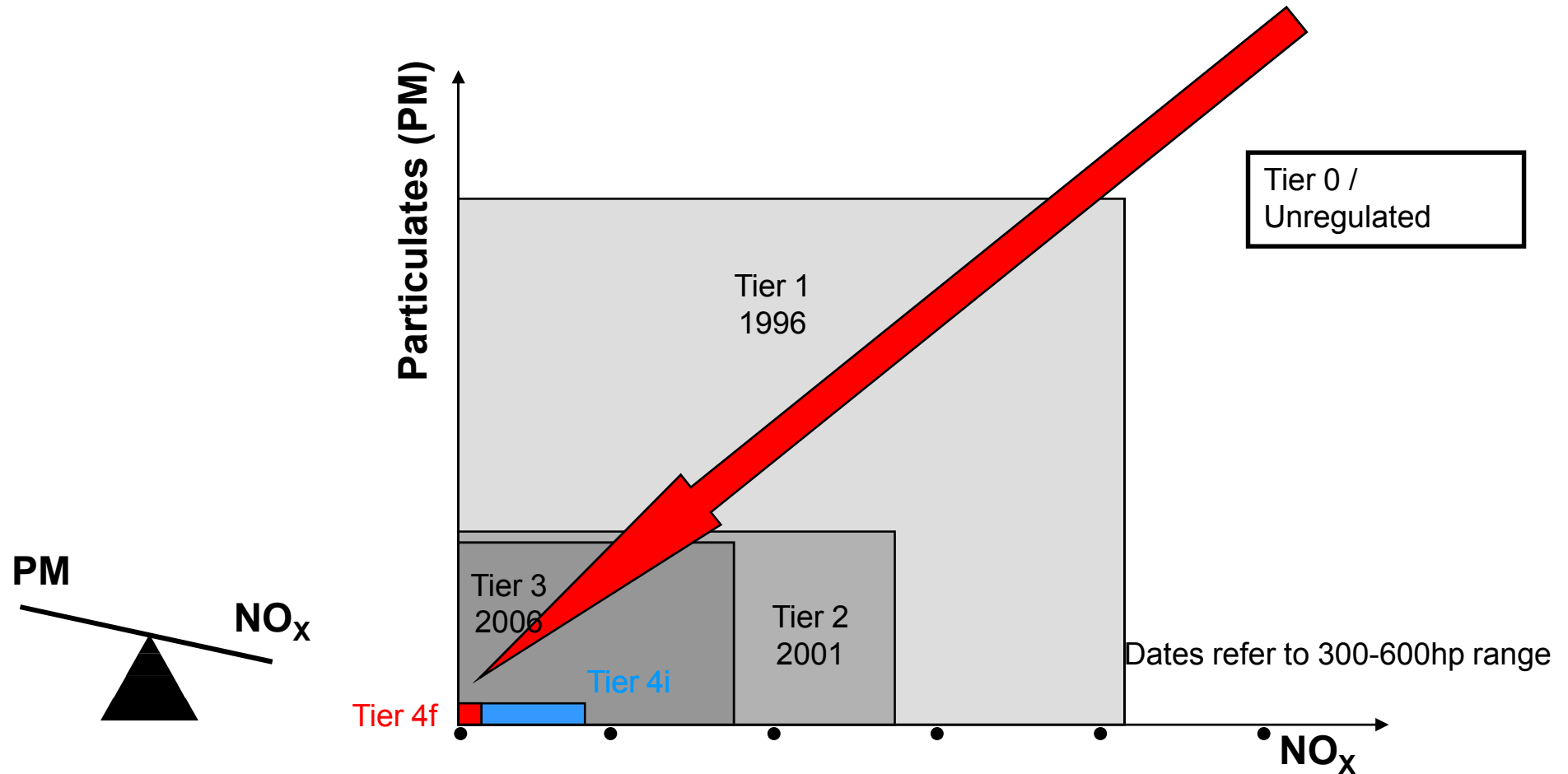
Tier 4a

Tier 3



Emission Regulations at a Glance

The Emissions Box: In general what is done to reduce NO_x creates PM.
What is done to reduce PM creates NO_x.

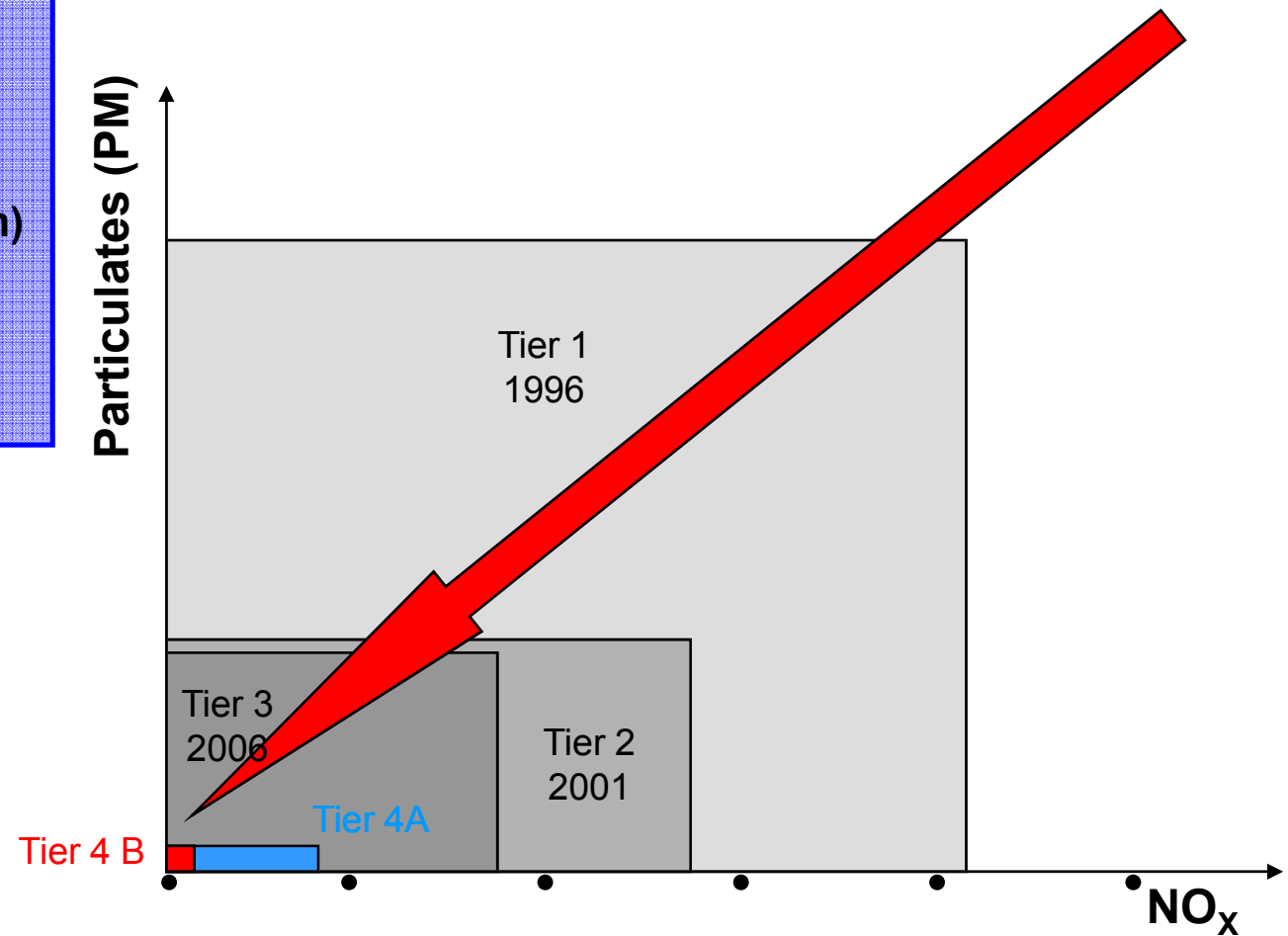


As high temperatures burn off the black soot or PM, it creates NO_x. Conversely, cooler temperatures reduce NO_x but increase soot (PM). This creates the problem of “getting in the box” that the engine developers fret about.

Emission Regulations at a Glance

When talking Tier 4, these terms are the same:

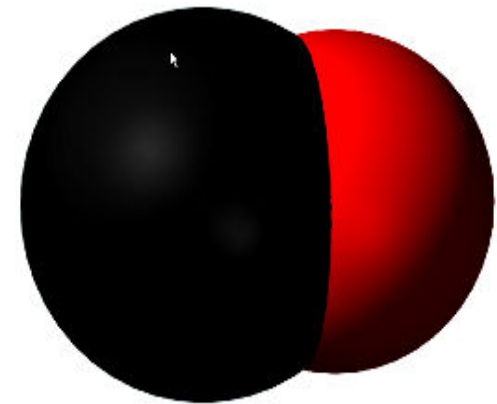
- Tier 4a & Tier 4i (interim)
- Tier 4b & Tier 4f (final)



What Emissions?

EPA regulations set limits on:

- HC – Hydrocarbons (organic compounds hydrogen & carbon)
(hydrocarbon fuels – diesel, gasoline)
- CO – Carbon Monoxide
- PM** – Particulate Matter
- NO_x** – Nitrogen Oxides



Carbon Monoxide

Particulate Matter

Particulate Matter:

- Soot – carbon particles resulting from the incomplete combustion of a hydrocarbon (lack of oxygen – rich, cold combustion) [NO_x is low]
- Aerosols – solid particulates or liquid droplets
- Sulfates – related to sulfur (ULSD)
- Silicates

Why is it bad?

Particulate matter is said to cause:

- Aggravation of respiratory illnesses
- It is said to cause Lung cancer and heart disease

It's the small particles that have the biggest health impact!

What are Nitrogen Oxides (NOx)?



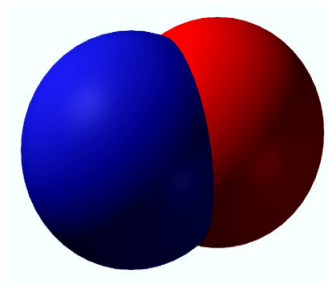
Nitrogen oxides are mainly NO & NO₂

Clear/Colorless

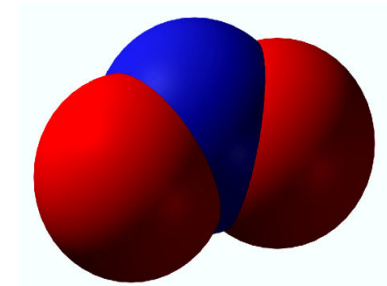
NOx is formed by **high combustion temperatures**

Engines tend to be most fuel efficient when producing the most NOx (great **fuel consumption**)

High temps burn off PM



NO - Nitric Oxide



NO₂ - Nitrogen Dioxide

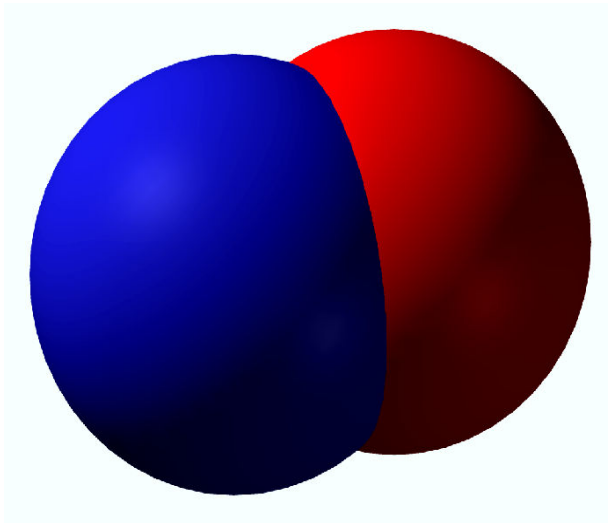
What are Nitrogen Oxides (NO_x)?

Why is it bad?

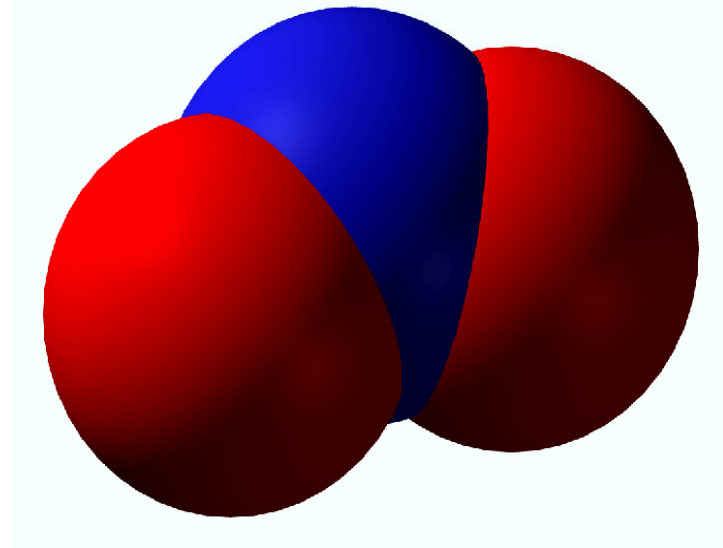
NO_x is said to contribute to reactions that cause:

- harmful particulate matter
- ground-level ozone (smog)
- acid rain

All may impact health and the environment (water quality & fish)



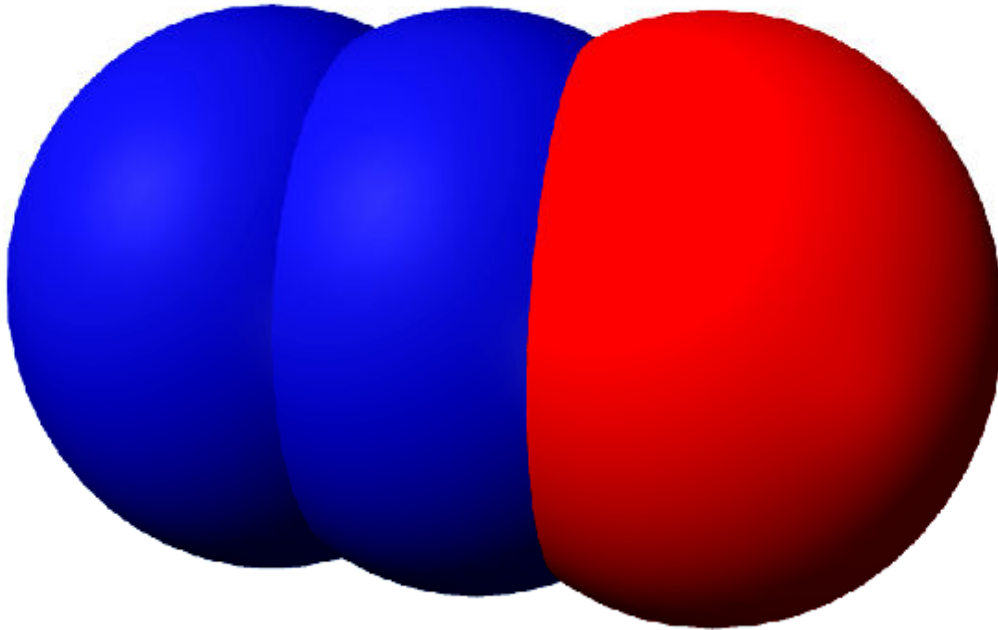
NO - Nitric Oxide



NO₂ Nitrogen Dioxide

NO_x – What its not

N₂O Nitrous Oxide – laughing gas



The “Terminator”

Fuel - ULSD

Fuel

ULSD is not only required within the Tier 4 EPA regulation, it is **critical** for some emissions control technology to work and to **extend** the life of engine components and **catalysts** in the exhaust system. Engine **DAMAGE** will occur!

Note: ULSD is backwards compatible with all Tier level engines

Machines requiring ULSD cannot be taken or sold to countries where it is not available!

**ULTRA LOW SULFUR
FUEL ONLY**



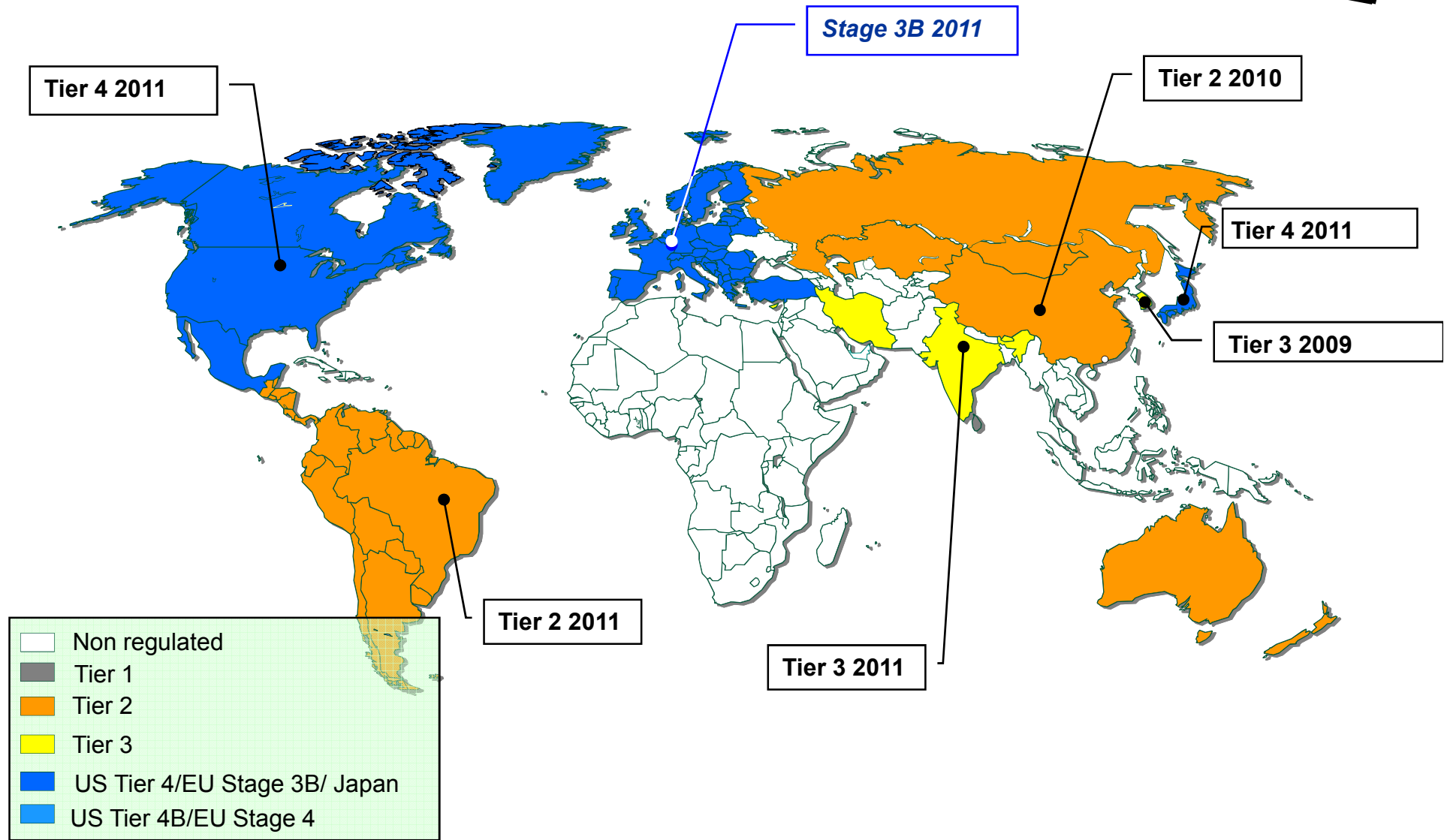
Equipment sold in the U.S. must be labeled near the fuel inlet with the text "**ULTRA LOW SULFUR FUEL ONLY**"

This required text may be used in conjunction with other symbols also.



Future advanced off-road exhaust emission standards 2012

Fuel



Technology

Engine

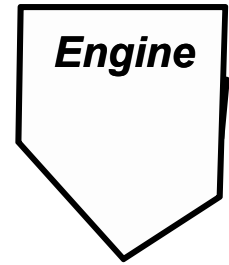
How will we get there and meet our customer's needs?

Manufacturers with **on-road** experience have benefited from experience

Transition to **off-road** will not be a new science.

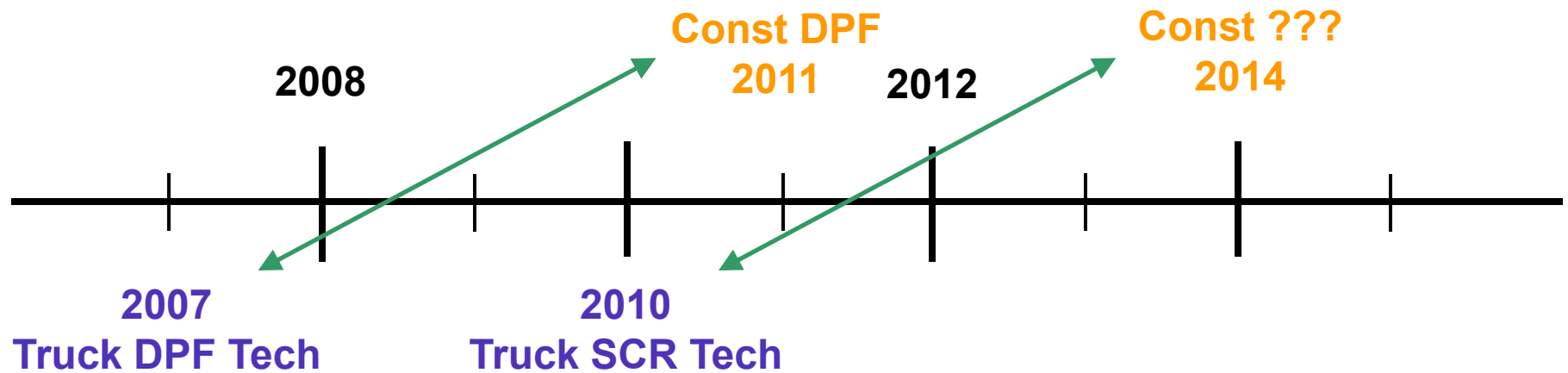


Technology



How will we get there and meet our customer's needs?

Off-road regulations lag on-road regulations, by about four years.

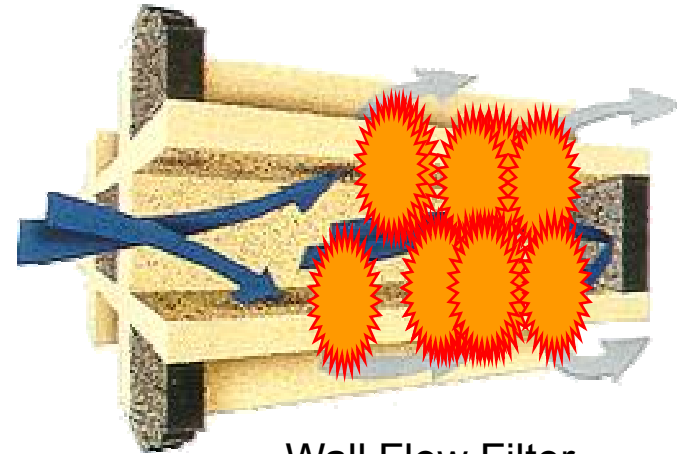
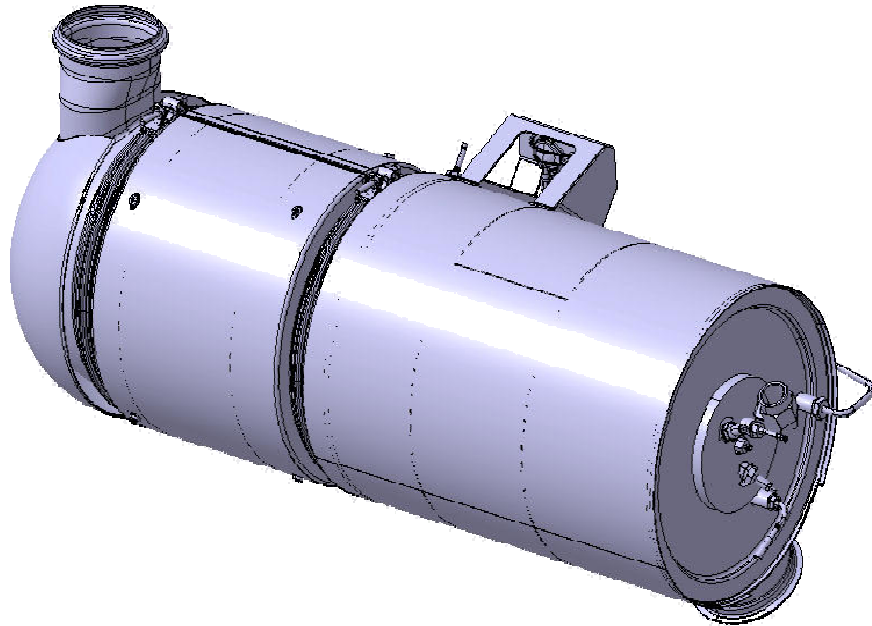


Technology – Tier 4i

Aftertreatment

Particulate Filter :

A particulate filter is used to collect the PM generated by combustion. Often called a particulate trap, it does just that – traps the PM. As more and more material is collected, backpressures increase and the filter must be cleaned.



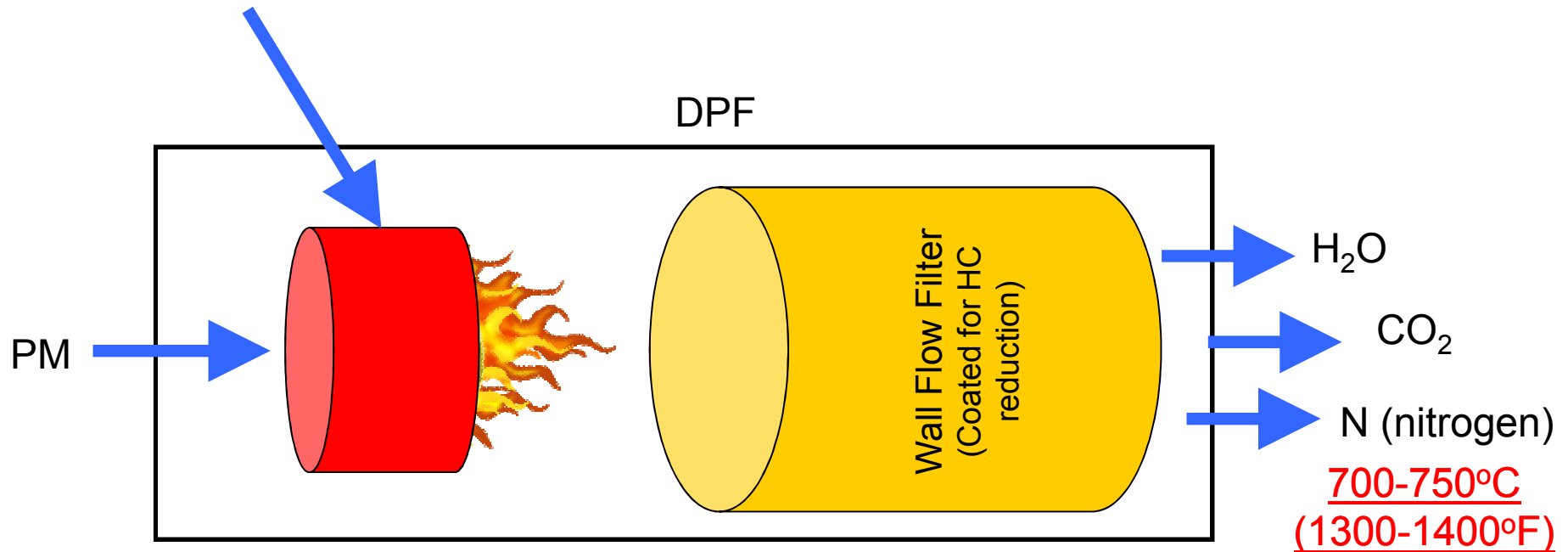
Wall Flow Filter

The filter cleans itself by oxidizing the material in a process called **regeneration**.

DPF Regeneration

Aftertreatment

Heat is generated in a number of ways



Regeneration creates the temperatures needed to oxidize the PM trapped in the DPF

This is done during machine operation and will require operator interaction!

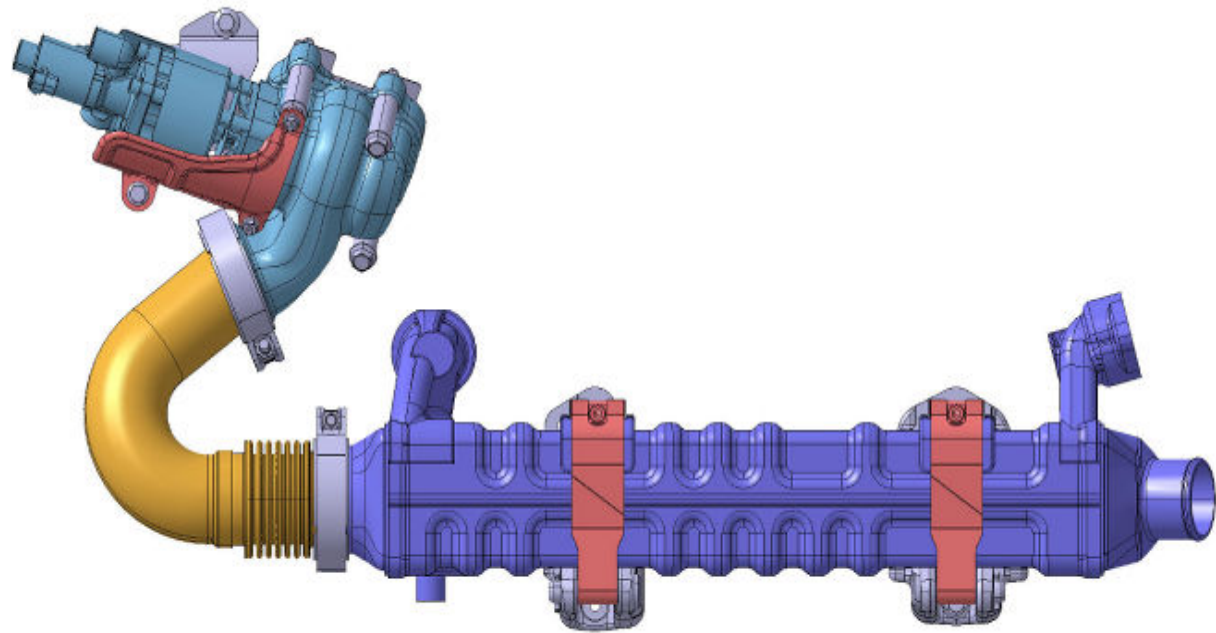
Technology – Tier 4i

Engine

Cooled Exhaust Gas Recirculation (EGR)

Cooled EGR is very effective at lowering combustion temperatures **reducing NOx**.

Controlled amounts of exhaust gas are routed through a cooler and routed back into the engine mixing with the fresh air in the cylinder. The amount of EGR varies from mild to massive.



EGR Cooler and Control Valve

Technology – Tier 4i

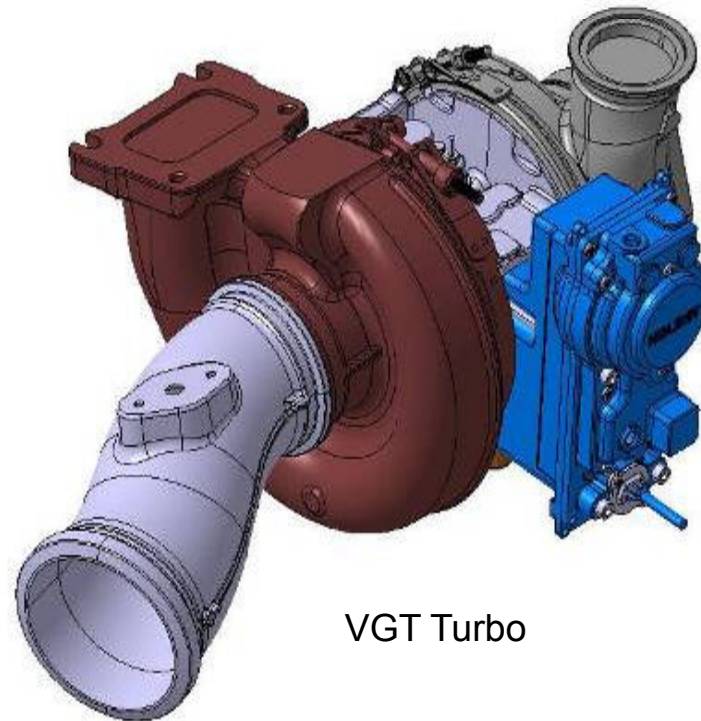
Engine

Air Handling and Turbo Charging

Turbo charging is part of the emissions design and creates the optimum pressure in the intake and exhaust manifolds. This makes it possible to tailor the **EGR** flow back to the inlet manifold and also have optimum performance and fuel economy.

Wastegated and **variable geometry turbo (VGT)** options allow specific tuning based on performance requirements.

Enhancing **fuel injection** and **air handling**, along with a new generation of **engine management systems** is a major part of the solution.



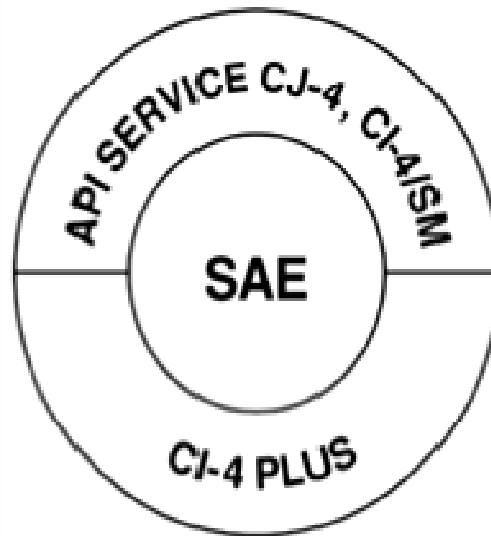
VGT Turbo

Tier 4 – Engine Oil

Lube
Oil

Required engine oil will be CJ-4

CJ-4 is a low ash oil that reduces the build up of ash in the DPF - increasing the time between ash cleaning

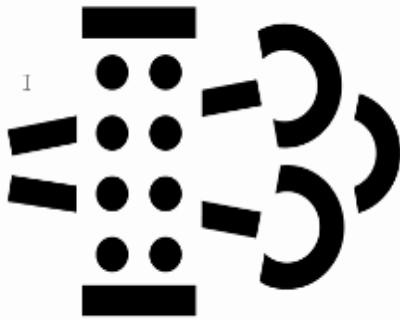


It is backwards compatible with the rest of your fleet and already available from Volvo as **ULTRA DIESEL ENGINE OIL VDS-4**

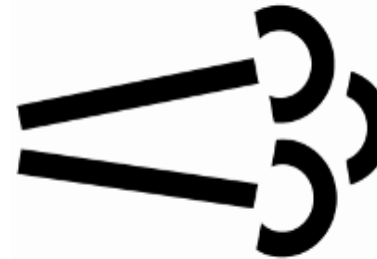
Tier 4 –Operator Interface

Note: All symbols are ISO standard

Machine

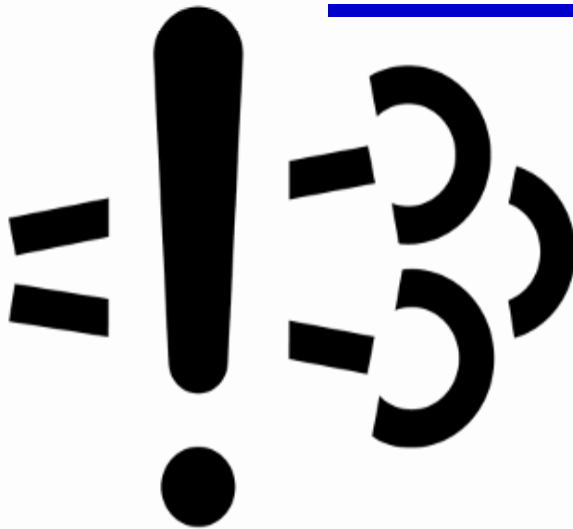


Particulate
Filter requires
regeneration
or other
attention

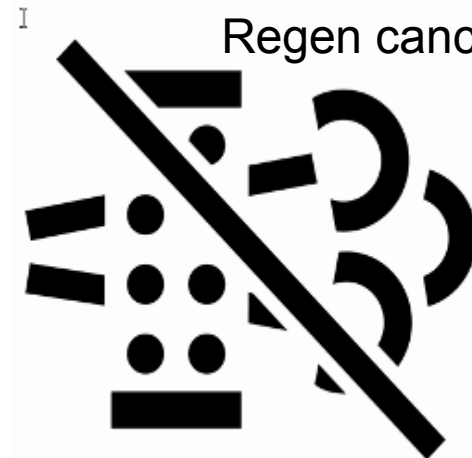


Exhaust
Temp high.
Should only
come on
during Regen

REGENERATION



Error in particulate filter
system (could be
ignored regeneration)



Regen canceled

Training

Machine

Operator will need training to understand the operation of the regeneration phase of the DPF

Why? – high exhaust temperatures during regeneration will cause concern if the exhaust pipe outlet is directed at flammable materials, vapors, heavy dust or structures

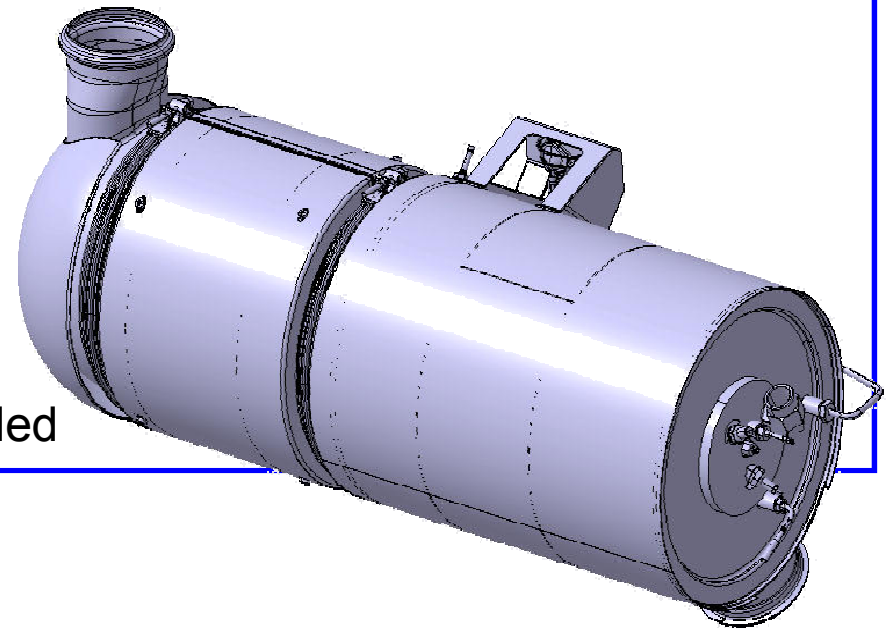
700-750°C (1300-1400°F)

Service

Machine

EPA mandates no scheduled customer paid service under 4500 hours

- All DPF's collect ash:
 - Ash formed from burned engine oil
 - Ash cannot be oxidized/regenerated out of the filter – it collects in the DPF
 - Low ash engine oils help extend the interval
 - Filters must be disassembled and the filters exchanged
- Clean filters will likely be available for exchange through a reman program similar to Volvo & MACK Truck
- Cleaning by the customer not recommended



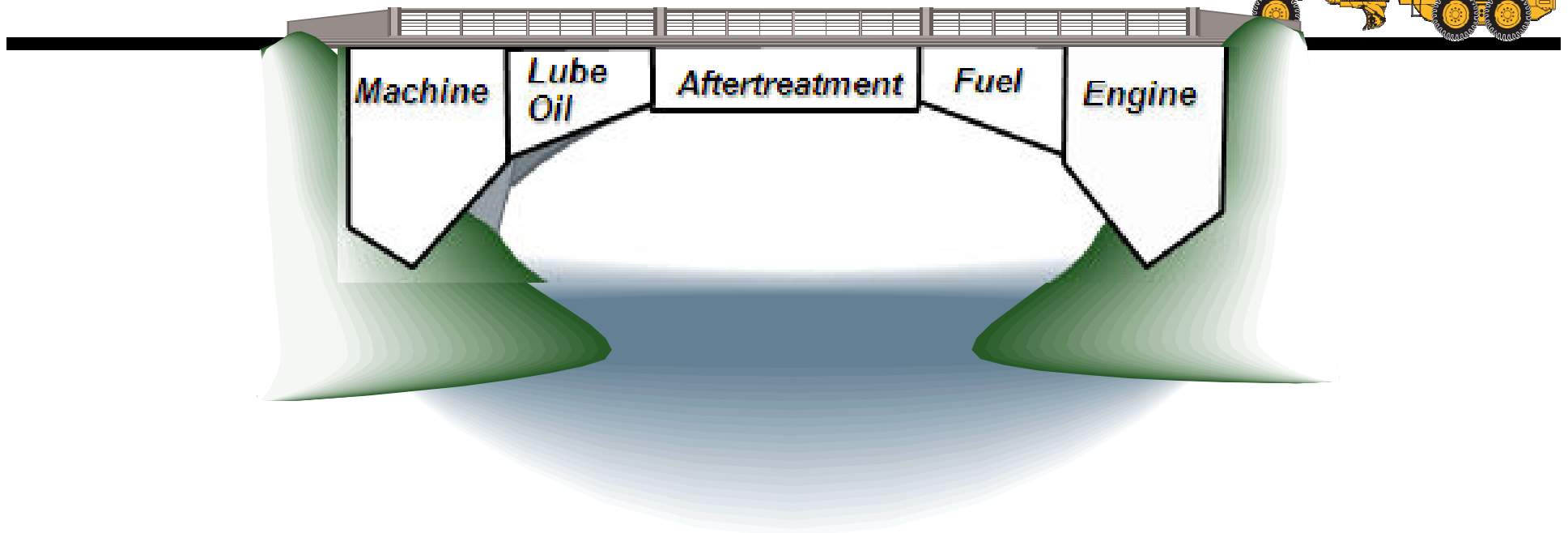
Tier 4a Journey

Tier 4a requires a systems approach. All systems must be in place to have a successful product. Engines alone cannot meet the new emissions requirements.

Tier 4a



Tier 3



Summary

- Significant reductions in emissions!
- Across border mobile fleets cannot take Tier 4 machines into non-ULSD countries
- Integration of particulate filters will have an impact on machine cost but at a lower % impact than on on-highway truck
- Operational impacts - none
- Training – needed (operator & technicians)

THANK YOU

Questions?

