

# SCR System (Selective Catalytic Reduction)

## Failure Diagnostics

PRESENTED BY **RALPH DEAYTON**  
MAMMOTH EQUIPMENT & EXHAUST

**MDEC 2022**

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## Agenda



- Introduction
- What makes an engine Tier 4 compliant
- Can I retrofit my engine to be Tier 4?
- What is an SCR?
- Common SCR issues
- Causes of failure
- How to spot failure occurring
- Recommended Maintenance
- What can be done if failure occurs



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## WHO WE ARE

•Mammoth Equipment & Exhausts – Global leading solution provider to the heavy diesel industry



- Established in 1974. Established in North America in 2015.
- 21 locations globally, 5 of which are in North America
- We Manufacture and sell direct to the end user
- Direct fit replacement parts for all OEM's
- We can service companies of any size
- Complete range of air intake parts / exhaust parts / thermal exhaust blankets / etc.
- Site specific online library of drawings available



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## GLOBAL PRESENCE

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Canada/USA:	Winnipeg (CA) Sales & Warehouse	Elko (USA) Warehouse	Chetwynd (CA) Warehouse
	Edmonton (CA) Sales & Warehouse	Montreal (CA) Sales & Warehouse	Denver (USA) Warehouse
International:	Tauranga (NZ) Manufacturing & Warehouse	Christchurch (NZ) Manufacturing & Warehouse	Argentina (AR) Sales & Warehouse
			Mexico (MX) Sales & Warehouse
Australia:	Perth Sales & Warehouse	Perth Factory & Warehouse	Perth Sales & Warehouse
	Kalgoorlie Warehouse	Newman Warehouse	Adelaide Manufacturing & Warehouse
		Mt Isa Warehouse	Brisbane Warehouse
		Melbourne Factory & Warehouse	Devonport Manufacturing & Warehouse
			Orange Warehouse



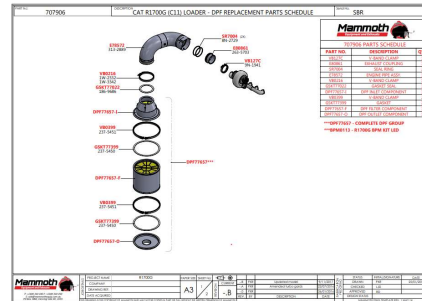
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## IF I ADD A DPF TO MY MACHINE DOES THAT MAKE IT TIER 4 EMISSIONS COMPLIANT?



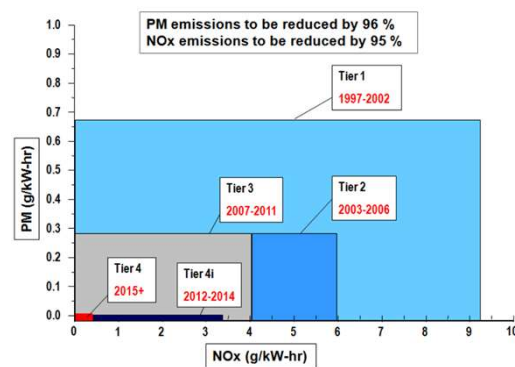
- Many sites today have Tier 3 or before powered equipment
- Does adding a DPF make it Tier 4?
- No – Adding a DPF will likely get it to Tier 4 interim emissions levels



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## WHAT MAKES A VEHICLE COMPLY WITH TIER 4 EMISSIONS REQUIREMENTS?

- To meet Tier 4 emissions requirements engines had to meet both DPM (particulate matter) and NOx emissions levels – 75-750hp
  - 0.4 g/kWh for Nox
  - 0.2 g/kWh for DPM
- For Euro Stage V (5) emissions the only difference is a particulate count level has been added. A DPF is an effective aftertreatment system for both particulate mass and count.



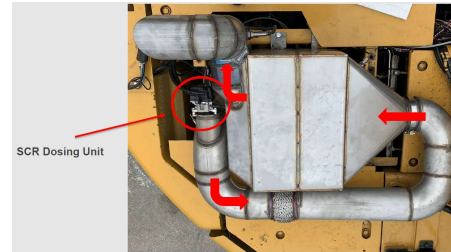
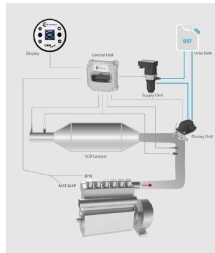
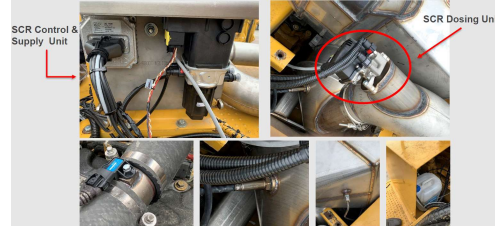
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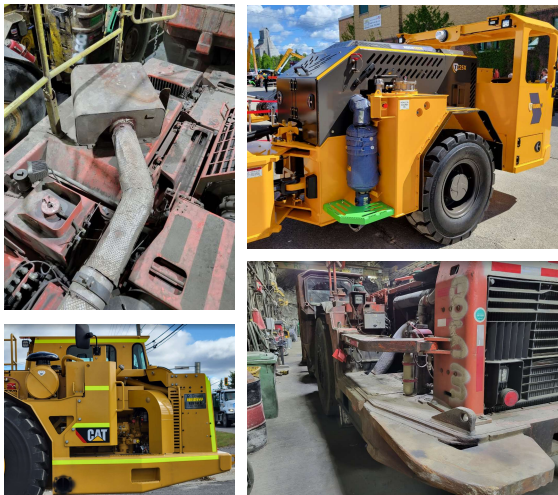
## WHAT DO I HAVE TO DO TO REDUCE NOX EMISSIONS FROM MY ENGINE?



- NOx can be reduced with a SCR system.
- Requires:
  - Control module – 24V supply
  - DEF Dosing module
  - DEF Dosing pump
  - DEF tank
  - DEF lines
  - Temperature, Pressure and NOx sensors
  - SCR Catalyst
- This would be in addition to whatever is on the vehicle for an exhaust system
- SCR systems can reduce Nox by up to 90%



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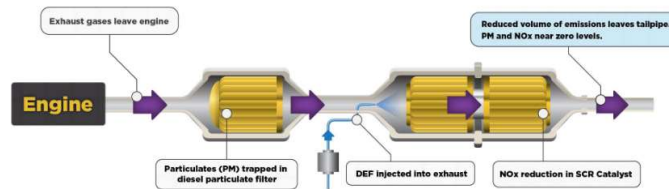
- CHALLENGES WITH RETROFITS
  - Space requirements for SCR catalyst, DEF tank, DEF Mixing chamber
  - Machine not designed to have SCR. Need to find space for these additional components and then sufficiently protected
  - Ensuring the work cycle/temperature/mixing for good DEF absorption
  - Providing operator/maintenance training

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### • WHAT IS AN SCR?

- SCR is Selective Catalytic Reduction – it is an active emissions control system that is designed to reduce NOx levels to near-zero.
- The high NOx hot exhaust gases leave the engine and are sprayed with DEF fluid. The Urea based DEF fluid is then absorbed into the exhaust gases which then as they pass over the SCR catalyst are separated into Nitrogen, Water Vapour and tiny amounts of CO2

#### Diesel Emissions Control System



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## SCR ISSUES

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- The Main issues that are seen with SCR systems are as follows:
  - DEF Dosing component failure
  - DEF Crystallization
  - Catalyst Coating
  - Catalyst substrate cracking/breaking up
  - SCR melting
- If ignored most vehicles will go into limp mode allowing the vehicle to idle only. This is hazardous and frustrating especially if vehicles are on the ramp or stuck away from the main garage or fill station



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## CAUSES OF FAILURE

- Dust preventing good DEF dosing/spray causing crystalization
- Soot loading of SCR catalyst substrate
- Engine component failure poisoning catalyst with oil – turbo failure, seals, rings
- Ammonia Nitrate coating from excessive DEF dosing
- Failure from excessive temperatures reached during desorb events (melting wires, damaging substrates etc.)
- Exhaust pipe failure, coating of substrate and causing high back pressure
- Engine failure/turbo fire sending excessive temperatures through the exhaust system



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## CRYSTALIZATION

- Occurs when DEF fluid is exposed, left open to oxygen
- Effectively the urea returning to its original state
- Will block lines, prevent good DEF spray, restrict exhaust pipe and cause back pressure



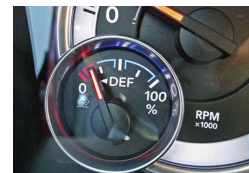
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## HOW TO SPOT FAILURE OCCURRING



- NOx conversion code on ECM
- Increased DEF usage (should be 2%-5% of diesel consumption depending on engine manufacturer – will increase as SCR fails)
- Increased number of SCR desorb events – some aftertreatment systems require or recommend regular desorb events to effectively 'self-clean' the SCR catalyst from becoming coated with crystalized DEF fluid/Ammonium nitrate. If the system requests these desorb events more frequently it would indicate that there is either a failure with the catalyst or with the DEF dosing. Desorb events require temperatures of 500C so run risk of compromising the catalyst coatings and melt down of nearby components if a fault occurs and temperatures runaway beyond 500 C



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## HOW TO PREVENT FAILURE



- Quality of DEF Fluid
  - Test regularly with refractometer to ensure urea concentration (32.5%) is maintained
- Storage of DEF Fluid
  - Out of sunlight – will lose urea potency if kept in direct sunlight too long
  - Freezing of DEF will change structure – more risk of crystallization
  - Temperature gets too hot you run the risk of evaporation and the structure will change
  - Store at between -5 C to 20 C for best longevity
- Prevent equipment from idling in extreme cold temperatures
- Cleaning DEF dosing spray nozzle
- Cleaning NOx sensor tips
- Ensure no mixing/contamination of fluids – different sized nozzles to ensure no diesel fluid/oils get into DEF tank and vice versa.
- Work cycle – no idle policy
- Avoid using master kill switch on equipment prematurely so that Urea properly drains out of lines prior to shut off. Otherwise urea can become 'stranded' in lines and will then crystallize
- Ensure that fluid properly drains from pumping nozzles when filling tanks

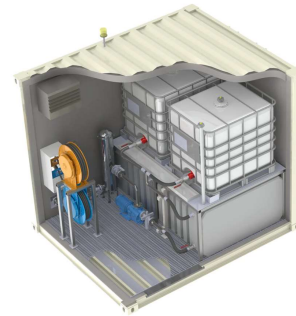
DEF Shelf Life vs. Temperature	
Constant Ambient Storage Temperature	Shelf Life in Months
≤50 °F (10°C)	36
<77 °F (25°C)	18
≤86 °F (30°C)	12
≤95 °F (35°C)	6
<104°F (40°C)	2

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### DEF STORAGE & HANDLING

- #1 enemy of DEF fluid / SCR is dust. Contamination from dust transfers from the tank to the dosing nozzle causing a blockage, leads to crystallisation – especially bad in dusty underground environments and concrete batching plants
- #2 enemy of DEF fluid is poor handling leading to crystalized particles to reach the dosing nozzle. Spills around the tank pump nozzle or fill cap can get into the tank or fluid



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### GOOD DEF/BAD DEF

- Has to be the right quality or it won't absorb into the exhaust properly
- 32.5% urea content is important
  - too much water and DEF pumps will dry out/burn out
  - Too much Urea and the pump will plug up
- Needs to be manufactured to meet ISO standards (ISO 22241), be a certified product. In USA regulated by American Petroleum Institute


ISO 22241-3:2008


Diesel engines — NOx reduction agent AUS 32 — Part 3: Handling, transportation and storing.

ISO 22241-3:2008 describes best practice recommendations and requirements for handling, transportation and storing of NOx reduction agent AUS 32 (aqueous urea solution), specified in ISO 22241-2. These recommendations and requirements are necessary to preserve the specified quality of AUS 32 from any point of production to the point where it is filled into the onboard tank of the vehicle, in order to ensure the proper function of the selective catalytic reduction (SCR) conversion system.

Language: en  
 Consideration date: 2008-02-07  
 ICS Codes: 43.080.40  
 Standard Number: ISO 22241-3:2008







# SAFETY DATA SHEET

## SECTION 1: PRODUCT IDENTIFICATION AND SUPPLY COMPANY DETAILS

Product name:	AUS 32 (preparation area exhaust DEF (Diesel Exhaust Fluid))
Recommendation:	Add to engine area exhaust DEF (Diesel Exhaust Fluid) (exhaust gases)
Supplier:	Mammoth Equipment and Exhausts
Job:	201 001 001
Street Address:	10 Emmet Clark Road, Centerville, WA 98555
E-mail:	sales@mammothexhausts.com
Telephone:	360 361 340
Emergency Telephone:	Australia: 0000 Information Centre 0 112

## SECTION 2: HAZARD IDENTIFICATION

Hazard Classification:	Non-Hazardous substance. Non-Hazardous goods according to GHS/CLP Chemical Hazard Classification Code (GHS/CLP Code)
Label Elements:	Not Applicable
Hazard Statements:	Not Applicable
Precautionary Statements: Prevention:	Not Applicable
Precautionary Statements: Response:	Not Applicable
Precautionary Statements: Storage:	Not Applicable
Precautionary Statements: Disposal:	Not Applicable

## SECTION 3: COMPOSITION INFORMATION

CHEMICAL ENTITY	CAS NO.	PROPORTION
Deionized water	7732-18-5	67.5%
Urea	57-13-6	32.5%



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## RECOMMENDED MAINTENANCE



- Check the inline filters in DEF lines/tanks – clean/replace filters to prevent contamination
- Check the condition of the onboard DEF filter in the tank
- Use dry break fittings/connection to prevent DEF fluid being left in nozzles
- Regular exhaust pipe inspection for signs of failure/leakage
- Clean tips of NOx sensors regularly to prevent soot build up
- Periodically flush DEF tank with deionized water
- Regularly top off DEF tank – DEF tanks can build condensation and a build up in water can lead to contamination

Dry Break Fittings



Tank DEF filter



Onboard DEF filter

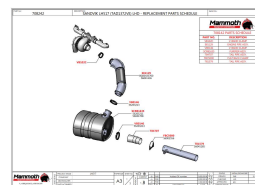


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## WHAT CAN BE DONE IF FAILURE OCCURS?



- Check and flush DEF lines and tank for signs of crystallization – use Deionized water
- SCR cleaning
  - Depending on type of failure depends on whether the SCR catalyst can be cleaned. If the failure is related strictly to DEF crystallization either in the pipe or around the SCR substrate then this can typically be cleaned and the SCR reinstalled
  - Dosing nozzles can be cleaned especially if you have an ultrasonic cleaner with deionized water in the tank
- SCR rebuild
  - In a worst case scenario where engine component failure has led to the SCR catalyst becoming oil soaked or contaminated then the SCR catalyst substrates will need to be replaced and the SCR casing thoroughly cleaned.
- SCR replacement – Direct fit replacement SCR's available for most makes and model of mining equipment



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Thank you / Contact details

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[mammothequipment.ca](http://mammothequipment.ca)

**WE HAVE MOVED!**

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**82 ROUTLEDGE AVENUE  
HEADINGLEY, MB R4H 0A9**



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**THANK YOU**



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