Safety is possible.

Checklist
Particulate filters for diesel engines used underground

Do you have full control over any problems that may occur when using diesel engines underground?

Diesel engine emissions (DEEs) contain carbon particles that are harmful to health and create further hazards.

Health effects:

- Unpleasant smell, watering eyes, nausea
- Cell changes to the nasal mucous membranes
- Coughs, expectoration, asthma
- Cancer (tumours).

Further hazards:

- Traffic accidents due to poor vision
- Uncontrolled actions resulting from exposure to DEEs

This checklist refers to important points that must be taken into consideration when using particulate filter systems (PFS).

A list of tested particulate filter systems (PFS) can be found at www.suva.ch/suvapro ➔ Business branch/technical topics ➔ Particulate filter requirement.

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working safely

A selection of important questions on the topic of this checklist is given below. If a question does not apply to your company, simply leave it out.

Wherever you answer questions with ☒ «no» or ☒ «partially», a measure has to be taken.

Make a note of these measures on the back page.

Prerequisites

1 Does **transportation planning** consider higher energy requirements of vehicles with tyres, hence more and dangerous emissions than vehicles on rails or conveyor belts? (q.v. Fig. 1)

☐ **yes**
☐ **partially**
☐ **no**

2 When **selecting diesel vehicles**, are those with lower raw gas emissions preferred?

- Pre-combustion chamber engines
- Euro II/Euro III engines
- Well-maintained engines

☐ **yes**
☐ **partially**
☐ **no**

Fig. 1: Tubular belt for the transportation of spoil. Conveyor belts are often more suitable than dumper trucks.

Selection of the particulate filter systems (PFS): suitable regeneration processes

3 When selecting the PFS, is consideration given to the advantages and disadvantages of **active regeneration**?

☐ **yes**
☐ **no**

Advantages:*

- Regeneration is independent of exhaust temperatures
- No additives are required in the diesel fuel
- Works with «normal» diesel fuel
- Is insensitive to changes in the use of the vehicle (working cycles, load collective, etc.)

Disadvantages of burner regeneration:

- Increased exhaust temperatures
- Complex installation
- Higher demands on trained personnel re. maintenance due to the sensitivity of the system

Disadvantages of filter replacement system:

- Organisational outlay
- Installation of the burning-off station
- Provision of several filters
- Limited period of vehicle use
- Outlay caused by filter replacement

Disadvantages of electrical regeneration:

- Organisational outlay
- Vehicle downtimes during regeneration
- Electrical energy has to be available

Active regeneration

Actively burning off carbon particulate matter. There are the following systems:

Regeneration with burner support
As soon as a predetermined back pressure is reached in the PFS, the burner starts regeneration.

Regeneration of the replaceable PFS on an electrically heated burning-off station
On a burning-off station, PFS are heated to such a temperature level that carbon particulates burn off within a certain time.

Regeneration by electrically heating the PFS on the vehicle
While the burning-off process is running, the vehicle cannot be used due to the electrical hook-up.

Fig. 2: Burning-off station for the regeneration of replaceable PFS.

4 Are the pros and cons of **passive regeneration** also taken into consideration?

☐ **yes**
☐ **no**

Advantages:
- Lower purchase price compared with active regeneration
- Lower installation costs

Disadvantages:
- Diesel fuel with additives and the correct dosage is required (regeneration problems arise both with too much and too little)
- CRT systems require diesel fuel with a very low sulphur content
- Diesel fuel with additives may only be used on vehicles with PFS
- A certain minimum exhaust temperature has to be attained to start the regeneration process
- Increased level of knowledge for the engine operator and the maintenance personnel is required
- Sensitivity to changes in the use of the vehicle (operating cycles, load collective, etc.)
- Shorter intervals for monitoring separation
- Additives create residues that are left in the PFS

Passive regeneration

The process of burning off particulates is solely initiated by reaching an exhaust temperature that is high enough.

Regeneration is favoured by:
- Addition of additives to diesel fuel
- Catalytic coating of the filter medium
- Burning the carbon (the particulate) by using excess oxygen from the NO2 -production of the inline oxidation catalyser (CRT system).

Selection of the particulate filter systems (PFS): make, type

5 Is **the intensity of use of the vehicles** considered when selecting PFS?

☐ **yes**
☐ **partially**
☐ **no**

Attention should be paid to the following:
- Load cycles: ratio between full load and partial load
- Length of use: in shifts or only sporadic use

6 **Are external influences** considered?(Fig. 3)

☐ **yes**
☐ **partially**
☐ **no**

For example:
- Danger of mechanical damage (collisions, falling material, etc.)
- Vibrations and shocks (state of the ground, hard ground; can lead to material damage of the filter medium matrix)
- Susceptibility of system components to damage (electronics, wiring, etc.)

Fig. 3: Tyred-wheel loader during dumping. When choosing a PFS, the rough conditions to which the machines are subject must be considered.

7 Is the load of **mineral dust** and **lubricating oil residues** on the PFS minimised?

☐ **yes**
☐ **partially**
☐ **no**

Use an intake air filter with a high degree of separation (Fig. 4)!

Fig. 4: Intake air filter system. Organisational measures must be taken for the maintenance of this type of filter!

8 Are all the relevant factors clarified and taken into consideration when **dimensioning the PFS**?

☐ **yes**
☐ **partially**
☐ **no**

Relevant factors include effective raw gas emissions and the exhaust temperatures of the engine in dependence on the load cycles, the load collectives, the altitude of the worksite, etc. Use data recording equipment!

9 Is the **supplier** of the PFS adequately informed of the peripheral conditions occurring when the vehicle is used?

☐ **yes**
☐ **partially**
☐ **no**

Installation of particulate filter systems (PFS)

10 During the installation of PFS: are you aware that any intervention into a system optimised by the vehicle manufacturer may bring about problems (e.g. in the engine management system, in the exhaust system, in the heat balance or in terms of the driver's visibility)?

Warning, product liability!

☐ **yes**
☐ **partially**
☐ **no**

11 Are suitable measures taken, in particular, to ensure that installations on the machine are not exposed to any additional **heat loads**?

Higher surface, exhaust and surrounding temperatures are generally caused by the PFS (Fig. 5).

☐ **yes**
☐ **partially**
☐ **no**

Fig. 5: Particle filters insulated against heat radiation. Precautionary steps for the prevention of wire-brittling due to heat are an absolute must.

Organisation, training, behaviour

12 Are there **any general rules** in your company re. avoiding air pollutants from diesel engines?

In particular:
- Avoiding vehicles with diesel engines if possible.
- Only such vehicles as provided for in ventilation planning when underground.
- Switching off engines when not in use.
- Regular maintenance of the air intake filters.
- Regular maintenance of the engines.

☐ **yes**
☐ **partially**
☐ **no**

13 Do the **operators of the vehicles** know how the PFS function and have they been trained to operate the PFS to the best possible degree?

☐ **yes**
☐ **partially**
☐ **no**

14 Are these operators of the vehicles in a position to recognise a fault on the PFS (too little separation)?

Properties:
- Black smoke when the engine is revved
- Abnormal back pressure (Fig. 6)
- Cracks in the casing
- Loss of vehicle-power

☐ **yes**
☐ **partially**
☐ **no**

15 Has care been taken **when using replaceable filters** to ensure that regenerated PFS are available at all times and that filter changing is a risk-free procedure?

Frequent faults:
- Poor accessibility
- Danger of falling off the vehicle
- Danger of getting burnt on hot PFS parts

☐ **yes**
☐ **partially**
☐ **no**

Fig. 6: Pressure gauge to display the back pressure in the particle filter.

16	Have the **maintenance personnel** been trained to the extent that the maintenance work specified by the PFS manufacturer can be carried out correctly? Are the required tools available?	☐ **yes** ☐ **partially** ☐ **no**
17	Are regular checks performed using an **opacity meter** as well as reports made in order to record whether the PFS has been achieving the required rate of separation (Fig. 7)? Are the displays on the **back-pressure gauges** also noted in a report (Fig. 6)?	☐ **yes** ☐ **partially** ☐ **no**

Fig. 7: Regular checks are made using an opacity meter (being used here on this diesel car) to see whether the PFS is satisfying the required rate of separation.

There may be specific other additional requirements within your company as far as the topic of the above checklist is concerned. If so, just jot them down and take the necessary steps (q.v. page 4)

Checklist completed by: Date: Signature:

Planning measures: particulate filters for diesel engines used underground

No.	Measure to be taken	Date	Person assigned	Done		Comments	Checked	
				Date	Signed		Date	Signed

Check repeated on: (Recommendation: every 6 months)

Any questions? Give us a call, for information: Tel. ++41 (0)41 419 50 60

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