

Procedure

PR0703 A1

Control of diesel engine exhaust emissions

Contents

1	Purpose	2
2	Scope	2
3	Procedure	2
3.1	Introduction	2
3.2	Procedure for the operation of portable diesel powered plant in enclosed locations (Class A1)	2
3.3	Procedure for the operation of large diesel engines in underground locations (Class A2 and S)	5
3.4	Approval and control procedure for toxic gas monitors	6
3.5	Use of operational safety plans (emissions)	9
3.6	Safety considerations	9
3.7	Composition of exhaust fumes	10
3.8	Standards	10
4	Person accountable for this document	10
5	Definitions	11
6	References	11
7	Document history	11
8	Attachments	12
8.1	LU workplace air quality exposure limits	12
8.2	Engine emission criteria	12
8.3	Neat exhaust emissions testing	13

1 Purpose

- 1.1 The purpose of this procedure is to provide instructions for the control of the toxic constituents of engine exhaust during use of diesel powered plant.
- 1.2 This document details the requirements of the approval processes for the use of diesel powered plant and outlines the necessary air monitoring requirements and control measures to ensure compliance with Health and Safety Legislation and LU standards.
- 1.3 This document also gives instructions on the control of toxic emissions and the required air monitoring strategy to ensure compliance with HSE Legislation and LU standards [S1171](#), [S1172](#), [S1173](#) and [S1174](#).

2 Scope

- 2.1 This procedure applies if you use diesel powered plant in enclosed locations.

3 Procedure

3.1 Introduction

- 3.1.1 Operation of diesel powered plant in enclosed locations can cause exhaust emissions to build up which present a health hazard to personnel working in the vicinity of the equipment. This document is aimed at reducing the exposure to diesel exhaust pollutants by the control of the operation of diesel engines on the Underground. It should be read in conjunction with standard [S1171](#) 'All Plant – Acceptance, Use and Maintenance'.

3.2 Procedure for the operation of portable diesel powered plant in enclosed locations (Class A1)

3.2.1 Introduction

- 3.2.1.1 For a definition of Class A1 see section 8.2.3

3.2.2 Staff training

- 3.2.2.1 In addition to a current Sentinel ID card, normal LU training requirements apply. The nominated person responsible for the operation of the toxic gas monitors must have successfully completed an LU approved training course on the use of this specific equipment and have been assessed as a competent person by their employer.
- 3.2.2.2 The project manager must:
- ensure that the tunnel ventilation at the work site is maximised and should consult the Maintenance Control Centre (MCC) as to the condition of the ventilation system covering the work site. If the work involves making the track unsafe, additional forced ventilation should be considered in order to ensure the build up of noxious gases is avoided

- review the requirement for the isolation of fire detection equipment which will depend on the nature and location of the proposed work site
- advise Access and Planning of the proposed work using diesel powered plant
- arrange for the Track Access Controller's Duty Manager to be informed between 22.00 and 23.00 hours on the night of work that diesel engines will be in operation in the Line Clear area
- ensure that approved equipment and the necessary support materials are available on site.

3.2.3 Working in tunnel areas

3.2.3.1 In tube tunnel locations, no more than one unit of diesel powered plant can be used in any running tunnel between adjacent stations.

3.2.3.2 In sub-surface locations no more than three class A1 units can be used between adjacent stations with a minimum distance between each plant of 150 metres.

3.2.3.3 On arrival at the worksite the gas monitoring person must:

- ensure that the appropriate fully operational fire extinguishers are available.
- identify a designated assembly point, away from the worksite which is free from exhaust fumes
- ensure that all staff are aware of the location of the designated assembly point
- determine the direction of the airflow
- define the work zone by placing warning signs. These signs must be positioned at a minimum distance of 100 metres from the equipment along all tunnels leading to the equipment. All work must be carried out upwind of the equipment at a distance of at least 3 metres from the unit. The toxic gas monitors must be positioned to monitor exposure to staff from the gases coming from the equipment and from any other diesel powered plant positioned upwind of them. This requires the use of additional toxic gas monitors. One toxic gas monitor must be positioned between the site of work and the diesel engines being used. Each additional toxic gas monitor must be positioned upwind of staff to provide protection from the other equipment. Toxic gas monitors must be positioned as close to staff as possible and preferably at head height.

3.2.4 Working in station areas

3.2.4.1 The equipment should be positioned, so far as is practicable, so that the exhaust gases flow away from the station into a tunnel or ventilation fan shaft. Where necessary and practicable, an exhaust extension pipe should be used. Exhaust fumes must not be vented through occupied areas of the station unless additional toxic gas monitors are used in these locations.

3.2.4.2 If any parties are working within an invert the diesel plant must be placed at least 10m away from the access and egress hatches.

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Page 3 of 15

Note: confined space gas monitors are configured differently to gas monitors used to measure emissions from diesel powered plant, hence will not monitor the correct gases.

3.2.5 Atmospheric conditions

3.2.5.1 The gas monitoring person must check the gas monitor on a regular basis and assess any elevation in readings.

Note: if the gas monitors are checked and found that the readings are steadily increasing, and approaching the limits quoted in section 8.1, an assessment should be made, and action taken to prevent further elevations.

3.2.5.2 If atmospheric conditions become unacceptable owing to high levels of emissions, the gas monitoring person must make sure all diesel powered plant is switched off, and undertake remedial action.

3.2.6 Toxic gas monitor alarm

3.2.6.1 If a toxic gas monitor alarm is activated, pollutant levels in the atmosphere have reached levels where remedial action is required and the following must be carried out:

- the engine(s) must be switched off immediately
- all staff must evacuate to the designated assembly point
- the gas monitoring person must try to cancel the alarm before leaving the worksite
- if the alarm can be cancelled then the gas monitoring person must carry out the action as described under “Remedial Action” below.

3.2.7 Remedial action

3.2.7.1 If an alarm has activated but the gas monitoring person is able to reset the toxic gas monitor, he must check the direction of the airflow to ensure the positioning of the diesel plant is correct. If the direction of airflow has changed the gas monitors and diesel generator should be re positioned such that the worksite is again upwind of exhaust fume.

3.2.7.2 If after reconfiguring the worksite and resuming works, the toxic gas monitor still activates, the diesel powered plant must be turned off again. An on site risk assessment must be performed immediately, this should take into account all actions required to make the track safe for trains to run.

3.3 Procedure for the operation of large diesel engines in underground locations (Class A2 and S)

3.3.1 Introduction

3.3.1.1 This section describes the requirements for the operation of diesel powered plant in enclosed locations. (Class A2, S and operation of multiple units). For definitions of class A2 and S, see sections 8.2.5 and 8.2.9 respectively. It deals specifically with the layout and monitoring strategy for the work site with respect to ensuring that exposure of personnel to toxic exhaust fumes is kept to a minimum.

3.3.2 Staff training

3.3.2.1 In addition to a current Sentinel ID card, normal LU training requirements apply. The TfL scientific services framework consultant (see section 3.3.2.2) must ensure the nominated persons responsible for the operation of the toxic gas monitors are deemed competent.

3.3.2.2 The project manager must:

- engage with a TfL scientific services framework consultant approved for supply of ventilation and emissions monitoring. They will be expected to prepare and implement an Operational Safety Plan for diesel emissions. (See Section 3.6.3)
- ensure that the tunnel ventilation at the work site is maximised
- review the requirement for the isolation of fire detection equipment which will depend on the nature and location of the proposed work site and ensure that approved equipment and the necessary support materials are available on site
- advise the Access and Planning department of the planned work using diesel powered plant
- if engineering hours only, arrange for the Track Access Controller's Duty Manager to be informed between 22.00 and 23.00 hours on the night of work that diesel engines will be in operation in the Line Clear area.

3.3.3 Atmospheric conditions

3.3.3.1 In addition to continuous monitoring using electronic gas monitors, the TfL scientific services framework consultant will monitor the atmosphere for the presence of other gases including total oxides of nitrogen and carbon dioxide, using gas detection tubes or electronic monitors. Airflow will also be monitored using a vane anemometer.

3.3.3.2 The TfL scientific services framework consultant must check the gas monitors on a regular basis and assess any elevation in readings. Note if the gas monitors are checked and found that the readings are steadily increasing an assessment should be made to prevent further elevations.

- 3.3.3.3 If atmospheric conditions become unacceptable owing to high levels of emissions, the gas monitoring person must make sure all diesel powered plant is switched off and undertake remedial action.
- 3.3.3.4 If a toxic gas monitor alarm is activated, pollutant levels in the atmosphere have reached levels where remedial action is required and the following must be carried out:
- the engine(s) must be switched off immediately
 - all staff must evacuate to the designated assembly point
 - the gas monitoring person must try to cancel the alarm before leaving the worksite
 - if the alarm can be cancelled then the gas monitoring person must carry out the action as described under “Remedial Action” below.

3.3.4 Remedial action

- 3.3.4.1 If an alarm has activated but the gas monitoring person is able to reset the toxic gas monitor, he must check the direction of the airflow to ensure the positioning of the diesel powered plant is correct.
- 3.3.4.2 An on site risk assessment by the TfL scientific services framework consultant must be performed immediately, which should take into account all actions required.

3.4 Approval and control procedure for toxic gas monitors

3.4.1 Introduction

- 3.4.1.1 This procedure describes the requirements for the control of toxic gas monitors used with diesel powered plant. This document covers the approval, issue, calibration and maintenance of these monitors. Use of these monitors on site is covered in section 3.5 of this procedure. The continuous use of “approved” toxic gas monitors is an LU mandatory requirement when operating diesel powered plant in enclosed locations.

3.4.2 Description

- 3.4.2.1 Toxic gas monitors are electronic instruments equipped with sensors for the continuous monitoring of specific toxic gases (carbon monoxide, nitrogen dioxide, nitrogen monoxide) produced by diesel powered plant. Instruments must be stand alone equipment incorporating high intensity audible, (85dB(A) at 1m), and visual warning indicators. The monitor should incorporate an alarm which is audible above the background noise generated by the process being undertaken and a flashing light which should be visible from all sides. The monitor must be simple to operate with a display indicating unambiguous information. The unit should be designed to avoid being accidentally switched off in service. All warning indications should be clearly shown by a large flashing warning light. Failure of the battery or malfunction of the instrument must be indicated by audible and visual alarms. The instrument must be robust and tamper proof. The alarm levels must be user definable and be capable of being set to LU limits. Monitors must be able to record data which should

be easily retrievable. This feature will assist in investigations following alarm events, and to provide a means of checking the usage of the equipment on site. A modular design with additional sensor ports to enable updating of the equipment in line with future developments of sensors would be desirable. The sensors must have three alarms levels. An instantaneous, a 15 minute STEL and 8 hour limit.

3.4.3 Equipment approval

- 3.4.3.1 Toxic gas monitors must be “type approved” specifically for use in conjunction with diesel engines before they are permitted to be used. The approval is undertaken by Senior Plant Engineer or his designated representative, who will ensure the units are entered onto the LU Product Register. It should be noted that monitors for use in confined spaces require different sensors, and are not suitable for use with diesel powered plant.

3.4.4 Notification of use of toxic gas monitors

- 3.4.4.1 Managers responsible for the control of toxic gas monitors should register the type and number of units under their control, with the Senior Plant Engineer or his designated representative. This is to enable LU to maintain a central record of the use of this type of equipment.

3.4.5 Issue of toxic gas monitors

- 3.4.5.1 Managers responsible for the control of toxic gas monitors must have written procedures to ensure that this safety equipment is controlled in a manner such that it is in good working order at all times.

This procedure must cover the following areas:

- each monitor must be regularly charged
- the monitor must be inspected for satisfactory operation before each hire/issue period
- alarm settings must be checked prior to each hire/issue period, or weekly, if the hire period is longer than this
- carbon monoxide, nitrogen monoxide and nitrogen dioxide sensors on toxic gas monitors must be tested with the respective gases at least weekly or prior to each hire/issue period to ensure sensors are functioning correctly
- a system for the reporting of malfunction/damage to monitors and withdrawal of equipment from service should be maintained
- a weekly downloading of recorded data from gas monitors should be maintained and records of data retained for a minimum period of 7 years. Written records should be supplied with each monitor prior to each hire/issue period. This should cover the following; latest calibration certificate, unique report reference, unique gas monitor number, alarm settings, checks undertaken prior to issue and name of the person responsible for checks.

3.4.6 Calibration

- 3.4.6.1 The monitors must be calibrated either by the equipment manufacturers or by their approved calibration agents. This must be undertaken at intervals of no more than six months. The equipment must indicate the last date on which it can be used before the next calibration and servicing is required.

Test certificates of toxic gas monitors must:

- show the instrument readings before and after calibration
- show the date when last serviced. All toxic gas standards used for calibration must be traceable to a nationally recognised standard. Any issuers undertaking in-house calibration, must have a fully documented procedure and be ratified by the unit's manufacturer. This procedure must be acceptable to the Senior Plant Engineer or his designated representative.

3.4.7 Maintenance

- 3.4.7.1 Arrangements should be made with the manufacturers/maintenance agency for the regular replacement of toxic gas cells, as these items have a life expectancy dependant on the type of cell and its manufacturer. Any supplier undertaking minor in- house maintenance, must have undergone appropriate training. All maintenance work must be recorded.

3.4.8 Records

- 3.4.8.1 Fully documented records (conforming to ISO9001 requirements) should be retained for 7 years. Records of issue of toxic gas monitors should be maintained and should cover the following information:

- details of instrument checks including sensors, audible and visual alarms
- date of use of equipment
- name of Company/department using equipment
- serial number of monitor.

- 3.4.8.2 Hirers should supply the following records:

- Name of site person in charge
- Location of work
- Details of diesel powered equipment in use.

3.4.9 Training

- 3.4.9.1 Staff responsible for the issue of toxic gas monitors must have undergone training by an approved supplier in the operation and issue of the specific type of toxic gas monitors. This should include, where appropriate, the handling of electronic data recorded by the toxic gas monitor. The technical content of all training requirements should be approved by the Senior Plant Engineer or his designated representative.

3.4.10 Auditing

The system for the control of toxic gas monitors will be audited yearly by a representative of the Senior Plant Engineer or his designated representative.

3.5 Use of operational safety plans (emissions)

3.5.1 The use of Operational Safety Plans for the equipment/process covering the use of diesel powered plant in enclosed locations must include details of the control measures being adopted to reduce the risks to health from diesel fumes.

3.5.2 This should cover the following:

- a) working method
- b) special site ventilation arrangements
- c) strategy for the use of approved toxic gas monitors (i.e. number of units and location/s)
- d) emergency Plan in the event of an alarm occurrence
- e) contingency/action for work completion
- f) person responsible for toxic gas monitors
- g) training/instruction of person responsible for toxic gas monitors
- h) record of site monitoring.

3.6 Safety considerations

3.6.1 The use of diesel powered plant in enclosed locations has the potential to create an unsafe working environment as toxic exhaust fumes could exceed the limits detailed in Health and Safety Executive Guidance Note EH40. It is for this reason that safety considerations and controls are vital. Failure to implement control measures such as additional forced ventilation could result in excessive fume accumulation going unnoticed giving rise to possible irreversible effects on the health of personnel.

3.6.2 Exposure to toxic diesel fumes of members of the public and staff not directly associated with engineering operations involving diesel engines must be controlled to an acceptable level.

3.6.3 Any engineering operation in enclosed locations, involving the use of diesel powered plant must have an Operational Safety Plan which must detail the specific controls to be used for the toxic exhaust fumes emitted. In addition, a suitable and sufficient COSHH assessment will need to be carried out by the end user. This plan must comply with the requirements of this document which is based on the Control of Substances Hazardous to Health Regulations 2002 and Health & Safety at Work Act 1974.

3.7 Composition of exhaust fumes

- 3.7.1 Exhaust emissions comprise of a complex mixture of chemical compounds, the composition of which can vary greatly. The engine operating conditions including loading, engine set-up, engine maintenance and exhaust gas after treatment all have major influences on its composition. The make-up of the exhaust is further influenced by the quality of fuel used and external environmental conditions such as temperature, pressure and humidity.
- 3.7.2 Exhaust emissions comprise of both gaseous chemical species and particulate matter. The gaseous constituents include carbon dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, oxides of sulphur and hydrocarbons. The term hydrocarbons in connection with diesel emissions is used to include all organic species present including aldehydes.
- 3.7.3 Uncatalysed gasoline (petrol) engines produce substantially more carbon monoxide (approximately 30 times the quantity) than diesel engines. Consequently, the use of petrol engines in enclosed locations can result in dangerously high concentrations in a very short space of time.

3.8 Standards

- 3.8.1 Concentrations of toxic gas in the workplace are generally assessed against Health and Safety Executive Guidance Note EH40. This document indicates safe working limits for many of the individual toxic gas constituents associated with diesel fumes. They include carbon dioxide, carbon monoxide, acrylaldehyde (acrolein - a specific aldehyde), formaldehyde (often measured as total aldehyde) and sulphur dioxide. This document details long term exposure limits (LTEL) and short term exposure limits (STEL) and the limits quoted are based upon those detailed in EH40 (issue 2).
- 3.8.2 Exposure limits for all oxides of nitrogen do not currently have limits assigned within EH40 and the limits quoted for these toxic species within this guidance document are based on information obtained from the Health and Safety Executive, COSHH and SCOEL, (Scientific Committee of Occupational Exposure Limits).

Note: The limits for oxides of nitrogen have been withdrawn because recent evidence indicates that the limits previously quoted can no longer be considered safe.

4 Person accountable for this document

Name	Job title
Gary Edwards	Senior HSE Manager

5 Definitions

Term	Definition
Competent Person	A person who has been assessed as being qualified and having the required practical and theoretical knowledge, experience and skills to carry out a particular rule, regulation, instruction or procedure.
COSHH	Control of Substances Hazardous to Health
dB(A)	Decibel – Measure of Noise - Weighted
Enclosed Location	Locations that are substantially below or under ground or where the presence of structures or features of the local environment may reduce the level of natural ventilation to an extent that will enable noxious or flammable gases to accumulate or oxygen to be depleted sufficiently to render the local environment unsafe. Enclosed locations include but are not limited to Confined Spaces, as defined UK Health and Safety legislation and all locations within the scope of LU Standard S1085, Fire safety performance of materials.
LU	London Underground

6 References

Document no.	Title or URL
BS EN ISO 9001:2008	Quality Management Systems – Requirements.
EH40	Health and Safety Executive Guidance Note EH40/2005 Workplace Exposure Limits (Second edition, published 2011)
S1011	Registration of Products
S1171	All Plant – Acceptance, Use and Maintenance
S1172	On-Track Machines – Design and Acceptance.
S1173	On-Track Plant – Design and Acceptance.
S1174	Non-Railborne Plant – Design and Acceptance.

7 Document history

Issue no.	Date	Changes	Author
A1	January 2017	M1032 rewritten as a procedure and updated and reformatted as per change number 02154.	Christopher Thompson

8 Attachments

8.1 LU workplace air quality exposure limits

The limits described below have been adopted to control exhaust gas pollutants and allow the routine operation of diesel powered plant under the supervision of staff trained in the required control measures.

Engineering operations utilising diesel powered plant should be designed to maintain toxic constituents of diesel exhaust fumes below these limits.

Constituent	Carbon Monoxide (ppm)	Nitrogen Dioxide (ppm)	Nitrogen Monoxide (ppm)	Diesel Particulate (mg/m ³)
Instantaneous	200	2	10	-
Short Term Exposure Limit (15 minute)	50	1	6	0.4
Long Term Exposure Limit (8 hour)	20	0.5	2	0.1

These limits have been based upon best occupational hygiene practice and those given in Health and Safety Executive Guidance Note EH40, as appropriate.

Engineering operations employing diesel powered plant in enclosed locations should be designed to ensure that levels of airborne respirable diesel particulate (smoke) should be as low as practicable, and should not exceed 0.1 mg/m³.

8.2 Engine emission criteria

- 8.2.1 Portable diesel engine powered equipment is classed as equipment with an engine capacity of less than 750cc (<0.75dm³)
- 8.2.2 There are three categories within the LU classification system, namely Class A1, A2 and Class S
- 8.2.3 Class 'A1' equipment is powered by small 'clean' engines, (<0.75dm³), that meet the following exhaust gas specification;

Carbon Monoxide (ppm)	Oxides of Nitrogen (ppm)	Visual Smoke
1500	500	Moderate

- 8.2.4 Visual smoke is categorised into four groups; Clear, Slight, Moderate and Excessive. The level of visual smoke should not be greater than moderate. Equipment failing to meet this requirement will not normally be acceptable for operation in enclosed locations.

- 8.2.5 Class 'A2' equipment has an engine capacity greater than 750cc (>0.75dm³) and must meet the following emission criteria:

Carbon Monoxide (ppm)	Oxides of Nitrogen (ppm)	Nitrogen Dioxide (ppm)	Visual Smoke
800	700	70	Moderate

- 8.2.6 Visual smoke is categorised into four groups; Clear, Slight, Moderate and Excessive. The level of visual smoke should not be greater than moderate. Equipment failing to meet this requirement will not normally be acceptable for operation in enclosed locations.
- 8.2.7 These conditions should be met throughout the engines normal operating range, including idle.
- 8.2.8 Diesel engines meeting the requirements of EC Directive 05/55/EC Stage V1 are expected to meet the LU requirements.
- 8.2.9 Class S (Special). This class of equipment does not meet the LU emissions requirements for Class A equipment. The use of this class of equipment is by a concession to the standard S1171. The concession will be dependant on the application and the additional control measures to be adopted on site. These additional control measures should be discussed in detail with an LU Scientific framework consultant, who has extensive experience of the LU track environment. Generally the maximum permitted exhaust levels are: Carbon Monoxide 2000 ppm Oxides of Nitrogen 1000 ppm. Smoke emission requirements are the same as for Class A1 and A2.

8.3 Neat exhaust emissions testing

- 8.3.1 The neat exhaust from each item of diesel powered plant requires that the level of carbon monoxide, nitrogen dioxide and total nitrogen oxides are measured, together with estimation of the smoke (particulate) content, at four engine operating conditions:
- a) engine idling from cold
 - b) engine idling after 10 minutes operation.
 - c) engine operating under load. The load applied to the unit should represent approximately 60% of the unit's maximum power output or a typical maximum working load when the unit is operated underground.
 - d) engine idling when fully warmed.
- 8.3.2 Measurements for all the gases are undertaken using Dragger tubes of the appropriate range or a suitable electronic instrument.

8.3.3 A visual assessment of the smoke is made at each engine condition.

There are four categorises of visual smoke:

- a) clear
- b) slight
- c) moderate
- d) excessive.

8.3.4 Maximum permitted levels of toxic exhaust gas constituents for Class A1 engines (<750cc) are:

- carbon Monoxide: 1500 ppm
- oxides of nitrogen: 500 ppm
- visual Smoke: moderate

8.3.5 Maximum permitted levels of toxic exhaust gas constituents for Class A2 engines (>750cc) are:

- Carbon Monoxide: 800 ppm
- Oxides of nitrogen: 700 ppm
- Nitrogen Dioxide: 70 ppm.
- Visual Smoke: moderate

8.3.6 Equipment which fails to meet these emission requirements (Class S) may only be allowed to work under a concession (see 8.2.9).

8.3.7 Reporting of Results

8.3.7.1 A 'Certificate of Satisfactory Exhaust Gas Emissions' should be issued for plant meeting Class A criteria. Copies of this certificate, which is valid for six months, should be given to the site manager and a copy sent to the Senior Plant Engineer.

8.3.7.2 Test certificates should generally meet the requirements ISO 9001 UKAS and should clearly record the following information:

- the company undertaking the measurement
- the standard to which the equipment conforms
- the length of time the certificate is valid
- the date of test
- type of equipment

- type of engine
- engine identification number
- type and size of test load
- type of test equipment
- calibration of test equipment (valid date of Dragger tubes)
- name and signature of the person authorising the certificate
- name and signature of the site analyst responsible for testing
- unique certificate number.

8.3.7.3 A failure report is issued containing the above information for all plant failing to meet the emission requirements.