

DRY SYSTEMS TECHNOLOGIES®

OPERATION AND MAINTENANCE MANUAL

DST DRY SYSTEM®

SECTION C
CO SAMPLING PROCEDURE

To be performed by a trained and qualified mechanic

M301-018-01

DRY SYSTEMS TECHNOLOGIES®

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OPERATION AND MAINTENANCE MANUAL PART C, M301-018-01

CO (Carbon Monoxide) SAMPLING INSTRUCTIONS FOR THE DST DRY SYSTEM™

Background:

MSHA requires that the engine-out untreated Carbon Monoxide of all Inby and heavy-duty Outby engines be checked weekly. The following is the applicable text (excerpts) that may be found in the **MSHA 30 CFR, Part 75.1914 (g) Regulations**. The test for untreated (engine out) CO emissions is mandatory and will also provide excellent feedback to the mechanic on the engine condition.

§75.1914 Maintenance of diesel-powered Equipment

(a) Diesel-powered equipment shall be maintained in approved and safe condition or removed from service.

(b) Maintenance and repairs of approved features and those features required by Sections 75.1909 and 75.1910 on diesel-powered equipment shall be made only by a person qualified under Section 75.1915.

(c)

(d)

(e)

(f)

(g) Undiluted exhaust emissions of diesel engines in diesel-powered equipment approved under part 36 and heavy-duty non-permissible diesel-powered equipment as defined in Section 75.1908(a) in use in underground coal mines shall be tested and evaluated weekly by a person who is trained to perform this task. The mine operator shall develop and implement written standard operating procedures for such testing and evaluation that specify the following:

- (1) The method of achieving a repeatable loaded engine operating condition for each type of equipment;*
- (2) Sampling and analytical methods (including calibration of instrumentation) that are capable of accurately detecting carbon monoxide in the expected concentrations;*
- (3) The method of evaluation and interpretation of the results;*
- (4) The concentration or changes in concentration of carbon monoxide that will indicate a change in engine performance. Carbon monoxide concentration shall not exceed 2,500 parts per million;*
- (5) The maintenance of records necessary to track engine performance.*

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The reasons for monitoring Engine-out CO Emissions

CO sampling became a mandatory procedure when MSHA released the new Part 75 regulations. It was introduced to ensure that diesel engines are operated in “as-approved” condition and settings. In most instances when a diesel engine develops a problem, the CO output will increase. Other emissions do not necessarily follow the same trend. Under normal operating conditions (at torque stall), CO output ranging from 200-300 ppm should be expected from a MWM D916-6 engine, 300-400 ppm for a Caterpillar 3300 engine. Whenever abnormally high CO is observed, an engine problem should be suspected, because CO increases when an engine develops a fault. Increased CO will not pinpoint to a specific problem, but based on past experience, the following may have happened: (In order of probability):

- The Intake Air Cleaner is plugged, causing too high an intake air restriction and air starvation of the engine. This makes the engine run too rich. (A plugged intake air cleaner is the cause in more than ¾ of all cases)
- Fuel injector problems, which could be a bad spray pattern of an injector and cause incomplete combustion.
- Improper fuel pump adjustment by having the fuel pump adjusted too rich or not properly de-rated for the operating altitude. This makes the engine run too rich.
- Mechanical problems with the engine, such as bad valve seals, leaking piston rings, low compression or similar problems. (Not frequent cause)
- The exhaust system is restricted, causing too high a backpressure.

CO (Carbon Monoxide) is an excellent diagnostic tool for the maintenance department to detect engine problems before they lead to failures. It has been used successfully by many mines in a similar way as oil analysis. The main purpose of CO sampling is to minimize exposure of the operator and other personnel to diesel exhaust.

The reasons for monitoring treated CO Emissions (after catalyst)

(Optional)

The DST Dry System™ is fitted with a catalyst that will reduce CO by up to 90% at exhaust temperatures above 300°F. A typical treated CO level in the exhaust is 20-40 ppm. If the catalyst would develop a problem, the treated CO levels will increase significantly. Therefore, whenever there is higher than normal CO, a problem with the catalyst should be suspected. If the treated CO levels are continuously greater than 100 ppm, the catalyst must be removed and checked for fouling.

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Permanently Installed CO Sampling Ports

To simplify this mandatory procedure, Dry Systems Technologies® developed and offers a permanently installed and MSHA Certified (31/D126) Flameproof Port™ assembly. All hardware remains permanently mounted in the exhaust system and on the machine. Drawn through a flameproof port, a cooling tube and a connecting hose, the exhaust gas portion for sampling is routed to the operator's cab. There, a soot filter and a water separator condition the exhaust gas to be suitable for **CO sampling with simple hand held instruments**.

A quick connect coupling is permanently mounted inside the operator's cab and allows the sampling from the safe location inside the operator's cab. The mating coupler is attached to the CO sampling instrument. **Only one person is required to sample the CO**. An optional Catalyst – out sampler may also be provided.

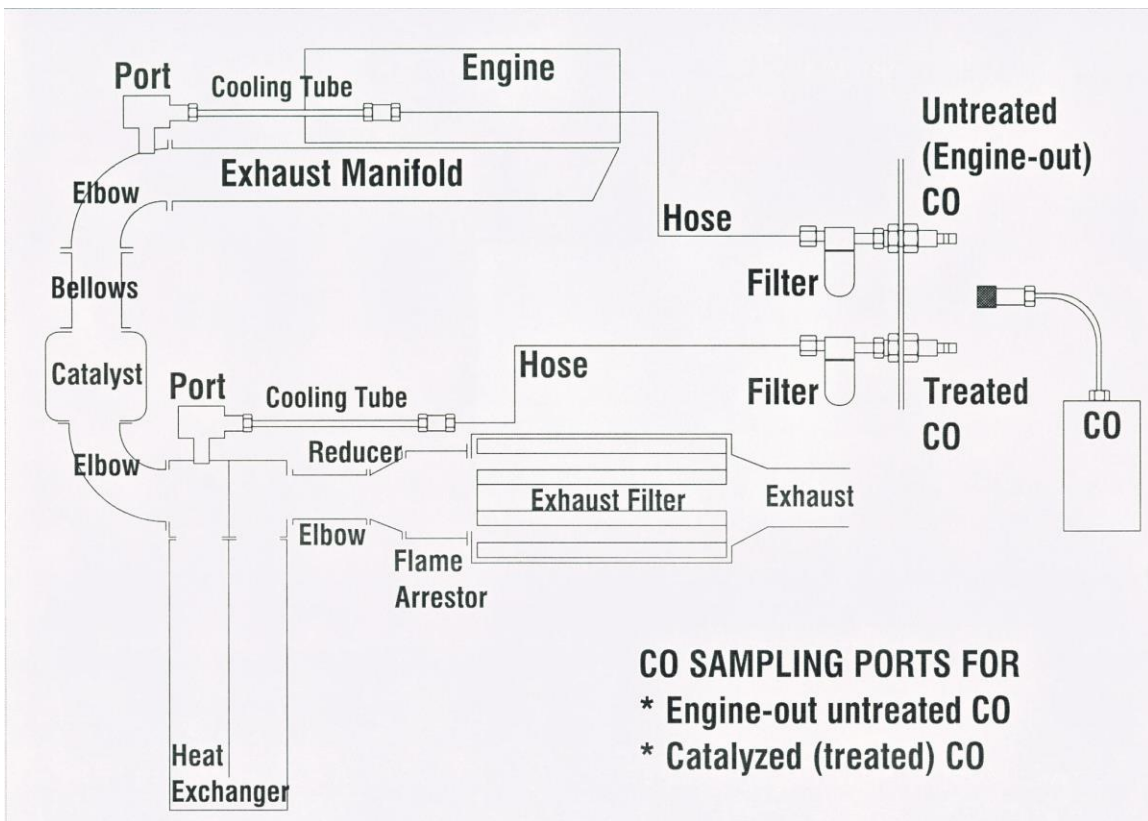


Figure 1: Sampling Schematic for untreated and (Optional) treated CO

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CO Sampling Procedure

The following is the standard procedure to obtain an accurate and repeatable CO sample.

- Place the machine in a safe location, make sure the area in front of the machine is clear and there is sufficient ventilation air. Sampling can be conducted in any area of the mine.
- Set the brakes and start the engine as outlined in the Operation and Maintenance Manual.
- Allow the engine to warm up to normal operating temperature. Taking the CO samples on a cold engine would provide incorrect results.
- Check all operating gauges to be in the normal operating range. The coolant temperature must be no lower than 170°F. If the intake restriction is greater than 25" WG or the exhaust backpressure is greater than 35" WG, perform the necessary maintenance before proceeding.
- Attach the CO Sampling Device to the quick connect port labeled "**Engine Out**" in the operator's cab.
- Re-check that the areas in front and behind of the machine are clear and that the parking brakes are set.
- Put the transmission into the **highest** gear and apply full throttle.
- Monitor the reading on CO Sampling Device. After about 45-90 seconds, the CO indication starts rising. Allow this to continue until the CO indication stabilizes.
- Start recording (5) separate sequential readings in one-minute intervals. Monitor the torque converter temperature while taking the samples. The intervals between the samples may have to be shortened to prevent overheating during the test. Do not allow the torque converter temperature to exceed the safe range.
- Stop sampling after (5) readings, or before if the torque converter fluid gets too hot.
- Slow the engine to low idle, put the transmission into neutral, then put the engine into high idle (without load) for about one minute to cool down the torque converter and the engine coolant.
- Remove the instrument and enter the CO readings on the report.
- Attach the CO Sampling Device to the Optional quick connect port labeled "**Catalyzed**" in the operator's cab.
- Re-check that the areas in front and behind of the machine are clear and that the parking brakes are set.
- Put the transmission into the **highest** gear and apply full throttle.
- Monitor the reading on CO Sampling Device. After about 45-90 seconds, the CO indication starts rising. Allow this to continue until the CO indication stabilizes.
- Start recording (5) separate sequential readings in one-minute intervals. Monitor the torque converter temperature while taking the samples. The intervals between the samples may have to be shortened to prevent overheating during the test. Do not allow the torque converter temperature to exceed the safe range
- Stop sampling after (5) readings, or before if the torque converter fluid gets too hot.
- Slow the engine to low idle, put the transmission into neutral, then put into high idle for about one minute to cool the torque converter and the engine coolant.
- Remove the instrument and record the CO readings on the report.

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CO Sampling Instruments

One of the advantages of the permanently installed CO sampling port system is that it conditions the exhaust gas where it can be monitored with inexpensive handheld instruments. The gas is cooled and filter for this purpose. There are three single gas (CO only) instruments that are readily available, relatively inexpensive and have acceptable accuracy and reliability:

- ECOM EM
- Industrial Scientific CO 260
- Industrial Scientific CO 262

More expensive instruments can be used if they are available to the mine, but provide not advantage. Handheld multi-gas instruments have been evaluated and did not have the necessary accuracy and reliability to be recommended. Handheld multi-gas instrument are fitted with very small sensors that tend to foul up in a very short period of time. The above listed handheld single gas instruments are fitted with larger sensors that hold up better.

Keep in mind that ALL instruments require periodic re-calibration. The calibration date is usually stated on a label attached to the instrument. Unless stated otherwise, we recommend calibration at least twice a year, or whenever inaccuracy is suspected.

Maintenance of the Flameproof Ports

When hot exhaust gas is drawn through small internal passages of the flameproof port and the cooling tube, it is cooled down and some soot will deposit inside the ports and the tubes. This is unavoidable.

When there is excessive soot inside the port, it will plug. As result no sample can be drawn and there is no indication on the CO instrument. As first corrective step, rotate the stem at the end of the flameproof port. If this does not clear the passage, the flameproof port must be removed, disassembled and both port and cooling tube cleaned with solvent. Make sure all solvent is cleaned off and the components are dry before reinstallation.

The filter and water separator remove soot and water that would otherwise damage the sampling head inside the CO sampling instrument. Periodically, the filter cartridge should be replaced. We recommend twice a year when the machine is in normal use. Failure to replace the filter will result in shorter sampler head life.

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Figure 2: Components of Flameproof Port Installation

- | | |
|------------|----------------------------------------------------------------------------------------------|
| Top left: | Intake restriction gauge and flameproof port for intake restriction |
| Top right: | Port for exhaust backpressure and CO sampling, Cooling tube (May be coiled or straight tube) |
| Center: | Exhaust backpressure gauge, water separator/filter (sample conditioner) and Quick Coupler |
| Bottom: | Matching quick coupler for CO instrument |

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Record Keeping (Sample Form)

The following is a sample form to record the CO readings:

Mine Name								
Engine Model								
Engine Serial No								
Machine Model								
Machine Serial Number								
Mine Machine ID								
Mechanic								
Date								
Engine hours								
		Baseline for reference	#1 Sample	#2 Sample	#3 Sample	#4 Sample	#5 Sample	Average
CO Engine-out	ppm							
Coolant	°F							
Exhaust	°F							
Torque Converter	°F							
Engine Speed	rpm							
CO Catalyzed	ppm							
Coolant	°F							
Exhaust	°F							
Torque Converter	°F							
Engine Speed	rpm							

Signature: