Dangers concerning the production of carbon monoxide by generators and other internal combustion engines

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CTIF Fire prevention comission
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Topics

- CO production
- CO risks
- CO prevention

Why?

- Small accidents with CO among firefighters – intoxication when working on the „scene“
  - Use of chain saw, power generators, ventilators…
  - Rescue operations – fires indoor and outdoor, suicides, water pumping…
- Dead of 3 firefighters in 2004 – use of water pump, powered by internal combustion engine
- Injuries among paramedics – for. ex. – 5 injured in one accident (small private house, chimney problems, February 2012).

CO production

Carbon monoxide can be produced in burning carbon-containing material. It can arise in dwellings when stoves burning charcoal, wood, oil, petroleum or gas (methane) are used. It can also be produced in internal combustion engines.

CO values

Concentration	Symptoms
35 ppm (0.0035%)	Headache and dizziness within six to eight hours of constant exposure
100 ppm (0.01%)	Slight headache in three hours
200 ppm (0.02%)	Slight headache within two to three hours; loss of judgment
400 ppm (0.04%)	Frontal headache within one to two hours
800 ppm (0.08%)	Dizziness, nausea, and convulsions within 45 min; insensible within 2 hours
1,600 ppm (0.16%)	Headache, tachycardia, dizziness, and nausea within 20 min; death in less than 2 hours
3,200 ppm (0.32%)	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400 ppm (0.64%)	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800 ppm (1.28%)	Unconsciousness after 2–3 breaths. Death in less than three minutes.

CO – facts and figures - 1

- It has a 240 times greater affinity to haemoglobin than oxygen and it combines with haemoglobin to produce carboxyhemoglobin, which usurps the space in haemoglobin that normally carries oxygen and in this way reduces the capacity of haemoglobin to deliver oxygen to bodily tissues.

CO – facts and figures - 2

- Due to lack of oxygen and slower cellular respiration, significant damage is caused to the central nervous system, especially to the brain.
- The most common symptoms of carbon monoxide poisoning may resemble other types of poisonings and infections, including symptoms like headache, nausea, vomiting, dizziness, fatigue, seizures, sleepiness, ending in a loss of consciousness.

CO – facts and figures - 3

- People usually think that CO is lighter than air, but this is not entirely true. The molar mass of CO is 28 g/mol. The molar mass of air is slightly higher, 29 g/mol. Since 79 % of air is nitrogen with a molar mass of 28 g/mol, the molar masses of CO and air are almost equal. This means that the movement of CO in an environment depends on two factors: the engine that produces CO and atmospheric conditions. The factors by which the generator effects the movement of CO include the speed and the temperature of exhaust gases at the end of the exhaust pipe.

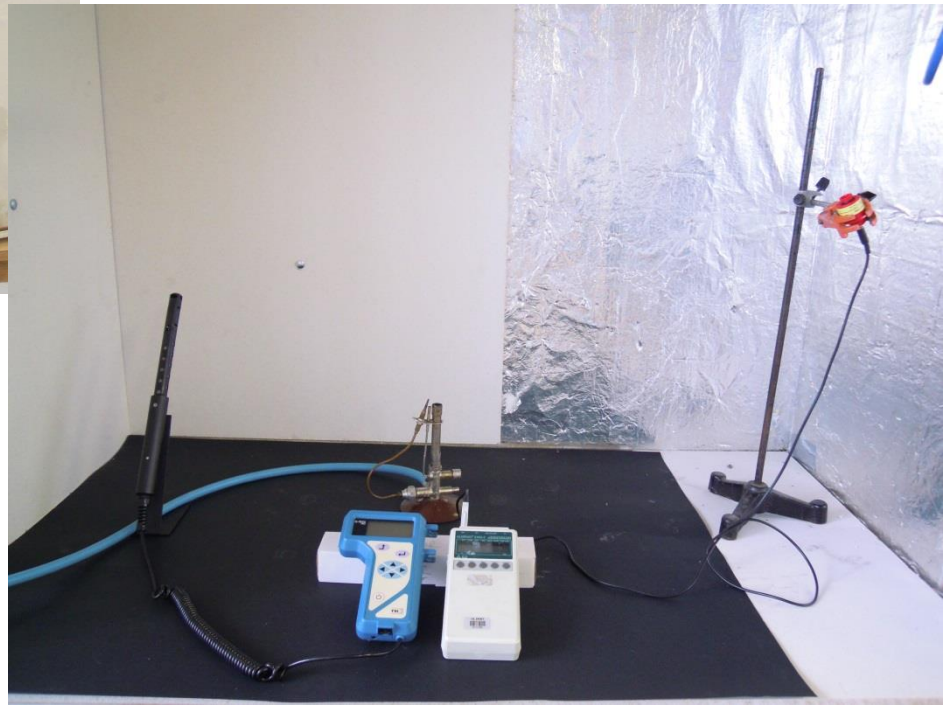
CO – facts and figures - 4

- The values of CO produced in stoves, water heaters and vehicles can therefore exceed the values specified in standards concerning the safety of users. Carbon monoxide can burn itself. The lower explosion level is 12,5 vol % or 125.000 ppm. This level is very high; it can occur exceptionally during a fire if air supply is limited. At this level CO can begin to burn. The phenomenon linked to CO produced during a fire and instantly igniting when fresh air enters the room is called backdraft.

$$2CO + O_2 \rightarrow 2CO_2 \qquad \Delta H = -281{,}5 \text{ kJ/mol}$$

Experiments

- Two scenarios
  - 1. propane butane burner
  - 2. gasoline power generator
  - 3. charcoal charring

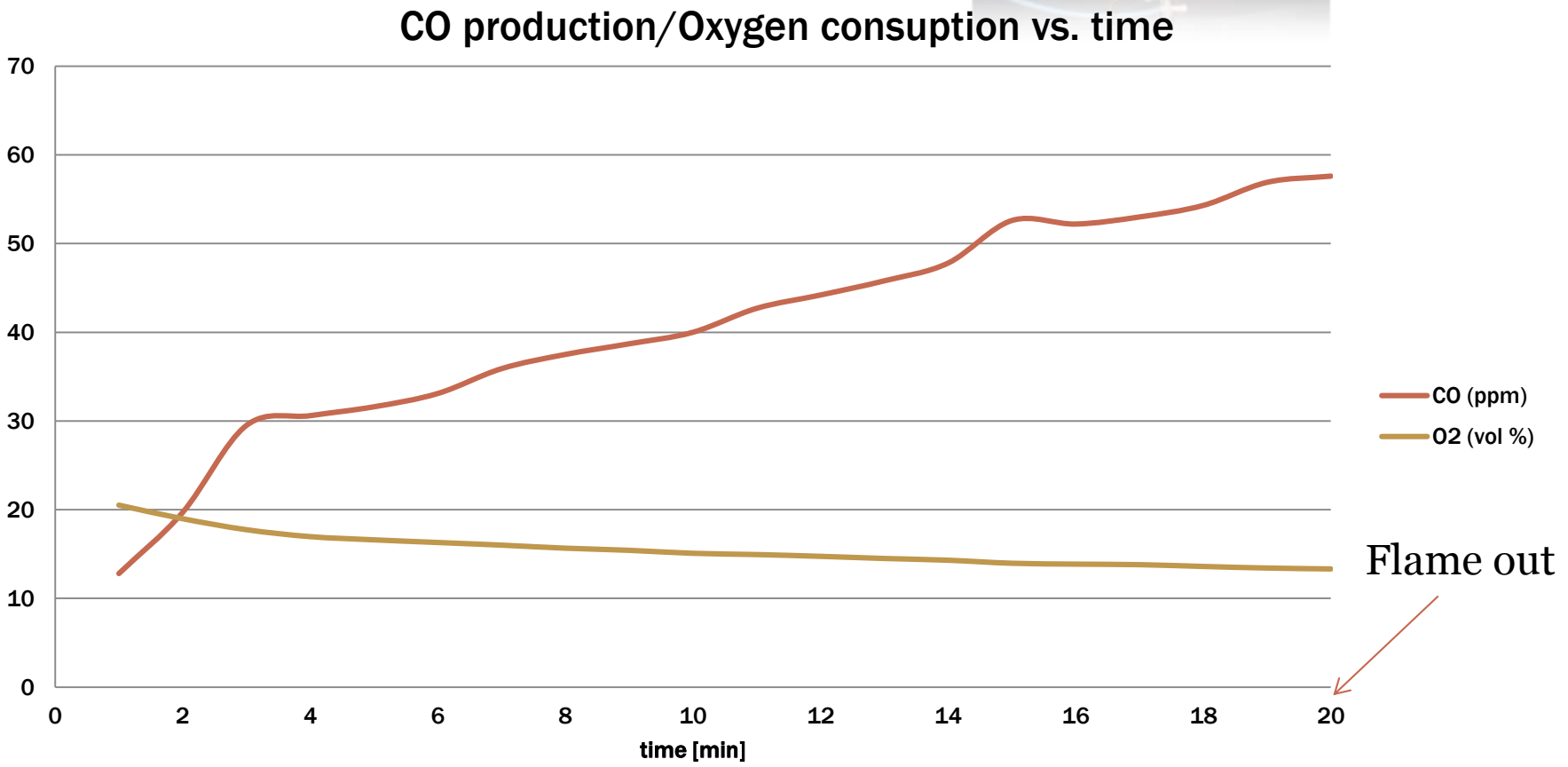


Experimental apparatus

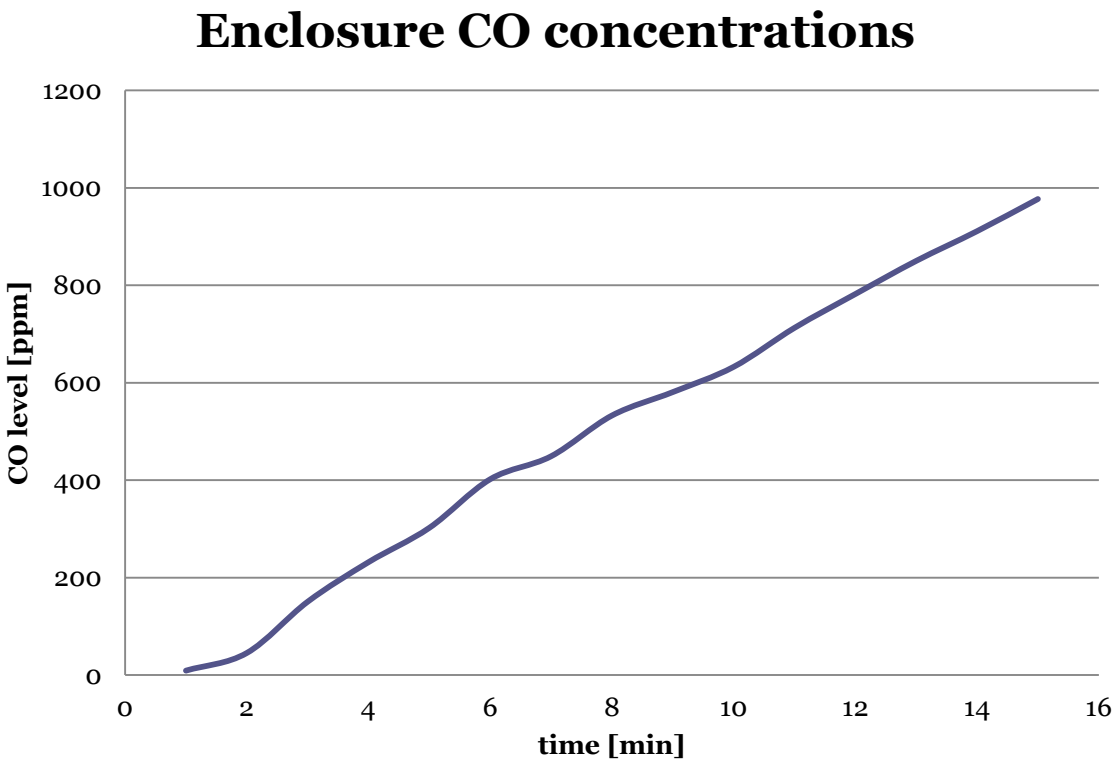
- box
- volume 1,2 m^3
- openings

Experiments

Sealed box



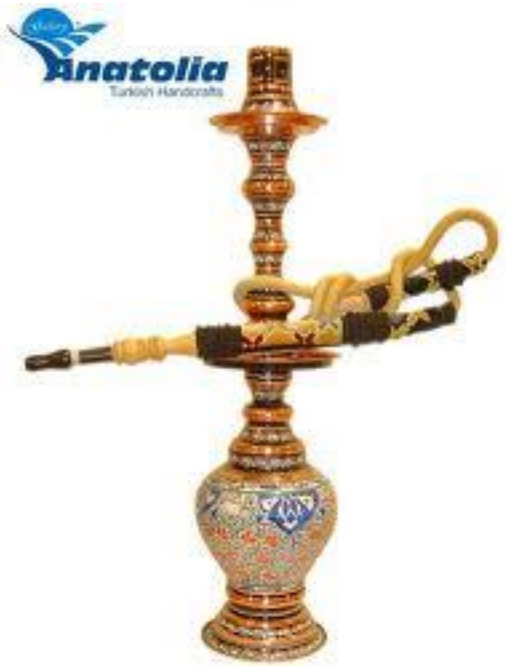
Experiments



Experiments

- Charchoal (for water pipes - shisha)

CO level exceeds 500 ppm in less than 3 minutes.



Document

CTIF – Fire prevention commission

Document: Dangers concerning the production of carbon monoxide by generators and other internal combustion engines

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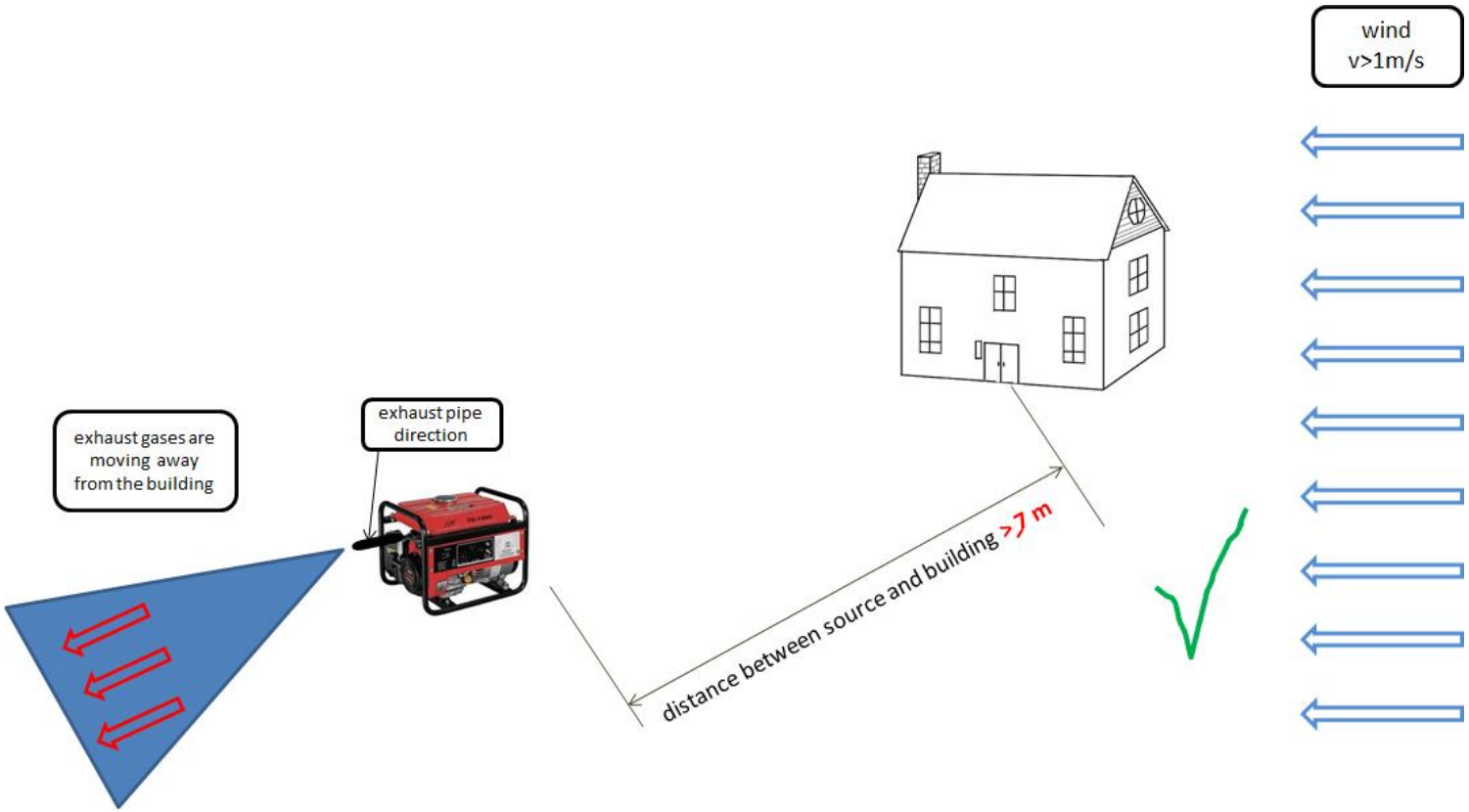
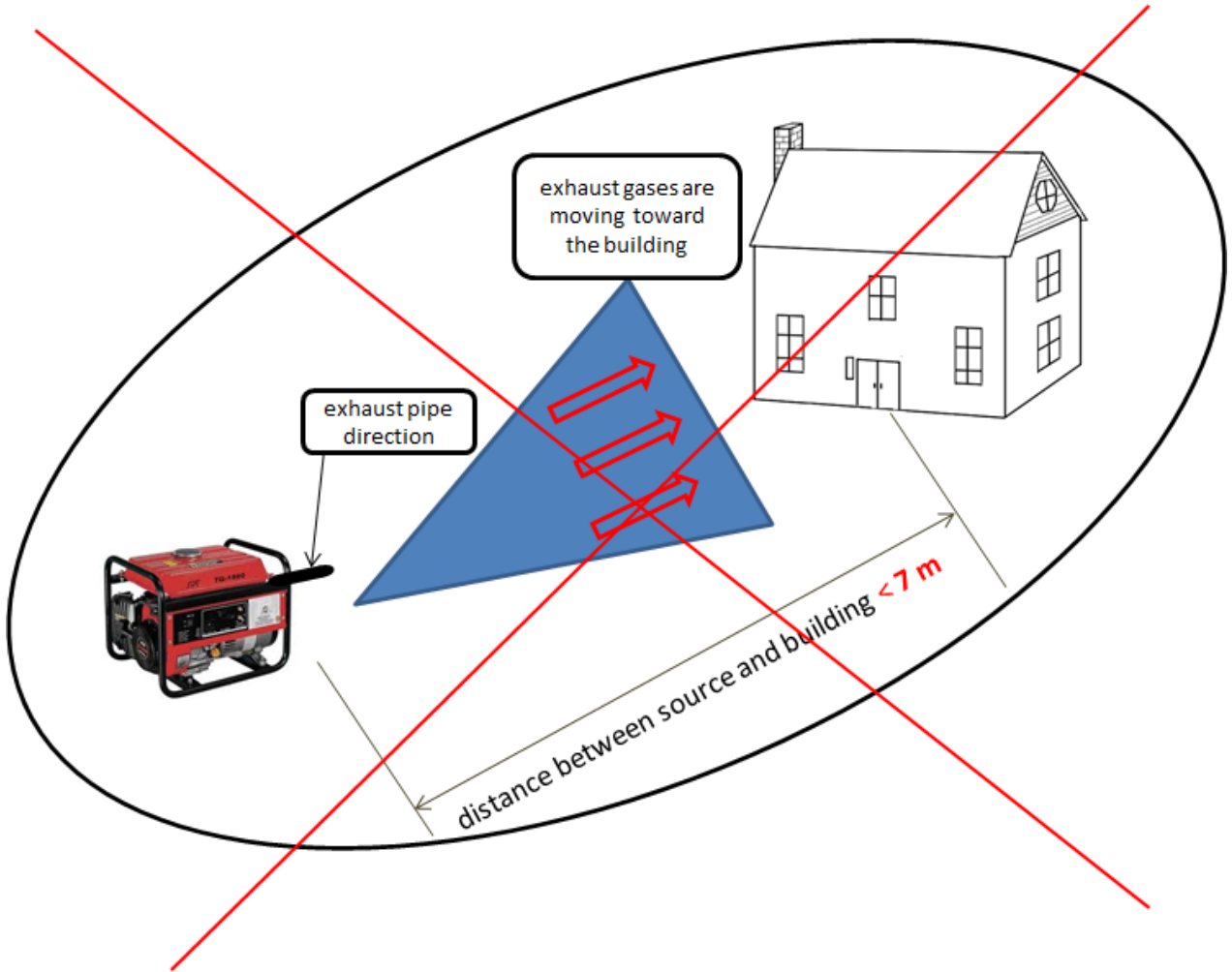
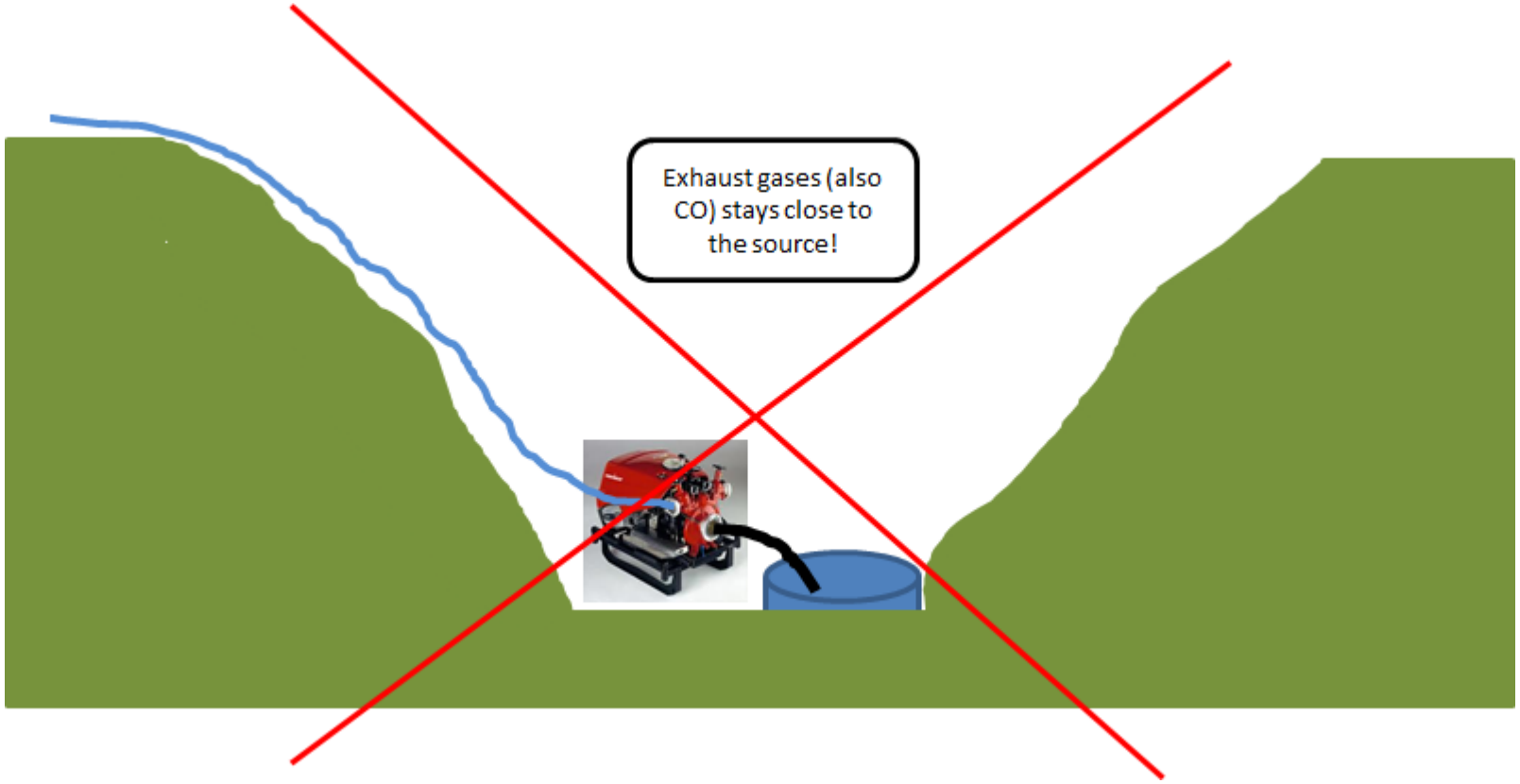
Examples


wind
v>1m/s
exhaust gases are moving away from the building
exhaust pipe direction
distance between source and building >7 m

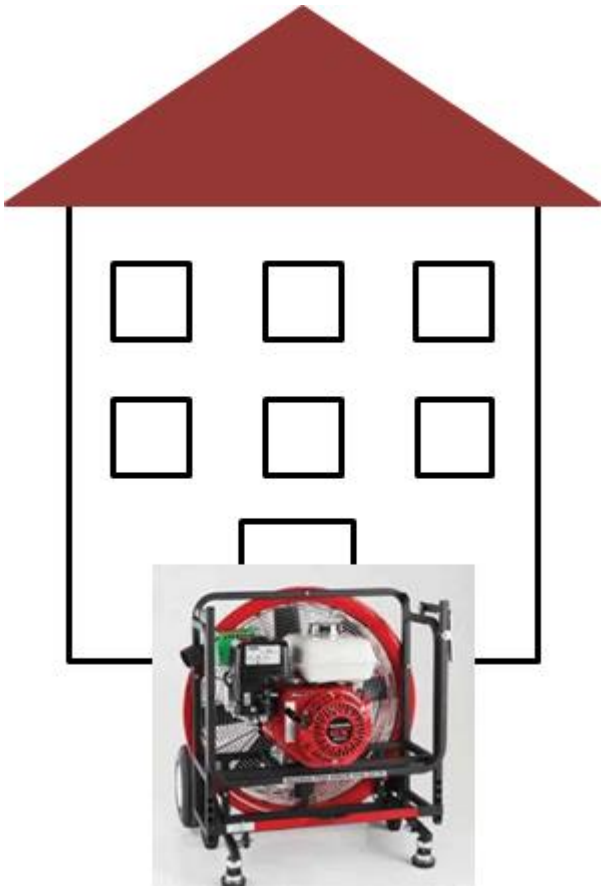
Examples


exhaust gases are moving toward the building
exhaust pipe direction
distance between source and building <7 m

Examples



Examples



Further analysis and tasks

- Reliability of CO detectors – 30% accuracy???
- Standard operating procedures for first responders
- Hydrogen cyanide (HCN) production!!!