

CARBON MONOXIDE AND POSITIVE PRESSURE VENTILATION FANS

Preface:

Each day the Phoenix Fire Department is called to numerous incidents involving fire, smoke and other products of combustion. After the fire is out we use a Positive Pressure Ventilation or PPV fan to remove the smoke and combustion products from the interior of the structure. At the same time we continue to place members inside the structure for salvage and overhaul and investigation. Often residents are allowed inside at this time to collect belongings.

Are the emissions from the PPV fans we are using adding to the levels of CO in the structure? Are we contaminating unburned areas with CO from the fans? Can we reduce these problems?

Introduction:

On Wednesday, April the 29th Captain Bryant Johnston, L33A, HM4, and L151A conducted a test of the CO emissions of Positive Pressure Ventilation fans. These tests were conducted at the Emergency Services Institute. A gas powered PPV fan from L151 equipped with an exhaust extension tube, and an electric PPV fan also from L151 were used for the tests. As an additional test the portable generator lamp was also monitored for emissions. This summary report will show the test procedures used, readings taken, results, conclusions, and recommendations of the test.

Procedures:

Two separate contents fires were set in the main burn room of the ESI burn tower. The fires consisted of basic combustibles found in the home. After 1 minute of free burning a CO reading was taken and recorded. The fire was extinguished windows opened and a PPV fan was set up. CO readings were taken at one minute increments up to five minutes. Each test was repeated using a different PPV fan or a exhaust tube extension. To test the effectiveness of the exhaust extension after five minutes of reading CO levels with the extension in place the extension was removed and five additional minutes were recorded.

Allowable CO Concentrations:

The American Council of Industrial Hygienists (ACGIH) sets the maximum allowable time waited average (TWA) at 25 PPM, The Occupational Safety and Health Administration (OSHA) sets the maximum TWA at 50 PPM. These are both widely accepted standards to insure the health and safety of workers. To see more data on the effects of CO on the body see the attachment entitled Natural Gas and CO.

Fire # 1

Fire number 1 was conducted using a gas powered PPV fan from L151 equipped with an exhaust extension tube. The fan is a 21” Tempest Model # BD -H-5.5 rated at 13,786 CFM. (we currently use a variety of gas powered fans the most prevalent is SuperVac 20” rated at 16,912 CFM)

Readings:

CO reading at 1 minute after fire was started	289 PPM
CO reading at 1 minute after PPV fan was started	110 PPM
CO reading at 2 minutes after PPV fan was started	50 PPM
CO reading at 3 minutes after PPV fan was started	48 PPM
CO reading at 4 minutes after PPV fan was started	35 PPM
CO reading at 5 minutes after PPV fan was started	25PPM

*At this point the exhaust extension was removed and readings were taken a additional 5 minutes

CO reading at 1 minute after removing extension	32PPM
CO reading at 2 minutes after removing extension	33PPM
CO reading at 3 minutes after removing extension	26PPM
CO reading at 4 minutes after removing extension	26PPM
CO reading at 5 minutes after removing extension	23PPM

Results:

The use of the standard exhaust extension was had a sizable impact on the level of CO introduced into the structure. This can be seen in the 8 PPM increase in CO after 2 minutes when the exhaust extension was removed.

The Gas powered PPV fan with the exhaust extension had a 91.38% efficiency in the removal of CO from the structure in a 5 minute time period.

$$289 \text{ PPM} - 25 \text{ PPM} = 264 \quad (264 / 289) = .913 = 91.3\%$$

As you can see from the readings the CO finally reached the maximum allowable PPM (25 PPM) at the 5 minute mark for the ACGIH TWA standard. The CO level did peak above the TWA when the exhaust tube was removed, before falling below the level after 5 minutes of running without the extension.

In contrast the CO level was at the maximum allowable PPM (50 PPM) after 2 minutes of the start of the fan for the OSHA TWA standard. And stayed below the TWA during the remaining minutes and after the extension was removed.

Fire # 2

Fire number 2 was conducted using an electric powered PPV fan from L151. The fan is a 21" Tempest Model # EB21EP rated at 10,241 CFM.

Readings:

CO reading at 1 minute after fire was started	465 PPM
CO reading at 1 minute after PPV fan was started	350 PPM
CO reading at 2 minutes after PPV fan was started	150 PPM
CO reading at 3 minutes after PPV fan was started	74 PPM
CO reading at 4 minutes after PPV fan was started	45 PPM
CO reading at 5 minutes after PPV fan was started	35PPM
CO reading at 6 minutes after PPV fan was started	25 PPM

*At this point the a gas powered generator light was placed in the room, readings were taken a additional 5 minutes

CO reading at 1 minute after placing light in room	28PPM
CO reading at 2 minutes after placing light in room	32PPM
CO reading at 3 minutes after placing light in room	35PPM
CO reading at 4 minutes after placing light in room	33PPM
CO reading at 5 minutes after placing light in room	35PPM

Results:

The use of the electric PPV fan was as effective as the gas powered fan. The electric fan lowered a 465 PPM environment to 35 PPM in 5 minutes. The CO level was lowered to 25 PPM in 6 minutes.

The Electric powered PPV fan received an efficiency rating of 92.5% in a five minute time period.

$$465 \text{ PPM} - 35 \text{ PPM} = 430 \text{ PPM} \quad (465 \text{ PPM} / 465 \text{ PPM}) = 92.5\%$$

The gas powered generator light released 10 PPM into the environment over five minutes.

As you can see from the readings the CO finally reached the maximum allowable PPM (25 PPM) at the 6 minute mark for the ACGIH TWA standard. The CO level did peak above the TWA when the generator light was introduced, and climbed steadily up during the 5 minute test.

In contrast the CO level was at the maximum allowable PPM (50 PPM) after 4 minutes of the start of the fan for the OSHA TWA standard. And stayed below the TWA after the generator light was introduced.

Observations:

The gas operated PPV fan took a 289 PPM environment to a reading of 25 PPM in 5 minutes, gaining a 91.3 % effective rating. The electric powered PPV fan took a 465 PPM environment to a reading of 35 PPM in 5 minutes, gaining a 92.5 % effective rating. The crews observations of the two atmospheres as far as smoke content at the end of each test fire was that the environments were equally clear to the eye.

Conclusions:

With the use of a exhaust extension tube a gas powered PPV fan can operate within 1.2 % of the efficiency of an electric PPV fan. We can also conclude that electric PPV fans can be as effective in smoke removal as comparable size gas powered PPV fans.

Gas powered generator lights do introduce a significant level of CO into a environment. The introduction of 10 PPM was in a large room the effect would be magnified in a enclosed space such as an attic or a crawl space.

Even with the use of exhaust tubes and electric PPV fans we are still not reaching safe CO concentrations until five minutes after the start of the PPV fans, According to ACGIH. Even at this point we have only reached the maximum allowable, and the introduction of generators and other machines will drive up the levels. Please note these fires were performed under ideal conditions with a small fire. Larger fires and certain materials involved may push these times back further.

Recommendations:

Based on the conclusions of this test recommendations are as follows:

- 1) The department should institute the use of gas powered PPV fans equipped with exhaust extension tubes. Additional testing should be done using the practice of “double tubing” to see if this reduces the level of CO significantly over the use of a single exhaust tube. This practice is accepted by the manufacturer of the fans.
- 2) The department should begin research into an alternative to the gas powered generator light for use inside structures. Dana Medlin in Resource Management has already begun this process.
- 3) The continued research of new PPV fan products such as rechargeable PPV fans. Currently the technology only allows for a 20 minute battery to be used. We should continue to follow this technology as it may advance to a stage where it can become an asset. Attached is the manufactures information on the rechargeable PPV fan.

Recommendations: (continued)

- 4) A benchmark should be set regarding the use of SCBA's inside smoke filled environments until a set time is reached after a PPV fan is implemented. Or until a reading is taken and the CO content falls below a set PPM on a CO meter.

The set PPM and or time can be determined by the department based upon the information in this report and other sources.

Attachments:

- 1) An excerpt from literature published by the Tempest fan company. The article is concerning CO and the use of PPV fans.
- 2) An article published by the International fire Service Training Association (IFSTA) on Carbon Monoxide.
- 3) Manufactures information on rechargeable PPV fans.

Attachment 1

**EXCERPT FROM THE TEMPEST FAN COMPANY ON
CARBON MONOXIDE AND PPV FANS**

Attachment 2

IFSTA ARTICLE ON CARBON MONOXIDE

Attachment 3

**MANUFACTURES INFORMATION
ON
RECHARGEABLE PPV FANS**

