Mobile Ventilation Unit Tunnel Test
BNSF Railway Seattle Tunnel
(Great Northern / King Street Tunnel)
November 14, 2002

Background

On November 14, 2002, Tempest Technology worked with BNSF Railway and the Seattle Fire Department to test the capabilities of the Mobile Ventilation Unit and Positive Pressure Ventilation for emergency ventilation of a one-mile long rail tunnel.

About Positive Pressure Ventilation

Positive Pressure Ventilation (PPV) is an emergency ventilation technique employed by fire departments to control the hostile environment inside a burning structure. To apply PPV, small gasoline or electric powered blowers are used to remove the smoke, heat, and gases from single-family dwellings and commercial buildings.

PPV works by positioning a specially designed blower outside the structure, blowing inward, so that the cone of air generated by the blower covers, or "seals" the entrance opening (*Figure 1*). When this seal is achieved, the air pressure is increased equally at all points inside the structure. When an exhaust opening is created, the air pressure is released. Because air always flows from high pressure to low pressure, all of the smoke, heat, and contaminants are forced through the exhaust opening.

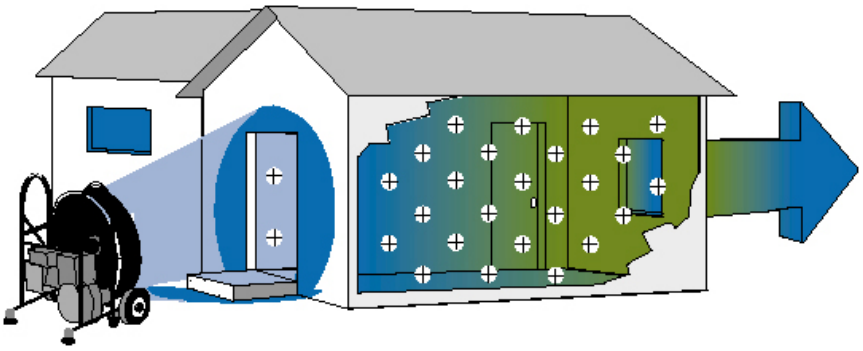

Figure 1: PPV Cone Simulation

The application of PPV results in reduced heat, improved visibility, and an overall increase in the level of safety for fire fighters who work inside a burning structure.

About the Mobile Ventilation Unit

The Tempest Mobile Ventilation Unit (MVU) used for this test is a 48” (1.25m) diameter, trailer mounted system (*Figure 2*).

- The MVU is a self-contained system that uses a diesel engine to power a hydraulic fan motor, lifting system, and fan adjustments.
- It can be mounted into a truck, trailer, or skid.
- The 48” MVU is capable of generating air volumes in excess of 130,000 CFM (221,000 m^3/hr)
- One 48” unit can ventilate a tunnel up to 3 miles (5 km) in length.
- The MVU is also available in 43” (1.1m) and 60” (1.53m) diameter sizes.

Figure 2: 48” Trailer Mounted MVU Used for Test

The Mobile Ventilation Unit is capable of ventilating a tunnel in the same manner that smaller blowers are used to ventilate smaller structures. The MVU is positioned outside of the tunnel portal and the fan is adjusted so that the cone of air generated by the MVU expands to seal the portal (*Figure 3*).

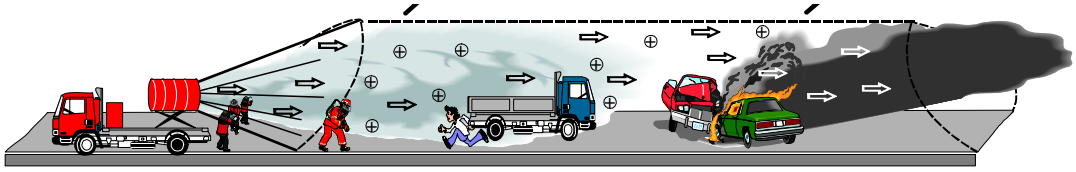

Figure 3: The MVU Applies PPV to a Tunnel

About The BNSF Tunnel

The BNSF Railway Seattle Tunnel (also referred to as the Great Northern or King Street Tunnel) is a double track rail tunnel that runs through the heart of downtown Seattle.

Tunnel Information:

- Constructed in 1904
- **Length**: 5,141 feet (1,582 meters)
- **Width**: 34.5 feet (10.6 meters)
- **Height**: 27.8 feet (8.6 meters)
- Tunnel runs North to South with two 4 degree curves.
- **Traffic**: Up to 50 freight trains/day (6 Amtrak trains/day).

PPV Test Scenario

The MVU was positioned near the South portal approximately 40 feet (12.3 meters) outside the tunnel entrance. It was located on the West side of the tracks in order to provide clear access for trains (*Figure 4*). To create an air seal at the entrance, the MVU was elevated and aimed at the center of the tunnel bore (*Figure 5)*.

Figure 4: MVU Positioned at South Portal

Figure 5: MVU elevated and aimed at center of tunnel bore

Two smoke generators were positioned at the mid-point of the tunnel to create artificial (cold) smoke. The smoke is created by pumping a water-based glycol solution through a heating element. The smoke generators were allowed to operate for 20 minutes before ventilation was started.

A locomotive and passenger car from the Sound Transit commuter rail system (*Figure 6*) were used to transport the smoke generators to the midpoint of the tunnel. Once the smoke machines were started, the train was positioned 200 feet inside the South Portal to simulate blockage that could occur during an emergency.

Figure 6: Sounder Train that was positioned 200' inside the South Portal

Airflow Performance

A 2 mph (1 m/s) Southerly natural wind existed at the time of the test. Because ventilation was initiated from the South portal, this wind was assisting the MVU during the test. In actual emergency situations where PPV is applied, fire fighters use prevailing winds to their advantage wherever possible. If ventilation had been initiated from the North portal, against the wind, PPV would have successfully cleared the tunnel.

AIR SPEED DATA	South Portal	Midpoint	North Portal
Natural Wind (no PPV)	2 mph	1 to 2 mph	1 to 2 mph
Ventilation with PPV	-1 to 7 mph *	5 to 6 mph	4 to 6 mph

* Due to air turbulence at the South Portal, air speed readings varied greatly.

Figure 5: Smoke exiting the North Portal due to natural ventilation.

Due to the 2 mph natural wind, smoke began exiting the tunnel before ventilation was initiated with the MVU (*Figure 5*). Once PPV was initiated, the air speed increased to 4 to 6 mph and smoke started exiting the tunnel instantly. Due to the smoke exiting the tunnel, visibility at the North portal was completely obscured (*Figure 7*).

Figure 7: Smoke exiting the North Portal during PPV.

Test Results

Once PPV was initiated, it took five minutes for the tunnel to become clear from the South Portal to the midpoint. This was confirmed by the fire fighters operating the smoke machines.

It took an additional five minutes for the tunnel to become clear from the midpoint to the North Portal. A total of ten minutes was required to completely clear the tunnel with the assistance of the 2 mph natural wind.

This test proved that one 48" Mobile Ventilation Unit can quickly clear a one-mile long rail tunnel of cold smoke. Tests conducted on similar tunnels using live fire have had the same results. (see MVU Applications CD-ROM, Version 1.0).

As fire departments search for new tools and techniques for dealing with emergencies in rail and subway tunnels, PPV is a versatile tool that offers a high level of control over the hostile environments they encounter.

For additional information on the applications of PPV for emergency tunnel ventilation, please contact:

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