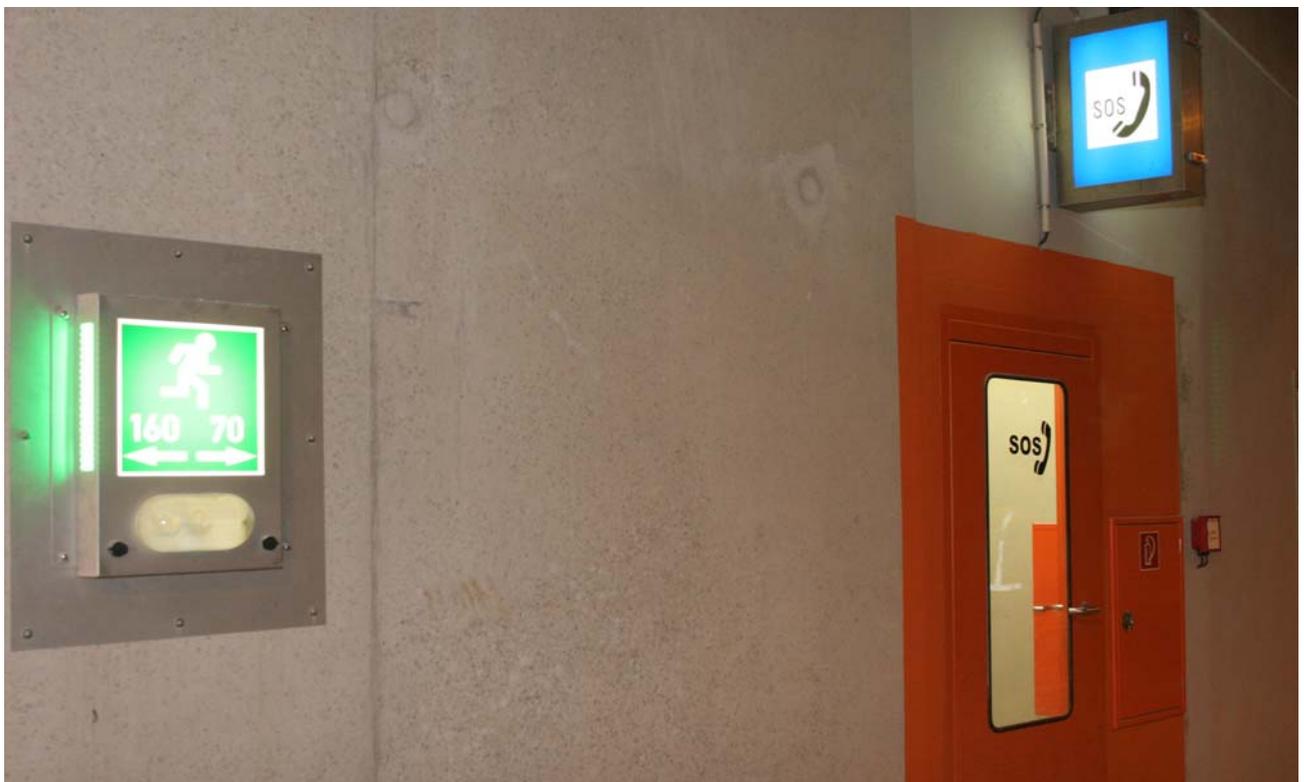


Pictures from a realistic full-scale fire test with two passenger cars and a HRR of 12 MW in the B260 Malberg tunnel at Bad Ems, Germany, on 27th of Sept. 2006



Picture 18: The site of the control building and of one, out of six, emergency stair-cases, and of five smoke extracting stations, out of twelve, located at the foot of the northern “Malberg” hill side.



Picture 19: The emergency phone booth with a secured box containing two fire extinguishers, a push-button fire alarm station, an illuminated SOS-signal with a flashing light, an illuminated escape signal with lateral LED-s indicating the distances to the next emergency exits and a walk way orientation light located next to the smoke extracting station #05 in the vicinity of the fire test-bed.



Picture 20: The Ford Sierra filled with 30 litres of diesel oil and the Opel Monza with 30 litres of petrol, each with 2 spare tires and all doors and hoods open, placed on 25 mm fire retardant plates.



Picture 21: The arrangement of two passenger cars in the fire test bed, the walls were heat protected by covers of 25 mm fire retardant plates, 5 m high and 10 m long, as well as 1 m high and 100 m long.



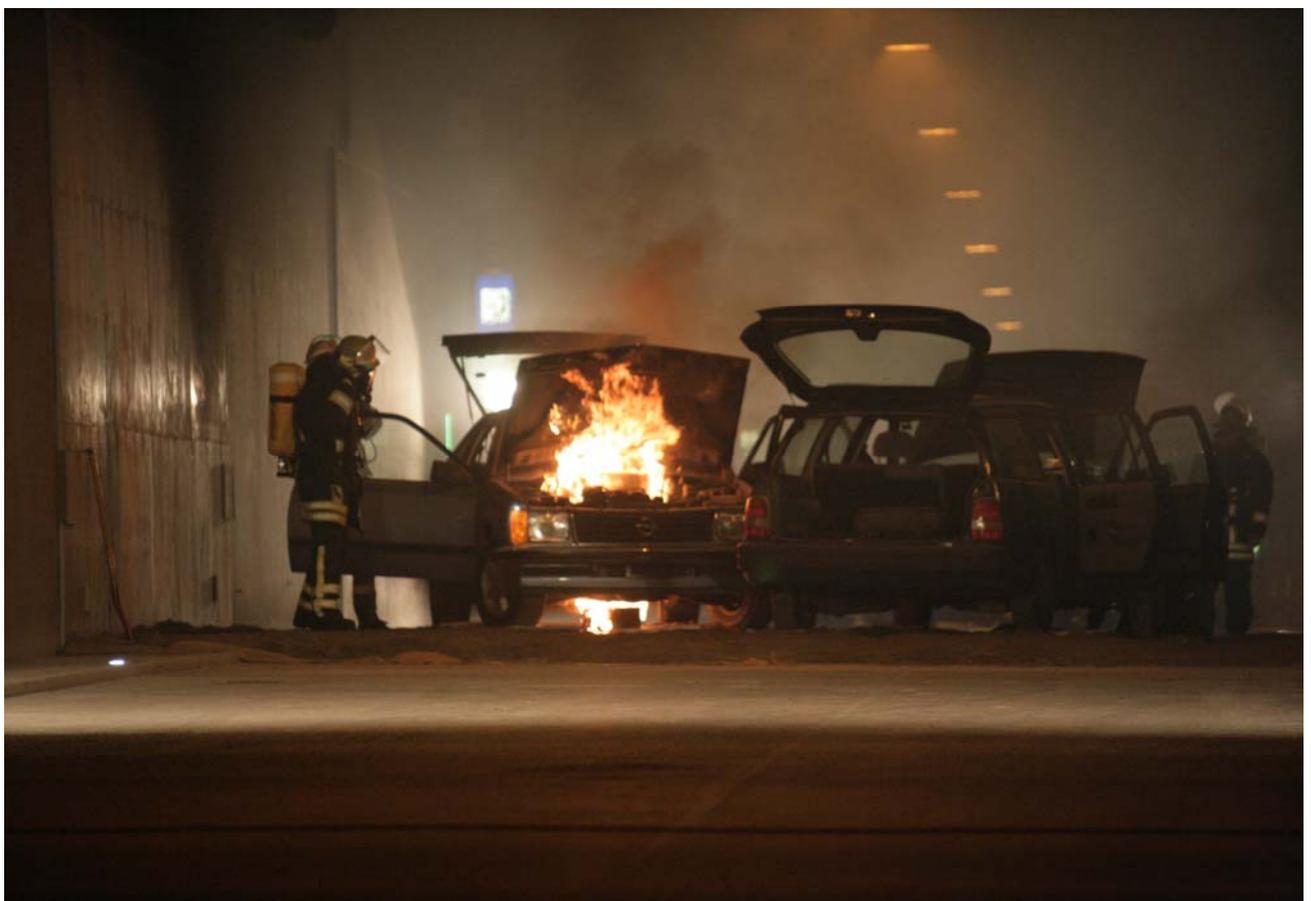
Picture 22: The heat protection at the ceiling, 9.5 m wide, 100 m long, made of 15 mm heat retardant plates. The light fittings, fire detection cable, radio antenna, electric cables, loud speakers, CCTV-cameras and measuring instruments remained unprotected, except the encapsulated ultra-sonic meters.



Picture 23: The placing of the ignition box (filled with 5 litres of petrol) under the gas-engine, the cars were set up in a 10 cm high sand bed (with wet cable sand), viewed from the east (the measuring apparatus have been installed under the ceiling in distances of 20 m to 30 m from the fire place).



Picture 24: The start of the fire in the fire box (ignited by a torch) created a slight plume of smoke, when viewed from the east.



Picture 25: The developing of the fire in the engine compartment (the batteries have been removed in advance) with slight dimming of the ceiling lights, viewed after 4 minutes from the east.



Picture 26: The fire viewed after 5 minutes from the east, when the ceiling lights were heavily dimmed.



Picture 27: The fire viewed after 6 minutes from the east, when the ceiling lights were totally dimmed.



Picture 28: The fire viewed after 8 minutes from the east, when the plume and the smoke layer grew up.



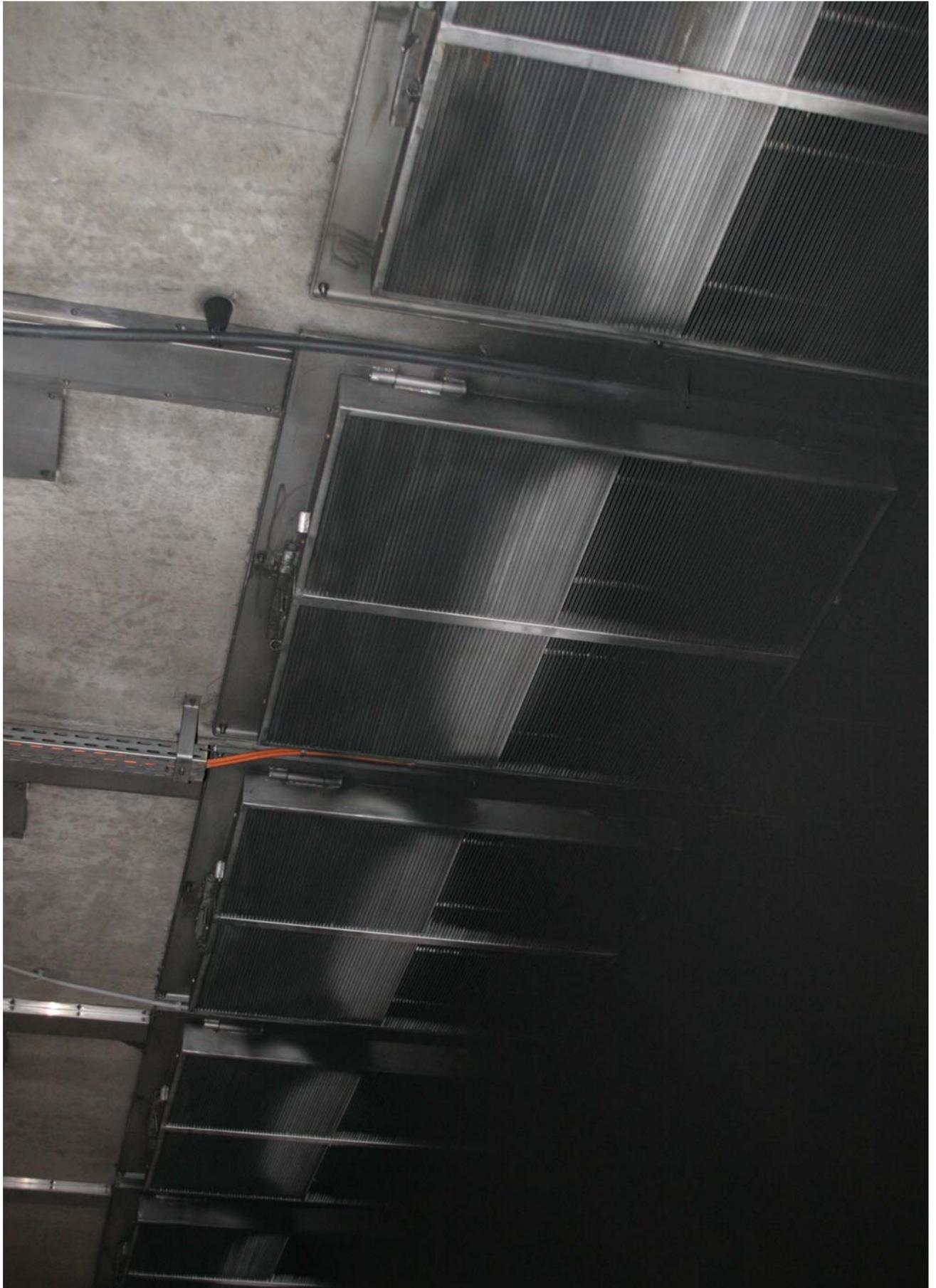
Picture 29: The fire viewed after 10 minutes, when the smoke layer was still stable and darkening the entire division of the tunnel between the two smoke extracting stations #05 and #06.



Picture 30: The fully burning first car, viewed after 12 minutes from the east.



Picture 31: The burning of two cars after the flash-over of the fire, viewed after 25 minutes from the east, the flow of the smoke layer was still stable when moving towards the smoke extracting station #6, all safety apparatus can be seen on the wall (the encapsulated ultra-sonic meter and the loud speakers) or below the ceiling (the ECS, the opacimeter, the black radio antenna and the white heat sensor cable).



Picture 32: The smoke extracting station #05 with six openings 1.25 x 1.25 m protected by flame stops attached to the ceiling, including six smoke extracting fans @14 m³/s each, with silencers, built-in into six exhaust shafts and covered by automatic motor driven dampers for the environmental protection.



Picture 33: The clouds of smoke were discharged from the smoke exhaust shafts #05 and #06 (both were at nearest to the fire place), viewed after 22 minutes from the east.



Picture 34: The smoke discharge from the exhaust shaft #05, viewed after 23 minutes from the east.



Picture 35: The plume of the smoke reached a height of about 25 m above the discharge openings of the exhaust station #05 (at minor wind influence), viewed after 23 minutes from the west.



Picture 36: The smoke as discharged from exhaust station #05, viewed after 28 minutes from the east.



Picture 37: The smoke as discharged from exhaust station #06, viewed after 23 minutes from the west.



Picture 38: The smoke as discharged from exhaust station #06, influenced and re-directed by the west wind, viewed after 29 minutes from the west.



Picture 39: The simultaneous test set with hand pump and 5 Dräger tubes to measure several inorganic, burnable gases at once in order to control the distribution of noxious gases in the vicinity of the exhaust shafts and the next housings (the measured values were absolutely zero).



Picture 40: The stable flow pattern of the smoke layer below the ceiling heading towards the extracting station #06, viewed after 12 minutes from the east, all escape routes, emergency walkways and stair cases were kept free from smoke over the entire test period, but ceiling lights were darkened and cameras went blind so that no useful video image from near the fire place was available in the control room.



Picture 41: The stable flow of the smoke layer below the ceiling heading towards the extracting station #05, viewed after 23 minutes from the west, the smoke layer had a height of about 1 m which equalled the height of the heat protection on the walls. As the jet fans of the western division ran in reverse mode they had no contact with the smoke layer and no smoke could by-pass the extracting station #05.



Picture 42: There was a maximum HRR of 12 MW from the burning cars, viewed after 24 minutes from the west, and still there was a stable smoke layer as the fire brigade organised for the near attack.



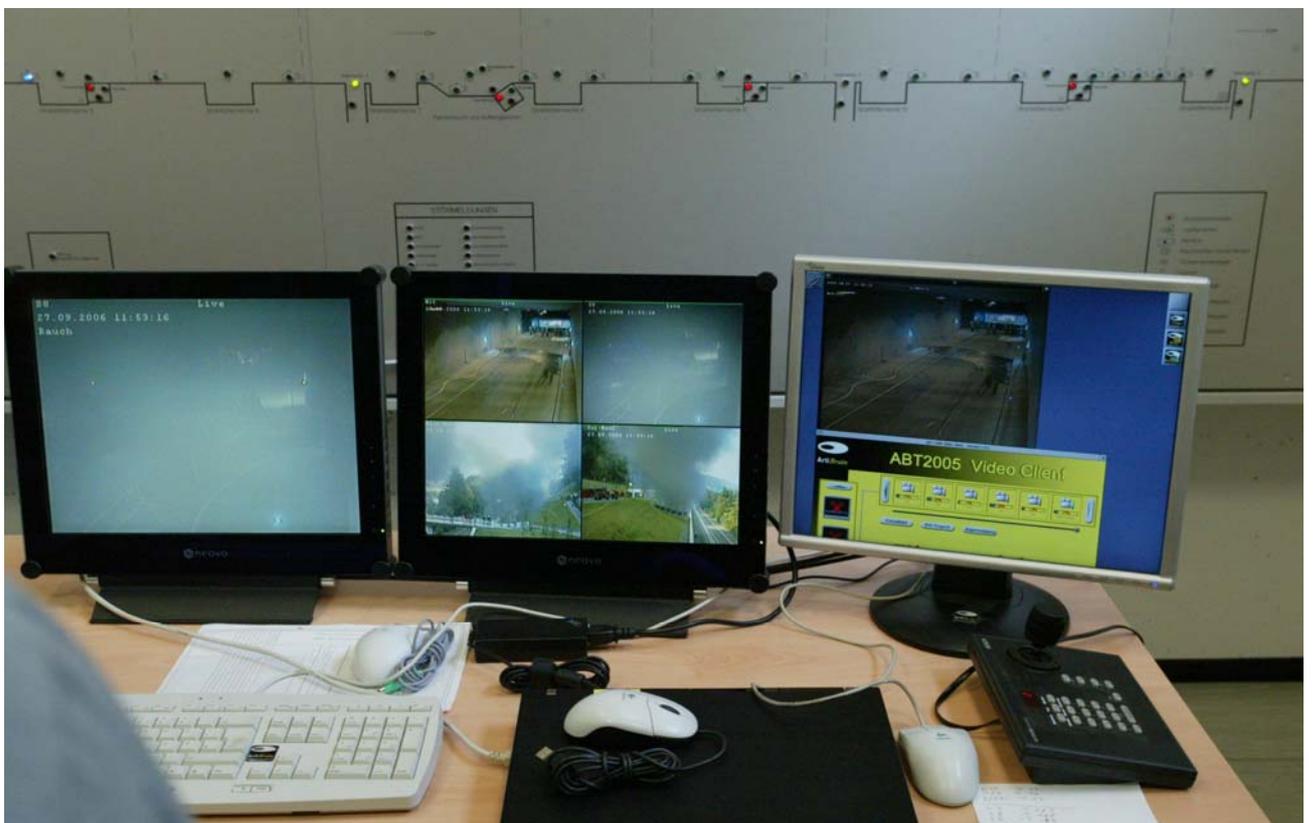
Picture 43: The cars were still burning, viewed after 26 minutes from the west and lighted by 4 floodlights, when the fire brigade observed the ongoing fire in a distance of 20 m, ready to fight it.



Picture 44: The cars were still burning, viewed after 27 minutes from the west, and still there was a stable smoke layer (stratification by density difference) when the fire brigade prepared itself for the attack.



Picture 45: The cars were still burning, viewed after 28 minutes from the west, and still there was a stable smoke layer (stratification by density difference) when the fire brigade lifted up the water guns connected through a size B hose with the adjacent hydrant located in a separate chamber of the tunnel niche and served from a central pumping and pressurisation unit located in front of the control building.



Picture 46: The control room has been furnished with a mimic board on the wall for the indication of the condition of the lighting, ventilation, smoke extraction, alarms, failures and traffic congestions. Video monitors have been placed on the desk next to the process monitors to supervise the traffic flow. Due to the dark smoke the video cameras and monitors went blind and were of no use during the test.



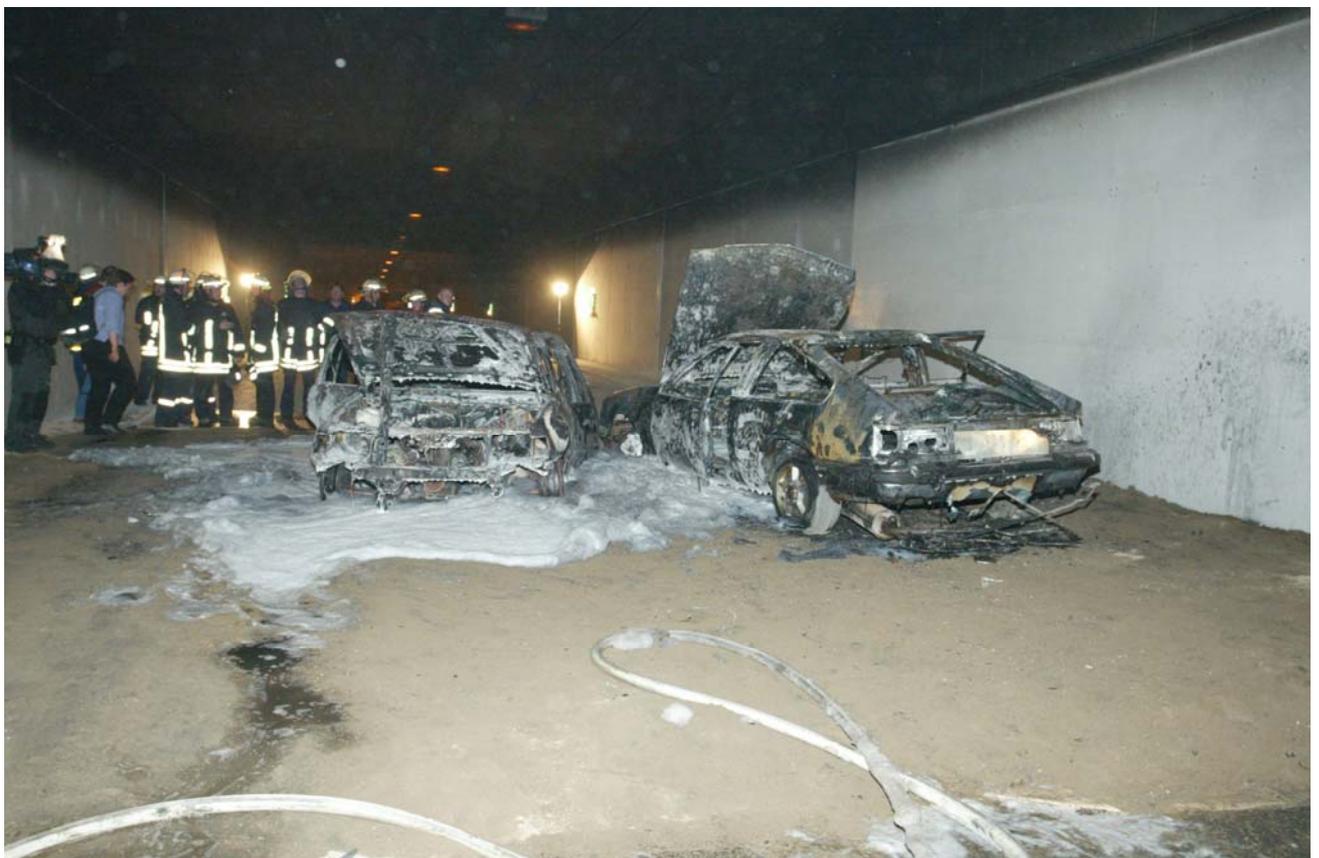
Picture 47: The work place has been installed in front of the mimic board. The mimic board contained 14 TFT-displays to show a life image of the smoke flow, its velocity, direction and temperature. The arrows have been moving in the same manner as the smoke did. The back-ground colour of each display changed with the actually measured local gas temperature. The speed of all fans, the status of all dampers and the values of all measured flow velocities, CO-concentrations, opacity coefficients and smoke temperatures have been indicated separately for each tunnel division on 14 TFT-displays (10.25”).



Picture 48: The attack from the west side started 28 minutes after ignition and ended 1 minute later. All over the testing and the extinguishing period the stratification of the smoke remained stable.



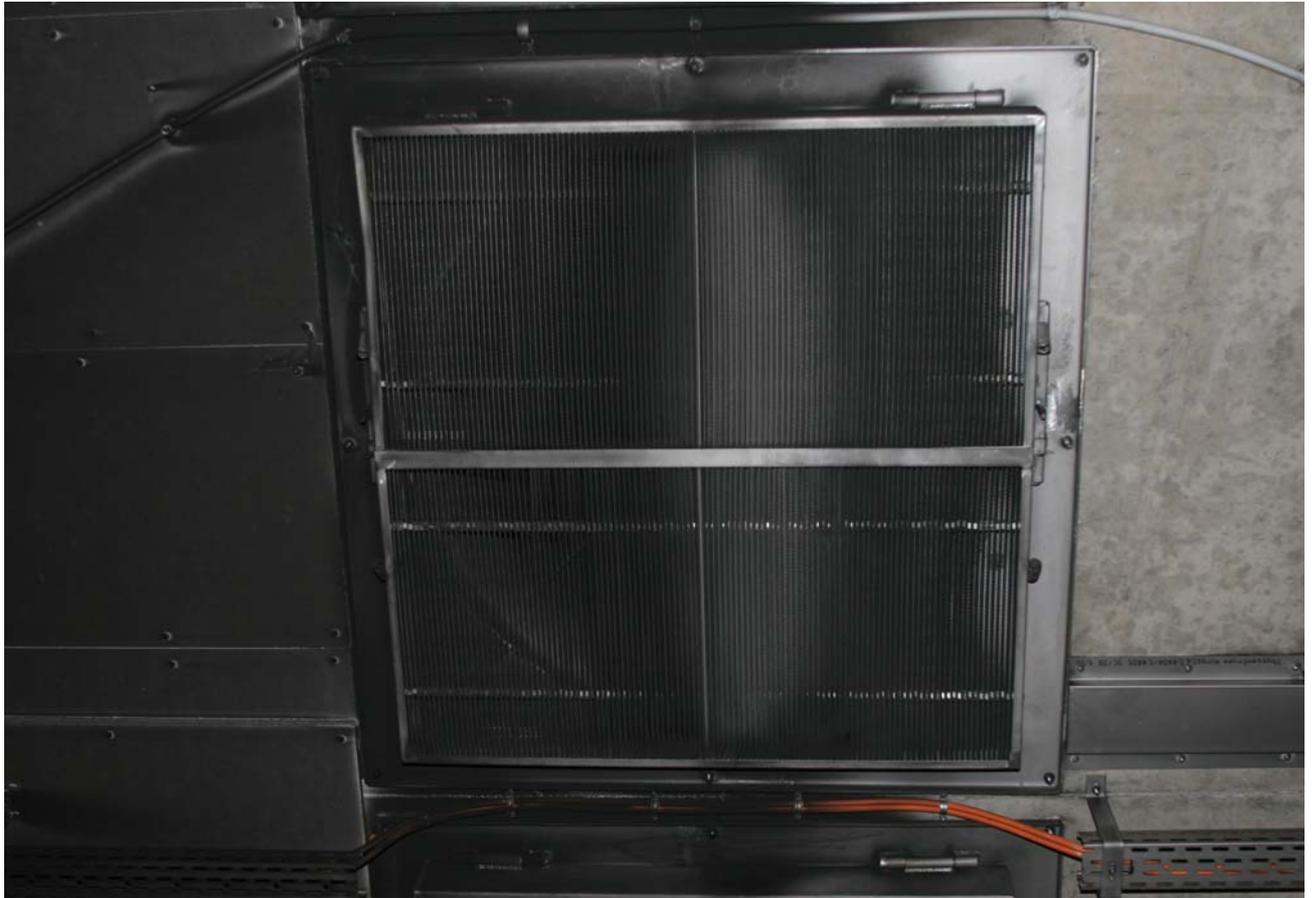
Picture 49: The steam layer replaced the smoke layer, viewed after 32 minutes from the west. The walls were blackened only along the ceiling on a 1 m high strip. The emergency phone booth and the emergency lightings remained visible and the hydrant niche remained accessible all the time.



Picture 50: The wrecked cars, viewed after the fire has been extinguished by medium foam. The light fittings and glasses fixed to the ceiling were blackened from soot and the heat sensor cable, the radio antenna, the lighting cables, the loud speakers and some measuring apparatus have been damaged.



Picture 51: The dampers of the smoke extracting station remained unharmed and have been well functioning after the test (this was the station #06 with dampers, levers and heat insulated gear motors).



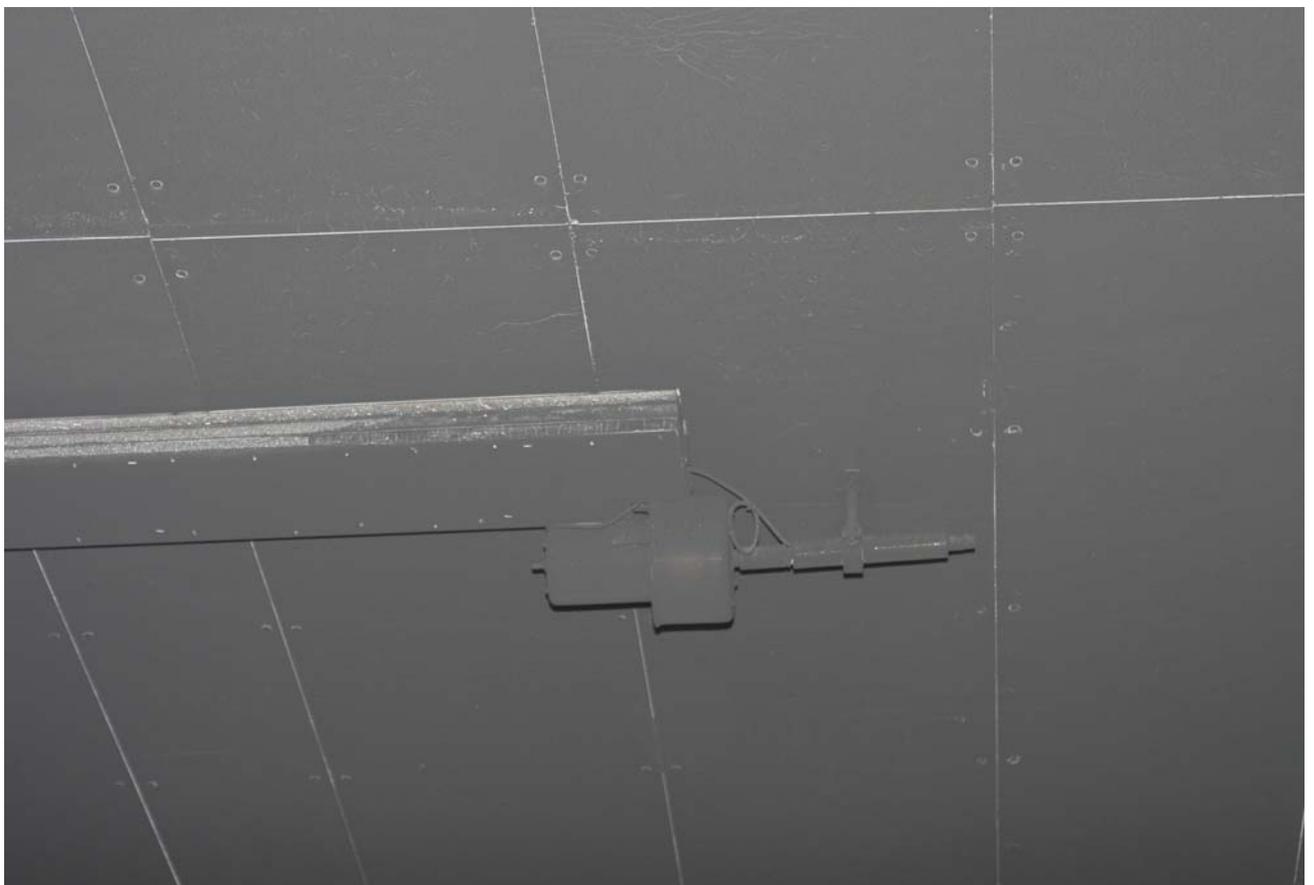
Picture 52: The flame stops of the smoke extracting station #05 remained undamaged.



Picture 53: The loud speaker's shell was made of plastic and fixed to the wall near the ceiling where it rapidly melted in the hot smoke layer.



Picture 54: The illuminated SOS-signal has been installed at the tunnel wall, about 2.5 m above the emergency walkway. So it has been outside of the smoke layer and remained unharmed and clean.



Picture 55: The photo-meter has been installed at the ceiling to detect and activate an early pre-alert in case of fire. So it has been inside of the smoke layer where it was blackened but still well functioning.



Picture 56: After the test, there was a blackened 1 m high strip to be seen on the northern wall next to the ceiling, extending over 100 m from the smoke extracting station #05 to the next one. During the fire alarm the jet fans in the western division operated in reverse mode without contact to the smoke. However, a small fraction of smoke circulated in the fan niche along the ceiling above the jet fan.



Picture 57: After the test, there was a blackened 1 m high strip to be seen on the southern wall next to the ceiling, extending over 100 m from the smoke extracting station #05 to the next one. The accurate border line of the black soot gave proof of the precise flow of the smoke layer during the entire test. The same traces from the stratification could be seen at the smoke extracting station #06 after the test.