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REPORT

Temperature and Smoke Gas Measurements During Tunnel Fire Extinguishing Tests in Åkrafjorden, Norway, 8 and 9 October 1997.

SINTEF Energy
Norwegian Fire Research Laboratory

October 1997

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SINTEF REPORT

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Temperature and Smoke Gas Measurements During Tunnel Fire Extinguishing Tests in Åkrafjorden, Norway, 8 and 9 October 1997.

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ABSTRACT

On request from LUX Brannteknologi AS, SINTEF Energy - Norwegian Fire Research Laboratory has performed measurement of temperatures and gas concentrations during fire extinguishment tests in a road tunnel in Åkrafjorden, Norway.

A total of 6 extinguishment tests were performed during October 8th and 9th 1997, by use of IFEX backpack units, fixed cannons and dual cannons mounted on a Hummer vehicle.

Four tests were performed with pool fires inside the tunnel, one test with two burning vehicles inside the tunnel, and one test with burning car tires outside the tunnel.

This report presents the temperatures and smoke gas concentrations measured during the tests with pool fires and burning vehicles. No measurements were made during the test with burning car tires.

All planning of the test series, including selection of fire scenarios, was performed by LUX Brannteknologi AS and IFEX GmbH.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	FIRE	BRANN
GROUP 2	EXTINGUISHMENT	SLOKKING
SELECTED BY AUTHOR	WATER MIST	VANNTÅKE
	EXPERIMENT	FORSØK

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1. INTRODUCTION

On request from LUX Brannteknologi AS, SINTEF Energy - Norwegian Fire Research Laboratory has performed measurement of temperatures and gas concentrations during fire extinguishment tests in a road tunnel in Åkrafjorden, Norway.

A total of 6 extinguishment tests were performed during October 8th and 9th 1997, by use of IFEX backpack units, fixed cannons and dual cannons mounted on a Hummer vehicle.

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This report presents the temperatures and smoke gas concentrations measured during the tests with pool fires and burning vehicles. No measurements were made during the test with burning car tires.

All planning of the tests, including selection of fire scenarios, was performed by LUX Brannteknologi AS and IFEX GmbH.

The measured temperatures and concentrations of O_2 and CO are presented as time curves in Appendix B.

2. TEST SET-UP AND INSTRUMENTATION

2.1 Test Set-up

The tests were performed inside a tunnel of app. 260 m length, app. 6 m base width, centre height of app 6 meters, and app. 3-4% inclination. The fires were located centrally inside the tunnel with an approximately equal distance to both openings and side-walls. Two fixed water cannons were located approximately 15 meter upwards and downwards the tunnel on each side of the pool (see Figure A.2 in Appendix A).

The test set-up with main dimensions and location of pool-fires and measuring points is shown schematically in Figure A.1 and A.2 in Appendix A. Approximate location of fixed water cannons, pool trays and cars for the car fire scenario, is shown schematically in Figure A.2.

2.2 Instrumentation

2.2.1 Temperatures

At start of the test series the vicinity of the fire was instrumented by five thermocouple racks extending down from the ceiling along the vertical centreline of the tunnel. Two thermocouples located right above the fire (Rack 3), four thermocouples upwards 10 metres from the fire (Rack 4), four thermocouples downwards 10 metres from the fire, five thermocouples 20 metres upwards (Rack5) and two thermocouples 20 metres downwards from the fire.

From test 02 and on, for fire scenarios involving pool fires, an additional thermocouple was located approximately 10 cm above the pool surface to indicate the state of ignition of the fire. In the car fire test (Test 06) this thermocouple was located on the drivers seat inside car 2 (see figure A.2 in Appendix.2) which was ignited first.

2.2.2 O_2 and CO concentrations

The oxygen and carbonmonoxide concentration was measured in one point 10 m upwards from the fire and 2 m above floor level corresponding to the position of thermocouple T42 on Rack4 (See figure A.1 and A.2).

From this measured value, the distribution of O_2 and CO has been calculated from the temperature distribution by assuming adiabatic conditions for the spreading of smoke gases from the fire.

For the areas close to the fire, this will represent a relatively rough estimate of the gas concentrations.

In addition to this, the reader should be aware of the transient and dimensional characteristics of the scenario. I.e. the relatively large distance between measuring points compared to the smoke spread velocity, will give variations in time scale which explains the difference in response time between measured temperatures and smoke gas concentrations.

3. TEST 01, 1.5 x 1.5 m Pool Fire

3.1 TEST 01, Characteristics

Fire type:	Pool Fire
Fire size:	1,5 x 1,5 m (2.25 m^2) quadratic.
Fuel:	60 litres diesel and 4 litres gasoline.
Pre-burn time:	App. 6 minutes.
Ext. System:	Four fixed water cannons. Two on the upper side of the pool and two on the lower side at a distance from the pool of 15 m for the first cannon and 30 m for the second. (Figure A.2 in Appendix A schematically shows position of water cannons).

3.2 TEST 01, Visual Observations

From outside the tunnel the fire seemed to be extinguished by the second shot of water (48 litres). Videorecordings performed by a camera located inside the tunnel, indicated extinguishment after the first shot (24 litres).

3.3 TEST 01, Temperatures and Smoke Gas Concentrations

Measured temperatures and smoke gas concentrations are given by time curves in Section B.1 in Appendix B.

4. TEST 02, 1.5 x 1.5 m Square Pool + 3 x 0.5 m^{Ø} Circular Pools

4.1 TEST 02, Characteristics

Fire type:	Pool Fires
Fire size:	1,5 x 1,5 m (2.25 m^2) quadratic pool. 3 x app. 0,5 m diameter (app. 0.6 m^2) circular pools.
Fuel:	120 litres diesel and 15 litres gasoline.
Pre-burn time:	App. 7 minutes.
Ext. System:	Water cannons mounted on Hummer vehicle for initial attack to get temperature down and final extinguishment by hand held impulse gun.

4.2 TEST 02, Visual Observations

Initially 5 x two shots (app. total 120 l water) with cannons on Hummer Vehicle before final extinguishment of residual fire in pools by 3 shots (app. total 3 l water) from hand held impulse gun.

4.3 TEST 02, Temperatures and Smoke Gas Concentrations

Measured temperatures and smoke gas concentrations are given by time curves in Section B.2 in Appendix B.

5. TEST 03, 1.5 x 1.5 m Pool Fire

5.1 TEST 03, Characteristics

Fire type:	Pool Fire
Fire size:	1,5 x 1,5 m (2.25 m^2) quadratic pool.
Fuel:	60 litres diesel and 4 litres gasoline.
Pre-burn time:	App. 6 minutes.
Ext. System:	Water cannons mounted on Hummer vehicle for initial attack to get temperature down and final extinguishment by hand held impulse gun with 1% AFFF.

5.2 TEST 03, Visual Observations

Initially 5 x two shots (app. total 120 l water) with cannons on Hummer Vehicle before final extinguishment of residual fire by 1 shot (app. total 1 l water with 1% AFFF) from hand held impulse gun.

5.3 TEST 03, Temperatures and Smoke Gas Concentrations

Measured temperatures and smoke gas concentrations are given by time curves in Section B.3 in Appendix B.

6. TEST 04, 1.5 x 1.5 m Pool Fire

6.1 TEST 04, Characteristics

Fire type:	Pool Fire
Fire size:	1,5 x 1,5 m (2.25 m^2) quadratic.
Fuel:	60 litres diesel and 4 litres gasoline.
Pre-burn time:	App. 6 minutes.
Ext. System:	Four fixed water cannons. Two on the upper side of the pool and two on the lower side at a distance from the pool of 15 m for the first cannon and 30 m for the second. (Figure A.2 in Appendix A schematically shows position of water cannons).

6.2 TEST 04, Visual Observations

5 shots by fixed cannons without extinguishment. Cannon fixings loosened after one of the first shots resulting in arbitrary direction of shots to walls and ceiling. Fire finally extinguished manually by hand held impulse gun.

6.3 TEST 04, Temperatures and Smoke Gas Concentrations

Measured temperatures and smoke gas concentrations are given by time curves in Section B.4 in Appendix B.

7. TEST 05, Fire in Rubber Tyres

7.1 TEST 05, Characteristics

Fire type:	Fire in passenger car tyres.
Fire size:	-
Fuel:	5 standard rubber tyres
Pre-burn time:	App. 6 minutes.
Ext. System:	Hand held impulse gun.

7.2 TEST 05, Visual Observations

Fire was extinguished with 5 shots from hand held impulse gun.

7.3 TEST 05, Temperatures and Smoke Gas Concentrations

Demo-test without instrumentation or measurements.

TEST 06, Car Fire

7.4 TEST 06, Characteristics

Fire type:	Car Fire
Fire size:	-
Fuel:	One passenger car and one van. See figure A.2 in Appendix A for location of cars.
Pre-burn time:	App. 6 minutes.
Ext. System:	Dual water cannons mounted on Hummer vehicle for initial attack to get temperature down and final extinguishment by hand held impulse gun.

7.5 TEST 06, Observations

Number of shots to extinguishment was not recorded in this test.

7.6 TEST 06, Temperatures and Smoke Gas Concentrations

Measured temperatures and smoke gas concentrations are given by time curves in Section A.5 in Appendix 1.

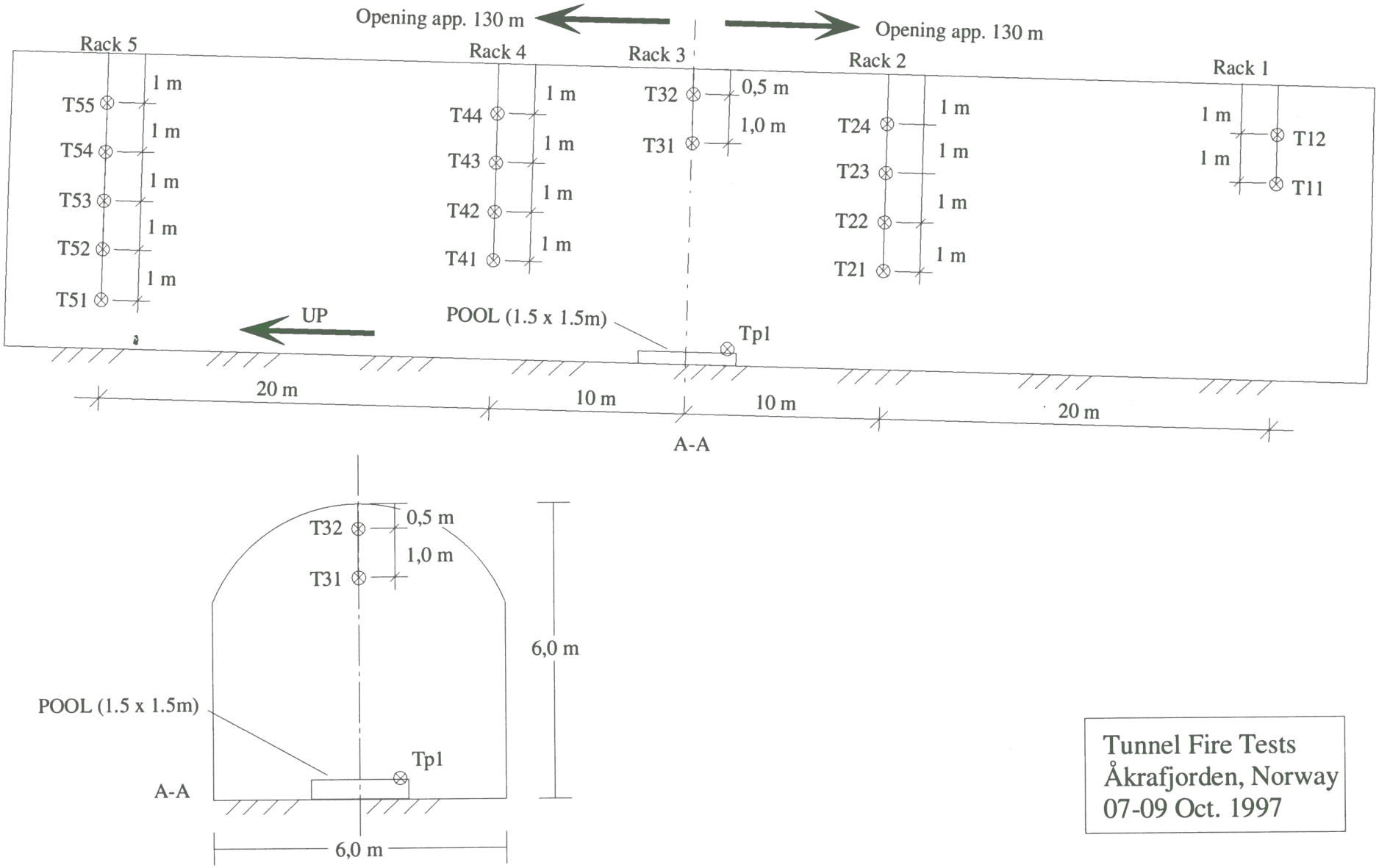

Figure A. 1 Lay-out and positions of Instrumentation and test set-up. Longitudinal and crossectional view.

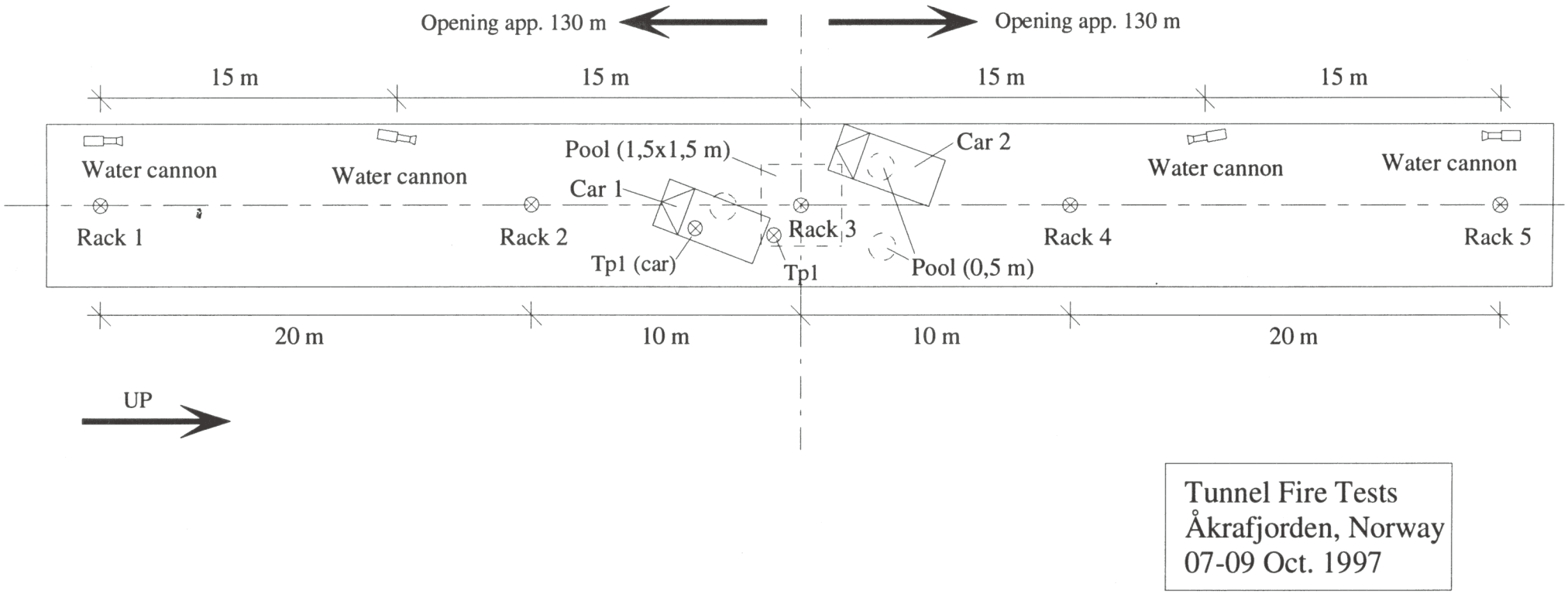

Figure A. 2 Lay out and positions of instrumentation and test set-up. View from above.

B.1 TEST 01, 1.5 x 1.5 m Pool Fire

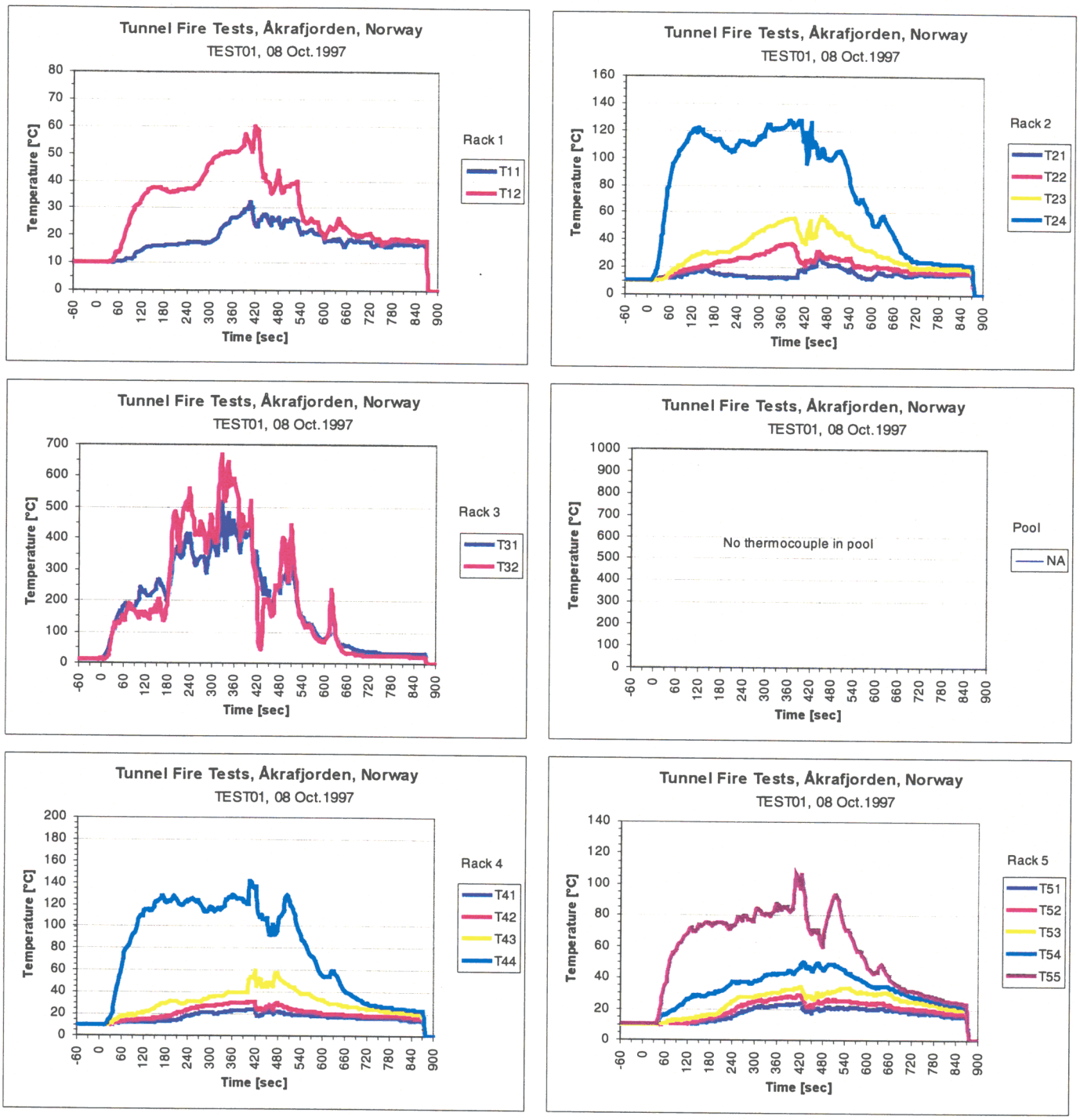

Figure B. 1 TEST 01, Temperatures

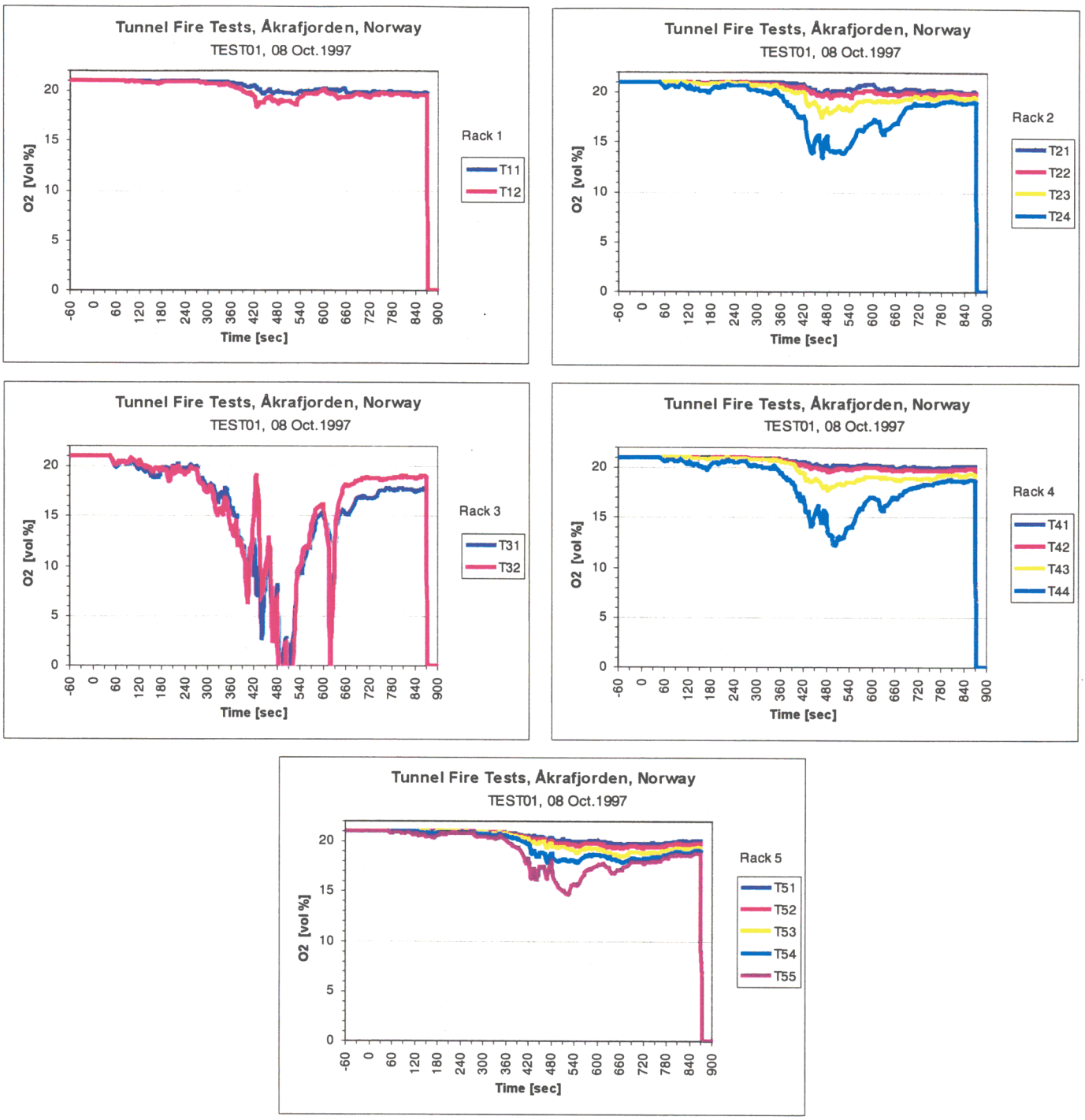

Figure B. 2 TEST 01, O_2 - concentrations

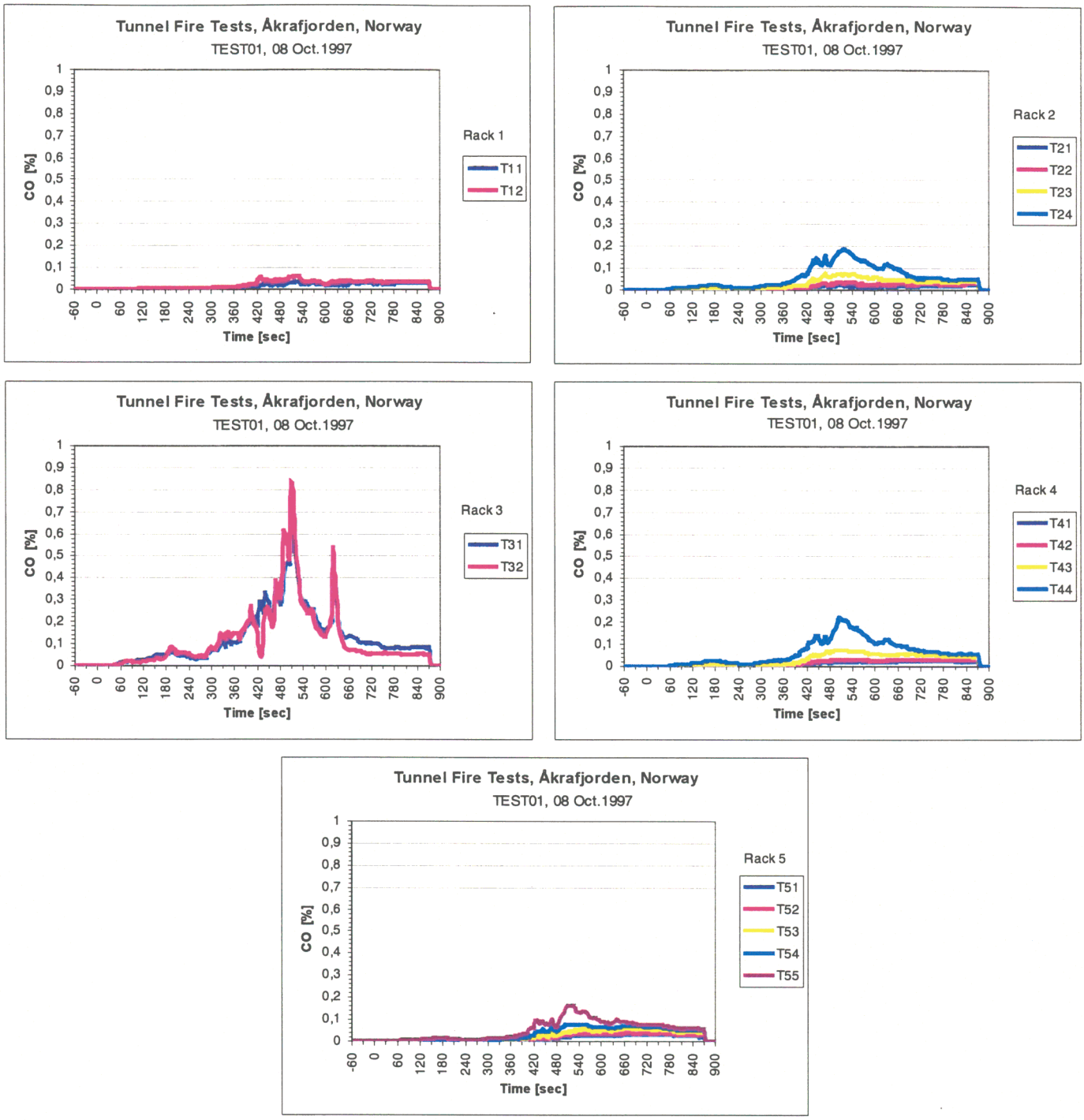

Figure B. 3 TEST 01, CO - concentrations

B.2 TEST 02, 1.5 x 1.5 m Square Pool + 3 x 0.5 m^{Ø} Circular Pools

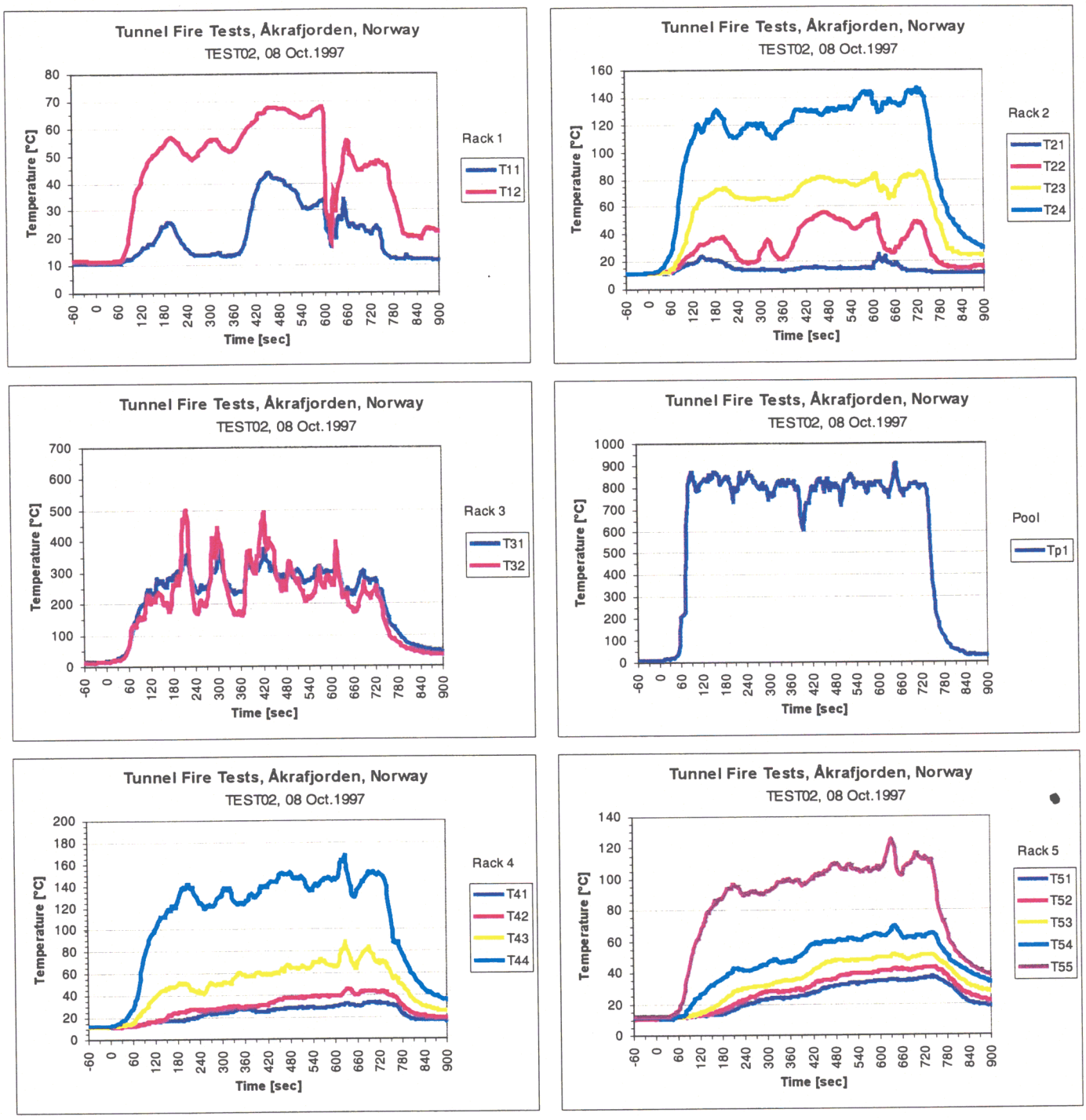

Figure B. 4 TEST 02, Temperatures

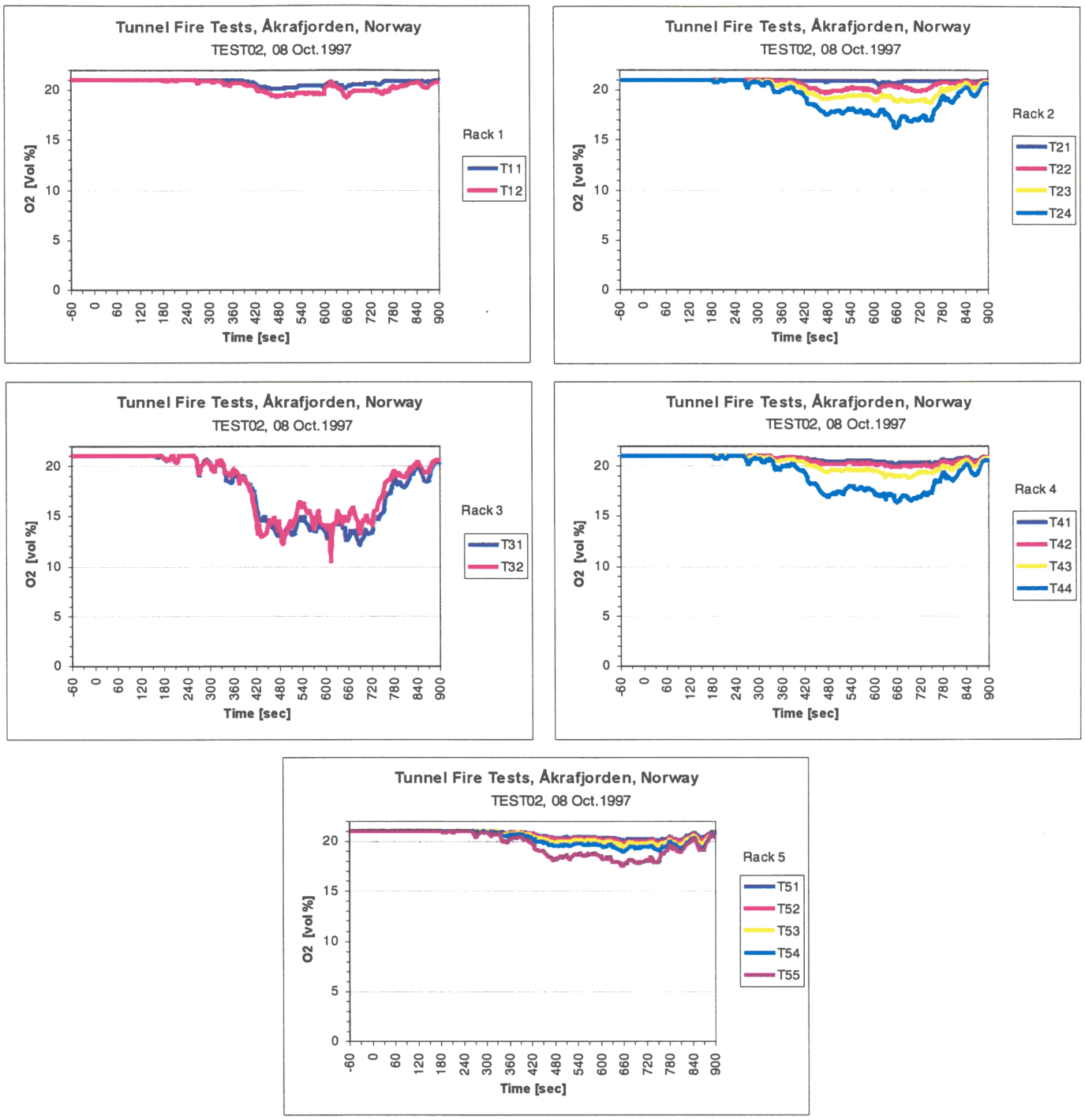

Figure B. 5 TEST 02, O_2 - concentrations

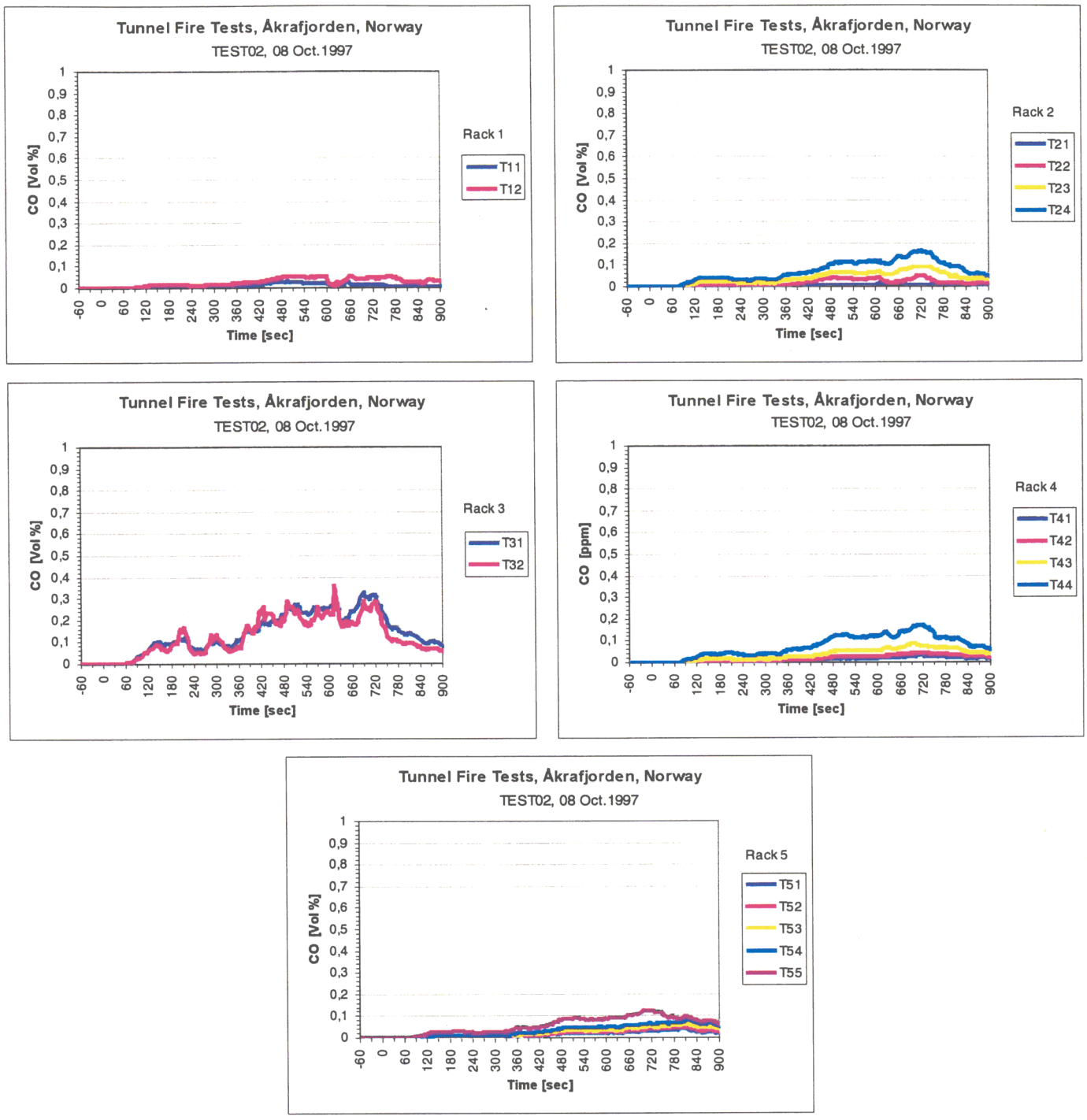

Figure B. 6 TEST 02, CO - concentrations

B.3 TEST 03, 1.5 x 1.5 m Pool Fire

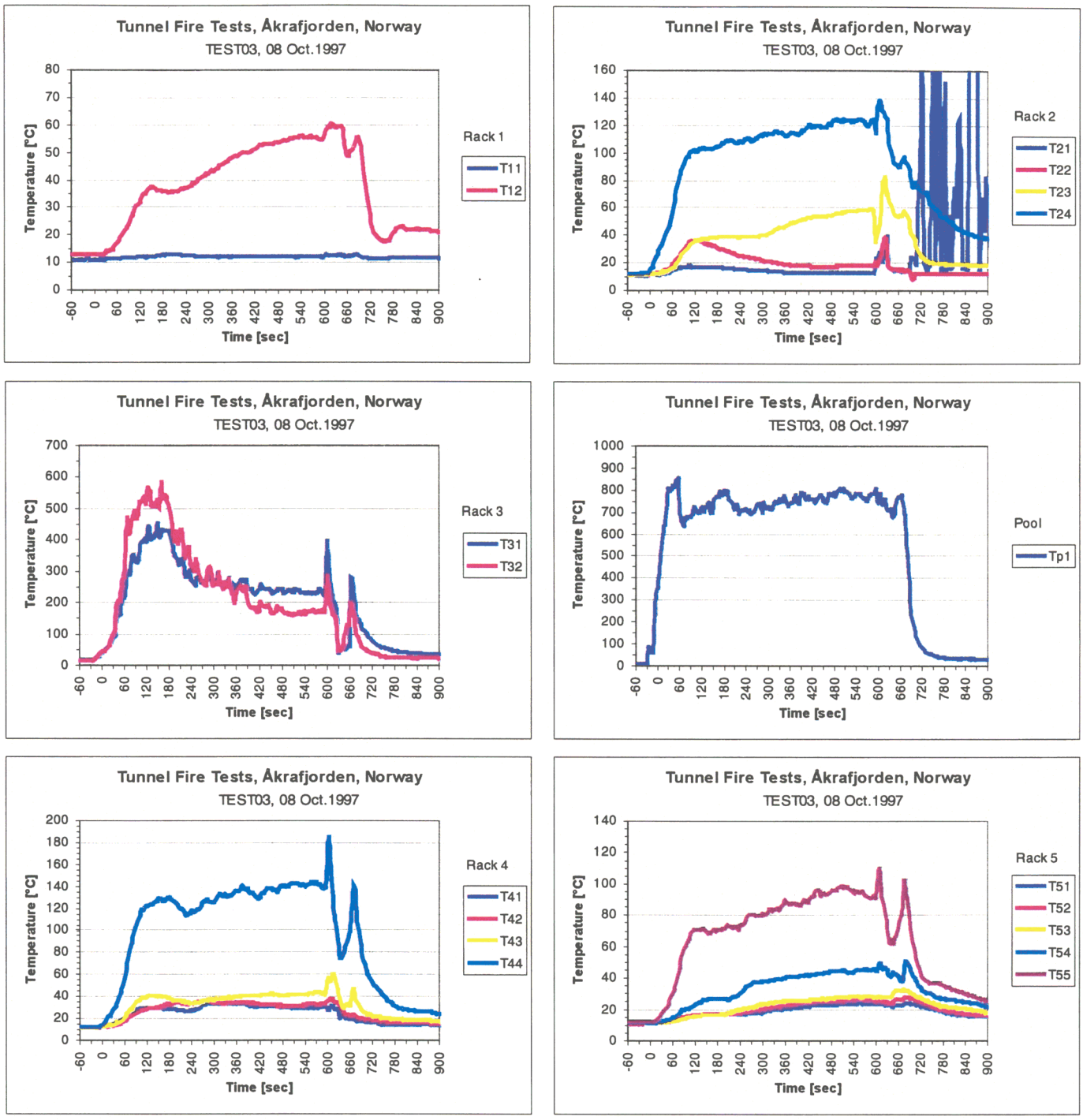

Figure B. 7 TEST 03, Temperatures

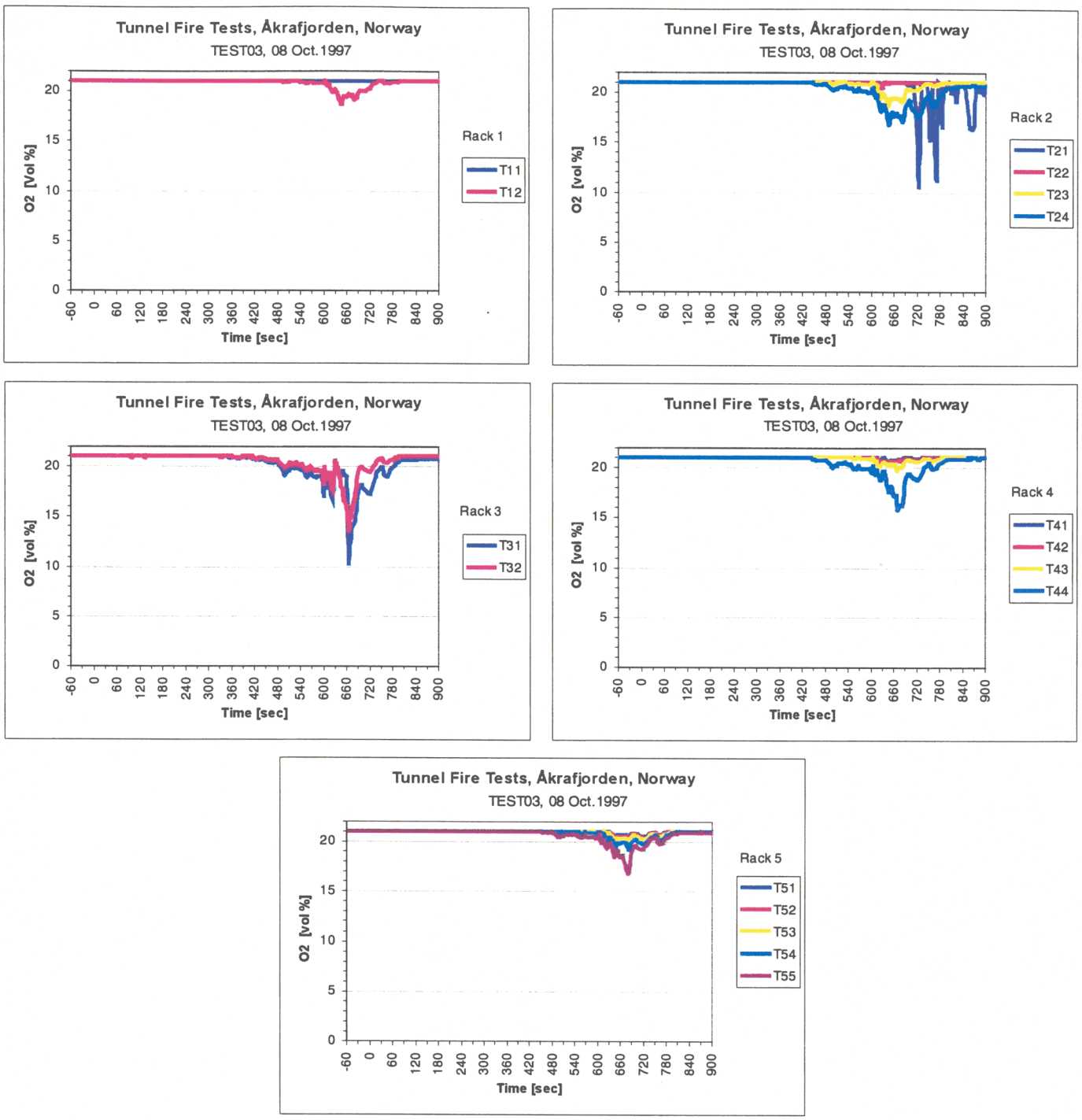

Figure B. 8 TEST 03, O_2 - concentrations

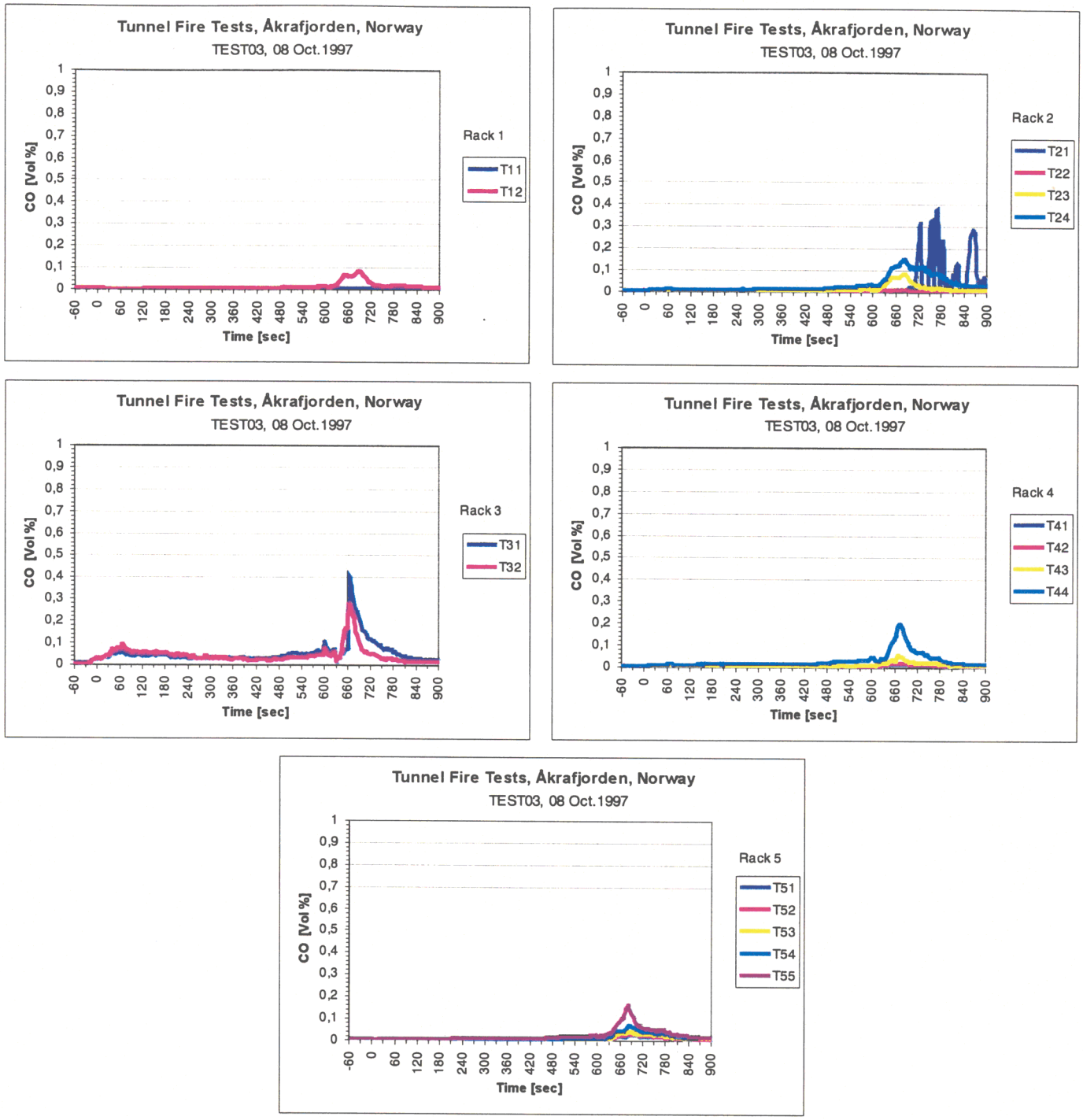

Figure B. 9 TEST 03, CO - concentrations

B.4 TEST 04, 1.5 x 1.5 m Pool Fire

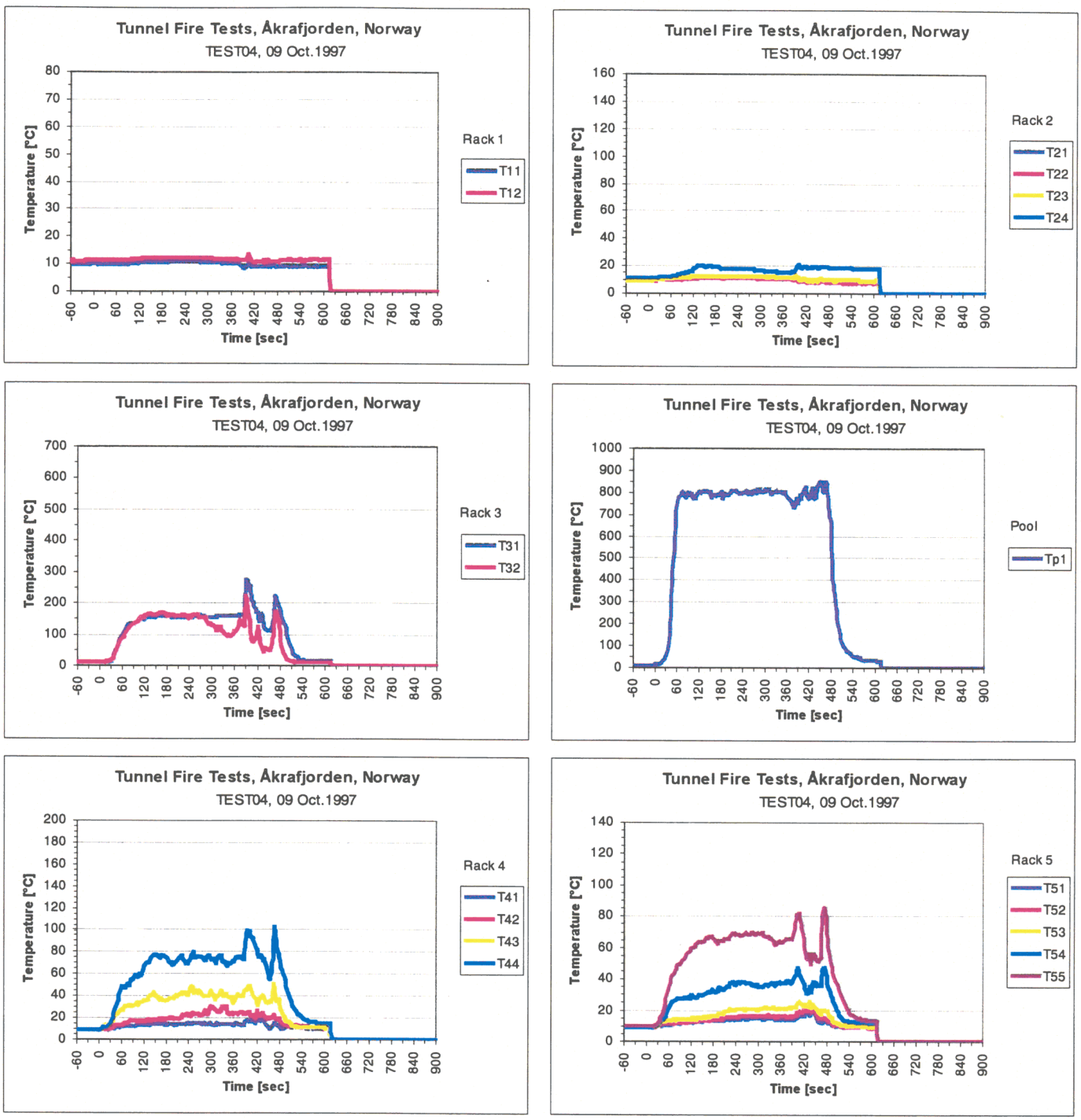

Figure B. 10 TEST 04, Temperatures

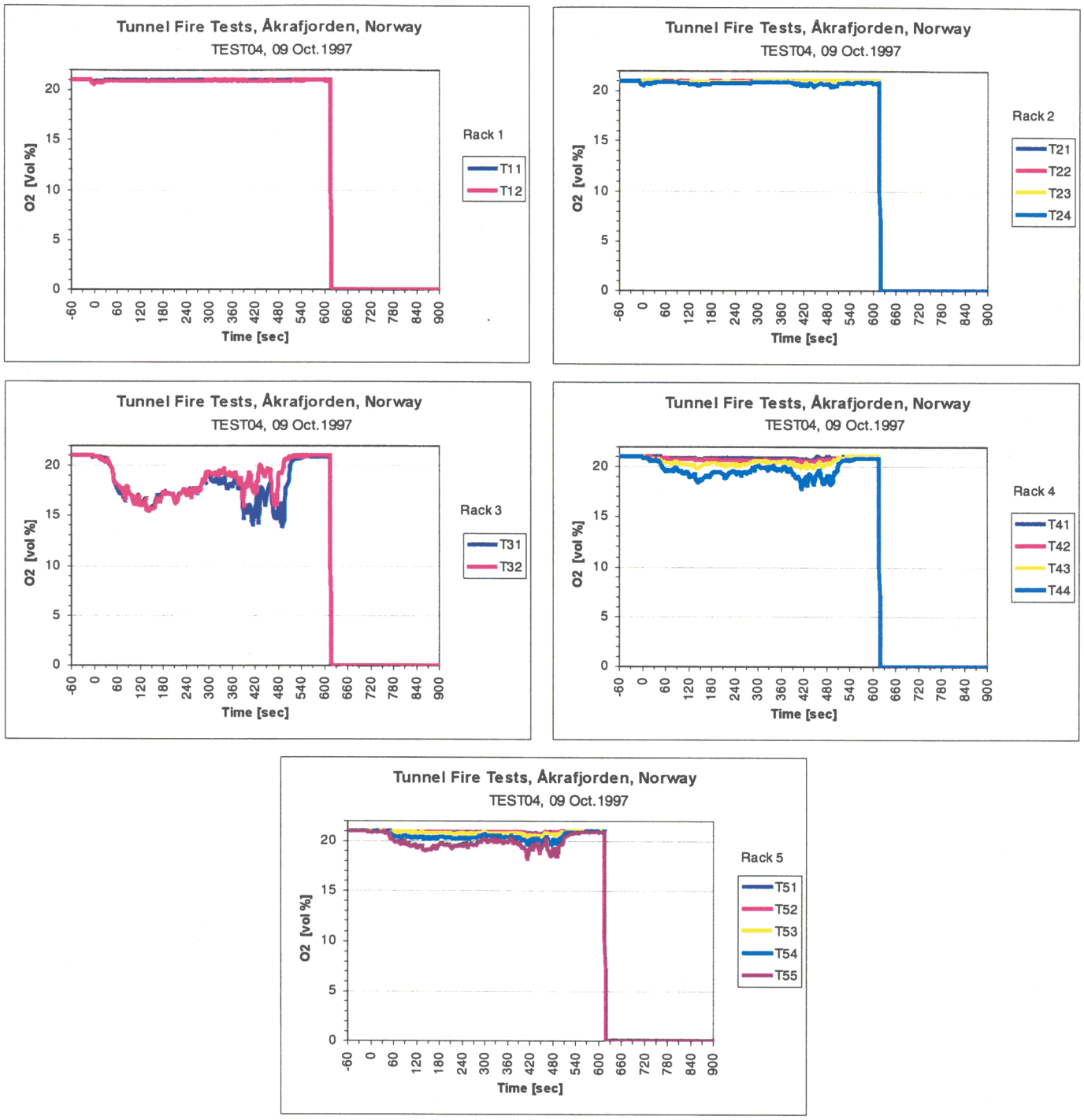

Figure B. 11 TEST 04, O_2 - concentrations

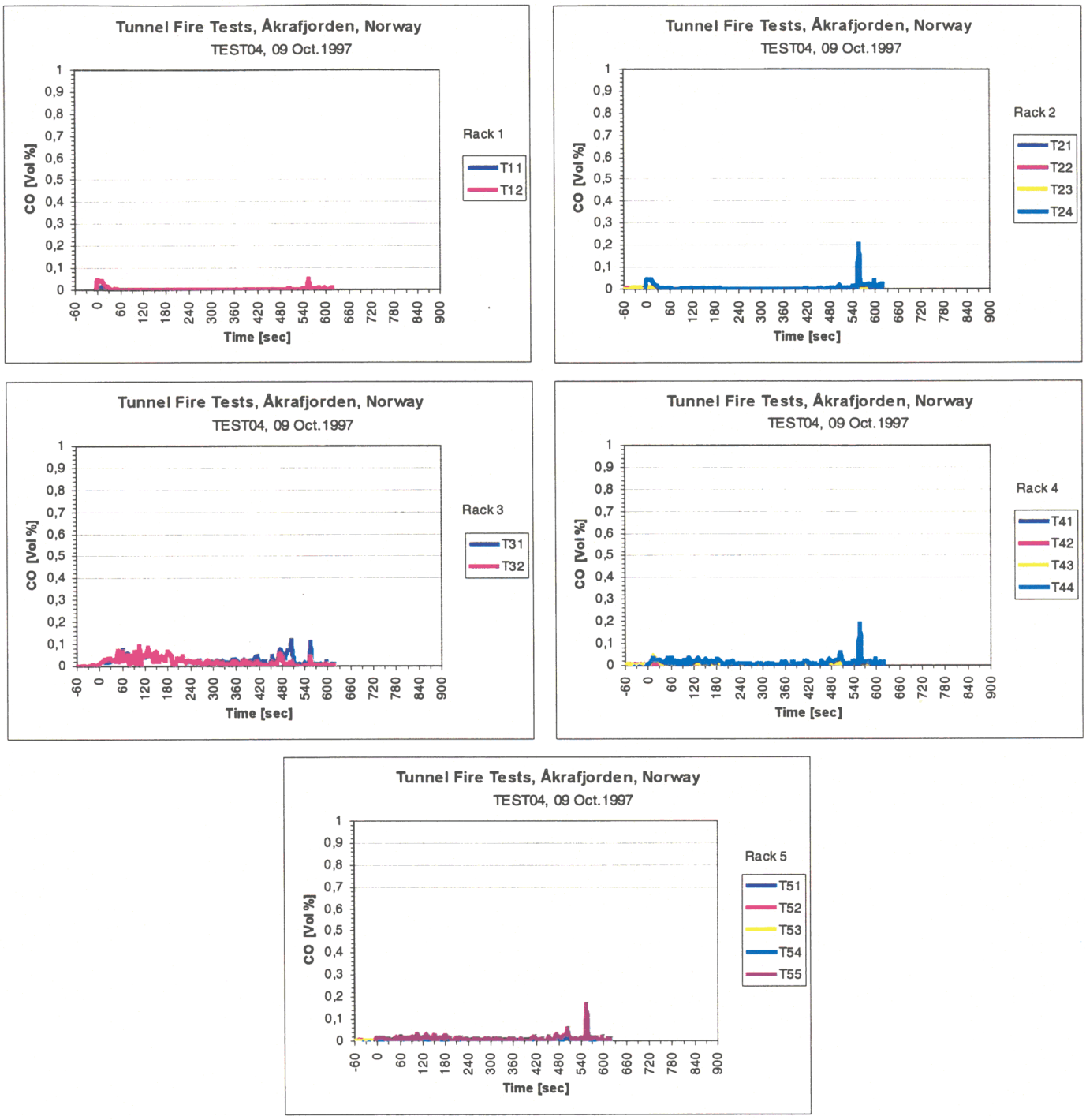

Figure B. 12 TEST 04, CO – concentrations

B.6 TEST 06, Car Fire

Please note that CO – measurements were corrupted in this test.

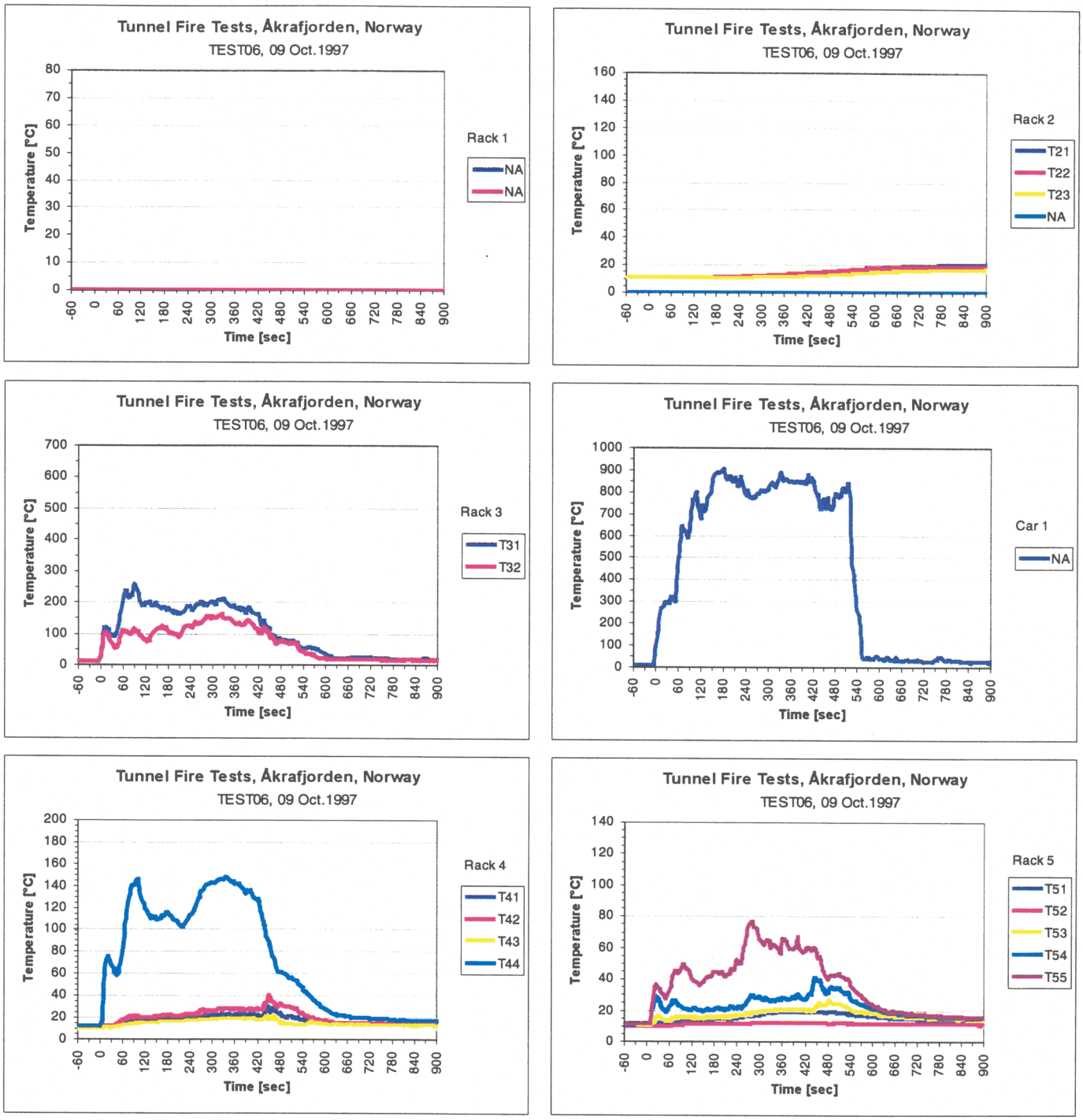

Figure B. 13 TEST 06, Temperatures

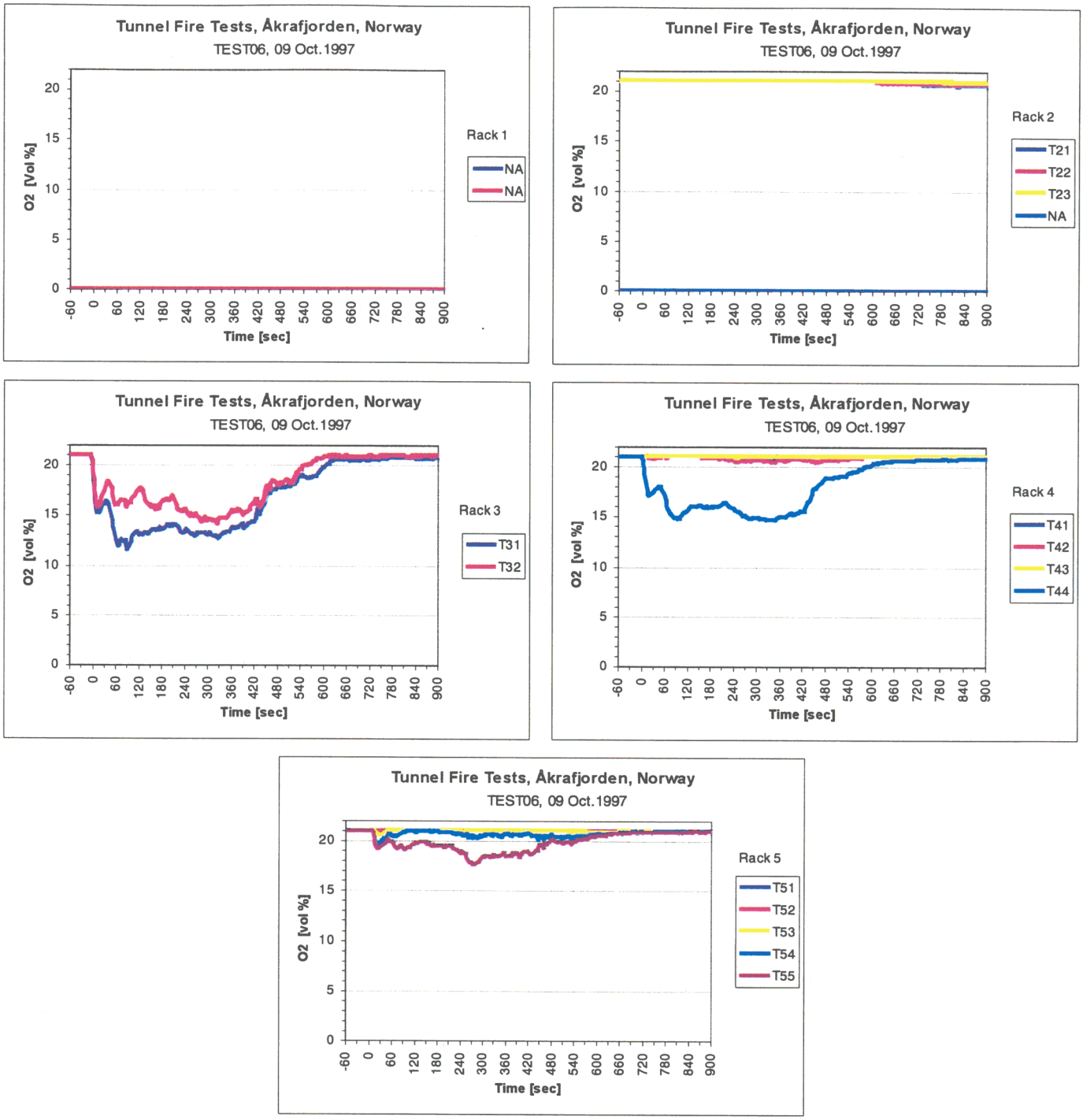

Figure B. 14 TEST 06, O_2 - concentrations