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MIS - TUNNEL TEMPERATURE TESTS

REPORT FOR OPERATIONS

PART I

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MIS - TUNNEL TEMPERATURE TESTS

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MTS - TUNNEL TEMPERATURE TESTS

PART I

1. Introduction

The tunnel temperature tests were carried out between 21st June 1979 and 29th June 1979 and consisted of eighteen separate tests including three repeats.

The basis of the tests were laid down by MTRC Operations Division in February 1979. A working group was set up in March 1979 consisting of MTRC staff and consultants from Parsons Brinckerhoff (Asia), Kennedy and Donkin International and Hong Kong Polytechnic.

The shape of the tests was gradually refined and the necessary equipment bought or hired in the intervening three and a half months. A six car test train was equipped with heating and recording equipment and loaded with weights. A test site in a tunnel was chosen and also equipped with recording equipment. Vacation students were hired and trained to man the equipment.

This report details the tests and equipment and also draws conclusions from the results of the tests. The conclusions hopefully will give Operations Division some practical information on conditions to be expected during operations with crowded trains and in particular where intolerable conditions may be met.

2. Test Train

It was agreed by the Working Group and Operations that a six car unit should be used as a test train. This was to ensure that all likely conditions relative to the operation of the MTS were obtained at this stage.

Because of the non-availability of type B cars, the six car unit was made up of a standard four car unit (cars 1-4) plus a two car unit (cars 5, 6) and the car arrangement from the front to the back was A-C-C-A-C-A. The open end of the C car of the two car unit was blanked off with a plywood panel.

Additional wiring between the two sections of the train was installed to allow the train to be driven from either front or rear cab.

Most of the grabpoles throughout the train were removed to create space for boxes of weights and plywood was laid on the floor as a protective measure.

3. Test Train Heating System

The basic heating system in each car was as shown in Figure A. Full details of the equipment is given in the Appendix.

Basically the heating equipment was designed to simulate the conditions on a train filled to a capacity load of 375 people and at 25°C with 65% relative humidity. This was calculated to be equivalent to a sensible heat load of 26.25kW and a latent heat load of 22.50kW per car, giving a total of 48.75kW per car.

70w/p
60w/p

Initially to produce these amounts of sensible and latent heat, six gas water boilers and four gas heaters were installed per car. Tests 1A, 1B, 2 and 3A were run with this arrangement but it was found that it could only produce the equivalent heat output of 300 people per car. Another gas heater was installed per car and the system was then balanced to produce the required equivalent heat output of 375 people per car for all the other tests. The actual measured heat output for these tests was a sensible heat output of 23.9kW per car and a latent heat output of 24.9kW per car. Thus the total heat output was correct and the split of latent heat and sensible heat (almost 50-50) was close to the split that occurs at the temperatures realised for most of the tests, that is, 29-30°C.

The heating equipment plus the safety devices were supplied and installed by the Hong Kong L.P. Gas Company under MTRC supervision. The water boilers were calibrated by the Hong Kong Polytechnic.

The water consumption and gas consumption for the heating system in each car was monitored and recorded on heater/boiler log sheet. This is shown in Figure F.

4. Air Temperature and Air Velocity Recording

The method of measuring air temperature and air velocity was a problem tackled by the Hong Kong Polytechnic for the MTRC with a team led by Mr. F. Mak of the Mechanical and Marine Engineering Department and Dr. H. MacAlpine of the Electrical Engineering Department.

A temperature sensor was developed that could read to ±1°C in a 20-60°C range with a response time of less than 2 seconds. Each sensor had its own power and transducer unit. Twenty sensors were supplied.

A hot wire anemometer was also developed to measure air velocity in the tunnel and this was linked to a pen recorder.

Reports on the work are included in the Appendix to this report.

The temperature recording systems were as follows:-

A. Air Temperatures within the Train

The wet and dry bulb temperatures inside each car were measured on portable psychrometers with built-in battery driven fans. There was one psychrometer per car, i.e. a total of six instruments. The wet bulb and dry bulb temperatures were recorded on a log sheet. See Figure E.

B. Air Temperatures on the Outside of the Train

A group of five thermistors with individual power supplies were placed in an array around the centre of the first car and at two points down the train. These seven sensors were corrected by co-axial cable to a twelve channel U/V recorder (UV1) placed in the first car at the control centre.

C. "Air On" and "Air Off" Temperatures at the Air-Conditioners

A group of nine thermistor sensors with individual power supplies were used to measure temperatures at the condensers of certain air-conditioning units on the test train. These nine sensors were connected by co-axial cable to a twelve channel U/V recorder (UV2) placed in the first car at the control centre.

D. Air Temperatures, Wall Temperature and Air Velocity in the Tunnel

A group of five thermistor sensors with individual power supplies were placed in the tunnel spaced around the test point, four to read air temperatures and one to read wall temperature (stuck to the wall with epoxy adhesive). These five sensors were connected by co-axial cable to a twelve channel U/V recorder (UV3) placed in the tunnel sump at the test point.

A hot wire anemometer was also positioned to read air velocity and connected to a single pen recorder also placed in the tunnel sump at the test point.

The layout of the sensors is shown in Figure B and a block diagram of the recording system is given in Figure C.

Details of the recording equipment are given in the Appendix in Part II.

5. Definition of Environmental Conditions

A psychrometric chart shown in Figure D was used to define the conditions during tests. The three conditions defined are : intolerable (or dangerous), tolerable (or very uncomfortable) and comfortable. In most cases, dangerous or intolerable conditions are reached when the wet bulb temperature is greater than 31°C and this temperature was used as a danger level criterion by the test team on board the test train.

6. Recording of Air-Conditioner Operating Status

The air-conditioners on the six car test train were numbered from the front of the train in sequence i.e. 1-12 with 1 and 2 for the first car, 3 and 4 for the second car and so on.

The operating status of each air-conditioner was monitored at a remote panel by three indicator lamps : green, yellow and red. The status of each of the air-conditioners was followed by recording changes in the indicator lamps lit. The definition of status A-E is as shown below. The most important conditions were status D (unloaded condition due to high refrigerant pressure) and status E (overload cut-out).

STATUS		DETAIL	GREEN	YELLOW	RED
A	Condenser 1st stage cooling	Return air temperature 25°C	*	*	*
B	Condenser 2nd stage cooling	Return air temperature 25.5°C	ON	*	*
C	Light Load	Compressor unloads 2 cylinders	ON	ON	*
D	Overload	Compressor unloads. Condenser pressure $26.7 kg/cm^2 \equiv 46^\circ C$	*	ON	*
E	Overload cut-out	Compressor trips. Condenser pressure $28 kg/cm^2 \equiv 56^\circ C$	ON	ON	ON

The train air-conditioning log sheet is shown in Figure G.

7. Air-Conditioner Unit No. 2

It was found that A/C unit no. 2 had an irregular performance throughout the tests in that it would sometimes trip when there was a change of air flow or air pressure. After the tests it was found that the unit had a leaking air pipe which meant the inlet air damper was performing incorrectly and would be affected by outside air pressure.

During any test where A/C unit no. 2 tripped, this was noted and the effect on car no. 1 particularly watched. It was useful in many cases to see the result of having only one A/C unit working in a car and comparing it to a car where both A/C units were working correctly.

8. Loading of Test Train with Weights

The equivalent weight of 375 people was estimated to be 20 tonnes. Wooden crates full of track ballast each weighing 2,800 lbs (or 1.27 tonnes) were loaded on to the train by fork lift truck and manoeuvred with a trolley into position. Sixteen were loaded on to each car except car 1 where fifteen only were placed to allow room for test equipment and personnel at the control centre adjacent to the front cab.

This loading ensured that the correct heat output from the train's brakes and traction motors was realised when the train was run prior to a test.

9. Acceleration/Braking Runs

The heating up of the brake resistors and traction motors was achieved by a acceleration/braking run (generally from Diamond Hill Station) immediately prior to a test. The train operator was instructed to accelerate up to 50-55 kph as quickly as possible and then to brake as hard as he could to about 5 kph. This was repeated as often as possible up to Lok Fu Station. At Lok Fu Station the final braking stop took place at the down end of the station. If a stop was required at the test point the train was then put into ATO (for an automatic stop at the ATO marker) and the train restarted as quickly as possible to retain as much heat as possible for the test.

10. Test Site

The test site was located on the down track between Lok Fu and Kowloon Tong. This site made use of the Line sump at chainage 300 m from Kowloon Tong and the U/V recorder (UV3) and pen recorder for the tunnel temperature and air velocity measurements were located there. There was reasonable room for two test personnel and a safety officer to be stationed there. Lights and a power supply point were provided.

An ATO marker developed by D. Mott of Kennedy and Donkin was inserted into the signalling equipment at Kowloon Tong to produce an automatic stop of the test train at 30 metres from the line sump. This ATO marker is described in the Appendix.

11. Test Control Centre and Communications

The control centre for the tests was located in car 1 adjacent to the driver's cab. At this point the recorders UV1 and UV2 and the air conditioner status lamps were located. A CO monitoring device was also placed on the floor at this location.

All the tests were co-ordinated at this point by the Test Director (the author) who had a master clock and access to the train's public address system in the cab.

Communication to System Control was via the train radio. The rac was also used to convey messages to the test personnel in the line sump in the tunnel.

The train's horn was used to signal to the personnel in the tunnel as follows :

3 blasts : Train leaving Lok Fu Station
1 blast : Train stopped at test point

12. Test Personnel

The following was the list of people involved in running the tests :

ON THE TRAIN :-	No.	Code
Test Director	1	TD
Test Adviser/Helper	1	TA
Temperature/Humidity Technician	6	TH1-TH6
Heater/Boiler Technician	6	HB1-HB6
U/V Recorder Technician	2	UV1, UV2
Air Conditioner Status Observer	1	
Safety Officer (Operations)	1	
Train Driver	2	
IN THE TUNNEL :-		
U/V Recorder Technician	1	UV3
Pen Recorder Technician	1	PR1
Safety Officer (Operations)	1	
IN SYSTEM CONTROL :-		
Test Co-ordinator	1	

13. Programme

The full programme for the tests was as follows :

Day	Date	Test	Time	Duration
Thursday	21/6	1A*	14.02 - 15.02	1 hr
		1B*	15.52 - 16.37	45 min
Friday	22/6	3B*	12.04 - 12.25	21 min
		2*	14.05 - 15.34	1 hr 29 min
Monday	25/6	1AR	14.05 - 15.05	1 hr
		2R	16.01 - 16.26	25 min
Tuesday	26/6	3A	11.52 - 12.17	25 min
		3BR	12.57 - 13.22	25 min
		7A	15.41 - 15.47	6 min
		7B	16.20 - 16.25	5 min

Day	Date	Test	Time	Duration
Wednesday	27/6	4A	12.08 - 12.13	5 min
		4B	12.45 - 12.54	9 min
		4C	14.16 - 14.25	9 min
		4D	14.50 - 14.55	5 min
		9	15.31 - 16.12	41 min
Thursday	28/6	6	11.35 - 12.15	40 min
Friday	29/6	5	12.54 - 13.05	41 min
		8	14.59 - 15.01	2 min

Notes

1. The "duration of the test refers only to time in test area or at test point. Does not include "run-in" time. Data recording time was always longer than this.

2* Indicates a test where the heating load was equivalent to 300 people/car. All other tests were carried out with a heating load equivalent to 375 people/car.

3. The R refers to a repeat test.

14. Test Descriptions and Results

Test 1A - Single Impulse Fan Operation Check

To investigate environmental conditions within and around a train brought to a stop in a tunnel under normal circumstances.

General Description

The test train underwent several run-stop cycles from DIH before stopping at the tunnel.test site, in order to approximate the heat release of a loaded train which had been following a normal operating profile prior to the tunnel stop. Tunnel ventilation was activated by the signalling system as in actual service. The conditions were held for 1 hour.

The timing of the test was as follows : -

13.58	Started run from DIH
14.01	Depart LOF
14.02.16	Stop at test point
14.02.40	Impulse fan ON
15.02	End of test

Maximum Temperatures inside the Train

N.B. Heat output equivalent to 300 people per car.

Car	1	2	3	4	5	6
DB	28.3	29.2	30.0	28.9	27.6	28.0
WB	23.6	23.8	23.8	24.6	22.2	24.1
RH	68%	63%	61%	72%	62%	72%
Time	14.40	14.42	14.53	14.40	14.15	14.20

Observations

1. At 15.04 when the impulse fan was switched OFF, A/C no. 2 tripped on high pressure trip.

2. The environmental conditions inside all six cars remained within acceptable limits for the test.

3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 1AR - Single Impulse Fan Operation Check

Repeat test 1A with maximum heat load.

The timing of the test was as follows :-

14.00	Depart DIH
14.05.09	Depart LOF
14.05.50	Stop at test point
14.05	Impulse Fan ON
14.22	Reset AC2 - not fully reset at DIH
15.05	End of test
15.07	Impulse Fan OFF

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 375 people per car.

Car	1*	2	3	4	5	6
DB	36.2*	33.6	34.4	33.7	32.2	31.6
WB	28.9*	28.4	28.4	27.5	26.4	25.5
RH	[illegible]	[illegible]	63%	63%	62%	62%
Time	14.20*	15.00	15.00	14.55	15.05	14.33

* AC2 OFF for 25 minutes. At 14.55 - DB:30 WB:25.1 RH:66%

Observations

1. A/C unit No. 3 tripped when the impulse fan was switched OFF at 15.07.

2. A/C unit No. 2 was OFF for the first 25 minutes because of not being reset correctly after previous test.

3. Throughout the tests, the environmental conditions did not become intolerable as the wet bulb temperature remained low although the dry bulb rose to 33 - 34°C.

4. See Part II for sensor Temperature/Time and Air Velocity/Time results.

Test 1B - Double Impulse Fan Operation Check

As for test 1A, but to evaluate degree of improvement with the additional tunnel air flow provided by the second impulse fan.

General Description

As for test 1A, except CCS activated second impulse fan after the signalling system automatically activated first impulse fan. The conditions were held for 45 minutes.

The timing of the test was as follows :-

15.48	Started run from DIH
15.51.07	Departure from LOF
15.52.11	Stop at test point
15.52.41	First Impulse Fan ON
15.53.20	Second Impulse Fan ON
16.37	End of test

Maximum Temperatures inside the Train

N.B. Heat load equivalent to 300 people per car.

Car	1	2	3	4	5	6
DB	27.6	27.8	28.7	29.1	27.2	28.0
WB	22.4	23.0	23.4	24.4	22.2	22.4
RH	64%	65%	64%	68%	62%	62%
Time*	15.55	16.18	15.57	16.05	16.25	16.28

* Two peaks of temperature - (1) at 16.00 approx.
(2) at 16.25 approx.

Observations

1. The environmental conditions remained tolerable throughout.

2. All the A/C units performed satisfactorily.

3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 2 - Train Air-Conditioner Performance Check

To investigate environmental conditions within and around a train brought to a stop in a tunnel with no mechanical ventilation of the tunnel. Of particular interest is the performance of the train A/C equipment. Specific objectives in this respect are :-

a. To determine the time lapse between the train stop and cut-out of the first A/C unit.

b. To determine the rate at which subsequent A/C units cut-out and the consequent effect on train and tunnel environment.

c. As a consequence of a, to determine whether the time delay associated with automatic activation of tunnel ventilation plant is satisfactory or should be modified.

General Description

After run-stop warm-up cycles, test train was stopped at test site. CCS suppressed the automatic activation of tunnel ventilation plant. Train continued to dwell for a period of 90 minutes.

The timing of the test was as follows :-

14.00	Started run from DIH
14.04.26	Departure from LOF
14.05.20	Stop at test point
14.52	End of test

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 300 people per car.

Car	1	2	3	4	5*	6*
DB	36.6	34.2	33.6	32.8	29.9*	28.0*
WB	31.2	27.6	29.2	27.0	26.0*	25.2*
RH	68%	61%	72%	63%	73%*	78%*
Time	14.55	14.58	14.50	14.55	14.50	14.45

* Gas system in cars 5,6 not functioning correctly, hence much lower temperatures.

Observations

1. With no tunnel ventilation the conditions inside the cars deteriorated rapidly.

2. After 37 minutes (14.42) A/C unit No. 3 tripped on high pressure trip.

   After 39 minutes (14.44) A/C unit No. 2 tripped on high pressure trip.

3. After A/C 3 and A/C 2 tripped the conditions deteriorated rapidly. The condition in cars 1 and 2 became intolerable 40 minutes after the train stopped at the test point.

4. The environmental conditions in the driver's cab were the worst on the train. It appeared that the cab ventilation was largely ineffective. Maximum dry bulb temperature was 36.6°C and corresponding wet bulb temperature was 31.2°C at the end of the test.

5. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 2R - Train Air-Conditioner Performance Check

General Description

Repeat of Test 2.

The timing of the test was as follows :-

15.46	Started run from CHH
16.00.25	Departure from LOF
16.01.05	Stop at test point
16.03	A/C no. 2 high pressure trip
16.26	Burners switched OFF
	End of test

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 375 people per car.

Car	1	2	3	4	5	6
DB	37.0	34.3	34.6	37.0	31.8	34.2
WB	33.8	29.9	31.0	31.2	28.6	28.8
RH	80%	72%	78%	63%	75%	66%
Time	16.23	16.20	16.20	16.20	16.20	16.20

Observation

1. The loss of A/C unit no. 2 after 2 minutes produced an intolerable condition in car 1 after 9 - 10 minutes.

2. With two A/C units functioning in car 4, an intolerable condition was reached after 20 minutes.

3. The environmental conditions in the driver's cab were the worst on the train. The maximum dry bulb temperature was 37°C and corresponding wet bulb temperature was 33.8°C at the end of the test.

4. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 3A - Loss of Traction Power Check

To investigate environmental conditions within and around a train which stops in a tunnel because of a traction power failure. Of particular interest is the question whether it becomes necessary or possible to detrain passengers in such circumstances.

General Description

After run-stop warm-up cycles, test train was stopped at the test site. The power to all train A/C units was cut after the train had stopped; car ventilation was then provided by emergency DC system. Tunnel ventilation was activated automatically by signalling system. Train continued to dwell until the environmental conditions became dangerous. (The test lasted for 25 minutes).

The timing of the test was as follows :-

11.47	Started run from DIH
11.51	Departure from LOF
11.51.53	Stop at test point
11.52.21	All A/C units (1 - 12) OFF
12.17	All A/C units reset
	End of test

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 375 people per car.

Car	1	2	3	4*	5	6
DB	36.4	36.0	37.5	37.4*	35.4	35.4
WB	31.2	30.6	29.6	30.0*	30.2	29.6
RH	69%	68%	56%	58%*	66%	65%
Time	12.05	12.17	12.16	12.00*	12.15	12.15

* Boilers and heaters relit at 11.55 after "blow-out".

Observations

1. Car 1 reached an intolerable level after 13 minutes at test point.

2. The other cars were still just tolerable at the end of the test but the conditions were deteriorating rapidly.

3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 3B - Loss of Traction Power Check - Two Impulse Fans

As for test 3A, but to evaluate degree of improvement with the additional air flow provided by the second impulse fan.

General Description

As for test 3A, except CCS activated second impulse fan after signalling system activated first impulse fan automatically.

The timing of the test was as follows :-

11.58	Started run from DJH
12.02	Departure from LOF
12.04.40	Stop at test point
12.05.06	All A/C units (1 - 12) OFF
12.08	Both impulse fans ON
12.25	End of test

Maximum Temperatures inside the Train

N.B. Heat output equivalent to 300 people per car.

Car	1	2	3	4	5	6
DB	37.2	32.2	35.0	32.6	33.0	29.8*
WB	30.4	28.4	28.6	28.0	28.8	26.0*
RH	61%	74%	62%	71%	72%	73%
Time	12.25	12.25	12.15	12.25	12.25	12.10*

* Gas ran out and system switched off.

Observations

1. The conditions inside the cars were similar to those in test 3A except overall the humidity was higher.

2. The conditions deteriorated and reached an intolerable level in car 1 approximately 20 minutes after the beginning of the test.

3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 3BR - Loss of Traction Power Check - Two Impulse Fans

General Description

Repeat of Test 3B.

The timing of the test was as follows :-

12.52	Started run from DIH
12.56.23	Departure from LOF
12.56.59	Stop at test point
12.57.28	All A/C units (1 - 12) OFF
13.22.28	End of test

Maximum Temperatures inside the Train

N.B. Heat output equivalent to 375 people per car.

Car	1	2	3	4*	5	6
DB	37.6	36.8	38.5	35.2*	35.6	36.8
WB	31.2	29.7	30.0	31.2*	30.2	30.5
RH	63%	60%	54%	75%*	68%	63%
Time	13.05	13.02	13.05	13.20*	13.05	13.20

* Gas system went off at beginning of test when train stopped suddenly. Relit shortly afterwards.

Observations

1. Conditions in car 1 became intolerable after 8 minutes. 7
2. The conditions in the other cars (especially car 6) were also becoming intolerable by the end of the test. 2
3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Tests 4A, B, C and D - Restricted Manual Running Check

To investigate environmental conditions within and around a train which, after stopping in a tunnel under normal conditions, proceeds to the next station under restricted manual. Of particular interest is the question of whether the train moves unde restricted manual at about the same speed as the tunnel air and if so the effect on train A/C operation.

General Description

4A After run-stop warm-up cycles, the test train was stopped at tunnel test site, for approximately 30 sec and then proceeded to KOT under restricted manual. Tunnel ventilation was activated by signalling system.

4B As for Test 4A, except test train dwelled at tunnel test site for 5 minutes before proceeding under restricted manual to KOT.

4C As for Test 4A, except automatic activation of tunnel ventilation plant suppressed by CCS. Also, test included restricted manual operation from KOT to LOF.

4D As for Test 4A, except CCS shut down tunnel ventilation plant activated by signalling system prior to the train proceeding in restricted manual to KOT.

The timing of tests was as follows :

4A	4B	4C	4D	
12.04	-	14.12	14.46	Started run from DIH
12.08.08	12.45.32	14.15.50	14.50.17	Departure from LOF
12.08.51	12.46.21	14.16.36	14.50.59	Stop at Test Point
12.09.27	12.51.23	14.17.12	14.52.01	Depart Test Point
12.11.50	12.53.46	14.19.13	14.53.58	Arrive at KOT
12.12.55	12.54.48	-	14.55	End of test
		14.20.20		Depart KOT
		14.25.22		Arrive LOF (End of tes for 4C)

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 375 people per car.

4A

Car	1	2	3	4	5	6
DB	31.4	30.4	33.2	32.6	27.0	29.6
WB	28.8	27.5	27.6	26.6	22.8	24.0
RH	82%	81%	66%	63%	68%	63%
Time	12.10	12.09	12.10	12.10	12.09	12.09

4B

Car	1	2	3	4	5	6
DB	30.0	27.6	28.4	*	29.8	30.4
WB	25.3	25.4	23.4	*	25.0	24.9
RH	6[illegible]%	84%	65%	*	67%	64%
Time	12.50	12.49	12.50	*	12.48	12.47

* Loss of gas supply.

4C

Car	1	2	3	4	5	6
DB	27.2	26.8	32.4	29.5	29.0	30.8
WB	23.2	23.6	27.6	25.8	24.2	26.2
RH	71%	75%	67%	76%	67%	70%
Time	14.20	14.24	14.20	14.20	14.22	14.22

4D

Car	1	2	3	4	5	6
DB	28.2	30.1	*	32.2	28.2	28.8
WB	23.8	25.8	*	26.1	22.8	25.4
RH	69%	70%	*	62%	62%	75%
Time	14.55	14.56	*	14.50	14.55	14.53

* Loss of gas supply.

Observations

1. To compare the four different modes of operation the temperatu distribution inside and around the train was checked at the ti the test train was between the test point and KOT station.

   The time chosen were :

4A	12.10
4B	12.52
4C	14.18
4D	14.53

   The results are shown at the end of this section.

2. Because of the short duration of each test it is difficult to compare the different modes of operation accurately.

3. See Part II of the report for Sensor Temperature/Time and Air Velocity/Time results.

Test 5 - Reverse Air Flow Check

To investigate environmental conditions within and around a train brought to a stop in a tunnel with automatic activation of tunnel ventilation plant by the signalling system; ventilation plant operation subsequently to be changed to an emergency mode with direction opposite the impulse fan air flow. Of particular interes are :

a. the time required to fully reverse the tunnel air flow.

b. tunnel air velocity in the reverse direction.

c. transitionary environment within and around the train and train A/C performance, during the flow reversal period.

d. tunnel environment from the viewpoint of effect on detraining decision.

General Description

After run-stop warm-up cycles, test train was stopped at tunnel test site under A10. Tunnel ventilation plant was activated automatically by signalling system and the situation maintained for approximately 15 minutes. On instruction from Test Director, CCS stopped the impulse fans and activated emergency ventilation equipment at LOF and KOT. Test continued until conditions equilibrated.

The timing of the test was as follows :

11.35	Started run from DIH
11.38	Arrived at LOF*
12.23.23	Departure from LOF
12.24.10	Stop at test point
12.30	Impulse fan ON
12.45	Impulse fan OFF
12.46	Emergency fans at KOT in supply mode ON
12.48	Emergency fans at LOF in exhaust mode ON
13.05	All emergency fans OFF
	End of test

* Loss of two M.A. sets at LOF held up the test for 40 minutes.

Maximum Temperature inside the Train

N.B. Heat output equivalent to 375 people/car

Car	1	2	3	4	5	6
DB	32.0	35.9	38.0	35.6	29.0	31.2
WB	26.6	27.6	30.6	29.4	23.4	25.2
RH	36%	55%	60%	64%	63%	62%
Time	12.35	12.55	13.00	12.55	12.35	13.00

Observations

1. Time to reverse the air flow: 3 minutes.
2. Air velocity with impulse fan: 2.8-3.1 m/sec.

   Air velocity with reverse air flow with emergency fans: 1.7-2.3 m/sec.
3. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 6 Push-Out Test

To investigate environmental conditions within and around a train brought to a stop in a tunnel; subsequently pushed out of the tunnel by a second train.

General Description :

After run-stop warm-up cycles, test train stopped at tunnel site. Tunnel ventilation plant was activated by signalling system. After approximately 10 minutes, CCS activated second impulse fan and second train proceeded into tunnel from LOF. Second train was coupled to test train and pushed it to KOT as the impulse fans continued to run.

The timing of the test was as follows:-

11.30.29	Started run from DIH
11.34.48	Departure from LOF
11.35.35	Stop at test point
11.57	Second train coupled to test train
12.11	Push-out commenced
12.13.40	Arrival at KOT
12.15	End of Test

Maximum [illegible] Train

N.B. Heat output equivalent to 375 people per car

Car	1	2	3	4	5	6
DB	29.4	28.0	32.8	30.2	28.6	33.8
WB	23.9	23.4	25.8	25.2	24.2	26.2
RH	63%	65%	57%	67%	68%	55%
Time	12.10	12.13	12.10	12.00	12.05	12.10

Observations

1. No problems experienced with the train A/Cs.

2. A small build up of heat was experienced when the push-out train was brought up to the test train but this was not enough to cause problems with the A/Cs.

3. As soon as the push-out began the conditions on the test train started to improve.

4. The empty push-out train had no problem in moving the fully loaded test train from the test site to KOT.

5. The temperature distribution inside and outside the test train was checked at three times: 11.40, 11.55 and 12.10. See end of this section for the results.

6. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 7A Restricted Manual Running Check

To evaluate environmental conditions within a train, and the performance of the train A/C units, when the train undergoes a station-to-station run under restricted manual.

General Description :

After run-stop warm-up cycles, test train proceeded into tunnel from LOF under restricted manual and continued at constant speed to KOT. CCS activated one tunnel impulse fan before train departed LOF.

The timing of the test was as follows:

15.34	Departure from CHH
15.41.09	Departure from LOF in restricted manual
15.45	Arrival outside KOT
	(Contractor had metal pole projecting onto track)
15.47	Stop at KOT
15.48	End of Test

A time of 15.42 was chosen to check the temperature distribution inside and outside the train. This is shown at the end of this section.

Observations

1. See test 7B for comments.

2. See Part II of the report for Sensor Temperature/Time and Air Velocity/Time results.

Test 7B Restricted Manual Running Check

To evaluate environmental conditions within a train, and the performance of the train A/C units, when the train undergoes a station-to-station run under restricted manual without tunnel ventilation.

General Description :

As for Test 7A, except CCS suppressed automatic start of tunnel ventilation.

The timing of the test was as follows:

16.16.43	Departure from DIH
16.19.50	Arrival at LOF
16.20.30	Departure from LOF
16.23.30	Passing sump
16.25.39	Arrival at KOT
16.26	End of Test

A time of 16.23 was chosen to check the temperature distribution inside and outside the train and to give a comparison with test 7A. This is shown overleaf.

Observations

1. The temperatures inside the cars for test 7B were overall 4-5°C higher than for test 7A. One factor was the short time allowed for heater and boiler warm up in test 7A and the fact that test 7B was run almost straight after test 7A.

2. Both test 7A and 7B are of very short duration which made accurate analysis of the results very difficult.

3. See Part II of the report for Sensor Temperature/Time and Air Velocity/Time results.

Test 8 - Normal Running Test

To investigate environmental conditions associated with a station-to-station train run following a normal speed-time profile. Of particular interest is the question of circulation of train A/C condenser discharge air to nearby condenser intakes.

General Description

After run-stop warm-up cycles, train proceeded from LOF to KOT following a normal speed-time profile.

The timing of the test was as follows :

14.56.19	Started run from DHH
14.59.44	Departure from LOF
15.00.45	Arrive at KOT
15.01.45	End of test

A time of 15.00 was chosen to check the temperature distribution inside and outside the train and provide a comparison with tests 7A and 7B. This is shown overleaf.

Observations

1. The short run between LOF and KOT only took 1 minute and this only allowed one reading on the psychrometers in each car. The figures below refer to 15.00 hours (approx) and show the comfortable conditions inside the car.

Car	1	2	3	4	5	6
DB	25.0	29.4	30.0	29.8	25.7	27.3
WB	22.2	24.0	24.2	25.6	20.6	22.8
RH	78%	63%	61%	76%	63%	68%
Time	15.00	15.00	15.00	15.00	15.00	15.00

2. See Part II for Sensor Temperature/Time and Air Velocity/Time results.

Test 9 - Loss of Impulse Fan Check

To investigate the environmental conditions within and around a train brought to a stop in a tunnel and automatic activation of tunnel ventilation plant; subsequently stopping the impulse fan and monitoring the deteriorating environmental conditions.

General Description

After run-stop warm-up cycles, the test train was stopped at the tunnel test site under ATO. Tunnel ventilation plant was activated automatically by signalling system and the situation maintained for 15 minutes. On instruction, the CCS stopped the impulse fan and the test was continued fro another 25 minutes.

The timing of the test was as follows :-

15.26.28	Started run from DIH
15.30.21	Arrival at LOF
15.30.44	Departure from LOF
15.31.30	Arrival at test point
15.32.05	Impulse fan at LOF ON
15.47.09	Impulse fan at LOF OFF
16.12	End of test

Maximum Temperatures Inside the Train

N.B. Heat output equivalent to 375 people per car.

Car	1	2	3	4	5	6
DB	37.5	34.3	35.4	36.1	33.6	34.1
WB	32.6	29.9	31.0	30.4	31.0	29.2
RH	71%	72%	73%	67%	82%	69%
Time	16.10	16.07	16.10	16.05	16.05	16.10

The temperature distribution inside and outside the train was checked at 15.31, 15.40, 15.50 and 16.15 to give a good picture of the effect of switching off an impulse fan.

The results are shown at the end of this section.

Observations

1. The conditions deteriorated badly within the train after the impulse fan was switched off. After 25 minutes with no impulse fan Car 1 was intolerable and cars 2, 3, 4 and 5 were very uncomfortable.

2. When the impulse fan at LOF was switched off A/C unit no 2 tripped as in test 1A. This is thought to be due to leaking air in the unit.

3. The Sensor Temperature/Time and Air Velocity/Time results are given in Part II of the report.

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