RAAD VOOR DE TRANSPORT VEILIGHEID

# FIRE IN HIGH-SPEED TRAM

*AT THE WEESPERPLEIN*

*METRO STATION, AMSTERDAM*

*ON 12 JULY 1999*

*4 July 2000*

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## FOREWORD

The fire in the high-speed tram on the Weesperplein metro station on 12 July 1999 resulted in massive smoke development. Smoke makes breathing difficult, hinders vision and rapidly causes a reduction in light levels. In underground areas, smoke also represents a major hazard for anyone present. The smoke development in this fire led to the entire metro station being evacuated. The present danger of fire in underground areas, the smoke development, the evacuation and the extremely limited possibilities open to the fire brigade to provide assistance underground were the background to the decision by the Council to investigate this serious incident, the sole objective of which investigation was to learn any lessons identified. The TRIPOD method was used for the investigation, a method developed by the University of Leiden and the University of Manchester. Essential to this method is the focus on 'manageable factors'. Specific attention in this investigation was therefore above all focused on concrete actions, with which accidents in the future can be avoided.

The Weesperplein metro station is part of the Amsterdam public transport network. The Municipal Transport Company in Amsterdam is responsible for this network. During the investigation, interviews were held with a large number of employees of the company. Many aspects were investigated, and many questions were asked and answered. The study itself proved useful on that level alone, for both the Council and for the company, whereby the degree of awareness of safety was considerably raised. Reports on this process, carried out under the auspices and management of the Council, with support from Railned, appear in the sub-reports referred to in the overview on page 24. This report is focused on the lessons which can be learned from this accident. Only that information has been included, which is relevant for this objective. The point of departure in identifying the relevant information was the situation identified immediately following the incident. Since this incident, the metro company has undergone considerable development. Following the incident, and during the investigation by the Council, the company took measures aimed at limiting the risks involved in underground passenger transport. These measures have not been included in the investigation or the analyses by the Council.

The Council is grateful for the open way in which all levels of the Municipal Transport Company cooperated in this investigation. As a result, a thorough investigation was possible, of a potentially very hazardous situation: fire in an underground transport system. Above all thanks to this open attitude, it was possible to investigate every aspect of the incident.

The Hague, 04 July 2000

Mr. Pieter van Vollenhoven
Chairperson

Mr. S.B. Boelens
Secretary-Director

## SUMMARY

On 12 July 1999, a fire occurred in a high-speed tram operated by the Municipal Transport Company of Amsterdam, in the Weesperplein metro station. The smoke development during this fire was such that the entire station, consisting of two underground levels, had to be evacuated. Fire and smoke in underground transport systems represent a particularly major hazard. Smoke rapidly reduces visibility and light levels. As a consequence, the evacuation process is seriously hindered, whilst in general the assistance provided by the fire brigade, due to the special circumstances, can be no more than marginal. For these reasons, the Council decided to initiate an investigation into this fire, in order to learn the necessary lessons.

The investigation clearly indicates that the events of 12 July 1999 are less coincidental than they would appear at first glance. Traction faults which occur frequently on warm summer days, such as on 12 July, interrupt the transport process, reduce the level of trust amongst drivers in the disruption signals issued by the high-speed tram, and contribute to communication disturbances between traffic controllers and tram drivers. Due to a concurrence of circumstances, a fire erupted on 12 July in a high-speed tram, at the Weesperplein metro station. Once the tram driver of the high-speed tram involved and his traffic controller had eventually established a clear picture of the seriousness of the situation, ad hoc decisions were taken, primarily aimed at as far as possible maintaining the level of the transport operation, in a situation where passenger safety in fact calls for other priorities. In addition, the communication infrastructure and equipment available to the traffic controller at that moment, proved insufficient and unsuitable for the tasks the traffic controller is required to carry out, in such circumstances. Furthermore, the distribution of tasks amongst traffic controllers is not geared towards crisis situations.

It also emerged that unlike normal metro stock, the high-speed tram has wooden floors, and that when the stock was delivered, insufficient testing was carried out aimed at tracing shortcomings in the design. The frequently occurring traction disruptions in warm weather have proven to be a technically-solvable problem.

Underground transport systems are complicated systems, whilst at the same time the risks to passengers and metro workers are considerable. In the organisation responsible for this system, safety must be built in structurally and systematically. At present, this is not sufficiently the case. The company culture is unilaterally geared towards the transport process.

The Board and Management of the Municipal Transport Company in Amsterdam are advised at both Board and Management level, to focus greater time and attention on safety, as a result of which limiting conditions will be established, for improving safety at all levels in the company. It is also recommended that safety in the transport process be raised, by in the immediate short term improving the fire safety of high-speed tram stock, improving the maintenance process, fully integrating high-speed tram line 51 into the metro system, developing scenarios, and improving the short-circuit procedure for the third rail.

# 1. INTRODUCTION

A fire in underground transport systems represents a major risk. A number of recent fires in road tunnels, such as the fire in the Mont Blanc tunnel on 24 March 1999, which resulted in the deaths of 39 people, underlines this fact. Fires, however, do not only occur in road tunnels, but also in underground train tunnels. The clearest example of such an incident is the fire in the Baku underground train tunnel (in Russia) in 1995, which led to the deaths of 289 passengers, and in which 265 were seriously injured. The fire was caused by a technical failure in a carriage. The majority of passengers died in this incident due to smoke development, and not as a result of the fire itself. In the escalator fire in the King's Cross underground station in London, in 1987, where 31 people died, the same phenomenon occurred. Here, too, the majority of deaths were due to smoke, and not so much actual fire. Each of these cases deals with an underground system which differs considerably from all the others, in terms of construction, construction date, depth below ground and escape possibilities. However, there is one major similarity: smoke caused the majority of problems.

On 12 July 1999, at around four thirty p.m. fire broke out in the bogie of a high-speed tram carriage, at the time carrying no passengers, at the Weesperplein metro station, in Amsterdam. The cause turned out to be a blocked disc brake. The smoke development generated by the fire led to the evacuation of the entire Weesperplein station. Eventually, the fire was extinguished by the fire brigade. Video recordings by the media demonstrated just how considerable the smoke development was, from this in itself small-scale fire. Fire in an underground area always represents a very major hazard. These circumstances caused the Council to investigate this incident.

## 2. THE MUNICIPAL TRANSPORT COMPANY

The Municipal Transport Company is part of the Municipality of Amsterdam. Under the responsibility of the Alderman for "Utility Companies", this company is managed by a central Board. Five companies together form the Municipal Transport Company: the bus company, the tram company, the metro company, the ferry company and the service and safety company. Every day, the metro company transports almost 235,000 passengers on 4 metro lines, with a total rail length of 105 km. Of this track, 8.5 km run underground, and in this underground section, there are 5 stations.

## 3. THE LOCATION


Fig. 1 Weesperplein station and surrounding area

The Weesperplein station has two underground levels. The tracks and the two platforms are located at the lowest level. Each platform has one exit intended for passengers, in the centre, with emergency exits at each end, but with limited capacity. On the upper level, shops and hospitality outlets are located. The access control is also located on the upper level. The shop level has 4 exits to street level.

The distance between the Central Station and the Weesperplein station, the route followed by the faulty tram, is more than 1 km. The entire underground section from the Central Station to the Amstel Station is dual-tracked. Only the Weesperplein station has a reserve track, which is positioned between the two through tracks. A faulty metro in this underground section immediately blocks the transport process, unless this train can be moved onto the reserve track in the Weesperplein station.

The metro network is permanently monitored by traffic controllers. All metro drivers can contact these traffic controllers direct, using systems which still operate in the event of a power failure. In the event of accidents and other incidents, the traffic controllers coordinate all activities from the central traffic control building.

# 4. THE CIRCUMSTANCES

## *4.1 Shortly before the fire*

Monday 12 July 1999 was a warm day, with temperatures exceeding 25 degrees Celsius. Such temperatures have troublesome consequences for high-speed tram equipment. Due to the high outside temperature, problems arise with the cooling of the inverter (the system which converts the voltage in the third rail into voltage and current suitable for the motors). As a result, the inverter overheats. The temperature monitoring system on the equipment simply shuts down the motors on the vehicle in question. As a result, three of the six motors remain in operation. The driver is notified of this situation by a warning lamp; "the general error signal" in front of him on the dashboard lights up. Only in the vehicle in which the fault has occurred does the signal lamp "traction fault" light up on the error panel. This panel is located behind the driver's seat. If this situation arises, the driver is required to slow down, and to continue at a maximum speed of 40 km per hour. As a result, the timetable can no longer be complied with. The timetable is based on a frequency of one train every two minutes in both directions at a maximum speed of 70 km per hour. On this afternoon, due to the warm weather, the traffic controller on line 51 was continuously required to take action, to limit the consequences of these disruptions.

When entering the Nieuwmarkt station, heading towards Amsterdam CS, the driver of the high-speed tram saw the "general error signal" lamp once again light up on his panel. Two trips previously, the high-speed tram which he was then driving had been taken out of service, because of a traction problem. The most important signal indicating a traction problem is the "general error signal".

As the tram accelerated, having stopped at the station, the signal was extinguished. Shortly thereafter, the driver saw the signal "disc brakes blocked" light up. This is a white signal lamp (not an alarm function) which normally only illuminates when the automatic parking brake is activated. This happens during every full braking cycle, as soon as the speed falls below 2 to 3 km per hour. In a vehicle in which the motors are shut down, the disc brake is used as the normal brake. In such a situation, the "disc brakes blocked" lamp lights up earlier and remains illuminated longer. When the driver noticed this lamp, he allowed his high-speed tram to roll the rest of the distance to Amsterdam Central. Having arrived, the driver called his traffic controller at 16.35 hours, and reported a brake problem. The traffic controller, assuming that this was merely one of the numerous traction problems being reported on that day, instructed the driver to travel on to the aboveground stabling zone, at a maximum speed of 40 km per hour. By this action, the traffic controller aimed to remove the faulty tram, the source of the disruption, as rapidly as possible from the system. Once the driver had asked all passengers present in the high-speed tram to descend from the tram, he walked to the other cab.

## *4.2 Start of the fire*

Whilst walking the length of the high-speed tram, the driver observed a burning smell, but paid it no further attention. Having departed from Amsterdam Central, the driver saw that the “disc brakes blocked” warning lamp remained illuminated. The driver continued at the agreed speed, passing through the Waterlooplein station, without stopping. A driver of a normal metro train, with passengers, driving in the opposite direction observed a high-speed tram passing the Waterlooplein station, with smoke emanating from the rear bogie. He immediately notified this fact to his traffic controller (53/54). This was at approximately 16.39 hours. The driver of the faulty high-speed tram also reported in at this moment, to his traffic controller (51) indicating that his brakes were still blocked. The traffic controller suggested not continuing beyond the Weesperplein station, stopping there on track 1, and subsequently, returning towards Central Station, with a view to reaching the stabling zone at the Weesperplein station, via the points, which by this time had been switched.

The driver stopped on track 1, as suggested by the traffic controller, and climbed out to walk to the other cab. Upon arriving at the other cab, he saw something glowing by the brakes on the bogie. He then tried calling the traffic controller (51) but was unable to reach him immediately. The driver then pressed the emergency button in the cab, issuing a signal to the traffic controller (51) that assistance was required. It was probably 16.43 hours, by this time.

## *4.3 The emergency services*

Following this emergency call, the traffic controller notified the fire brigade, had the switch control officer shut off power along platform 1, and called out an electrical engineer, to short-circuit the shut down third rail. Following the emergency call-out, the driver of the smoking high-speed tram tried to remove the fire extinguisher from the cab. He failed, because the extinguisher was trapped in its holder. The driver then collected the extinguisher from another cab, and started extinguishing. At that moment a colleague joined him, in extinguishing the fire. It rapidly emerged that their attempts were failing, and that the fire was getting out of control. The two drivers then took the initiative to evacuate the station. The stationmaster, whose workplace is on the shop level, was notified of the fire, by a passenger. The stationmaster also assisted in the evacuation process.

Fig. 5. Platform level, immediately following arrival of high-speed tram

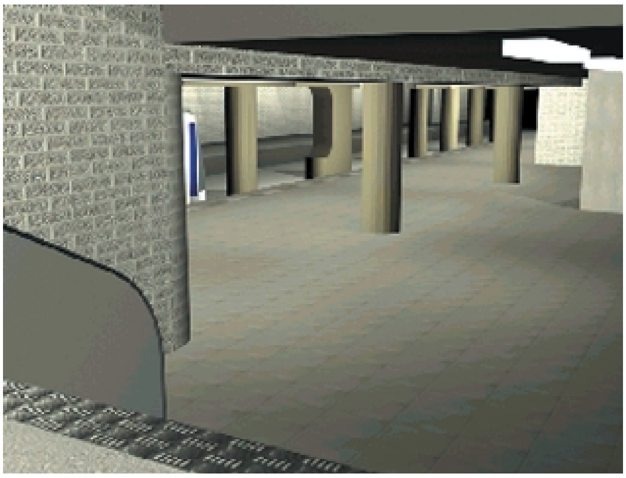

Fig. 8. Platform level access stairs, following arrival of high-speed tram

Fig. 6. Platform level after 5 minutes

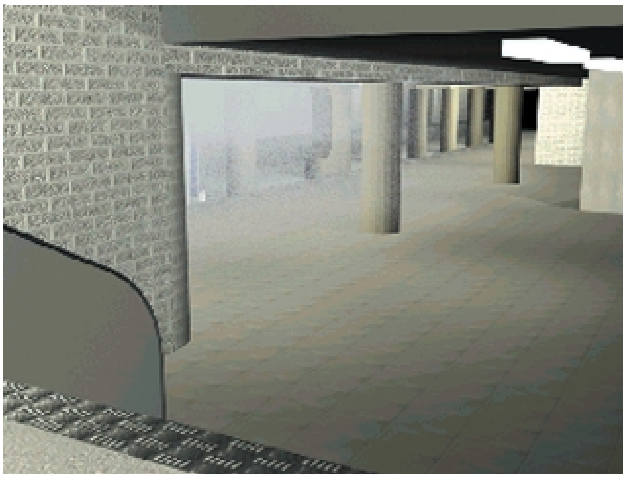

Fig. 9. Platform level access stairs, after 5 minutes

Fig. 7. Platform level after 10 minutes

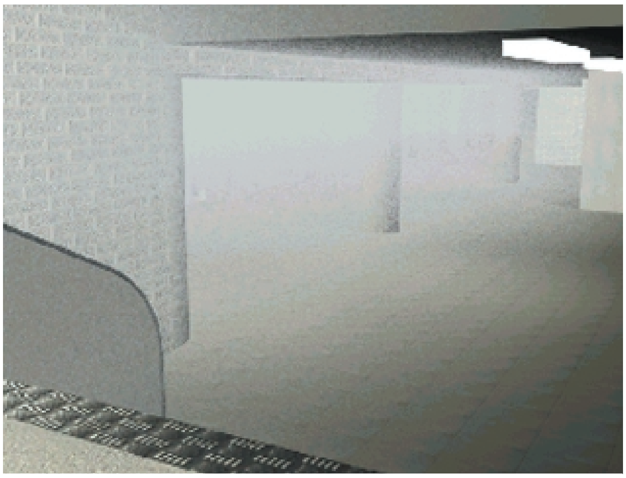

Fig. 10. Platform level access stairs, after 10 minutes

Illustrations based on a simulation carried out using a computer model.

Simulation by MottMacDonald Limited England.

Fig. 11. Shop level with empty space, after 10 minutes

Fig. 14. Shop level, hall, after 10 minutes

Fig. 12. Shop level with empty space, after 15 minutes

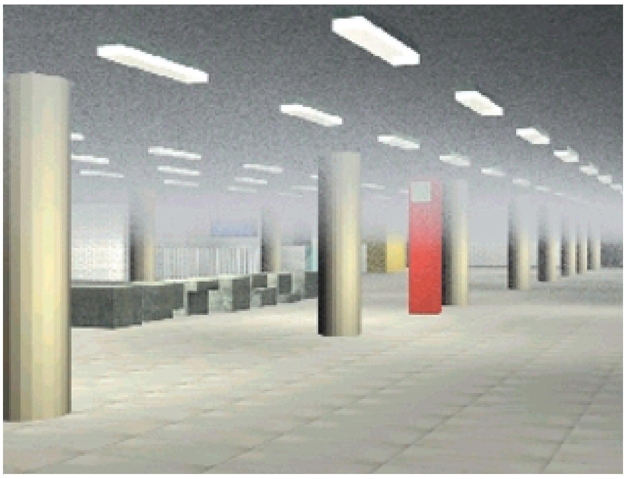

Fig. 15. Shop level, hall, after 15 minutes

Fig. 13. Shop level with empty space, after 20 minutes

Fig. 16. Shop level, hall, after 20 minutes

Illustrations based on a simulation carried out using a computer model.

Simulation by MottMacDonald Limited England.

The fire brigade arrived at the station, at 16.55 hours, with two automatic spray tenders, a communication link vehicle and a so-called A-tender with additional breathing apparatus. The fire brigade crew which arrived first did not know the location of the fire, in the station, or which of the four entrances they could best use. Passers-by provided the information required. The fire brigade then entered the station. At shop level, by this time, there was no severe smoke development. The fire officer in charge, accompanied by a number of fire fighters, went down to the tram on track 1. As they arrived on the platform, at station level, the smoke development was so considerable that breathing apparatus had to be used. They attempted to extinguish the fire using CO2 extinguishers. The current to the third rail had been shut down, but the third rail had not yet been short-circuited, so extinguishing using water was not possible. However, the CO2 extinguishers had no effect.

The fire officer in charge went back upstairs, on the way meeting the electrical engineer called up by the traffic controller, to short-circuit the third rail. The fire brigade provided the engineer with breathing apparatus. By chance, he was one of the engineers who had been trained in the use of breathing apparatus. However, this is not a standard component of the training course. Smoke development by this stage was so considerable that even the shop level could not be entered, without breathing apparatus. Smoke was now escaping from all four station exits on the ground floor level. Once provided with the necessary equipment, the electrical engineer attached the short-circuit. The fire on the tram was then rapidly extinguished, using the fire reels on the platform. The police reported that there were still people present in the cafe at shop level. This indeed turned out to be the case. The fire brigade guided these individuals outside, via the nearest exit.

At 16.53 hours, the fire brigade called the Central Ambulance Dispatch Post, with the request to send ambulances to the Weesperplein station. This message never reached the Central Dispatch Post. At 17.04 hours, a passing ambulance reported the presence of large numbers of fire brigade at the Weesperplein station, and that smoke was escaping from the metro ventilation grids. The Central Dispatch Post then requested the fire brigade for further details. On the basis of the information provided, ambulances were sent to the site, arriving at 17.15 hours. Two employees of the metro were taken to hospital, with slight smoke inhalation. Following arrival, the inhalation was determined as not serious, and the two were able to leave the hospital, soon afterwards.

# 5. THE SYSTEM

## *5.1 The station*

The Weesperplein metro station is used by three public transport lines: (1) the line Central Station - Gaasperplas (53), (2) the line Central Station – Gein (54) and (3) the combined metro/high-speed tram line Central Station - Poortwachter (51). This line, on the section Zuid/WTC – Poortwachter, which is entirely aboveground, is not a metro line but a tram line. The differences between a metro and a tram are considerable, and are laid down in law. Just like motor vehicles, trams drive on the public highway "by sight". Metro trains, like all other trains, travel according to signals. Metros (and trains) travel along predetermined routes, which are indicated by signals. These routes are determined for all Amsterdam metro lines, at a single location in the Central Traffic Control building. In one room, in this building, are the traffic controllers each responsible for a section of the Amsterdam metro network. The section of line 51 in Amstelveen, where the high-speed tram 51 travels "by sight" as an ordinary tram, is subject to special rules, for this reason.

Fig. 2 Traffic controllers post. The two computer screens provide a schematic overview of the network and the positions of the metros and high-speed trams on the network. Using the keyboard, routes are selected. The adjacent system provides the link to the drivers on lines 53, 54 and the emergency services. The next piece of equipment provides a link to the drivers on line 51 (high-speed tram). To the left, outside this picture, is the installation for the station PA system. In the background, the monitors which provide a view of the stations, are just visible.

## 5.2 The traffic controller

When selecting routes, the traffic controller uses electronic systems, in combination with computers. The traffic controller needs only to indicate the tracks and points via which he wishes the train to travel from A to B. The system does the rest, and at the same time prevents a selected route using a section of track also required for another route. A request for a route from A to B which would result in a collision with another metro, would therefore not be approved by the system. However, this is not the limit of the electronic support available to the traffic controller. In modern traffic control systems, account is often already taken of the timetabling requirements. This means that at the right moment, and depending on a number of limiting conditions, the computer system controls the points and sets them in the position required for the timetable. The traffic controller then merely monitors the process as it takes place, at least if the timetable is running according to plan. On the computer screen, he can see precisely how and when the routes are selected, and whereabouts on the selected routes, the metros and high-speed trams are located.

Disruptions have major consequences for the traffic controller. As a result, his role is constantly changing from one moment to the next, from that of supervisory, general manager, to specifically acting problem solver. The computer controls metro traffic on the basis of the input timetable. If the timetable is disrupted, the computer no longer correctly controls metro traffic, because the disrupted situation does not tie in with the situation as assumed by the computer. If no action is undertaken, the computer simply continues to operate the timetable, as if it were not disrupted. For this reason, in disruption situations, the entire metro and high-speed tram traffic has to be controlled manually, by the traffic controllers.

In Amsterdam, the situation differs from the normal situation elsewhere in the railway world. Normally, one traffic controller is responsible for one section of the rail network. In Amsterdam, one traffic controller is responsible for two lines, 53 and 54 (the old metro lines) and another is responsible for the new line 51, the combined metro and high-speed tram line. The selection of routes for a metro or high-speed tram on the shared section between Central Station and Spaklerweg is carried out by either traffic controller. In other words, one and the same set of points can be operated by two different traffic controllers. For this reason, it is often necessary for the two traffic controllers to consult one another. The working agreement is that in the event of special circumstances, the traffic controller responsible for lines 53 and 54 is in charge. Communication with the drivers on a line is always via their "own" traffic controller.

The primary task of the traffic controllers is to select the routes on lines 51, 53 and 54. Their second task is to communicate with the drivers of their line or lines. For this communication, more or less the same applies as for selecting routes. If everything is running according to timetable, there is effectively no communication between traffic controllers and drivers. After all, formal communication takes place via the signals along the route. And if everything is running according to the timetable, there is little need for contacting the traffic controller. This situation does not apply in the event of disruptions. Then every driver wants to know his precise situation. The workload on the traffic controllers increases very rapidly, in the event of disruptions.

The traffic controllers are the sole people with an overview of the precise location of the metros and high-speed trams, at any given moment. This overview consists of a schematically simplified picture of the selected routes, and the positions of the metros on a computer screen. A metro itself indicates its location by establishing an electrical connection between the two tracks. The entire line is broken down into sections of several hundred metres. As a result, the traffic controller can see the section in which the metro is located. But that is the only information known. In the tunnels, which link the stations together, there are no video cameras or other monitoring systems installed. For observing fires or accidents, the traffic controller is entirely dependent on the drivers of the metros or high-speed trams. However, there are video cameras on the 33 stations. The number of cameras is far larger than the number of displays available to the traffic controllers. The traffic controller is therefore required to select what he wants to see, and then to select the cameras on the station, which provide the pictures he requires, using a computer program which is not really user-friendly.

For issuing passenger information, and for emergency situations, the traffic controller has a PA system, via which he can contact the passengers on the platform of any selected station.

Finally, the traffic controller is the central figure in the event of disruptions and accidents. The traffic controller warns the emergency services such as fire brigade and police. In order to monitor disruptions and accidents, the traffic controller as it were has access to all the eyes and ears of the drivers of metros, who report such incidents to him, and to video pictures of the stations, which he himself is required to monitor closely. He has no other options available. The stations, metro tunnels and rolling stock, unlike office buildings, are not equipped with automatic smoke sensors or fire alarms, or other safety systems which would facilitate early detection.

## *5.3 Electrical power supply*

For their electrical power supply, metros do not have a catenary system, but a third rail. On the top and sides, the rail is insulated against direct contact. The sliding contact on the metro connects with the underside of the rail, which is supplied with 750 V DC. The presence of this rail makes it dangerous to step onto the ballast bed, even if it is certain that no metros are expected. In order to be able to safely walk on the ballast bed, the voltage on the third rail must have been shut down. Specially trained individuals are authorised to carry out work on the track, even if the third rail is switched on. Such work must not be carried out in the immediate vicinity (0.5 to 1 metres) of the live rail.

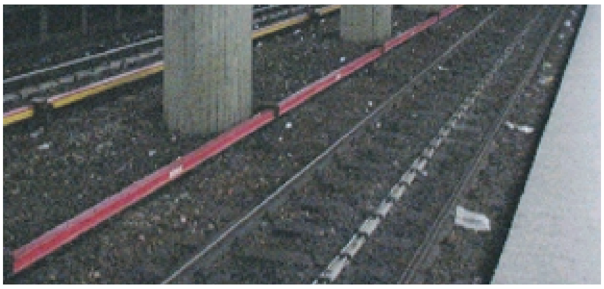

Fig. 3. The ballast bed and tracks. The red construction is the electrical power supply which first has to be short-circuited, before walking on the ballast bed, or extinguishing with water.

The third rail is switched on and off from the switching room, which is also located in the central traffic control building. The switch control officer has an overview of the entire metro network, on a monitor screen. This screen shows which sections are switched on, the normal situations and which sections are switched off for example for work on the rail. This switching room is located close to the traffic control room.

The switching on and off of sections must always be carried out in close consultation with the traffic controller. The traffic controller can obviously not access the sections of track on which the power is shut down, and is thus immediately subject to a major disruption of the timetable. Once it is certain that the power is shut down, and that no vehicles are expected, track workers and the fire brigade, and other third parties are permitted access to the ballast bed. Because the third rail is shut down remotely, following telephone consultation, it is not possible, in situ, to determine with any certainty whether the rail is live or not. It is therefore better to install a visible "short-circuit" of the third rail. Via a copper cable, the third rail is then short-circuited to one of the two other rails. This is a guarantee for anyone walking on the ballast bed, that such action is safe. In addition, the installation of this short circuit makes the accidental switching on of the power, by the switch control officer, impossible. The short-circuiting of the third rail is a precondition for the fire brigade, before extinguishing with water.

## 6. THE STOCK

Fig. 4. The high-speed tram stock at the platform

For the operation of line 51, the Municipal Transport Company has 25 units, each consisting of two carriages. These can be powered via the third rail or by the catenary lines. The high-speed tram can travel with multiple units connected together. The journey in question involved a tram unit consisting of carriages numbers 68 and 57.

# 7. THE ANALYSIS

## *7.1 Conditions*

Train and metro systems have specific safety characteristics, because special conditions apply to rail transport. Speeds are high and the numbers of passengers often carried simultaneously, possibly many of them standing, can exceed five hundred, in just a single metro. Due to the high speeds and large passenger numbers, the consequences of accidents are very considerable. Rail safety as a consequence has a special character. High safety levels in rail transport can only be guaranteed if the risk of an accident is very small. Rail transport is therefore in principle designed and organised in such a way that accident risks are excluded. This in fact also applies for metros travelling aboveground. In the case of underground rail systems, due to the limited space, the consequences of accidents such as collisions or fire are more serious than aboveground, whilst the possibilities available to the emergency services for limiting those consequences are far more restricted. Against this background, in design and operation, maximum attention must be focused on safety. As demonstrated by this case, even with a small fire, a whole station, of two floors can be entirely filled with smoke. If this fire had taken place with a platform full of passengers, and a shop level full of passers-by, in total a group of several thousand people, the occurrence of panic could not have been excluded.

## *7.2 Scenarios*

A metro system is a complex and complicated system, in which management, traffic controllers, metro drivers and stationmasters occupy important functions. Complex systems share the general characteristic that spontaneous, intuitive reactions rarely have the desired effect. Complex systems require a systematic approach. All hazardous situations must be thoroughly thought through in advance, and a determination must be made in advance, of the required reaction of those involved, in these situations. For everyone involved in the metro system, there must be good, clear scenarios stating: if this happens, then I must do that. This is the only way in which complex systems can be managed, under almost all circumstances. The well-considered, prescribed actions are based on knowledge of the system and all subsystems, consultation with parties involved, and a consideration of the hazards and the interests in the given circumstances. These actions are considered as being the best possible actions, for the situation. Because the prescribed actions are based on the balancing of interests, it is necessary that these actions be formally laid down by the management.

## *7.3 The design*

Very high demands must be placed on stock travelling underground, in terms of fire safety. Unlike standard metro stock, with a steel floor, covered with a thin, wooden top floor, the high-speed tram stock has solid wooden floors. Normal Amsterdam city trams all have wooden floors. In addition it has become clear that the mud guards and insulation for the wiring can also generate considerable volumes of smoke. Both elements represent unnecessary risks.

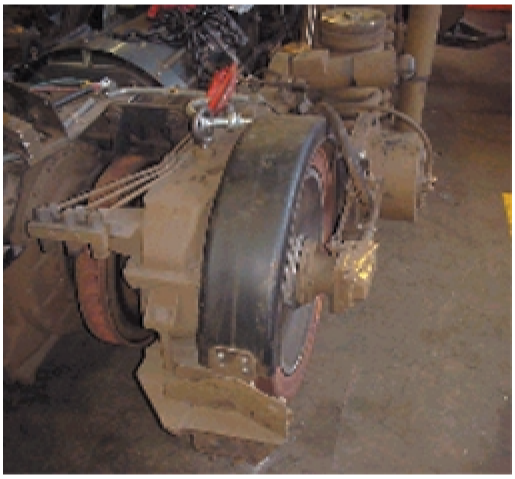
Fig. 17. The wheel below the mud guard. The brake disc is located to the left.

The disc brakes are applied via mechanical springs and released via oil pressure. The immediate cause of the fire was identified as a relay in the pump circuit for the disc brake, which is insufficient for the capacity it is required to handle. This relay became overheated and as a result was unable to switch on the oil pump. As a consequence, the disc brakes remained locked, and became overheated. The mud guards above the wheel, the plastic wiring and a wire harness above the bogie, and the approx. 2 cm-thick base plate of impregnated plywood, which serves as a floor to the tram, ignited, as a consequence. If sufficient tests had been carried out following handover of the stock, the underdimensioned relay, a design error, would have been detected earlier. In addition, the vehicle in question was fitted with a hand-operated oil pump, with which the brake could have been released.

The system of short-circuiting, which requires waiting for an electrical engineer from the company, is a weak link in the action to be taken by the emergency services. At least in underground stations, consideration should be given to the possibility of installing permanent short-circuit facilities, which can be operated by the fire brigade, or remotely via the switch control officer. A number of railway companies are already equipped with a system of this kind.

## *7.4 Traction fault*

If the outside temperature rises above 25 degrees, the cooling for the system which converts the 750 V DC into a voltage suitable for the traction motors experiences problems. The cooling is provided by freon, with an evaporation temperature of 25° C. Over time, the connections in the in principle air-tight system containing the cooling freon, start to leak, as a result of which air joins the freon and reduces the cooling capacity. The large number of resultant faults created a climate in which incorrect interpretations of signals became common. These incorrect interpretations resulted in the fire, followed by the evacuation. Replacing the gaskets in the connections will prevent this fault occurring.

## *7.5 The transport process*

On 12 July 1999, for the second time during his shift, the high-speed tram driver was faced with a “general error signal”. This time, in combination with the disc brakes blocked signal. On the basis of poor communication, whereby it was incorrectly assumed that this was a traction problem, the traffic controller and driver initially decided to remove the high-speed tram from service, and to drive it away empty. In this decision, priority was given to the interests of the transport operation. In a metro tunnel, with two tracks, a stationary high-speed tram more than halves capacity. In the period running up to the rush hour, this means full platforms, with thousands of waiting passengers. The decision appears obvious, but involved considerable risks. A determination should first have been made whether it was safe to drive away the high-speed tram.

During the journey to Weesperplein, the energy which caused the fire in the high-speed tram was built up. A number of fires had already occurred in precisely this way, on aboveground routes. The metro company failed to investigate these fires, and no measures were taken. The worries of the driver concerning the continuous illumination of the disc brakes blocked warning lamp, and a notification of smoke to the traffic controller, were the reasons for which the decision was taken to halt the high-speed tram on the middle track, at the Weesperplein station. Here, too, priority was given to the transport operation. After all, a high speed tram "parked" on the middle track does not block the through track. However, at this point, there are no extinguishing facilities, and the track is practically inaccessible, to the fire brigade. This decision, too, was accompanied by considerable risks.

Due to smoke development, the high-speed tram could not travel beyond platform 1 at the Weesperplein station. At this stage, the traffic controllers knew of the smoke development situation. However, the traffic controllers could no see what was going on at the station, the monitors having been faulty for more than a week. It was therefore decided to allow the first metro, containing passengers, which was travelling behind the high-speed tram, to drive through the station, via the unblocked left-hand track, to allow the driver an opportunity to observe the situation. In order to minimise the risks as far as possible, the driver was instructed to drive straight through, and not to stop at the platform. Another decision entailing major risks for driver and passengers.

The situation on track 1 got out of hand. The driver called in assistance. Aided by a colleague, the driver started evacuating the platform. The traffic controller advised the passengers to evacuate the station, via the station PA system. The fire brigade arrived at one of the entrances, and quite by coincidence came across the engineer responsible for short-circuiting the third rail. The stationmaster assisted with the evacuation of the station. All of these actions had a good outcome, but certainly did not represent a well-considered scenario. The evacuation of the platform by the drivers proved to be a very wise action. Question marks, however, do arise in relation to the call by the traffic controller to evacuate the station. The traffic controller had no view of the situation at the station. The platforms have only one normal exit. And although there were emergency exits at each platform end, due to the dimensioning of the station, their capacity is extremely limited. The call to evacuate the platforms could have resulted in very hazardous situations, had the platforms been full.

> *Investigation into the King's Cross Underground Fire.*
> *Recommendation  no 11 (most important)*
> *A rendezvous point for the emergency services and a staff assembly point at each station must be agreed and marked.*

None of the parties involved were aware of a clear rendezvous point on the station for the stationmaster (or other metro employee) and fire brigade, nor for the service engineer responsible for short-circuiting the third rail, and the fire brigade. There is no scenario for information transfer between stationmaster and fire brigade, nor between engineer and fire brigade. A clear rendezvous point was one of the key recommendations which came out of the investigation into the fire in King's Cross underground station in London. All these matters should be clearly settled in advance, and recorded in a contingency plan. The initiative for such actions must be with the Municipal Transport Company.

## 8. CONCLUSION

The core finding from this investigation is that *the risks of this complex underground system were insufficiently identified, and operation was not sufficiently harmonised to these risks. Concern in respect of safety is not laid down structurally and systematically, within the organisation*. As a consequence, a number of fires went unanalysed, and no lessons were learned.
The course of events on 12 July 1999 shows how a normal operating disruption can result in the evacuation and shutting down of an intensively-used station. There were no predetermined scenarios, aimed at guaranteeing safety in the given situation. This is a serious shortcoming. In addition it emerged that the organisation of the traffic control system, with its separation between high-speed tram and metro, the design of the high-speed tram whereby the normal metro parameters were not employed, and the maintenance of the high-speed tram stock could be structurally improved. Effectively, within the Municipal Transport Company, there is no specific attention for safety. As a consequence, a company culture has emerged, focused solely on transport operations.

## 9. RECOMMENDATION

The Board and Management of the Municipal Transport Company in Amsterdam are advised to focus greater time and attention at Board and Management level on safety on the basis of which limiting conditions are established, for improving safety at all levels in the company. In addition it is recommended that safety in the transport process be increased, by in the near future:
– improving fire safety of the high-speed tram stock;
– improving the maintenance process;
– fully integrating high-speed tram line 51 into the metro system;
– developing scenarios and
– improving the third rail short-circuiting procedure.

## OVERVIEW OF SUB-INVESTIGATIONS

The following sub-reports, drawn up under the aegis of the Council for Transport Safety, form the basis for the final report. These sub-reports describe particularly the various facts (operational, technical, organisational). The sub-reports are available on request.

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Fact finding
By the Council for Transport Safety / Railned

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Control process
By the Council for Transport Safety / Railned

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Frameworks and rules
By the Council for Transport Safety / Railned

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Material damage
By the Council for Transport Safety / Railned

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Environmental risks
By the Council for Transport Safety / Railned

Investigation into fire in high-speed tram at Weesperplein metro station
Sub-report dated 17 February 2000: Tackling consequences
By the Council for Transport Safety / Railned

Investigation into fire in metro on 12 July 1999 in Amsterdam
Sub-report dated May 2000: Tackling consequences
Fire Fighting and Contingency Planning Inspectorate, Ministry of Home Affairs

Visualisation of smoke spread in Weesperplein Station
Nick Waterson, Mott MacDonald Limited, 03 February 2000