An Enquiry

into the

reasons for burning

of

Coach-6

of the

Sabarmati Express

January 2005

Hazards Centre
New Delhi

Executive Summary

This report is the outcome of an independent investigation by the Hazards Centre into the burning of the S-6 coach of the Sabarmati Express in February 2002. It gives observations and conclusions about:

- **The Coach** – the pattern of fire marks on comparable coaches and what they indicate.
- **The Fire** – what may be deduced about the manner in which the fire was initiated and spread.
- **The Depositions** – an analysis what 41 passengers in the coach had to say to the police.
- **The Mortalities** – an analysis of 27 post mortem reports and the procedures followed therein.
- **The Injuries** – an analysis of 56 injury reports and what is the correlation with the spread of the fire.

Based on the above, the investigating team has come to the following main conclusions:

1. The fire probably originated in the region between the last two cabins (8 & 9) and it is highly unlikely that it could have started on the floor of the passage or the floor outside the toilets by throwing of inflammable fluid.

2. The resultant dense and high temperature smoke spread along the ceiling of the carriage and eventually resulted in a flash over when the fire engulfed the entire coach from the top.

3. In the above circumstances, people must have gathered trying to escape and been subjected to dense and toxic fumes and radiative heat, resulting in asphyxiation and death.

4. Systematic recording of the evidence and scientific investigation of the case has been marked by its absence. Specific procedures need to be developed for mapping the damage and interviewing the witnesses.

5. Procedures for scientifically collecting and analysing samples also need to be pursued in line with modern approaches in forensics and medical investigation.

6. Serious thought needs to be given to the design of doors and exits and emergency escape designs for Indian carriages, considering the high passenger load per compartment.

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Introduction

The 9166 Sabarmati Express was on its way to Vadodara in the early morning of 27 February 2002. It was running almost five hours late at 07.47 hours, when a chain pulling was reported just as it began pulling out of Godhra station with reports of an altercation and stone throwing at the station. The vacuum was apparently set right and the train moved out again but stopped a few minutes later again slightly ahead of A Cabin. There was reportedly a longer period of stone throwing at the train and then the S-6 coach caught fire. Before the tragic event could be brought under control, 58 persons had perished on the spot.

Almost 32 months later, the Hazards Centre has undertaken an investigation into the probable causes of the fire. The study was initiated because of increasing concern over the manner in which previous investigations had been conducted and the absence of an explanation consistent with the facts as recorded. Hence, the Centre set up a multi-disciplinary group consisting of the following persons:

- A K Roy, M Tech in Chemical Engineering, with expertise in hazards and safety, Hazards Centre, Delhi
- Professor Dinesh Mohan, PhD in Biomedical Engineering, with expertise in human tolerance to injuries, Indian Institute of Technology, Delhi
- Professor Sunil Kale, PhD in Mechanical Engineering, with expertise in thermodynamics and fluidisation, Indian Institute of Technology, Delhi
- S N Chakravarty, Mechanical Engineering, with expertise in coaching section of the Railways for 10 years, Consultant, Mumbai

Several other individuals from different fields, as well as the Railway authorities, also assisted the group as and when necessary. Their cooperation is gratefully acknowledged.

On different occasions the group members analysed the documents available from previous investigations, visited the railway workshops at Matunga and Jagadhri, viewed video footage of the Sabarmati Express S-6 coach, and observed the burnt coach at Godhra. Other coaches, not belonging to the Sabarmati Express and which have caught fire at other places and times, and now lying at Gandhinagar and Jagadhri, were also examined to learn more about the broader processes and results when such coaches burn. After several consultations this final report has been prepared for wider public discussion and debate.

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The Coach

The burnt Coach-6 at Godhra was physically observed 2½ years after the incident. Hence, clearly allowance has to be made for the passage of time and the changes that may have been brought about by exposure to weather, investigating teams, and curious onlookers. However, the Hazard Centre's team was fortunate enough to be able to view video footage of the coach taken two months after the burning incident, and the visual evidence suggests that the essential features of damage to the coach remain the same. The photographs (video stills) of the Godhra Coach-6 included in Annexure 1 are taken from this video footage.

The observations of six other coaches (burnt at other locations) presently parked at Gandhinagar (one) and Jagadhri (five) were also very useful for comparing the fire patterns across coaches in order to understand the manner in which the flames spread. The team discovered that one coach kept at Jagadhri was very similar to the burnt coach at Godhra. This coach (16526 GSCN – hereafter referred to as the Delhi coach) caught fire while under maintenance in the washing line of Delhi Junction Station on 21 November 2003. Comparative pictures of the two coaches (Godhra coach S-6 and Delhi coach) are given in Annexure I.

Observations

1. The heat marks are clearly visible on the sides of both the Delhi and Godhra coaches where the paint has got scorched and peeled or vaporised off. The heat marks on the left and right side of both the coaches are roughly similar and more severe on the upper half of the coaches. The patterns are also very similar, indicating that the heat was greater at one end of the coach in both cases. It should be noted that the Delhi coach was painted blue while the Godhra coach had a red coat. In the case of the Delhi coach it is also known that no materials were thrown from outside.

2. The crinkling of the steel body and the roof is also similar and has taken place in the middle section but more towards the end where the scorch marks are more pronounced. This crinkling took place as the coach expanded with increasing temperature and the sheet metal folded to take up the structural expansion from one end.

3. The pattern of heat marks on the outside of the coaches is clearly correlated to the conflagration inside. In both the coaches almost half the plywood floor has crumbled in one half where the fire presumably originated, although the under-floor remains intact. The vinyl and foam berths and sunmica partitions have been completely destroyed in this half and the steel is mangled. On the

other half of the coaches the various components are better preserved, particularly for the Delhi coach.

4. The seat and window details in both the coaches are also remarkably similar. The reinforced fibre shutters and glass panes as well as the aluminium frames have vanished on the side the fire originated. As the distance from the centre of the fire increases, the aluminium frames and reinforced fibre shutters slowly begin to reappear, as do scorched remains of the seats.

5. The damage to the ceilings indicates that in those regions where the highest temperatures obtained, the asbestos ceiling has crumbled, the fan blades have got warped and the underlying synthetic wool insulation has fallen down because of the melting of the bitumen paint, even behind the intact portions of asbestos.

6. In the Godhra coach, two important features stand out towards the eastern end, where the floor has also crumpled under the intense heat. Firstly, the aluminium water tank above the luggage compartment next to seats 68-70 displays a large hole towards the inner side indicating that the heat was greatest in the upper portion of this end of the compartment. Secondly, the vestibule near this end also shows burnt patches on the upper side while the lower portion of the rubber seal remains intact.

Conclusions

7. Given that, for the Delhi coach, there was no evidence of anyone throwing inflammable fluid on to the coach, the heat marks on the outside must have been caused by the heat inside. Any inflammable fluid thrown from the outside could not have produced such heat marks on the top end of the carriages unless the coach was on fire throughout its length inside.

8. It was reported for the Delhi coach that the fire was initiated, without the use of any inflammable fluid on the floor inside, between the first and second cabins and the seats burnt first. It took about 15-20 minutes for the fire and smoke to spread throughout the coach from the time the smoke was first noticed.

9. Therefore, in the case of the Godhra coach (where the damage is strikingly similar to the Delhi coach), it is possible that the fire originated in the region between the last two cabins and started by burning the lower berth first. The resultant dense and high temperature smoke spread to the top of the carriage and then moved along the ceiling and between the ceiling and the roof through the length of the coach. The radiative and convective heat generated

eventually resulted in a flash over when the fire engulfed the entire coach towards the top.

10. Hence, in the Godhra coach, it is highly unlikely that the fire could have started on the floor of the passage or the floor outside the toilets. Inflammable plywood and foam in three tiers of seats would not be available for the fire to burn in this area. If the fire was started by an inflammable fluid on the floor, the flames would have been noticed right away in a very crowded carriage, precluding the possibility of a long smouldering source.

11. Systematic recording of the evidence is highly desirable in all cases of burning of coaches to preserve and collate the evidence as soon as possible. A damage-mapping matrix is provided in Annexure II for the recording of data. This matrix clearly demonstrates the pattern of the fire in the Delhi coach and is amenable to analytical exercises for the purposes of understanding the source and course of the fire.

12. The procedures followed by the Forensic Science Laboratory in collecting and analysing samples leave much to be desired since simple activities like mapping, locating samples along a grid, developing an inventory of inflammable substances, and doing detailed spectroscopic analysis have not been pursued.

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The Fire

The similarities between the fire patterns in the Godhra and Delhi coaches are striking, as is the fact that both were stationary at the time the smoke and fire were noticed. However, the major difference is that, in the first case, the coach was more than full with passengers while, in the second case, the coach had no passengers as it was in the washing line. Hence, apart from the inflammable materials in the structure of the coach it is also necessary to consider the other materials that may possibly be accompanying passengers. A list of materials and their combustibility is given in Annexure III.

Observations

1. In the coach the most flammable material is the latex foam in the seat. This is, however, protected by a plywood base and a vinyl cover. The next most flammable material is the plywood base itself and if this is exposed to a source of ignition it will rapidly catch fire and, in turn, set the foam on fire too. The plywood can be set on fire by clothes and other materials stored by passengers below the seat. These materials can be set on fire by cigarettes, matchsticks or cigarette lighters that are still burning. If there is any cooking equipment with fuel stored below the seat, this can worsen matters (see Annexure III for burning properties of these materials).

2. The latex foam creates enormous clouds of hot, dense, asphyxiating, black smoke and this itself becomes the source of ignition for other materials as the temperature rises to flash point. The total combustible mass per berth is 10 kg. If this drops to the floor while it is burning, it will also ignite other berths, partitions, panels, and the vinyl flooring. Other materials in the coach that will melt and vaporise are the vinyl fabric cover (rexine) of the seat, laminated plastic partitions (sunmica) and vinyl flooring (linoleum). All these materials will jointly produce hydrogen cyanide, isocyanates, carbon monoxide and dense smoke.

3. The luggage carried by each passenger in a coach varies between 5-10 kg, and almost all luggage will carry clothes that are highly flammable. Any smouldering or lighted particle can set the luggage on fire, if it remains in contact long enough to raise the temperature for flammable materials to catch fire. For materials like cloth, plastics, paper, etc. to smoulder and set the plywood on fire it can take 10-20 minutes. Then the foam in the seat can be completely on fire within 5-10 minutes.

4. The depositions of the passengers suggest that very few escaped from the 9^{th} cabin side. The damage in the Godhra coach is similar to the Delhi coach. In the Delhi coach the fire is said to have originated on the 9^{th} cabin side. These

two pieces of evidence suggest that the fire must have originated on the 9th cabin side for the Godhra coach too. For the initial fire to have enough material to burn the seat plywood and foam on fire, and spread quickly, the fire would have to originate under the seats belonging to the partition between the 8th and 9th cabin.

5. If the fire originated around the 8th and 9th cabin, then the passengers in these cabins would have a chance to escape from the 9th cabin end and all the passengers in cabins 1-7 and some of those in 8 would move toward cabin 1 to escape. This is also suggested by the testimony of the witnesses.

Conclusions

1. To scientifically establish and understand the process of combustion, a dual strategy of experimental and computer simulations needs to be adopted. For the experimental part, instruments for measurement of temperature, gas sampling, and videography will have to be attached to a coach shell. Successive experiments will have to be conducted to set fire to differently furnished cabins and record the processes that follow.

2. By using coach geometry, materials and their properties, the fire can be simulated on a computer model for different scenarios. The results could be used for deciding location of fire detectors and safety interventions.

3. The available evidence for the Godhra coach strongly suggests that the fire initiated in the luggage below the seat in the 8th or 9th cabin and then spread through radiative and convective heating from the overhead smoke.

4. It is possible that the material below the seat smouldered and the plywood smouldered for 10-20 minutes or more before the smoke was noticed. Heavy smoke is not likely to have appeared immediately after the initiation of the fire.

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The Depositions

The statements made by several passengers and railway, police, and fire brigade employees to the police and the High Level Committee are available on record and provide some important insights into the incident. After careful screening it was found that there were 41 passengers, some bona fide and others not so, whose statements had some bearing on the pattern of the fire. Of these, about half could provide some idea of which seat they were occupying at the time of the incident. Their statements are summarised in Annexure IV.

Based on the statements given by those 19 passengers who could recall their position or exit mode, we have made an attempt to map the possible escape routes from the burning coach. The interpretation has been based both on what the passengers stated as well as an observation of which window bars were broken and the area of intense heat in which the floor was burnt. This map has been provided in Annexure V.

Observations

1. Of the 11 passengers who made statements in this regard, only 1 said that the fire began towards the engine (front) end of the coach. The rest were unanimous that the fire began from the guard (rear) end.

2. The limited information available from 4 statements suggests that the time taken for the fire and smoke to spread could vary between 10 to 20 minutes. All these statements have been made by passengers who were further away from the origin of the fire.

3. 14 passengers have testified to stone pelting on the coach and 5 of them were sure that the stones had come from the South (or platform) side.

4. 23 passengers said that some inflammable substance was flung into the coach. 10 of these even specified that this was in the form of a burning rag or “mashal” or petrol and acid thrown from outside. All these 10 passengers were in the 5^{th} or 6^{th} cabin from the front but did not mention their specific seat.

5. 4 passengers said some liquid was thrown into the lavatory. Of these, 3 belonged to one family who were located in the 1^{st} cabin. 4 passengers noticed some liquid on the floor and all of them were in the 5^{th} cabin.

6. 17 passengers said they had escaped out of the door and they all specified that this was towards the yard (North) side. 13 other passengers escaped out

of windows, again presumably towards the yard side because of alleged stone-throwing on the other side.

7. The mapping exercise indicates that all those passengers who were towards the passage side up to the 6th cabin and probably noticed the smoke first escaped out of the door on the yard side of the front end of the coach. Only 1 person escaped from the other door on the same side because he was sitting on berth 72 closest to the door. 3 others of one family in the 1st cabin said they had forced their way out from the space between the connecting vestibules in the front. 2 windows from which some of the bars were broken appear to have been the exit route for 6 other passengers. The bar joints can be broken from the inside by a few sharp blows with something heavy.

Conclusions

1. Those passengers with easy access to the door appear to have made their way quickly through it as soon as the first signs of smoke began appearing.

2. Others who were further away from the door and closer to the origin of the fire had to break their way out through the windows.

3. Apparently stone pelting from the South meant that people hesitated to make an exit from that side.

4. The huge majority (16/23) of those who said that inflammable substances were thrown from outside could not specify which seat they were in or what was their reserved berth. Of the remaining 7, only 3 were located near where the fire began near the 9th cabin. Of the other 4, 3 also belonged to the family that said they saw liquid being poured into the lavatory and were at the opposite end in the 1st cabin, while the 4th was in the 2nd cabin. Hence, the evidence points to the fact that the fire could not have been ignited by pouring petrol on the floor and setting it ablaze.

5. Recording of statements from passengers by the police has been totally unsystematic and shoddy. No method has been followed in the procedure, and many of the statements are repetitive as if they have been dictated. Thus vital clues have been missed and a scientific analysis of the probable causes of the fire has been subverted. A detailed and systematic procedure for recording of evidence must be laid down and all police personnel trained in adopting these procedures.

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The Mortalities

A total of 27 post mortem reports have been made available to us. The salient data from these reports is summarised in the Annexure VI. Out of 27 reports, 26 are for those who died on 27 February 2002 and one for an individual who died on 3 April 2002. Summary facts for 26 post mortem reports of 27th February 2002 are given below.

Observations

1. All post mortems except one were conducted in the railway yard.

2. 8 doctors performed the post mortems.

3. The reported time taken for the post mortems ranged between 20 to 75 minutes with an average of 38 minutes.

4. All the 8 doctors record almost exactly the same details for injuries with all body parts charred/roasted/burnt including internal organs and contents.

5. For all cases, the diagnosis is that the burn injuries were “ante mortem”.

6. For all cases, the cause of death is recorded as “shock due to burns”.

7. The estimated age of all victims ranges from 4 to 45 years. Only 3 persons were estimated to be less than 10 years old. The average age is 31 years, comprising 12 females, 14 males and 1 unknown.

8. Out of 17 post mortem reports, the identity of only 5 persons is known.

9. In 11 cases some details of the colour of clothes are recorded.

Conclusions

1. The post mortem reports can be considered unscientific and unreliable for the following reasons:
    a) 26 were conducted in the yard without adequate equipment and support needed for a scientific post mortem.
    b) Time taken (average 38 minutes) for the post mortem is far too little for obtaining details of injuries, preserving relevant tissues, etc.
    c) It is not possible that 26 bodies will have almost identical injuries.

2. In most cases it is recorded that almost all body tissues, including internal ones, were roasted/charred/burnt. For example, it is recorded that the

particles found in the small and large intestines were “roasted”. This is not possible unless the skin covering the abdomen and the intestines is itself completely burnt first in order to char or burn the contents. This is unlikely in all cases. If the burns are so deep and extensive some of the bodies would not have any structural form. This could also be true for many other internal body tissues recorded as roasted or charred. The fact that some of the bodies still had clothes whose colour could be recorded shows that the post mortem reports indicating all body parts to be charred/roasted/burnt are likely to be untrue.

3. In all cases the burns are recorded to be “ante mortem” and death caused by “shock due to burns”. There is no indication how all the doctors have arrived at this conclusion. Sophisticated methods are now available to determine cause of death by examining various body organs. In this case, at least the lungs should have been preserved to examine the contents of the tissues. Scientific examination of lung tissues available could have disclosed what chemicals were present whether the presence of such chemicals could have produced asphyxia. Similarly, examination of blood vessel and brain tissues may have given clues whether death was due to inhalation of poisonous fumes and/or asphyxiation or burns. None of this has been done.

4. It is well known among forensic scientists that even in house fires the victims very often become unconscious from inhaling fumes before they get burnt. It is surprising that this possibility was not considered by the doctors conducting the autopsies. In this case, the fire would have released isocyanates, hydrogen cyanide and carbon monoxide (Annexure III). With the presence of these gases people can fall unconscious and die within minutes depending on the concentration of gases.

5. It appears that those passengers, who were located at the rear end of the crowd and were from cabins 5-8 waiting to escape from the seat 1 end, never got a chance. They probably fell unconscious and/or died from asphyxia before the fire burnt them completely. This may be why all the passengers who died are reported to have been charred completely.

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The Injuries

A total of 56 injured victim reports are available with us. The salient data from these reports is given in Annexure VII. Out of 56 reports, 48 (86%) were examined on the 27th of February and 8 (14%) on the 28th February 2004. Summary facts for the 56 injury cases are given below:

No	Injury type	Number	Percent	
1	**Smoke and heat inhalation injuries, total**	**38**	**68**	
	Only inhalation	17	30	(45% of total)
2	**Burns, total**	**12**	**21**	
	Scalp and facial burns	10	18	(83% of burns)
	Upper limb	07	13	(58% of burns)
	Lower limb	03	05	(25% of burns)
	Torso	02	04	(17% of burns)
3	**Injuries, total**	**12**	**21**	
	Fractures (lower limb)	02	04	(17% of injuries)
	Lower limb injury	07	13	(58% of injuries)
	Upper limb injury	04	07	(33% of injuries)
	Torso	04	07	(33% of injuries)
		Total is greater than 56 as one person can have more than one injury type	*Total will be greater than 100 as one person can have more than one injury type*	

Observations

1. A majority of patients (68%) reported trouble in breathing due to smoke and heat inhalation. Almost half of these victims had no other problems except breathing trouble. Soot marks were largely on the face, head and upper body, at times on the hands. This indicates that soot laden smoke was only on the upper half of the carriage in the region where these victims spent their time before escaping.

2. Burn patients comprised only 12% of the patients treated. Of all the burn patients, 83% had facial and head burns and 58% had upper limb burns. Only 3-4 patients had more than superficial burns. This indicates that:
    a) Among these survivors, it is unlikely that any of them faced the full impact of the heat generated by the carriage fire. They probably managed to escape while the fumes were still in the upper regions of the compartment.

b) The fumes and the heat were localised in the upper half of the compartment where they were gathered before escaping.

3. Only 21 percent of the survivors comprising this sample suffered physical injuries. Only 2 injuries include fractures of the hand. Most of the injuries were to lower limbs and could have been sustained while escaping and falling from the compartment. The height of the compartment floor from the ground was more than 1.5 m. A fall from this height hands first can fracture an ulna. Falling head first from this height can produce serious head injury, especially among older people. If someone jumps feet first, fractured ankles, sprains, and bruises to knees etc. are very likely. Very few injuries to the upper body parts are recorded, indicating that they might not have been subjected to violence from others.

Conclusions

1. The fire initiated from the 8^{th} or 9^{th} cabin (seat 72 side) after smouldering for a while. The initiation is unlikely to have been noticed by any one and therefore it is unlikely that any burning material was thrown from outside as they would have then taken action before it smouldered.

2. It is unlikely that there was any fire on the floor as long as these survivors were in the compartment. If the evidence given by some passengers from the 5^{th}–6^{th} cabin that some inflammable substance was flung into the coach and that there was fuel on the floor is correct then this fuel would have caught fire and burnt the lower parts of passengers' bodies. Since this is not true for a vast majority of the cases, it is unlikely that there was any inflammable fluid on the floor in any significant quantity.

3. When the fire started and gave out a great deal of smoke, the occupants in the region of seats 64-72 (approximately) would have been taken by surprise and moved away. Most of them would have tried to escape from the exits on the seat 72 side. The occupants on seats 1-64 (approximately) side would have tended to move toward seat 1 to escape.

4. In the above circumstances, 150 or more people must have gathered between seats 1 and 50 or so trying to escape. These passengers must have been subjected to dense and toxic fumes emanating from the roof and upper levels of the compartment and radiative heat as the ceiling heated. At this time it is unlikely that there was anyone left between seats 48-64 where the smoke and fire would have been intense.

5. Most of the survivors are likely to be those who were in the region of the seats 1-40 and managed to get ahead. These survivors are those who sustained

the injuries mentioned above as they escaped the debilitating effect of the fumes.

6. Serious thought needs to be given to the design of doors and exits and emergency escape designs for Indian carriages, considering the high passenger load per compartment. Specific attention may be paid to the possibility of vestibuling all coaches and enlarging the passage way.

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Summary Conclusions

13. It is most probable that the fire originated in the region between the last two cabins (8 & 9) and started by burning the lower berth first. It is highly unlikely that the fire could have started on the floor of the passage or the floor outside the toilets by throwing of inflammable fluid.

14. The evidence regarding the initiation of fires suggests that materials like clothes, wood, etc., smoulder for 10-20 minutes at least before a major fire starts.

15. The resultant dense and high temperature smoke spread along the ceiling of the carriage and eventually resulted in a flash over when the fire engulfed the entire coach from the top.

16. The initiation is unlikely to have been noticed until the dense asphyxiating smoke emerged from the burning latex foam. The evidence from the Delhi coach suggests that after the first dense smoke is detected, it takes about 20-30 minutes for the whole coach to be on fire and full of smoke.

17. The nearest occupants in the last cabins (8 & 9) would have been taken by surprise and tried to escape from the exits on the seat 72 side. The occupants on seats in the other cabins would have tended to move toward seat 1 to escape.

18. In the above circumstances, 150 or more people must have gathered trying to escape, and been subjected to dense and toxic fumes emanating from the roof and upper levels of the compartment and radiative heat as the ceiling heated.

19. Since it would take a long time for the people to exit, a group of people from the last few cabins is likely to have been asphyxiated by toxic fumes full of soot and fallen unconscious to be burnt by the fire.

20. Passengers with access to doors and broken windows appear to have escaped as soon as the first signs of smoke began appearing. Apparently stone pelting from the South meant that people hesitated to make an exit from that side.

21. Such passengers logically show signs of soot, breathing difficulties, burns, and injuries in the upper body. Other injuries could be caused by falling from a height.

22. Systematic recording of the evidence and scientific investigation of the case has been marked by its absence. Specific procedures need to be developed for mapping the damage and interviewing the witnesses.

23. Procedures for scientifically collecting and analysing samples also need to be pursued in line with modern approaches in forensics and medical investigation.

24. A dual strategy of experimental and computer simulations needs to be adopted to understand the process of combustion. The results could be used for deciding location of fire detectors and safety interventions.

25. Serious thought needs to be given to the design of doors and exits and emergency escape designs for Indian carriages, considering the high passenger load per compartment.

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ANNEXURE 1
COMPARISON BETWEEN GODHRA AND DELHI COACHES

HEAT MARKS ON THE OUTSIDE OF THE COACH WITH PAINT MELTING GREATER ON THE END WHERE FIRE INITIATED

GODHRA COACH

COACH 16526 BURNT IN DELHI

HALF THE FLOOR LENGTH CRUMBLED ON THE SIDE WHERE FIRE STARTED

GODHRA COACH

COACH 16526 BURNT IN DELHI

DETAILS OF THE SIDE WHERE FIRE INITIATED

GODHRA COACH

COACH 16526 BURNT IN DELHI

SEAT AND WINDOW DETAILS

GODHRA COACH

COACH 16526 BURNT IN DELHI

CRINKLING OF THE BODY

GODHRA COACH

COACH 16526 BURNT IN DELHI

CEILING DAMAGE

GODHRA COACH

COACH 16526 BURNT IN DELHI

SPECIFIC FEATURES OF GODHRA COACH

GODHRA COACH, WATER TANK FROM THE SEAT 72 END

GODHRA COACH, SEAT 72 END. DAMAGE MARKS SHOW FIRE SPREAD TO THE END FROM THE TOP

Annexure II
Damage Mapping Matrix

		Vest.	Toilet	Pass.	C1	C2	C3	C4	C5	C6	C7	C8	C9	Pass.	Toilet	Vest.
Vestibule		O														O
Toilets	Right		O												X	
	Left		O												½	
Passage	Floor			O										O		
	Ceiling			O										O		
Partitions	Upper				O	X	X	X	X	X	X	X	X	X		
	Lower				O	O	O	O	X	X	X	X	X	X		
Side Panel	Upper				O	X	X	X	X	X	X	X	X	X		
	Lower				O	O	O	X	X	X	X	X	X	X		
Window Right	Shutter				O	O	O	O	X	X	X	X	X	X		
	Inner				O	O	½	½	X	X	X	X	X	X		
	Frame				O	O	O	O	O	X	X	X	X	X		
Window Left	Shutter				O	O	X	X	X	X	X	X	X	X		
	Inner				O	½	½	X	X	X	X	X	X	X		
	Frame				O	O	O	X	X	X	X	X	X	X		
Berths					O	O	O	O	X	X	X	X	X			
Floor					O	O	O	O	O	X	X	X	X			
Ceiling	Asbestos				O	O	O	O	O	O	O	½	½			
	Insulation				O	O	O	O	O	O	O	O	O			
Fan warping					O	O	X	X	X	X	X	X	X			
Under-floor					O	O	O	O	O	O	X	X	O	O	O	
Outer paint	Lower				O	O	O	O	½	X	X	X	X	O	O	
	Upper				O	X	X	X	X	X	X	X	X	X	X	

O = not damaged
½ = half damaged
X = fully damaged

Annexure III
Combustibility of Materials in Sleeper Coaches

A. Inventory of coach materials

S.No.	Item	Material	Fire Resistance
1.	**Seat**		
1.1	Base	Plywood	Inflammable
1.2	Cushion	Latex foam	Highly inflammable
1.3	Cover	Vinyl coated fabric	Resistant
2.	**Shell**		
2.1	Coach shell	Mild Steel	Highly resistant
2.2	Inside coating	Bituminous emulsion	Slowly inflammable
2.3	External finish	Ready mixed paints	Resistant
3.	**Floor**		
3.1	Base	Compreg plywood laminated with Phenol Formaldehyde	Resistant
3.2	Covering	Vinyl sheet	Resistant
3.3	Under-floor	Steel trough with bitumen underlay	Resistant
4.	**Ceiling**		
4.1	Bitumen adhesive	Bitumen	Slowly inflammable
4.2	Insulation	Synthetic wool	Resistant
4.3	Covering	Limpet Asbestos	Highly resistant
5.	**Side & Separating walls**		
5.1	Panels	Laminated plastic	Resistant
6.	**Window assembly**		
6.1	Frame	Aluminium extruded	Melts
6.2	Glass window frame	Aluminium	Melts
6.3	Window sheet	Safety glass	Shatters
6.4	Shutter	FRP moulded	Light resistance

B. Inventory of passengers and goods

S.No.	Item	Material
1.	Clothing	Fabric+Garment Leather Plastic (chappal)
2.	Human tissue	
3.	Carrying case/bag	Molded plastic Soft cover plastic Cloth Plastic bags Metal trunk
4.	Personal goods	Cloth Paper Metals Food Water Leather
5.	Cloth sheet	Cloth
6.	Pillow	Plastic Cloth
7.	Other materials	Fuel

C. Combustible materials - mass comparisons

Coach material per passenger = 1 berth + an apportioned amount of the floor
Mass of 1 berth = 1 kg foam + 500 g vinyl fabric (estimates)

Personal material per passenger = Clothes + Luggage
Mass of clothes = 1 kg
Mass of luggage = 5 – 20 kg

Total mass of combustible materials brought in by passengers is greater than that in the coach.

Also, materials brought in by passengers are more flammable than coach materials with the exception of the latex foam.

D. Ignition sources

Sources of ignition could be one of the following:

1. Electric spark
   Many office and pandal fires are attributed to short circuits. In the coach the wiring is in conduits and with relatively insignificant amounts of flammable material around it.

2. Burning or smouldering match-stick
   Such an ignition source has been the cause of coach, domestic and other fires in the past. A person lighting a match-stick and then throwing it down after use can initiate a fire if the smouldering match-stick falls on clothes or baggage that is inflammable.

3. Cigarette/beedi
   A person smoking in a coach is not unusual. A lighted cigarette/beedi could come in contact with cloth/clothes on the floor which could initiate the fire.

4. Burning material from outside
   A burning rag or other combustible material thrown from outside would have to first penetrate between the bars on the windows before landing on people and luggage to initiate a fire.

5. Lighted Stove
   It is possible that someone was carrying a stove with fuel in it and had placed it under a seat.

E. Location of ignition

The ignition, particularly from lighted cigarette or burning match-stick, could occur at either of the following locations:

a. On the floor
   Materials such as plastic bags, cloth bags or newspapers lying on the floor could be the location of the ignition source.
b. Beneath the seat
   Personal luggage under the seat could ignite when the source comes in contact with it.
c. On the upper berths
   Items that could ignite would include bed sheets spread out on the berth or luggage (particularly plastic bags and cloth items) placed in the middle or lower berths.

d. External effect
Operating ceiling fans on a train has the effect of circulating air in the compartment that could fan the fire, accelerating the burning rate.

F. Ignition and burning properties

Critical Radiant Flux for ignition (in kW/m^2 - an indicator of flashover) of:[1]

1.	Newspaper	20
2.	Polyurethane (foam)	16-34
3.	PVC (rexine etc.)	21

Average surface temperature at ignition in degrees C

Untreated cotton	~250[2]
Untreated polyesters and nylons	250 - 350[2]
Newspaper	292
PVC	507

("When the polyurethane foam started smouldering about 10-20 minutes after cigarette placement substantial heat feedback to the cigarette core apparently occurred. Peak smoulder temperatures in polyurethane foam were about 400°C or higher, and smoulder front progress in those foams which smouldered was about 6 mm/min")[3]

Cardboard	636
Cigarettes[3]	
Center	763-802
Surface	394~510
Butt temperature	627~72
Wood	300-500[4]

It may be noted that even buildings constructed of non-combustible materials will almost without exception contain materials that burn under certain circumstances. Hot surfaces can also cause fire. A heated metal surface can transfer sufficient heat (by conduction) to raise the temperature of some materials above their ignition temperature. When a fire has generated sufficient heat to make the upper reaches of a room very hot, there can eventually be sufficient radiation from this hot layer to ignite essentially all of the remaining unburnt materials in the area. This is termed flashover. Survival in the room would not now be possible.[4]

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[1] Source: Fire Protection, 16th Edition, National Fire Protection Association, Quincy, Mass, 1986.
[2] Personal Protective Equipment — PPE005, OHS Act & Regulation & Code, Government of Alberta, Edmonton.
[3] John F. Krasny (1987) Cigarette Ignition of Soft Furnishings - a Review With Commentary. Technical Study Group, Cigarette Safety Act of 1984. Center for Fire Research, National Bureau of Standards, Bethesda, MD.
[4] F.R.S. Clark (1988). Control of Ignition in Building Materials, CBD-249. The Institute for Research in Construction ,National Research Council, Ottawa.

Gases released[5]

PVC: Carbon monoxide (CO) and hydrochloric acid.

Foam (CO). Free isocyanates, hydrogen cyanide, carbon monoxide

Effects of free isocyanates:[6]

- eye irritation, watering and discomfort;
- irritation of the respiratory tract;
- dryness of the throat;
- tightness of the chest;
- difficulty in breathing;
- headaches;
- asthma attacks;
- reddening, swelling and blistering of exposed skin if not washed off; and dermatitis

Effects of hydrogen cyanide on humans:[7]

Hydrogen cyanide can cause rapid death due to metabolic asphyxiation. Death can occur within seconds or minutes of the inhalation of high concentrations of hydrogen cyanide gas. A recent study reports an estimated LC(50) in humans of 3,404 ppm for a 1-minute exposure; other sources report that 270 ppm is fatal after 6 to 8 minutes, 181 ppm after 10 minutes, and 135 ppm after 30 minutes.

Effects of carbon monoxide on humans:[8]

Carbon monoxide is an asphyxiant in humans. The signs and symptoms of acute exposure to carbon monoxide may include headache, flushing, nausea, vertigo, weakness, irritability, unconsciousness, and in persons with pre-existing heart disease and atherosclerosis, chest pain and leg pain.

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[5] Polymer Encyclopaedia, Suppl. Vol. Page 887.

[6] Guidance Note - Controlling Isocynate Hazards at Work (2001), Document ID: 3384, WorkSafe Western Australia.

[7] Occupational Safety and Health Guideline for Hydrogen Cyanide (2000), U.S. Department of Labor, Occupational Safety & Health Administration, Washington, DC. http://www.osha-slc.gov/SLTC/healthguidelines/hydrogencyanide/recognition.html

[8] Occupational Safety and Health Guideline for Carbon Monoxide (1996,) U.S. Department of Labor, Occupational Safety & Health Administration, Washington, DC. http://www.osha.gov/SLTC/healthguidelines/carbonmonoxide/recognition.html

Annexure IV
Statements of Passengers

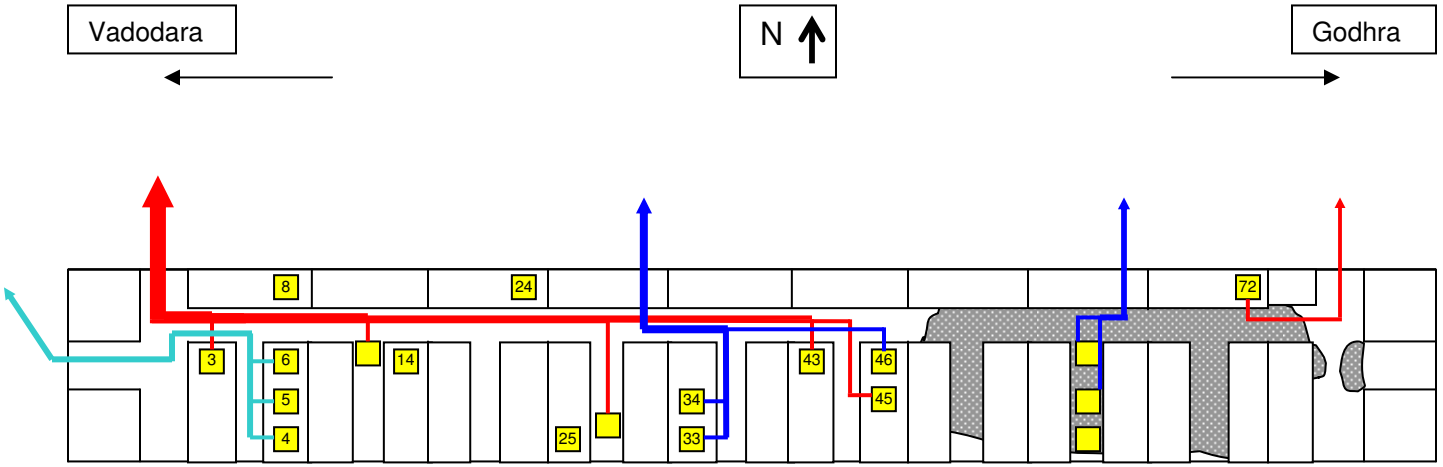
no	Name	Seat in S-6		Initial fire*		Spread time	Stone pelting		Substance thrown				Escape route	
		Reserved	Actual	Rear	Front		South	Unknown	Inflammable	From outside	Liquid		Door	Window
											lav	flr		
1	R R Rajput	62,63,64	Near 62	Y				Y	Y					Y
2	S Pal	58,59,61	On floor							Y				
3	V Pal	58,59,61	On floor											Y
4	R K Pande	45	45					Y					Y	
5	H M Joshi	41,44	43	Y			Y						Y	
6	S R Mishra	33,34,35	33,34											Y
7	Archanaben	33,34,35	33,34											Y
8	A J P Tiwari	18,19,20,21	Near 25		Y	10 min								Y
9	Poonam	18,19,20,21	24	*Page missing*										
10	H M Sharma	11,13	Near 13	Y				Y			Y		Y	Y
11	G R Panda	9	3	Y		15-20							Y	
12	L Chaurasiya	8,72	8			10-15								
13	G Chaurasia	8,72	72							Y			Y	
14	B S Kushvai	4,5,6	4							Y	Y			
15	Pujaben	4,5,6	4							Y	Y			
16	Umaben	4,5,6	4							Y	Y			
17	D R Patel		4th row	Y										
18	Savitaben	{5h comp}	20/25	Y				Y		(rag)		Y		
19	R B Patel	{mid-coach}	5th comp	Y					Y	(mash)		Y		
20	N C Patel		5th comp	Y				Y		(mash)		Y		
21	D N Patel		5th comp	Y				Y		(mash)		Y		
22	Gayatriben		41,46							(pet/acd)				Y
23	J U Patel			Y			Y			(ker)				Y
24	D K J Patel						Y			(pet/acd)			Y	
25	M J Shah						Y			(pet/acd)			Y	
26	Mandakiniben									(pet/acd)				Y
27	N T BHatia						Y			(pet/acd)				Y
28	J M Goswami												Y	
29	M Chaudhari					sudden								Y

30	Kumari Ruby		Near tl										Y	
31	Prema Devi													Y
32	Pushpa Devi		Near tl										Y	
33	M J Shah								Y				Y	
34	S Sukhadiya								Y				Y	
35	R B Thakor								Y					
36	Jankiben								Y				Y	
37	H U Patel								Y				Y	
38	D R Patel							Y	Y				Y	
39	B U Patel							Y					Y	
40	A G Patel							Y						
41	L K B Jadav	32 {S-7}	S-6										Y	

* fire also includes smoke
Rear means towards the guard (Godhra) side
Front means towards the engine (Vadodara) side
lav = in lavatory
flr = on floor
Door is the one towards the engine side (West) facing the yard (North)
Window is facing the yard (North) where mentioned
Y = yes
Comp = compartment
tl = toilet towards the engine side
rag = burning rag
mash = burning 'mashal'
pet = petrol
acd = acid

Annexure V

Escape routes as suggested from S-6 coach passenger depositions



25 Passenger on seat number as given

Passenger on the floor near the seat

Approximate area of burnt floor

Probable escape routes

Annexure VI
Post Mortem Reports

SN	Identity	Age	Sex	Description of injuries	Injuries	Cause of Death	Date of Autopsy	Time taken for autopsy	Remarks	Doctor's name
1	Unknown	30	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	75	red coloured chaniya	SN Sutaria
2	UK	45	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	50	bl sweater, ring	Rajesh Kumar
3	VP PATEL	35	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	50	pant bukra coloured	Rajesh Kumar
4	UK	25	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	45		Rajesh Kumar
5	UK	40	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	45	saree yellow red	Rajesh Kumar
6	UK	35	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	45		PG Rathod
7	RS VAGELA	25	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	60		PG Rathod
8	UK	10	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30		MS Patel
9	UK	8	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30		MS Patel
10	UK	40	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30		MS Patel
11	UK	30	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30	Ankle silver ornament	MS Patel
12	Devkala Ben	42	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	60		Y Jain
13	UK	20	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	60		Y Jain
14	UK	4	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	35		Y Jain

15	UK	30	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	25		Y Jain
16	UK	35	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	20		Y Jain
17	ABJ Patel	40	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30	Bukra colour pant, bl purse	KB Sainik
18	UK	35	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30	yellow bangles	KB Sainik
19	UK	30	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30		KB Sainik
20	UK	40	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30	Head and neck missing	S Sinha
21	UK	40	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30		S Sinha
22	UK	5	?	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	25		SB Shah
23	UK	45	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	25	Brown shoes	SB Shah
24	UK	35	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	20	Glass Bangles	SB Shah
25	UK	40	M	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	40		SB Shah
26	UK	25	F	Charred/ burnt/ roasted	Ante mortem	Shock due to burns	27-Feb	30	Plastic chappal	SB Shah
27	Prahalad Bhai Jayanti Bhai Patel	42	M	Bandage on Head, lt shoulder, both ankle, Rt venal section	Ante mortem	Septic shock due to burns	03-Apr	60		SK Yadav
	Summary/ Average	31	12 F 14M and 1UK					38		

Annexure VII

Summary of victims treated for injuries and burns

N	Dt of treatment (Feb)	Symptoms
1	27	Inhalation problems
2	28	Inhalation problems, burning in neck and chest
3	27	Inhalation inj difficulty breathing
4	27	Inhalation inj, face with soot
5	27	Inhalation inj throat and chest, face soot
6	27	Inhalation inj, eyes, throat chest hurting
7	27	Inhalation inj, eyes, throat chest hurting
8	28	Inhalation inj in throat, both hands and r. lower limb inury
9	28	Inhalation inj
10	28	Burns both knee, upper 1/3 of both leg, 20% burns
11	27	Inhalation burns, Facial burns
12	28	Inhalation inj
13	27	Back injury, reddish skin
14	28	Injury rt knee
15	28	Blunt inj rt chest
16	28	Anxiety and depression
17	27	3 inch laceration scalp, laceration finger
18	27	Fx ulna
19	27	Swollen forearm, swollen leg, fx lower 1/3 ulna
20	27	Inhalation inj
21	27	Ankle swelling
22	27	Inhalation inj
23	27	Inhalation inj, rt leg pain
24	27	Inhalation inj
25	27	Inhalation inj
26	27	Inhalation inj
27	27	Inhalation inj, Face and hands singed
28	27	Inhalation inj
29	27	Inhalation inj, face with soot
30	27	Inhalation inj, face superficial burn
31	27	Inhalation inj, face with soot
32	27	Chest pain
33	27	Inhalation inj
34	27	Inhalation inj, facial & rt hand burn
35	27	Inhalation inj, sup burn face and both forearm
36	27	face and hands soot
37	27	Superficial burns face, rt forearm, hand, back lumbar reg, lt hand
38	27	Superficial burns lt thigh and knee joint
39	27	Superficial burn face and both hand
40	27	Inhalation inj, 5% superficial burn
41	27	superficial burn scalp, back rt upper limb, lt hand
42	27	Inhalation inj, burn face and both hands
43	27	Inhalation inj
44	27	burning pain in eyes
45	27	Inhalation inj, abrasion rt knee jt
46	27	Abrasion
47	27	Inhalation inj, pain rt chest
48	27	Inhalation inj
49	27	burning in eyes, pain & swelling rt foot
50	27	Inhalation inj
51	27	Inhalation inj
52	27	Inhalation inj
53	27	Inhalation inj
54	27	Inhalation inj
55	27	Inhalation inj
56	27	Inhalation inj