

A STUDY ON THE EMERGENCY RESPONSE MANUAL FOR URBAN TRANSIT FIRES

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ABSTRACT

Inadequate guidelines for the manual of fire emergency procedure could result massive damage subway passengers evacuation. Information about the early situation of fire propagation is important for the judgment of suppression and safe evacuation during the emergency response. Practical procedures for fire emergency are suggested on the flow chart with required activities and actions to take under certain levels of heat radiation and evacuation process, firepower, and speed of fire propagation.

KEYWORDS: Emergency response communication, Fire evacuation

INTRODUCTION

The response to a subway fire incident depends on the rapid and proper judgment of locomotive engineer, operation control center, and stationmaster and staffs including size of the fire and early response using fire equipment.

Major obstacles that were found by analyzing subway fire response capacity in Korea generally rose from inadequate understanding of initial status because of impractical operational guidelines and communication system.

The existing manual neglects the relation between the speed of fire propagation and safe evacuation conditions.

Actual case of fire propagation had been simulated and analyzed from Daegu subway fire and it is found that in 7 minutes 20 second a whole subway cabin burnt with flashover and spread to the next cabin.¹ The result implies that under such circumstance it is difficult to separate the burning cabin from the subway train and to suppress the fire with limited size of extinguisher.

However, if heat resistance was improved the time to flashover can be delayed so that emergency response such as evacuation or fire suppression can have more strategical process by accounting driving schedule and suppression condition.

This paper reviews the case of Daegu subway fire (2003) and Seoul metro 7 line fire (2005) from the view of efficient and practical emergency response manual.

THE ANALYSIS FOR FIRE EMERGENCY AND RESPONSE AT SEOUL METRO SUBWAY 7 LINE

An arson fire accident occurred at 7:10 a.m. Jan. 3, 2005 at the 6th cabin on subway Line 7. Passengers reported to the train driver about the situation through the interphone, however, the driver could not catch up the situation due to the noise from interphone. Aside a passenger called the fire brigade and reported the situation.

As soon as the train arrived to the next station (chulsan) passengers on cabin 6, 7 and 8 and who were waiting for the incoming train at the platform (about 120 people) rapidly evacuated by themselves, but

there were no proper message announcement in the train neither platform nor the alarm activation. The train stayed for 4 minutes at the station to confirm the situation, however, finally, the train driver misjudged the situation because the driver watched smoke at the rare side of platform that he thought fire happened from out side of the train, so that driver shut the doors and promptly move the train to the next station (Kwangmyeong).⁴

After the train arrived the following station (Kwangmyeong) the fire propagated a quarter part of a cabin, the station master and employee suppress the fire by applying 20 kg, A, B, C type extinguisher in 2 minutes 40 seconds.

TABLE 1. Accident situations and response

Station	Garibong	Cheolsan	Gwangmyeong	Cheonwang	Onsu			
Time	7:10 Started	7:13.18 arrived 7:17.19 Started	7:19.22 arrived 7:22.03 Started	7:28.25 Passed	7:31.44 arrived	7:36	8:54	10:44
delay time	3.18		4.01	2.03	2.41	6.22	3.19	4.16
due Time	2 minutes		2 minutes		3 minutes	3 minutes		
S i t u a t i o n	<ul style="list-style-type: none"> • Fire started about 7 : 12 (presumed burning time about 7 min 22 sec) 			<ul style="list-style-type: none"> • Between 9 minutes 41 second recurrence fire • One of a passenger car fire occurrence while moving 	<ul style="list-style-type: none"> • A passenger car complete combustion after arriving. The train ignites again 		<ul style="list-style-type: none"> • It supplies an electricity in the train railway line 	
	R e s p o n s e	<ul style="list-style-type: none"> • The passenger propagates a fire situation in the engine driver • The passenger propagates a fire situation in the fire station • The cleaner propagates a fire situation in the station employee • Getting off(6,7,8 40+platform80) About 120 people it takes shelter 	<ul style="list-style-type: none"> • 3 person stations employee fire suppression execution • Passenger all getting off • After fire suppression confirming with car shed operation instruction, Opposition side train railway line operation execution 	<ul style="list-style-type: none"> • Train passage . Interval maintenance proceeding slowly, 	<ul style="list-style-type: none"> • Firemen arrived • Fire suppression completion 			

At Kwangmyeong station all passengers on the train had dismissed. The station master reported to the train controller about the fire suppression and promptly decided to return all the line operation in normal schedule except the accident train. However, from the emptied subway train a ceased charcoal reignited and entirely burnt down two cabins on its way returning to the switch yard.

The problems in this case can be pointed out from the train fire process to the related persons` response as follows.

First, the driver missed the passengers` message from interphone and no further actions to take to follow and confirm the situation. Second, the station masters judged by themselves that the fire ceased with no inspection and approval from professional fire brigade. Third, at the switch yard for refurbishment of burnt cabin it was difficult to use fire hydrant because of install location and electricity cut off system.

EXISTING SUBWAY FIRE EMERGENCY RESPONSE MANUAL WITH ITS PRESENT SITUATION AND PROBLEMS

The current emergency manual for subway fire accident consists of comprehensive operation control, station, crew, rolling stock, and electricity. It contain with actions and activity followed by fire

occurrence scenarios. (Fig. 1)

The existing manual has problems as follows.

- (1) Existing response plan deals with only general patterns of fire accident. It needs to start from fire detection (human or hardware) to confirm the situation, information transfer to the operation controller, judgment of response action procedure.
- (2) The initial stage of fire occurrence situation is important to decide the response strategy, considering actual time required, position, number of injured passengers, and relevant information about the situation.
- (3) There are more than 30 cases of driving interference report from minor to major situations a day. All possible accidents need to be classified in order for more effect and timely response.

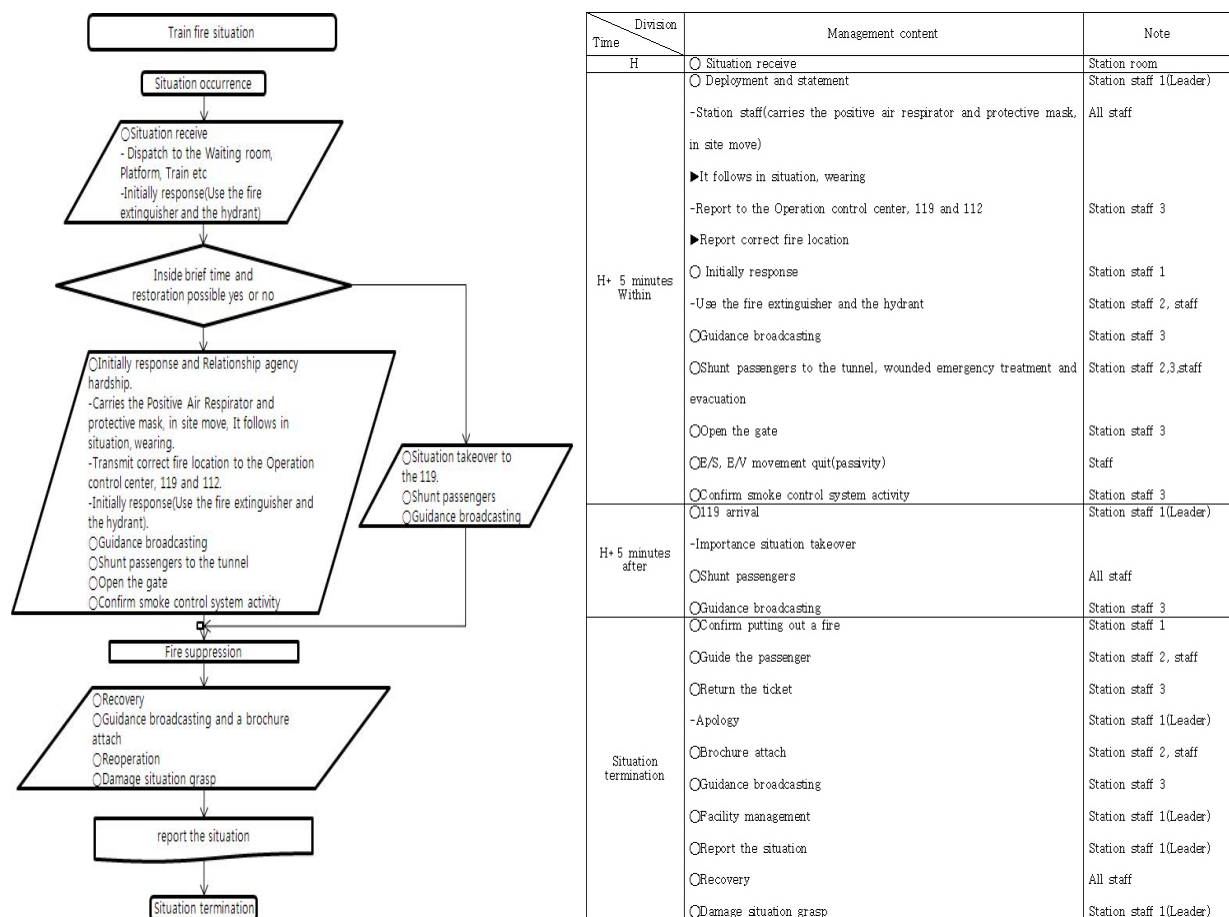


FIGURE 1. Current response flows and action required

FORMULATION OF EMERGENCY LEVELS AND RESPONSE PHASES

Based on the emergency level, a proper initial response to subway fire is required considering the spatial characteristics since the subway operates underground and the speed of fire propagation.

TABLE 2. Emergency levels

Level	Definition	Staff
Level 1 (Incident)	1. The initial stage of fire occurrence situation - No damage 2. The fire is detected by the fire detection system	Passenger, Driver operation control center, Station crew
Level 2 (Accident)	Ignition and the initial stage of enlarge combustion	Passenger, Driver operation control center, Station crew, a volunteer fire brigade
Level 3 (Major Accident)	The stage of after flashover situation	The organs concerned Fire brigade, Police, Hospital

Emergency level is classified by the size of fire and response phases. Definition of emergency status and levels are shown in Table 2. Level 1 (incident) is the initial stage of fire occurrence with no damage. In this stage, the fire is detected by the fire detection system and damage can be checked by passengers or crews. The information is disseminated to passengers, driver, operation control center, station crews, and outside.

Level 2 (accident) is the initial stage of fire spread and suppression and control is possible by passengers, station crew, or volunteer fire brigade in this level. This level can be defined as the period between fire spread and flashover. When the fire cannot be controlled, the level goes to the next stage, level 3.

It is analyzed that the flashover is reached in 2 to 3 minutes after the fire started in a cabin with normal inside-materials in it. This was the case of Daegu subway arson incident. However, when tested in a cabin with improved inside-materials, the flashover did not occur.*

Level 3 (major accident) is the stage that the flashover is reached and the fire is uncontrollable. Massive damage is expected including human casualties, property damages, and environmental impact. At this stage trains can be burnt totally and fire suppression and passenger evacuation need outside help.

Fire caused by arson depends on the fire origin and location and specific circumstances such as crowdedness of the train in Levels 1 and 2. In Level 3, however, response procedures are similar since the fire characteristics are somewhat identical.

The speed of fire propagation and size of heat radiation is completely conditional. However, the threshold decision of emergency from level 2 to level 3 may need more practical guidance.

For instance, the refurbished Seoul metro's subway cabin interior materials have demonstrated its heat resistance level that if similar situation were happened (arson applied 4 liters gasoline), the fire cannot reach flashover point.

It has simulated if 9.8 liters of gasoline were applied and 7000 kW of heat burnt on 2.9 m² floor, the delayed time for flashover could takes about 60 s.

* Judgment of Flashover (based on the ISO 9705 Room Corner Fire Test)

- * The heat radiation ratio (H.R.R.) is over 1MW
- * The heat flux reaches 25kW/m² on the floor
- * Ceiling smoke temperature is over 650°C
- * The flame escapes through the door
- * Paper on the floor catches fire

The assumed heat radiation level of 100°C can be reach to the people in the center of cabin at the height of 1.8 m takes about 7 to 10 s.

Therefore, the available condition of evacuation and suppression should be taken instantaneously, and if the fire propagate beyond flashover point emergency actions should be taken from level 3.

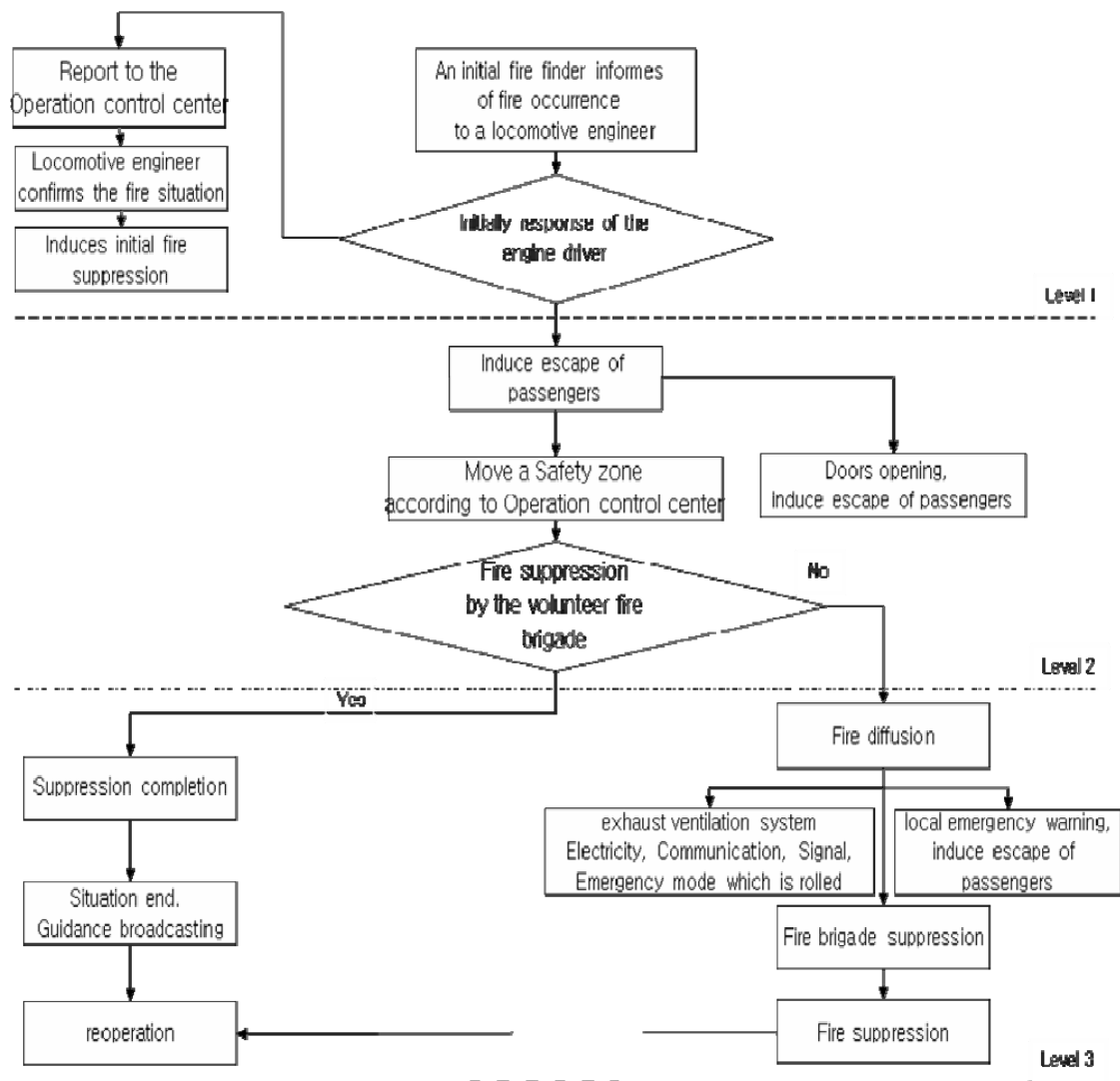


FIGURE 2. Emergency response procedures for train fire

For subway fire, emergency response procedures are shown in Fig. 2. When passengers notify to the driver about the fire, the driver reports to the operation control center (OCC), confirms the fire, and encourages the passengers to distinguish the fire as Level 1. Unless the fire is distinguished, the level goes to Level 2. At this stage train doors need to be opened, passenger evacuation is necessary under the control of OCC, and volunteer fire brigade is mobilized to suppress the fire.

In Level 3 outside fire brigades are mobilized and cooperation with other agencies is necessary. Recovery programs for resume of operation or train return are put in force during this stage.

SUGGESTION OF EMERGENCY RESPONSE MANUAL CONSIDERING CODE AND EMERGENCY LEVEL

Table 3 shows code classification according to the emergency situation identifying accident type, accident object, train type, and accident location using 4-digit code. For example, F114 refers that the first 'F' indicate fire, the second digit '1' indicate train, the Third digit '1' indicates passenger train, and fourth digit '4' indicate tunnel. So, code F114 scenario means that a fire accident happening on a passengers transport train in tunnel

TABLE 3. Classification of train accident

Number	F	1	1	4
Class	Accident Type Letter	Accident Object Number	Train Type Number	Location Number
Notation	<ul style="list-style-type: none"> ▪C :Collision ▪D :Derailment ▪F :Fire ▪P :Person ▪R :Rolling stock ▪I :Infrastructure ▪H :Hazard ▪N :Nature ▪T :Terror 	<ul style="list-style-type: none"> ▪ Train ▪ Cabin ▪ Building ▪ Facility ▪ Etc. 	<ul style="list-style-type: none"> ▪Passenger ▪Cargo ▪Hazmat ▪Passenger-Cargo ▪Passenger-Hazmat ▪Cargo-Hazmat ▪Others 	<ul style="list-style-type: none"> ▪Station ▪General Track ▪Bridge ▪Tunnel ▪Crossing ▪Switch Yard

Fire scenario for code class “fire-train-passenger-tunnel” is shown in Fig. 3. It displays detection of the fire, information dissemination, fire confirmation, emergency response level, etc. In Fig. 4, emergency response plan is shown separating initial fire suppression stage and evacuation stage based on the fire scenario.

Table 4 shows initial response recommendation for various responders based on the emergency scenarios. Effective emergency response will be possible through early response and minimizing damages.

CONCLUSIONS

A successful emergency response depends on the initial response at the fire site and the initial response depends on the efficient and proper information flow among passengers, the driver, operation control center commander, and stationmaster and staffs.

Fire suppression and evacuation plan should be considered in advance and formulated as a manual. The manual is supposed to consider the size of initial fire, train operation hours, locations, positions, and others with specified levels and phases.

The manual, however, should be simple enough to be familiarized by the drivers and station staffs for an efficient emergency response.

Fire Scenario

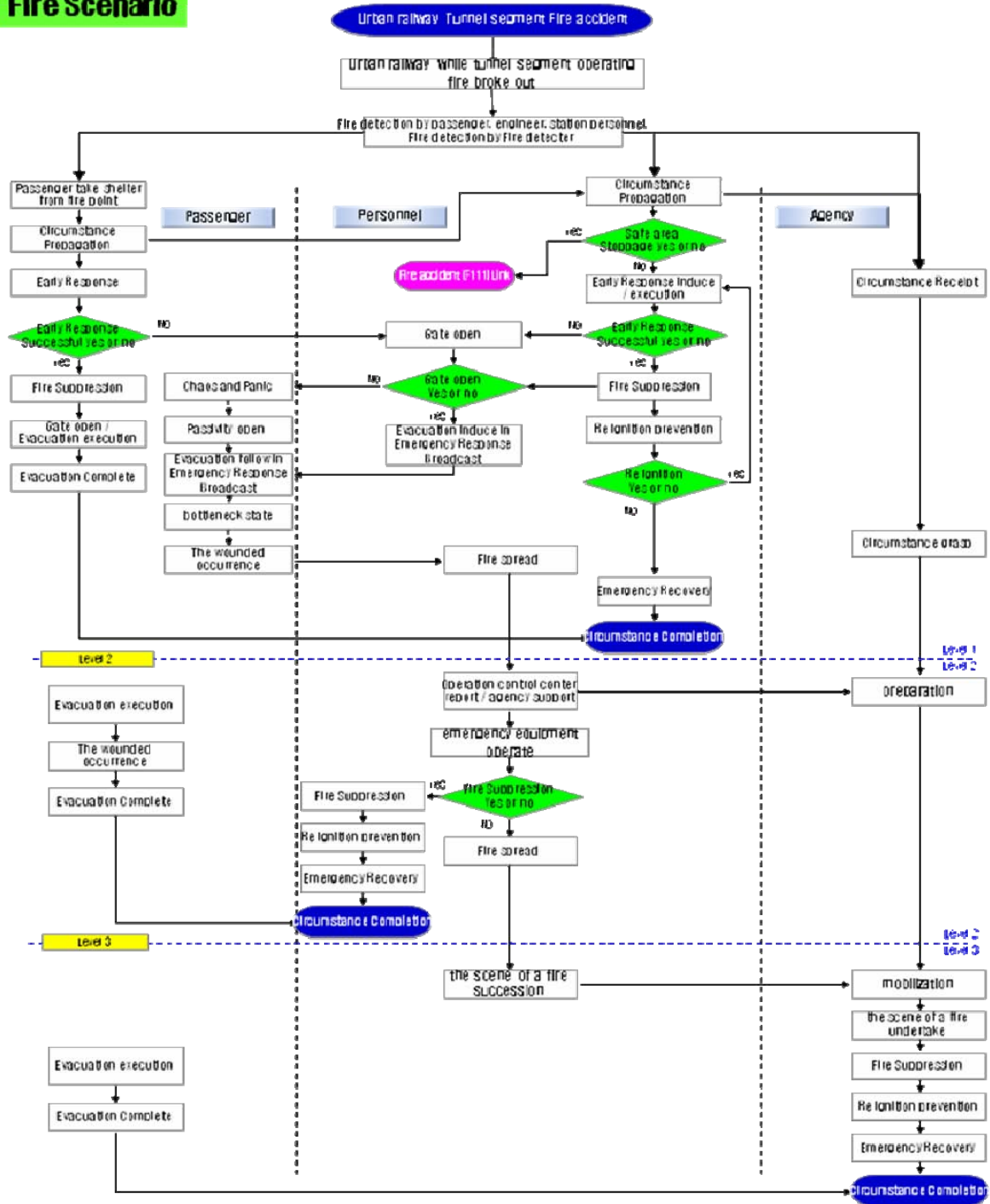


FIGURE 3. Fire scenario

Emergency Response Manual

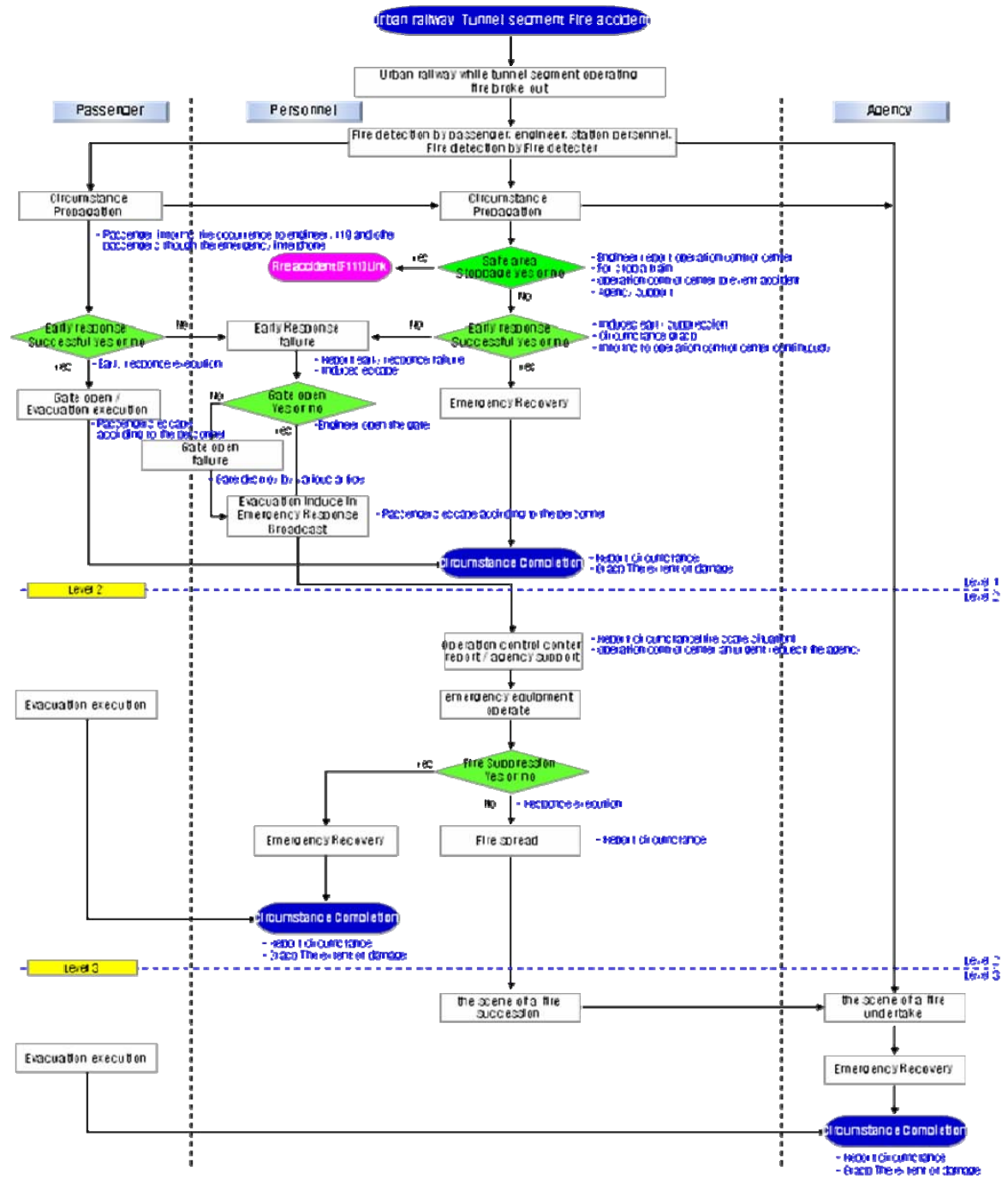


FIGURE 4. Emergency response manual

TABLE 4. Emergency response plans

	Emergency response under scenarios
Passenger	<p>An initial fire finder (passenger) informs fire occurrence to a locomotive engineer through the emergency interphone. At this time, it must be informed accident situations in minute detail. Information about accident must be informed to other agencies (operation control center, 119, 112, and other passengers).</p> <p>First passenger extinguishes initial fire by installed fire extinguisher in train. (For Flammable liquid fire, if the case not to do initial fire suppression, passenger must cope with it rapidly because the propagation of fire is very fast)</p> <p>After fire fighting, passengers escape from fire car to other cars quickly and observe fire location to prepare re-combustion.</p> <p>When the train stops, passengers escape according to the guidance of the staff.</p>
Locomotive engineer	<p>After receipt, locomotive engineer confirms the fire situation and inform all passengers of fire accident.</p> <p>The driver informs operation control center quickly that the fire situation is receipted, induces initial fire suppression and receipts information of passengers.</p> <p>For movement a train, he induces passengers from fire car to other cars and directs passengers to observe re-combustion.</p> <p>He informs to operation control center continuously so that it can deal with this situation.</p> <p>For stop a train, he must open doors quickly, induce escape of passengers with station staffs and gaze into the fire site.</p>
operation control center	<p>Receive the situation (location, damage, Etc.) of an accident and inform to other agencies (119, 112 and concerned stationmaster).</p> <p>Inform to concerned operation control center (other line operation control center, total traffic control center of transit co., etc.), grasp the possibility of initial fire suppression, grasp either restore or not and either operate or not short time, decide either stop or move a train, direct isolation stop or transit (prevent concerned accidents).</p> <p>Prohibit stop of the following train at a space between two stations, if not, direct backward movement or stoppage of the train service before a direction of passenger evacuation.</p> <p>Inform a situation according to the delay operation and the damage.</p> <p>When is over, grasp and inform the damage, inform the reoperation (to locomotive engineers and stationmaster), direct normal service and arrange operation.</p>
Stationmaster & staff	<p>Stationmaster who receives information of accident from operation control center informs staffs and passengers in station that train fire breaks out by a local emergency warning.</p> <p>Receive the situation of an accident and inform to other agencies (119, 112 and concerned stationmaster).</p> <p>After stoppage of the train service, exhaust ventilation system is operated but inlet system is not.</p> <p>And then move to the scene of an accident rapidly and grasp the fire site.</p> <p>Station staffs induce escape of passengers and extinguish fire.</p>
The organs concerned	<p>Fire brigade (fire fighter)</p> <p>Fire and rescue teams begin relief activities (emergency evacuation of townsfolk around the fire site, etc.) first.</p> <p>After fire suppression, grasp the damage and take care of casualties.</p> <p>Police</p> <p>The police begins fire investigation and protects townsfolk within a fire site (a shunt order, etc.)</p> <p>Hospital</p> <p>Evacuate casualties to the hospital.</p>

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