Measures for Improvement of the Standard Operating Procedures (SOP) for Emergency Response to Urban Railway

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Abstract: To reduce human error, this study suggest ways to respond to accidents and measures to improve the standard operating procedures (SOP) applied by the Korean metropolitan rapid transit system. The study expects to develop a proper emergency response instruction and enhance social relief on the urban railway safety.

Keywords: Human error, SOP, Emergency Response, Railway Safety

1. INTRODUCTION

1.1 Background and Purpose of the Study

Railway, in comparison with other modes of transportation, boasts excellent punctuality and safety. When an accident happens, however, it causes serious damage to people and property. Moreover, rail accidents tend to involve multiple causes in diverse patterns, making it difficult to take precautions based on relevant incidents in the past (Lee et al., 2014).

While the numbers of accidents caused by mechanical defects are falling, those attributable to human factors are on the rise; especially accidents caused by human error have so many variables that they are difficult to predict (KAIST, 2009). For instance, 72 percent of the train engineers in Korea answered that they had experienced misreading signals momentarily (Korea Railroad Corporation, 2012). Scholars are conducting research into rail accidents from various perspectives to reduce human error (Embrey, 1992; Rasmussen, 1982; Reason, 1995, Reason, 2003) to prevent future accidents.

Despite such efforts, many factors that threaten safety still exist. The “unmanned” railway system is designed to cut human error by mechanical means, but it does not completely guarantee the safety of machine-operated railway. For example, Daegu Subway No. 3 and the Shinbundang Line in Korea are already equipped with technical facilities for unmanned operation, yet on-board safety personnel are still required. The reason for this is because while unmanned train operation and unmanned train stations are increasing, safety has not been proven and research in relation to emergency management is not yet satisfactory. In a train operated automatically, the safety personnel are expected to perform multiple roles as a driver, conductor, and station employee simultaneously, which means that the roles fulfilled by conductors and drivers are merged into one.

This study aims to suggest ways to respond to accidents, rather than those to cut accidents, and measures to improve the standard operating procedures (SOP) applied by the Korean metropolitan rapid transit system. No matter how great a system is, effective emergency management is the most important factor for safety after an accident.

1.2 Scope of this Study

The railway system in Korea is divided into two: the conventional railway system; and the urban railway system. The conventional railway system includes the high-speed rail system, which has been in operation since 2004; the diesel locomotive system; and the rail freight system. The urban railway system, includes diverse systems that utilize both new and conventional technologies since the opening of Seoul Subway Line 1 in 1974. While all these railway systems require diverse safety measures in accordance with their operational environments, this study focuses exclusively on urban railway, as it is the most frequently used mode of transportation in metropolitan areas. Accordingly, safety should be given top priority.

2. RAILWAY ACCIDENTS AND EFFORTS FOR PREVENTION IN KOREA

2.1 System Improvement and Increase in Human Error

According to the Korea Transportation Safety Authority (2013), the annual railroad accidents in general are showing a gradual decline. In 2008, for instance, the number of railway accidents reached 408, while that in 2012 decreased by 38.3 percent, or 250 accidents. Also, the railway fatalities in 2012 declined by 32.1 percent compared with those in 2008.
To be more specific, the table shows that all types of railway accidents have decreased, except those other accidents and Rail facility damages.
The railroad traffic accidents, in particular, showed a sharp decline from 251 in 2008 to 150 in 2012. Table 1 below shows that the annual number of railway accidents has been declining.

Table 1. Railway Accidents by Type

(Unit: No. of accidents)

Classification			2008	2009	2010	2011	2012	Mean
Railway traffic accidents	Train accidents	Collisions	2	0	0		1	0.6
		Derailments	5	3	4	2	4	3.6
		Train fires	0	0	0		1	0.2
		Others	0	0	0	0	0	0.0
		Subtotal	7	3	4	2	6	4.4
	Level-crossing accidents		24	20	17	14	10	17.0
	Railway fatalities caused by traffic accidents	Passengers	127	128	110	68	73	101.2
		General public	105	97	78	93	62	87.0
		Employees	19	13	16	9	15	14.4
		Subtotal	251	238	204	170	150	202.6
Railway accidents caused by negligence	Train fires		1	2	2	2	0	1.4
	Railway fatalities caused by negligence	Passengers	30	42	18	16	8	22.8
		General public	13	2	6	8	0	5.8
		Employees	82	75	66	63	73	71.8
		Subtotal	125	119	90	87	81	100.4
	Damage to rail facilities		0	0	0	2	3	1.0
	Other accidents		0	0	0	0	0	0.0

-Source: Korea Transportation Safety Authority, 2013, p.49

Despite this decreasing trend, however, traffic casualties are still high, accounting for over 60 percent of all railway accidents every year. It means that while railway accidents are in decline, they result in high casualties when they do occur.
According to the report on railway accidents (2013) published by the Aviation and Railway Accident Investigation Board (ARAIB), railway accidents in Korea happen four to ten times annually and accidents related to urban railroad account for 27.8 percent among the total number of railway accidents.

Despite various efforts for system improvement and investment, accidents occur consistently. Nagel (1998) forecasted that accidents caused by mechanical problems would decrease while those caused by human error would increase. This implies that advances in scientific technology would improve machine safety, but interactivity between machine and humans is arbitrary, which may create unexpected circumstances that lead to accidents.

2.2 Diversity in Types of Railway Accidents and Fatal Accidents

Railway accidents tend to occur not because of one cause but rather by various factors in combination. Also, the cause of an accident involves a variety of problems that are closely interrelated with one another. Accidents caused by human error, in particular, can be categorized by type, but, unlike accidents caused by mechanical defects, they tend to be unpredictable. In this respect, it is more important to assess how we can efficiently manage diverse railway accidents rather than determine how we can find out causes by using various accidents that occurred in the past as examples. (Sul, et al., 2014).

Railway accidents are fatal in most cases around the world. The Daegu subway fire, which occurred at Jungang-ro Station on Daegu Subway Line 1 on February 18, 2003, and took the lives of 192 people, with 21 people missing, and 151 people injured, remains the deadliest train accident ever in Korea. The Amagasaki rail crash in Japan and rapid transit accident in Europe also took a heavy toll.

The reason why a railway accident is often fatal once it happens is partly because of its characteristic as high-capacity public transport. Accordingly, what is at stake is how to reduce accident damage to people and property. With the recent Sewol ferry disaster as the motive, social demands for effective initial reaction to any accident are now stronger than ever before, mainly due to the criticism that the rescue team lost the “golden time” to minimize fatalities due to ineffective initial crisis management. Based on the lessons learned from the Sewol Ferry tragedy, the railroad operators in Korea reviewed their emergency response manuals including strategic plans for passenger evacuation and added the concept of the “golden time” to the manual in order to cut casualties to the minimum through effective initial management in case of an emergency.

2.3 Measures to Prevent Accidents and Reduce Damage

2.3.1 Utilization of Cutting-edge Technology

There are diverse technologies available for the prevention of railway accidents, such as the locomotive vehicles ergonomically designed for convenient operation under consideration and level crossings with road underpasses or overpasses. Also, the train control system designed to perform comprehensive control functions for unmanned trains to prevent accidents. (Korea Institute of Ocean Science & Technology, 2013)

2.3.2 Promotion of Changes in Human Behavior

One of the best ways to reduce human error and improve performance directly related to safety is to provide the relevant people with proper training and education. In fact, railway operators in Korea are required to draw up plans for safety education and evaluation for their employees every year (The Ministry of Land, Infrastructure and Transport, 2012 and 2013). Railway operators should provide their employees with safety education and assess their qualifications.

2.3.3 The Emergency Management Manual

The emergency management manual stipulates the measures employees should take in order to promptly and accurately assess the situation and respond properly when an accident occurs. The Ministry of Land, Infrastructure and Transport announced the guidelines for the formulation of the railway emergency management plan in accordance with the Railroad Safety Act (The Ministry of Land, Infrastructure and Transport, 2013) and formulated the standard operation procedures and emergency response drill procedures for efficient emergency management in accordance with the on-site manual.

The emergency management manual stipulates various measures to take and detailed management procedures in accordance with the emergency management plan in case of an emergency. The manual includes the purpose, legal basis, targets, step-by-step measures and scenario, individual and common roles and duties, announcement wording, and an emergency contact network, among others.

Each urban transit operator has its own detailed manual and phased scenario for emergency management. The number of casualties depends upon the time spent on responding to an accident. In the wake of a series of recent fatal disasters, urban transit operators are now acutely aware of emergency management and are making concerted efforts to reduce damage and casualties by designating the first five minutes after an accident as the “golden time” and sending an urgent message. During the “golden time”, the railroad engineer should contact the control room for train protection and open the door for passenger evacuation, while the conductor should share information about the situation with the railroad engineer, announce an evacuation message, and assist the railroad engineers in evacuating promptly. Table 2 is a summary of the comprehensive emergency management manual drawn up by the 12 Metropolitan Rapid Transit Corporations in Korea.

Table 2 Time-based measures railway personnel should take (Changeable subject to the situation)

Classification	Time	Action to take	Relevant personnel
Accident scene	H+ 00 minutes	◦Perception of a fire (situation receipt) – Repetition of “000 fire” two to three times ◦Report to 119 and the general control room (①): Separation of duties	Station Office
		◦Operation of the fire management system - Separation of duties among all employees for fire suppression	Stationmaster
Mission	H+ within 5 minutes Golden	◦Station employees’ arrival at the accident scene (②) Open the gas mask storage and wear an air respirator (when necessary) - Radio, loudspeaker, light-emitting baton, fire extinguisher at hand	Deputy station master Station employees 2 Station employees 3,4

	time	◦Initial emergency management (along with ① and ②) - Use fire extinguishers and hydrants (Check out electric facilities before using hydrants)	Deputy stationmaster Station employee 2
		◦Report to 119 and general control room ※ Prompt report in accordance with the report format	Stationmaster
		◦Announcement – Fire scene and evacuation guidance	Station employees 1
		◦Ask for support to 112, nearest stations and relevant organizations	
		◦Confirm smoke control system operation - Operate the ventilation system to the maximum at the fire scene and stop air supply - Operate the ventilation system in the area across the fire scene and stop air supply (maintain differential pressure ※ Operate the ventilation system to the maximum at the fire scene and stop air supply (when differentiation is not possible) ◦Operate the smoke control system in case of a fire at transfer stations (other sections) - Initial: Operate the ventilation system and stop air supply - Smoke influx : Operate the ventilation system and stop air supply (when necessary)	
		◦Operate the water-proof firestop system	Deputy stationmaster
		◦Operate sprinkler and firestop systems	Stationmaster
		◦Passenger evacuation guidance (using loudspeakers, light-emitting batons, etc.) = Passenger evacuation guidance at each fire scene	Station employees 3
		◦Switch the gate into Emergency mode, Open the Speed gate ◦Stop elevator and escalator operation (manual operation at fire scene for the prevention of secondary accidents)	Station employees 1
		◦ Make sure to open Platform Screen Door	Deputy stationmaster
		◦Evacuate to tunnel when fire spreads (when station waiting room is filled with smoke and toxic gas) - Stop train operation - Install fire escape ladders and rescue trolleys	Station employees 3
	H+ Within 10 minutes	◦First aid to injured and evacuate.	Station employees 4
		◦Arrival of 119 and fire suppression - Fire scene, hydrant location, major facilities, etc.	Deputy stationmaster Station employees 2
		◦Continued alert announcement	Station employee 1
		◦Continued passenger evacuation	Station employees 3

3. ASSESSMENT OF THE EMERGENCY ACTION PLAN

3.1 Railroad Engineer-centered Disaster Prevention Plan

It seems that the efficiency of the current emergency action plan is limited in cases where the railway engineer is injured or dead. Regardless of the type of accident, the survival of the railroad engineer should be confirmed first because he or she should perceive the emergency situation and take action immediately. Accordingly, the death of the engineer may result in delayed emergency management and consequently more damage. In order to respond more promptly and efficiently, it would be important to decentralize the roles of the railroad engineer.

3.2 Absence of a Detailed Plan for the Announcement (for foreign passengers)

The emergency management manual states that the conductor should make an announcement when an emergency occurs. However, the manual used by the majority of the urban railway operators in Korea mentions about an announcement in Korean only, although some operators need to make an announcement in other languages after the announcement in Korean.
As the emergency management manual is designed to reduce casualties, it needs to be revised to help all passengers understand the announcement and evacuate promptly in an emergency situation.

3.3 Action Plan without Consideration of Accident Type

In case of an accident caused by terrorism, the emergency action plan should reflect the type of terrorism. When a gas attack occurs, for instance, the contaminated area should be blocked to prevent the arrival of another train and stop the operation of the ventilation facilities in order to prevent the influx and spread of poison gas. On the other hand, when a fire caused by a terrorism-related explosion occurs, the operation of the ventilation system is essential for smoke control. In other words, the emergency action plan should reflect various types of accidents and include detailed action steps in order to minimize damage to people and property.

In addition, emergency response strategies should consider the characteristics of the exact spot of an accident. For instance the evacuation plan for an accident that happens in a bridge should be different from what happens in a tunnel or a rail section.

3.4 Difficulty in Perceiving an Accident

A railway accident is perceived and responded visually by railroad engineers and conductors. However, accidents that occur in blind spots, such as the rear and the side of the train, are difficult to detect by the railway engineer, unless a conductor or a passenger reports an accident to him or her. It is virtually impossible for the railway engineer, who operates the train alone on a railway, to perceive an accident unless passengers notify him or her. The Daegu subway fire serves as a good, although sad, example. At that time, the train was operated by a lone railway engineer and a fire occurred in the rear train car. The engineer, who was operating the train in the cab in the front of the train, missed the "golden time" of perceiving and managing the accident, resulting inevitably in magnifying the damage.

Unattended train operation is gradually increasing these days. There should be a device or system that allows the engineer to perceive any sign of accident in any direction even when he or she works alone.

4. MEASURES TO IMPROVE THE MANUAL FOR THE REINFORCEMENT OF SAFETY

4.1 Considerations for Manual Improvement

4.1.1 Simple and Easy Action Plan

Accidents happen unexpectedly and require proper judgment and responses by railroad staff including controllers as they, as an integral part of the disaster prevention system for safety, is key to railway safety; their mistakes in protecting passenger safety lead to the failure of railway safety beyond personal failure. The railroad engineers, in particular, are the frontline safety personnel who have to act with the passengers in an extremely tense situation when an accident occurs.

The initial response to an accident, such as a fire and derailment, is the most important. However, it would be difficult for on-train staffers to take many actions all at once efficiently. Since assistance will be given by staff in the nearest station within a few minutes, the on-train staff should be able to make proper and logical decisions for passenger safety and contact the control room promptly for assistance while isolated. Accordingly, the emergency response manual should be simple and easy to follow so that on-train staff can make decisions and take action promptly and efficiently. The Seoul Metropolitan Rapid Transit Corporation provides all staffers with a pocket-size emergency response guidebook so that they can familiarize themselves with it anytime and anywhere.

4.1.2. Proper Order of Action and Prevention of Omission

Accidents make even well-trained railroad engineers feel vulnerable and insecure. With their psychological insecurity aside, the railroad engineers should take disaster preventive action such as train protection, entrance/exit door shut down, and fire suppression. Especially, they should report the emergency situation to the control room and send alert messages to the passengers. The omission of such information sharing may cause the failure of automatic train protection and vehicle control for passengers' safe escape through the rail track. Accordingly, priority should be set in a timely manner so that railway staffers can engage in efficient and logical disaster prevention activities in an emergency situation.

4.1.3. Satisfaction of Passengers' Demand for Information

In an emergency situation, passengers' composure and order are critical for safety and minimum damage. Passengers' staying calm may be possible when they are acutely and accurately aware of the situation. Passengers can become extremely uneasy when they are told to "keep waiting" without any follow-up on-train message and may take dangerous action themselves, such as attempt to escape on their own. Sharing accurate information with passengers is essential for efficient emergency management through cooperation between railroad staffers and passengers.

4.1.4. Communication between Railroad Operators and Passengers

Communication between urban railway operators and passengers is important because they share in common responses to emergency situations. As not all passengers are familiar with emergency response measures, it is important to share emergency response strategies with them. According to the current emergency manual prepared by urban railway operators in Korea, in case of a fire in a train while traveling, for instance, on-train staffers are required not to “stop the train and taking action immediately” but to “stop at the next station to extinguish a fire in cooperation with colleagues if possible.” When the train stops in a tunnel for fire suppression, passengers may not be able to evacuate and even be exposed to toxic gas, which is why the manual requires the railway engineer to keep the train moving and extinguish the fire at the next station equipped with fire extinguishers and workforce. When passengers are not informed of the strategic situation in which the train keeps traveling up to two minutes at a full speed despite the fire, they may attempt to open the entrance doors by hand, causing the train to stop automatically and making the emergency response plan useless. In this respect, on-train communication with passengers is essential for reducing damage to the minimum in an emergency situation.

4.1.5. Measures in the Event of an Injury to the Railway Engineer

The emergency response manuals drawn up by urban railway operators in Korea stress the role of the railway engineer in an emergency situation due to derailment, collision, fire, and terrorist attack. Over 70 percent of the manuals specify that the engineer should perceive and report an accident to the control room and take proper action including an alert announcement. When the engineer is incapable of performing his duties due to injury or death, the current emergency response system becomes extremely vulnerable. As was the case with the subway accident at Sangwangsimni Station in 2014, the inability of the engineer to issue an alert announcement could possibly cause passenger unrest.

The current emergency response system with heavy emphasis on the role of the engineer should be improved further and alternative measures should be prepared.

4.2. Suggestions for the Emergency Action Plan

The following suggestions are based on the emergency response action plan in case of collision, derailment, fire, and terrorist attack formulated by the urban transit operators as mentioned in Section 1. These suggestions reflect the goals and procedures of the current manuals, as well as the suggestions made in this study, such as simplicity of the action plan, prevention of omission, satisfaction of passengers’ demand for information, and communication between the on-train staffers and the passengers. However, the recently revised measures for "golden time" management are not reflected as they are expected to be incorporated in the manual in the future. The following is a brief summary of the suggestions with improved measures:

- Confirmation of the “injury or death of the railroad engineer (on-train staff)” for the activation of the emergency response manual and preparation for the utilization of special measures in case of the incapability of the railroad engineer, the most important on-train staffer, to perform his or her duty.
- The on-train announcement procedure in order to convey information on the situation-possible responses-evacuation and emergency action in order to meet the passengers’ needs for information sharing.
- The “train operation control by the control room” as an important procedure for train protection and passenger safety and accordingly an essential part of the emergency

action plan.
- "The passenger evacuation" procedure, including assistance of mobility-disadvantaged people for their evacuation.
- The alert announcement "in case of a fire" should inform passengers that the train stops at the nearest station for fire suppression and ask nearby passengers to extinguish the fire.
- Differentiation of "terrorist attack" into "gas attack" and "explosion" for proper responses (Gas attack requires the shutdown of the ventilation system and use of a gas mask, while explosion requires the operation of the smoke extraction system and nearby vehicle control.)
- The emergency action plan should be simple enough to consist of up to ten steps.
- Each step in the emergency action plan should be easy to understand and carry out.

5. CONCLUSION AND IMPLICATIONS

This study aims to provide an emergency response manual that reflects simplicity, clarity, and appropriateness, but there are some problems that cannot be solved by simply improving the manual.

Above all, the current manuals are highly vulnerable in the case of injury or death of the railroad engineer. This study shows the importance of the roles of the conductors and assistance in the nearby station and the necessity of on-train announcements and a remote operation system, among others, based on the accurate judgment of the control room.

In the case of an unattended operation system, the current manual should include measures to prevent passenger isolation without outside help for several minutes right after the occurrence of an accident or a terrorist attack. Currently, the unattended operation systems maintain safety personnel, but the manual does not specify what to do in the case of injury or death of safety personnel or other on-train staff.

In case of communications disruption, the railway engineer is required to communicate with the control room using his or her own cell phone, but it should be confirmed if it is possible to utilize a personal cell phone for communication in the underground tunnel regardless of the availability of electricity as communication equipment tends to rely heavily on the system outside.

A possible terrorist attack could be, for example, either a gas attack or an explosion, which can be handled similarly to fire. In this case, however, the roles of the railroad engineer and other on-train personnel near passengers are extremely important. Accordingly, the railroad engineer should be protected in order to operate the emergency management system organically along with various devices to handle the situation.

5.1. Improvement of the Urban Railway Emergency Response Manual

5.1.1. Short-term Measures for Improvement

Above all, the format of the flow chart in the manual, which includes an action plan for each emergency situation, should be standardized and the "golden time," a key strategy for risk mitigation, should be utilized.

Also, the manual should suggest an action plan for each type of accident. For instance, a terrorism-related accident should be responded to differently depending upon whether it is a gas attack or an explosion. However, some emergency response manuals do not distinguish types of accidents, causing confusion to urban railway operators.

In addition, the manual should include an emergency contact network or a cooperative system for emergency relief among fire stations, hospitals, and other related organizations near the railway stations in order to minimize damage when an accident occurs.

5.1.2 Mid- and Long-term Measures for Improvement

The current emergency response system needs immediate improvement as all disaster prevention plans put heavy emphasis on the railroad engineer without the consideration of the situation in which he or she is injured or killed in the event of an accident. Of course, there are some urban subway sections equipped with facilities that allow the control room to make an announcement instead of the railroad engineer, but in most cases, the railroad engineer is the single most important person responsible for diverse duties.

It is also problematic that most disaster prevention plans focus mainly on fire. Since accidents are caused by a variety of interrelated factors, there should be an emergency management plan for each type of accident.

The alert announcement in various languages should be available for international passengers. Each urban railroad operator has its own on-train alert announcement system now and some operators offer the alert announcement only in Korean, while some others provide it both in Korean and other languages. While it is not compulsory for railroad operators to make an alert announcement in various languages in case of an emergency, the safety of foreign passengers as well as their convenience should be given attention. With the rapid increase in foreign residents in Korea, an announcement in English, along with Korean, is essential in this global era. Also, there should be further discussions on how to make an alert announcement in Korean and other languages.

The fact that each organization has a different emergency response manual seems problematic as well, although it has its own circumstances and constraints. However, the emergency response manual in a standardized format will be much more useful for information sharing and research in relevant areas.

5.2. Policy Proposal

5.2.1. Effectiveness of the Division of Labor through an Analysis of Duties and Performance Capacity

Punctuality and safety are the most outstanding strengths of the railway transportation system. Rail transport has far fewer accidents and casualties than other modes of transport, which is one reason why it enjoys public trust. However, the railway safety system is now undergoing a big change with the rapid advancement of scientific technology and changes in facilities. The workforce for railroad operation is decreasing with the widespread use of cutting-edge technology and more and more sensor and monitoring systems are available along with existing ones. Moreover, the widespread use of the unattended operation system is ushering in rapid changes in the duties of railroad workers.

In fact, the number of railroad workers is tapering off, but it is not known if it perfectly reflects the number of jobs required to ensure passenger safety. In other words, the increase in the number of railroad workers means that each worker has now more responsibilities as far as safety is concerned.

Cutting-edge technology and automated operation may be the natural outcomes of scientific advancement. However, it is necessary to examine if technology can replace humans and is capable of accurate operation even in an emergency situation. It is also necessary to analyze the technologies considering the relationship with railroad workers' duties, characteristics of the duty, response time, etc. in unexpected emergency situations, in addition to safety measures in normal operation. Especially, human error should be reduced through an analysis of railroad workers' performance with their work-related capacity, working hours, and fatigue and boredom induced by repetitive work under consideration.

5.2.2. Installation of a Panic Room for the Safety of the Railroad Engineer

It has been pointed out several times that, although there has been an effort made to improve the emergency response manual right after an accident, it is extremely difficult to take action in accordance with the manual when the railroad engineer is injured or killed in an accident under the present urban railway system. The railroad engineer should be protected as part of the emergency response system rather than one of the on-train staff or one of the passengers. Various devices for the railroad engineer, such as a safety belt and an airbag, have been suggested in various studies, but their applicability is questionable as the railroad engineer are responsible for active, not static, duties.

Considering the characteristics of train accidents, the installation of a panic room in the engine room seems practical as trains collide after a lapse of at least a few seconds. The panic room equipped with safety devices can protect the railroad engineer from collision or other dangerous situations so that he or she can carry out the emergency response plan for the passengers right after an accident. In this respect, the installation of a panic room is not for the safety of an individual but for the protection of the disaster prevention system for its efficiency in time of emergency.

5.2.3 Application of Critical Time in the Emergency Response Manual

The unattended operation system is an interactive system between railroad workers and passengers at a long distance. The present railroad safety focuses on the prevention of accidents or recurrent accidents through the decrease of human error. The emergency response manual is designed for predictable accidents, although it includes new measures, such as the "golden time" utilization system.

However, high traveling speed and underground operation are some of the general characteristics of urban railway. New technology may be accompanied by new operational obstacles beyond the predictable level and an increase in the speed of rapid transit may aggravate the seriousness of an accident once it happens. Studies show that dangerous factors are not found until fatal accidents happen, which prompts us to make every effort to improve safety rather than passively looking for dangerous elements. Therefore, it is necessary to find ways to manage emergency situations by classifying the accidents that happened in the past and, at the same time, find ways to handle the accidents that cannot be classified in accordance with the current classification system. The action plan should be formulated for flexible yet prompt decision-making after the initial management of an accident.

Also, the emergency manual should include the concept of "critical time" to stress the importance of the initial responses during the crucial few minutes right after an accident, or the "golden time."

5.2.4. Discovery of Survival Factors for Minimum Casualties

The people-oriented safety measures are necessary not only for the prevention of predictable accidents but also for the protection of passengers and safety improvement at an emergency situation. Various efforts to prevent the recurrence of accidents and improve passenger safety are carried out by identifying effective survival factors and creating new vehicle designs and re-designing of human traffic lines. An analysis of the causes of accidents and various common responses to accidents may be useful to develop technology and policy for the prevention of recurrent accidents and reduction of casualties at an accident.

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