IMPROVING TAIPEI MASS RAPID TRANSIT FIRE-FIGHTING SAFETY FROM THE EVENTS OF ARSON ATTACK

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Abstract：On February 18, 2003 in Daegu, South Korea, and January 5,2004 in Hong Kong, two arson attack were taken place. It appeared a practical fire condition on underground rapid transit system, also providing an opportunity of self-examination, self-inspection to the industry of rapid transportation.

Although the design of fire- fighting safety in Taipei Mass Rapid Transit (MRT) depends on the local fire-fighting code, international in general using mass rapid transit standard, it should have still the space of self-criticism, improvement according to the above present living examples of arson event on subway. After referring to the cases of Daegu as well as of Hong Kong, by inviting the scholars, experts, related departments to study and discuss the improved measures of fire-fighting safety for Taipei Rapid Transportation System. It provides the more safe surroundings by trains to Taipei Metropolitan public, the relevant improved measures can also offer to the other rapid transit system of the world for references.

Keywords: Closed Circuit Television system, Side Platform, Smoke Extraction System, Arson Attack

1. INTRODUCTION

On February 18, 2004, an arsonist set fire on subway in Daegu, South Korea, causing the heavy injures and deaths. It was not unique, but had its counterpart that against took place an arson attack in the subway of Hong Kong by a disabled person who accumulated animus on January 5, 2004 at 09:10. Fourteen people were only slightly injured, but it can be seen that deliberate arson attack may be taken place in any subway system of the world. Indeed, we can’t prevent an arson case from occurring, it is the measure of effect radical reform that actively takes into the research and studies how to enhance the relevant fire prevention facilities.

On February, from 21 to 24, 2003, Taipei City Government appointed eight members who came from Taipei Rapid Transit Corporation, Department of Rapid Transit Systems, Department of Transportation and Fire Department to visit Daegu and understand the arson case, in order to re-investigate the fire-fighting safety of Taipei MRT, also getting ready to handle any possible

challenge in future.

2. SUMMARY OF THE TWO ARSON CASES IN SUBWAY

2.1 The arson case of subway in Daegu, South Korea

On February 18, 2003 at 9:53 A.M., a man like the mental illness set fire on the No.1079 train in the Jungangon Station of Daegu subway, who used lighter to light flammable liquid with the sauce bottle which contained gasoline about 1 to 2 liters. The fire spread to burn quickly. Four minutes later an opposite-bound No. 1080 train went into the station. Two trains, which amount to 12 carriages, were completely burnt down. The platform was burnt to cause the heavy injures and deaths. The Jungangon Station has three levels underground. The underground third level is the platform and track. The underground second level is concourse, which sets up with the staff rooms, automatic ticket issuing machines, ticket gates and plant rooms. The underground first level connects with the ground entrance and a shopping mall. The Jungangon Station is located at the most prosperous region in Daegu, nearby a lot of movie theaters, department stores as well as extension schools etc. On February 22, 2003, in the process of reconnaissance, visitors had a mourn heart for deaths on the scene of the accident. After seeing the scene of the accident,

the explanation of relevant disaster situation was as follows：

1. The fire of the accident mainly concentrated in two trains, which were stopped at underground third level on the track beside platform, as figure 1. The main area of burnt destruction for trains were car and its above zones, the frame of trains were only slightly damaged, here it might know from the fact that the two trains could be dragged more than ten kilometers to go back to the depot. Because above the track zone belonged to the heat storage of the main fire, the cement flaked as well as concrete reinforcing rode bared on the slab.
2. The floors, wall panels, ceiling panels as well as the passenger seats of the train were burnt out, only leaving the related frames. As for the car, which the materials of car body were made of stainless steel, itself was slightly damaged.
3. The finish materials of the station in this accident can be withstood test by fire. The fire of trains only let the ceiling panels above the platform deform as well as glazed tile of sidewall drop, as figure 2., the phenomena were more obvious where were closed to the trains, these ceiling boards were not deformed by the fire, but were suffered the heat to deform. The high heat as well strong smoke did not bring the fire to spread upward underground first or second levels. At the underground first and second levels, the sight of everything is all blacken of the trace by strong smoke, as figure 2.

Figure 1.The underground third floor of track zone in the subway Jungangon Station

Figure 2.The underground second floor of the concourse level in the subway Jungangon Station

4. The clear sight at any level was blacken of the trace by strong smoke, because the hot smoke fled upward. The wall and column where were above floor about one meter, almost had no blacken trace of the smoke. This phenomenon was obvious at underground the third level. Because the strong smoke was cooling gradually, the blacken trace was close to floor on underground the first and second levels.

2.2 The arson case in the subway of Hong Kong

On January 5, 2004 at 9:10 a.m., a suspect with 「mysterious person」 set fire on a Tsuen Wan Line train (as figure 3.) in the subway of Hong Kong. This train went from Tsim Sha Tsui Station to Admiralty Station, when passing through the under-sea tunnel, the arson suspect attempted to ignite six sets of paint thinner (analogy the flammability liquid of the rosin) by a self-made napalm bomb and five small bottles of gasoline to ruin with whole passengers in the car, but some passengers discovered and gave a loud shout to stop his act. Unfortunately a napalm bomb and a bottle of gasoline have been ignited, the first car was fall into fire and strong smoke filled in the air. The passengers vied with each other to flee for life toward the tail of the train. There were fourteen people hurt and taken to hospital.

The fire was very close to the driving cab in this arson case. The driver first felt the occurrence of fire at 09:10, and advised the Operation Control Center at 09:12. The Operation Control Center noticed the station staff of next station to be ready to assist at 09:13, and reported the Fire Service Department at 09:14. The train entered the next station and station staff used fire extinguishers to put out fire immediately. The Operation Control Center informed the Transportation Department of Hong Kong to release the red alarm at 09:16. From 09:14 to 09:16 am, during the incident, train service on the Tsuen Wan Line was maintained only between Tsuen Wan and Tsim Sha Tsui Station. Island Line service operated as normal, but

trains did not stop at Admiralty Station. The fire was extinguished at 09:17 and fire engines had arrived at the same time. At 09:34, the train was removed from the operational line.

The crisis relief and all MRT trains service resumed normal at 09:40. The relevant contingency was extremely quick, as well as the driver did not get flurried to stop the train in the process of treatment, and let the train go into the station according to the procedures. It could let passengers evacuate from the train quickly.

After the event of arson attack, the media and people of Hong Kong requested a self-criticism. A brief explanation was as follows:

1. The MRT Corporation of Hong Kong increased people to patrol; made a selection to check the goods that passengers took, also would consider to install the closed circuit televisions inside car.
2. Nine passengers pushed the emergency communication button to report the fire alarm in the process of the fire, due to speaking at the same time, the driver didn't hear what passengers said, either didn't know how serious the fire was, hence regarding as a fire alarm to do the contingency by himself.
3. In this arson case, all the fire extinguishers that were installed inside car did not be used. The reasons were initially judged that the human nature regarded the safety of self as the main considerations and took priority to flee for life; on the other hand, the installed fire extinguishers were not obvious enough or easy usage.
4. The processing skills were suitable by the subway corporation, the driver advised the occurrence of the fire alarm to the Operations Control Center in time. When the train entered station, station staff quickly put out fire. At the same time passengers were immediately evacuated from the train and platform, avoiding the accident to cause the heavy injures and deaths.
5. After the occurrence of the fire alarm, passengers with fluster turned toward the train tail, whether was this method of evacuation proper or not? It shall consider how can convenience to let passengers can flee for life in time, for example, installing the side door, rather than depended on the head-tail emergency exits of a train. Furthermore if a accident took place in the tunnel, the train could not drive and stop, the subway corporation also made the design as well as guide lines to teach the station staff how to assist passengers to evacuate.
6. The subway corporation by quick team response could dissolve a crisis that embroiled over many lives, and this depended on to practice from time to time. After the occurrence of the arson case of in the subway of Daegu, drills were conduced at every partition two months in the subway of Hong Kong.
7. In addition, station staff to use fire extinguishers put out the fire; it was also an important factor that trains are made entirely of non-inflammable materials.

3. QUESTIONS STUDING

After understanding the process of arson attack in the subway of Daegu, South Korea and

Hong Kong, the following questions are provided everybody to discuss together. :

3.1 The two arson cases were occurred on trains. Therefore the materials of fire resistance, low smoke, halogen emission for car body, floor, seat, sidewall, ceiling panels, wires, cables etc. are very important to the safety of people when a fire was developed. In Taipei Mass Rapid Transit Systems, the materials of car body are made of stainless steel; the interior materials of car comply with relevant standards, such as NFPA and UIC895OR etc. The materials for flammability and smoke emission both are taken into account, the materials of cable shall be not easily damaged, don't spread to burn, expect to withstand test. After all, arson cases may take place at anywhere.

3.2 The trains in the subway of Daegu adopt the way of side door to evacuate, do not set up emergency exit on the headstock or car tail, but trains are install headstocks-car tail emergency exits in the mass rapid transit systems of Seoul, Hong Kong and Taipei. When emergency accidents take place in the tunnel, the emergency exits at the head train and tail train are used to evacuate. In regard to mass rapid transit systems, the ways of evacuation are not the same in every rapid transit system of the world. But in regard to the evacuation method of side door, the evacuation paths from carriages to the track zone are uneven, and whether the evacuation paths allow passengers to go into at the same time also must re-examine. The Taipei MRT Electrical Multiple Units (EMU) used car interior gateway as a safe aisle to provide passengers to turn toward a terminal by the headstock-tails emergency exits to evacuate, but the speedy of evacuation is still equally restricted.

3.3 Generally speaking, the materials of car body are made of stainless steel or aluminum. In addition to defending collision, car window can resisting temperature over 300 ^{O}C, and the floor are made of fire-resisting material. So it is difficult for a fire to burn inside the car in a short time. However the construction of gangway exterior is made of flexible sailcloth with combustible materials. So a fire can be spread to burn by flexible sailcloth. In Taipei MRT EMU, the gangway exterior is the same flexible sailcloth, but gangway interior is covered by stainless steel, as figure 3, the fire should be able to greatly reduce or avoid the spreading of the fire.

Figure 3. The construction of coupling between cars in Taipei MRT

3.4 Subway tunnels contain various construction types. There are single span double track (as figure

4.) or single span single track (as figure 5). In fact, each has its advantages and shortcomings. In order to keep the fire from spreading to burn between trains or have concise the planning of evacuation paths, the tunnel of single span single-track span gains advantages more.

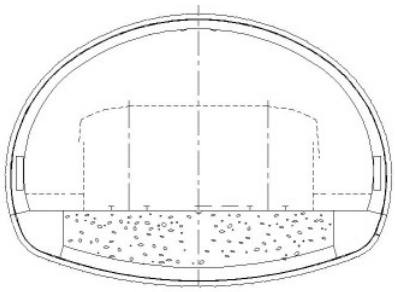

Figure 4. The diagram for the single span double track type of the tunnel

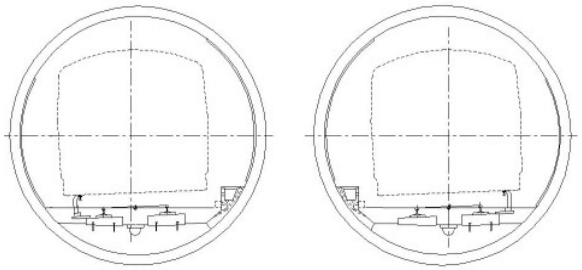

Figure 5. The diagram for the single span single-track type of the tunnel

3.5 In the subway accident of Daegu, most of deaths and injures were not on the accident train but another train on the going into the station was burnt by the spreading fire. Because the platform of subway station was a side platform (as figure 6), namely station was double-track, separating double platforms layout. In Taipei Mass Rapid Transit, most of underground stations are island platforms (as figure 7); it is better to prevent fire from spreading.

Figure 6. The station of the side platform

Figure 7. The station of the island platform

3.6 Underground stations are very difficult to exact smoke in case of a fire. Particularly, if it is not good measure to smoke control, it will make the strong smoke follow the direction of stairs to diffuse, it is also the same as the paths of passenger's evacuation. Passengers will be caught up with the strong smoke to have the trouble to take refuge. Taipei Mass Rapid Transit Systems comply with the local codes to install smoke zone and smoke extraction equipments at the levels of concourse and platform, however the train catches fire in the track besides platform, it makes use of under platform fans and tunnel ventilation fans to extract smoke, smoke will be passed to ground level through the draught relief shaft and release to atmosphere. In this time, the platform level becomes negative pressure zone; expecting to draw fresh air form entrances at stress to follow stairs and reduce smoke to go into stairs of the station, don't effect the

evacuation of passengers, as figure 8.

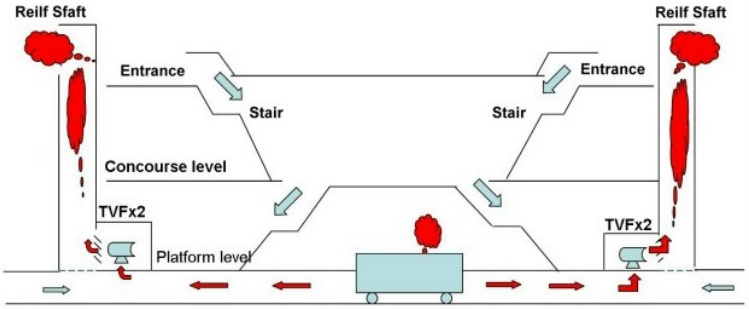

Figure 8. The smoke control of a train arriving with a fire in Taipei MRT

3.7 It is argued whether do the auto sprinkle system be installed or not in the public of the subway station for the fire-fighting industry of Taiwan. In the survey of the arson case in the subway of Daegu, the fire spread from the trains to the side platforms. Even if the auto sprinkle system was installed at the platforms will not help. In addition, it all shall be considered, including whether the smoke layer will be rapidly descent or not at act of the auto sprinkle system, adding the obstruction of passenger evacuation at wet ground, whether passengers get an electric shock or not, etc. The design of auto sprinkler system for Taipei Mass Rapid Transit Systems comply with the NFPA130, it shall be provided at shops, storage rooms, trash rooms, staff offices etc. where have the more fire load.

3.8 To provide disaster relief in underground mass rapid transit space, it is very important to use the fire fighting appropriated wireless system. The materials for leaky cable (as figure 9), amplifier etc. parts shall be carefully chosen to use. If these equipments are damaged in the early stage of a fire, the providing disaster relief will be delayed.

3.9 The power supply methods of mass rapid transit system for train generally have two kinds, which are overhead line of alternating current or third rail of direct current. Each one has its advantages and shortcomings, in regard to the standpoint of the fire. Because the fire and high heat, the overhead line is easier to be damaged than third rail. Besides, when train caught a fire, it is very important to supply the power at single track. For example, the materials of cables adopt the less smoke, fume, and fire-resisting materials.

3.10 The strong smoke generally rose upwards. According to the scene of the accident in Daegu, the upper half of the wall was blacken by smoke, as figure 18. To guide the evacuation of passengers, emergency illuminated direction signs are installed at the maximum height (one meter is away from the floor) to get better effect. But the emergency direction sign were hung but did not turn on until the power was interrupted in the subway station of Daegu, as figure 10. Although it could save the power and reduce the rate of lamp failure etc., from the subway accident of Daegu, there were not the ground type (being closed to ground) of emergency direction signs to guide the passenger evacuation in the darkness. It would be difficult for

passengers to evacuate. If the emergency direction signs being turned off in normal times, it was unknown whether they might immediately turned on or not at the occurrence of accidents.

Figure 9. The leaky cable of the underground station in Taipei MRT

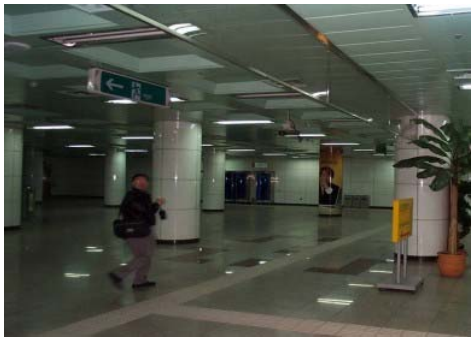

Figure 10. The emergency direction sign didn't light at

3.11 All trains are equipped with fire extinguishers, but the locations and quantities of fire extinguishers are different in the mass rapid transit system. Some of them are fitted into cabinets; the others are directly fixed in the walls. Unfortunately, the passengers on the train did not use fire extinguishers to put out fire in the arson cases of Hong Kong or Daegu. Each car shall have fire extinguishers of indirect pressure type, each containing at least 3.5 kg of A.B.C. dry chemical powder. The fire extinguishers shall be vertically installed on the side door of carriage, each extinguisher is arranged to conveniently use and with direct access to the passengers, as figure 11. But depending on the experience of each arson case, each car has increased the quantities of fire extinguisher at least four sets.

3.12 The emergency intercommunication of the train is installed in the different ways and positions at the rapid transit systems. It was reported that total nine passengers used the emergency intercommunications to talk with the driver in the arson case of Hong Kong. Because the passenger talked at the same time, the driver couldn't hear clearly what they reported. According to these two experiences of subway arsons cases, the passenger emergency intercommunication location shall consider the accessibility and convenience for passengers, as figure 12. In addition, how to improve the multi-user uses at the same time, the question that could not hear clearly also should take into the consideration.

Figure 11. The location of fire extinguisher in Taipei EMU

Figure 12. The location of emergency intercommunication in Taipei EMU

3.13 Passengers usually evacuated from the station by entrances at the emergency accident. If firemen carry a great deal of the equipments, also using the entrances to enter into the station at this time, it will obstruct the passenger evacuation. According to the accident of Daegu, the firemen couldn't enter into station because the strong smoke upward entrances. In Taipei Mass Rapid Transit Systems, a second access is installed on every station. not use by passengers for evacuation, is available to firemen to get into station. The second access is usually at air intake shaft of the station, as figure 13. Vertical access between each level for firemen set up appropriation stairs that provide firemen to relief from appropriation entrance to get into station, and its path should keep the positive pressure from harassing by smoke. The minimum width of the stairs shall be 1m, and the slope of the stair is less than 60 degrees.

3.14 Each rapid transit system of world both establishes the control centre in regard to take charge of the normal operation of the whole system. The control center of Taipei rapid transit systems can be divided into several subsystems that include line control, train regulate, communication control, power supply control, supervising/monitoring/controlling equipments (electricity, mechanic fire-fighting), and engineering control etc., each subsystem has its own work. Another established the Chief Controller to unify commanding, and above each subsystem as well as the Chief Controller accumulate the same operation of room, as figure 14. While meeting an emergency condition to have the better contingency, otherwise if each subsystem is located separately at different rooms, even different floors, each subsystem controller just realizes a partial condition under the emergency condition. By all accounts it will hardly do the best decision.

Figure 13. The second access in Taipei MRT

Figure 14. The Control Center Room in Taipei MRT

3.15 The arson case of subway in Daegu, the second train No.1080 went into the station to cause the heavy injures and deaths. So the occurrence of a fire in the station, whether should related trains do not stop or prohibit into the station or not, should be examined again. After all, for a burning body (either train stopped at a station or station oneself), trains, which did not stop at station, led the strong air streaming to enhance the fire. The better policy should keep other trains from

entering the station.

3.16 In the operational training of the rapid transit systems, the on-line staff, trains are taught that operational instructions shall comply with the Control Center Room. However the arson case of subway in Dageu , the second train No.1080 went into the station with fire accident, even though the driver understood the condition, the initial response took too much time so that the seriousness of the accident caused heavy deaths and injures. So for the emergency accident of a fire should be examine again the relevant contingency to meet the physical situation.

4. FIRE SAFETY PROMOTIONS ON THE MRT STATIONS

4.1 Smoke extraction system

Some MRT system use the air return duct/fan as smoke extraction system, with normal open extraction openings (see figure 15), just like the initial state of Taipei MRT. After examination we find each extraction opening only with very few extraction amount and the smoke spread everywhere. So we redesign the smoke extraction system and use smoke barrier (at least 50 ㎝ height), normal close extraction opening, addressable fire/smoke detector, and make every smoke extraction zone smaller than 500 ㎡ (at entrance area 300 ㎡), in order to concentrate the extraction amount on the right place to extract the smoke. We follow the local codes and assume 2.5MW as the heat release rate in station area. This heat release rate is base on a gas arson attack with an amount of about 20 liters, this amount also base on an experience that the weight for a normal human to take.

Although the Taipei MRT has the smoke extraction system described above, but following items still must be taken into consideration to reach a more powerful smoke control system:

1. Redundancy:

A standard MRT underground station include concourse and platform levels, we adopt the following considerations to promote its' redundancy, as figure 16:

(1). Different level with independent smoke extraction fans and ducts, i.e., concourse and platform level can not use the same one smoke extraction system

(2). Limit the number of smoke extraction zones that serve by the same smoke extraction system, i.e., one smoke fan/duct system only serve few number of smoke extraction zones and then have a lower risk even when the smoke extraction system out of order.

(3). Adopt the leakage type ceiling and allow the smoke to up to the space above ceiling, this can enlarge the total amount of smoke storage and give the passengers/staff have more time to escape even when the smoke extraction system out of order.

(4). Even though the local code has some regulations about the amount of smoke extraction system, we adopt the worse case to design the smoke extraction system of underground MRT station, i.e., every smoke fan has the capacity never lower than 600CMM and the flow rate through each extraction opening can not exceed 10M/S.

(5). Adopt a chamber and damper system just between these two independent smoke

extraction systems of concourse and platform level (see figure 17), whenever the smoke extraction system of concourse level out of order then it automatically operate the chamber and damper and then use the smoke extraction system of platform to support the necessity of concourse level.

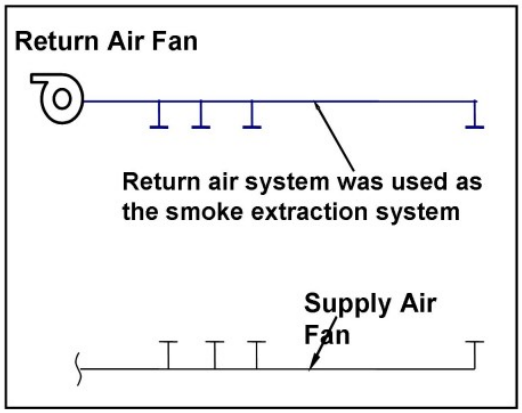

Figure 15. Smoke extraction system utilize air return duct/fans

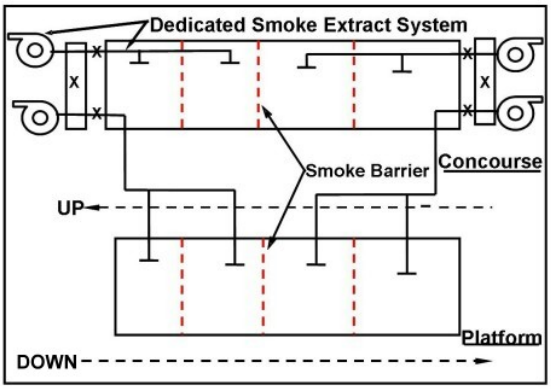

Figure 16. Smoke extraction system with redundancy

2. The OTE（Over-the-track Exhaust）smoke extraction system.

Base on the experiences of Daegu and Hong Kong arson attack, the track area just beside platform has a high risk to catch fire. In the new design underground MRT station we install the OTE smoke extraction system above the track area. The OTE system will cooperate with the tunnel ventilation fans (4 fans for one platform) to extract smoke whenever a fired train stop/arrive the station track area. The OTE system also equips with smoke barriers and will be operated by manually.

4.2. Escape sign:

There are many types of escape sign adopted in Taipei MRT system, such as suspension type, wall mounted type, recess on the floor type. All these escape signs are normally illustration type. But base on the experience of Daegu incident, in the case of fired the suspension type escape signs and emergency lighting equipments will be affected by the smoke and can not normally operate, so the on floor type escape sign is more preferable than other types. We are now planning to install luminous type escape signs (see figure 18) along the escape route to help the passengers to escape in case of fire and power shutdown.

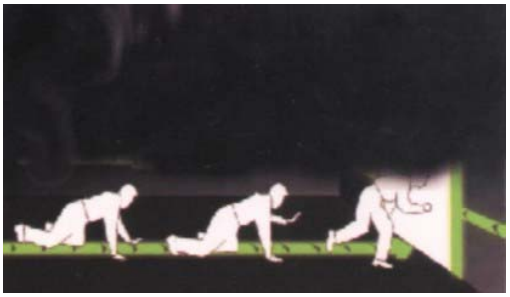

Figure 17. On ground escape sign Figure 18. Luminous escape sign

4.3. The CCTV and fire alarm systems in underground station public area interlocked：

In general the evacuation design concept of MRT station use the following timing as evaluate parameters to make sure that all passengers in worse case can evacuate from the systems:

1.the time begin to evacuate（T1）: This time start from the fire happened to the time that passengers begin to evacuate, it include the time needed to detect the fire, the time needed for human (may be staff or passengers) to response to the fire, and the time needed to make the passengers begin to evacuate.

2. The time needed to evacuate（T2）: The overall time needed to finish the evacuation.

3.the time permit to evacuate（Ta）:This time start from the time that fire happened to the time that the environment present dangerous for the passengers to evacuate (it means that the passengers can not evacuate by itself), it include(a)the time needed that the temperature increase to very high that human can not resist(b) the time needed that the density of smoke increase to very high that human can not resist.

$$T1+T2 \leqq Ta$$

If the total time needed to evacuate shorter than Ta then this building is safe, otherwise it is dangerous.

In the formula shown above, Ta is the final control parameter to determine whether or not the passengers can safely escape. The value of Ta affected by the size of fire, the material of building construction, and the function of fire partition, and so on, but normally decided on the timing when the building completed. If the following maintaining work done very well then Ta can be deem as a fixed value. The value of T2 affected by the numbers of stairs, entrances and so on, it also can be deem as a fixed value when the building completed. For the purpose to escape as quick as possible, passengers can start to escape as early as possible, i.e., let the value of T1 shorter and shorter, tend to be very important. In fact the value of T1 include the time for fire alarm system to sense the fire, the time for the station staff to acknowledge it’s really a fire and notice to the passengers start to escape. In general the time needed for the fire alarm system to sense the fire depend on the sensitivity and type of the fire detector, but the timing difference between different type fire detector is very small. The

majority of T1 is the time needed for the station staff to make sure that a fire really happened and then notice the passengers to escape, especially for a MRT underground station only with very few staffs.

In regard to the amplitude of a station, it may take more than few minutes to evacuate, so it is worthy of us to inquire into how to shorten this period time. In addition, in the accident of Daegu, the fire alarm system of station at first the time once acted to give warning, but station staff took it that is a false fire alarm and didn't especially pay attention to it. When station staff saw the passenger to evacuate hurriedly, then having known the severity of situation. So it delayed the first prime time of relief. We consider that may make use of the existing the fire alarm system interlock to CCTV system, as long as the fire alarm system detects the condition of fire, namely the on-line goes to the CCTV system to make camera synchronously, as figure 19, lock the scene. Let the station staff in the PAO to control the condition in time. Certainly there are some restricts conditions, because the originally installed purpose of the CCTV is for the sake of public security purpose. The CCTV are located at the entrance, stair way, escalator, platform head wall etc. of the public zones, it not necessarily covers the location where the fire alarm system can covers the whole areas of the station. So for this improvement suggestion of Taipei Mass Rapid Transit, we just aim at the CCTV system of the public area to take into interlocking, and even if a false fire alarm is discovered on the CCTV, and still demands that the station staff shall still arrive on the scene to confirm.

Figure 19. The CCTV and fire alarm systems in underground stations' public area interlocked

4.4. The fire protection strategy for underground side platform station:

Base on the experiences of arson attack on Daegu and Hong Kong MRT systems, station entrance and track area beside platform seems to be very high-risk areas that can catch fire. The arsonist can easily attack the station by throw gas bottle to the entrance and then run away. If the arsonist did not select the station entrance to attack, then the highest possibility attack model must be like Daegu or Hong Kong arson attack, i.e., the arsonist bring gas bottle into the train and then fired. The reason why we make this assumption is that the construction material of station area seems can resist the fire and the large dimension of station with staff or security and variety type of fire protection equipments make the evacuation of passengers seems very easy. But an arson attack on the train, especially a train running in tunnel, can raise a very bad

situation and very difficult to save the passengers. A general guideline to the train driver is whenever the train catches fire, he must do his best to make the train arrive the station and then escape the passengers from the station. So we can say that the track area beside platform is a high-risk area to catch fire. Although the track area beside platform is so dangerous to catch fire, but if the station is a island platform station then a fired train can not spread its' fire to another train which just stop in this station. We find that there have two side platform underground station just like the arson station in Daegu MRT system which has higher possibility to spread fire from one train to another one, we decided to install form sprinkler systems in these two stations' track area as a auxiliary fire protection equipment.

4.5 To enhance the fire protection capability of platform area:

As mention above, the track area beside platform has a high risk to catch fire, so the fire protection capability of platform area seems to be very important. We install the fire hydrant and portable fire extinguisher at platform according to the local code; in addition to these we add the number of portable fire extinguisher to facilitate the fire fighting action.

4.6 Strongly limit the introduction of flammable materials into the MRT station:

Generally speaking, there are many commercial advertising panels in the MRT station and these panels always made of flammable and toxic materials. Its' our strongly suggestion to limit these dangerous material been introduced into the underground MRT station to protect the systems.

5. FIRESAFETY PROMOTIONS ON THE EMU

5.1 The basic evacuation concept of Taipei MRT in case of emergency is as follows：

1. If the train is stop just beside the platform, the driver in the cab use one pushbutton to open the one side all doors for the passengers to escape from the train, or the driver can use the air release vent valve at the exterior of the train (see figure 20) to open only one door for the passengers to escape from the train.
2. If the train is stopped in the tunnel or the doors cannot open, then the driver must follow the operation guide to operate the escape ramp (see figure 21) at the front or rear end of the train for the passengers to escape.

Figure 20. The exterior air release vent valve of the Taipei MRT car

Figure 21.The Escape ramp of the Taipei MRT car

5.2 The opening door way of outside car just can open one door at the present time, it will add another set that can open four doors at the same time, in order to let passengers evacuate form the train quickly.

5.3 The each materials of the fire resistance in the train which include seat, sidewall, ceiling panels, wires, cables etc. comply with NFPA, UIC895OR etc. relevant stands, flammability and smoke emission both have strict standards. The cables were insulted with materials to adopt that are not easily damaged, met the heat not to assist combustion, do not spread to burn, and compared other systems of adopting standard. In addition to maintain the primary standard fire prevention for the minimum requirements, adding the specifications that materials must restrict to produce noxious fume or smoke and have the fire proof.

5.4 .Add the new function that when the emergency communication was operated but the driver didn't response exceed 30 seconds then the emergency communication will transfer automatically to the Control Center.

5.5 Install CCTV and fire alarm systems in the train cabinet, in case of fire then the CCTV and the fire alarm system will be interlocked mutually and send an alarm message to the driver's cab to indicate which car is on fire and show the real situation on the CCTV monitor. Otherwise, the CCTV and fire detectors can be installed on train, in order that provides the driver to know the fire quickly, saving the precious time to go the location of occurring fire. In addition to interlock to the fire alarm system, the CCTV can also interlock to emergency intercommunication on the train. It also provides a way to confirm the fir information. It is a proper decision to install the CCTV on the train; in fact, it has a preventive effect for a criminal act.

5.6 Increase the number of portable fire extinguishers from two to four in each car to enhance the capability of fire fighting.

6. CONLUSION

Because the arson attack seems can happen on any time at any MRT systems, and whenever it happen only very few time left to response and escape. How to enhance the fire safety of MRT system is very important. Base on the experiences of Daegu and Hong Kong arson attack, how to make the construction materials of EMU and station can resist fire or at least postpone the fire to spread and decrease the density of smoke and toxic material is the most important thing to be done as quick as possible. The next important thing is to reevaluate the operation codes and response procedures and make sure every staff of the system clearly understand how and what to do once the emergency case happen.

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