Suggestions on Emergency Rescue’s Supplemental Equipment in Railway Tunnel Emergency Rescue Station

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Abstract. The object of this work was to ensure the passengers’ safety in railway tunnel rescue station. Firstly, background of tunnel rescue station and rescue process were reviewed. Secondly, problems and suggestions on emergency rescue’s equipment were analyzed including protective clothing, safety rope and explosion-proof light. Thirdly, the supplemental equipment was summarized. Further study should focus on relative standards’ revision and new technique.

1. Introduction

As the development of railway in China, more tunnels were built to pass through the mountains in northern west and southern west. To ensure the passengers’ rescue safety, the special rooms were built in the middle of the long and large tunnel [1]. If the tunnel’s length was between 10 km and 20 km, the refuge and emergency exit should be built in the middle of tunnel. Then the accident train could use the residual power to exit. If the tunnel or tunnel groups’ length was over 20 km, the tunnel rescue station should be built in the middle of tunnel. Then the accident train could use the residual power to exit or reach the emergency rescue station. Then the passengers could escape through the exits or stations. To improve safety level, the studies on relative equipment had been carried out.

Table 1. The tunnel emergency rescue station.

| Tunnel name  | Province         | Station locations in the railway                  |
|--------------|------------------|---------------------------------------------------|
| Qingyunshan  | Fujian Province  | One station in DK502+352.5.                       |
| Lvliangshan  | Shanxi Province  | Two stations in DK84+100 and DK69+546.            |
| Xiqinling    | Gansu Province   | Two stations in DIK409+234 and DIK423+388.        |

2. Background of tunnel rescue station

The relative standard was TB 10020-2017 Code for design on evacuation engineering for disaster prevention and rescue of railway tunnel. The half-portable extinguisher, ventilation systems and fixed emergency light should be installed in the station according to this standard. The passengers should get off the train, land onto the platform, run into the transverse passage-way and escape into the other hole or other route. The whole escape time was 6 minutes from the first passenger getting off the train to the last passenger running into the transvers passage-way.
After entering into the tunnel with 20 km length, the train might have a fire accident immediately. Then the emergency response was carried out. If the fire was out of control, the train would stop at the rescue station. The platform’s height was 950 mm higher than the rail surface. The passengers could get off from the train and land onto the platform easily. Compared with other place in tunnel, the station’s platform width could reach 2.3 m which permitted 180 passengers from 3 carriage doors. So all the passengers could pass through the platform and enter into the passage-way in 6 minutes. Then the air supply system in transvers passage-way worked and provided air to prevent smoke’s spreading. The fixed light in passage-way was also turned on. Finally, the passenger would pass through the passage-way and escape into the other hole or escape route.

3. The problems and suggestions on emergency rescue’s equipment

3.1 The protective clothes

The fire extinguishing equipment in the train included portable dry powder extinguisher and portable water based extinguisher for early fire. The crew member in the train could use portable extinguisher. If the fire was out of control, the half-portable water mist gun in emergency rescue station’s two walls was introduced [2]. The crew member should get off from the train and use water mist gun to put out the bigger fire. To protect crew members’ safety, the protective clothes should be also prepared including protective clothing for proximity fire fighting, protective clothing for firefighters and adiabatic protective clothing for firefighter. In new study, the compressed air foam cabinet was also introduced to extinguish Class A fire, and the crew member using foam gun also needed cloth.

| The different clothes                     | Use area                | Colour              |
|----------------------------------------|-------------------------|---------------------|
| Firefighters’ protective clothing      | Accident area           | Tigerlily orange    |
| for rescue                             |                         |                     |
| Protective clothing for                 | Fire area               | Dark navy blue      |
| firefighters                           |                         |                     |
| Protective clothing for                 | High thermal radiation  | Silver white        |
| proximity fire fighting                 | area                    |                     |

If the crew member put out the early fire in the train using portable extinguisher, firefighters' protective clothing for rescue would be enough [3]. Although this tigerlily orange clothing couldn’t prevent thermal radiation, this cloth could have flame retardancy to early fire. The relative standard was GA 633-2006.
Table 3. The parameters of firefighters' protective clothing for rescue.

| The parameters                                      | Data                      |
|-----------------------------------------------------|---------------------------|
| Outer layer’s damaged length                        | <100 mm                   |
| Outer layer's afterflame time                       | <=2s                      |
| Outer layer                                          | No melting or dropping phenomenon |

If the crew member put out the bigger fire in the rescue station using half-portable water mist gun, protective clothing for firefighters would be enough [4]. This dark navy blue clothing could both have flame retardancy and prevent thermal radiation. The relative standard was GA 10-2014.

Table 4. The parameters of protective clothing for firefighters.

| The parameters                                      | Data                      |
|-----------------------------------------------------|---------------------------|
| Inner layer’s thermal stability                      | <=10% (180°C, 5min)      |
| Other three layers’ thermal stability                | <=10% (260°C, 5min)      |
| Four layers’ TPP                                     | >=28                      |
| Four layers                                          | No melting, brittle fracture or shrinkage phenomenon. |
| Outer layer’s damaged length                         | <100 mm                   |
| Outer layer's afterflame time                        | <=2s                      |
| Outer layer                                          | No melting or dropping phenomenon |

If the crew member wanted to put out larger scale fire, they should put on protective clothing for proximity fire fighting. This silver white clothing not only had flame retardancy and prevent thermal radiation, but also had radiant heat penetration resistance property [5]. The relative standard was GA-634-2006. However, the target of tunnel rescue station was to ensure the passengers’ safety. If the fire’s scale was so large, all the people should escape including train crew member.

Table 5. The parameters of protective clothing for proximity fire fighting.

| The parameters                                      | Data                      |
|-----------------------------------------------------|---------------------------|
| All layers’ radiant heat penetration resistance property | <25°C (40 kW/m², 40s)    |
| All layers’ TPP                                     | >=28                      |
| Comfort layer’ thermal stability                     | No melting or dropping phenomenon |
| Thermal barrier layer’ damaged length                | <=100 mm                  |
| Thermal barrier layer’ afterflame time               | <=2s                      |
| Thermal barrier layer                                | No melting or dropping phenomenon |
| Thermal layer’s thermal stability                    | <=5% (180°C, 5min)       |
| Outer layer’s damaged length                         | <=100 mm                  |
| Outer layer's afterflame time                        | <=2s                      |
| Outer layer                                          | No melting or dropping phenomenon |

So the firefighters’ protective clothing for rescue and protective clothing for firefighters should be prepared in the train or in the tunnel rescue station except the firefighters’ protective ensemble for rescue. Using which the crew member could put out the early fire or bigger fire. In addition, the firefighters could put on the clothing in 30s and the crew member should be trained further.
3.2 The safety rope
The fire service life safety rope could be used to load body during the rescue. This rope had breaking load, elongation and high temperature performance [6, 7]. The relative standard was GA 494-2004. In addition, the safety rope with luminescent function should be preferred in train or emergency tunnel rescue station.

Table 6. The parameters of safety rope.

| The parameters                        | Data                                      |
|---------------------------------------|-------------------------------------------|
| Breaking load                         | >=20kN                                    |
| Elongation                            | [1%, 10%]                                 |
| Diameter                              | [9.5mm, 16mm]                             |
| High temperature performance          | 204°C without melting or coking phenomenon |

3.3 The explosion-proof light
The explosion-proof light could be used in flammable and explosive locations. Although the fixed light was on the tunnel hole and passage-way, but some escape route also needed light tool. For example, some inclined shaft as escape route didn’t have enough fixed light. The explosion-proof light could also helped the passengers to get a clearer view. This type of light could meet the requirement of Exdia II C T6 [8]. Because this light should be maintained monthly, this equipment should be prepared in the train except emergency tunnel rescue station.
There was some other equipment might be needed. For example, the hatchet for firefighters could be used to break the train’s window. Then the crew member could set the foam gun on the broken window and didn’t need to enter the dangerous carriage. For example, the compressed air breathing apparatus could help the crew member to breath in a smoke-laden atmosphere. This equipment should set on the train instead of rescue station, which need maintained monthly.

4. Conclusion

In this paper, suggestions on emergency rescue equipment in railway tunnel rescue station were summarized. Firstly, the firefighters’ protective clothing for rescue and protective clothing for firefighters should be prepared in the train or in the tunnel rescue station to extinguish early fire or bigger fire. Secondly, the safety rope with luminescent function should be prepared in train or emergency tunnel rescue station. Thirdly, the explosion-proof light should be prepared in the train. The further study should focus on new standard’s revision especially to TB 10020-2017 Code for design on evacuation engineering for disaster prevention and rescue of railway tunnel.

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