General analysis of train tunnel’s fire-fighting equipment analysis

Jianjun Xia*, Qiang Zhang and Rongji Wang

Fire extinguishing agent research division, Tianjin Fire Research Institute, Tianjin, 300381, China

*Xiajianjun@tfri.com.cn

Abstract. The object of this work was to improve train tunnel’s safety level. Firstly, the portable dry powder extinguisher and water-based extinguisher were set in the freight train and passenger train. Secondly, the half-portable water mist gun was set in the tunnel emergency rescue station. Thirdly, the fixed water mist sprinkler and water mist circle could be set in the tunnel. Different extinguisher had different scale fire control abilities. More study on advanced fire-fighting technique should be carried out in the future.

1. Introduction
A tunnel is an underground passageway for bus, car, train or passenger. As high-speed train’s fast developing in recent years, more attentions were paid on the tunnel’s safety like structure design, fire-proof treat and fire-fighting equipment [1]. The fire-fighting equipment included portable extinguisher inside the train, half-portable extinguisher and fixed extinguisher outside the train [2]. This paper would summarize relative extinguishing techniques systematically.

![Figure 1: The entrance of Lvliang railway tunnel.](image)

2. Portable extinguishers
There were portable extinguishers inside train including water-based extinguisher and dry powder extinguisher [3]. In freight train, the portable water-based extinguisher was set on the locomotives for diesel fire. In freight carriage, the portable dry powder extinguisher was set near the electric cabinet for electric fire. In passenger train, the portable water-based extinguisher and portable dry powder extinguisher were set in the carriage junction.
2.1. The portable dry powder extinguisher
The MFZ/ABC 2 dry powder extinguisher was equipped on CRH3 carriage. This extinguisher could be used to put out Class A, Class B and Class C fire. In the confined room like carriage, dry powder was quite effective by destroying the fire's chemical chains. But this dry powder was useless in open space especially when the running train carriage’s shell was burnt through. For example, the high-speed train G281 was burnt through and the fire couldn’t be put out using portable extinguisher on January 25, 2018. Then firemen went to the train station and extinguish the bigger fire using vehicle extinguisher.

2.2. The portable water based extinguisher
For another example, the MSWZ/2 water based extinguisher was equipped on CRH3 carriage. This extinguisher could be used to put out Class A, Class B, Class C and electric fire. The water based extinguisher could put out the fire by cooling and coverage. In high-speed train, most fires were Class A fire. According to GB 4351-2005, this water based extinguisher should put out Class A fire with rating 1A solid fire. There were 72 pieces of wood, whose length was 500 mm (6 pieces *12 layers) to 1A wood crib. And the ignition pan size was 400*400*400 mm. Relative study showed that the heat flux meter density near the crib with the distance 0.5 m. Then the heat release rate (HRR) of this 1A crib fire could be calculated according to point source model. So the portable extinguisher could put out early small fire with 0.02 MW in 5 minutes with 2 L/min spraying flow rate.

\[ H = D \times 4 \times 3.14 \times R^2 \]  

Table 1. The comparison between different fires.

| The heat flux density | The calculated heat release rate |
|----------------------|----------------------------------|
| 1 0.0070 MW/m²       | 0.02198 MW                      |
| 2 0.0065 MW/m²       | 0.02041 MW                      |
| 3 0.0073 MW/m²       | 0.02292 MW                      |
| 4 0.0088 MW/m²       | 0.02763 MW                      |

3. The half-portable water mist equipment
The emergency rescue station was set on the train tunnel whose length was over 20 km. This station had the platform to evacuate the passengers. In addition, the fire-fighting equipment was also set up on this station like the water mist gun. The relative water mist gun boxes were set up on both sides of the tunnel wall.
Figure 3: The half-portable fire extinguisher in Lvliang railway tunnel emergency rescue station.

The relative water mist main machine was set up on the passage-way which was perpendicular to the tunnel. This main machine could provide the water resource 210 L/min. Then four water mist guns with 32 L/min could be working at the same time, whose water mist could be used to put out the 144B liquid fire with 1 MW inside the passenger train [4].

Table 2. The half-portable fire extinguisher parameters.

| The parameter          | The data |
|------------------------|----------|
| 1 Length of one soft pipe | 30 m     |
| 2 Distance of extinguisher box | 60 m     |
| 3 Pressure of water mist | 10 Mpa   |
| 4 Flow rate of one pipe gun | 32 L/min |
| 5 K index              | 3.2      |
| 6 Range of water mist  | 5 m      |

4. The fixed water mist equipment
The fixed water mist equipment in tunnel had different types. One type was the water mist sprinkler on the tunnel roof. According to the relative standard, the supply intensity of water mist with the way of total flooding should be higher than 2 L/(min m²) if the confined room’s height was between 3 m and 5 m [5]. To half-confined room tunnel, this supply intensity should be higher. Relative studies showed that the liquid fire with 6 MW and the spray fire with 1 MW could be put out using water mist sprinkler [6].

Another type was the water mist circle, which could be applied in the circle subway tunnel for passengers’ escape and metro’s fire extinguishing. For example, Tianjin metro had a maneuver using water mist circle in the subway Line 1 on May 22nd, 2018. The water mist circle could be set in a
distance [7]. If the accident train couldn’t stop at the nearest station, the train would stop in the middle of the tunnel. The water mist circle near the accident carriage would work and form a cylinder water mist part. The passengers would escape from here when smoke and fire were limited in the cylinder water mist.

Figure 5: The water mist sprinkler’s nozzle.

5. Conclusion
In this paper, three types of fire-fighting extinguishing equipment were reviewed on train tunnel [8]. Firstly, the portable extinguisher as dry powder extinguisher and water-based extinguisher could be used to put out the early fire with less than 0.1 MW. Secondly, the half-portable water mist gun could be used to put out the fire with 1 MW. Thirdly, the fixed water mist system could be used to put out the fire with more than 1 MW. The further study focus points should be advanced fire-fighting techniques like discharging tool more suitable for train tunnel and relative additive agent with higher efficiency.

Acknowledgments
This paper is supported by National Science Technology Support Program No. 2014BAK17B03 and CECS Standard Program 2016.

References
[1] Ingason H, Li Y Z, Lönnermark A. Tunnel fire dynamics[M]. Springer, 2014.
[2] Lönnermark A. Fire suppression and structure protection for cargo train tunnels: Macadam and HotFoam[C]//3rd International Symposium on Safety and Security in Tunnels. 2008: 217-228.
[3] Schroll R C. Industrial fire protection handbook[M]. CRC press, 2016.
[4] Chow W K, Yao B. The potential application of water mist systems for fire protection in atria[J]. ASHRAE transactions, 2001, 107: 171.
[5] Back G G, Beyler C L, Hansen R. The capabilities and limitations of total flooding, water mist fire suppression systems in machinery space applications[J]. Fire Technology, 2000, 36(1): 8-23.
[6] Vaari J. A transient one-zone computer model for total flooding water mist fire suppression in ventilated enclosures[J]. Fire Safety Journal, 2002, 37(3): 229-257.
[7] Santangelo P E. Experiments and modeling of discharge characteristics in water-mist sprays generated by pressure-swirl atomizers[J]. Journal of Thermal Science, 2012, 21(6): 539-548.
[8] Wang Z, Wang X, Huang Y, et al. Experimental study on fire smoke control using water mist curtain in channel[J]. Journal of hazardous materials, 2018, 342: 231-241.