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National Fire Agency Demonstrates Firefighting Robot Tactics for Tunnel Fire Response

- ▶ Unmanned firefighting robot proves its effectiveness in dense smoke conditions where conventional fire engines may fail
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The National Fire Agency of Korea, led by Commissioner Kim Seung-ryong, announced that it has successfully completed the second phase of a live demonstration to verify the effectiveness of unmanned firefighting robots in responding to fires in long tunnels.

The latest demonstration was conducted at the Sillim-Bongcheon Tunnel in Seoul, following the first phase held earlier this month at the live-fire training facility of the Gyeongbuk Fire Service Academy.

The demonstration was designed to test how unmanned firefighting robots can overcome the physical limitations of internal combustion fire vehicles and firefighters in extreme tunnel fire environments.

Overcoming the Limits of Fire Engines and Firefighters

Tunnel fires can create severe conditions, including rapidly decreasing oxygen levels and dense smoke. In such environments, conventional internal combustion fire vehicles face a high risk of engine shutdown, while firefighters are limited by the capacity of their self-contained breathing

apparatus, which typically allows about 45 minutes of operation.

The first phase of the demonstration recreated extreme conditions similar to real tunnel vehicle fires. The results showed that electric battery-powered unmanned firefighting robots can operate stably regardless of oxygen concentration and effectively support fire suppression in enclosed spaces.

Precise Fire Suppression from More Than One Kilometer Away

The second phase focused on verifying the robot's ability to overcome communication limits and conduct practical fire suppression operations in an actual long tunnel under construction.

Due to radio signal shielding in underground environments, the wireless control distance had previously been limited to around 120 meters. In this demonstration, however, the Agency successfully extended the control range to more than one kilometer inside the tunnel by establishing a relay communication system among multiple robots, including an unmanned firefighting robot, a mobility robot, and a quadruped robot.

Even in an extreme environment filled with dense smoke and low oxygen, where internal combustion fire engines could shut down, the electric battery-powered unmanned firefighting robot advanced steadily to the fire source.

The Agency also demonstrated a reverse-entry tactic, in which the robot approached the fire from the tunnel exit side while taking into account vehicle congestion and the direction of smoke flow. Using an infrared thermal imaging camera, the robot was able to accurately discharge water even when visibility was blocked by smoke.

The demonstration confirmed that firefighting robots can enter areas

that are difficult or unsafe for firefighters to access and conduct initial fire suppression, marking a significant shift in tunnel fire response tactics.

Toward Standard Operating Procedures for Long-Tunnel Fires

Based on data from the Sillim-Bongcheon Tunnel demonstration, the National Fire Agency plans to conduct a final verification of swarm operations and cooperative tactics among robots at a Korea Expressway Corporation test site in July.

In September, the Agency plans to establish a management and operation manual for unmanned firefighting robots reflecting the demonstration results. It will also revise the Standard Operating Procedures for long-tunnel fire response and formally incorporate unmanned firefighting robots as a key resource in the national disaster response system.

“The successful demonstration at the Sillim-Bongcheon Tunnel shows that advanced robotics technology can protect firefighters and maximize fire suppression efficiency in the unique disaster environment of long tunnels,” the National Fire Agency said.

“Based on verified data, we will continue to enhance the performance of unmanned firefighting robots and establish them as essential equipment in tunnel fire response plans,” it added.