



White Paper

**FIRE SUPPRESSION SYSTEM DESIGNER PROTECTS ARMORED VEHICLES
WITH LEAK-FREE, LONG-LIFE METAL BELLOWS**



Servometer®
Precision Manufacturing Group, LLC

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To protect the crews of armored fighting vehicles, a leading manufacturer of fire suppression systems exploited the sensitivity and fatigue life of flexible electrodeposited nickel bellows. System engineers at Kidde Aerospace and Defense (KAD); a unit of United Technologies Corporation's Hamilton Sundstrand division, needed a responsive pressure-sensing element that could signal an extinguisher discharge in milliseconds (ms). They also needed a long-life mechanical link that could withstand the stresses of a rapid, high-pressure actuation at least 20 times without repair or replacement. The same corrosion-resistant element had to maintain its spring action and leak-tight integrity despite routine expansion and contraction over a broad temperature range. Extinguisher system engineers found a cost-effective solution to their combined requirements in an electrodeposited nickel bellows assembly from Servometer[®] - PMG, LLC.

Kidde Aerospace in Wilson, NC has long been a global leader in fire protection products for military and civil aircraft. Fire suppression systems for armored fighting vehicles represent a new but cost-conscious market. "It's a significant and growing part of our business," explained the Kidde Materials Manager. "Production rates for vehicle extinguishing systems are exceeding aircraft systems and the solutions we typically use in aircraft are too expensive for ground vehicles." Kidde Aerospace now supplies fire suppression systems for the Grizzly combat engineer vehicle, the new Stryker infantry carrier vehicle, and several international programs.

Pressure Sensor

A typical combat vehicle fire suppression system might have four extinguisher bottles in their crew areas and two in their engine compartments. "The idea is to provide lots of redundancy," explained the Senior Technical Specialist of Kidde. To make sure the redundant extinguishers work, every bottle has a bottom valve assembly containing a dual-purpose pressure switch. In standby mode, the pressurized switch warns of a leak or accidental discharge from a cylinder full of fire-fighting agent. When the fire suppression system is triggered electronically or manually, the switch confirms proper flow or triggers another cylinder should the bottle fail to discharge.

Central to the switch is a pressure-sensing element that moves a plunger to actuate the associated electronics. The function is usually performed in aircraft fire suppression systems by a bimetallic disk that flexes up and down to operate the switch. Though the bimetallic element is too costly for ground applications, the vehicle switches must still open instantly and perform reliably.

The pressure sensing element must remain leak-tight despite constant flexure due to temperature changes and the sudden surge of a fire-fighting discharge. To actuate the vehicle switch, system designers incorporated an electrodeposited nickel bellows assembly from Servometer.

The pressure switch has a 0.340 in. diameter nickel bellows measuring 0.321 in. long in its relaxed state and when activated travels 0.021 in. to a stop. In standby operation, the bellows are compressed by a fire-fighting agent and nitrogen pressurized to 750 or 900 psi. They expand and contract slowly as pressure varies from 400 to 1,350 psi at temperatures from -65 to +160°F. Loss of pressure allows the bellows to extend to their full, relaxed length and move the central plunger. “If the bottle leaks below a set point, the switch opens to indicate low pressure,” explained Kidde’s Senior Technical Specialist.

Alternatively, opening the valve in an emergency releases the fire-fighting agent, relieving pressure and allowing the bellows to spring back from compressed to relaxed length. System specifications call for the bellows to expand fully and signal successful extinguisher operation within just 5 milliseconds. “If the valve does not operate as required, the pressure in the bellows remains unchanged, so the switch stays closed, noted the Kidde Senior Technical Specialist. Our electronics distinguish that and trigger the extinguisher next to it.”

[Responsive And Reliable](#)

Military requirements call for the fire suppression system valves to withstand 20 discharge cycles without component repairs or replacements. “Though it’s meant for a one-shot actuation, the system is meant to be re-used, and the valves have to pass endurance discharge testing,” the Kidde Senior Technical Specialist also noted. To reset the switch, the bellows must retain their integrity and spring rate through repeated actuations. Significantly, electrodeposited bellows make it possible to tailor fatigue life to the application.

The walls of the pressure switch bellows are just 0.0026 in. thick. However, Servometer electroforms nickel with 125,000 psi minimum tensile strength, 110,000 psi minimum yield strength, and 270 Vickers hardness. The good mechanical properties of the metal and conservative design margins of the bellows make a flexible part with essentially infinite life. Nickel bellows can be compressed to 40% of their free

length, and they maintain negligible hysteresis to recover their original shape quickly.

The electrodeposited nickel bellows also proved compatible with a range of chemicals. Though widely used Halon 1301 fire-fighting agent is inert, some other alternative agents raised worries. “We were concerned about corrosion,” recalled their Senior Technical Specialist. “We did high- and low-temperature exposure and all kinds of environmental testing. It came through fine.”

The bellows has performed successfully in pressure switches for years on a variety of vehicles. To maintain quality and reduce assembly cost, Kidde Aerospace has Servometer install the center plunger then solder assemble the bellows to the brass switch housing. “We originally used to buy the bellows separately, but now we have Servometer do the soldering,” said Kidde’s Materials Manager. “We like getting it all from one shop.”

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