WOOD HARVESTING

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FOAM FIRE-SUPPRESSION SYSTEM FOR MOBILE FORESTRY EQUIPMENT

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Abstract

A foam fire-suppression system for mobile forestry equipment was developed to overcome some of the deficiencies of conventional dry chemical systems. The development was a joint effort of the Forest Engineering Research Institute of Canada (FERIC), MacMillan Bloedel Limited, Fleck Brothers Limited, Angus Fire Armour Limited, and Ropec Industries Limited. In February 1991, the system was tested on a Thunderbird 1146BC log loader at MacMillan Bloedel Limited's Kelsey Bay Division on Vancouver Island, British Columbia.

Introduction

Fires in mobile forestry equipment can result in capital loss, operator injury, mechanical down time, and environmental damage. Certified dry chemical fire-suppression systems are the industry standard for use with mobile forestry equipment. Although dry chemical systems are designed according to tested criterion, the following features make them less than ideal:

- Dry chemical is difficult to dispose of after it is deployed.
- Moisture contamination can cause the chemical to cake and thus adversely affect deployment.
- Air turbulence may hinder deployment.
- Dry chemical sometimes fails to reach deep-seated or concealed points of combustion.
- If the engine or compressor ingests dry chemical, extensive damage may occur.

These problems demonstrate the industry's need for an alternative to using dry chemical for fire suppression in mobile forestry equipment.

MacMillan Bloedel Limited (MB) asked the Forest Engineering Research Institute of Canada (FERIC) to investigate alternative suppression systems. With co-operation from MB, Fleck Brothers Limited, Angus Fire Armour Limited, and Ropec Industries, a prototype foam fire-suppression system was installed on a Thunderbird 1146BC log loader at MB's Kelsey Bay Division on Vancouver Island, British Columbia. It was evaluated in February 1991.

Methodology: Preliminary Research

FERIC began this project in early 1990 by examining the existing technology and conferring with equipment suppliers and those involved in the certification of fire-suppression systems. Foam fire-suppression technology, with its wide-spread use and success in other applications, offered interesting potential for forest machinery applications.

The decision to investigate foam as a possible alternative to dry chemical was based on foam's greater heat-absorbing ability and penetrating propensity. Easier cleanup and more reliable deployment were also anticipated with foam.

Fire suppressant foam is an air-entrained aqueous solution that forms a tenacious blanket over liquids and other surfaces to isolate the fuel from the oxygen, suppress gaseous emissions from hot combustibles, and cool possible sources of ignition. The stability of this blanket is a key factor, and is attributable to the reduced water-surface-tension resulting from inclusion of a foam concentrate.

Most foam concentrates are made from protein

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compounds. Class A foam is used on nonhydrocarbon-based fires, such as wood, cloth, and paper, while Class B has a special ability to suppress re-ignition by maintaining a water/foam layer on top of diesel fuel, hydraulic oil, and other hydrocarbons prominent on forestry equipment.

Air inclusion increases the foam volume, thus enhancing fuel isolation and suppression of combustible gases. Low-expansion foam has a foam-to-water-volume ratio of less than 20:1. The medium-expansion ranges from 20:1 to 200:1, while high-expansion foams have ratios exceeding 200:1.

Deployment of medium-expansion foam requires a large nozzle, which would be problematical in the closely encased high-risk fire areas of most forest machinery. High expansion foam requires forced-air injection at the nozzle; these systems are appropriate for enclosed areas where wind is not a factor, and expanded foam can completely displace the oxygen supply. However, the open design of forestry machinery and the turbulence of the engine fan renders medium- or high-expansion foam less effective than low-expansion foam. The objective of using a low-expansion foam system is to cool machinery surfaces to below the kindling temperature of the fuel, and to create a barrier to prevent the fuel vapours and the oxygen mixing.

Having completed the investigation of existing technology, FERIC's next step was to transfer foam technology to mobile forestry equipment.

Concept Development

FERIC's preliminary research and consultations resulted in the following design objectives. The prototype must offer quick response, effective coverage despite wind and fan turbulence, and minimal dependency on other machine systems. It must also be able to operate under normal ambient temperature fluctuations and offer automatic and manual deployment. Simplicity of design, ease of installation, and ease of cleanup were also required.

A nozzle, reservoir, air compressor, and other basic equipment were tested under lab conditions to identify design parameters for optimum foam deployment (Figure 1).

Initial tests, using a premixed solution of foam concentrate and water, indicated that a pressure range of 415 to 590 kPa in the reservoir produced good foam and the best spray pattern. Results improved significantly when the 13-mm diameter hose feeding the nozzle was replaced with a 19-mm diameter hose. Tests showed that secondary air injected ahead of the nozzle to enhance foaming restricted flow and caused sporadic deployment.

A local fire hall provided a safe facility for testing the equipment on small diesel fires. Both Class B and Class A foams were used in the fire tests to confirm that re-ignition of hydrocarbon-based fires was much less likely to occur with Class B foam.

Because some forestry machines work in sub-zero temperatures, FERIC considered measures to prevent the solution from freezing. The simplest and least costly freezing protection is the addition of non-toxic antifreeze which would allow the system to operate in a temperature range of -37°C to 50°C. It should be noted that the foam *concentrate* has a

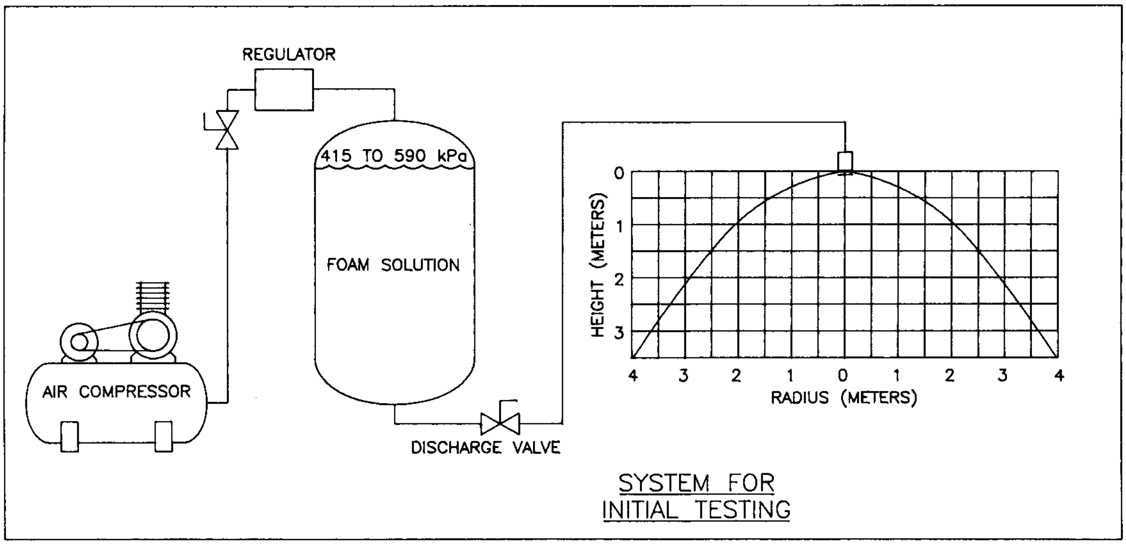

Figure 1. Equipment for lab tests.

freezing point of -37°C and it cannot be altered by the addition of antifreeze. Under colder operating conditions, heating and insulation would likely be required at added cost. FERIC's experiments showed no evidence that antifreeze altered performance in above-freezing temperatures. Performance in sub-freezing temperatures is yet to be tested.

Design and Operation

FERIC designed a prototype foam fire-suppression system (Figure 2) for a Thunderbird 1146BC log loader supplied by MB's Kelsey Bay Division on Vancouver Island.

The backbone of the system consists of a dedicated supply of bottled nitrogen that pressurizes a 230-L reservoir to 590 kPa (maximum). This forces the foam solution, made up of 3% foam concentrate and 25% antifreeze, through three Angus K40 nozzles in the engine compartment (Figure 2), and a fourth near the boom base. During deployment, nitrogen does not reach the nozzles nor is it a component of the foam.

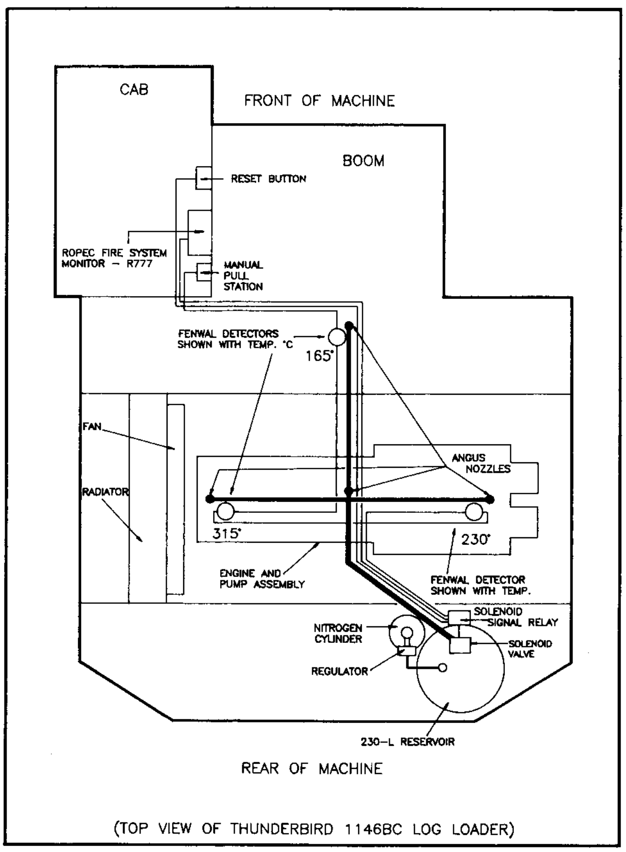

Figure 2. Drawing of a prototype foam fire-suppression system for mobile forestry equipment.

The system is controlled by a cab-mounted Ropec R777 monitor (Figure 2) which responds to a signal from one of three strategically placed Fenwal fire detectors that are factory set to response temperatures appropriate to their location. The monitor opens a normally closed, 38-mm diameter, zero-leak, solenoid valve on the reservoir outlet line. The valve and lines to the four nozzles were designed to achieve complete foam deployment in one minute.

Although the detectors deactivate after the initial cooling of the fire, a solenoid signal relay, mounted on the reservoir, ensures that the discharge valve remains open for the full deployment by locking the signals from the detectors. This ensures that the flow of foam to the fire is not prematurely interrupted. While the system is activated, the reset button mounted on the tank, and the cab-mounted reset button, will both be illuminated. The relay and discharge valve will reset when the operator presses one of the two buttons and the lights go out.

The monitor has two alarms. A fast-pulse alarm signals a fire, and a slow-pulse alarm signifies a disabling power interruption or broken connection. The system's electrical supply is continuous and is not disconnected with the night switch. The fire-suppression system may also be activated manually by a switch mounted in the cab, near the monitor. An operational check may be performed by manually activating the system and shutting it off seconds later with an adjacent reset button.

When the system is activated, an alarm on the monitor will sound and foam will be discharged. The engine will shut down fifteen seconds later, allowing the operator to bring the machine to a safe stop. If the operator requires more time, he may press the "engine shutdown override" button on the face of the monitor. This action will not delay the deployment of foam. The system monitor is reset by turning the ignition key "off" and then "on."

The system was installed in February 1991, and final shop tests were conducted to evaluate the overall performance. The first test, conducted with no foam additive and the engine off, was intended to evaluate flow distribution of the four nozzles and their spray patterns. After the first test proved successful, a final test was conducted with complete foam solution and the engine running (Figure 3); the total discharge time was 55 seconds. The engine shutdown occurred as anticipated, and the foam coverage was complete and unaffected by the turbulence of the engine fan.

Excess foam flowed to the lower machinery areas and onto the ground (Figure 3). This would likely

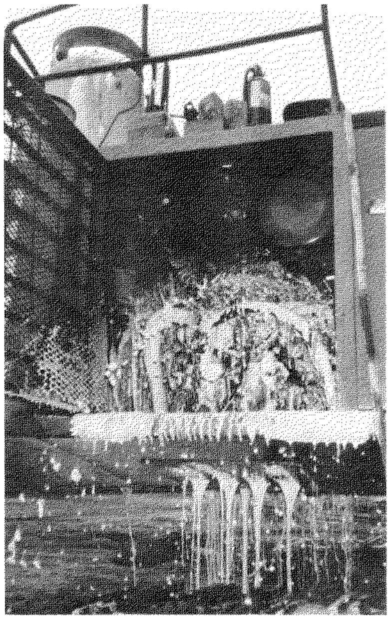

Figure 3. A final test was conducted with foam and engine running.

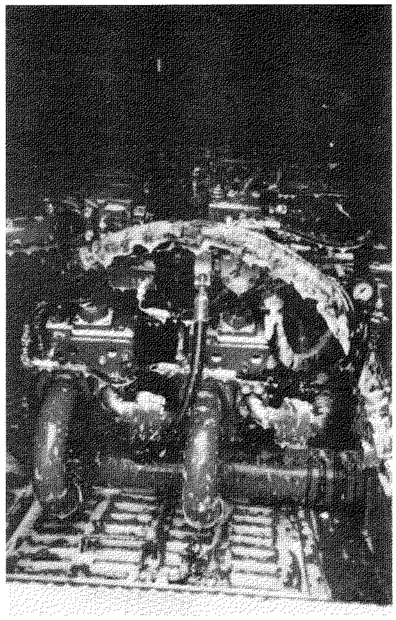

Figure 4. Following deployment, foam remained on the machinery surfaces, but was easily washed away with water.

prevent any proliferation of fire due to dripping oil or fuel. Following deployment, the foam remained on the machinery surfaces (Figure 4), providing extended protection, but was easily washed away with water.

Conclusion

FERIC designed a prototype Class B foam fire-suppression system and tested it on a hydraulic log loader in early 1991. With two exceptions, which are still to be tested, FERIC was able to demonstrate that the system met the original design objectives:

- Quick response.
- Effective coverage despite wind and fan turbulence.
- Minimal dependency on other machine systems.
- Simplicity of design and ease of installation.
- Ease of clean-up.

Deployment in freezing weather and automatic deployment in a large-scale machine fire are points which have yet to be explored. Also, the system should be tested on other types of forestry equipment. Larger machines, such as a swing yarder, would require more nozzles and a larger reservoir. For trucks, skidders, and other machines where the threat of fire centres around the engine compartment, a single nozzle and a 60-L foam solution reservoir should suffice. Further testing may also involve nozzle modifications to achieve spray patterns more suited to each application.

This work should follow more precise clarification of the performance requirements for foam-deployment rate, expansion rate, coverage, and blanket stability for forestry equipment applications. A long-term objective of this work would be to acquire certification, similar to that for dry chemical systems, to promote conformity, reliability, and possibly reduce insurance premiums. The more direct benefits of foam fire-suppression technology are improved operator safety, reduced capital loss and mechanical down time, and less environmental damage.

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