Fire suppression

# Burning issue

FAA Fire Safety Branch experts are tackling the disparate challenges of developing a new oil burner for engine fire safety testing and finding a replacement for halon in aircraft fire-extinguishing systems

BY PAUL E EDEN

In the case of powerplant fire testing, the Federal Aviation Administration (FAA) is both a regulator and researcher, and its Technical Center Fire Safety Branch has taken the lead in developing a next-generation (NextGen) fire test burner. The requirements of fire testing are exacting and, for powerplant work, ideally satisfied by an oil burner, but the majority of such products mentioned in FAA advisory circulars and reports are no longer in production.

Power Plant Engineering Report No. 3A, Standard Fire Test Apparatus and Procedure (For Flexible Hose Assemblies), Revised March 1978, for example, lists acceptable fire test burners, including the Lennox OB-32, Carlin 200 CRD, and Stewart-Warner HPR 250 and FR-600 – none of which remain commercially available.

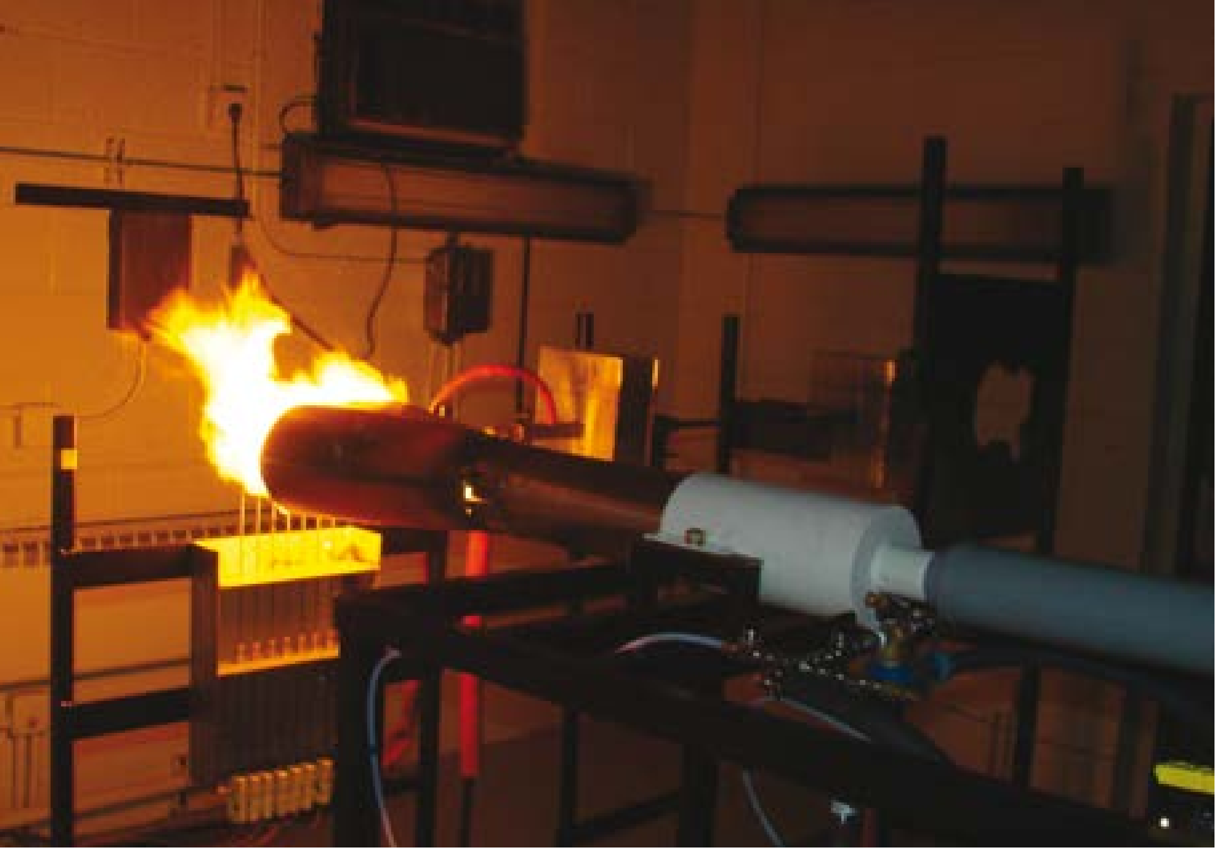
Advisory circular 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria, published in February 1990, references the same burners, adding the SAE 401 propane-fueled burner adjusted to 9.3BTU/ft$^{2}$s, and propane and oxy-acetylene torch-standard and diverging nozzles (for small components) to the list. The pattern has continued with subsequent reports, referencing existing notes and even introducing alternative burners, including the Park DPL 3400 (also no longer available) and the SAE AS401B propane burner.

FAA advisory circulars deliver general guidance on acceptable means of compliance to regulations, and though specific test equipment may be specified, they note that alternative acceptable devices may be used. The aerospace industry is left operating existing oil burners, but primarily using propane burners for powerplant fire testing, which, although capable of matching regulatory standards, require careful handling to replicate a powerplant fire.

## TEST ENVIRONMENT

When an engine installation burns, oil, fuel, and hydraulic fluids are typically involved, generating flames of similar temperature and heat flux to propane, but of greater opacity. Tested with a propane burner, materials re-radiate heat into the transparent propane flame as they near its temperature, causing a rapid loss of surface heat – there is no heat loss through a flammable-liquid flame. Thus the Fire Safety Branch set about defining standards for the NextGen, or sonic burner, aimed at delivering fully representative, repeatable test conditions.

Compared with the Park DPL 3400, which had been in widespread use, the NextGen burner is engineered to deliver greater consistency using compressed air and a pressurized fuel system in place of the earlier model's electric motor. Nitrogen gas applies a head pressure to the burner's jet fuel supply for consistent pressure and flow rates, and modifications to the burner configuration include installation of a flame retention head. The latter increases flame uniformity and early material fire tests revealed the potential for improved test result repeatability, all initially thanks to work based on



LEFT: The FAA's NextGen burner is being developed to deliver fully representative, repeatable test conditions

a US$50 part purchased from a central heating supplier. Indeed, the NextGen burner has been developed for ease of reproduction, so that machines assembled at different locations will behave as identically as possible.

In early NextGen burner tests against a slug calorimeter (a sheet of copper with a thermal absorptive coating and thermocouple(s) on its rear face to determine heat flux), 2024 aluminum sheet and a double layer of 8611R polyacrylonitrile, the FAA confirmed consistency between individual burners. Flame temperatures and heat flux were similar to those generated with the DPL 3400. Through the FAA's extensive collaboration with industry, nine laboratories subsequently became involved, testing against 12 materials.

When all the test data has been collated, analyzed, and confirmed to be consistent, work will begin on rewording AC20-135. Steve Summer, from the FAA's Fire Safety Branch, explains: "We're conducting research to implement the burner in all the areas where it'll be used – in materials flammability tests for seat cushions, cargo liners, and powerplant fire testing. In the latter, the burner is used as a certification means to determine the fire worthiness of a component or material. Components must maintain their function for a specific period of time when exposed to the burner."

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### HALON PROGRESS

While the NextGen burner will help to prove passive fire safety – the ability of components to withstand fire and continue to function – there is a raft of unrelated research and test work aimed at finding a replacement for halon 1301 in fire-extinguishment systems. Combined with fire detection sensors, fire-extinguishment equipment provides active fire safety.

Universally ratified by the UN on September 16, 2009, the Montreal Protocol on Substances that Deplete the Ozone Layer banned continued halon production. The EU and ICAO specified that alternative engine/APU fire-extinguishing agents must be used in new-design aircraft after 2014, while the EU also requires the completion of retrofit work to replace halon equipment in legacy aircraft by 2040. Regardless of these deadlines, regular maintenance requirements are dependent upon recycled halon supplies, which will become depleted over time.

To date, the FAA has approved several built-in non-halon fire extinguishers for litter bins, as well non-halon hand fire extinguishers for use in the cockpit and cabin. However, only one built-in non-halon fire extinguisher has been approved for engine use. The FAA's William J Hughes Technical Center continues to work with the International Aircraft System Fire Protection Working Group on non-halon research, supporting industry in developing alternative fire-extinguishing agents suitable for use in the challenging environment of the engine/APU and cargo hold.

This group created the minimum performance standards (MPS) for all aircraft applications. The MPS provide recognized test protocols establishing the performance equivalency of the non-halon agent compared with halon agents. Completion of the MPS is the first step in approving a non-halon extinguishment/suppression system for use on transport-category aircraft.

Additional installation issues must be addressed to obtain FAA approval, including operation of the extinguishing/suppression system considering the effects of altitude, temperature, humidity, and so on, at worst-case operating temperatures. The possibility of material interaction between the agent and the parts that are likely to be exposed to it during storage or discharge must also be evaluated, as must its shelf life and installation life limitations on the aircraft.

Meanwhile, the Halon Alternatives for Aircraft Propulsion Systems (HAAPS) consortium was formed in October 2014 to "mitigate both the regulatory and supply risks by leveraging the combined resources and knowledge of the aircraft manufacturers, fire-extinguishing system suppliers, engine/APU/nacelle companies, governments, and other key stakeholders to develop a non-

## TEST SETTINGS USED ON NEXTGEN BURNER WITH FRH FITTED

| | |
|---|---|
| FUEL PRESSURE: | 90-100psi |
| FUEL TEMPERATURE: | 42°F (±10°F) |
| AIR PRESSURE: | 50psi |
| AIR TEMPERATURE: | 50°F (±10°F) |
| AVERAGE FLAME TEMPERATURE OVER 14 TESTS: | 1,901°F (6°F standard deviation) |
| AVERAGE HEAT FLUX OVER 14 TESTS: | 6,065BTU/h (370BTU/h standard deviation) |

## Q&A

### STEVE SUMMER FROM THE FAA'S FIRE SAFETY BRANCH

HOW WILL USERS ENSURE THEIR NEXTGEN BURNER IS CREATING A FLAME OF THE REQUIRED STANDARD?

**"Calibration specifications of the fuel and air flow rate and temperature will be specified to ensure the flame is of the proper intensity. Once the required flow rates and temperatures are determined, periodic checks of the burner will be required to ensure proper functioning of the equipment."**

HOW CLOSELY IS THE FAA WORKING WITH INDUSTRY ON NEXTGEN BURNER TESTING?

**"We're working extensively with industry, collaborating with several test labs to assess burner performance and consistency. This work is coordinated through the Powerplants Fire Test Task Group, which functions as part of the International Aircraft Systems Fire Protection Working Group."**

HAS THE DEVELOPMENT OF NEW AIRFRAME MATERIALS INFLUENCED THE NEXTGEN BURNER'S DESIGN?

**"Not its design, but we are evaluating the process to identify what changes the test requirements might need to properly test those components."**

WAS ANY INDIVIDUAL IN PARTICULAR RESPONSIBLE FOR NEXTGEN DEVELOPMENT?

**"Dr Robert Ochs of the FAA Fire Safety Branch developed the burner for a recent regulation on insulation burn-through resistance. It has since been incorporated into many of the materials' fire test requirements for seat cushions and cargo liners. We are now looking to incorporate it into the powerplants' fire test requirements."**

DOES THE NEXTGEN BURNER HAVE A PLACE IN HALON-REPLACEMENT RESEARCH AND DEVELOPMENT WORK?

**"No, the burner doesn't impact halon-replacement research, but it will have a key role in proving the passive fire safety standards of future powerplants and components. It's used to ensure the proper functioning of equipment and materials under a realistic fire condition, whereas halon replacement focuses on finding a suitable replacement that provides the same fire suppression."**

halon replacement." Comprising representatives from Airbus, Boeing, Bombardier, Embraer, Textron, and the Ohio Aerospace Institute (OAI), HAAPS is managed by OAI's Carol Cash.

A HAAPS update document released in May this year proposes a three-phase approach, with Phase I – creation of the consortium – complete. Phase II, tentatively timetabled to last one year from the third or fourth quarter 2015, will develop a technical statement of work, while Phase III, likely to run for 12 months from the third/fourth quarter 2016, will include test and analysis work to identify a replacement agent and systems.

Doug Ingerson is part of the FAA's engine nacelle halon replacement effort. He confirms: "Test work is progressing, with multiple FAA offices involved. We've become the focal point for conducting the testing, coordinating with industry and other airworthiness authorities. There are particular test protocols for the powerplant, cargo compartment, handheld extinguishers on the main deck, and fire extinguisher bottles in trash cans in the lavatories of all transport-category aircraft."

Many factors will decide on the effectiveness of the halon replacement, among them the rate at which it is released. With the cargo compartment, Ingerson notes: "In some of the systemic design considerations, quickness can be detrimental (in an oversimplified example, injecting too much candidate into the compartment too rapidly might defeat the structural boundary of the cargo compartment, thus losing the necessary containment).

"Effective function would also include minimal production of noxious decompositional by-product as the halon replacement is exposed to the fire and thermally decomposes during its resident time. Also, the cargo compartment must contain the fire whether the fire-extinguishing agent is resident or not. This part of its design is assessed without consideration of a fire-extinguishing system used to protect the compartment. Fire containment and fire extinguishment are two different design goals in the cargo compartment."

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BELOW: **FAA's NextGen burner in the lab**