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ADEQUACY OF STANDARD FIRE TEST APPARATUS AND PROCEDURE FOR TESTING THE FIRE RESISTANCE OF POWERPLANT COMPONENTS ON THE NEWER TYPE AIRCRAFT WITH HIGH THRUST ENGINES

by

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Purpose: To present information on the standard burner used in fire resistance testing of aircraft powerplant components and the effect of engine size on fire resistance requirements.

Discussion: It is doubtful that the new large engine installations will make engine fires more severe than the fires experienced on current engines. The increased quantities of fuel and airflow are not expected to increase the severity of a fire for the following reasons:

1. Although the quantity of airflow is greater, the air velocity will probably be low due to the proportionally larger compartment volume. The large quantities of flammable fluids should not change the temperature level and the fire characteristics since even a relatively small leak on present installations produces a large intense fire due to the limited quantity of available air. If the air velocity and flame temperature remain the same, the convective heat level during a fire on a new large engine can be expected to be similar to that experienced in the past.

2. Although the physical size of the new installations are greater, the clearance between engines or engine components and nacelles probably have not increased substantially. Therefore the depth of the fire will remain limited by this small clearance. If the flame temperature and the depth of the flame remain the same, the radiant heat level during a fire on a new large engine can be expected to be similar to that experienced in the past.

The adequacy of a burner in testing the fire resistance of a component depends primarily on the temperature, velocity and size of the flame produced by the burner. The standard 2 gal/h burner currently used for this purpose produces 2000°F flame over a 58 square inch cross-sectional area with an estimated flame velocity of 1-1/2 feet per second.

The 2000°F flame temperature seems to be realistic for a fire in which the fuel and air are not premixed. During full-scale testing on the 720B powerplant installation, it was found that during fires resulting from spray releasing and igniting JP-4, temperatures above 1800°F were quite localized. The maximum temperature reported for these tests was 2100°F. In a case where the fuel and air are premixed producing ideal burning or where there is an engine case burn-through, the flame temperature may approach 3000°F.

The 1 1/2 ft/s flame velocity produced by this burner is considered to be low. Convective current in a nacelle can be expected to produce greater velocities due to existing temperature gradients alone. If the cooling or ventilating airflow produce high velocities over a component, the burner flame velocity should be increased. For example, the convective heat transferred to a 1/2-inch O. D. tube with a 1 1/2 ft/s, 2000°F flame impinging at 90° to the tube axis is theoretically 3.8 BTU/ft^2 tube surface area per second. If the velocity is increased to 25, 50, or 100 ft/s with the flame temperature constant, the convective heat level would increase to 11.5, 16.0, or 23.7 BTU/ft^2-sec respectively.

The adequacy of the size of burner flame depends on the size of component to be tested and the tightness of the nacelle in the area of the component. It the component is normally located in a restricted area, the size of the burner flame can be expected to be adequate. Measurements have indicated the burner produces a radiant heat level of 6.8 BTU/ft^2-sec. The radiant heat produced by a flame is a function of the flame temperature and the depth of the flame. The maximum theoretical radiation level for a 2000°F fire is 14.75 BTU/ft^2-sec. This requires a flame having a depth of 15 inches or greater. Therefore if the component as installed in the nacelle is surrounded by a large free volume, the radiation level may exceed the 6.8 BTU/ft^2-sec produced by the burner.

The 2-gal/h burner may not be adequate for large components since from the standpoint of both convective and radiant heat transfer it is important that the flame completely engulfs the exposed portion of the component with some depth.