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HANDBOOK OF AVIATION FUEL PROPERTIES

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APPENDICES

Appendix A — Membership of CRC Advisory Group on the Aviation Fuels Handbook A-1

2.7 ELECTRICAL CHARACTERISTICS

Fuels have electrical characteristics that are important to aircraft and fuel system designers. These characteristics become evident in the manner in which a fuel reacts to the flow of an electrical current. Of major importance is the conductivity of a fuel which plays a primary role in the electrostatic charge buildup in a fuel as it flows through a system. The dielectric properties relate to the way a fluid varies the capacitive reactance of a pair of parallel electrodes, and is the key to the design of fuel gages.

2.7.1 Dielectric Constant (Permittivity)

The dielectric constant of a fuel is experimentally determined by establishing the ratio of the electrical capacitance of a device filled with the fuel as compared with the electrical capacitance of the same device when filled with air. Measurements of the dielectric constant of a fuel at various temperatures show that the dielectric constant is a linear function of temperature, decreasing with increasing temperature and varying with the applied frequency. Figures 30 and 31 give the relationship between dielectric constant versus temperature for the various aircraft and missile fuels. The data presented are at 400 Hz, which is the most used frequency in commercial and military aircraft. This indicates that fuel gages based on this fuel property must be calibrated for the particular fuel being measured.

2.7.2 Electrical Conductivity

Pure hydrocarbons and mixtures of hydrocarbons such as fuels are essentially nonconductors of electricity. In practice, however, they always contain trace amounts of materials which increase their conductivity to a lesser or greater extent, depending upon the chemical nature and the concentration of the impurities. In most cases, the conductivity of the fuels is still very low. In any event, this low conductivity is the fundamental property that can cause a very hazardous situation to arise in handling flowing fuels.

A fuel when flowing tends to become electrically charged due to a shearing mechanism called "charge separation." This phenomenon can cause the development of high levels of electrostatic charges within the fuel which cannot be dissipated due to the low conductivity of the fuel. These free charges can build up to levels high enough to cause static discharges through the vapors in tanks. Depending upon the composition of the vapor phase, ignition may occur. The phenomena are highly complex and involve a multitude of variables depending upon the system and conditions being encountered. Such factors as high contact areas encountered in filter separators, relaxation time required for charge dissipation, fuel system design, protruding devices in flow channels, impurity levels in the fuel, and many other factors influence the degree of hazard. At the root of the problem, however, is the fundamental low conductivity of fuels which in most cases is in the range of 0.1 to 5.0 pS/m, even with trace impurities present.

Although devices have been developed in an effort to decrease and measure the charge buildup in fuels, the most successful approach has been the introduction of an additive to increase the overall conductivity of the fuel. A minimum of 50 pS/m is considered to furnish adequate conductivity for handling safety. The maximum limit of 600 pS/m is set low enough to prevent malfunctions of fuel quantity gages. Fuels will generally show decreased conductivities at lower temperatures. Due to this factor, most fuels are treated with enough additive to produce a conductivity of 175 to 200 pS/m at 15.5°C, so that they will still retain conductivities of at least 50 pS/m at lower temperatures. Figure 32 shows the change in conductivity versus temperature for typical JP-4 and JP-8, with and without additives.

A complete review of the generation and dissipation of electrostatic charge with a selected literature survey can be found in Reference 1.

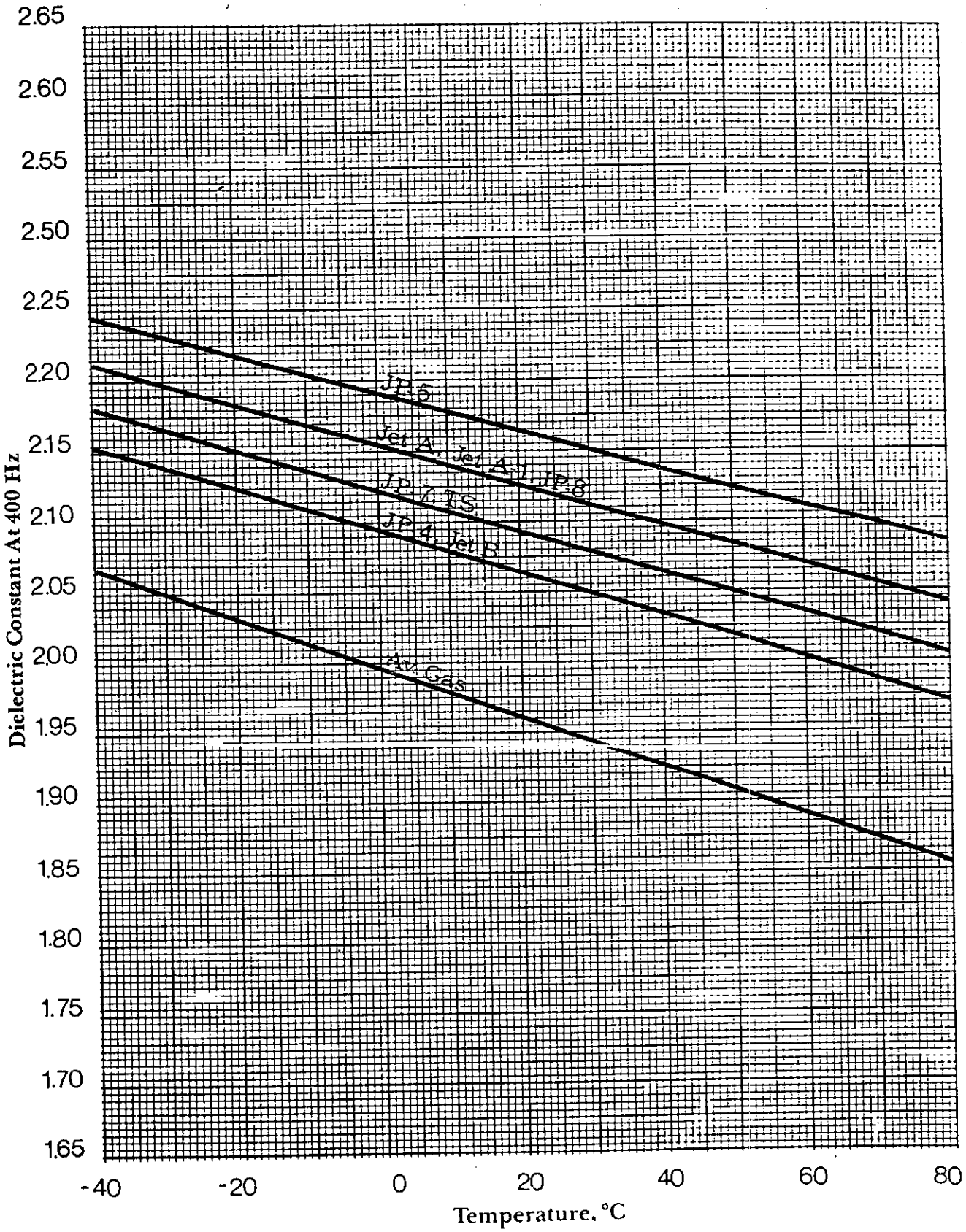

Figure 30
Dielectric Constant vs. Temperature For Typical Aircraft Fuels

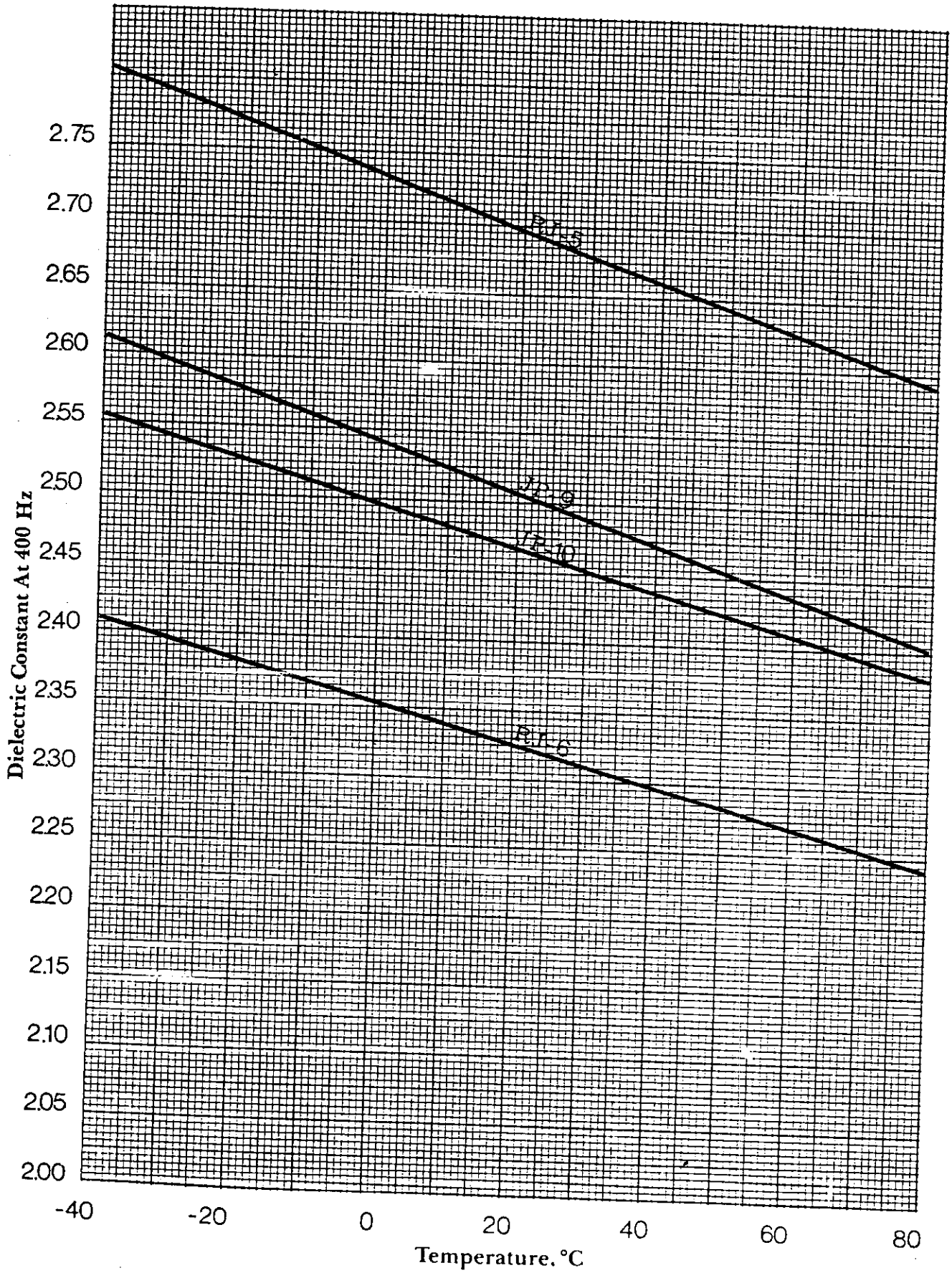

Figure 31
Dielectric Constant vs. Temperature For Typical Missile Fuels

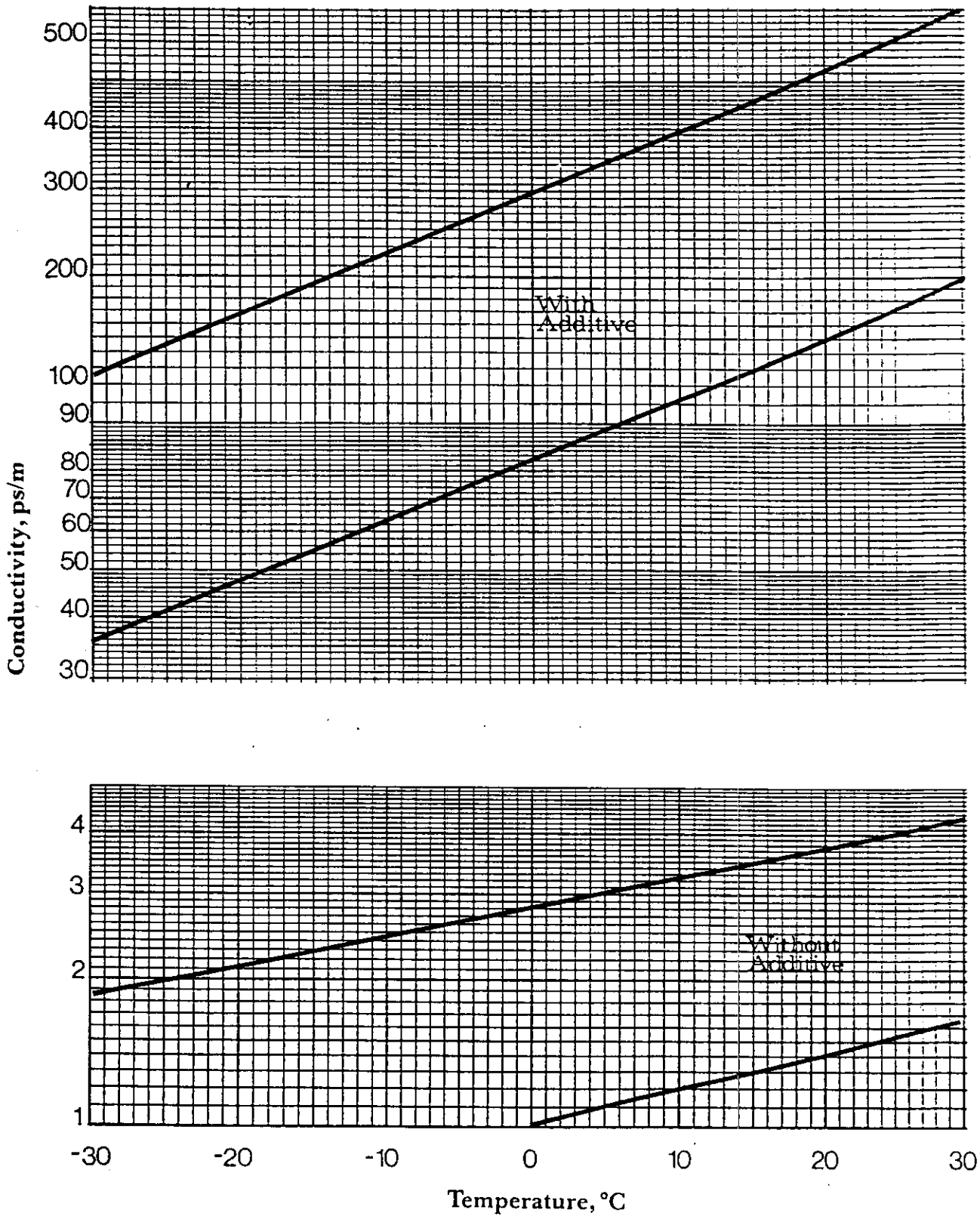

Figure 32
Typical Range of Conductivity vs. Temperature for Aircraft Fuels

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