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F I N A L

UNIRRADIATED CHARACTERISTCIS OF U-Si ALLOYS AS DISPERSED-PHASE FUELS

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To satisfy the power demands of many research reactors, a new LEU fuel with a high density and U content was needed. Any fuel must be compatible with Al and its alloys so that it may be fabricable as a dispersed-phase in Al alloy and Al matrix plate-type elements following, as nearly as possible, established commercial manufacturing techniques. U-Si and U-Si-Al alloys at or near the composition of U_3Si were immediately attractive because of work documented by the Canadians[1,2,3].

Figure 1 illustrates the U-Si system[4]. All intermediate phases, within the experimental ability to define them, are line compounds. For the goals of the RERTR program, attention has focused on the compounds U_3Si (3.9 wt.% Si) and U_3Si_2 (7.3 wt.% Si) and to compositions between these limits. Densities and hardness for as-arc-cast as well as heat treated ingots in this composition range are shown in Figure 2[5]. Photomicrographs corresponding to these compositions and conditions are shown in ref. 5. Because of its higher U content and density, U_3Si was the more attractive candidate fuel even though a prolonged heat treatment is required to complete the peritectoid reaction[6]. As will be discussed by others, U_3Si_2 has performed better than U_3Si in an irradiation environment.

With dispersed-phase powder metallurgy technology as the fabrication process of principal if not exclusive interest, comminution of U-Si alloys to <150 μm powders is required. Large pieces as well as powders of U-Si alloys

in the composition range of interest are quite stable under ambient conditions. During crushing, however, the alloys react with oxygen due to the combined effects of fresh surfaces being created and the heat generated in crushing. Commercial processes now in use require all comminution to be conducted in a glovebox with a neutral atmosphere (N_2 or Ar) with a small amount of O_2 not only permitted but preferred. Oxygen at levels of ~1% or slightly more apparently serves to passivate the newly-formed surfaces.

U_3Si_2 being hard and brittle is quite easy to crush. Generating too many fines (particles <40-45 μm) while comminuting is probably the only problem other than recognizing and controlling its pyrophoric nature. U_3Si, however, is tough and relatively soft, making conversion to powder a challenge which is still being addressed. For any U-Si alloy jaw crushers have worked effectively but not efficiently and the use of other devices such as roll crushers and impact mills is being explored. It is premature to report on the possible merits of these techniques.

Powders of U_3Si, U_3Si_2 and compositions between these compounds have been successfully generated and fabricated into miniplates as well as full-size plates elements. With only minor modifications, established fabrication procedures used for U_3O_8-Al and UAl_x-Al plates are being commercially employed today. During fabrication, fuel alloy-Al reactions are minimal to non-existent. However, some oxidation of fuel particles during preheating (~500°C) for the first rolling pass may occur if proper procedures and precautions are not observed.

Samples from fabricated plates have been used to determine the thermal conductivity of the dispersions and plates[7]. In a separate set of experiments, the enthalpies and temperature regimes of the Al-U_3Si and Al-U_3Si_2 reactions have been quantitatively measured.[8]

While attention is still being given to the considerations of comminution and oxidation during fabrication, U-Si alloy fuels are today a commercial reality on an international basis.

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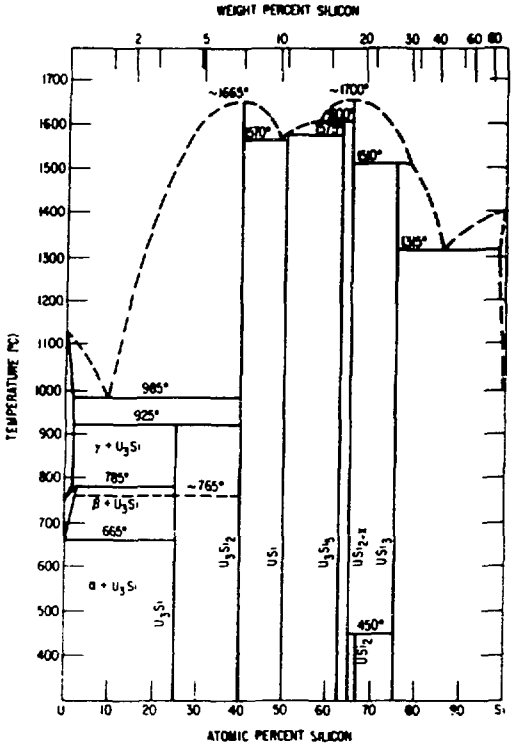

Fig. 1 The U-Si System

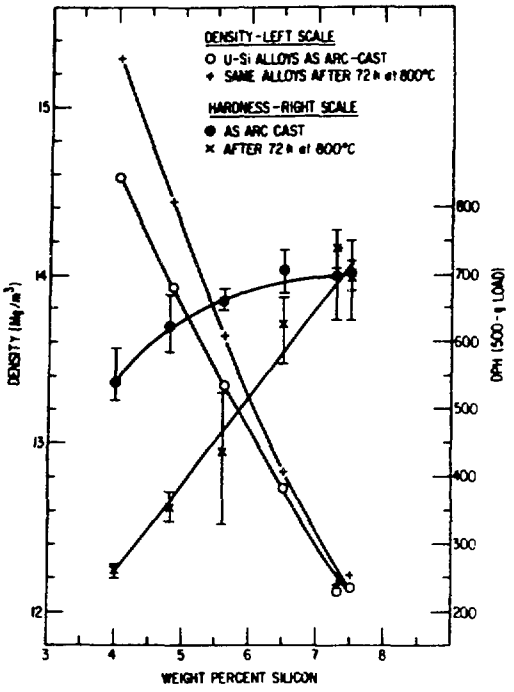

Fig. 2 Densities and Hardness of Some U-Si Alloys