U-V (Uranium-Vanadium)

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[98Sta] has recently proposed a revised version of the U-V phase diagram. His experimental investigation in the temperature region between the eutectoid reaction at 727 °C and the eutectic reaction at 1040 °C found the same phase fields as in the early diagram proposed by [53Sal]; however, there were significant shifts in compositions along the solvus of the cubic (γU), the γ phase, and in the eutectoid composition, which was shifted from the 2.08 wt.% of [53Sal] to 1.0 wt.% V. These changes lead to a maximum V content in the γ phase of 2.5 wt.% V at 1040 °C, a eutectic composition at 1040 °C of 4.5 wt.% V, and a maximum terminal solubility in (βU) of 0.14 wt.% V. It is not stated explicitly, but the latter value was probably inferred from combination of the shifted eutectoid composition and the van't Hoff equation. The terminal solubilities of (V), the δ phase, on the V-rich side of the diagram between 727 and 1040 °C were found to be essentially the same as determined by [53Sal].

Table 1 Elemental Content of the Three Alloys of [98Sta]

Element	2.10 wt.% V, wt. ppm	1.38 wt.% V, wt. ppm	0.82 wt.% V, wt. ppm
C	60	55	85
H	0.25	0.20	0.35
O	9	20	24
N	39	50	46
Fe	110	105	120
Al	15	16	8
Si	190	150	120
Mg	3	5	1
Total	**426.25**	**401.2**	**404.35**
U (wt%) by difference	**97.86**	**98.58**	**99.14**

[98Sta]'s experiments were carried out with three alloy compositions: 2.10 wt.% V, 1.38 wt.% V, and 0.82 wt.% V. The alloys were prepared as 20 kg ingots by pouring molten U over plates of V in a vacuum induction furnace. The cast ingots were given a homogenizing treatment for 100 h under a vacuum of 10^{-6} mm Hg (10^{-9} bar) at 1010 °C. The ingots were then rolled, and samples were cut from the sheet. Samples of all compositions were equilibrated at twelve temperatures between 760 and 1010 °C inclusive and subsequently quenched. Metallography, SEM, and hardness testing were used to examine the samples. Scanning electron microscopy examination with application of energy dispersive spectroscopy (EDS) and wave dispersive spectroscopy (WDS) were used to determine compositions. Table 1 gives the compositions of the bulk material of the three samples. Metallographic examination showed that small black precipitates were present in all equilibrated samples. Scanning electron microscopy examination of these precipitates showed them to be an extraneous V_2C phase indicating that the high thermodynamic stability of that phase

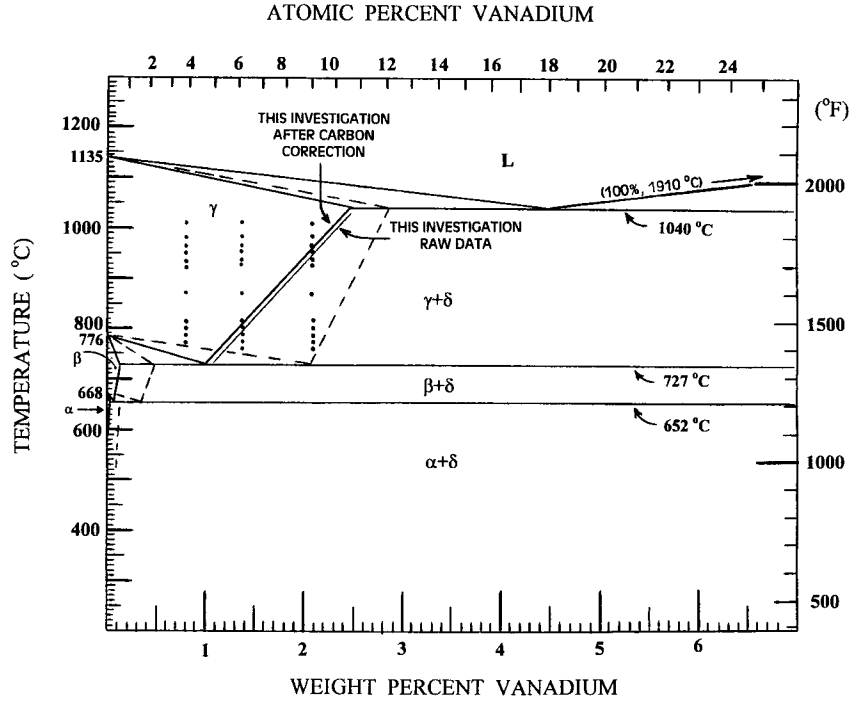

Fig. 1 U-rich region of the U-V system: solid line, [98Sta]; dashed lines, [53Sal].

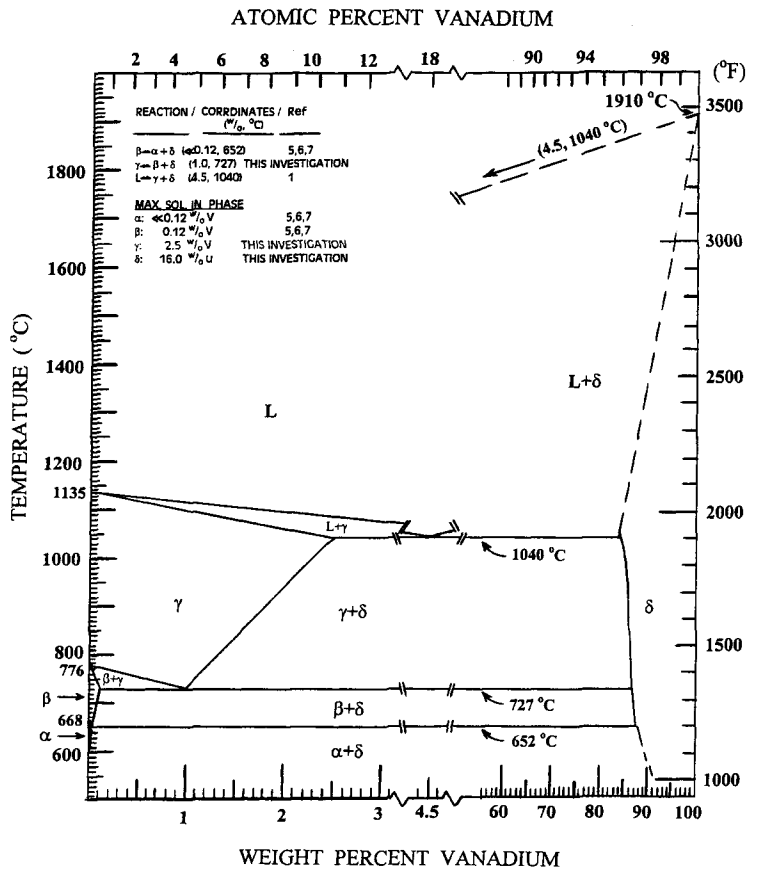

Fig. 2 U-V temperature-composition diagram (after [98Sta]).

abstracted C from interstitial solution in U. The precipitates were, in the 0.82 wt.% V alloy at all equilibration temperatures and in the 1.38 and 2.10 wt.% V alloys at higher equilibration temperatures, solely of the V_2C phase; however, at lower temperatures in the 2.10 wt.% V alloy and at still lower temperatures in the 1.38 wt.% V alloy, an additional, smaller precipitate phase was observed.

Scanning electron microscopy analysis of this additional precipitate phase showed the composition to correspond to the V-rich terminal solution, δ phase. The onset temperature of δ phase precipitation was bracketed as being between the equilibration temperature of nonappearance and equilibration temperature of first observation. This temperature was further refined with hardness measurements, and the two compositions provided two temperature-composition points along the γ/(γ + δ) solvus. Similarly, compositions of the δ precipitates at different equilibration temperatures provided compositions for the (γ + δ)/δ solvus. Extrapolation of a line between the two γ/(γ + δ) solvus points to 1040 °C provided the γ composition participating in the eutectic reaction, and extrapolation to 727 °C provided the eutectoid composition. Figure 1 shows a comparison of the [98Sta] diagram with solid lines and the [53Sal] diagrams with dashed lines. The solvus line indicating a change due to "carbon correction" was obtained by abstracting from the alloy composition the amount of V present as V_2C rather than in bulk alloy. Figure 2 gives [98Sta]'s complete diagram.

The U of the [98Sta] investigation was probably of higher purity than that used by [53Sal], who did not give detailed analytical data. The [98Sta] diagram is thus likely to be more representative of the pure binary system. Even so, his alloys contained a total of 75 to 125 wt. ppm interstitial impurities plus 175 to 270 wt. ppm metallic and metalloidal impurities. When converted to atoms of impurities per atom of U, the numbers increase significantly so that further reduction in impurity levels might well lead to further changes in the phase diagram. However, the [98Sta] diagram is certainly of practical use because it predicts the alloying behavior of currently available U.

Cited References

53Sal: H. Saller and F.A. Rough, *Trans. AIME, 197,* 545-548 (1953).
98Sta: M.A. Staker, *J. Alloy. Compd., 266,* 167-179 (1998).