100 alloy to 33 MPa√m (30 ksi√in.) for AISI H11 (UNS T20811).

The one alloy with higher fracture toughness, AF1410, gives up some of the strength needed for aerospace parts and components. AerMet 100 has a yield strength of 1725 MPa (250 ksi), compared with 1515 MPa (220 ksi) for AF1410.

As shown in Fig. 2, all alloys in this group can be heat treated to tensile strengths of 1655 to 2000 MPa, (240 to 290 ksi). However, with the exception of AerMet 100, those steels that reach the highest tensile and yield strengths (H11, 300M, and 4340) also exhibit the poorest fracture toughness.

Fracture toughness values for these alloys were obtained by measuring the amount of energy required to fracture precracked test samples. The tests, in effect, provided a measure of how large a flaw each alloy could withstand before it failed.

Charpy V-notch tests on the alloys determined how much impact energy was needed to produce a break (Fig. 3): AF1410 tested at 70 J (52 ft·lbf); AerMet 100, 45 J (35 ft·lbf); all other alloys, below 45 J (35 ft·lbf). The lowest value obtained was 25 J (18 ft·lbf) for both 300M and Hll.

In separate tests performed by the federal government, the Charpy V-notch value for AerMet 100 was determined to be 40 J (28 ft·lbf) at –55°C (–65°F), indicating that the alloy retains superior toughness even in very cold environments. Most high-strength steels tend to become brittle at these low temperatures.

Relative toughness of the alloys also was measured in terms of elongation and reduction in area (Fig. 4). AerMet 100 and AF1410 showed elongation of 13 and 15%, respectively, while the remaining four alloys were significantly lower. The differences in reduction in area (RA) were even greater, with AF1410 measuring up to 68% reduction, AerMet 100 up to 65%, 18Ni(250) (UNS K92890) up to 57%, and the remaining three steels measuring less than half the highest %RA.

The excellent combination of high strength and high toughness gives AerMet 100 better fatigue resistance than that offered by any of the other high-strength alloy steels.

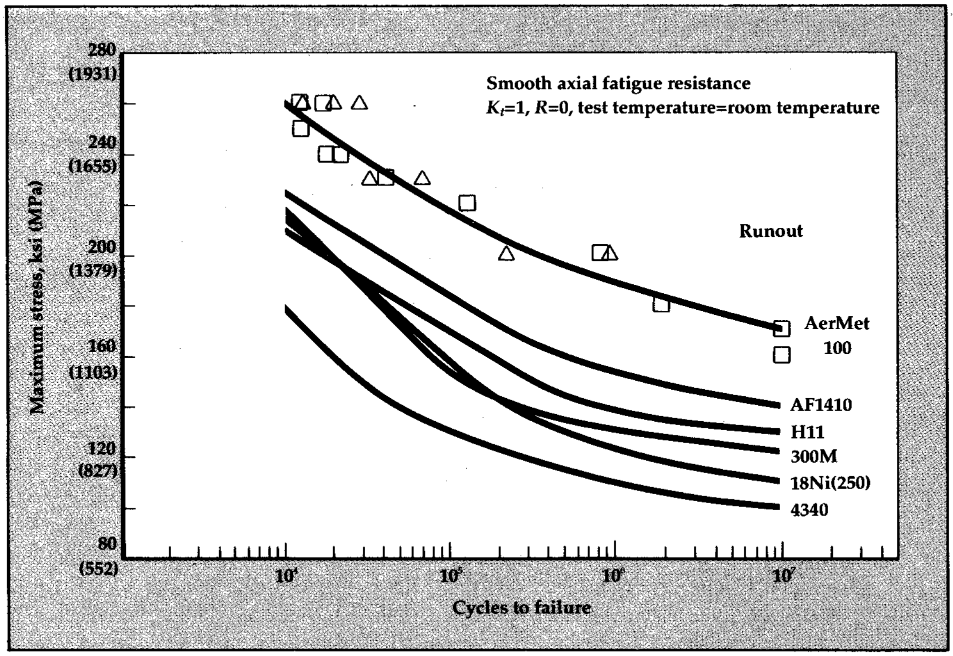

Fig. 6 — AerMet 100 fatigue resistance data are for both 470 and 480°C (875 and 900°F) aging treatments (different laboratories). Other data are from MIL-HDBK 5 *or* Aerospace Structural Metals Handbook. *Smooth axial tests at room temperature,* K*t* = *1,* R = *0; longitudinal data.*

These properties, along with 51 to 55 HRC hardness, offer more latitude in designing stronger parts for longer operation under severe operating conditions.

Independent laboratory tests show the relative fatigue resistance of the six alloys (Fig. 6). AerMet 100 data are for both 470 and 480°C (875 and 900°F) aging treatments. Other data are from *MIL-HDBK 5* or the *Aerospace Structural Metals Handbook*.

SCC resistance: McDonnell Douglas subjected AerMet 100 and 300M to severe tests to evaluate their relative resistance to stress-corrosion cracking (SCC). Test samples were bent 180° and immersed in a sodium chloride solution for 6 min, then removed to dry for 52 min. The cycle was repeated continually for 35 days. In this qualitative way, AerMet 100 demonstrated much better resistance to SCC than 300M.

In another test (Fig. 5) to measure resistance to SCC, precracked test specimens were put under load and immersed in a 3.5% salt solution for up to 5000 h. The test measures how long it takes for each sample to fail, and at what strength level failure occurs. AerMet 100 alloy provided a K_{Iscc} of 38 MPa√m (35 ksi√in.), showing much greater resistance than four of the competing alloys, but less than the lower-strength AF1410.

Statistically-based minimum design values for AerMet 100 mechanical properties will be included in the MIL-HDBK 5 design handbook that will be published this year. The data, obtained by means of an intensive test program at Battelle, were gathered from 10 lots of material in bar sizes from 75 to 255 mm (3 to 10 in.) in thickness and in three bar configurations for the 1930 to 2070 MPa (280 to 300 ksi) tensile strength range.

Using this information, engineers will be able to determine minimum design values for tensile yield and ultimate strengths, compressive yield strength, shear ultimate strength, and bearing yield and ultimate strengths for longitudinal and short-transverse grain directions in the bar sizes tested.

Typical tensile and compressive stress-strain curves for longitudinal and short-transverse grain directions for AerMet 100 also will be shown in *MIL HDBK 5*. Precise values will be provided for tensile and compressive moduli of elasticity in the longitudinal grain direction (Young's modulus is 195 GPa, 28 million psi).

Due to AerMet 100's ultrahigh strength and high hardness (51 to 55 HRC), shear tests were difficult to perform. To test shear specimens of the alloy, which has a