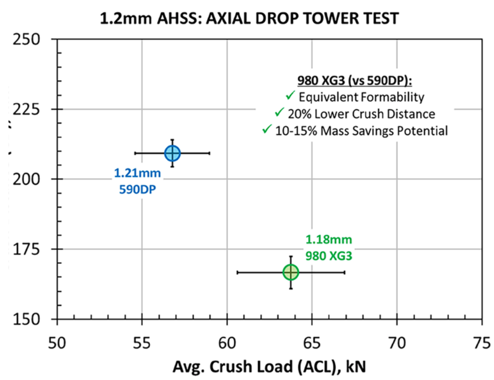
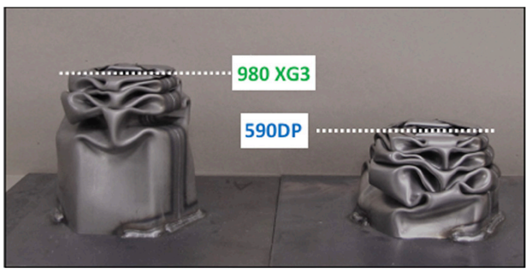
PERFORMANCE
AUTOMOTIVE SOLUTIONS

XG3

CRASHING & CRUSHING

We've put 980 XG3 through its paces, ensuring that it scores highly in several performance-based tests.





Drop-Tower Crush Test

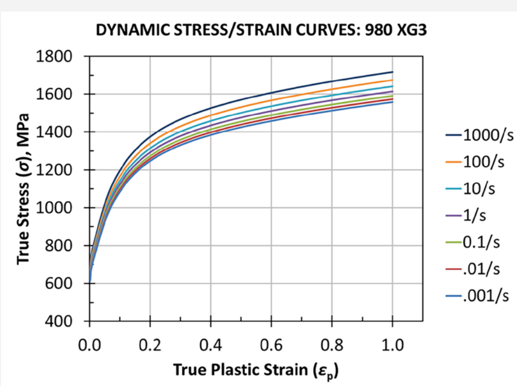
U. S. Steel 980 XG3 exhibits superior energy management behavior over 590DP with equivalent overall formability performance. Axial drop-tower crush tests were conducted at the United States Steel Corporation Research and Technology Center in Munhall, Pennsylvania, where 1.2mm 590DP and 1.2mm 980 XG3 were evaluated head-to-head.

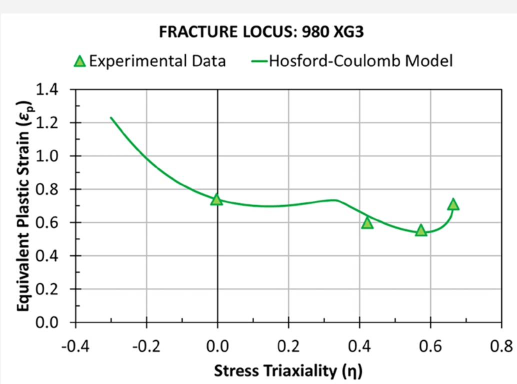
In this test, a 450 kg mass impacts a tapered hexagonal tube specimen along its axis at 7.1 m/s with a nominal kinetic energy of 11.3 kJ. Specimen fabrication details are given elsewhere (re Link & Hance 2017). The following conclusions were drawn from this analysis:

• Under the same nominal conditions (geometry, thickness, impact energy), 980 XG3 showed 20% less axial crush distance than 590DP.

• For equivalent energy management performance, 980 XG3 offers 10% to 15% weight savings potential over 590DP.

The axial drop-tower test results are summarized here, where error bars represent ±1 std deviation (n=5). Example crush test specimens are shown for each material.





Crashworthiness Modeling:

United States Steel Corporation has developed laboratory testing protocols to generate dynamic stress-strain data and fracture criteria for use in LS-DYNA® based vehicle crashworthiness models. Example CAE model inputs for USS 980 XG3 are shown here:

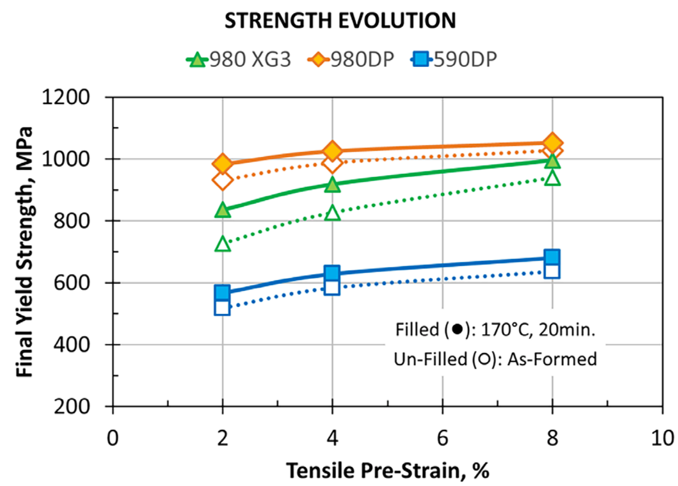
1 — True stress-strain curves for strain rates ranging from .001/s to 1000/s;

2 — Multiple-stress-state fracture model calibrated with experimental data (Mohr and Marcadet 2015).

Occupant cabin intrusion and crash energy management characteristics are measured against the FMVSS requirements defined by the National Highway Traffic Safety Administration (www.NHTSA.gov). U. S. Steel continues to evaluate the crucial role of 3rd Generation AHSS such as 980 XG3 in meeting these increasingly stringent standards.

[LS-DYNA is a registered trademark of LSTC (Livermore Software Technology Corporation); FMVSS = Federal Motor Vehicle Safety Standards]

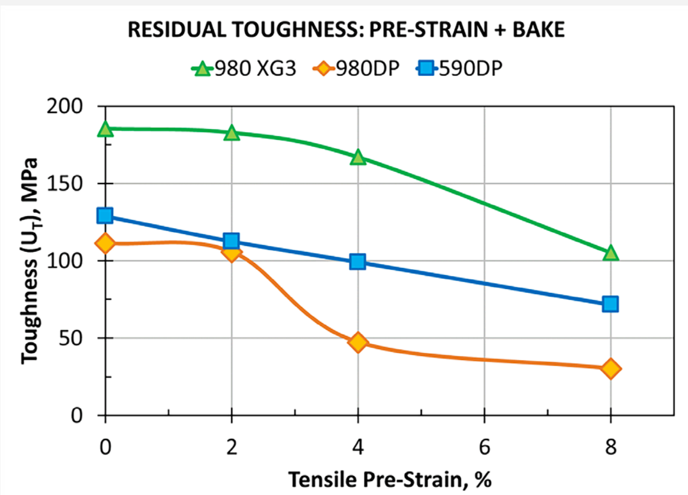
STRENGTH & TOUGHNESS



Strength Evolution

U. S. Steel 980 XG3 exhibits a substantial strain-and-bake strengthening response. The net result is 40-50% greater in-service yield strength vs 590DP.

At larger deformations, the final yield strength of 980 XG3 is similar to that of 980DP. Work-hardening and strain-aging (bake hardening) combine to help compensate for thinning and to increase intrusion resistance (resilience) in side impact and roof crush applications, for example.



Residual Toughness

Residual toughness is the amount of “leftover” energy absorption capability after forming and bake hardening (e.g. 170°C, 20 min).

Toughness is commonly defined as: $U_T = (1/2)(YS+UTS) x(TE/100)$, where YS = yield strength, UTS = ultimate tensile strength and TE = % total elongation (Dieter 1986).

In other words, U_T is an approximation of the area under the engineering stress-strain curve to fracture [units: stress = energy/volume]. In this context, in the 0% pre-strain condition (baked only), the toughness of U. S. Steel 980 XG3 is 44% higher than that of 590DP (lower strength) and 67% higher than that of 980DP (lower ductility).

After 8% tensile pre-strain and baking, the respective toughness values of 980 XG3 and 590DP decreased by 40-45%, while that of 980DP decreased by more than 70%. The rapid initial work hardening and lower intrinsic ductility of 980DP combine for an abrupt decrease in residual toughness between 2% and 4% pre-strain.