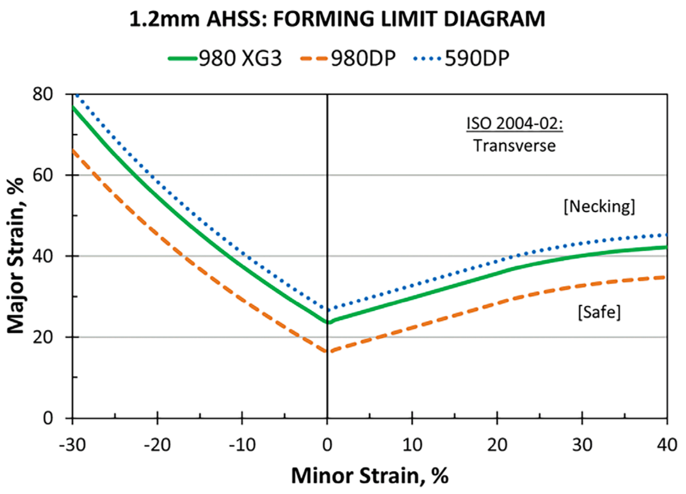
FORMABILITY
AUTOMOTIVE SOLUTIONS

XG3

PUSHING AHSS TO NEW LIMITS

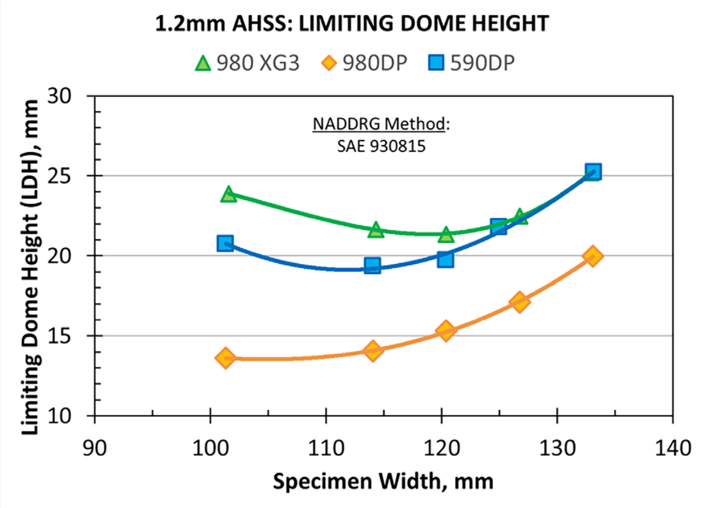
980 XG3 challenges what we've come to accept when it comes to the formability of an AHSS product. Here's the proof.



Forming Limit Diagram

The forming limit curve (FLC) is a conventional measure of formability. Here, the FLCs of various 1.2mm-thick advanced high strength steels are shown on a single forming limit diagram.

In this context, U. S. Steel 980 XG3 is superior to 980DP and nearly equivalent to 590DP.



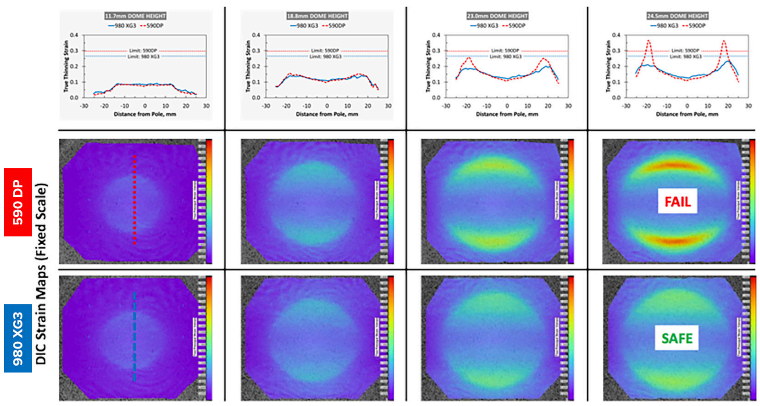
Limiting Dome Height

The performance advantage of U. S. Steel 980 XG3 is more clearly illustrated by the limiting dome height (LDH) test.

In this test, a fully-clamped rectangular sheet specimen is stretch-formed by a 100mm (4in) diameter hemispherical punch. The test is completed when necking failure is reached – marked by a critical punch force change (load drop).

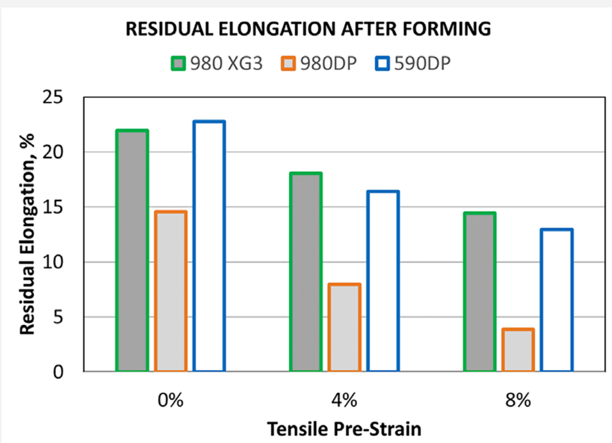
By modifying the specimen width, a variety of deformation modes ranging from uniaxial tension to biaxial stretching is achieved. For nominally identical thickness and surface conditions (1.2mm, uncoated), the LDH value of 980 XG3 is greater than or equivalent to that of 590DP.

STRAIN & ELONGATION



Strain Distribution

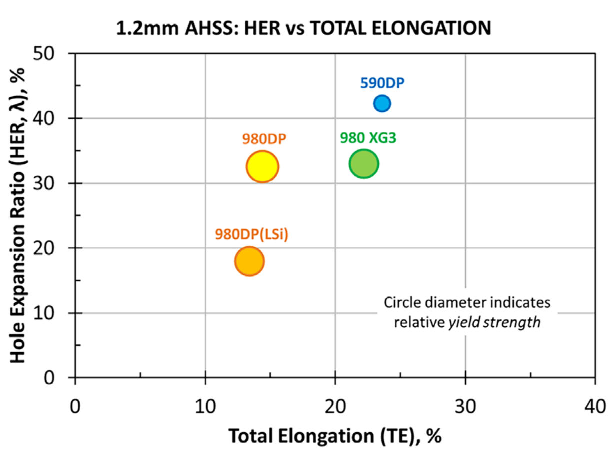
In this example, Nakazima-type dome testing coupled with digital image correlation (DIC) technology reveals the superior strain-distribution performance of U. S. Steel 980 XG3 vs. 590DP under near-plane-strain deformation conditions (Huang & Shi 2018).



Residual Elongation

Residual ductility after modest deformation is critical in complex, multi-step forming processes and in cases where springback compensation is achieved via binder stake-bead application.

In this example, after 8% tensile pre-strain, the total elongation of 980DP is reduced to less than 5%, while U. S. Steel 980 XG3 and 590DP retain 10-15% elongation.



Hole Expansion Ratio

Relationships between local and global formability are conventionally shown by plotting the hole expansion ratio (ISO Std 16630) against total elongation.

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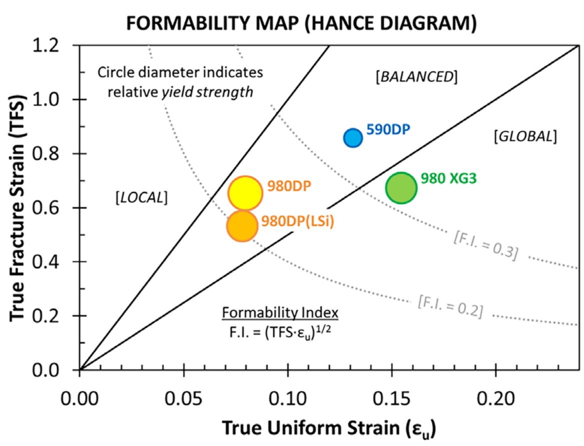
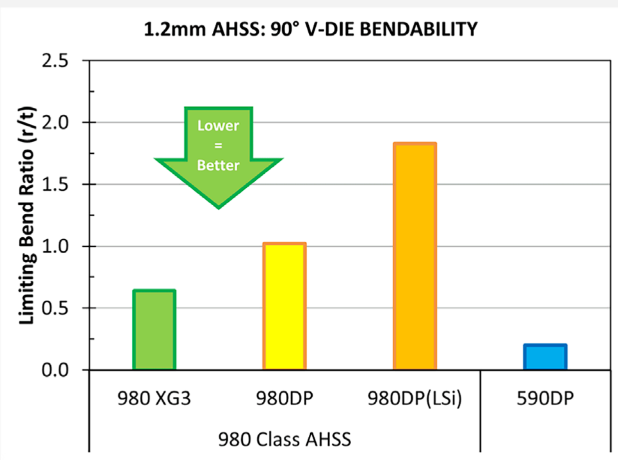
A LOT MORE BEND WITH LESS BREAK



Formability Map (Hance Diagram)

True fracture strain (TFS) and true uniform strain (εu) are intrinsic measures of local and global formability, respectively (Hance 2016, 2018).

The Formability Index (F.I.) defines the overall formability level: F.I. = (TFS·εu)1/2. In this context, the formability equivalence of U. S. Steel 980 XG3 (global character) and 590DP (balanced character) is indicated by F.I. > 0.3.

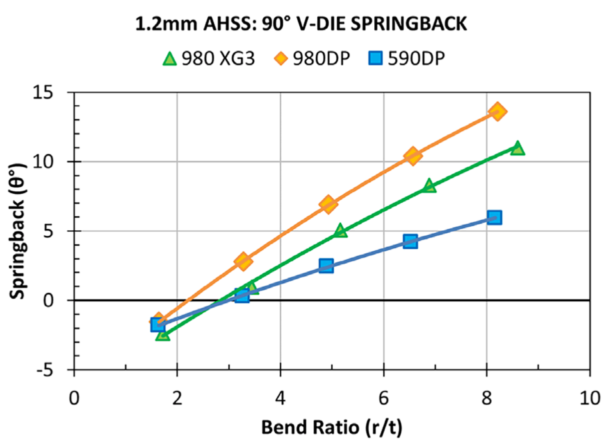


90° V-Bend

Bendability is a combined function of local and global formability (Hance 2016).

With a limiting bend ratio (r/t) consistently below 1, the performance of U. S. Steel 980 XG3 is superior to other 980 Class advanced high strength steels (90° V-die; worst case orientation: bend axis parallel to sheet rolling direction).

In this example, after 8% tensile pre-strain, the total elongation of 980DP is reduced to less than 5%, while U. S. Steel 980 XG3 and 590DP retain 10-15% elongation.



Springback

The unique work-hardening behavior and low yield-to-tensile ratio (YS/UTS) of U. S. Steel 980 XG3 combine to reduce overall bending springback in contrast to conventional 980 Class AHSS materials. This inherent advantage—combined with greater overall formability—translates into increased part design flexibility and more efficient springback compensation.