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# Forming and Fracture Limits of Sheet Metals Deforming without a Local Neck

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## ABSTRACT

Under certain strain paths (e.g., balanced biaxial) and during some forming processes (e.g., incremental forming, micro forming), sheet metals may deform and fail without forming a local neck. In these cases, it is challenging to determine the forming limits using standard tests and measurement methods (ISO) designed to detect the formability from a sharp, single local neck. In this work, local necking was suppressed in an Al-6061-T6 alloy and a DC-04 steel with an in-plane biaxial (cruciform) test, and the fracture limits of these materials were measured at various strain paths together with the forming limits by an alternative Marciniak-Kuczynski based thickness strain ratio method (TRM). The measured strains were compared with the standard Nakajima tests containing sharp local necks. Due to the unique geometry of the cruciform test, both materials developed strain localizations and deformed until fracture without deviating from the predetermined strain ratio. This enabled a true measure of fracture strains of both materials, which was not possible with the standard tests. Moreover, the ISO method was not applicable to the case without local necking, whereas TRM resulted in similar forming limits in both tests.

**Keywords:** Cruciform Test; Nakajima Test; FLC; Aluminum; Steel; Formability