

## A New Look at Time-Temperature-Thickness Requirements for PWHT

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Post-welding heat treatment (PWHT) operations are typically performed for either residual stress relief or property improvement purposes, or both. As far as residual stress relief is concerned, there is a growing interest in various industries to reduce PWHT hold time requirements. This is largely because, in addition to economic incentives, a prolonged hold time as typically required by codes and standards can have detrimental effects on weldment properties for some materials. In this investigation, detailed finite element residual stress and creep-relaxation models are used to reveal the fundamental residual stress relief mechanisms associated with PWHT operation. Creep relaxation data collected from an earlier study was used to validate the computational model. Both carbon steel and 2-1/4 Cr-Mo steel of drastically different thicknesses (0.5" to 4") are considered. The following are the major findings:

- 1) Residual stress relief occurs rapidly as a weldment is heated up to near typical PWHT temperature and immediately after that, as shown in Fig. 1, provided a relative uniform temperature within the weldment is maintained such as in furnace
- 2) The primary stress relief mechanism is attributed to creep-relaxation phenomenon. As a result, there exists a characteristic temperature  $T_0$  at which creep relaxation is activated by a characteristic stress (creep activation stress  $\sigma_0$ ) for a given class of materials
- 3) Under typical PWHT operating conditions, the stress relief process is essentially completed during a short of period of time at the beginning of hold time, far shorter than typical hold time required in current practice (see Fig. 1). In addition, weldment thickness effects can be effectively prescribed by heat transfer considerations so that everywhere within entire weldment follow a pre-determined temperature cycle within a maximum-allowed temperature differential
- 4) The observations have been validated using creep relaxation tests using 2-1/4 Cr-Mo steel coupons.

The findings from this investigation are currently being considered for the upcoming ASME code revision as unified time-temperature-thickness requirements for performing PWHT for stress relief purposes.

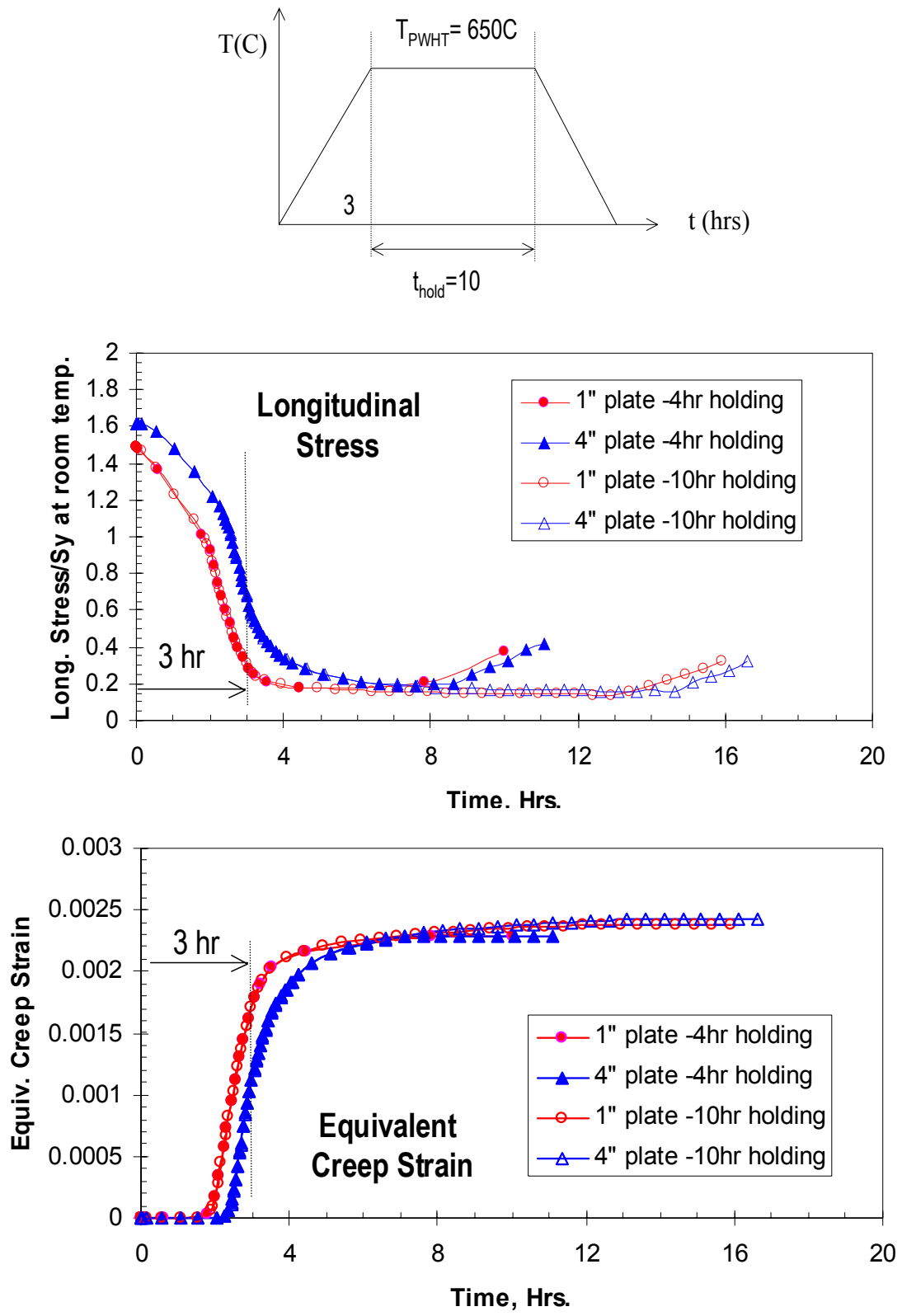


Fig. 1: Residual stress relaxation and creep strain development – 2-1/4 Cr-Mo weldments