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Welding Research Council, Inc.

Bulletin

Recognition of UNS K91201 (Grade T/P 921 9Cr-2Si-1Cu) Alloy in API 579-1/ASME FFS-1 and API Std 530

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E^2G | The Equity Engineering Group, Inc.

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FOREWORD

Grade 921 (UNS K91201, SA-213 T921 and SA-335 P921) is a ferritic alloy steel developed for use in refinery fired heaters that service processes with a high tendency for coke formation and fouling. Such services include cokers, crude and vacuum heaters, visbreakers, heavy-oil hydrotreaters and others. Grade 921, nominal composition 9Cr-2Si-1Cu, is a variant of the traditional fired heater material, 9Cr-1Mo, with additions of copper and silicon to reduce the tendency for coke formation (i.e., fouling nucleation and accumulation) on the process-exposed inside surface. Grade 921, however, is not a member of the Creep Strength Enhanced Ferritic (CSEF) group of 9-12% Cr alloy steels. Some publications refer to Grade 921 as "P9Mod" or "Modified 9Cr," however to avoid confusion with the more common Grade 91 steel (9Cr-1Mo-V – which is widely deployed and referred to by these same names), Welding Research Council, Inc. (WRC) will refer to this material only as Grade 921 or the product-form-specific grade names, T921 and P921. The creep resistance of Grade 921 is comparable to that of conventional 9Cr-1Mo material over most of the temperature range, and codes and standards have (or are in the process of) establishing time-dependent allowable stresses for Grade 921 which are nearly identical to those of conventional 9Cr-1Mo. The alloying additions of copper and silicon do, however, provide for a significant amount of precipitation hardening to occur simply during normal manufacturing heat treatment (normalizing and tempering). As a result, the time-independent (tensile and yield) strengths over the useful temperature range are significantly higher for Grade 921 than for conventional 9Cr-1Mo. This Bulletin presents currently available high temperature strength data for Grade 921. The elevated temperature tensile and yield strength properties are provided for the establishment of time-independent allowable stresses in API Std 530, along with recommended safety margins accounting for the limited size of the dataset. A discussion of the Grade 921 creep properties is provided, along with WRC's recommendation that, at this time, the alloy utilize the Larson-Miller (LM) and rupture exponent properties of conventional 9Cr-1Mo.

It is expected that Grade 921 will be formally recognized in the 2nd Addendum to the 7th Edition of API Standard 530 (API 530 7.2), which is currently out for ballot by the API Subcommittee on Heat Transfer Equipment. As outlined in this Bulletin, the LM properties used to develop allowable stresses in API 530 7.2 are identical to those for conventional 9Cr-1Mo. Efforts by WRC are underway to include Grade 921 in an Addendum to the 3rd Edition of WRC Bulletin 541 (WRC 541 3.1). Formal recognition of Grade 921 in API 579-1/ASME FFS-1 (API 579) will not be reflected in the 2021 Edition of this document but is expected to occur in a subsequent edition. Until the alloy is formally recognized in API 579, FFS practitioners may utilize the creep rupture properties of conventional 9Cr-1Mo in creep assessments of Grade 921 or may utilize the specific LM or MPC Omega method properties provided in this Bulletin. For guidance on specific applications (Omega testing, remaining life determination, etc.), inquirers are encouraged to write to WRC.

Dr. Martin Prager
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ABSTRACT

This WRC Bulletin records the data used to gain approval of ASME and API for application of Grade 921 (UNS K91201, 9Cr-2Si-1Cu) alloy at elevated temperatures. This novel alloy has been developed by Vallourec to resist coke formation in refinery heavy oil services and has already gained ASTM (A213 and A335) and ASME (Code Case 3007) approval. All data and property equations are provided herein in both US Customary and Metric units. Included in the data collections and curve fits are yield and tensile strengths, Larson-Miller (LM) stress-rupture properties, and MPC Omega Method properties, including Omega parameter and initial creep strain rate coefficients corresponding to the stresses and temperatures for which data were provided. Also contained within this Bulletin are available data for welded joints, intended to demonstrate the suitability of welded constructions of Grade 921 for elevated temperature service, and establish recommended modifications to the provided base metal properties to account for the behavior of welded joints.