

8306-009

## FORMABLE HOT-ROLLED STEEL WITH INCREASED STRENGTH

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### ABSTRACT

HOT-ROLLED STEELS WITH GOOD FORMABILITY are normally available up to the 550 MPa (80 ksi) yield strength level. For higher strength the quenched and tempered steels are predominant. At Svenskt Stål AB, Domnarvet a new hot-rolled formable strip steel with increased strength has been developed, DOMEK 640 XP. The minimum yield strength is 640 MPa (92 ksi) and the steel is commercially available in thicknesses 3 to 8 mm.

The steel can be classified as a carbon-manganese steel microalloyed with 0,035 % niobium and 0,14 % vanadium. The high strength is achieved through controlled processing in a wide hot strip mill. Despite the high yield strength the steel shows very good bending properties as a result of (1) low carbon content (2) small amounts of non-metallic inclusions and (3) sulfide-shape control (calcium-treated). The formability has also been characterized by drawability and stretchability tests together with forming-limit diagram curves.

The new steel can be welded easily with all conventional methods. Properties as impact toughness, fatigue strength and dent resistance have also been tested and are discussed. Typical applications are in areas where low weight is of importance e.g. mobile cranes and earth-moving equipments.

### INTRODUCTION

The development of as-rolled steels as alternatives to the more expensive heat-treated steels in many applications is of considerable interest for economical reasons. As-rolled steels produced in wide hot strip mills are normally available with minimum yield strength up to 550 MPa (80 ksi). In the higher strength region the quenched and tempered steels are predominant.

Svenskt Stål AB (SSAB), Domnarvet has a family of hot-rolled High-Strength Low-Alloy

(HSLA) Cold-forming Steels. These sheet steels are processed in a wide hot strip mill and sold under the trademark DOMEK. This series has been available since 1978 and up to now approximately 150 000 tons have been produced. In 1978 the highest strength in the family was a minimum yield strength of 590 MPa (85 ksi) for a grade called DOMEK 590 XP. The base chemistry of this steel was 3 % manganese and 0,02 % carbon which made this grade uneconomical. Therefore a new type of steel was developed 1980-81 based on the microalloying elements niobium and vanadium and now even the 640 MPa (92 ksi) yield strength level was achieved.

The present paper describes the development and initial production experience of the new grade DOMEK 640 XP as well as some of the more important properties and typical applications.

### DEVELOPMENT

REQUIREMENTS - A high-strength low-alloyed formable steel has to possess other properties than just high strength and good formability. The most important are weldability and impact toughness.

A minimum yield strength level of 590 MPa (85ksi) or if possible 640 MPa (92 ksi) was aimed at. The requirement for the bend formability was an inner radius of at least two times the sheet thickness in the transverse (most difficult) direction. Sheared edges with the shear burr in tension should be used when testing the bend formability as this is the normal practice in the work-shop. One common criteria of weldability is the carbon equivalent ( $E_c$ ) which gives information of the risk for hydrogen induced cracking in the heat-affected zone (HAZ). The IIW-definition of  $E_c$  is

$$E_c = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$$

If  $E_c \leq 0,41$  the risk of cracking is negligible for the sheet thicknesses of interest (3-8 mm).