Thor® 115

Tenaris High Oxidation Resistance Steel

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The best solution to maximize efficiency for the newest gas turbines.

HIGHER EFFICIENCY
LONGER LIFE MATERIAL
REDUCED CO_2 EMISSIONS

Power Gen market is requiring more efficient and sustainable solutions. The modern power plants are increasing the use of new generation gas turbines, aiming at reducing CO_2 emissions while improving the performance standard.
To support Original Equipment Manufacturers in achieving higher plant efficiency, more sophisticated materials are needed to withstand higher steam temperature.
Tenaris invested more than 10 MLN $ to develop a new alloy for tubes with improved resistance to steam oxidation allowing Power Plant designers to exploit the full potentiality of newest Gas and Steam Turbines in Combined Cycle power plant.
Thor®115 (Tenaris High Oxidation Resistance Steel) is characterized by:

- **increased steam oxidation resistance** (working above 600°C),
- **long term stability** based on modified microstructure,
- **superior creep behavior** than grade 91.

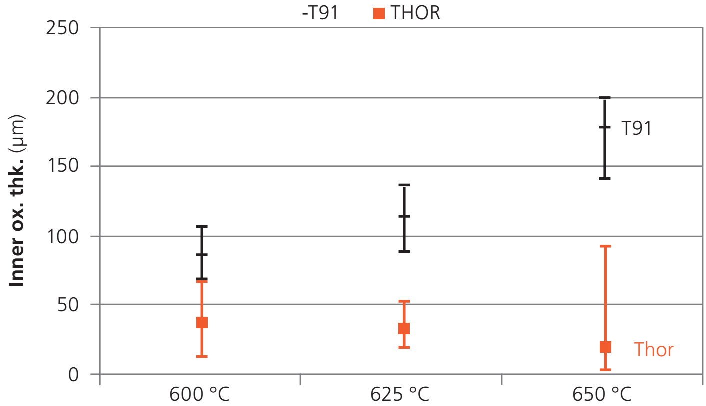
Chemical composition

Thor®115 is a new creep strength-enhanced ferritic steel for service in supercritical and ultra-supercritical boiler applications.
This steel is an evolution of the popular ASTM grade 91, with increased Cr content in order to allow better steam oxidation resistance at high temperature and suitable alloying balance to ensure a fully martensitic microstructure, and stability of the strengthening precipitates after long term ageing.

C	Mn	Si	Cr	Ni	Cu	Mo	Al	V	Nb	N
0.1	0.4	0.4	11.0	< 0.2	< 0.15	0.5	< 0.02	0.2	0.04	0.05

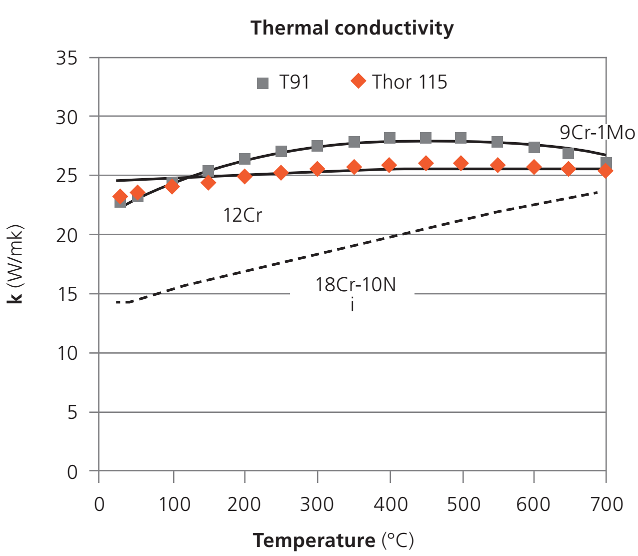
Steam oxidation

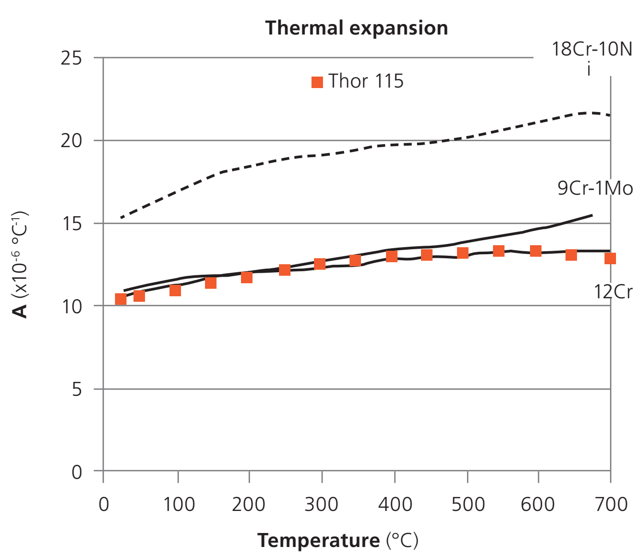
Long duration steam oxidation testing was performed at the Oak Ridge National Laboratory. Testing involved Thor®115 (materials ScA and ScB) and grade SA-213 T91. Measurement confirms that Thor oxidation is similar from 600 to 650 °C, while T91 oxidation accelerates. This is believed to be an effect of the faster Cr diffusion at higher temperature, which, combined with greater Cr availability in Thor than T91, allows the formation of a Cr-richer, more protecting oxide scale.



Physical properties

As a ferritic steel, Thor®115 presents smaller thermal expansion and better thermal conductivity with respect to austenitic grades.



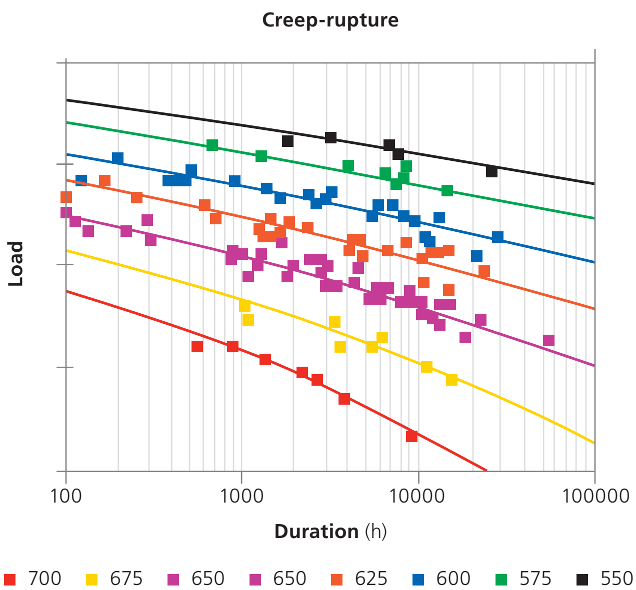


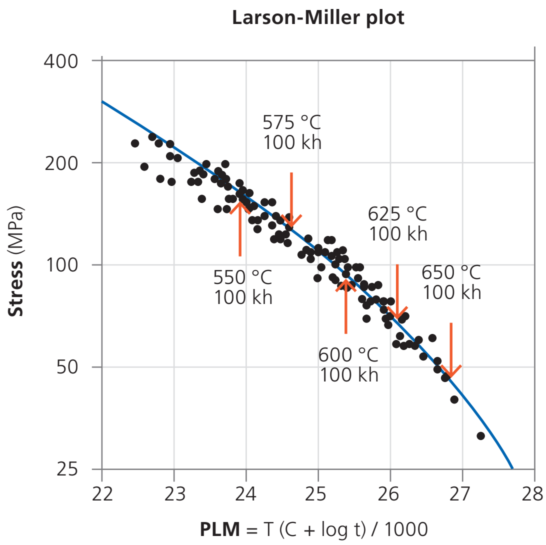
Mechanical properties and allowable stress

Thor® 115 enforces the same tensile strength and hardness requirements as ASME grade 91:

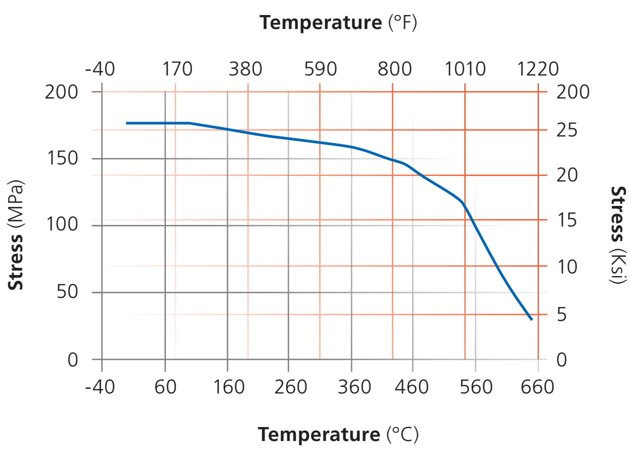
Yield strength	Tensile strength	Elongation	Hardness
≥ 450 MPa	620-830 MPa	≥ 19% longitudinal	190-250 HBW
≥ 65 ksi	90-120 ksi	90-120 ksi	200-265 HV

Thanks to the formation of stable precipitates, creep strength is guaranteed in the long term, as is demonstrated by over 1 million hours of creep testing from trial heats – plates, tubes and pipes – covering and exceeding the whole time-temperature range required for rupture strength assessment.





The allowable stresses have been independently evaluated from tensile and creep testing data, resulting in similar or superior performance with respect to ASME grade 91.

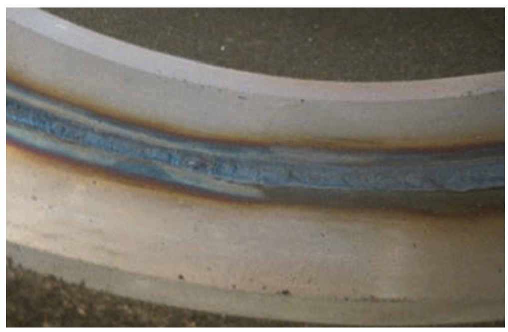


Weldability

Welding trials were performed with several third parties. Plate, tube and pipe butt welds were fabricated according to different procedures, using the gas-tungsten arc (GTA), shielded metal arc (SMA), and submerged arc processes (SA).
For welding purposes, Thor®115 behaviour is nearly identical to that of ASME grade 91, because the strength of the base material is comparable, as well as the heat treatment temperatures, as the alloying is based on similar strengthening principles.
No custom filler metal is therefore required for Thor; instead, the filler materials that are conventionally employed for grade 91 steel were chosen for trials, because the strength of the base material is comparable, as well as the heat treatment temperatures, as the alloying is based on similar strengthening principles.
By this rationale, the qualification of a new filler material is avoided and welding procedures that are consolidated for grade 91 components may be applied to Thor as well; for the purpose of establishing a welding procedure, Thor was then considered to be a material with P-Number 15E (i.e., in the same group as grade 91).
Thor-Thor welding trials were then made using modified 9Cr-1Mo steel filler metal; Ni-based filler metal may be used for those applications were localized corrosion/ oxidation are an issue. For Thor to austenitic steel welds, Ni-based consumable was chosen; for Thor to grade 22 (2¼Cr-1Mo) welds, 2¼Cr filler was chosen in order to prevent de-carburation of the lower grade HAZ.

Completed pipe welds using a procedure with combined welding processess: manual GTAW (top) and manual SMAW (bottom).

GTA Weld (ER90S-B9)



GTA Root Pass – ID View (ER90S-B9)

SMA Weld (E9015-B91)

Close-up of SMAW Cap (E9015-B91)

Dimensional range

Tubing

Outer diameter	Wall thickness	Length
31.8 to 114.3 mm	2.9 to 20.0 mm	Up to 26 meters

Pipes

Outer diameter	Wall thickness
73 to 711 mm	8.0 to 40.0 mm

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For additional information, please visit
www.tenaris.com

For technical assistance, please contact
Simone Baietta - sbaietta@tenaris.com
Antonella Ferrara aferrara@tenaris.com

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