



GOODWIN STEEL CASTINGS LTD

Summary Technical Specification for Goodwin Alloy G410+

Alloy Description:

Grade G410+ is a carbon/manganese steel with an excellent combination of strength and ductility suitable for low temperature application. The material is supplied in the quench and tempered condition to ensure optimal through section mechanical strength and has controlled CE and PCM, which ensures excellent weldability.

Applications:

Used for casting applications where a yield strength of >410N/mm² is required, with superior low temperature impact strength, and exceptional weldability characteristics.

Chemistry:

Table 1: Typical Chemistry

Composition in Mass (%)

Element	Symbol	Typical
Carbon	C	0.12
Silicon	Si	0.30
Manganese	Mn	1.50
Sulphur	S	<0.005
Phosphorus	P	<0.010
Nickel	Ni	<0.75
Chromium	Cr	0.20
Molybdenum	Mo	0.10

Melting Route:

Grade 410+ is produced by electric arc or induction primary melting, followed by secondary AOD refinement. The AOD refinement has major chemistry benefits with regards to ultra low sulphur and deleterious residual elements, along with low residual nitrogen and hydrogen gas content. By reducing these elements enhanced mechanical properties are obtained.

Carbon Equivalent (CE) and Parameter Crack Measurement (PCM):

Table 2: Shows the maximum CE and PCM (%)

Process	Unit	max
Carbon Equivalent	(%)	0.48
Parameter Crack Measurement	(%)	0.28*

*when not specified is taken as a target maximum

Where PCM is calculated using the following equation:

$$PCM = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

Where CE is calculated using the following equation:

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

Heat Treatment Requirements:

Table 3: Typical Heat Treatment Cycle

Process	Unit	Typical
Homogenisation	°C	930
Austenitise + Quench	°C	930
Quench Media	Recirculated Water	
Temper	°C	610-680

Typical Mechanical Properties:

Tempering performed at 610°C

Table 4: Typical Centre Section Properties

Section size ≤50mm (t=1/2)		
Property	Unit	Typical
Tensile Strength	N/mm ²	600
Yield (0.2% proof)	N/mm ²	460
Elongation	%	25
Reduction in Area	%	72
Avg Impact Strength	J	105
Section size=100mm (t=1/2)		
Property	Unit	Typical
Tensile Strength	N/mm ²	580
Yield (0.2% proof)	N/mm ²	440
Elongation	%	20
Reduction in Area	%	55
Avg Impact @ -20°C	J	94
Avg Impact @ -40°C	J	83
Avg Impact @ -60°C	J	40
Section Size=360mm (t=1/2)		
Property	Unit	Typical
Tensile Strength	N/mm ²	535
Yield (0.2% proof)	N/mm ²	350
Elongation	%	21
Reduction in Area	%	45
Avg Impact @ -20°C	J	91
Avg Impact @ -40°C	J	81
Avg Impact @ -60°C	J	21



Grain Size:

Table 5: Typical cast grain size

Grain Size (ASTM E112)
Section size = 100mm to 360mm
Range 12 (or finer) to 7.5

Cast Microstructure:

Fig: 1 Typical Microstructure

(50mm section)



Mag X500 :

Showing fine tempered acicular ferrite and pearlite

Fabrication Welding:

Goodwin alloy G410+ has enhanced weldability characteristics due to controlled CE and PCM values.

Filler Materials:

Weld Repair is carried out using fillers with matching strength and low temperature impact strength:

1% Ni fillers (AWS designation E8018-C3) can be used and give all filler metal proof stress values of typically 470-550N/mm², and impact strength of 65Joules at -60°C “as welded”.

Ni content is limited to 1% to meet the requirements of NACE MR0175. It is possible using this filler to carryout minor repairs without PWHT when supported with a conforming weld qualification and procedure.

Alternatively, Mn/Mo filler can be used (AWS designation E9018-D1). The chemistry of this filler is a low carbon steel alloyed with Mn and Mo which enhances hardenability. However, these fillers require PWHT and should not be used in the “as welded” condition giving typical all filler metal proof stress values of 550–600N/mm² and impacts of 30 to 55 Joules at -50°C. (weld metal hardness hardness typically 210HV)

When yield strength of >410MPa is not required, standard carbon steel fillers can be used for weld repair such as E7018 with typical yield strength after PWHT of 350 to 400MPa.

Post Weld Heat Treatment:

Casting repairs require post weld heat treatment (PWHT) typically 585°C to 630°C. However, PWHT shall always be at least 15°C less than the final tempering temperature.

Machinability:

Grade G410+ has good machinability and compares well to conventional carbon steel.