DI-MC

DI-MC – THE WELDER´S FIRST CHOICE

Excellent weldability

DI-MC´s decisive advantage over conventional structural steels is its excellent weldability. This is the result of these material´s low levels of carbon and other alloying and impurity elements, which allow extremely low values for carbon equivalent. Various formulae for the calculation of this equivalent have been evolved, depending on the particular application, and can be used for the assessment of the weldability of a steel.

Plate thickness t [mm]	DI-MC 355 B/T typical CET [%]	DI-MC 355 B/T typical CEV [%]	DI-MC 355 B/T max. CEV [%]	See EN 10025-4 max. CEV [%]
8 ≤ t ≤ 16	0.24	0.34	0.36	0.39
16 < t ≤ 40	0.24	0.35	0.37	0.39
40 < t ≤ 63	0.21	0.33	0.34	0.40
63 < t < 80	0.21	0.33	0.35	0.45
80 ≤ t ≤ 120	0.22	0.33	0.35	0.45
120 < t ≤ 150	0.23	0.38	0.40	0.45
Plate thickness t [mm]	**DI-MC 460 B/T typical CET [%]**	**DI-MC 460 B/T typical CEV [%]**	**DI-MC 460 B/T max. CEV [%]**	**See EN 10025-4 max. CEV [%]**
t ≤ 16	0.27	0.38	0.40	0.45
16 < t ≤ 40	0.27	0.38	0.40	0.46
40 < t ≤ 63	0.25	0.37	0.39	0.47
63 < t ≤ 80	0.25	0.37	0.39	0.48
80 < t ≤ 100	0.25	0.38	0.41	0.48
100 < t ≤ 120	0.25	0.40	0.42	0.48
120 < t ≤ 150	0.26	0.41	0.43	0.48

Typical and max. carbon equivalents of DI-MC steels

DI-MC steels express their excellent weldability in three important features:

1. Preheating can be significantly reduced or even omitted completely, permitting significant savings on fabrication time and costs.
2. After welding, DI-MC steels exhibit extremely good toughness and low hardness values in the heat affected zone (HAZ), enhancing process reliability and product strength and stability.
3. Thanks to these special properties, DI-MC can tolerate much greater variations in welding conditions than conventional structural steels, with a concomitant significant reduction in the

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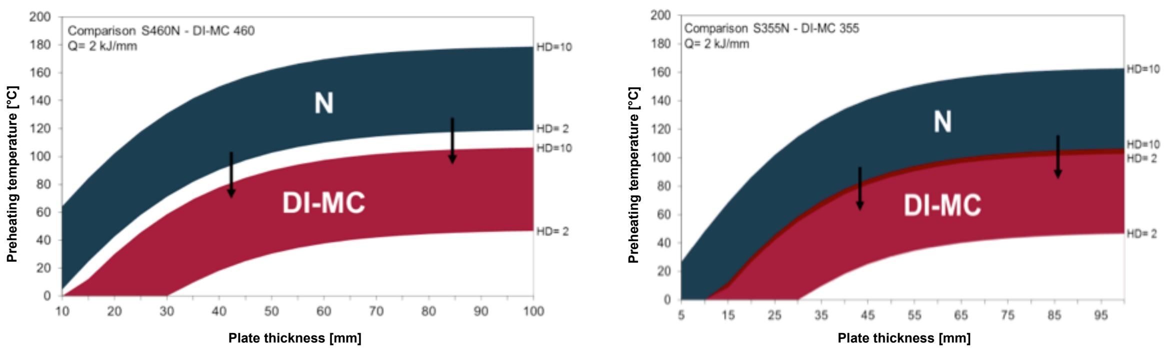
Reduced preheating temperature

Due to the risk of cold cracking, steel plates in grade S355N/NL are usually preheated for welding, depending on the particular standards applied and the technological status of the individual fabrication shop, whenever plate thickness is greater than 20 to 30 mm. This time and cost intensive operation can generally be simplified or even omitted completely for welding of DI-MC steels, however. Below figures illustrate well the reduction of preheat temperature made possible by the use of DI-MC steels. The limit for the necessity of preheating can be extended up to the maximum suppliable plate thickness when, in particular, welding filler materials with low hydrogen contents are used. The preconditions in every case for this are quality assurance provisions such as the correct selection, storage and handling of the welding filler materials.

Extensive recommendations concerning welding, including selection of the minimum necessary preheating temperature, can be found, for example, in Method B in the EN 1011-2, standard, and in the SEW 088 guideline. These recommendations state that Carbon Equivalent CET, as an indicator of susceptibility to hydrogen cracking, can be used for calculation of minimum preheating temperature. It is presupposed for this purpose that the Carbon Equivalent CET of the filler metal is lower than that of the base material by not less than 0.03%. Otherwise, the preheating temperature for cold cracking resistant welding is based on the CET of the filler metal plus a safety addition of 0.03%.



Comparison of preheating temperatures calculated in accordance with EN 1011-2, Method B, for typical analyses of S355N/S460N and DI-MC 355/DI-MC 460 as a function of plate thickness and hydrogen content HD of the welding filler material

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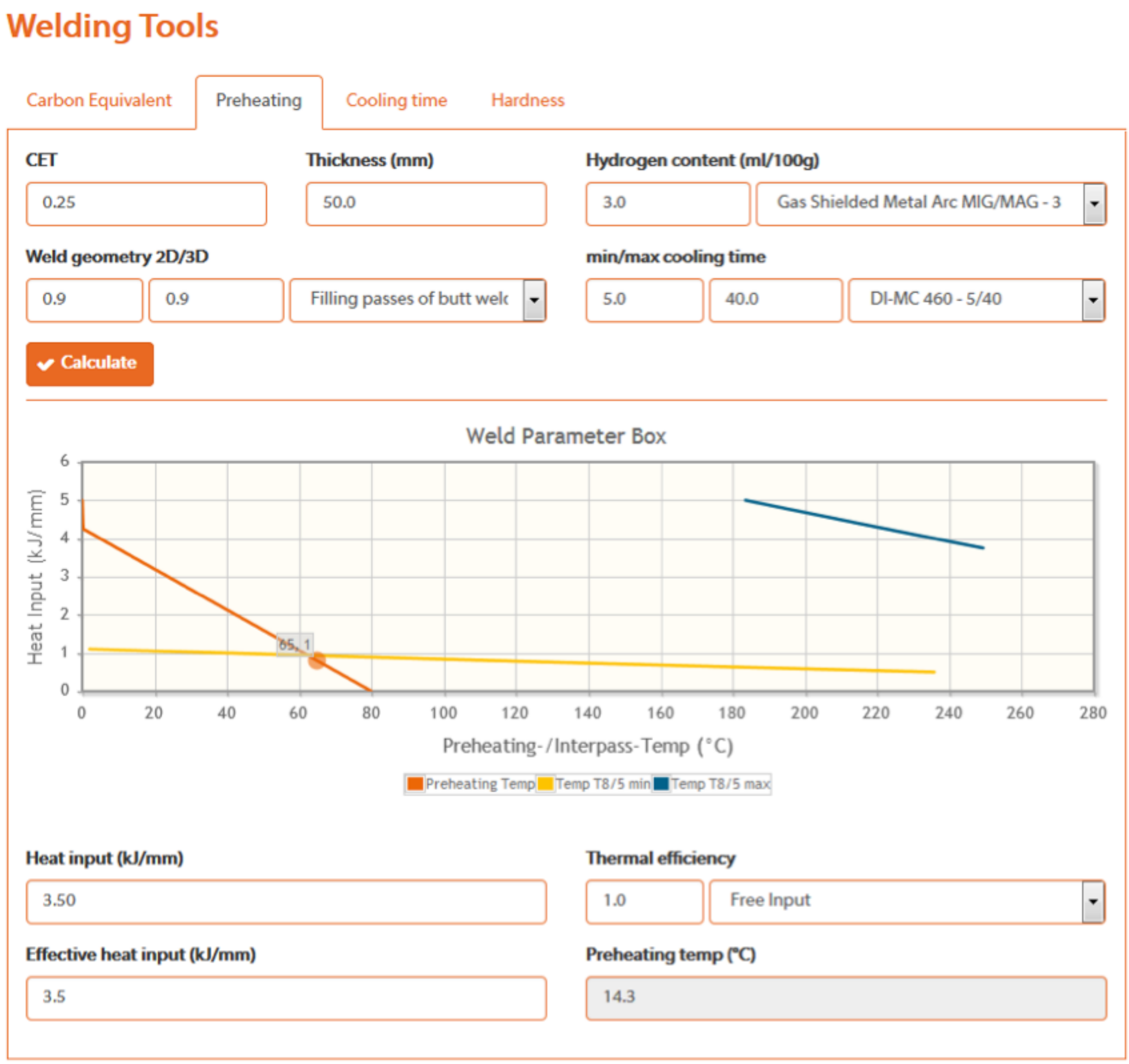
At its E-Service area, Dillinger provides for its customers a welding assistance program which permits simple and clear calculation of characteristics and parameters relevant for welding. As a first step, the various carbon equivalents can be calculated via input of chemical composition. Using this data, the suggested minimum preheating temperature can be determined as a function of plate thickness by stating further welding parameters.



The user interface of the welding assistance tool in Dillinger´s E-Service area

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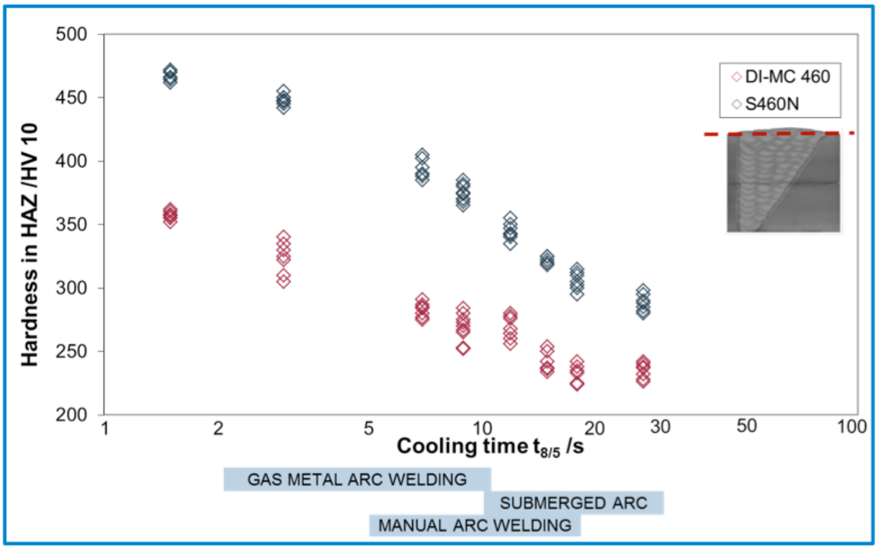
Low hardening

DI-MC possesses only a low tendency towards hardening in the heat affected zone (HAZ). The carbon equivalent CEV, in particular, which is also frequently specified in materials standards and which is, as shown before, significantly reduced in the case of DI-MC steels, provides information here. Thanks to their moderate alloying concept, the hardness values for DI-MC steels for widely applied cooling times are generally below 270 HV 10. Slightly higher values may occur in laser welding, as a result of the lower heat input and higher rate of cooling.



Comparison of hardness data in the heat affected zones of the top passes of welds in DI-MC 460 and conventional structural steel S460N. Due to the tempering effect of the subsequent welding beads, the hardness values in the filler passes are generally lower.

Resistance to brittle fracture

DI-MC steel´s extremely high initial toughness has positive benefits for the brittle fracture resistance of the heat affected zone. High standards for toughness in the HAZ are thus met even after welding with high heat inputs. Below figure shows that Charpy V-notch impact energy in the HAZ of a DI-MC 460 achieves extremely good values virtually irrespective of the energy input per unit of weld length, with the result that extremely high component safety can be assumed even with high heat inputs of up to 3.5 kJ/mm. The good toughness achieved after welding also permits cost efficient and rapid fabrication without any need to anticipate problems with the quality of the weld.

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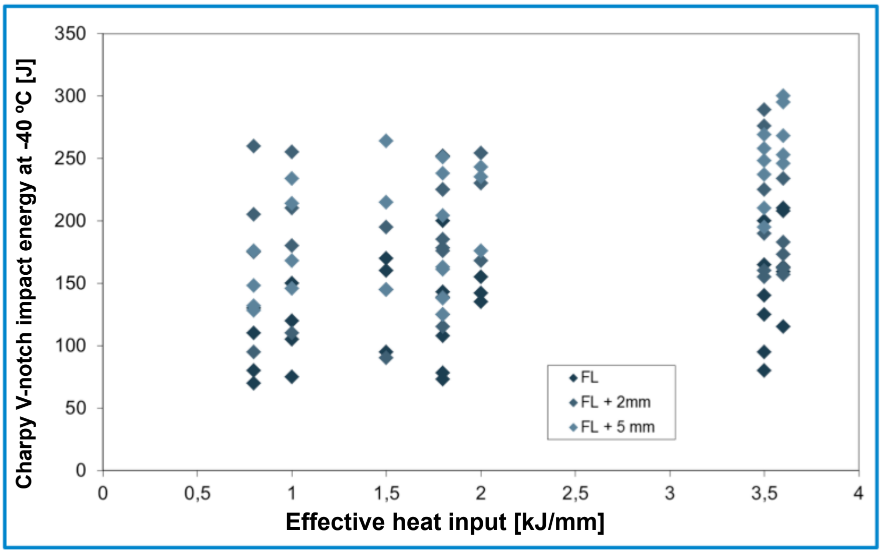

Example of Charpy V-notch impact energy (average values, measured at - 40 °C) in the HAZ of a DI-MC 460, as a function of heat input during welding (FL = fusion line)

Hot cracking resistance

Hot cracking, i.e., cracks occurring at high temperatures due to low melting point phases (e.g. sulphur compounds) are generally not a problem when using these grades, thanks to the extremely high cleanness of these steels (extremely low levels of such impurity elements as sulphur, phosphorus, boron, etc.).

Weld preparation

Weld preparation can be performed by means of machining or thermal (flame, laser or plasma) cutting. The weld zone must be metallically bright, dry and free of thermal cutting slag, rust, scale, paint and all other contamination before welding starts. Dillinger offers to its customers, in the form of individual weld preparation by means of milling, an additional service which assures high cost effectiveness for fabrication. Our staff will be pleased to advise you on this.

Welding filler materials

Thanks to their outstanding weldability, all DI-MC steels can be welded using any of a large range of suitable welding filler materials. Below table shows suitable welding filler materials.

DI-MC	Manual arc welding	Submerged arc welding	Shielded arc welding (MAG)
355	EN 499 E42 6 B 42 H5	EN 756 S 42	EN 758 T42 BC3 H5 EN 440 G42
460	EN 499 E 46 6 1Ni B 42 H5	EN 756 S 46	EN 758 T 46 1Ni B C3 H5 EN 440 G46

Typical welding filler materials for use in welding of DI-MC steels

It is, of course, not possible to examine all the details of the welding behaviour of DI-MC steels here. For this reason, Dillinger provides for special applications intensive technical consulting services for its customers prior to the ordering of the steel.

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