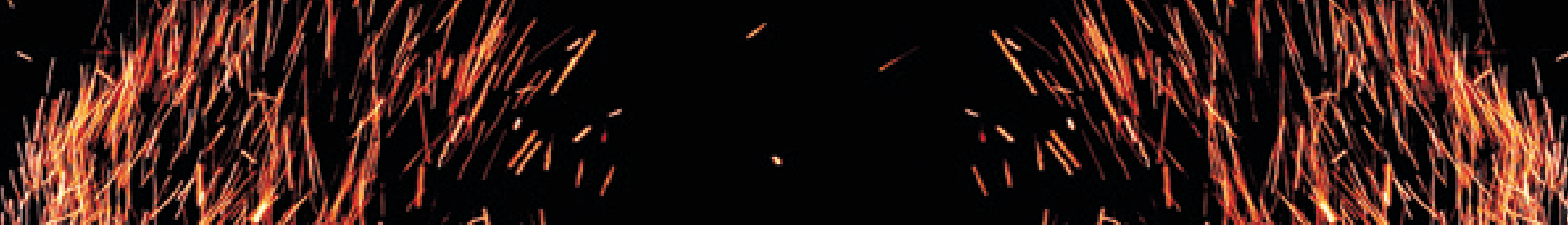


Welding recommendations Miilux 400 | 450 | 500

GENERAL WELDING INFORMATION

Abrasion resistant steel grades are manufactured by hardening, and thus attention should be paid on their heat input and pre-heating. Abrasion resistant steels must be welded with filler material a with low hydrogen content. Carbon equivalent value (CEV) clearly affects the weldability of steels. The carbon equivalent value of abrasion resistant steels is calculated using the following equation: CEV= C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15 The composition needed in order to calculate the carbon equivalent value is indicated in the manufacturer's inspection document. The higher the carbon equivalent value the easier the steel hardens and loses its tensile properties in welding.

WORKING TEMPERATURES AND HEAT INPUT

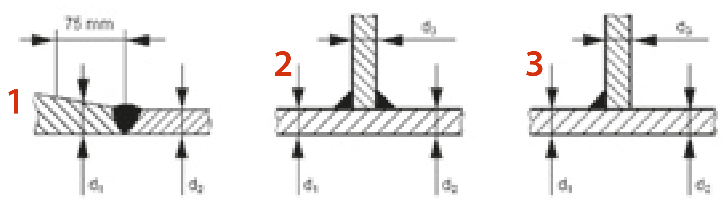
Table 1 shows the recommended working temperatures of certain heat input values Q. The pre-heating temperature of the plate must be a minimum of 70% of the working temperature, and the temperature of the plate must not exceed the recommended working temperature by much over 30%. Thin plates in particular tend the heat too much, which will cause abrasion resistant steel to lose its good properties. The composition of attachments and wall thickness must be taken into account when determining pre-heating and working temperatures. Equations for combined plate thicness are shown in figure 1. The recommended heat input area for a 20 – mm plate (combined plate thickness) is 1 – 2 kJ/mm, 40-mm plate 1.5 – 2.5 kJ/mm, 60-mm plate 1.5 – 3.0 kJ/mm and 80 mm plate 2 – 3.5 kJ/mm.

↓ Table 1. Recommended working temperatures

Steel grade	Q (kJ/mm)	Combined plate thickness d1 + d2 + d3					
		20 mm	30 mm	40 mm	50 mm	60 mm	70 mm
miilux® 400	1			100 °C	125 °C	125 °C	150 °C
miilux® 400	2			75 °C	100 °C	125 °C	125 °C
miilux® 400	3			75 °C	100 °C	100 °C	125 °C
miilux® 450	1		100 °C	125 °C	125 °C	150 °C	200 °C
miilux® 450	2		100 °C	100 °C	125 °C	150 °C	175 °C
miilux® 450	3		75 °C	100 °C	100 °C	125 °C	150 °C
miilux® 500	1	100 °C	125 °C	150 °C	175 °C	200 °C	200 °C
miilux® 500	2	100 °C	125 °C	125 °C	150 °C	175 °C	200 °C
miilux® 500	3	100 °C	100 °C	125 °C	125 °C	150 °C	175 °C

Q=(U*I*60)/(v*1000)[kj/mm]

↓ Figure 1. Calculation of joint plate thickeness



1 d_1 = Average thickness in 75mm long section
Combined plate thickness $= d_1 + d_2$

2 Both sides are welded simultaneously
Combined plate thickness = ½ x $(d_1 + d_2 + d_3)$

3 Combined plate thickness $= d_1 + d_2 + d_3$

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Welding conditions

Difficult conditions at the site, such as wind, rain or dirt, will negatively affect the quality of the weld and poor lighting will make welding more difficult. Poor welding equipment are not suitable for the welding of abrasion resistant steels: welding wire feed must work or the welding electrode must remain firmly in the welding socket. Without these factors, making a good welded joint is difficult.

It is recommended to turn the welded object to the most favourable welding position, which most often is the flat position.

➜ A repaired bucket

GROOVE PREPARATION AND SHAPE

Cleaning the weld grooves from swarf, dirt and grease before welding is important in groove preparation. Carbon arc gouging should be avoided when manufacturing the grooves because it causes carbonization of the melt created during gouging and its hardening properties, due to the high carbon content, may be critical. Carbon content after carbon arc gouging may be as high as double, in which case a critical zone in terms of strength and tensile properties will be created inside the weld. The need for carbon arc gouging can be avoided by using a sufficiently large root opening (2 – 4 mm) in the groove. When welding a thick

plate, an ample root opening and wide groove must be used. A smaller root opening and, for example, one-sided V-groove are sufficient when welding a thin plate. In case of joining thick and thin plates by welding, the groove should always be on the side of the thinner plate. Fillet welds in abrasion resistant steels present a risk. The joint tends to crack under the fillet. If using a fillet weld cannot be avoided, the weld must be made as robust and solid as possible. Good engineering must be used in order to avoid difficult corner welds in abrasion resistant steels. Accessibility should thus be taken into account when designing weld joints. A groove must be finished by grinding.

SELECTION OF THE WELDING PROCESS

Heat input limits of steel grades and the method of welding must be taken into account when selecting the welding process. The impact of the selection of the welding process, welding method and welding energy is highlighted as the strength of the steel grades increases and the quality class of impact strength rises. Good impact strength in the weld can be achieved using all common welding processes (MIG/ MAG, flux-cored welding, submerged arc welding, metal arc welding) provided that welding energy is maintained in compliance with the recommendations for a given steel grade. It is recommended to use mechanical welding whenever possible, because it allows better productivity and usually also better impact strength than in manual welding.

SELECTION OF FILLER METALS

hWhen welding abrasion resistant steels, it is often beneficial to use filler metals that are softer than the basic material and use engineering in order to avoid locating welded joints in parts that are most loaded or exposed to extensive abrasion. In addition, in the case of the highest alloyed steel grades, the mixing of basic material with the weld metal increases the strength of the weld material as much as about 100 MPa compared to the listed values for pure filler metals. It is also recommended to select low-hydrogen filler materials to keep the hydrogen level sufficiently low. The commonly used filler metals for abrasion resistant steels are ESAB OK 48.00 and OK Autrod 12.51. If high strength in the welded state is required from the filler metal, it is recommended to use the OK 75.75 or OK Autrod 13.10/13.12 filler metals. When higher abrasion resistance is required from the weld, it can finally be coated with two or three hard surfacing layers using a suitable filler metal, such as, for example, OK 83.28. Soft and highly alkaline filler metals such as OK Autrod 12.10 and OK Flux 10.61 can be used in submerged arc welding. Equivalent filler metals can also be found from other suppliers, such as Elga, Lincoln and Oerlikon. Austenitic rods can be used for repair welding, but they create a larger stress field in the weld, because of which the risk for cracks in the heat affected zone increases. When using austenitic filler materials, the plates must be at a minimum of room temperature. If the plate thickness exceeds 30 mm, preheating to 100 – 150°C is recommended.

HANDLING OF FILLER METALS

Filler metals must be dried before use to ensure that they contain no hydrogen. The producer's instructions must be followed in storing, handling and using filler metals.

WELDING ORDER AND FINISHING

When welding abrasion resistant steels, two superimposed passes must always be used. This way, the lower pass can be annealed (hardness decreases but tensile strength increases). Consecutive measures can be considered after two passes have been welded. The harder the material, the more important it is to have two superimposed passes. The last pass should be left incomplete rather than overfilled. Filling the weld transversally is not recommended under any circumstances. Temperature control is very important in welding. Welding must be completed properly (from hefts to grinding using the same temperature), because welding on top of a cooled pass will multiply welding stress, which increases the total stress of the work. This in turn exposes the weld and the welded work to breaking in use. It must be borne in mind that every pass causes longitudinal stresses equivalent to the yield point of the material in the piece welded. Welding is completed only when the joints are filled and surfaces and corners have been round. The weld class can be defined, for example, on the basis of the SFS EN-ISO 5817 standard.

↓ It may be justified to use mineral wool to slow down cooling in case of critical welding, see photo.

WELDING OF LIP PLATES

The inner joints of a lip plate are first filled as much as possible. If there is a risk that the root tears open under the root pass, the root is opened, and a couple of passes are welded on the root side, after which filling from the inside is continued. If there is no risk of cracking, the inside is completed first, after which the root side opened by grinding will be welded. Carbon arc gouging should be avoided in groove preparation. See Groove preparation and shape. The position bridging of lip plates must be symmetrical and thicker from the middle than from the edges in the longitudinal direction. Welding must be carried out from centre to edges in a symmetrical way. Bridging at the edges can systematically break due to welding stresses, but it is easy to open and rewelded, in which case the stresses around edges remain lower. The curvature of the plate can be controlled by welding several passes in the middle of the plate. Welding order can thus be used in a predetermined way to control the shape of the piece of work and even the direction and extent of stresses. It is recommended to use end plates when welding lip plates. This way, it is possible to avoid ending welding at a critical point and instead take the welding to the end plate. When the joint is completed, the end plate is removed from the lip plate and the cut section is finalised by grinding. A lip plate compiled from several components is not as durable as a lip plate made of one piece.

REPAIR WELDING

In repair welding, it is of the utmost importance to open the crack deep enough and grind it enough. A weld made on the plate surface will not be durable. Austenitic rods can be used in repair welding, see Selection of filler materials.

THERMAL CUTTING

Preheating and working temperatures must be adapted in thermal cutting. When using a large cutting nozzle in thermal cutting, travel speed must be proportionally greater. Travel speed is too great only when drag starts to form on the lower surface of the cut joint.

FURTHER INFORMATION

Further information and instructions on welding from our Customer Service customer.service@miilux.fi

Miilux Oy
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Ruonankatu 1, 92100 Raahe FINLAND
Tel: 010 5856 000
Fax: 010 5856 381
www.miilux.fi

KESTOTEC

Kestotec Oy
31300 TAMMELA
Puh. 010 231 2830
kestotec@kestotec.fi
www.kestotec.fi

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