

Uddeholm Formvar®

Welding recommendations

GENERAL

Uddeholm Formvar is a high performance chromium-molybdenum-vanadium alloyed hot work tool steel, which offers a very good resistance to hot wear and plastic deformation.

Good results when welding can be achieved if proper precautions are taken (joint preparation, choice of consumables and welding procedure). If the tool is to be polished, it is necessary to use a filler material that has the same chemical composition as the base material.

RECOMMENDED FILLER MATERIAL

Welding Method	Gas Tungsten Arc Welding GTAW (TIG)	Gas Metal Arc Welding GMAW (MIG/MAG)	Shielded Metal Arc Welding SMAW (MMA)	Laser	Comments
Filler material	Dievar TIG Weld QRO 90 TIG Weld Unimax TIG Weld	Dievar MIG Weld QRO 90 MIG Weld	QRO 90 Weld	Dievar Laser Weld	Dievar TIG Weld and Dievar Laser Weld is recommended when the surface are going to be polished or photo-etched
	Type AWS ER 312 AWS ER NiCrMo-3		E 29 9 R		Use soft filler material for buffering layer
Hardness as welded	48 – 58 HRC	48 – 52 HRC	48 – 52 HRC	48 – 52 HRC	

DIMENSIONS FILLER MATERIAL

Type	TIG				MIG	MMA			Laser
Dia. Ø mm	1.0	1.6	2.4	3.2	1.2	2.5	3.25	4.0	0.3 – 0.7
Dia. Ø Inch	0.040	1/16	3/32	3/32	3/64	3/32	1/8	5/32	0.012 – 0.028
Dievar TIG Weld	X	X	X	X					
QRO 90 TIG Weld	X	X	X						
Unimax TIG Weld		X							
Dievar MIG Weld					X				
QRO 90 MIG Weld					X				
QRO 90 Weld						X	X	X	
Dievar Laser Weld									X

PARAMETERS

Condition	Soft Annealed 160 HB	Hardened 45 – 52 HRC	Comment
Preheating Temperature	330°C ± 25°C 625°F ± 50°F	330°C ± 25°C 625°F ± 50°F	The temperature should be kept constant during the welding operation. Start with buffering layers if not all cracks are removed
Interpass temperature	Max 150°C, 270°F above preheating temperature	Max 150°C, 270°F above preheating temperature	The temperature of the tool in the vicinity of the weld. When passed, the tool will have a risk for distortion, soft zones or cracking in and around the weld (the HAZ).
Cooling rate	20 - 40°, 35 - 70°F C/h The first 2 hours then freely in air <70°C, 160°F		
Post treatment	Soft anneal Harden Temper	Temper 25°C, 50°F below previous tempering temperature	Holding time when tempering, 2h. The temperature depends on the last used tempering temperature. When soft annealing and hardening, see heat treatment specification in Uddeholm Formvar product brochure.*

* Note. We have seen that in many cases a high temperature tempering, 2h, of ~750°C (1380°F) functions instead of a complete soft annealing when welding in soft annealed material.

PROCEDURES

- Clean weld area.
- Preheat material to 330°C ± 25°C / 625°F ± 50°F and maintain temperature during welding.
- Do not let the temperature in the vicinity of the weld (the HAZ) increase more than 150°C / 270°F above the preheating temperature. There is a risk of lowering (softening) the hardness of the base material or/and cracking in the HAZ. Use temple sticks or other temperature-measuring devices.
- For finishing layers use consumables which give suitable hardness.
- Wait a few minutes between each layer of strings, both for soft and hard filler, in order to let the layer equalize and minimize stresses, if possible use pre-heating furnace. Peen to minimize stresses.
- If possible, change welding direction 180° between each layer.
- Cool slowly after welding, 20 - 40°C/h, 35 - 70 °F/h for the first two hours and then freely in air < 70°C / 160°F.
- Temper 25°C / 50°F below previous tempering temperature for two hours.
- Tools welded in the annealed condition must undergo a full soft annealing immediately after welding. Allow tool to cool to room temperature before soft annealing. If a complete soft annealing cannot be done, which we recommend, a high temperature tempering at 750°C / 1380°F could be used. Be aware of that the working properties of the material will be somewhat reduced, if the high temperature tempering is used instead of the soft annealing.

Dies welded in their production equipment.

This is something, which we **do not recommend**, but we are aware of that it happens and therefore we have made the following guideline.

Pre-heat, preferably with Propane, to at least 150°C / 300°F, around the area that are going to be welded. After finished welding, let the dies go down to < 70°C / 160°F. Do a second heating, preferably with Propane, to at least 200°C / 390°F.

Use these guideline recommendations along with
“Welding of Uddeholm Tool Steel” for complete instructions.