GENERAL WELDING PROCEDURE

SHARK™ GROUND ENGAGING TOOLS

Contents

1.0 SCOPE:

This procedure is intended to provide background information and supplementary instructions to subcontractors/welders who are assembling and welding Shark Ground Engaging Tools (G.E.T) products and components.

2.0 WELDING SAFETY:

All thermal work such as welding, grinding, gouging and arc welder cutting process are a significant safety risk. Ensure the following is adhered to:

- Welding safety standards ANSI Z49.1:2021 ,AS1674:2007 or equivalent globally recognized standards.
- Personal Protective Equipment (PPE) including but not limited to:
  - Full sleeve non-flammable work wear. (No gaps)
  - Non-flammable welding gloves
  - Steel toe cap boots,
  - Safety glasses,
  - Hearing protection
  - Full-face welding shield
  - Other PPE as recommended by Sandvik Guideline SG-02 and/or the site-specific or workshop-specific guidelines.
  - Site-specific and/or workshop-specific safety requirements.
  - Suitable ventilation is available for the person completing the operation.
  - Mechanical lifting aids for the safe handling of GET parts are available to the person completing the operation.
  - The area where welding is to be conducted is not damp or wet.
  - The area is free of anything flammable and suitable fire extinguishers are easily available.
  - If other people are working in the area, ensure welding flash shields are utilized.
  - Good general housekeeping to ensure the work area is safe and free from clutter.
  - Ensure appropriate tags for your workplace and work environment are used.

3.0 WELDING PROCESS:

The following welding processes used as a single process or in combination with other listed processes are pre-approved for welding SHARK™ G.E.T. products.

MMAW / SMAW	ISO 4063, 111	Basic type low hydrogen electrodes only
GMAW (MAG)	ISO 4063, 135, 138	Solid or metal cored wire / active gas
FCAW (MAG)	ISO 4063, 136	Flux cored wire / active gas
SAW	ISO 4063, 121	Solid wire only

Table 1

The use of self-shield FCAW welding processes and consumables (ISO 4063, 114) is prohibited for welding SHARK™ G.E.T. products.

4.0 ELECTRICAL PARAMETERS

The workshop completing the weld should refer to the weld machine manufacturer's specification to determine the optimal settings to complete the weld. Actual welding current, Voltage and Electrode Stick Out(E.S.O) used will depend on machine characteristics, plate thickness, run size, shielding gas and operator techniques etc.

5.0 WELDING CONSUMABLES:

Welding consumable selection must be done carefully based on restraints in the welded joint. Soft, high ductility, under-matching strength consumables are recommended for the crack prone/restrained welded joints.

For best results welding High Strength Quenched and tempered hard wear resisting steels, use under-matching strength, low hydrogen soft filler materials with CVN Charpy V-notch impact strength of at least 47Joules at -40C.

Recommended consumables are as in Table 2

Welding Consumable Classifications				
MMAW SMAW (111)	AS/NZS 4855	ISO 2560	AWS A5.1	NOTE
	B-E4916 U H5	A-E 42 2B 12 H5	E7016	-
	B-E4918 U H5	A-E 46 3B 32 H5	E7018	-
GMAW (135)	AS/NZS 14341	ISO 14341	AWS A5.18	NOTE / GAS
	A-G42 3 M 3Si	A-G42 3 M 3Si	ER70S-6	ISO 14175 M21
	A-G42 3 C 3Si	A-G42 3 C 3Si	ER70S-6	ISO 14175 C1
GMAW (138)	A-T463 M M 2 H5	A-T463 M M 2 H5	E70C-6M	ISO 14175 M21
FCAW (136)	AS/NZS 17632	ISO 17632	AWS A5.20	NOTE / GAS
	B T493 T1 0CMA H5	B T493 T1 0CMA H5	E70T-1C/M	ISO 14175 C1 / M21
	B T493 T1 1CMA H5	B T493 T1 1CMA H5	E71T-1 MJ H4	ISO 14175 C1 / M21
SAW (121)	AS/NZS 14171	ISO 14174	AWS A5.17	NOTE
	B-S49A 2 SU22	SA AB 1 67 AC H5	F7A4-EM12K	-

Table 2

6.0 WELDING PREPARATION:

All welding surfaces must be free from dirt, scale, grease, water, and paint to ensure a good surface for welding and reduce the chances of weld cracking. The heat from welding breaks down any moisture or hydrocarbons in the area and releases hydrogen. Hydrogen along with any residuals can be absorbed in the weld resulting in inclusions, porosity, and cracking.

Weld preparation can be in the form of grinding, sanding, sand blasting and shot blasting. If carbon arc gouging process was used for cutting or gouging, ensure to remove carbon rich layer/carbon deposits.

7.0 PRE-HEAT /INTER-PASS/ POST-WELD COOLING:

It is important to preheat the work piece prior to commencing thermal cutting or welding to ensure the components are maintained within the acceptable temperature range. Heat can be applied though several methods such as propane or butane gas flame burners or torches and magnetic induction. Local overheating must be avoided during preheat.

Note: Temperatures in Table 3 are to be used as a guide only, please refer to the product-specific Weld Procedure for individual product pre-heat and inter-pass temperature requirements.

Material	Target Pre-heat Temperature ºC	Max Inter-pass temperature ºC
Q&T Castings/wear steel (350-500HB)	160-190	230
Lip plates (ASTM A514 Steels)	As per the manufacturer's recommendation	As per the manufacturer's recommendation

Table 3 Preheat, Inter-pass temperature

The minimum preheat / inter run temperature for welding Sandvik G.E.T. products are as shown in the table 3: The minimum preheat shall extend and be recorded at a minimum of 75 to 100mm (3" to 4") away from all weld joint faces. Care shall be taken at all times to avoid heating SHARK™ G.E.T. components to >230°C (>446˚F) to avoid embrittlement/degradation of mechanical properties.

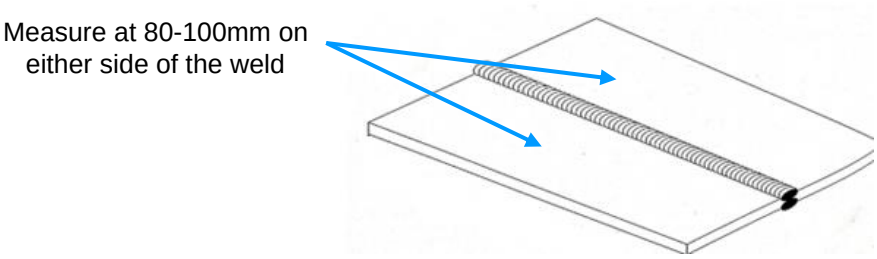

Figure 1 Preheat temperature measuring points

Digital contact thermometers or infrared heat guns are the best tools to accurately provide welding pre-heat temperatures quickly. However, thermal crayons/chalk – which melt when they reach a certain temperature can still be used.

Preheating with multiple burners is much more effective when the heat is applied from the bottom side of the workpiece with insulating blankets on the topside. The blankets help to dissipate the heat evenly as well as retain it.

Maintaining the correct inter-pass temperature is important to ensure the work piece does not get too hot. Allowing the steel to become too hot can cause embrittlement or will temper the steel and soften it, reducing its hard-wearing properties.

Completed welds shall be cooled slowly to ambient temperature over a period of 8hrs from above the minimum preheat / inter run temperature. If the temperature drops reheating is recommended. Depending on the environment, it is considered good practice to use an insulating thermal blanket during the post-welding process to control the rate of cooling. Rate of cooling should not exceed 50C per hour. Use of thermal insulation to control the rate of cooling is mandatory in sub 10ºC environments.

8.0 WELDING SEQUENCE/ PROCEDURE:

Generally, a welding sequence is favoured which minimizes the restraining forces between the welded parts. This is ensured by giving the parts the freedom of movement during the welding operation.

The use of the stringer bead welding technique is recommended. Any slag should be removed from the weld deposit between each pass, by chipping, peening, or wire-brushing. After each pass, check for undercut, slag and porosity, and grind out as required.

9.0 WELD FINISHING & TESTING (VISUAL & CRACK TESTING):

Welds should be ground to smooth surface removing roughness and ripples. Grind finish the weld with grinding marks transverse to the welding direction as shown in Figure 2. Also, the weld should transition smoothly with a minimum 3mm radius.

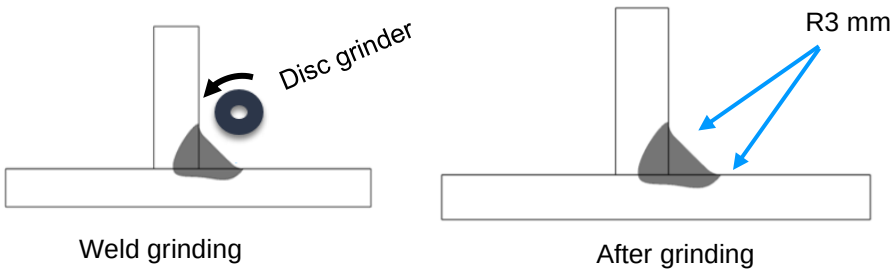

Figure 2 Weld finishing

Following cooling to ambient temperature all completed welds to Sandvik G.E.T components shall be 100% visually inspected. Welds should be checked for correct sizing. The surfaces of all welds and ground areas shall be free of cracks, weld pass termination craters, gross porosity, and slag inclusions. Magnetic Particle Inspection (MPI) or dye penetrant test is mandatory to perform after all the parts have cooled or after 48 hours depending on size of the weld. Typically completed welds will be assessed to ISO 5817 Level B or C as directed by Sandvik.

Any cracks detected must be completely gouged out and re-welded. Finish the repair and re-inspect for cracks.

10.0 AVOIDING HACC & STRESS CRACKING:

The welding of SHARK™ G.E.T products and components demands specific welding precautions to reduce the risk of Hydrogen Assisted Cold Cracking (HACC) and stress cracking.

Hydrogen assisted cold cracking usually appears to be initiating, at or near to, toe of a weld and propagating into the heat affected zone of the parent metal. They may occur with higher hydrogen consumables or also occur in weld metal if higher strength weld metals are used. Crack location is usually in the heat-affected zone (under bead cracking).

Cracking is due to a combination of high residual stress, hydrogen contamination and crack susceptible microstructures. Cracking is usually prevented by use of sufficient pre-heat to retard the formation of martensitic structures and allow sufficient time at temperature for hydrogen diffusion after weld metal solidification. Restraint and resulting plastic strains during weld metal cooling cannot be avoided. Hydrogen controlled welding practices are essential.

Precautions during assembly and welding activities as follows:

1. Use only new, unopened, and appropriately conditioned welding consumables. Any consumable exhibiting deterioration, or where moisture absorption is suspected, or packaging is damaged is caused to discard.
2. All edges prepared for welding to exhibit a bright metal finish, free of surface oxide or any other material that may contaminate weld deposits. Joint preservation coatings are not permitted.
3. Apply and maintain preheat / minimum inter-run temperatures and use balanced welding techniques to reduce residual stresses. Welds shall be at least 30% filled prior to cooling.
4. Weld each pass or layer 100% along the weld joint length before commencing the next. Partial length two pass techniques are recommended where stress crack sensitivity at the first pass is high.
5. Welding is only permitted within workshop locations in an environment free of moisture and excessive breeze. Outdoor locations shall be avoided and if required full wind and moisture protection is required. Such protection shall be approved by Sandvik representatives.
6. Light peening using needle gun equipment between weld passes to remove slag and assist with residual stress reduction is recommended. Do NOT peen weld deposit cap passes.
7. Do not stack weld starts and stops within welded joints and use run on / off tabs where practicable. The minimum preheat / inter-run temperature shall be applied where run off tabs are removed using thermal cutting or gouging.
8. Do not over weld joints. Refer to individual product family specific weld procedure for weld profile requirements. This is important to avoid stress cracking.
9. Grind weld toes during multi pass welding. Completed welds will benefit with weld toe grinding to remove stress concentrations where cracks may initiate.
10. Delay non-destructive examination for a minimum of 24 hours following weld cooling to ambient conditions. Welds completed under high restraint conditions should adopt a 48-hour delay.

11.0 REVISION HISTORY:

Rev #	Notes	Prepared By	Checked By	Approved By	Date
0	Initial Release	N. Dennis	-	-	14.11.2007
1	Steps revised	M. Karlsson	-	-	16.05.2008
2	Steps revised	J.Jose	Weld Consultant	B.Dallard	21.12.2016
3	Format changed to new Sandvik Technical Procedure template	J.Jose	B.Dallard, D.Köhler	R.Schmitz	24.11.2017
4	SHARK™, MAKO™ & BLUE POINTER™ Trademarks updated	J.Jose	D.Köhler	R.Schmitz	15.03.2017
5	Procedure updated as per review comments by Weld consultant	J.Jose	Weld Consultant	M.Javadi	27.09.2022
6	Procedure updated as per review comments by Weld consultant	J.Jose	Weld Consultant	M.Javadi	24.02.2023
7	Added weld temperature table	R.Lauchlan	M.Javadi	M.Javadi	12.10.2023