HDPE Pipe Buttfusion Welding Technology Guidance

SHANDONG SIFFO PLASTIC TECHNOLOGY

I. Background Introduction

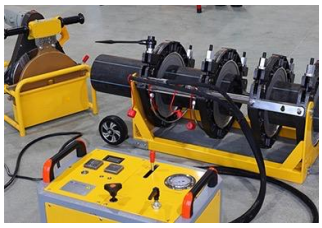
HDPE (High-Density Polyethylene) pipes are widely used in water supply and drainage, gas transmission, municipal engineering, and chemical fluid transportation due to their excellent corrosion resistance, impact resistance, flexibility, and environmental friendliness. As a thermoplastic material, the connection quality of HDPE pipes directly determines the safety, sealing performance, and service life of the entire pipeline system. Butt welding is the most core and commonly used connection method for HDPE pipes. Its principle involves heating the two pipe ends to a molten state using controlled temperature, then applying specific pressure to allow the molten ends to fully adhere and fuse. After pressure holding and cooling, an integrated joint with strength comparable to the pipe body is formed. Compared to other connection methods, butt welding offers advantages such as good joint sealing, strong internal pressure resistance, excellent aging resistance, and wide construction adaptability, effectively preventing safety hazards such as leakage and rupture caused by connection failure during pipeline operation. Therefore, strictly and accurately implementing the butt welding process and rigorously controlling key parameters and quality standards at each stage are core prerequisites for ensuring the quality of HDPE pipeline projects.

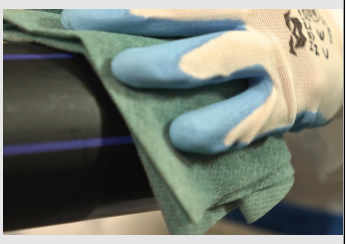
ADD: 12 / F, YUNLONG INTERNATIONAL, YIHE ROAD, HEDONG DISTRICT, LINYI CITY, SHANDONG PROVINCE,CHINA
WEB: www.siffopipeline.com
Email: siffopipe@siffo.cn

II. Refined Welding Process

2.1 Preliminary Preparation (Basic Guarantee)

The core objective of this step is to ensure that the materials and equipment meet the requirements and the on-site environment is up to standard, so as to lay the foundation for subsequent welding operations and avoid welding defects due to insufficient preliminary preparation.

Operation Link	Refined Requirements	Image
Inspection of Materials and Equipment	1. Inspection of Pipes/Fittings: Check the specification model, SDR series, and material grade of each pipe and fitting one by one to ensure consistent matching; conduct appearance inspection for no scratches, cracks, depressions, deformations, or excessive ovality, and no burrs or damage at the ports; reserve 10 – 20mm cutting allowance according to welding needs to avoid incomplete end face processing due to insufficient allowance. 2. Equipment Selection and Inspection: Select hydraulic or manual butt fusion welding machine suitable for the pipe diameter (hydraulic welding machine is preferred for pipe diameter > 200mm to ensure stable pressure); check the integrity of core accessories such as heating plate (ensure flat surface, no scratches, no oil residue, suitable for pipe specification), milling cutter (sharp and wear-free cutting edge, firm installation), pressure gauge (sensitive pointer, up-to-standard accuracy, need to be calibrated in advance); prepare auxiliary tools such as anhydrous isopropanol with a concentration of 90% and above, lint-free cleaning cloth, marker pen, and tape measure. 3. Safety Protection Preparation: Equip personal protective equipment such as high-temperature resistant gloves, impact-resistant goggles, and non-slip work shoes; check whether the welding machine is well grounded to avoid electric shock risks; equip dry powder fire extinguisher on-site to prevent potential safety hazards during heating.	
On-site and End Face Cleaning	1. On-site Arrangement: Select a flat, debris-free, and water-free construction site away from flammable and explosive materials; use special	

	pipe supports to level the pipes to be welded, ensure that the joint parts of the two pipes are on the same horizontal plane, and ensure that the end faces are perpendicular to the pipe axis to avoid welding misalignment caused by pipe inclination. 2. In-depth Cleaning of End Faces: Dip a clean lint-free cloth in anhydrous isopropanol with a concentration of 90% and above, and repeatedly wipe the end faces of the pipes and the surface of the heating plate to be in contact, thoroughly removing oil stains, oxide layers, dust, moisture, and other impurities on the end faces; it is forbidden to use ordinary water-containing alcohol or other solvents for cleaning to avoid bubbles and poor fusion on the end faces during heating; after cleaning, do not directly touch the end faces and the working surface of the heating plate with hands to prevent oil and sweat on the hands from contaminating the contact surfaces.	
Clamping and Centering	1. Pipe Clamping: Select chucks matching the pipe diameter, fix the two pipes to be welded in the chucks at the fixed end and movable end of the welding machine respectively, ensure that the chucks are clamped firmly without looseness; avoid scratches and extrusion deformation on the pipe surface caused by the chucks during clamping. 2. Precision Centering: Adjust the movable end pipe through the adjustment mechanism of the welding machine to make the axes of the two pipes completely coaxial; evenly draw 3 alignment lines (spaced 120 °) on the pipe circumference as the benchmark for centering inspection; use a feeler gauge to check the gap between the end faces of the two pipes, requiring the gap ⩽ 0.3mm; use a straightedge to closely fit the pipe surface to check the misalignment, which should be ⩽ 10% of the pipe wall thickness (for example, for a pipe with a wall thickness of 10mm, the misalignment ⩽ 1mm);	

	if the gap or misalignment exceeds the standard, re-adjust the clamping position.	

2.2 Milling End Faces (Prerequisite Link for Fusion Quality)

The purpose of this link is to remove the oxide layer and uneven parts of the pipe end face through milling, obtain a flat, smooth, and fresh end face perpendicular to the axis, and provide good conditions for subsequent molten fitting.

1.Installation and Inspection of Milling Cutter: Install a sharp milling cutter on the milling mechanism of the welding machine and tighten the fixing bolts; check the rotation direction of the milling cutter before starting the machine (ensure forward rotation to avoid poor end face processing caused by reverse rotation), and test run to confirm that the milling cutter speed is stable without abnormal vibration or noise.

2.Milling Operation: Slowly rotate the feed handle of the welding machine to move the movable end pipe towards the fixed end pipe, driving the milling cutter to gradually contact the end faces of the two pipes; continue to feed evenly until the milling cutter can cut the end faces of the two pipes simultaneously, producing continuous and uniform chips (chips are strip-shaped or coil-shaped, no gaps, burrs, or particles); keep the feed speed uniform during milling to avoid wavy or step-shaped defects on the end face caused by too fast feeding, or affecting milling efficiency due to too slow feeding.

3.Cleaning and Re-inspection After Milling: After completing milling, stop the machine first, then rotate the feed handle in the reverse direction to move the movable end pipe back and take out the milling cutter; thoroughly clean the end faces of the two pipes and the chips around the chuck with a lint-free cleaning cloth to avoid chips remaining between the end faces affecting centering accuracy and fusion quality; re-check the flatness of the end face (no obvious unevenness visually) and perpendicularity (end face perpendicular to the axis without inclination), and recheck the gap and misalignment; if not up to standard, re-perform the milling operation.

2.3 Heating and Heat Absorption (Core Temperature Control Link)

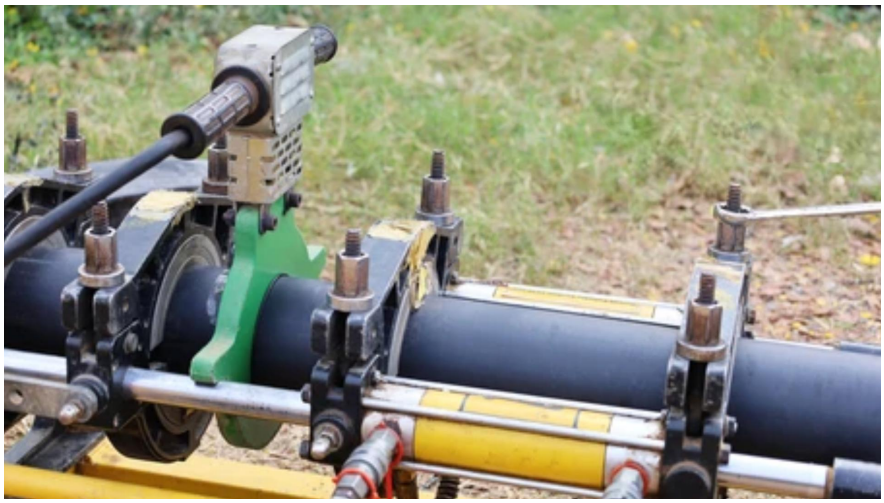
This link makes the pipe end face reach the specified molten state by precisely controlling the heating temperature and heat absorption time, provides sufficient heat for subsequent butt fusion, and is a core step to ensure welding strength.

4.Preheating and Calibration of Heating Plate: Install the cleaned heating plate on the heating mechanism of the welding machine, turn on the heating switch, and set the heating temperature to 210 – 230℃ (the specific temperature needs to be fine-tuned according to the pipe material grade and the manufacturer's technical requirements); after the heating plate is heated up, keep it warm for more than 10 minutes to ensure that the entire working surface temperature of the heating plate is uniform (temperature deviation ≤ ± 5 ℃); use a portable temperature measuring instrument to detect the temperature at different positions on the surface of the heating plate, focusing on calibrating the edge area (the edge temperature is prone to be low), and ensure that the temperature meets the standard before subsequent operations.

5.Pressurized Heating and Initial Bead Formation: Put the preheated and qualified heating plate stably between the end faces of the two pipes to ensure that the heating plate is completely fitted with the two end faces; apply initial heating pressure through the welding machine's hydraulic system or manual feed mechanism (for example, the initial heating pressure of DN200 pipe is about 0.1MPa), so that the pipe end face is closely fitted to the heating plate under pressure, gradually melted and formed an initial bead; the thickness of the initial bead is controlled at 1 – 2mm, and the bead is uniform without bubbles; if the bead is too thin, it indicates insufficient pressure; if the bead is too

thick, it is easy to cause stress concentration in the subsequent joint.

6.Pressure Holding and Heat Absorption: After the initial bead is formed, adjust the pressure to the drag pressure (only need to offset the friction between the pipe and the heating plate to ensure that the end face is continuously fitted), and start timing for pressure holding and heat absorption; the heat absorption time is calculated according to the pipe wall thickness, generally determined by wall thickness × 10 – 12s (for example, the wall thickness of DN200 pipe is 11.9mm, and the heat absorption time is about 120s); when the ambient temperature is lower than 5℃, the heat absorption time needs to be extended by 10 – 20%; continuously observe the bead state during heat absorption to ensure that the bead grows uniformly without abnormal deformation, bubbles, or carbonization.



2.4 Switching and Butt Fusion (Rapid Fusion Link)

The core of this link is to shorten the time interval between removing the heating plate and butting the pipes, avoid oxidation or cooling of the molten end face, ensure sufficient fusion of the molten end face, and form a high-quality joint.

7.Rapid Switching and Removal of Heating Plate: After the heat absorption time reaches the specified value, immediately start the switching operation, which is coordinated by 2 operators (1 person is responsible for removing the heating plate, and 1 person is responsible for operating the pipe butt joint), and take out the heating plate stably and quickly within ≤ 3 seconds; during the removal process, avoid the heating plate touching the molten end face of the pipe, and prevent the molten material on the surface of the heating plate from dripping

and contaminating the end face; it is forbidden to operate without protection in a windy environment to avoid rapid cooling and oxidation of the molten end face.

8.Pressurized Butt Fusion and Fusion Bead Formation: After removing the heating plate, immediately push the movable end pipe quickly and uniformly through the welding machine's feed mechanism to make the two molten end faces fit precisely; quickly apply welding pressure (the welding pressure is adjusted according to the pipe diameter, for example, the welding pressure of DN200 pipe is about 0.15 – 0.25MPa), and keep the pressure stable; under the action of pressure, the molten end faces are fully fused to form a symmetrical and full welding bead; the width of the bead is controlled at 2 – 4mm (the larger the pipe diameter, the appropriately larger the bead width, such as the bead width of DN200 pipe is 3 – 4mm), and the height of the bead is uniform without offset or gaps.

9.Inspection After Butt Fusion: After the butt fusion is completed, visually inspect the appearance of the bead to confirm that the bead is symmetrical and has no obvious defects; check whether the circumferential alignment lines of the pipes coincide to ensure no offset in the butt joint; if the bead is seriously asymmetrical or offset, stop the operation immediately, analyze the cause and re-weld.

ADD: 12 / F, YUNLONG INTERNATIONAL, YIHE ROAD, HEDONG DISTRICT, LINYI CITY, SHANDONG PROVINCE,CHINA
WEB: www.siffopipeline.com
Email: siffopipe@siffo.cn

2.5 Pressure Holding and Cooling (Strength Setting Link)

This link gradually solidifies the molten and fused joint through continuous pressure holding and natural cooling to form stable mechanical strength; the stability of the cooling process directly determines the final strength of the joint.

10. Continuous Pressure Holding: After the butt fusion is completed, keep the welding pressure unchanged and enter the pressure holding and cooling stage; during the pressure holding process, it is strictly forbidden to adjust the pressure, move the pipe, or touch the bead to avoid stress or structural damage inside the joint.

11. Natural Cooling: Adopt natural air cooling method for cooling; it is strictly forbidden to use water cooling, forced air cooling, or other accelerated cooling methods to prevent the joint from cracking and embrittlement due to excessive temperature difference; the cooling time is determined according to the pipe diameter, and the reference values are: DN90 pipe about 60s, DN110 pipe about 90s, DN200 pipe about 180s; the final cooling standard is that the bead is hard and has no heat sensation when touched by hand, and the temperature is close to the ambient temperature; when the ambient temperature is lower than 5℃, the cooling time needs to be extended by 50%.

12. Unclamping and Pipe Removal: After the cooling meets the standard, release the pressure slowly and loosen the welding machine chuck (first loosen the movable end, then the fixed end) to avoid pipe rebound and joint damage caused by too fast pressure release or improper unclamping sequence; after loosening the chuck, smoothly move out the welded pipe and place it on a flat site to avoid collision and extrusion of the joint.

2.6 Quality Inspection (Qualified Judgment Link)

This link verifies the joint quality through multi-dimensional inspection to ensure that the welded joint meets the engineering use requirements and avoids unqualified joints from being put into use.

13.Appearance Inspection: Visually inspect the welding bead, requiring the bead to be symmetrical and continuous, without defects such as air holes, cracks, impurities, carbonization, and material shortage; measure the width and height of the bead with a straightedge to ensure that the width and height meet the specified values; check the misalignment with a feeler gauge, which should be ≤ 10% of the pipe wall thickness; unqualified joints in appearance inspection need to be

cut off immediately and re-welded.

14. Buckling Test: For joints with qualified appearance, select some samples for buckling test (the first piece must be done during batch construction); cut off the beads on both sides of the joint with a cutting machine, bend the pipes at both ends of the joint in the reverse direction (the bending angle is determined according to the pipe specification, generally not less than 90 °), and observe whether the joint part has delamination or cracking; if there is no delamination or cracking after bending, it indicates good fusion; if there is delamination or cracking, it is judged as unqualified, and the cause needs to be investigated and re-welded.

15. Pressure Test: For important pipe network projects or joints in key parts, a water pressure test is required; connect the welded pipe section to the pressure test system, slowly raise the pressure to 1.5 times the working pressure, and maintain the pressure for 30 minutes; during the pressure maintaining process, observe whether there is leakage or pressure drop at the joint; if the pressure is stable and there is no leakage, it is judged as qualified; if there is leakage or pressure drop, find the leakage point, handle it and re-test.

3. Reference Table of Core Welding Parameters (Ambient Temperature 20℃, PN10 Series HDPE Pipes)

Pipe Diameter (mm)	Pipe Wall Thickness (mm)	Heating Temperature (℃)	Initial Heating Pressure (MPa)	Heat Absorption Time (s)	Switching Time (s)	Welding Pressure (MPa)	Cooling Time (min)	Bead Width (mm)
90	6.6	210–230	0.10	50	≤3	0.15	1	2–3
110	8.1	210–230	0.10	80	≤3	0.15	1.5	2–4
160	11.8	210–230	0.10	100	≤3	0.20	2.5	3–4
200	11.9	210–230	0.10	120	≤3	0.20	3	3–4
250	15.3	210–230	0.12	150	≤3	0.25	4	4–5

Notes: 1. When the ambient temperature is lower than 5℃, the heat absorption time and cooling time need to be extended by 10–20%; 2. Parameters of HDPE pipes from different manufacturers and with different material grades may vary; actual construction shall prioritize following the manufacturer's technical manual.

ADD: 12 / F, YUNLONG INTERNATIONAL, YIHE ROAD, HEDONG DISTRICT, LINYI CITY, SHANDONG PROVINCE,CHINA
WEB: www.siffopipeline.com
Email: siffopipe@siffo.cn

4. Precautions for the Entire Process (Detailed by Link)

4.1 Preparatory Work Link

• Material Storage: During transportation and storage of HDPE pipes and fittings, avoid direct sunlight, rain, and collision; the storage site shall be flat and dry, away from heat sources (such as welding equipment and open flames) to prevent aging and deformation of pipes.
• Cleaning Taboos: It is strictly forbidden to clean the end face and heating plate with ordinary water-containing alcohol, gasoline, acetone, and other solvents to avoid corrosion of the pipe surface or bubbles during heating; the cleaning cloth shall be a special lint-free cloth to prevent lint residue from affecting fusion.
• Equipment Debugging: Before starting the welding machine, check whether the hydraulic system and electrical system are normal, whether the hydraulic oil level is sufficient, and whether there is any leakage in the pipeline; the heating plate and milling cutter are firmly installed to avoid falling off during work.

4.2 Milling End Face Link

• Milling Cutter Maintenance: The cutting edge of the milling cutter should be replaced in time after wear to avoid rough end face processing and burrs caused by blunt cutting edges; if the chips are discontinuous or the end face is fuzzy during milling, stop the machine to check the state of the milling cutter.
•Operation Specifications: The feeding speed during milling should be uniform, not too fast or too slow; after milling, stop the machine first and then move the pipe back to avoid scratching the end face due to idling of the milling cutter.
•Chip Cleaning: Chips should be cleaned in time to avoid accumulation between the chuck or end faces, affecting the subsequent centering and heating fitting effect.

4.3 Heating and Heat Absorption Link

•Temperature Control: The temperature of the heating plate should be precisely controlled with a deviation of ≤ ± 5 ℃; excessive temperature is likely to cause carbonization and degradation of the end face, affecting fusion quality; too low temperature will result in insufficient melting of the end face and insufficient joint strength.
•Bead Observation: Continuously observe the state of the initial bead during heat absorption; the thickness of the bead is preferably 1 – 2mm; if the bead is too thin, appropriately increase the initial heating pressure; if bubbles or carbonization appear on the bead, stop the machine to check the temperature or the cleaning condition of the end face.
•Environmental Protection: When the wind speed is > 5m/s, set up a wind shield to cover the heating area to avoid excessive heat loss of the heating plate and oxidation of the molten end face.

4.4 Switching and Butt Fusion Link

• Coordinated Cooperation: The switching operation requires multi-person coordination with fast and stable actions to ensure that the heating plate is removed within ≤ 3 seconds, shorten the exposure time of the molten end face, and reduce oxidation.
•Pressure Control: The welding pressure should rise uniformly to avoid bead offset and internal pores in the joint caused by impact pressure; the pressure should be strictly set according to the pipe diameter and cannot be increased or decreased at will.
•End Face Protection: After removing the heating plate, it is forbidden for any objects to touch the molten end face to prevent contamination or damage to the end face.

4.5 Pressure Holding and Cooling Link

•Cooling Taboos: It is strictly forbidden to move the pipe, tap the bead, or use water cooling, forced air cooling to accelerate cooling during the cooling process to avoid cracking and embrittlement of the joint and reduce mechanical strength.
• Pressure Maintenance: Ensure stable pressure during pressure holding without pressure relief; if pressure drop occurs, timely investigate the cause and supplement pressure, but avoid sudden pressure rise.

•Unclamping Specifications: After cooling meets the standard, release the pressure slowly; the unclamping sequence is to first loosen the movable end and then the fixed end to avoid pipe rebound and joint damage.

4.6 Quality Inspection Link

• Inspection Standards: Appearance inspection, buckling test, and pressure test shall be strictly implemented in accordance with relevant specifications; unqualified joints shall be cut off and re-welded immediately and cannot be used after repair.
• Batch Sampling Inspection: During batch construction, select joints for sampling inspection in proportion; after the first piece is welded, the buckling test and pressure test must be carried out, and construction can continue only if qualified.
• Record Retention: Detailed records of welding process parameters and quality inspection results shall be made, including pipe diameter, heating temperature, heat absorption time, welding pressure, cooling time, inspection results, etc., to establish a quality traceability file.

5. Common Problems and Handling Solutions

Common Problems	Detailed Cause Analysis	Handling Solutions
Asymmetrical and Offset Bead	1. Pipe centering deviation, non-coaxial axes; 2. Loose chuck, pipe displacement during welding; 3. Inclined heating plate, uneven heating at both ends; 4. Uneven application of welding pressure.	1. Stop welding and cut off the unqualified joint; 2. Re-clamp the pipe, precisely center it, and fasten the chuck; 3. Calibrate the heating plate to ensure it is flat and horizontal; 4. Adjust the welding machine's pressure system to ensure uniform pressure

		application.
Cold Welding and Insufficient Fusion of Joint (Delamination in Buckling Test)	1. Insufficient heating plate temperature, insufficient melting of the end face; 2. Too short heat absorption time, insufficient heat; 3. Too small welding pressure, insufficient fitting of the molten end face; 4. Too long exposure time of the molten end face, severe oxidation.	1. Cut off the unqualified joint and re-weld; 2. Calibrate the heating plate temperature to ensure it reaches the specified value; 3. Extend the heat absorption time and accurately calculate the heat absorption duration according to the wall thickness; 4. Increase the welding pressure, shorten the switching time, and strengthen environmental wind protection.
Air Holes and Cracks in Bead	1. Incomplete cleaning of the end face, with oil stains, dust, and moisture; 2. Impurities and oil stains on the surface of the heating plate; 3. Excessive heating temperature, carbonization and degradation of the end face; 4. Too fast cooling speed, stress inside the joint.	1. Cut off the unqualified joint; 2. Re-clean the end face and heating plate with anhydrous isopropanol; 3. Adjust the heating plate temperature to the specified range; 4. Adopt natural cooling, extend the cooling time, and avoid accelerated cooling.
Too Thin or No Bead	1. Insufficient initial heating pressure,	1. Stop welding and re-weld; 2. Increase the

	insufficient fitting of the end face with the heating plate; 2. Too low heating plate temperature, insufficient melting of the end face; 3. Too short heat absorption time.	initial heating pressure to ensure the end face is closely fitted with the heating plate; 3. Calibrate the heating plate temperature and extend the heat absorption time.
Joint Leakage (Unqualified Pressure Test)	1. Insufficient fusion, internal gaps in the joint; 2. Hidden cracks or impurities in the bead; 3. Unstable pressure during welding, pressure relief.	1. Locate the leakage point, cut off the unqualified joint and re-weld; 2. Strengthen appearance inspection, and increase the sampling ratio of buckling test if necessary; 3. Check the welding machine's pressure system to ensure stable pressure during pressure holding.