Studwelding Troubleshooting Guidance

Introduction

This document contains useful information from ISO 14555, along with some additional supplementary information that will allow users to troubleshoot some common welding problems.

Acceptable materials

Certain combinations of materials are recommended for better compatibility with studwelding processes. Studwelding is not restricted to these combinations, but weldability of other materials not mentioned in the tables below should be assured by appropriate WPS or WPQR requirements.

Welding compatibility of materials using the Drawn Arc or Drawn Arc Short Cycle processes

Stud Material	Parent Materials			
	ISO/TR 15608 material groups 1 and 2.1	ISO/TR 15608 material groups 2.2 and 3-6	ISO/TR 15608 material groups 8 and 10	ISO/TR 15608 material groups 21 and 22
S235 4.8 (weldable) 16Mo3	Highly weldable for any application[a]	Weldable within limits[b]	Weldable within limits[b,c]	Not weldable
1.4742 1.4762	Weldable within limits[d]	Weldable within limits[d]	Weldable within limits[d]	Not weldable
1.4828 1.4841	Weldable within limits[b]	Weldable within limits[b]	Weldable within limits[b]	Not weldable
1.4301 1.4303 1.4401 1.4529 1.4541 1.4571	Weldable within limits[b] / Highly weldable for any application[a,e]	Weldable within limits[b]	Highly weldable for any application[a]	Not weldable
EN AW-Almg3/5754 EN AW-AlMg5/5019	Not weldable	Not weldable	Not weldable	Weldable within limits[b]

a. For example, for force transfer
b. For force transfer
c. Only for Drawn Arc Short Cycle process
d. Only for heat transfer
e. Up to 12mm in diameter

Welding compatibility of materials using Capacitor Discharge with tip ignition

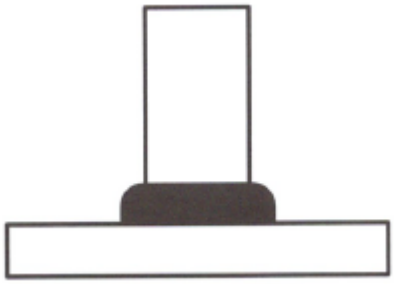
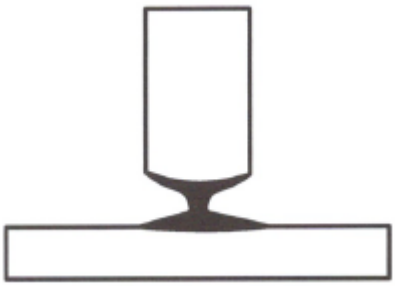
Stud Material	Parent Materials				
	ISO/TR 15608 material groups 1-6 , 11.1	ISO/TR 15608 material groups 1-6, 11.1 and galvanised or metal coated steel sheet maximum thickness coating thickness of 25 µm	ISO/TR 15608 material group 8	Copper and Lead free copper alloys, e.g. CuZn37 (CW508L)	ISO/TR 15608 material groups 21 and 22
S235 4.8 (weldable)	Highly weldable for any application[a]	Weldable within limits[b]	Highly weldable for any application[a]	Weldable within limits[b]	Not weldable
1.4301 1.4303	Highly weldable for any application[a]	Weldable within limits[b]	Highly weldable for any application[a]	Weldable within limits[b]	Not weldable
CuZn37	Weldable within limits[b]	Weldable within limits[b]	Weldable within limits[b]	Highly weldable for any application[a]	Not weldable
EN AW-Al99.5	Not weldable	Not weldable	Not weldable	Not weldable	Weldable within limits[b]
EN AW-AlMg3	Not weldable	Not weldable	Not weldable	Not weldable	Highly weldable for any application[a]

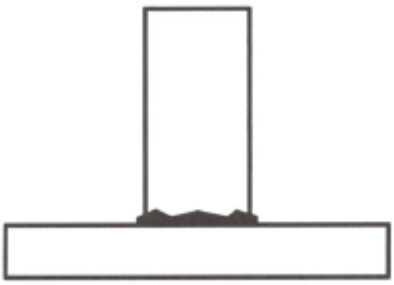
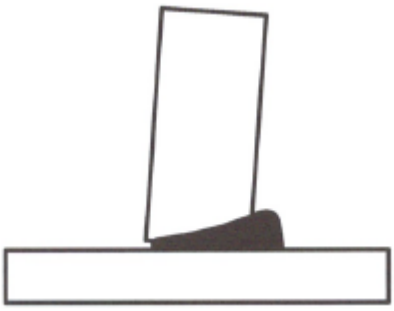
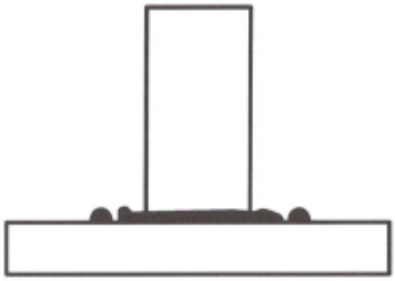
a. For example, for force transfer
b. For force transfer

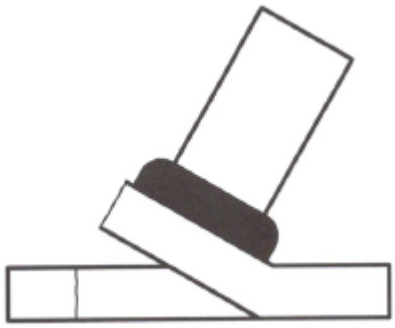
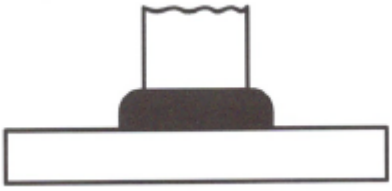
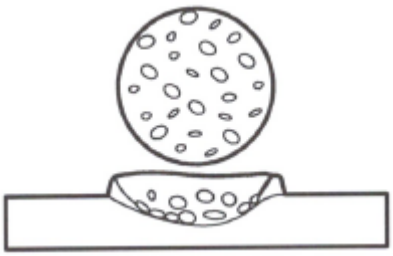
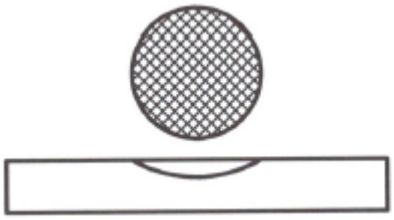
Visual and Mechanical welding assessment results and corrective actions guidance

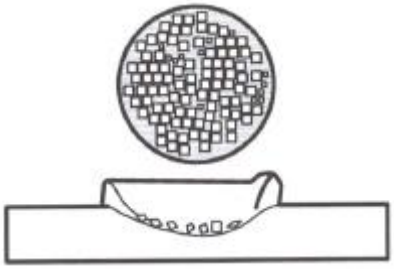
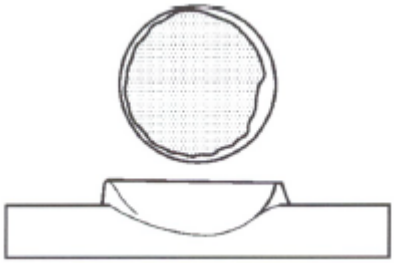
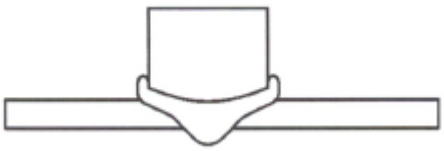
The below tables cover results visual and mechanical testing results for the different processes, and offer some guidance on what actions can be taken to help eliminate failures, as well as some more general information that may be helpful with weld assessment.

Drawn Arc studwelding with ceramic ferrule or shielding gas

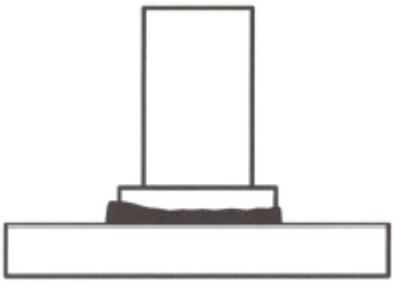
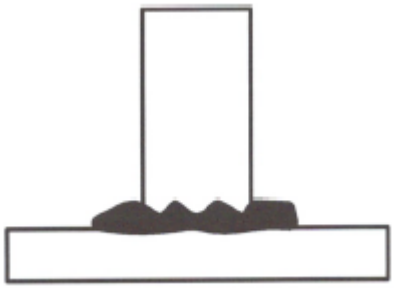
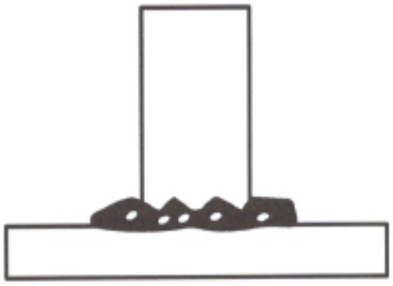
Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Collar regular, bright and complete. LAW correct. 	Acceptable	None	The weld collar does not have to be of uniform height around the stud, but should be present around the whole circumference of the stud. LAW (Length After Weld) should be within tolerance, i.e. stud is NOT longer than nominal length.
Reduced diameter weld. LAW too long 	Insufficient protrusion or lift	Increase protrusion or lift	In case of insufficient protrusion, the stud lacks the necessary reach to penetrate into the parent material.
	Insufficient centring	Check centring of stud in ceramic ferrule	Stud should travel through ferrule without any catching up on the shoulder.
	Welding power too high	Reduce current	Excessive current vaporises end of stud.
	Welding time too high	Reduce welding time	Excessive time allows molten material to drip across the arc, cutting weld out partway through the process.
	Damping too strong	Reduce damping / disengage damper	Excess damping causing slow return to weld pool.

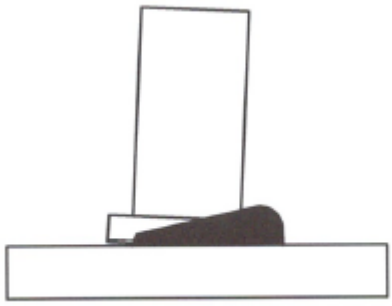
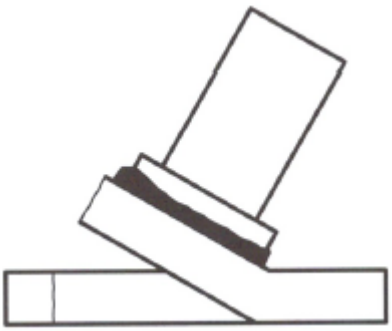
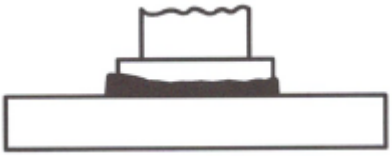
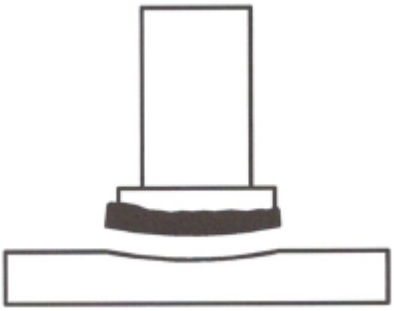
Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Reduced, irregular and greyish collar. LAW too long. 	Weld power too low	Increase current/time	Insufficient energy input to complete a good weld.
	Ceramic ferrule is wet	Use dry ferrules	Ferrules that contain residual moisture should not be used.
	Lift too short	Increase lift	Stud does not significantly away from weld, so lack sufficient momentum for penetration into the weld pool.
Collar off-centre with significant undercut. 	Effect of arc blow	See guidance on earth position sections below	Arc blow is a effect of strong magnetic fields during welding. Earth positioning needs assessment.
	Insufficient centring	Check centring of stud in ceramic ferrule	Stud is likely against side of ferrule, or ferrule is not correctly seated in holder.
	Stud not perpendicular during welding	Check operator positioning and tooling	During welding the stud is not perpendicular to the workpiece. **Testing Note** – when testing for acceptable undercut, bend tests must be in the direction OPPOSITE the undercut.
Collar height extremely reduced, bright, large, lateral projections. LAW too short 	Weld power too high	Reduce weld current or time	Too much energy input into weld
	Plunge rate too high	Reduce protrusion and/or check damper engagement	The return speed to the weld pool is too high. This can be caused by too much protrusion giving excessive tension on the spring in welding tool, or the damping action is not working, due to disengagement or alteration of damper position.

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Mechanical testing assessment			
Plug failure in parent material 	Acceptable	None	**Testing Note** - acceptable if plug failure is around the circumference of the stud, or if a significant amount of the cross-section of the weld area comes away with the stud, otherwise treat as weld failure.
Fracture above collar after sufficient deformation 	Acceptable	None	**Testing Note** - acceptable after stud exceeds mechanical testing limit.
Fracture within weld area. High porosity 	Weld power to low Unclean Surface Material not suitable for stud welding	Increase current/time Clean the surface Select suitable material	Insufficient energy input to complete a good weld. Excessive surface contamination is causing impurities to be trapped in weld area. Carbon content or CEV is too high, for best results use materials with a CEV of 0.25 or lower.
Fracture in HAZ. Greyish fracture surface without sufficient deformation 	Hardening increased Cooling rate too high	Select suitable material Increase weld time, preheating may be required.	Material hardness is too high, material not suitable for studwelding. Material cools too quickly post-weld, causing contraction cracking. Increase weld time to increase latent heat in material, or consider preheating/ postheating to ease cooling rates.

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Mechanical testing assessment			
Fracture in weld, bright sparkling appearance. 	Flux content of stud is too high	Reduce flux quantity on studs	Excessive flux creates layer of impurity in weld.
	Welding time too low	Increase weld time	Insufficient weld time results in flux not being fully removed during welding.
Fracture in weld area after insufficient deformation with lack of fusion in border areas 	Cold plunge	Provide hot plunge	Control unit may not allow hot plunge, contact manufacturer for guidance.
	Return speed too low	Insufficient protrusion	Increase protrusion.
	Damping too strong	Reduce damping / disengage damper	Excess damping causing slow return to weld pool.
	Extraordinary friction	Ensure welding tool shaft moves smoothly and freely	Because of the quick weld times, even brief obstructions of the tool in the shaft can result in weld failures.
Burn-through 	Weld pool penetrates parent material	Increase parent material thickness	For drawn arc processes a minimum ratio of stud diameter: parent metal thickness applies as follows; Drawn Arc ≤ M10 3:1 Drawn Arc > M10 4:1
		Reduce energy input	If the above ratios are applied and burn-through is still a problem, then the weld time is too high

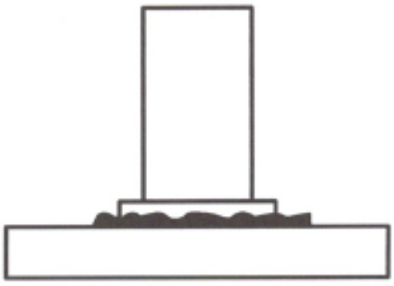
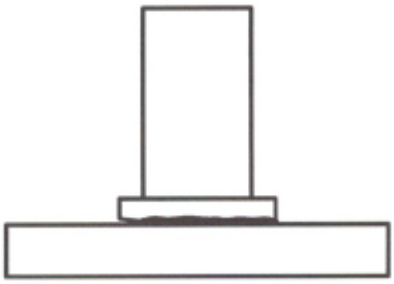
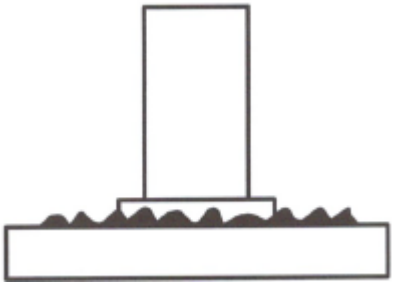
Drawn Arc Short Cycle studwelding

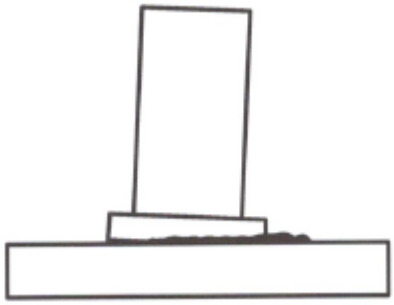
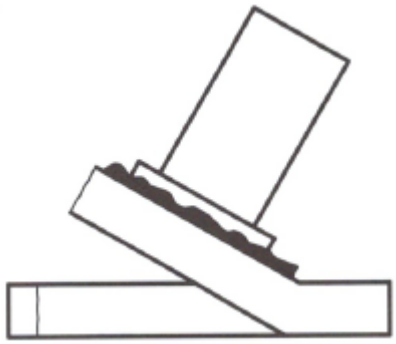
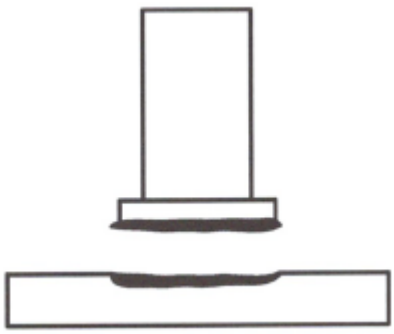
Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Regular collar, no visual defects 	Acceptable	None	Collar should be present all the way around the circumference of the stud.
Partial weld 	Weld power too low	Increase current/time	Energy input is to low to complete a good weld.
	Polarity incorrect	Correct polarity	Usually the handtool will be the negative electrode. Changing this will change heat distribution across the weld.
Large irregular collar 	Welding time too long	Reduce welding time	Energy input to weld too high resulting in excess molten material produced during welding.
Pores in Collar 	Welding time too long	Reduce welding time	Welding time too long allowing greater chance of oxidation.
	Current too low	Increase current	Current too low to burn contaminants out of weld area, increase current or clean material.
	Oxidation of weld pool	Provide suitable shielding gas	Select appropriate shielding gas for material.
	Surface contamination	Clean the surface	Excessive surface contamination is causing impurities to be trapped in weld area.

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Collar off-centre with unacceptable undercut 	Effect of arc blow	See guidance on earth positions section below	Arc blow is a effect of strong magnetic fields during welding. Earth positioning needs assessment. **Testing Note** – when testing for acceptable undercut, bend tests must be in the direction OPPOSITE the undercut.
Mechanical testing assessment			
Plug failure in parent material 	Acceptable	None	**Testing Note** - acceptable if plug failure is around the circumference of the stud, or if a significant amount of the cross-section of the weld area comes away with the stud, otherwise treat as weld failure.
Fracture above collar after sufficient deformation 	Acceptable	None	**Testing Note** - acceptable after stud exceeds mechanical testing limit.
Fracture in HAZ 	Material not suitable for stud welding	Select suitable material	Carbon content or CEV is too high, for best results use materials with a CEV of 0.25 or lower.

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Mechanical testing assessment			
Lack of Penetration 	Heat input too low Incorrect polarity	Increase current/time Correct weld polarity	Energy input is too low to complete a good weld. Usually the handtool will be the negative electrode. Changing this will change heat distribution across the weld.

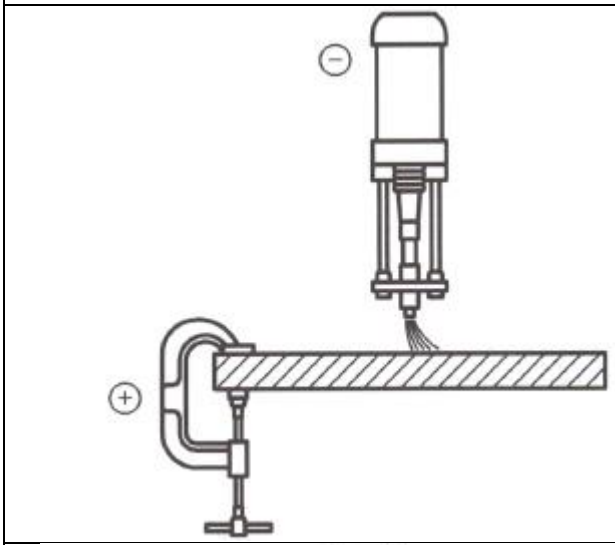
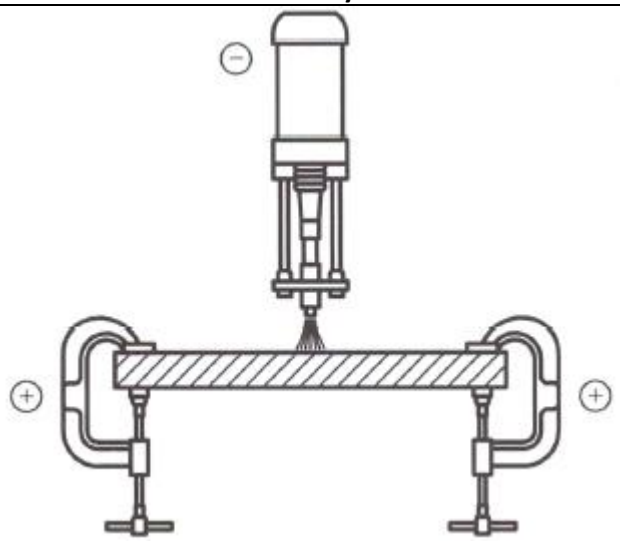
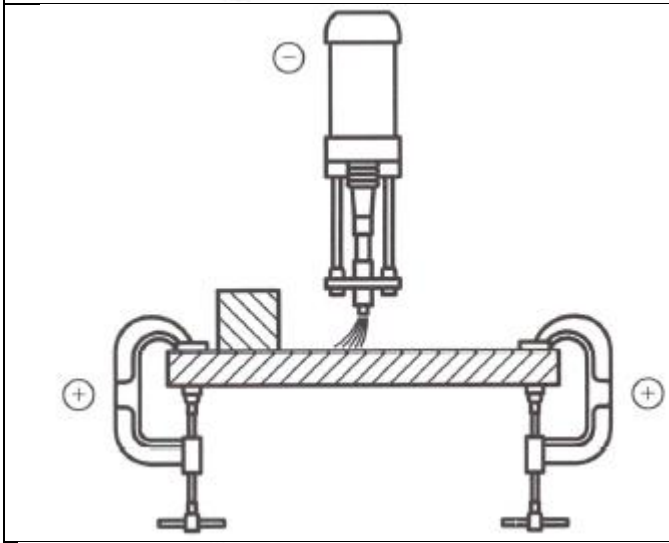
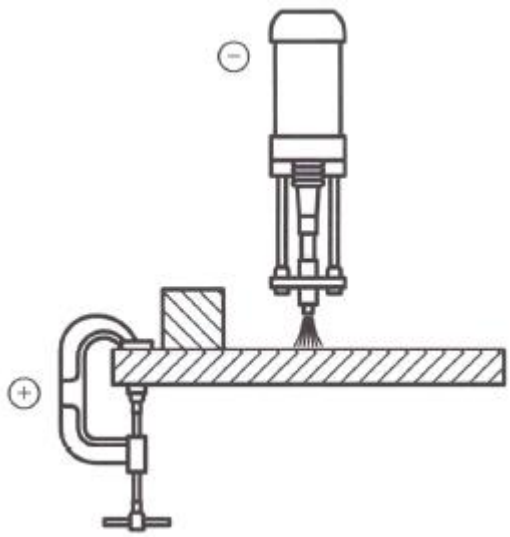
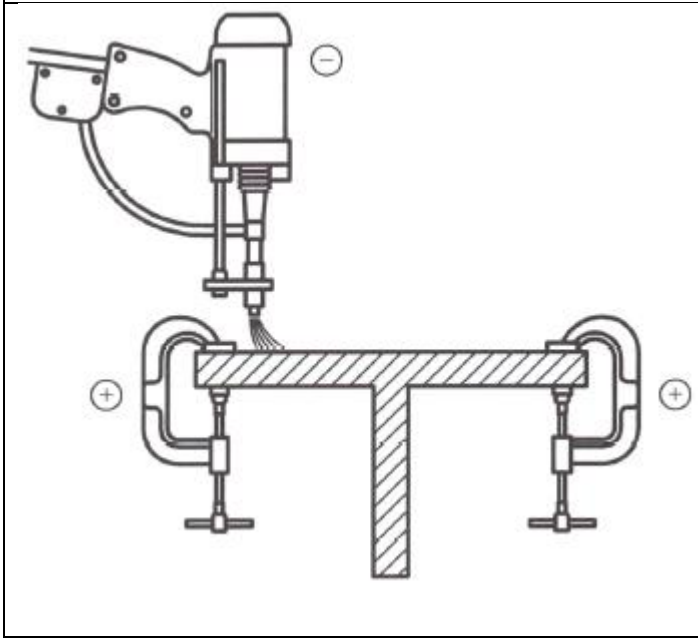
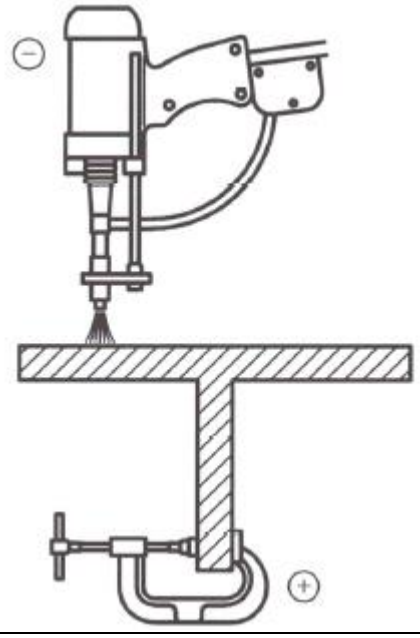
Capacitor Discharge studwelding

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Small weld spatter around joint, no visual defects 	Acceptable	None	Spatter should be present all the way around the circumference of the stud.
Gap between flange and parent material 	Weld power too low Return speed too low Insufficient parent metal support	Increase voltage Increase spring pressure Provide support to underside of material	Insufficient energy input to complete weld. Higher spring pressure makes a faster return. Thin material may flex if unsupported. Support material to eliminate any flex.
Considerable spatter around weld 	Weld power too high Return speed too low	Reduce voltage Increase spring pressure	Excessive voltage causes increase in spatter around weld. Slower return time causes excessive material ejection from weld area.

Appearance & description	Assessment of problem	Recommended corrective actions	Notes
Visual examination or macro cross-section			
Weld spatter off-centre with undercut 	Effect of arc blow	See guidance on earth positions section below	Arc blow is a effect of strong magnetic fields during welding. Earth positioning needs assessment. **Testing Note** – when testing for acceptable undercut, bend tests must be in the direction OPPOSITE the undercut.
Mechanical testing assessment			
Plug failure of parent material 	Acceptable	None	**Testing Note** - acceptable if plug failure is around the circumference of the stud, or if a significant amount of the cross-section of the weld area comes away with the stud, otherwise treat as weld failure.
Fracture of stud above flange 	Acceptable	None	**Testing Note** - acceptable after stud exceeds mechanical testing limit.
Fracture in weld area 	Weld power to low Return speed too low Combination stud/parent material unsuitable	Increase voltage Increase spring pressure Select suitable materials	Insufficient energy input to complete weld. Higher spring pressure makes a faster return. Carbon content or CEV is too high, for best results use materials with a CEV of 0.25 or lower.

Guidance on positions of earth clamps and remedies to effect of arc blow

The below table shows some situations in which arc blow is being caused and then gives some examples of how the problem may be remedied.

Cause	Remedy
	
	
	

Arc blow is caused by the strong electro-magnetic field established during the welding process, and causes the movement of material from the weld pool under the stud during the welding process.

When the arc is struck, the plate material is melted and takes on the same positive charge as the earth clamps, as the earth clamps are strong positive electrodes, they repel the plate material from underneath the stud.

The effect of arc blow is proportional to the current intensity and can be influenced by positioning of the earth clamps and by placing additional masses of metal as compensators to reduce the effect of arc blow. Arc blow causes the weld to only melt one side of the stud and creates additional porosity in the weld area, so taking appropriate measures to counteract arc blow is essential.