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BUYER'S GUIDE: K-TIG vs K-PAW

Keyhole welding comparison

Keyhole welding provides enormous productivity gains over conventional welding techniques.

Keyhole Plasma Arc Welding (K-PAW) was developed in the 1960's , and until recently was the default choice where deep penetration welds were required. A much more recent innovation is Keyhole Tungsten Inert Gas (K-TIG) welding, a high performance TIG welding process that performs single-pass, full penetration welds up to 16mm without filler or edge preparation at speeds of up to 100x TIG welding speeds.

K-TIG welding torch

K-TIG
KEYHOLE TIG

K-PAW welding torch

K-PAW
KEYHOLE PLASMA

	K-TIG	K-PAW
PENETRATION	Up to 16mm	Up to 10mm
SPEED	Up to 1000mm/min	Up to 500mm/min
COMPLEXITY	Extremely simple	Highly complex, numerous critical parameters
TOLERANCE	Tolerant to joint imperfections	Requires very precise fit-up
KEYHOLE STABILITY	High inherent stability, self-correcting keyhole	Inherently unstable
MAINTENANCE COSTS	Very low	High
SKILL OF OPERATOR	Very low	High
ELECTRODE ALIGNMENT	Not significant	Critical, frequent intervention required
CONSTRICTION OF ORIFICE	No orifice	Critical, limited life due to erosion from plasma
PILOT ARC STARTING	No pilot arc required	3 to 15 amp pilot arc starting system required
DUTY CYCLE	100%	Typically 60%

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POINT OF COMPARISION	K-TIG	K-PAW
PENETRATION	**Up to 16mm** K-TIG comfortably performs single pass welds in 16mm thick titanium, 14mm zirconium, 13mm austenitic stainless steels, Hastelloys, Inconels and a wide range of nickel and cobalt alloys, and 9mm in conductive materials such as ferritic steels & carbon steels.	**Up to 10mm** Claims for the penetration capabilities of K-PAW vary. The practical upper limit for single pass K-PAW welding is generally considered to be 8 -10mm. K-PAW is typically used for root passes of 4-6mm, followed by filler passes using TIG.
SPEED	**Up to 1000mm/min** K-TIG welding is significantly faster than K-PAW. Typical speeds are: 3mm material at up to 1000mm/min 4mm material at up to 750 mm/min 6mm material at up to 600mm/min 8mm material at up to 500mm/mi 12mm material at up to 350mm/min 14mm material at up to 250mm/min 16mm material at up to 200mm/min	**Up to 500mm/min** K-PAW welding is significantly slower than K-TIG. Typical speeds are: 3mm material at up to 500mm/min 4mm material at up to 400 mm/min 6mm material at up to 300mm/min 8mm materials at up to 200mm/min 12mm material – n/a 14mm material – n/a 16mm material – n/a
COMPLEXITY	**Extremely simple** K-TIG is very simple to operate. The arc structure and keyhole develop spontaneously and are maintained automatically by the controller throughout the weld. There is no plasma nozzle or orifice, no precise electrode alignment is required, only one welding gas is used, flow rate is not critical, and the torches are very robust.	**Highly complex, numerous critical parameters** K-PAW is widely regarded as the most complex of the arc welding processes. The constricted, high energy density plasma jet is produced by maintaining a critical balance between plasma gas flow rate, shielding gas flow rate, current, orifice diameter and the alignment between the electrode and the orifice .This requires meticulous set-up and frequent maintenance.

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POINT OF COMPARISION	K-TIG	K-PAW
TOLERANCE	**Tolerant to imperfections** Moderately tolerant to imperfections in fit-up due to non-constricted, lower energy-density, conical-shaped arc. 	**Requires very precise fit-up** Intolerant to imperfections in fit-up due to highly constricted, high energy-density, columnar-shaped arc. 
KEYHOLE STABILITY	**High inherent stability, self-correcting keyhole** K-TIG keyholes have extremely high stability. The K-TIG keyholes have a relatively wide opening relative to their depth, and the front face opening is considerably wider than that in the root. Surface tension alone renders the K-TIG keyhole very stable. As a result, there is no requirement to seek a balance between arc forces and surface tension - the nature of the keyhole surface is such that it naturally and dynamically self-corrects for fluctuations in the arc forces.	**Inherently unstable keyhole** K-PAW keyholes are inherently unstable. The keyhole must be held open against gravity & surface tension by a combination of gas pressure & recoil pressure from metal evaporating from the walls of the keyhole. Since the energy density & the plasma pressure are in turn dependent on many other process variables (gas flow rates, electrode-orifice alignment, current and orifice diameter being the most critical), the keyhole is highly sensitive to changes in welding parameters, making it difficult to control.
MAINTENANCE COSTS	**Very low** K-TIG welding systems incur very low maintenance costs due to their simplicity. K-TIG systems have few consumable components, are robust and extremely reliable.	**High** K-PAW systems incur the highest maintenance costs of any arc welding process due to their complexity. K-PAW systems require frequent maintenance by skilled operators in order to ensure parameters remain within tolerance.

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POINT OF COMPARISION	K-TIG	K-PAW
SKILL OF OPERATOR	**Very low** K-TIG requires minimal training due to the simplicity of the process and the sophistication of the K-TIG controller. An unskilled operator is sufficient. Operator training can be completed in 3 hours and comprehensive supervisor training in 1 to 2 days.	**High** K-PAW requires extensive operator training due to its complexity and sensitivity to the many critical variables involved. Operators must be skilled in maintenance of these parameters. A skilled operator is required. Training times are typically 1 to 2 weeks.
ELECTRODE ALIGNMENT	**No alignment required** As K-TIG requires no plasma nozzle or orifice, no precise electrode alignment or associated maintenance is required.	**Critical, frequent intervention required** The alignment of the electrode is one of several critical parameters and requires frequent attention.
CONSTRICTION OF ORIFICE	**No orifice required** The K-TIG welding process uses natural arc forces to achieve keyhole penetration, does not require a plasma nozzle, orifice or constriction of the arc in any way.	**Critical** The plasma nozzle bore diameter is critical and has a limited life due to plasma erosion and melting. The rating of the nozzle is further reduced if helium is desirable for plasma gas.
PILOT ARC STARTING	**No pilot required** K-TIG does not require a pilot arc starting system.	**3 to 15 amp pilot required** K-PAW requires a pilot arc starting system, typically 3 to 15 amps.
DUTY CYCLE	**100%** K-TIG utilises a 1000 amp power supply, which is considerably more than is required for any keyhole process, and is rated for 100% duty cycle.	**Typically 60%** K-PAW welding systems are typically provided with power supplies in the range of 300-500 amps, and are typically rated for 60% duty cycle.