

## Energy Transfer Efficiencies (ETE) for Fusion Welding Processes

Welding Process	Reported ETE	Recommended ETE	Reference
EBW, Electron Beam Welding	90%	90%	[1]
GMAW, Gas Metal Arc Welding. (MIG)	85%	85%	[2, 3]
GTAW, Gas Tungsten Arc Welding. (TIG)	67-80%	75%	[4-6]
CO2 Laser Beam seam welding.	20-90%	See OSLW or reference	[7]
Nd:YAG Laser Beam spot welding	38-67%	50%	[8]
PAW, Plasma Arc Welding	47-75%	60%	[3, 5]
SAW, Submerged Arc Welding	90%	90%	[2, 3, 9]
VPPAW, Variable Polarity Plasma Arc Welding, aluminum	41-62%	50%	[10]
SMAW, Shielded Metal Arc Welding (Stick)	75%	75%	[2]

- [1] D. T. Swift-Hook and A. E. F. Gick, "Penetration Welding with Lasers," *Welding Journal*, vol. 52, pp. 492s-499s, 1973.
- [2] A. Okada, "Application of Melting Efficiency and its Problems," *J. of the Japan Welding Society*, vol. 46, pp. 53-61, 1977.
- [3] J. N. Dupont and A. R. Marder, "Thermal Efficiency of Arc Welding Processes," *Welding Journal*, vol. 74, pp. 406s-416s, 1995.
- [4] H. B. Smartt, J. A. Stewart, and C. J. Einerson, "Heat Transfer in Gas Tungsten Arc Welding," presented at ASM International Welding Congress, Toronto, Canada, 1985.
- [5] P. W. Fuerschbach and G. A. Knorovsky, "A Study of Melting Efficiency in Plasma Arc and Gas Tungsten Arc Welding," *Welding Journal*, vol. 70, pp. 287s-297s, 1991.
- [6] N. Collings, K. Y. Wong, and A. E. Guile, "Efficiency of Tungsten-Inert Gas Arcs in Very High Speed Welding," *Proc. Inst. Electr. Engr.*, vol. 126, pp. 276-280, 1979.
- [7] P. W. Fuerschbach, "Measurement and Prediction of Energy Transfer Efficiency in Laser Beam Welding," *Welding Journal*, vol. 75, pp. 24s-34s, 1996.
- [8] P. W. Fuerschbach and G. R. Eisler, "Effect of laser spot weld energy and duration on melting and absorption," *Science and Technology of Welding and Joining*, vol. 7, pp. 241-246, 2002.
- [9] N. N. Rykalin, *Calculation of Heat Flow in Welding*. Moscow: Translated by Zvi Paley and C. M. Adams Jr., 1951.
- [10] P. W. Fuerschbach, "Cathodic Cleaning and Heat Input in Variable Polarity Plasma Arc Welding of Aluminum," *Welding Journal*, vol. 77, pp. 76s-85s, 1998.