WELCOME TO THE FACTORY OF THE FUTURE

ENGINEERED BY:
LOCAL VACUUM ELECTRON BEAM WELDING
WHO ARE CVE?

CVE designs and builds Electron Beam Welding Systems and has more than 60 years manufacturing experience from its base in Cambridge, UK with over 1200 systems installed globally. With 95% of our equipment exported from the UK we have an excellent legacy sales and service support business with Centres in Beijing and Springfield, Massachusetts. Ebflow represents the latest in a long line of EB Innovations.

<table>
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<th>Our blue chip clients include:</th>
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**Europe:**

![List of European clients]

**USA:**

![List of US clients]

**Asia & Australia:**

![List of Asian and Australian clients]
How Traditional Electron Beam Welding Works

Electron Beam Welding (EBW) uses high-energy electrons to join materials:

**Electron Gun**
Produces a focused beam of high energy electrons.

**Anode**
Has positive potential attracting the electrons. The electrons pass through a hole in its centre, on towards the work piece.

**Focusing coil**
Focuses the beam to a fine point in order to achieve sufficient power density to weld metals.

**Internal vacuum chamber**
Contains tooling/fixtures used for holding and moving a work piece. A vacuum is required to allow the beam to be focused effectively.

**Work piece**
Depending on the thickness to be welded, the gun’s beam power is varied.

**Fundamental benefits of Electron Beam Welding**
- Narrow weld bead
- Narrow Heat Affected Zone
- Weldments exhibit excellent mechanical properties
- Low levels of component distortion
- Low overall heat input to the component
- Low metallurgical impact
- Can join many dissimilar and ‘difficult’ materials
- Accurate and repeatable

**Key Hole Welding:**

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How Ebflow Works

CVE has developed a local vacuum EB welding system which can be readily transported and operated on site and applied to structures significantly larger than can be accommodated in a vacuum chamber.

Ebflow eliminates the need for a vacuum chamber through a local, coarse vacuum which is established and maintained only where it is needed.

High performance EBW can take place in any plant where large components are welded on a large scale as long as adequate shielding from X-Rays can be provided. Using a system of sliding seals and precision handling enables fast longitudinal and circumferential welds on large work pieces.

A coarse vacuum is ideal for thick section welding – achieving the fastest thick section welding rates ever.

There is no filler wire, the autogenous weld can be heat treated and the weld rendered metallurgically indistinguishable from the parent material.

<table>
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<tr>
<th>Submerged Arc Welding</th>
<th>LVEBW Welding</th>
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<td>90 passes at 500mm/min</td>
<td>Single pass at 100mm/min</td>
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<tr>
<td>= 6mm/min</td>
<td>= 18 times faster</td>
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What is Ebflow?

Ebflow brings all the advantages of Electron Beam Welding to steel structures of unlimited size. The natural next step in CVE’s product offering, it brings the following advantages:

- Facilitating very high joint completion rates in ‘thick’ section metals (ferrous and non-ferrous i.e. carbon steels, stainless steels, aluminium, titanium)
- 20 to 30 times faster than conventional submerged arc welding, 200mm per minute in 150mm thick steel has been achieved, allowing for the fastest thick section welding rates ever
- A coarse vacuum is established and maintained only where it is needed
- Welding without pre-heating possible
- Minimal weld prep/bevel required, ‘edge to edge’ fit up
- Welding consumables are not required (no filler wire-autogenous)
- Increased quality and reliability
- Immediate post weld inspection possible
- Using a system of sliding seals and precision handling enables fast set up and pre-welding operations for variety of work piece dimensions
- Minimal distortion

Coarse vacuum operation

Ebflow’s differential pumping and RF heated diode gun allow for operation in Local Vacuum pressure of c.1mbar (high vacuum is 5x10⁻¹ - 1x10⁻¹ mbar).

Precision robotics

Precision handling of the head of the Ebflow system. Can be mounted flexibly, e.g. on circular tracks.

Local seal

Seals around the welding head create the coarse vacuum. A box seal is provided for the rear of the weld.

Fast, flexible welding

Fast longitudinal and circumferential welds are possible on large work pieces. The Local Vacuum nature of Ebflow is particularly suitable for large tubular thick section material.

Background

High productivity welding is an important factor influencing the economics of fabrication of large structures destined for use in the pressure vessel and offshore and heavy engineering fabrication industries. Electron beam welding is a process which offers significant benefits in terms of productivity increases and repeatability/accuracy in the fabrication of large, heavy wall structures. To date the use of this process has been limited by the need for a vacuum chamber of appropriate dimensions.
Creating Your Factory of the Future

Quality
Single pass, low heat input welds result in reduced distortion. Autogenous electron beam welding facilitates continuous/repeatable high quality welds.

Economy
Costs are driven down by huge increases in throughput. Pre-heat can be omitted and NDT testing can be performed immediately after welding, saving more time. No welding consumables required and much lower energy usage.

Productivity
High volume factory throughput. Increase your sales by a magnitude as your factory capacity just went through the roof!

Lower Carbon Footprint
Eflow requires as much as 75% less power/electricity than conventional arc processes.
**Lower Carbon Footprint**
- Ebflow requires much less electrical power than conventional arc processes. Reduced transportation costs as well as the fact that there is no need for filler materials, chamber and associated pumping equipment, pre-heating or loading/unloading operations combine to offer a far lower carbon footprint when compared with traditional processes.
- The energy consumed in one metre of weld is 75% less using Ebflow than in standard submerged arc welding process.

**Economy**
- Lower working capital requirements
- Lower personnel costs
- No chamber and associated pumping equipment
- Reduced transportation costs
- No filler materials – lower consumable costs
- Smaller factory footprint possible
- The energy consumed in one metre of weld is 75% less using Ebflow than in standard submerged arc welding process.

**Productivity**
- Higher speed of manufacture
- On site welding
- No weld joint bevel required
- Flexibly weld objects of any size
- No pre-heating required
- No loading, evacuating and unloading operations

**Quality**
- Immediate post weld inspection possible
- Single pass welding capability
- Post Weld Heat Treatment (PWHT) can create a weld rendered metallurgically indistinguishable from the parent material enabling welded components to be used in place of a single forging.
- Localised residual stresses
- Weld rendered metallurgically indistinguishable from the parent material

**Minimal distortion**
- Increased accuracy and repeatability
**TECHNOLOGY DEVELOPMENT**

**LINEAR LOCAL VACUUM METHODS:**

Ebflow local vacuum technology has been developed to suit specific applications and processes. Utilising sliding box seals or a sliding local head operating along or around the work piece which can remain static or rotate under the beam.

Developed to linearly weld rolled tubular pieces. Linear box seals are deployed internally and externally. The specially designed gun operates in a coarse vacuum created within the box seals. An arrangement of sliding plates maintains the vacuum as the gun station travels along the main axis of the work piece.

In this method the external box seal is replaced with a local head. A coarse vacuum is created between the head and the work piece and is maintained as the gun station travels along the main axis of the work piece.

**CIRCUMFERENTIAL LOCAL VACUUM METHODS**

Internal sealing to maintain the required coarse vacuum can be achieved through a variety of means – flexible and mobile inflatable seals, simple TIG welding or box seals.

Operating on the same principles, the arrangement of sliding seals or local head can be deployed to weld the same large structures circumferentially.

Work Pieces are rotated under the gun in either the horizontal or vertical plane. For very large tubulars the gun station with local head rotates around the static work piece.

**LEAD SHIELDING**

Various methods of shielding the welding process with lead containers have been designed. In principle the lead shielding is designed to suit the particular application and process whilst being as efficient as possible. The thickness of steel being welded shields the x-ray emissions enabling full protection with ‘local’ solutions rather than very large chambers.
APPLICATIONS

Oil and Gas
- Anchor Piles
- Jacket structure including nodes, cones, braces, legs and conductor framing
- Piles and followers
- J-tubes and caissons
- Riser clamps
- Flotation tanks and buoyancy tubes
- Module support frame including nodes, cones, braces
- Module framing including nodes, columns, fabricated beams
- Flareboom
- Subsea structures such as manifold and production system support

Pressure Vessels
- Process Vessels (columns, reactors, separators, drums etc)
- Heat Exchangers (directly cooling towers, indirectly shell & tube/plate)
- Storage Tanks

Civil Engineering
- Flat plate
- Flat plate-strip
- Long product open sections i.e. I&H universal beams and columns
- Structural hollow sections
- Plate girders

Nuclear
- Pressure vessels for conventional power, small modular reactor (SMR) and micro modular reactor (MMR) fabrication as well as associated pressure retaining and structural components

Shipbuilding
- Modular joining
- Hull shell
- Decks
- Tanks
- Web frames
- Bulkheads

Offshore Renewable Energy
- Monopiles
- Jacket structure including nodes, cones, braces, legs and conductor framing

Wider applications that require thick joint welding
- General construction
- Earthmoving equipment
- Engineering and machinery
- Mining and quarrying
- Turbine generators
- Tunnel boring machines
- Liquid Hydrogen containers at -250 degrees C.