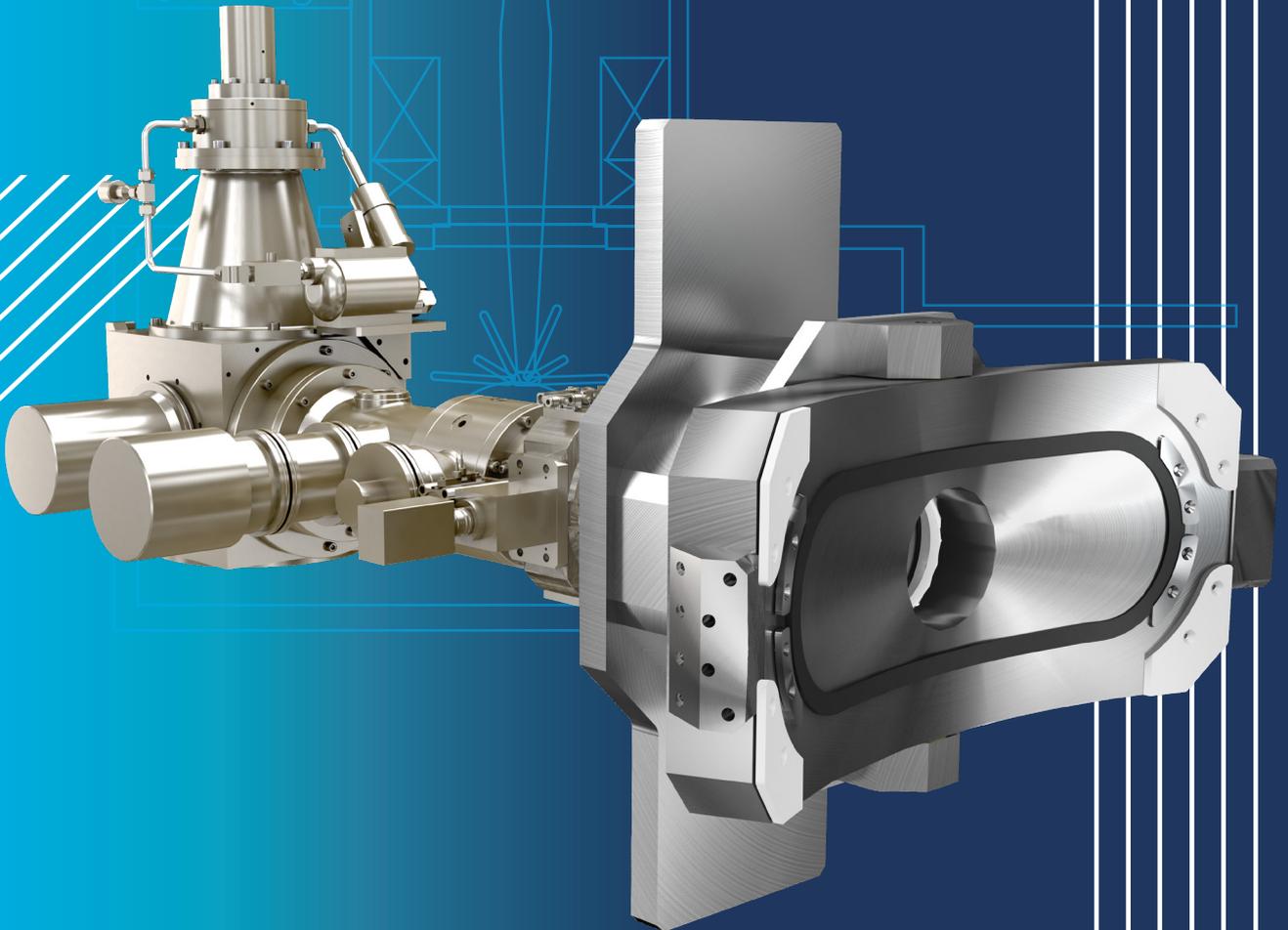


**ebflow**

# WELCOME TO THE FACTORY OF THE FUTURE

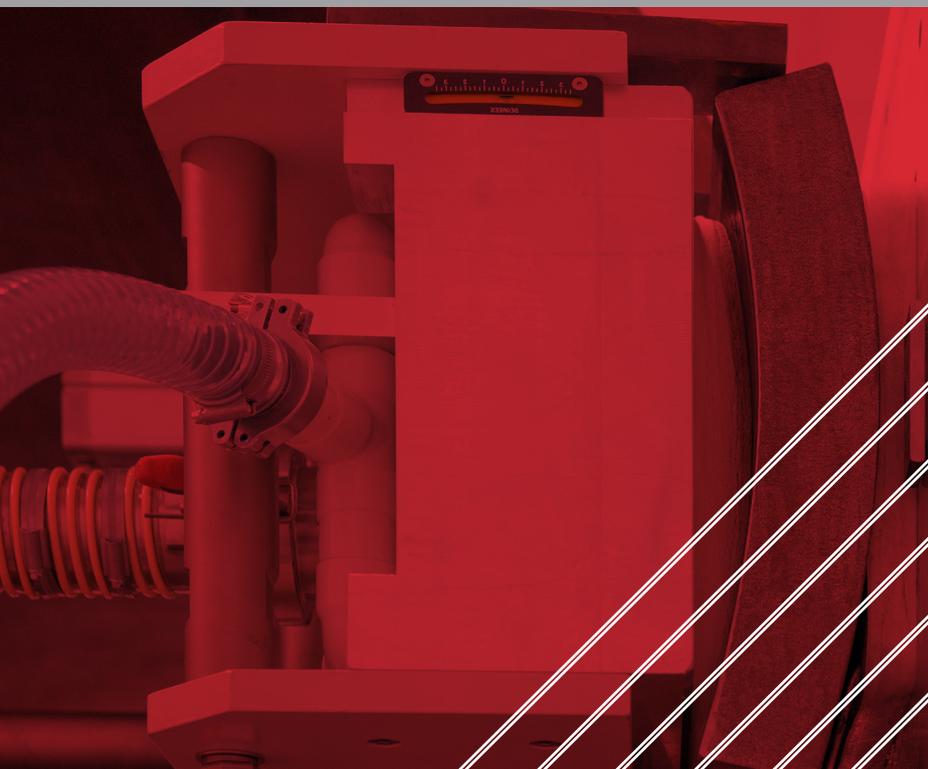
ENGINEERED BY:

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.



# Our blue chip clients include:

## Europe:

smiths

 Rolls-Royce®

PHILIPS

THALES



 JAGUAR



SAGEMCOM



ALSTOM

BAE SYSTEMS

VOLVO AERO



 SAFRAN  
Messier-Bugatti-Dowty

## USA:

Honeywell



EATON



TEXTRON



## Asia & Australia:



# 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

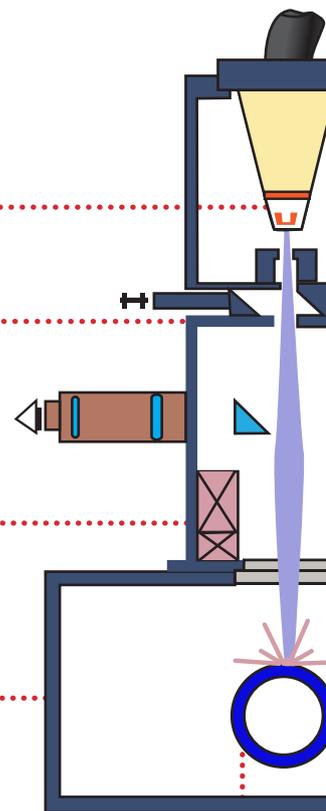
Focuses the beam to a fine point in order to achieve sufficient power density to weld metals

## 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

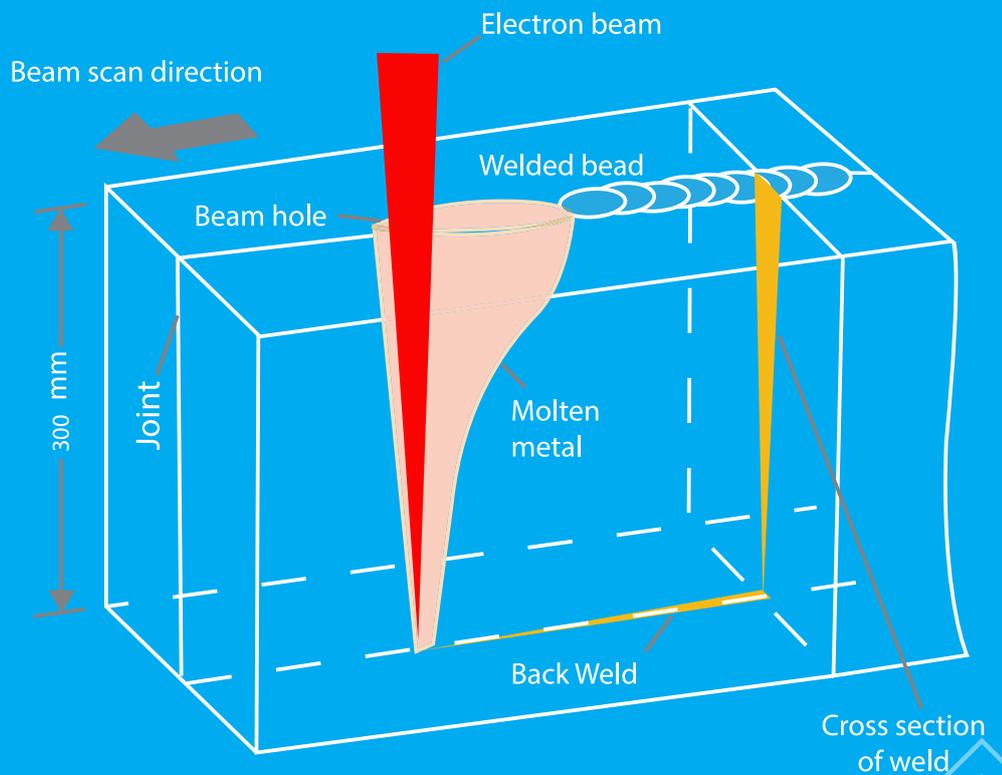
Depending on the thickness to be welded, the gun's beam power is varied



## 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:



Work piece also sits within a Vacuum Chamber

# How Ebflow Works

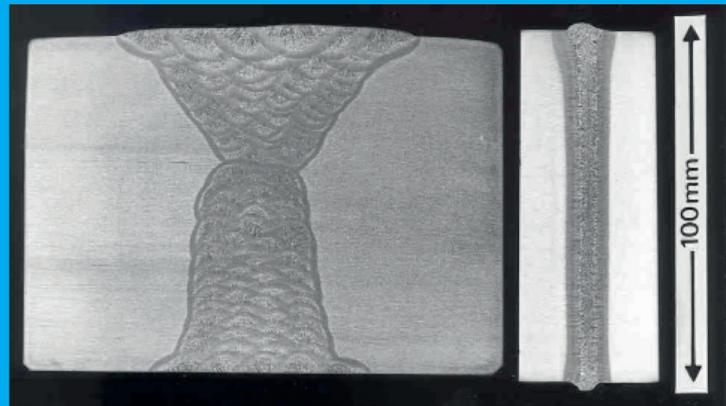
CVE has developed a local vacuum EB welding system which can be readily transported and operated on site and applied to structures significantly larger than can be accommodated in a vacuum chamber.

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.



**Submerged Arc Welding**  
90 passes at 500mm/min  
= 6mm/min

**LVEBW Welding**  
Single pass at 100mm/min  
= 18 times faster

## 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

# 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  $5 \times 10^{-1}$  –  $1 \times 10^{-1}$  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

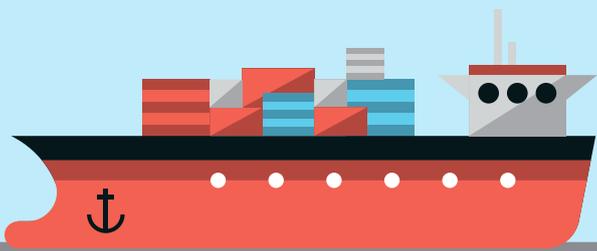
Fast longitudinal and circumferential welds are possible on large work pieces.  
The Local Vacuum nature of Ebflow is particularly suitable for large tubular thick section material.

# Background

High productivity welding is an important factor influencing the economics of fabrication of large structures destined for use in the pressure vessel and off-shore 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.

- 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

# 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.



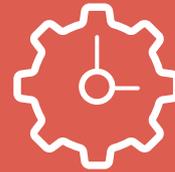
## Lower Carbon Footprint

Ebflow requires as much as 75% less power/electricity than conventional arc processes.



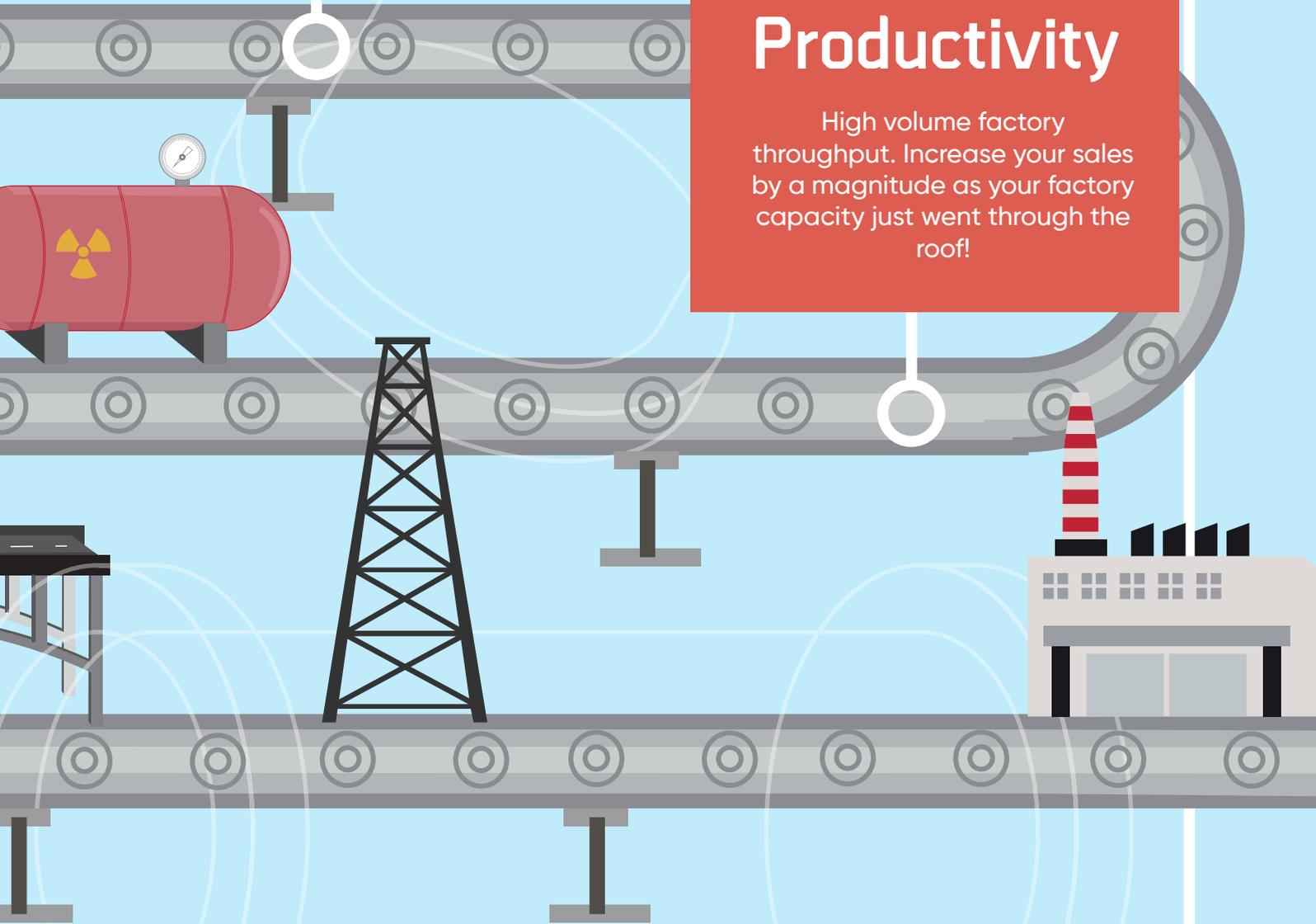
## Economy

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!



# EBFLOW BENEFITS

## Lower Carbon Footprint

- Ebflo 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 Ebflo than in standard submerged arc welding process

## Productivity

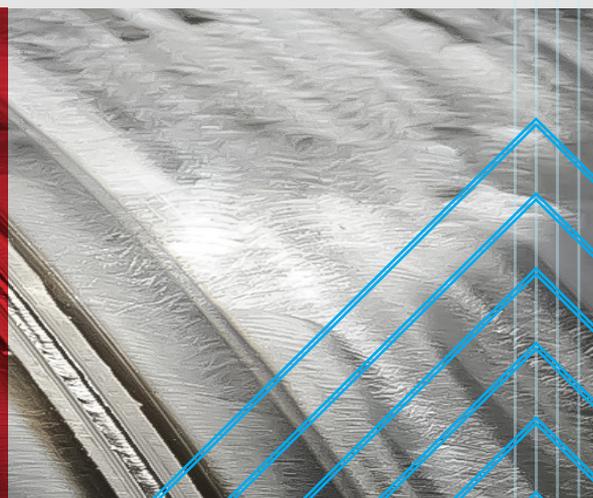
- Higher speed of manufacture
- On site welding
- No weld joint bevel required
- Flexibly weld objects of any size
- No pre-heating required
- No loading, evacuating and unloading operations
- Immediate post weld inspection possible
- Single pass welding capability
- Post Weld Heat Treatment (PWHT) can create a weld rendered metallurgically indistinguishable from the parent material enabling welded components to be used in place of a single forging

# 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 Eflow than in standard submerged arc welding process

# Quality

- Eflow facilitates continuously repeatable high quality welds
- Localised residual stresses
- Weld rendered metallurgically indistinguishable from the parent material
- Minimal distortion
- Increased accuracy and repeatability



# TECHNOLOGY DEVELOPMENT

## LINEAR LOCAL VACUUM METHODS:

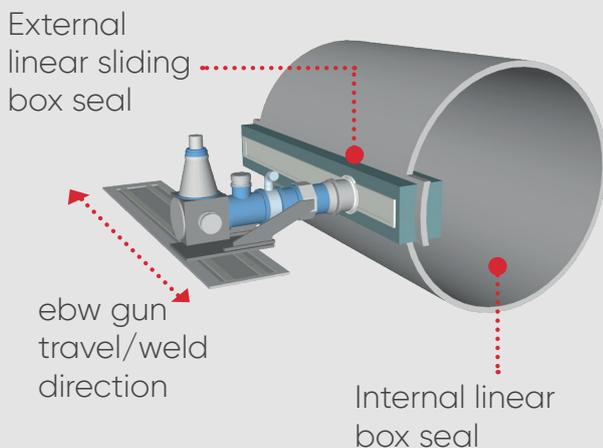
Ebflow local vacuum technology has been developed to suit specific applications and processes. Utilising sliding box seals or a sliding local head operating along or around the work piece which can remain static or rotate under the beam.

Developed to linearly weld rolled tubular pieces. Linear box seals are deployed internally and externally. The specially designed gun operates in a coarse vacuum

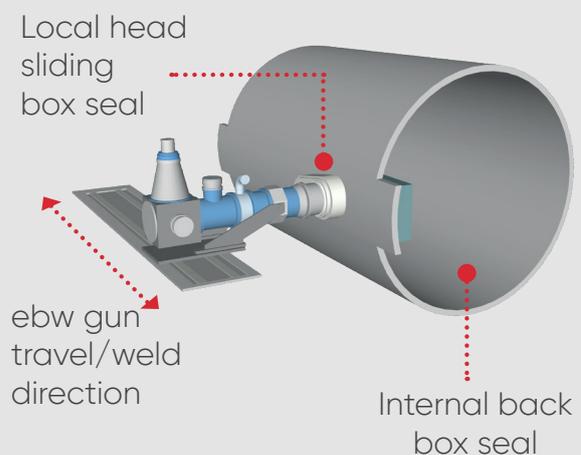
created within the box seals. An arrangement of sliding plates maintains the vacuum as the gun station travels along the main axis of the work piece.

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.

### Internal and External Linear Box Seals



### Local Head Linear Sliding Seal with Back Box



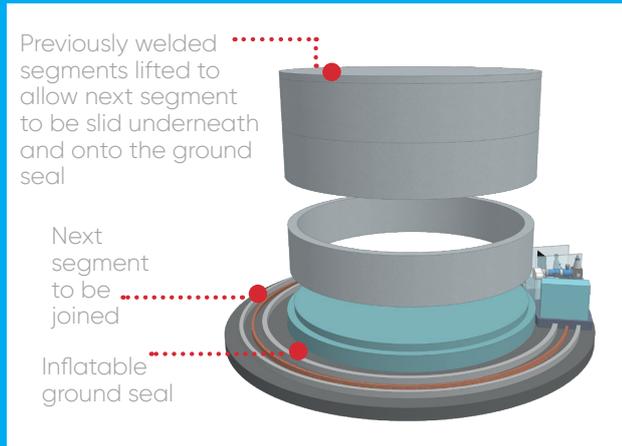
# CIRCUMFERENTIAL LOCAL VACUUM METHODS

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.

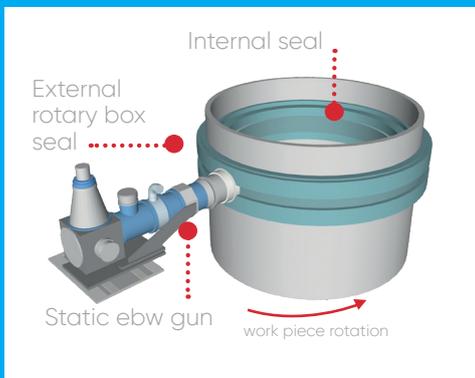
Operating on the same principles, the arrangement of sliding seals or local head can be deployed to weld the same large structures circumferentially.

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.

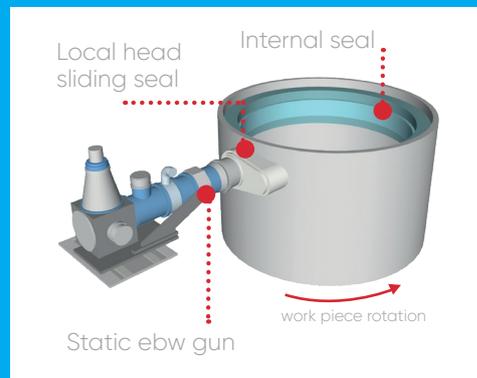
Rotary Local Head and Ground Seal



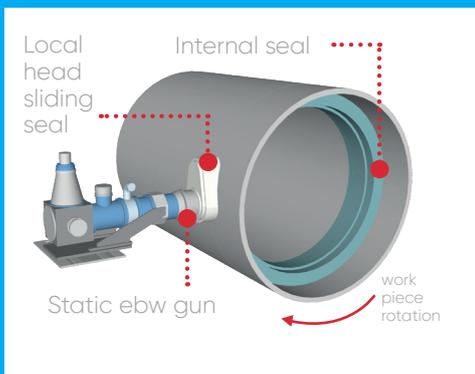
External Box Seal and Internal Seal



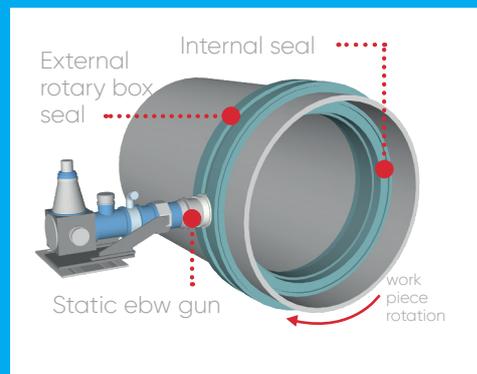
Rotary Local Head and Internal Seal



Local Head Sliding Seal and Internal Seal

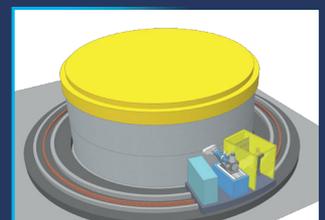
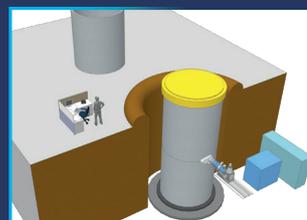
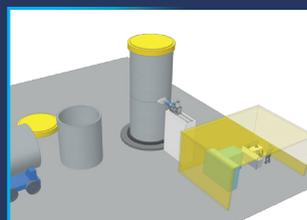
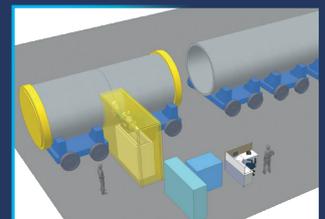
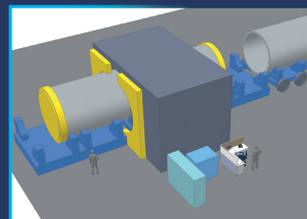
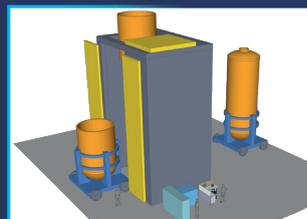


Local Head Sliding Seal and Internal Seal



## 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

## 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

## 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

# 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.



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