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PIN BRAZING

A metalurgically safe method of making electrical connections to pipelines and other metallic structures, which are to be cathodically protected or electrically earthed.

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INTRODUCTION

Pin Brazing is an easy, metalurgically safe method of making electrical connections to steel and ductile iron pipelines as well as other metallic structures, which are to be cathodically protected or electrically earthed.

Whilst the system has major advantages over alternative systems, some of which can cause unacceptable levels of irreversible damage to the structure itself, it is imperative that operator training and equipment maintenance is to a high standard.

This paper explains the pin brazing process, the technique, the effects of this, alternative processes such as Cad Weld and also demonstrates system operation.

THE PROCESS

The BAC pin brazing technique is based primarily upon Electric-arc silver soldering using a specially designed portable pin brazing unit, a hollow brazing pin containing silver solder and flux.

The brazing process is initiated by depressing a trigger on the brazing gun. This as with most forms of electrical welding simply completes a circuit through which a DC current is passed. The pin tip is the point of highest resistance at which point an arc is drawn, melting the solder flux whilst simultaneously heating the lug material and the surface of the structure or pipeline to the required soldering temperature.

After approximately 1.5 seconds the circuit is mechanically or electronically broken, the solenoid is de-energised and the brazing pin is pushed forward into the molten pool of brazing alloy. The pin tip, brazing alloy, flux and lug cool into a homogenous unit.

The pin brazing process is well suited for joints between insulated pipe sections, connection to measuring cables, installation of sacrificial anodes and bonding zinc bracelets to offshore pipelines, due to the ease and speed of installation, high mechanical strength and extremely low resistance.

Within a cathodic protection system there are a multitude of connection requirements for anode cables, measuring posts etc, being extremely versatile, the pin brazing system is ideally suited to this. Attachments can be made vertically, horizontally or even overhead. If preferred, threaded pins with nuts can be attached or cable bonded directly onto the pipe by means of a special cable lug which can be crimped on site or supplied complete as a unique integrally crimped attachment. The BAC pin

brazing unit contains all the equipment and tools required to make safe cable connections. A welding generator may also be utilized as a power source wherever a battery unit may be impractical or a great many connections need to be made in such places as pipe-coating yards or lay-barges etc.

PIN BRAZING UNITS

BB1 / EASYBOND & EBRS

Electro-mechanical control
20 braze capacity
Fully portable
Low cost

BB1 is suitable for all types of installation and maintenance programmes. It was primarily designed for the occasional user who required a simple rugged, low cost piece of machinery but to date has proven to be the most popular and widely utilised pin brazing unit. Differing from its counterparts considerably in that it contains no electronic components and relies on the use a fuse wire (located on the brazing pin) to control brazing time.

The popularity of this unit stems from the fact that it is easy to use and maintenance requirements are minimal. Due to ever improving technologies the Easybond now features sealed power cells and microprocessor controlled charging equipment which has resulted in greater reliability, less hazard in confined or on site environments, easy storage and a very low risk when being transported or charged over long periods.

Sister to the Easybond is the Easybond Reach System (EBRS), a unit which has been recently developed to cater for the ever growing demand for the vacuum excavation technique. Utilizing virtually all components within the standard unit but incorporating a lightweight aluminum extension system operating up to 2.5 meters below ground in areas as narrow as 15 centimeters and a surface mounted triggering device. Hugely successful for being one of the most economical and cost effective methods of making retrofit connections to buried pipelines.

BB2

Digital ECU
50 Braze capacity
Fully portable
High capacity

BB2 is suitable for all types of installation and maintenance programmes. The equipment is portable and easy to transport. The pin brazing process in the BB2 is digitally controlled to provide an optimum brazed connection every time by being able to detect possible adverse brazing conditions and canceling the braze process before the actuation of electrical Arc. The batteries are of a new high

power gel type design, completely sealed and maintenance free. New microprocessor controlled charging equipment has resulted in greater reliability, less hazard in confined or on site environments, easy storage and a very low risk when being transported or charged over long periods.

BB3

Digital ECU
100 Braze capacity
High capacity
Heavy duty

BB3 is suitable for all types of installation and maintenance programmes. The equipment is portable and easy to transport and features a chassis mounted system with optional running gear for rail or site terrain. The pin brazing process in the BB3 is digitally controlled to provide an optimum brazed connection every time by being able to detect possible adverse brazing conditions and canceling the braze process before the actuation of electrical Arc. The batteries are of a new high power gel type design, completely sealed and maintenance free. New microprocessor controlled charging equipment has resulted in greater reliability, less hazard in confined or on site environments, easy storage and a very low risk when being transported or charged over long periods.

POWER TOOLS AND ACCESSORIES

Brazing gun

Consisting primarily of a solenoid which when activated lifts the brazing pin 1.5 to 2mm from the surface of the structure intended for bonding, thus creating a point of high resistance and resulting arc. Housed within the aluminium body are the manually operated and fully serviceable trigger mechanism, fuse wire ejection system (mechanically operated system only), adjustment control and separate chucks for the brazing pin and ceramic insulator (ferrule). The gun is extremely robust and the basic design has remained relatively unchanged since it was introduced over fifty years ago.

There are various brazing guns available all to suit specific operations as well as the reach system mention previously there is an extended gun available for depths up to 150mm, angle gun for offset bond locations and a heavy duty welding generator compatible tool for extremely high volumes. As well as individual part number identification, brazing guns can usually be identified by colour, red and yellow are associated with the light duty mechanical systems and green would indicate heavy duty equipment whether mechanical or electronic and are often operated using a higher current.

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42 Volt grinding machine

A high speed, lightweight grinding machine which plugs directly into the battery unit via the grinder/charging socket. Utilising a self cleaning carbide burr, this allows for the removal of surface contamination such as corrosion, oil and coating epoxy from the areas of bonding and ground cable attachment. This piece of equipment is classified as an optional accessory but comes highly recommended as a thoroughly clean, bright metal surface is imperative in the pin brazing process.

Elite. Charging unit

This Microprocessor Controlled Automatic Battery Charger is designed to provide fast, automatic charging and ensures peak performance from your batteries. Features include Short circuit shutdown facility without the risk of blown fuses, reverse polarity protection, 3-stage charge CI-CV-FLOAT, fast constant current bulk charge, constant voltage proportional timing for minimal gas emission, trickle charge facility, independent overrun (fault) timer and digital electronics for stability and reliability.

MAINS ON The red indicator will light to show that the AC Power is ON.

CHARGING The yellow indicator will light to show that the battery is connected correctly.

CHARGING The yellow indicator will start to flash when the battery is approximately 80% fully charged. This also indicates the start of the automatic timer for the Constant voltage charge stage. The Constant voltage stage will last for half the time taken to reach the Constant voltage stage plus one hour. (Proportional Timing).

FLOAT/STANDBY The green indicator will come on when the battery is fully charged and is ready for use. This will take a minimum of one hour, and may take up to eighteen hours from start of charging depending on the size of battery and the depth of discharge. While the green light is on the battery will be trickle charged to compensate for self-discharge, and ensure the cells are equally charged. For best results, the battery should be left connected and on charge until required for use.

ERROR DETECTION

If the GREEN indicator is FLASHING at the end of charge, this indicates a FAULT condition. This may be due to a battery defect, a fault in the charger, or the battery may not be fully charged within the 18 hour override timer. The battery and charger should be tested if this happens.

Unplug the AC Cable from the power outlet before disconnecting the charger from the battery. Before use please read WARNINGS & check the Charger Rating Label.

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12/36 Vehicle Powered Appliance Charger (VEPAC)

The BAC Vehicle Powered Appliance Charger (VEPAC) is a DC to DC Voltage Converter designed for charging 36 Volt Pin Brazing Units from a vehicle 12 Volt supply.

The **VEPAC** includes a number of features designed to simplify installation and optimise performance.

A built in voltage comparator circuit shuts down the unit when the car engine is not running to avoid discharge of the car battery. When a car is parked, its battery voltage is typically about 12.50 Volts, rising to around 14.25 Volts when the vehicle is being driven. The **VEPAC** detects this voltage increase and draws power from the 12 Volt supply only when the vehicle is running, so it can be permanently installed without requiring a switch to isolate it from the vehicle supply. It also has a voltage limiter on its output to provide a constant charge voltage to the 36 Volt system, to prevent overcharge.

The **VEPAC** will divert charge current from the car charging system to recharge the destination batteries while the car is being driven. The unit waits until the car battery has been recharged before starting to divert power to the 36 Volt load, so the vehicle battery will always be recharged first.

CONSUMABLES

Brazing Pins

Manufactured in two formats, 'Threaded' providing a stud on which a standard cable lug can be bolted to and 'Direct' for the attachment of a special BAC pin brazing lug or bonding cable. Various types of each are available. Pins must be kept free from grease, dry and stored in delivery tins taking care not to mix different part numbers. Each brazing pin is tipped with low temperature brazing alloy and the correct amount of flux. Pins for use with the mechanical system have attached a copper fuse wire at the other end which acts as a circuit breaker to control the brazing time. It is imperative that these are protected, bent or re-straightened fuse wires will break the pin brazing circuit prematurely. **Note: there is factory installed kink at the end of every fuse wire required for termination within the gun, this must not be removed or straightened. Pins with fuse wire must be used once loaded into the brazing gun, removing or ejecting unused pins will damage the fuse wire and could damage ejector mechanism.** Brazing pins are for single use only.

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Ceramic Ferrules

Various sizes are available. Designed for several purposes, firstly an insulator which prevents the body of the gun becoming energized and localising heat concentration to the point of brazing. Also to provide true platform for correct adjustment of the brazing tool. Ceramic ferrules must be kept dry and free from grease, stored in delivery tins and care taken not to mix different part numbers. Ceramic ferrules are for single use only.

Cable Lugs

Not to be confused with standard crimp lugs. BAC cable lugs are specially manufactured for use with the 'Direct' pin brazing process and are available in sizes ranging from 10mm^2 up to 50mm^2, special sleeves are also available which reduce the inside diameter of the 10mm^2 cable lug to suit cable as small as 2.5mm^2

Bonding cables

Taylor made to suit the specific cable requirements of the customer these are pre-manufactured bonds with a cable lug type arrangement for 'Direct' brazing. The advantages include a special integral attachment of cable to connection point which does not rely on a mechanical crimp. This is then brazed to the pipeline or structure where cable and surface are fused directly, producing an extremely strong, low resistance connection.

OPERATION

All staff undertaking pin brazing for any form of attachment should have attended an approved course in the pin brazing technique and hold a current certificate of competency. Pin brazing attachments can be successfully made to wet steel and in mildly inclement weather, i.e. light rain, drizzle or snow. Heavy rain may cause the pin fuse wire to burn out prematurely resulting in no bond being made. It is also possible to undertake pin brazing attachment to steels at sub zero temperatures. The appropriate personal protective equipment must be worn at all times.

The BAC system of pin brazing requires the use of a brazing unit utilising common Brazing Pins, Ceramic Ferrules and various types of bonds.

Battery unit (various)

The standard brazing unit consists of 3 heavy duty 12.7v lead-acid batteries connected in series and contained within a box with handle and external connections, a brazing gun, magnetic earth lead and battery charger. Weights vary and are approximately 25 to 50Kg, the capacity depending on age of equipment and climate would be around 15 brazes with the smallest machine to over 100 brazes utilizing heavy duty equipment (including use of a grinder)

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The safety of staff must be of prime consideration on every occasion that works on or about the site is to be carried out, staff must comply with all current safety requirements.

Protective goggles must be used during grinding and brazing by the operator and any staff within 3meters.

The batteries must be filled, charged and connected according to the instructions supplied. Due to a short standing shelf life, batteries must always be kept on charge when the unit is not in use and preferably stored in a dry room or cabinet where a constant power supply to the battery charger can be made available. There must be adequate ventilation at all times to prevent possible build up of gas evolved from the batteries.

The unit can be transported safely in the rear of a vehicle if secured to prevent movement and it is recommended that an in car charging system is utilised for long periods of travel so as to ensure the system does not fully discharge .

When non-sealed batteries are being used, after each day's work each battery should be examined to ensure that the level of electrolyte is 5mm (3/16") above the plates and topped up with distilled water as necessary.

Warning:- No Smoking or Naked Lights, explosive gases may be evolved.

With the battery box door open and each cell top removed to allow any gases to escape, battery charging should be undertaken using the approved charger via the appropriate socket. If the plates in any cell are not covered by the electrolyte the charger may not operate and damage to the batteries could result. Each cell must have its specific gravity checked by a hydrometer, a fully charged cell should be in the order of 1.28. and the set should not be used when the specific gravity of any cell reaches a reading of 1.20. Care must be observed not to tilt the equipment. Take care when dealing with electrolyte (Sulphuric Acid) spillage - refer to local COSHH assessment.

At regular intervals the battery connections should be checked for tightness using an approved insulated spanner, and greased with petroleum jelly. Battery cables and battery cases should be wiped clean and dry to avoid tracking, particularly after charging or spillage.

Connection of power tools to equipment must be as secure a possible, most new attachments are standard DINSE type welding connectors with a 'push and twist' termination or bayonet sockets fitted with a safety catch. If equipment is poorly secured to the battery pack then arcing may occur and equipment could become damaged.

When using electronic equipment, ensure that the correct program (F, B or G) is selected on the control unit panel. This information can be retrieved from the identification label on the brazing pin container, failure to do this could seriously affect brazing results.

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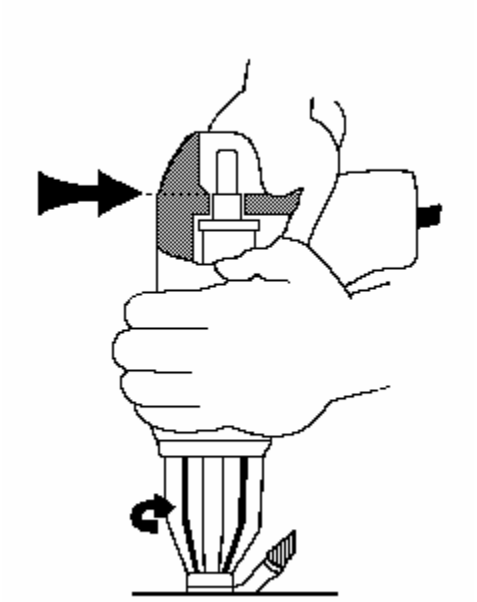
Brazing gun loading preparation and adjustment

Load the gun with a brazing pin and ceramic ferrule, ensuring that they are back fully home and tight. The legs of the pin holder must be adjusted as necessary to ensure a firm grip of the pin while maintaining concentricity within the ferrule holder. As mention previously the kinked end of fuse wire must not be straightened or removed and under no circumstances should a brazing pin which has been inserted and then removed from the gun be re-inserted and used for brazing without checking the kinked end profile and fuse wire connection to pin. Before connecting the earth clamp to the steel, adjust the brazing pin "Lift Height" as follows:

Hold the copper bond lug flat on the steel surface. Insert a loaded brazing pin into the hole in the bond lug and press the gun/ferrule against the surface of the lug evenly overcoming the internal spring. Turn the ferrule holder until the white adjustment indicator tube is flush with the gun's rear face. The brazing gun should now be correctly set.

When using threaded brazing pins, i.e. M8 brazing pin, the ceramic ferrule must be flat against the steel surface when checking the white adjustment indicator tube.



If necessary the surface encompassing the pin braze area and adjacent earth connection shall be degreased before any grinding operation. Scrape and clean the steel and grind an area for the earth clamp as near as possible to the braze area. The surface must be ground to a bright finish to ensure a sound electrical connection between the earth device and the work piece and an area in excess of the cable lug must be correctly located and cleaned to a bright finish using the grinder provided. All pits and marks must be removed. To prevent the ground surface re-oxidising so brazing must take place as soon as possible after grinding, i.e. not more than 5 minutes.

The magnetic earth lead attachment must then be attached to the cleaned surface to ensure a sound electrical circuit.

With the correct pin and ferrule fitted the brazing gun must be adjusted. Locate the brazing pin so that the pin is in the centre of the hole in the cable lug. For vertical surfaces, the pin must be at the upper part of the hole in the cable lug. Apply sustained pressure on the brazing gun so that full contact is made between the ferrule and the bond attachment (or the steel surface when using threaded pins). When the operator is ready to braze his stance should be stable enough to ensure as little movement as possible. Movement during the brazing operation could alter the critical positioning of the gun.

Hold the gun firmly and close the circuit by squeezing the trigger. It is recommended that the trigger be depressed for the duration of the braze cycle of approximately 2 seconds, after which the fuse wire should rupture, disconnecting the circuit. The arc will extinguish and the pin or stud will be shot forward into the molten filler.

In the event of a fuse not rupturing after the normal time, the gun must be withdrawn completely from the work keeping the trigger depressed.

After the fuse has ruptured, the gun must be held in place for a further 3 seconds to allow the braze to set, then remove the gun by pulling straight off in line with the pin. Break out the ferrule if this has remained in the gun only by levering against a suitable edge, beware, it may be hot. Holding the gun in a vertical position, depress the ejector button and expel the remaining fuse wire into your hand so as to ensure it has been ejected.

Threaded pin attachments should be tested by a torque device. For an M8 pin the torque device should be set to 10 Nm, the threads will fail at 25 Nm so do not use excessive force.

To test the Direct Braze pin attachments, the shank of the plain pin must be carefully broken off with a hammer taking care not to damage the lug. This must be done before another pin braze is made to the bond. After breaking off the shank the broken surface should be level or thereabouts with the outer surface of the lug (Fig. 1). The lug shall be complete in all aspects.

If the surface of the broken pin is proud of the surface of the lug this is an indication that the brazing time was too short. This result however is considered normal when using standard cable lugs part number 273 100 9000 and 273 100 7360 and in this case figure 2 would be acceptable due to thickness of copper material at braze area. Height of remaining brass shank should however not exceed 2mm and the braze time would not be altered. The reason for a short braze time is usually the result of excessive current being drawn due to the gun "lift height" being incorrect. This short time can also be caused by a poor earth connection. If the surface of the broken pin is below the surface of the lug, this is an indication that the brazing time was too long (Fig. 3). The reason for a long braze time is the result of insufficient current being drawn. Insufficient current is usually the result of a poor battery condition. If it is known that the battery is good then the cause may again be incorrect setting of the gun "lift height". In cases where the copper lug becomes burned the cause is usually due to coming into partial contact with the arc. If the ferrule not being held flush against the copper lug then the arc will escape and damage the lug.

If an unsuitable connection is made then it can be removed using a flat cold chisel, repeated bond attempts must not be made at the same position as this may cause structural or metallurgical damage to the base steel.

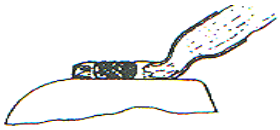


Fig.1

Fig.2

Fig.3

Some common problems can be experienced by operators when first using the equipment. Listed below are a series of faults together with the most likely cause and effective solutions. In the event of persistent problems or faults, contact the Service Engineer for advice or repair.

PROBLEM	CAUSE	REMEDY
No arc	Circuit not complete	Check fuse wire on pin is engaged
	Batteries flat	Check earth lead is connected Charge/replace batteries
Arc time too short(Fig.2)	Excessive current drawn Poor earth connection	Check setting of gun. Improve earth connection
Arc time too long(Fig. 3)	Insufficient current drawn	Check setting of gun Charge up batteries
Bond falls off when tested	Too short brazing time Base metal not clean	See above Clean area to be brazed properly
Fuse wire stuck in contact nipple	Pin loose in holder Failure to eject previous fuse wire	Tighten fit of pin.Replace contact nipple (see manual)

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MAINTENANCE

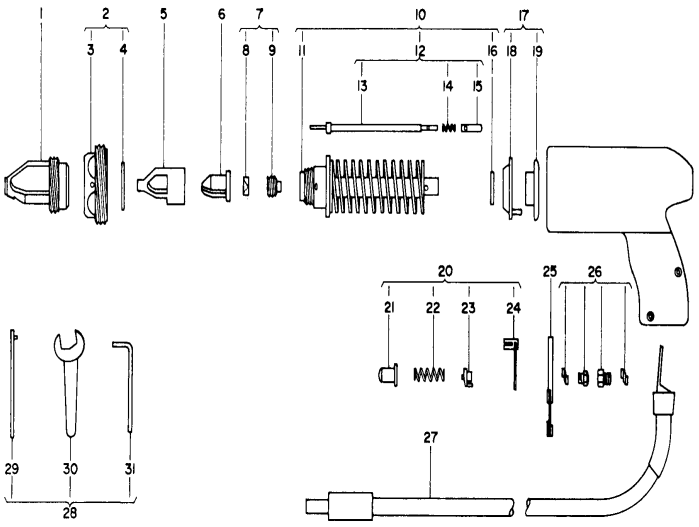
When the equipment is in use, time must be allowed during a working period to carry out the necessary checks and servicing required. Carrying out these procedures will prevent time wasted on site, when work is aborted due to faulty equipment. Time and personnel must also be allocated to the general servicing of equipment on a routine basis. If the servicing procedures set out in this paper have been correctly carried out and a problem still exists contact the Technical Service Engineer at BAC Corrosion Control Limited. If it is necessary to return the equipment for repair, ensure that the complete pin brazing set including all ancillary equipment is despatched to permit full functional testing.

Servicing, maintenance and repair should always be carried out by trained personnel, Should difficulties persist then the complete unit must be sent directly back to the manufacturers at the address below for examination and/or repair.

Important note

Parts that are damaged or defective in any way should be replaced. Experience has shown that it is uneconomical to replace single parts. The package system operated is designed to replace complete sets of parts to ensure effective repair and reliable operation.

The numbers in brackets in the text refer to the figure below



Centre piece (10) removal

Unscrew the ferrule holder (1) and the front piece (3). Extract the centre piece by holding the base of the pin holder (5) securely in a vice and applying a sharp pull to the gun body. Blow clean with compressed air. Do not lubricate any part of the gun or centre piece

Dismantling the centre piece (10)

Unscrew the pin holder (5) and remove the spark shield (6) and washer (8).

Check that the setting piece is unbroken and the spring is in good condition, especially the surface in contact with the conductor ring (18).

Push in the ejector rod (12). Check that it moves freely and that the ejector pin protrudes out of the contact nipple (9). If defective, replace as follows.

Dismantling the ejector rod (12)

Turn the ejector button (15) to bring the locking pin in line with the holes in the setting piece.

Rest the brass core of the centrepiece on a support.

Drive out the locking pin with a 1.8mm punch.

Remove the ejector button (15) and withdraw the ejector spring (14).

Unscrew the contact nipple (9) using the peg spanner (29) and discard.

Remove the ejector rod (13).

Ejector rod re-assembly

Insert a new ejector rod (13) into the centre piece (11).

Slide a new spring (14) and ejector button (15) over the end of the ejector rod.

Turn the ejector button and ejector rod until the holes are aligned and also aligned with the holes in the setting piece.

Rest the brass core of the centrepiece on a support and tap in the locking pin.

Screw in a new contact nipple (9) with the peg spanner (29). Do not grip the centrepiece by the spring when tightening. The nipple should be a tight fit and screwed down fully. The nipple should be flush or no more than 0.2mm below the front face.

Never re-use a contact nipple.

Centre piece re-assembly

Check that the brazing pin is a tight fit in the pin holder (5).

Adjust the legs if necessary.

Fit the washer (8) into the spark shield so the concave side faces to the front of the gun.

Align the grooves in the spark shield with the legs of the pin holder.

Hold the centrepiece vertical and screw the pin holder on from below.

Check that the brazing pin is still a tight fit in the pin holder.

If not, the legs of the holder are probably not aligned with the grooves in the spark shield.

Check that the remanence washer (16) is in place around the brass core of the centrepiece.

Inspection of the contacts (26), contact arm (25) and flexible conductor (24).

Visual inspection

Remove the gun handle cover screws using the allen key (31).

Inspect the contacts (26) for signs of damage. If necessary replace as below.

Clean the interior of the handle with compressed air.

Inspect the gun cable (27) for signs of damage to the insulation or the connections.

Inspect the contact arm (25).

There must be no damage to the tufnol strip or the leaf spring.

Inspect the flexible conductor (24). The copper braid must not be frayed.

Dismantling the contact set (26)

Unscrew the flat contact with the spanner (30) and remove the gun cable (27).

Unscrew the other contact.

Dispose of both contacts.

Dismantling the contact arm (25)

Remove the two screws retaining the contact arm (25) to the handle of the gun.

Check the trigger assembly (20). The trigger spring (22) should be 29.5mm +/-0.5mm long and must not be adjusted. In case of damage, replace the entire assembly (20) as follows.

Dismantling the trigger assembly (20) and flexible conductor (24).

Insert a thin screwdriver between the flexible conductor (24) and the UPVC insulation at the upper part of the handle. Ease the flexible conductor rearwards until it is released.

Let the conductor ring (18) and the insulating ring (19) slide out of the gun housing. Check both are clean and undamaged.

Trigger set re-assembly (20)

Obtain a tube with an OD of 46mm, an ID of 43mm and a length of approx. 115mm. Fit the flexible conductor (24) into the handle. Press a wedge between the conductor bracket and the inside rear surface of the gun to secure the conductor firmly.

Make a mark on the conductor ring (18) indicating the position of the pin.

Insert the conductor ring (18) and insulating ring into the gun barrel.

With the aid of the mark, align the pin with the flexible conductor bracket.

Using the tube, push the conductor ring so that the pin engages fully with the flexible conductor bracket.

Measure the distance from the conductor ring to the step at the base of the threads at the front of the gun barrel. This dimension should be 68.5mm, +/-0.5mm.

Remove the wedge and check that the flexible conductor is still in position.

Fit a new trigger button (21), new trigger spring (22) and new spring bracket (23).

Contact arm (25) re-assembly

Check the length of the short screw. Insert this screw into the upper hole.

The screw should project a minimum of 2mm and a max. of 2.4mm.

Fit the contact arm into the groove in the tufnol insulation at the top of the handle next to the flexible conductor and in front of the moving tufnol ring in the rear of the gun barrel.

Secure the contact arm with both screws.

Ensure that the spring bracket (23) is located correctly in the contact arm.

Contact set (26) re-assembly

Screw the domed contact into the spring bracket (23). Ensure that the spring washer is located correctly in the groove in the contact.

Place the flat contact through the hole in the gun cable lug (27) and offer both up to the location.

Do not over tighten the contacts.

Centre piece (10) refitting

Insert the fully assembled centre piece into the gun and push firmly.

Check the fit by pushing in all the way, the setting piece should protrude by 1.5mm at the rear of the gun or 2mm with heavy duty/electronic equipment.

The centrepiece should move freely against the spring.

Clean the brass core with fine emery paper if not. Do not lubricate.

Check that the locking ring (4) in the front piece (3) is undamaged.

Screw the front piece into the gun.

Check the ferrule holder is undamaged and screw into the front piece.

Check that the locking ring (4) provides enough friction to the ferrule holder to prevent easy movement.

Final inspection

Insert a brazing pin into the gun and press the pin so that the centrepiece is fully depressed. Place a thin piece of paper between the contacts (26) and press the trigger. This should produce a click as the contact arm (25) flicks over. Release the trigger. The contacts should remain closed and the paper gripped firmly. Ease off the pressure on the gun and allow the centrepiece to slide forward slowly. The contacts will open with a click. Refit the handle cover.

Should any of the above not occur please refer to the list below.

Contact arm moves over when centrepiece is depressed without pressure on the trigger.

Worn or damaged leaf spring. Replace contact arm (25)

Defective trigger spring (22). Replace spring.

Contacts remain closed after pressure is released from centrepiece.

Misaligned contact arm (25). Check position of tufnol strip relative to slot in upper part of handle.

Check contact arm is engaged correctly with moving tufnol part in gun barrel.

Top contact arm retaining screw too long. Check and replace.

Service schedule

Daily

Check the cable (27) to the battery unit is undamaged.

Check that the pin and ferrule holders are undamaged and hold the brazing pin and ferrule securely.

Weekly

Check and clean the contacts (26) using emery cloth.

Every 2500 brazes

Conduct a full service as described in this manual. Do not strip down the ejector mechanism unless required.

ANALISYS

Some specifications for pin brazed joints used to connect cathodic protection cables to pipelines include a requirement for pre-qualification, metallographical measurement testing of fusion line depth, microhardness and copper penetration on cross sections of the finished joint.

When working with steel pipelines, in accordance with BS4515:1996, the fusion line of the braze should not be more than 1mm below the pipe surface. Intergranular copper penetration of the pipe material should not exceed 0.5mm beyond the fusion line when a micro-section is examined at a magnification not exceeding x 50. When conducting a hardness survey, each section should be tested as described in BS 427 using a 10KG load. Traverse should be made across the weld zone and should consist of at least 6 impressions; two in the heat affected zone (HAZ) each side of the braze and one in the parent metal each side of the braze.

Although various test reports have been produced into the metallurgical effects of pin brazing, several by BAC Corrosion Control Ltd and also by independent bodies Such as Bodycoat Materials Testing Ltd. Companies involved in the use of pin brazing products generally perform their own independent test reports to satisfy the individual specifications set within their own standards.

Typically, the maximum permitted hardness is 300 or 350 HV[10][1]. This section discusses two possible reasons for setting a maximum hardness, and their applicability to the operating conditions on CP cables.

IMPLICATIONS OF HIGH MICROHARDNESS IN PIN BRAZED JOINTS USED FOR ATTACHMENT OF CATHODIC PROTECTION CABLES

Sulphide Stress Cracking [SSC]

SSC occurs in sour environments, i.e. those containing hydrogen sulphide in sufficient concentration and at sufficient pressure in the presence of water. It is a complex phenomenon, requiring interaction between a number of factors, one of which is the metallurgical condition of the materials exposed to the sour condition. It is not appropriate here to go fully into all aspects of mitigation of SSC, other than to comment that control of hardness of pipeline steels is important. NACE International, in their material requirement MR0175[2], specify a maximum hardness in both the bulk material, and in welds, of 22 HRC[3]. This is approximately equivalent to 260 HV[10]. The requirement can also extend to bolting materials in flanged joints if exposure to H2S may be expected.These requirements are often also applied to sweet fluids [no H2S], as a precaution to allow for the future development of sour conditions due to changes in reservoir chemistry.

Hydrogen Embrittlement [HE]

Hydrogen embrittlement can occur in some materials by the conjoint action of:

inappropriate metallurgical condition

sufficient stress, and

a source of hydrogen, such as cathodic protection.

Again a full description of the phenomenon is not attempted here, other than to comment that all three need to act together for failure to occur. As part of the strategy to minimise the risk of HE, Det Norske Veritas [DNV] recommend[4] that hardnesses in bulk materials and welds should not exceed 350 HV[10].

Relevance to Pin Brazed Connections

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[1] Vickers Hardness: 10 kg load

[2] MR0175 2002 'Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment'

[3] Rockwell 'C' Hardness

[4] DNV Recommended Practice RP B401, 'Cathodic Protection Design'

In general, the control of hardness to mitigate SSC caused by internal fluids is not relevant to pin brazed CP cable joints external to the pipe, although it could be argued to be a consideration if H2S exposure is expected outside the line.

HE due to CP is acknowledged as a possible problem, and might be thought to require hardness control of any external welding or brazing in conformation with DNV.

However, for both cases it can reasonably be argued that such hardness control is unnecessary.

Firstly, as stated earlier, the welded joint must be stressed for failure to occur. If correct installation procedures are carried out, in particular by securing the cable by looping round the pipe at a location away from the connection point, the brazed joint will not be under stress. Secondly, as well as repairing any local damage to the pipe coating, it is good practice to fully encapsulate the location of the pin brazed joint with mastic or epoxy. This excludes the local environment and removes any possibility of HE, or indeed SSC. Finally, the very limited extent of the fusion zone in a pin brazed joint means that even if failure occurs the integrity of the pipe is not compromised.

The above does not preclude the need to exercise a degree of control over the pin brazing operation. High joint hardness could still imply a brittle joint, but this should be readily detected by the standard hammer test required on all such cable joints.

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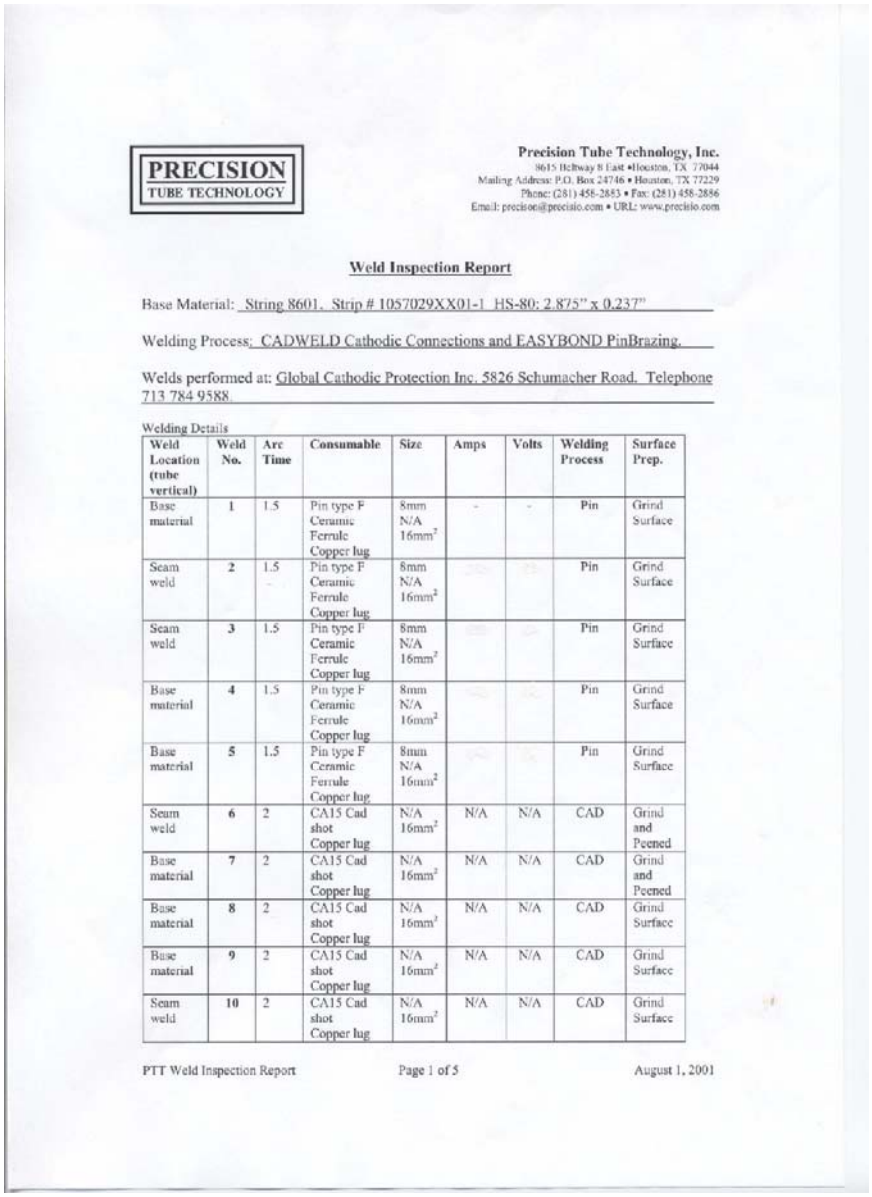
REPORTS

The following is a typical example of a standard test report which was independently conducted by a customer wishing not only to investigate the structural effects of pin brazing. But to also conduct a comparative study into an already approved bonding method, in this case cadwelding



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Weld Inspection Report

Base Material: String 8601, Strip # 1057029XX01-1 HS-80: 2.875" x 0.237"

Welding Process: CADWELD Cathodic Connections and EASYBOND PinBrazing.

Welds performed at: Global Cathodic Protection Inc. 5826 Schumacher Road. Telephone 713 784 9588.

Welding Details

Weld Location (tube vertical)	Weld No.	Arc Time	Consumable	Size	Amps	Volts	Welding Process	Surface Prep.
Base material	1	1.5	Pin type F Ceramic Ferrule Copper lug	8mm N/A 16mm²	-	-	Pin	Grind Surface
Seam weld	2	1.5	Pin type F Ceramic Ferrule Copper lug	8mm N/A 16mm²			Pin	Grind Surface
Seam weld	3	1.5	Pin type F Ceramic Ferrule Copper lug	8mm N/A 16mm²			Pin	Grind Surface
Base material	4	1.5	Pin type F Ceramic Ferrule Copper lug	8mm N/A 16mm²			Pin	Grind Surface
Base material	5	1.5	Pin type F Ceramic Ferrule Copper lug	8mm N/A 16mm²			Pin	Grind Surface
Seam weld	6	2	CA15 Cad shot Copper lug	N/A 16mm²	N/A	N/A	CAD	Grind and Peened
Base material	7	2	CA15 Cad shot Copper lug	N/A 16mm²	N/A	N/A	CAD	Grind and Peened
Base material	8	2	CA15 Cad shot Copper lug	N/A 16mm²	N/A	N/A	CAD	Grind Surface
Base material	9	2	CA15 Cad shot Copper lug	N/A 16mm²	N/A	N/A	CAD	Grind Surface
Seam weld	10	2	CA15 Cad shot Copper lug	N/A 16mm²	N/A	N/A	CAD	Grind Surface

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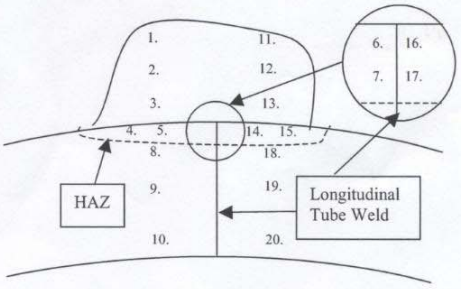
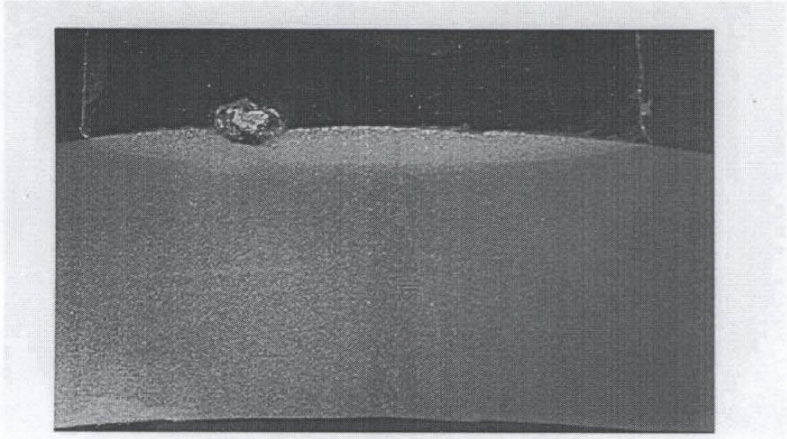
Sample #6 Cad weld located over the longitudinal weld.

CAD weld hardnesses: HV5 CAD weld located over Longitudinal Weld.				
CAD	1.	87.7	11.	81.0
CAD	2.	88.1	12.	86.1
CAD	3.	86.9	13.	88.3
HAZ	4.	266	14.	296
HAZ	5.	302	15.	304
HAZ	6.	302	16.	307
HAZ	7.	271	17.	261
BASE	8.	197	18.	209
BASE	9.	224	19.	237
BASE	10.	217	20.	217





Sample 6 Cad Weld centered over the Longitudinal Weld. Magnification is approximately 9.5X on the original photomicrograph but may be distorted during electronic formatting. Base material is 0.237" nominal and the HAZ (lighter colored area at interface) is approximately 0.031". Note the large dip on the left, and slight dip on the right interface; these are believed to be a result of the peening process and are not due to melting of the surface. The Longitudinal weld is located just right of center and may be identified by the light areas at the center of the tube wall bending upwards to a point. The center of the point is the center of the longitudinal weld.

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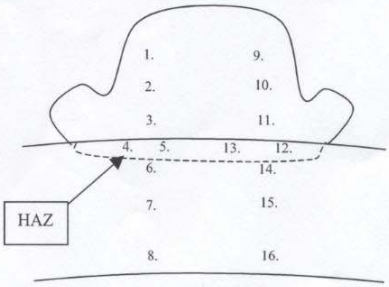
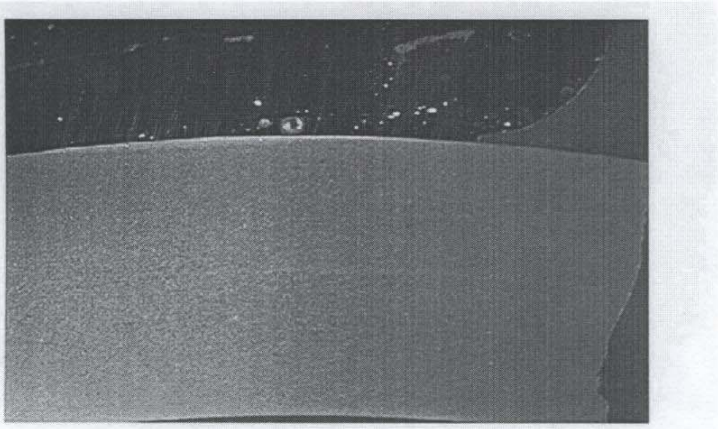
Sample #1 EASYBOND Pin Weld on the base material

Pin Brazing Hardnesses: HV5 PIN located over base material.				
PIN	1.	122	9.	137
PIN	2.	111	10.	121
PIN	3.	121	11.	117
HAZ	4.	274	12.	309
HAZ	5.	307	13.	318
BASE	6.	204	14.	205
BASE	7.	198	15.	204
BASE	8.	214	16.	226





Sample #1 EASYBOND Pin Weld on the base material. Magnification is approximately 9.5X on the original photomicrograph but may be distorted during electronic formatting. Base material is 0.237" nominal and the HAZ (lighter colored area at interface) is essentially negligible. The edge of the pin braze may be seen in the upper right hand corner where the red bakelite meets the curved copper pin

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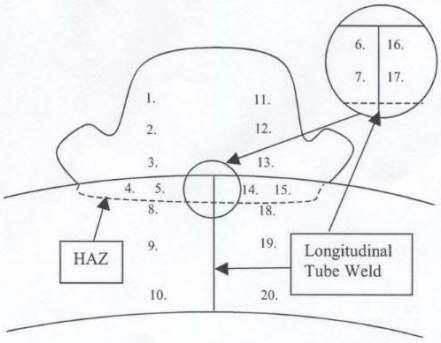
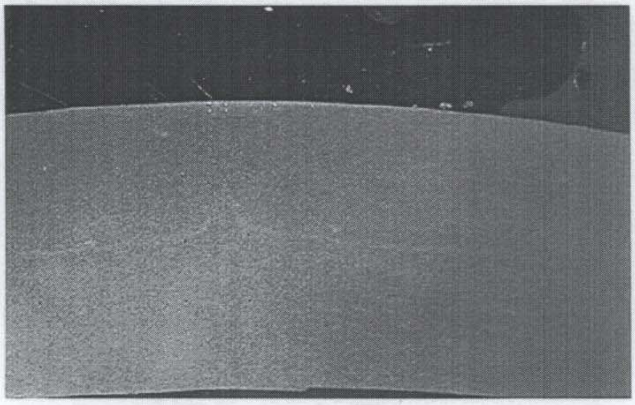
Sample #2 EASYBOND Pin Weld centered over the longitudinal weld.

Pin Brazing weld hardnesses: HV5 PIN weld located over Longitudinal Weld				
PIN	1.	139	11.	112
PIN	2.	112	12.	114
PIN	3.	115	13.	113
HAZ	4.	244	14.	238
HAZ	5.	296	15.	330
HAZ	6.	362	16.	338
HAZ	7.	300	17.	300
BASE	8.	188	18.	209
BASE	9.	199	19.	203
BASE	10.	201	20.	197





Sample #2 EASYBOND Pin Weld centered over the longitudinal weld. Magnification is approximately 9.5X on the original photomicrograph but may be distorted during electronic formatting. Base material is 0.237" nominal and the HAZ (lighter colored area at interface) is essentially negligible. The Longitudinal weld is located just left of center and may be identified by the light areas at the center of the tube wall bending upwards to a point. The center of the point is the center of the longitudinal weld. The edge of the pin braze may be seen in the upper right hand corner where the red bakelite meets the curved copper pin weld.