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Title:	Procedure for Stud welding
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1.0 SCOPE

This procedure describes stud welding performed as part of the production and/or installation of a FSM Corrosion Monitoring System. The procedure shall ensure that the stud-welds are performed correctly giving sound welds for the measuring points (M3 studs) and current excitation points (M6 studs).

Stud welding is considered to be a special process, ref. NS ISO-9001.

The welding as described is defined as *capacitor discharge stud welding with tip ignition* in the standard ISO 14555, Welding – Arc stud welding of metallic materials.

2.0 RESPONSIBILITY

The responsibility for execution of all works concerning stud welding for FSM belongs to Force Technology Canada Ltd.

Force Technology Canada Ltd. will keep complete record of qualification/test-forms related to procedures in use. These documents will be part of the total "As built" documentation.

3.0 SAFETY

All personnel involved in stud welding shall be trained and qualified to perform the operations described in this procedure.

Record from such qualification and Force Technology Canada Ltd shall maintain training.

For safety for the operators reference is made to HES procedure HMS-B-02 see /4/

4.0 STUD-WELDING WITH HEMATIC KES 1600 & CD 1500

4.1 Purpose

The purpose of this procedure is to secure that the equipment for stud welding (Hematic KES 1600 & CD 1500) is used in such a way that a good weld is achieved between the bolt and the base material.

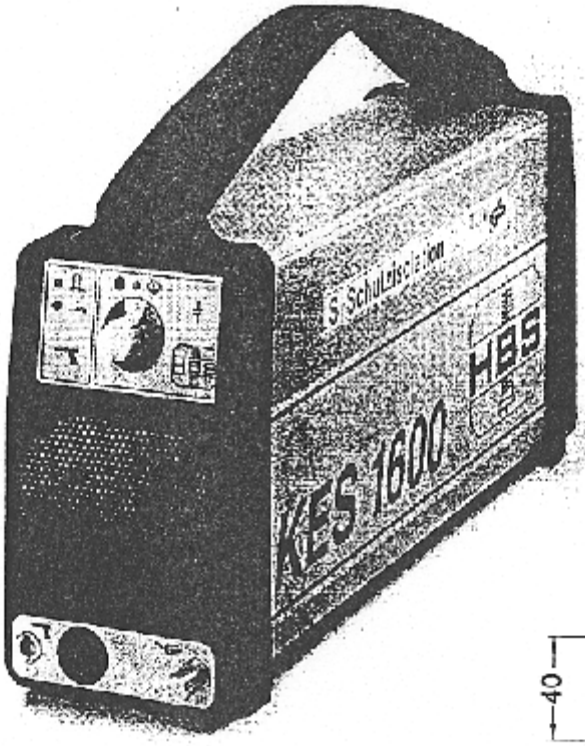
4.2 Validity

This procedure is valid for all personnel using the stud welder Hematic KES 1600 & CD 1500 for welding where this procedure is specified.

4.3 Equipment and Consumables

- Hematic Bolzensweisse Systeme (HBS) KES 1600 (Fig. 1) or CD 1500 shall always be used.
- Welding Gun HBS PMK-20 (Fig. 2) shall always be used.
- For welding on curved surfaces (i.e. on pipes) the positioning tube PPR2 (Fig. 3) shall always be used.
- On carbon steel base material St 37.3 bolts shall always be used
- On high temperature base material (>140^{O}C) where studs of 1.4301 also can be used.
- On Cr-Ni Steel base material 1.4301 bolts shall always be used.

Figure 1



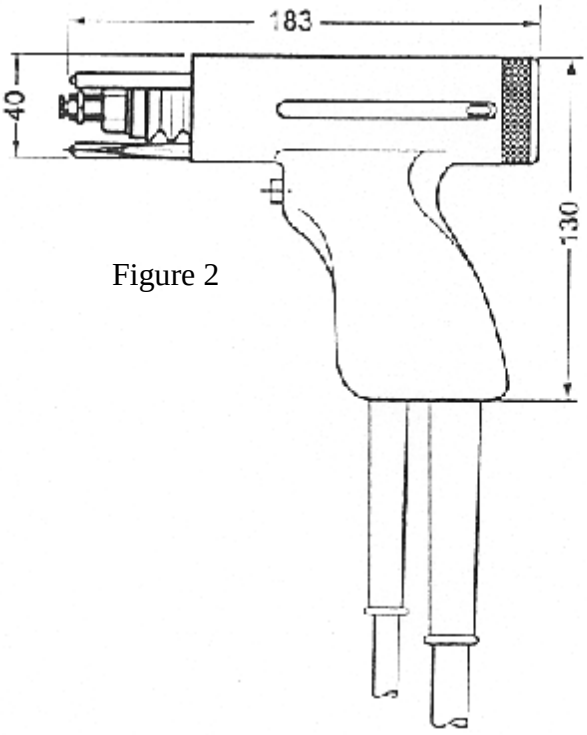


Figure 2

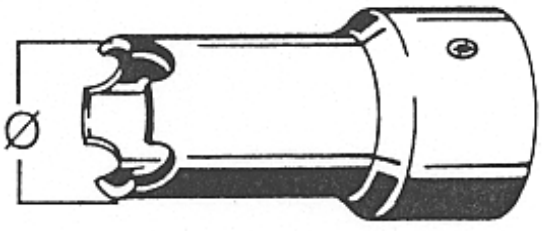


Figure 3

4.3.1 Marking

Mark all points for stud-positions by a punch mark.

Note that stud-welding must not be done directly in punch marks, but approx. 5 mm offset on same side for all stud-welds. This corresponds to locating the edge of the positioning tube PPR2 (fig. 3), on the punch mark.

4.3.2 Surface Preparation

Clean location to be welded on by abrasive wheel, using fiber rondel until the surface is completely free of rust, painting, grease or other contaminations.

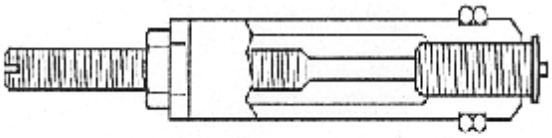
To ensure a good weld when welding on curved surfaces such as small pipe diameters (typical less than 10") the surface must be flattened by grinding.

The use of abrasive wheel shall be held to a minimum in order to minimize loss of base material. Good cleaning is essential in order to achieve a good weld.

4.3.3 Equipment Preparations

- Place the stud welding equipment near the working place.
- Connect both clip tongs symmetrically around the position on the base material to be welded on. (Paint etc. must be removed to secure a good electrical connection). If necessary stud weld one or two studs for connection of clip tongs.
- Choose the appropriate bolt holder for M3 or M6 bolt depending on what size of stud is to be welded.
- For bolts with maximum length of 20mm, position the impact pin of the bolt holder with its threads away from the stud. For bolts with length exceeding 20mm, position the impact pin with its threads towards the stud. See Fig. 4
- Adjust the impact pin of the bolt holder with a bolt inserted to a distance of 50mm from outside of nut to outside of bolt flange as shown in fig. 5.
- Fix the bolt holder in the Welding Gun.
- When welding on curved surfaces, always use the Positioning Tube PPR2 (Fig. 3) mounted to the Welding Gun.

- For studs up to ¾" (20mm) in length, the non-threaded part is seated in the chuck:



- For studs longer than 3/4" (20 mm) in length the non-threaded portion projects from the chuck:

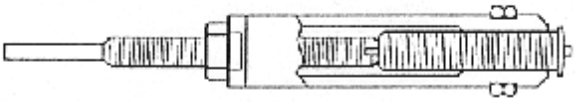


Figure 4

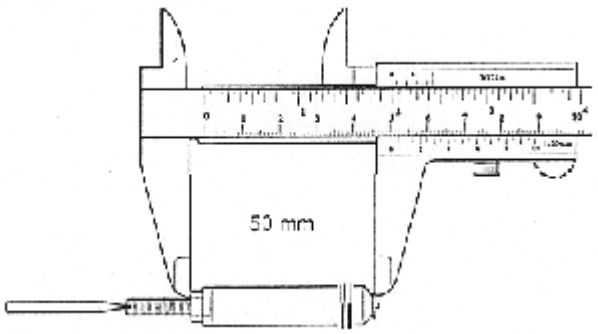


Figure 5

4.3.4 Adjustment spring pressure of Weld Gun PMK 20

Set spring pressure for both M3 & M6 bolt to 3. See fig. 6.

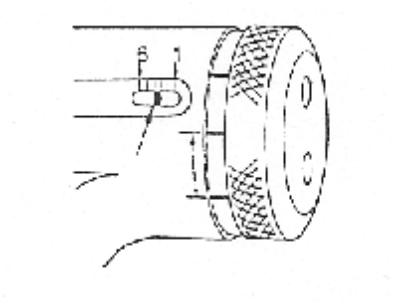


Figure 6

4.3.5 Energy Level Adjustment Hematic KES 1600 and CD 1500

- Switch on the power of the apparatus and adjust the charging voltage with the energy switch (Scale from 1-11). Use the normative values below.
- All adjustments and testing is to be done on a test-section of similar pipe material as the base material of the FSM-system
- Final adjusted value for the charging-voltage is to be included in the test-form in paragraph 4.7.

Normative settings:	KES 1600	CD 1500
for M3 stud in St. 37.3	: 2-3 (Energy level)	3 (Energy Level)
for M6 stud in St. 37.3	: 6-7 (Energy level)	6-7 (Energy Level)
for M3 stud in 1.4301	: 1,5 (Energy level)	3 (Energy Level)
for M6 stud in 1.4301	: 4,5 (Energy level)	6 (Energy Level)

When welding on high temperature base material (> 140 degr. C) These values shall be increased by 1.

4.4 Test welding

Weld three M3 studs and three M6 studs to the test piece of identical material to the material you will be welding on 5mm offset from punch marks.

M3:

- Visually inspect the welds.
- Test the M3 studs on the test-section by bending them approx 30 degrees in 4 directions repeatedly until the studs break off.

M6:

- Visually inspect the welds.
- Proceed to test the M6 studs by impact strokes to approx. 30 degrees in 4 directions repeatedly until the stud breaks off.

4.4.1 Acceptance Criteria

Acceptance criteria for the three M3 test stud-welds on the test-section:

- The welds shall look similar to weld in fig. 7.
- The studs shall not separate from the base material during bending but break in the bottom section of the bolt.

Acceptance criteria for the three M6 test stud-welds on the test-section:

- The welds shall look similar to the photograph in fig. 7.
- The studs shall not separate from the base material during impact strokes but break in the bottom section of the bolt.

If one or more of the acceptance criteria are not met, repeat the following steps until sound welds are achieved for both M3 and M6 studs.

1. Check that the equipment is used as previously specified.
2. Check that the Bolt holder is correctly assembled and adjusted as previously specified.
3. Check that the positioning tube has been used to ensure a perpendicular weld on a curved surface, if applicable
4. Check that the Spring setting is as previously specified.
5. Repeat the cleaning operation, if needed.
6. If all above items are correct, adjust the charging voltage by one notch up or down depending on whether the voltage is suspected to be too low or too high. See next paragraph for indications of voltage based on Visual inspection of the weld.
7. Commence from the start of this paragraph (4.4).
8. Check that ground is connected on both sides of the area where you are going to weld.

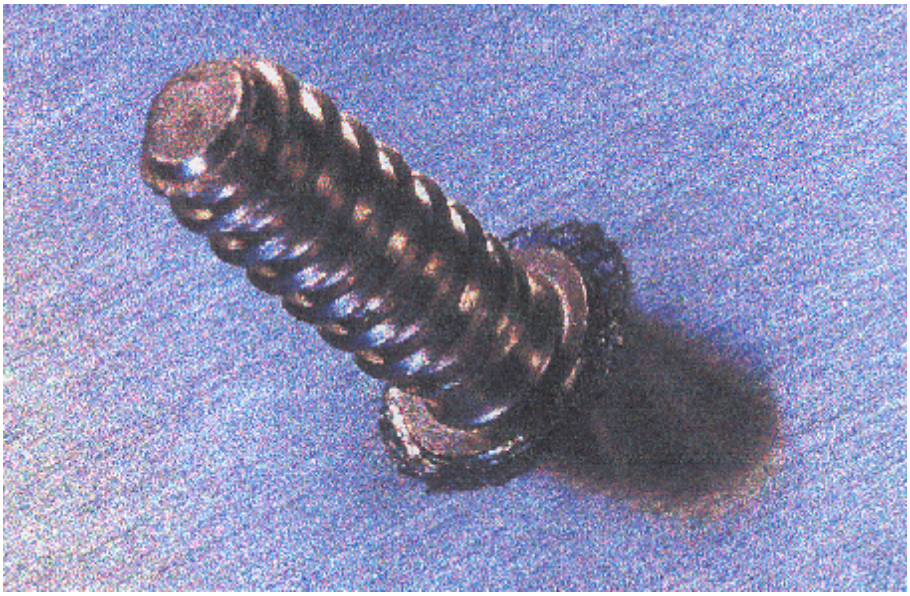


Figure 7

4.4.2 Visual Inspection

A visual inspection gives a good indication of what is wrong if the bolt does not pass the test. Some common reasons for faults are as follows:

If the weld is good, the flange is completely welded all around. Weld sputter from the weld-bath can be seen just outside the flange.

Too cold weld-bath: The flange has not full contact. None or very little weld-sputter is visible outside the bolt.
Reason: Too low charging voltage or too low spring pressure.

Too hot weld-bath: the flange is heavily melted down and most of the weld bath is outside the flange.
Reason: Too high charging voltage or too little high spring pressure

See fig. 7 for picture of a successful stud-weld, which can be used for guidance.

4.5 Welding on FSM Spool

When sound welds have been achieved in testing, welding on the FSM can commence.

- Make sure all adjustments and equipment assembly are as previously described.
- Place the welding gun perpendicular. Use positioning tube PPR if welding on curved surfaces.
- Offset gun 5mm (to same direction for all positions) from punch marking.
- Perform welding.
- Lift the welding gun perpendicular from the base material after bolts has been welded to avoid damage to the bolt holder.

4.6 Inspection and testing on FSM Spool

4.6.1 M3 stud-welds

- Visually inspect all M3 stud-welds as described in section 4.4.1 and 4.4.2.
- Test all M3 studs by bending approx 30 deg. in 2 directions.
- On high temp. Application (>140^{O}C) test by bending 1 direction only.

4.6.2 M6 stud-welds

- Visually inspect all M6 stud-welds as described in section 4.4.1 and 4.4.2.
- Test all M6 studs by (use a nut to protect the threads) light impact strokes without bending them.

4.6.3 Acceptance criteria:

The stud shall not fall off or separate from the base material during impact or bend test. If acceptance criteria are not met, repeat procedure from chapter 4.4.

4.6.4 Qualification/Test Record

The enclosed qualification/test form shall always be filled in when welding with new bolts or welding to other/new base materials and when welding to the same base material is interrupted.

4.6.5 Coating of Welds. N/A on high temp applications (>140^{O}C).

After all the studs M3 & M6 have been successfully stud-welded and matrix connected, apply a thin layer of primer covering the bolt and the cleaned surface for each measuring point. This must be completed no later than four (4) hours after the last stud weld

4.7 Qualification/test-form

QUALIFICATION/TEST-FORM STUDWELDING WITH HEMATIC KES 1600 / CD 1500 & PMK-20	
PROJECT TITLE:	
PROJECT NO.:	DATE:
BASE MATERIAL TYPE:	
CHARGE NO.:	
BOLT DIMENSION:	BOLT MATERIAL:
SPOOL NO.:	
CLEANING OF BASE MATERIAL:	
BOLT HOLDER ADJUSTMENT:	mm
SPRING PRESSURE SETTING :	
LOCATION OF CLIP-TONGS: (sketch below)	
ENERGY LEVEL:	
VISUAL CHECK:	

QUALIFICATION/TEST-FORM STUDWELDING WITH HEMATIC KES 1600 & PMK-20	
BENDING TEST/IMPACT TEST:	
NUMBER OF BOLTS CHECKED:	
NUMBER OF BOLTS PASSED TEST:	
NUMBER OF BOLTS NOT PASSED TEST:	
PIN NUMBERS WELDED (ONLY FOR 3 mm BOLTS):	
PERFORMED BY:_____	DATE/SIGN_____
VERIFIED AND ACCEPTED BY:_____	DATE/SIGN: _____

5.0 REFERENCES

For specifications and performed tests regarding Stud welding of base-material reference is made to:

/1/ ISO standard 14555 Welding -Arc Stud welding of Metallic Materials

/2/ User manual for Hematic KES 1600 / CD 1500 and Weld Gun PMK-20

/3/ Material Certificate according to DIN 50049 3.1B for:

(Shall be filled in and verified before document is filed as a Project Document)

Spool No.: _____

Line pipe no._____

Heat no._____

/4/ Procedure for personnel safety, HMS-B-01

6.0 ATTACHMENTS

Qualification/test-forms needed are included in the procedure.

For a detailed description of positioning of the FSM measuring pins on the line pipe section see project drawing no.: _____