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**HTR-M**

**European Project for the development of HTR Technology -  
Materials for the HTR**

**CONTRACT N°**  
**FIKI-CT-2000-00032**

**Modified 9Cr-1Mo Steel**  
**Manufacturing of welded joints**

by

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Framatome-ANP

Dissemination level : CO  
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Commercial-in-Confidence

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## REVISION

| REV. | DATE | PARAG. | PAGE | APPENDIX | SCOPE OF THE REVISION       |
|------|------|--------|------|----------|-----------------------------|
| A    |      |        |      |          | First issue of the document |
|      |      |        |      |          |                             |

## SUMMARY

Within the scope of the HTR-Project, some welded joints were produced by Narrow Gap TIG welding.

The first seam was performed for welding test and mechanical characterization by FRAMATOME-ANP, the second one is the contractual seam intended for tensile testing, creep testing and instrumented impact testing performed before and after irradiation testing.

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## 1. **FOREWORD**

Within the scope of the HTR-Project, some welded joints were produced by Narrow Gap GTAW automatic process.

The first seam was performed for welding test and mechanical characterization by FRAMATOME-ANP, the second one is the contractual seam intended for tensile testing, creep testing and instrumented impact testing performed before and after irradiation testing.

## 2. **MATERIALS**

### 2.1. **Base Material**

The coupons were taken from a 150mm thick plate manufactured by MARREL (INDUSTEEL)

Heat Number 88295 - plate Number 88295-1

The following heat treatments were performed :

- Austenitization 1070°C, then water quenching.
- Tempering 765°C-6h45

The acceptance tests of the plate were carried out after Austenitization + tempering and after the following Stress Relieving heat treatment 750°C-15h.

The APPENDIX 1 gives the chemical analysis and the mechanical properties of the plate.

### 2.2. **Filler metal**

KOBE wire – product name TGS-9CB – diameter of wire 12mm.

Lot EZ00773.

The chemical analysis is given hereafter.

| C    | Mn   | P     | S     | Si   | Ni   | Cr   | Mo   | Nb   | V    | N <sub>2</sub> | Cu   |
|------|------|-------|-------|------|------|------|------|------|------|----------------|------|
| 0.08 | 1.00 | 0.004 | 0.005 | 0.18 | 0.71 | 9.03 | 0.90 | 0.04 | 0.18 | 0.0189         | 0.17 |

## 3. **WELDING**

Both welded joints are performed in the same conditions.

MC/TS 1973 Seam is intended for welding test and mechanical characterization

TFCW 2056 seam is the contractual seam.

### 3.1. Chamfer

The APPENDIX 2 shows the chamfer used.

### 3.2. Welding parameters

- GTAW Process
- Narrow gap ( 2 passes/layer )
- Welding position PA/1G (flat)
- Pulsed current
- Average welding current 200A
- Arc voltage 12V
- Travel Speed 13cm/mn
- Heat Input 11KJ/cm
- Shielding gas He-Ar.

### 3.3. Heat parameters

- Preheating 150-200°C
- Interpass temperature  $\leq 200^{\circ}\text{C}$
- Post heating 300-350°C / 2 h

## 4. NON-DESTRUCTIVE EXAMINATIONS

### 4.1. Liquid penetrant testing

Specifications COPS LA/NXX 0300 revision B and COPS LA/NXX 0302 revision B.

- MC/TS1973 seam → no defect
- TFCW 2056 seam → no defect

### 4.2. Radiographic testing

Specifications CORSRU/NGV 0100 revision B and CORSRU/NGV 0105 revision C.

- MC/TS1973 seam → no defect
- TFCW 2056 seam → no defect

#### 4.3. Ultrasonic testing

Specifications COUSRU/NGV 0200 revision A and COUSRU/NGV 0208 revision A.

- MC/TS1973 seam → no defect
- TFCW 2056 seam → no defect

### 5. METALLURGICAL CHARACTERIZATION

The characterization was performed on the MCTS 1973 seam after Stress Relieving heat treatment.

#### 5.1. Heat treatment

The stress relieving heat treatment applied is given below:

- Heating rate :  $\leq 25^{\circ}\text{C} / \text{h}$  (from  $300^{\circ}\text{C}$ )
- Holding time :  $760 \pm 5^{\circ}\text{C} - 10 \text{ h } 30$
- Cooling rate :  $\leq 25^{\circ}\text{C} / \text{h}$  (down to  $300^{\circ}\text{C}$ )

#### 5.2. Chemical composition

The table below shows the chemical composition of the weld.

| C     | Mn    | P      | S     | Si    | Ni             | Cr             |
|-------|-------|--------|-------|-------|----------------|----------------|
| 0.072 | 0.922 | 0.0067 | 0.005 | 0.18  | 0.71           | 8.94           |
| Mo    | Nb    | V      | Cu    | Al    | N <sub>2</sub> | O <sub>2</sub> |
| 0.913 | 0.045 | 0.199  | 0.145 | 0.007 | 0.020          | 0.0011         |

#### 5.3. Tensile properties

The specimens were fully taken from the weld metal at 20mm below the outside surface (longitudinal specimens). The tests were performed at room temperature,  $450^{\circ}\text{C}$  and  $550^{\circ}\text{C}$ .

The results are given in the table below.

|                         | Test temp | Tensile Strength MPa | Yield Strength MPa | Elongation % | Reduction of area % |
|-------------------------|-----------|----------------------|--------------------|--------------|---------------------|
| <b>Requirements (1)</b> | 20° C     | 580 – 700            | ≥ 400              | ≥ 20         | Ind.                |
|                         | 550° C    | ind.                 | ≥ 260              | ind.         | Ind.                |
| <b>results</b>          | 20° C     | 669                  | 546                | 27,5         | 78                  |
|                         | 450° C    | 490                  | 416                | 18           | 79                  |
|                         | 550° C    | 393                  | 260                | 24           | 86                  |

(1) the requirements for the base material are in accordance with the RCC-MR RM2432 specification

#### 5.4. Impact test

AFNOR Charpy V notch specimens were taken at ~ ½ T location. The notch was normal to the surface and on the weld centreline.

The tests were performed at room temperature, -20°C and +20°C.

The results are given in the table below.

The requirements for the base material are in accordance with the RCC-MR RM2432 specification

| + 20° C                | 0° C                                         | - 20° C                                     |
|------------------------|----------------------------------------------|---------------------------------------------|
| single value<br>≥ 72 J | Average value. ≥ 58 J<br>single value ≥ 40 J | Average value. ≥ 40 J<br>single value ≥ 28J |

| + 20° C              |                      |            | 0° C                 |                      |            | - 20° C              |                      |            |
|----------------------|----------------------|------------|----------------------|----------------------|------------|----------------------|----------------------|------------|
| Impact Energy joules | Lateral expansion mm | Shear %    | Impact Energy joules | Lateral expansion mm | Shear %    | Impact Energy joules | Lateral expansion mm | Shear %    |
| 262                  | 2,48                 | 100        | 273                  | 2,23                 | 100        | 262                  | 2,25                 | 100        |
| 268                  | 2,48                 | 100        | 276                  | 2,51                 | 100        | 264                  | 2,24                 | 100        |
| 263                  | 2,49                 | 100        | 284                  | 2,47                 | 100        | 257                  | 2,24                 | 100        |
| <b>264 (1)</b>       | <b>2,48</b>          | <b>100</b> | <b>278</b>           | <b>2,4</b>           | <b>100</b> | <b>261</b>           | <b>2,24</b>          | <b>100</b> |

(1) Average value

#### 5.5. Bend test

Three side bend test specimens, transverse direction, were taken across the thickness.

The test conditions were the following :

- Mandrel Ø40mm
- Angle 180°

The results were : no defect

## 5.6. Metallographic examination

The examinations were performed before and after the Post Welding Heat Treatment.

The Appendix 3 shows the macrography

The examinations revealed micro cracks in the weld deposit .The Appendices 4 to 7 show examples of micro cracks.

Micrographic examinations using an optical microscope are performed in As-welded condition and after Post Weld heat treatment and in various regions : basaltic zone and refined zone for the weld metal, HAZ and base material (see Appendices 8 to 11).

## 5.7. Hardness tests

Vickers hardness tests under a load of 5 kg were performed in the as-welded and PWHT conditions.

Various hardness lines are obtained parallel to the welded seam through the base material, the HAZ and the weld metal : a hardness line at 2 mm under the surface and a hardness line at mild-thickness of the seam. A third line was performed across the thickness of the weld metal (see Appendix 12).

The Appendix 12 shows a table of results, the Appendix 13 presents the hardness curve obtained.

The following table summarizes the maximum and average values obtained per area.

|                     | HAZ        | Weld metal |               |
|---------------------|------------|------------|---------------|
|                     | max. value | max. value | average value |
| As-welded condition | 376        | 396        | 342           |
| 760°C-10h           | 227        | 232        | 216           |

# 6. CONTRACTUAL SEAM - TFCW 2056

The welding conditions and the non destructive examinations are presented in paragraphs 3 and 4.

## 6.1. Heat treatment

The stress relieving heat treatment applied is given below:

|         | Requirement                                                           | Achievement                                       |
|---------|-----------------------------------------------------------------------|---------------------------------------------------|
| Heating | $\leq 25^{\circ}\text{C} / \text{h}$ (from $300^{\circ}\text{C}$ )    | $25^{\circ}\text{C/h}$                            |
| Holding | $760 \pm 5^{\circ}\text{C} - 10 \text{ h} - 0 + 30 \text{mn}$         | $761^{\circ}\text{C} - 10 \text{h} 26 \text{ mn}$ |
| Cooling | $\leq 25^{\circ}\text{C} / \text{h}$ (down to $300^{\circ}\text{C}$ ) | $24,8^{\circ}\text{C/h}$                          |

## **6.2. Cutting of the seam**

The seam was cut and six plates were taken. The Appendices 14 and 15 show the location and identification of these plates.

## **7. CONCLUSIONS**

Within the scope of the HTR-Project, some welded joints were produced by Narrow Gap TIG welding.

The first seam was performed for welding test and mechanical characterization by FRAMATOME-ANP, the second one is the contractual seam intended for tensile testing, creep testing and instrumented impact testing performed before and after irradiation testing.

## **APPENDIX 1**

## APPENDIX 1.1

|                                                                                                                                                                                                                                                                                                 |                                                                                  |                                                                                                                              |                                                                               |                                                  |                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------|
| <b>CREUSOT-LOIRE INDUSTRIE</b><br><br>Division<br><b>CREUSOT-MARREL</b><br>Usine de<br><b>CHATEAUNEUF</b>                                                                                                                                                                                       | <b>CLIENT</b> <b>FRAMATOME ST MARCEL</b><br>Customer - Kunde                     |                                                                                                                              | <b>ANALYSES CHIMIQUES</b><br><br>Chemical<br>Analysis<br>Chemische<br>Analyse |                                                  |                                        |
|                                                                                                                                                                                                                                                                                                 | <b>CDE CLIENT</b> <b>89.03182702.P.70012</b><br>Customer order - Auftrag n       |                                                                                                                              |                                                                               |                                                  |                                        |
|                                                                                                                                                                                                                                                                                                 | <b>PROJET</b><br>Project - Projekt                                               |                                                                                                                              |                                                                               |                                                  |                                        |
|                                                                                                                                                                                                                                                                                                 | <b>CDE CREUSOT-MARREL</b> <b>25 771.L.</b><br>Creusot-Marrel order               |                                                                                                                              |                                                                               |                                                  |                                        |
| <b>NUANCE steel grade - Werkstoff</b> <b>Z 10 CDV - Nb 9.1</b><br><b>SPECIFICATION</b> <b>MC / TS 88.2154 rev.0 + cde client</b><br>specification<br>spezifikation<br><b>TRAITEMENT THERMIQUE SUR TOLE</b> <b>TREMPE + REVENU</b><br>Heat treatment on plate - Wärmebehandlung Zustand am blech |                                                                                  |                                                                                                                              |                                                                               |                                                  |                                        |
| <b>COULEE N°</b> <b>88 295</b> <b>TOLE N°</b> <b>88 295.1</b> <b>REPERE</b><br>Heat n° - Schmelze nr Plate n° - Blech nr Item                                                                                                                                                                   |                                                                                  |                                                                                                                              |                                                                               |                                                  |                                        |
| <b>DIMENSIONS</b> <b>1 tôle 2270 x 3000 x 150 mm</b><br>sizes - Abmessungen                                                                                                                                                                                                                     |                                                                                  |                                                                                                                              |                                                                               |                                                  |                                        |
| <b>ANALYSE COULEE Heat analysis-Schmelze analyse</b>                                                                                                                                                                                                                                            |                                                                                  | <b>ANALYSE PRODUIT Product analysis-Stückanalyse</b>                                                                         |                                                                               |                                                  |                                        |
| %                                                                                                                                                                                                                                                                                               | IMPOSE<br>Required<br>Soll                                                       | OBTENU<br>Obtained<br>Ist                                                                                                    | IMPOSE<br>Required<br>Soll                                                    | OBTENU HAUT<br>Obtained top<br>Ist kopf - 1/2 EP | OBTENU BAS<br>Obtained btm<br>Ist fuss |
| C                                                                                                                                                                                                                                                                                               | 0.080 / 0.120                                                                    | 0.105                                                                                                                        | 0.080 / 0.120                                                                 | 0.110                                            |                                        |
| Mn                                                                                                                                                                                                                                                                                              | 0.30 / 0.50                                                                      | 0.440                                                                                                                        | 0.30 / 0.50                                                                   | 0.450                                            |                                        |
| Si                                                                                                                                                                                                                                                                                              | 0.20 / 0.50                                                                      | 0.240                                                                                                                        | 0.20 / 0.50                                                                   | 0.250                                            |                                        |
| Ni                                                                                                                                                                                                                                                                                              | ≤ 0.20                                                                           | 0.080                                                                                                                        | ≤ 0.20                                                                        | 0.085                                            |                                        |
| Cr                                                                                                                                                                                                                                                                                              | 8.00 / 9.00                                                                      | 8.410                                                                                                                        | 8.00 / 9.00                                                                   | 8.410                                            |                                        |
| Mo                                                                                                                                                                                                                                                                                              | 0.85 / 1.05                                                                      | 0.950                                                                                                                        | 0.85 / 1.05                                                                   | 0.960                                            |                                        |
| Cu                                                                                                                                                                                                                                                                                              | ≤ 0.10                                                                           | 0.035                                                                                                                        | ≤ 0.10                                                                        | 0.030                                            |                                        |
| Al                                                                                                                                                                                                                                                                                              | ≤ 0.040                                                                          | 0.013                                                                                                                        | ≤ 0.040                                                                       | 0.013                                            |                                        |
| S                                                                                                                                                                                                                                                                                               | ≤ 0.010                                                                          | 0.0016                                                                                                                       | ≤ 0.010                                                                       | 0.0014                                           |                                        |
| P                                                                                                                                                                                                                                                                                               | ≤ 0.020                                                                          | 0.008                                                                                                                        | ≤ 0.020                                                                       | 0.008                                            |                                        |
| Sn                                                                                                                                                                                                                                                                                              | INFO                                                                             | 0.004                                                                                                                        | INFO                                                                          | 0.004                                            |                                        |
| V                                                                                                                                                                                                                                                                                               | 0.18 / 0.25                                                                      | 0.250                                                                                                                        | 0.18 / 0.25                                                                   | 0.250                                            |                                        |
| Nb                                                                                                                                                                                                                                                                                              | 0.06 / 0.10                                                                      | 0.080                                                                                                                        | 0.06 / 0.10                                                                   | 0.085                                            |                                        |
| N <sub>2</sub>                                                                                                                                                                                                                                                                                  | 0.030 / 0.070                                                                    | 0.033                                                                                                                        | 0.030 / 0.070                                                                 | 0.034                                            |                                        |
| As                                                                                                                                                                                                                                                                                              | INFO                                                                             | 0.008                                                                                                                        | INFO                                                                          | 0.008                                            |                                        |
| date et résultats du contrôle Date and results of examination-Prüfdatum : <b>6.10.89</b>                                                                                                                                                                                                        |                                                                                  |                                                                                                                              |                                                                               |                                                  |                                        |
| <input checked="" type="checkbox"/> conformes à la spécification imposée<br>conforming to required specification<br>Anforderungen gemäss spezifikation                                                                                                                                          |                                                                                  | <input type="checkbox"/> non conformes-voir FA n° du<br>not conforming-see NCR n° dated<br>Unzulässige befunde-siehe QAB vom |                                                                               |                                                  |                                        |
| <b>RESULTATS VERIFIES</b><br>Results checked<br>Ergebnisse geprüft am                                                                                                                                                                                                                           | <b>CREUSOT-MARREL</b>                                                            | <b>FRAMATOME</b>                                                                                                             |                                                                               |                                                  |                                        |
| <b>24 OCT. 1989</b>                                                                                                                                                                                                                                                                             | CREUSOT LOIRE INDUSTRIE<br>Division CREUSOT-MARREL<br>Dépt. de Recette A. MILLET |                                                                                                                              |                                                                               |                                                  |                                        |

[illegible]

### APPENDIX 1.3

|                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                          |                            |  |                                                                                          |
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| <b>CREUSOT-LOIRE INDUSTRIE</b><br><br>Division<br><b>CREUSOT-MARREL</b><br>Usine de<br><b>CHATEAUNEUF</b>                                                                                                                                                                                                                                                                                                                                         | CLIENT<br>Customer - Kunde                                                                                                                                                                                               | <b>FRAMATOME ST MARCEL</b> |  | <b>TRAITEMENTS THERMIQUES</b><br><br>Heat Treatment<br><br>Wärmebehandlungsbescheinigung |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CDE CLIENT<br>Customer order - Auftrag nr                                                                                                                                                                                | <b>89.03182702.P.70012</b> |  |                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PROJET<br>Project - Projekt                                                                                                                                                                                              |                            |  |                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CDE CREUSOT-MARREL<br>Creusot-Marrel order                                                                                                                                                                               | <b>25 771.L.</b>           |  |                                                                                          |
| NUANCE steel grade - werkstoff <b>Z 10 CDV - Nb 9.1</b><br>SPECIFICATION <b>MC / TS 88.2154 rev.0 + cde client</b><br>specification<br>spezifikation<br>TRAITEMENT THERMIQUE SUR TOLE <b>TREMPE + REVENU</b><br>Heat treatment on plate - Wärmebehandlung am blech                                                                                                                                                                                |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| COULEE N° <b>88 295</b> TOLE N° <b>88 295.1</b> REPERE<br>Heat n° - Schmelze nr Plate n° - Blech nr Item                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| DIMENSIONS <b>1 tôle 2270 x 3000 x 150 mm</b><br>sizes - Abmessungen                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| <b>TRAITEMENT THERMIQUE SUR TOLE</b><br>Heat treatment on plate-                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>1070 °C Maintien (Hold time): 4 h 30</p> <p>Trempe eau par immersion<br/>(water quenching by immersion)</p> </div> <div style="text-align: center;"> <p>765 °C Maintien (Hold time): 6 h 45</p> <p>Ref. air libre<br/>(still air cooling)</p> </div> </div>                                                                                      |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| <b>TRAITEMENT THERMIQUE SUR COUPONS</b> Heat treatment on coupons                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| <div style="text-align: center;"> <p>750 °C Maintien (Hold time): 15H18</p> <p>Chauffage (heating rate) 50°C/h</p> <p>Reft. (cool. rate) 50°C/h jusqu'à (down to)</p> <p>400°C 400 °C</p> <p>Puis Ref. air libre ( then still air cooling)</p> </div>                                                                                                                                                                                             |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| date et résultats du contrôle Date and results of examination - Prüfdatum : <b>6.10.89</b>                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| <div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> conformes à la spécification imposée<br/>           conforming to required specification<br/>           Anforderung gemäß spezifikation         </div> <div> <input type="checkbox"/> non conformes-voir FA n° du<br/>           not conforming-see NCR n° dated<br/>           Unzulässige befunde-siehe QAB Nr vom         </div> </div> |                                                                                                                                                                                                                          |                            |  |                                                                                          |
| RESULTATS VERIFIES<br>Results checked<br>Ergebnisse geprüft am                                                                                                                                                                                                                                                                                                                                                                                    | CREUSOT-MARREL                                                                                                                                                                                                           | FRAMATOME                  |  |                                                                                          |
| <b>24 OCT. 1989</b>                                                                                                                                                                                                                                                                                                                                                                                                                               | <div style="border: 1px solid black; padding: 2px;">             CREUSOT LOIRE INDUSTRIE<br/>             Division CREUSOT-MARREL<br/>             Signé: <i>[Signature]</i><br/>             A. MILLET           </div> |                            |  |                                                                                          |

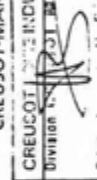
## APPENDIX 1.4

|                                                                                                                                                                                                                                                                         |                                        |                                                                                                                                                                                                                   |                                                      |                                                                                                                |                                                   |                                                |                                                               |                                                                                                                                                 |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>CREUSOT-LOIRE INDUSTRIE</b><br>Division<br><b>CREUSOT-MARREL</b><br>Usine de<br><b>CHATEAUNEUF</b>                                                                                                                                                                   |                                        | <b>CLIENT</b><br>Customer - Kunde<br><b>CDE CLIENT</b><br>Customer order - Auftrag nr<br><b>NUANCE</b><br>Steel grade - Werkstoff<br><b>Z 10 CDV - Nb 9.1</b><br><b>COULEE N°</b> 88 295<br>Heat n° - Schmelze nr |                                                      | <b>FRAMATOME ST MARCEL</b><br><b>89.03182702.P.70012</b>                                                       |                                                   | <b>CDE CREUSOT-MARREL</b><br><b>25 771.L</b>   |                                                               | <b>ESSAIS MECANIKES</b><br>Mechanical tests<br>Mechanische erprobung<br><b>RESILIANCES-PELLINI</b><br>Charpy V-drop weight-<br>Kerbschlagproben |  |
| <b>SPECIFICATION</b><br>Specification - Spezifikation<br><b>MC / TS 88.2154 rev.0 + cde client</b>                                                                                                                                                                      |                                        | <b>TOLE N°</b> 88 295 . 1<br>Plate n° - Bech nr                                                                                                                                                                   |                                                      | <b>DIMENSIONS - Sizes-Abmessungen:</b> 1 tôle 2270 x 3000 x 150 mm                                             |                                                   |                                                |                                                               |                                                                                                                                                 |  |
| <b>TRAITEMENT THERMIQUE SUR TOLE</b><br>Heat treatment on plate-Wärmebehandlung am blech                                                                                                                                                                                |                                        | <b>TREMPÉ + REVENU</b><br>Heat treatment on coupons-Wärmebehandlung des probencoupons                                                                                                                             |                                                      | <b>TRAITEMENT THERMIQUE SUR COUPONS DETENTE</b><br>Heat treatment on coupons-Wärmebehandlung des probencoupons |                                                   |                                                |                                                               |                                                                                                                                                 |  |
| <b>L = Long</b><br>Läng.                                                                                                                                                                                                                                                | <b>T = Travers</b><br>Transv. - Quer   | <b>M = 1/4 ep.</b><br>1/4th. - 1/4dicke                                                                                                                                                                           | <b>C = 1/2 ep.</b><br>1/2th. - 1/2dicke              | <b>P = peau</b><br>Surf - Haut                                                                                 | <b>PS = peau sup.</b><br>Upper surf-Haut ober     | <b>PI = peau inf.</b><br>Lower surf-Haut unter | <b>1/8 = 1/8 ext. 1/2 ep.</b><br>1/8thick-1/8dicke            | <b>M1 = sous 1/4 ep.</b><br>under 1/4 th. unter 1/4 dicke                                                                                       |  |
| <b>CONDITIONS IMPOSEES:</b> KCV 0°C $\geq 7,0 \text{ daJ / cm}^2$ moy, 5,0 mini pour 1 valeur - KCV - 20°C $\geq 5,0 \text{ daJ / cm}^2$ moy, 3,5 mini pour 1 valeur<br>Required conditions - Soll bedingungen KCV + 20°C $\geq 9,0 \text{ daJ / cm}^2$ mini individuel |                                        |                                                                                                                                                                                                                   |                                                      |                                                                                                                |                                                   |                                                |                                                               |                                                                                                                                                 |  |
| <b>REPERS</b><br>Mark<br>Prob. Kennz.                                                                                                                                                                                                                                   | <b>MACH N°</b><br>Equip n°<br>Gerät nr | <b>PRELEVEM.</b><br>Location-<br>Probenlage                                                                                                                                                                       | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat. | <b>ENERGIE DE RUPTURE</b><br>Energy-Bruchfestigkeit                                                            | <b>VALEURS RESILIENCE</b><br>Impact tests results | <b>MOYENNE</b><br>Average                      | <b>EXPANSION LATERALE</b><br>Lateral expan.-laterale breitung | <b>CRISTALLINITE</b>                                                                                                                            |  |
| <b>HAUT</b>                                                                                                                                                                                                                                                             |                                        | <b>PT</b>                                                                                                                                                                                                         | 0°C                                                  | 176-176-168                                                                                                    | 22,0-22,0-21,0                                    | 21,6                                           | 2,45-2,45-2,30                                                | 20-20-25                                                                                                                                        |  |
|                                                                                                                                                                                                                                                                         |                                        | <b>MT</b>                                                                                                                                                                                                         | 0°C                                                  | 162-171-166                                                                                                    | 20,3-21,4-20,3                                    | 20,8                                           | 2,15-2,25-2,20                                                | 35-30-20                                                                                                                                        |  |
|                                                                                                                                                                                                                                                                         |                                        | <b>PT</b>                                                                                                                                                                                                         | -20°C                                                | 170-172-161                                                                                                    | 21,3-21,5-20,1                                    | 20,9                                           | 2,40-2,35-2,15                                                | 30-30-35                                                                                                                                        |  |
|                                                                                                                                                                                                                                                                         |                                        | <b>MT</b>                                                                                                                                                                                                         | -20°C                                                | 173-103-141                                                                                                    | 17,9-12,9-17,6                                    | 16,1                                           | 2,05-1,50-2,20                                                | 45-45-50                                                                                                                                        |  |
|                                                                                                                                                                                                                                                                         |                                        | <b>PT</b>                                                                                                                                                                                                         | +20°C                                                | 220-226-221                                                                                                    | 27,5-28,3-27,6                                    | 27,8                                           | 2,40-2,50-2,55                                                | 0-0-0                                                                                                                                           |  |
|                                                                                                                                                                                                                                                                         |                                        | <b>MT</b>                                                                                                                                                                                                         | +20°C                                                | 211-212-193                                                                                                    | 26,8-26,5-24,1                                    | 25,8                                           | 2,35-2,50-2,50                                                | 0-0-0                                                                                                                                           |  |

**RESULTATS OBTENUS:**  
Results obtained

☒ Conformes à la spécification imposée  
Conforming to required specification

☐ Non conformes à la spécification imposée - voir FA N°  
Not conforming to required specification - see NCR n°

|                                                                         |                                                                                                                                                             |                  |
|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>RESULTATS VERIFIES LE</b><br>Results checked - Ergebnisse geprüft am | <b>CREUSOT-MARREL</b><br>CREUSOT INDUSTRIE<br>Division - Abteilung<br> | <b>FRAMATOME</b> |
| <b>24 OCT. 1989</b>                                                     |                                                                                                                                                             |                  |

## APPENDIX 1.5

|                                                                                                                                                                                                                                                                          |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>CREUSOT-LOIRE INDUSTRIE</b><br>Division<br><b>CREUSOT-MARREL</b><br>Usine de<br><b>CHATEAUNEUF</b>                                                                                                                                                                    |                                        | <b>CLIENT</b><br>Customer - Kunde<br><b>CDE CLIENT</b><br>Customer order - Auftrag nr<br><b>89.03182702.P.70012</b> |                                                        | <b>FRAMATOME ST MARCEL</b>                             |                                                   | <b>CDE CREUSOT-MARREL</b><br><b>25 771.L.</b> |                                                               | <b>ESSAIS MECANIKES</b><br>Mechanical tests<br><b>Mechanische erprobung</b><br><b>RESILIENCES-PELLUNI</b><br>Charpy V-dmg weight-<br>kerbschlagproben |                                                            |
| <b>NUANCE</b><br>Steel grade - Werkstoff<br><b>Z 10 CDV - Nb 9.1</b>                                                                                                                                                                                                     |                                        | <b>COULEE N°</b><br>Heat n°-Schmelze nr<br><b>88 295</b>                                                            |                                                        | <b>TOLE N°</b><br>Plate n°-Blech nr<br><b>88 295.1</b> |                                                   | <b>PROJET</b><br>Project - Projekt            |                                                               | <b>REPERE</b><br>Item                                                                                                                                 |                                                            |
| <b>SPECIFICATION</b><br>Specification - Spezifikation<br><b>MC / TS 88.2154 rev.0 + cde client</b>                                                                                                                                                                       |                                        | <b>DIMENSIONS</b><br>Sizes-Abmessungen<br><b>1 tôle 2270 x 3000 x 150 mm</b>                                        |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>TRAITEMENT THERMIQUE SUR COUPONS</b><br>Heat treatment on coupons-Wärmebehandlung des probencoupons                                                                                                                                                                   |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>TRAITEMENT THERMIQUE SUR TOLE</b><br>Heat treatment on plate-Wärmebehandlung am blech                                                                                                                                                                                 |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>L = Long</b><br>Läng.                                                                                                                                                                                                                                                 | <b>T = Travers</b><br>Transv. - Quer   | <b>J = Travers courts</b><br>Through th.-Quer kurz                                                                  | <b>M = 1/4 ep.</b><br>1/4th.-1/4dicke                  | <b>C = 1/2 ep.</b><br>1/2th.-1/2dicke                  | <b>P = peau</b><br>Surf - Haut                    | <b>PS = peau sup.</b><br>Upper surf-Haut ober | <b>PI = peau inf.</b><br>Lower surf-Haut unter                | <b>1/8 = 1/8est.</b><br>1/8thick-1/8dicke                                                                                                             | <b>M1 = solus 1/4 ep.</b><br>under 1/4 th. unter 1/4 dicke |
| <b>CONDITIONS IMPOSEES :</b> KCV 0°C $\geq 7,0 \text{ daJ / cm}^2$ moy, 5,0 mini pour 1 valeur - KCV - 20°C $\geq 5,0 \text{ daJ / cm}^2$ moy, 3,5 mini pour 1 valeur<br>Required conditions - Soll bedingungen KCV + 20°C $\geq 9,0 \text{ daJ / cm}^2$ mini individuel |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>REPERES</b><br>Mark<br>Prob. Kennz.                                                                                                                                                                                                                                   | <b>MACH N°</b><br>Equip n°<br>Gerät nr | <b>PRELEVEM.</b><br>Location-<br>Probenlage                                                                         | <b>Θ D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat. | <b>ENERGIE DE RUPTURE</b><br>Energy-Bruchfestigkeit    | <b>VALEURS RESILIENCE</b><br>Impact tests results | <b>MOYENNE</b><br>Average                     | <b>EXPANSION LATERALE</b><br>Lateral expan.-laterale breitung | <b>CRISTALLINITE</b>                                                                                                                                  |                                                            |
| <b>HAUT</b>                                                                                                                                                                                                                                                              |                                        | <b>P T</b>                                                                                                          | <b>0°C</b>                                             | <b>JOULES</b>                                          | <b>daJ / cm²</b>                                  | <b>daJ / cm²</b>                              | <b>(mm)</b>                                                   | <b>(%)</b>                                                                                                                                            |                                                            |
|                                                                                                                                                                                                                                                                          |                                        | <b>M T</b>                                                                                                          | <b>0°C</b>                                             |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
|                                                                                                                                                                                                                                                                          |                                        | <b>P T</b>                                                                                                          | <b>-20°C</b>                                           |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
|                                                                                                                                                                                                                                                                          |                                        | <b>M T</b>                                                                                                          | <b>-20°C</b>                                           |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
|                                                                                                                                                                                                                                                                          |                                        | <b>P T</b>                                                                                                          | <b>+20°C</b>                                           |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
|                                                                                                                                                                                                                                                                          |                                        | <b>M T</b>                                                                                                          | <b>+20°C</b>                                           |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>GRAIN AUSTENITIQUE (POUR INFO) = 178</b>                                                                                                                                                                                                                              |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>RESULTATS OBTENUS :</b><br>Results obtained                                                                                                                                                                                                                           |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>RESULTATS VERIFIES LE</b><br>Results checked - Ergebnisse geprüft am<br><b>24 OCT. 1989</b>                                                                                                                                                                           |                                        |                                                                                                                     |                                                        |                                                        |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |
| <b>CREUSOT-MARREL</b><br>CREUSOT LOIRE INDUSTRIE<br>Division<br>Direction<br>Date 24.10.1989                                                                                                                                                                             |                                        |                                                                                                                     |                                                        | <b>FRAMATOME</b>                                       |                                                   |                                               |                                                               |                                                                                                                                                       |                                                            |

Non conformes à la spécification imposée - voir FA N°  
Not conforming to required specification - see NCR n°

Conformes à la spécification imposée  
Conforming to required specification -

## **APPENDIX 1.6**

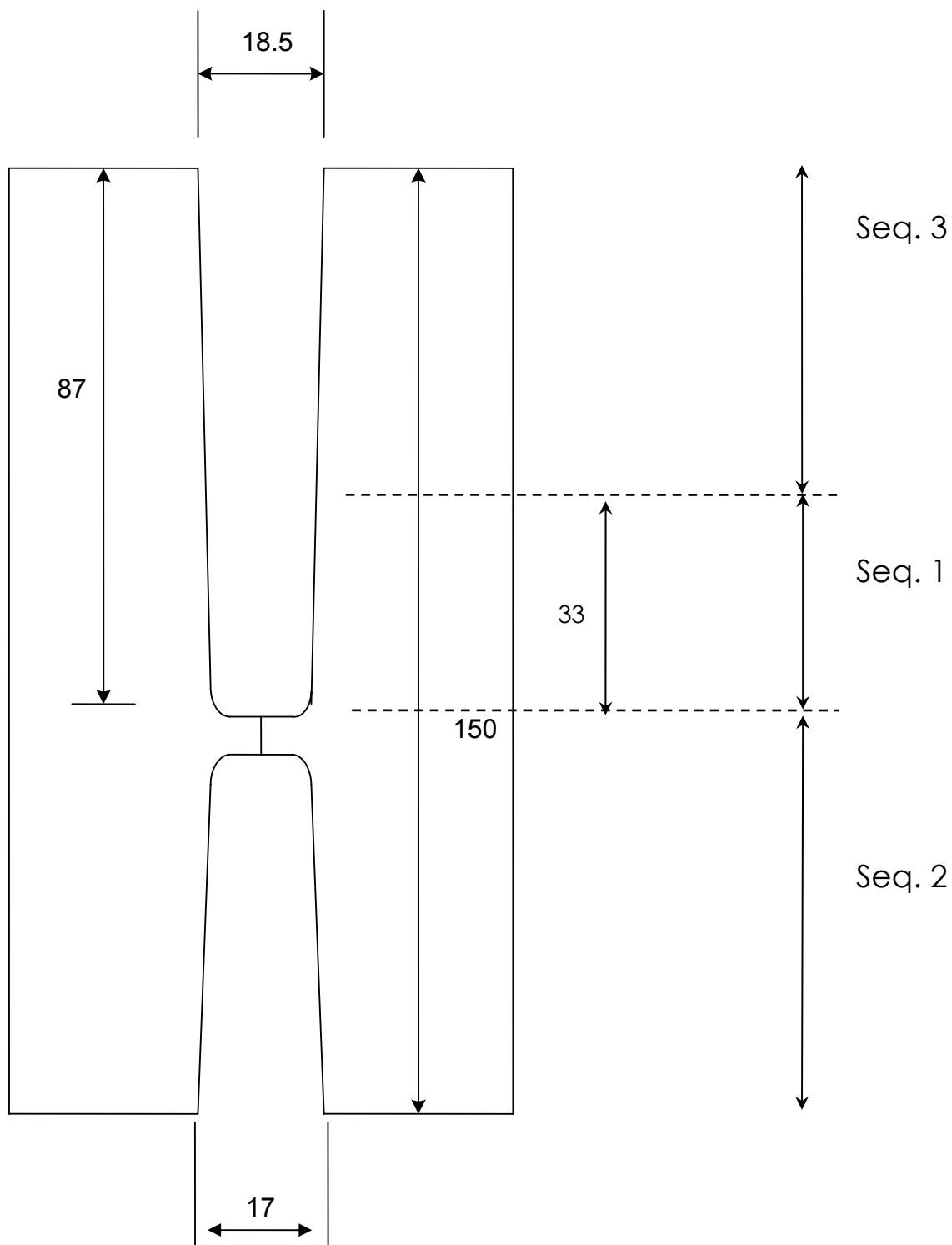
|                                                                                                                      |  |                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                    |  |                                                                      |  |                                                                                                                                                            |  |
|----------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>CREUSOT-LOIRE INDUSTRIE</b><br>Division<br><b>CREUSOT-MARREL</b><br>Usine de<br><b>CHATEAUNEUF</b>                |  | <b>CLIENT</b><br>Customer - Kunde<br><b>CREUSOT-LOIRE INDUSTRIE</b><br>Customer order - Auftrag nr<br><b>89.03182702.P.70012</b><br><b>NUANCE</b><br>Steel grade - Werkstoff<br><b>Z 10 CDV - Nb 9.1</b><br><b>COULEE N° 88 295</b><br>Heat n° - Schmelze nr<br><b>88 295.1</b> |  | <b>CDE CLIENT</b><br>Customer - Kunde<br><b>89.03182702.P.70012</b><br><b>NUANCE</b><br>Steel grade - Werkstoff<br><b>Z 10 CDV - Nb 9.1</b><br><b>COULEE N° 88 295</b><br>Heat n° - Schmelze nr<br><b>88 295.1</b> |  | <b>CDE CREUSOT-MARREL</b><br>Project - Projekt<br><b>25771.L.</b>    |  | <b>ESSAIS MECANIKES</b><br>Mechanical tests<br>Mechanische erprobung<br><b>TRACTIONS ET PLIAGES</b><br>Tensiles and bend test<br>Zugproben u. Biegeversuch |  |
| <b>SPECIFICATION</b><br>Specifications - Spezifikation<br><b>MC / TS 88.2154 rev.0 + cde client</b>                  |  | <b>TOLE N° 88 295.1</b><br>Plate n° - Blech nr<br><b>1 tôle 2270 x 3000 x 150 mm</b><br>Sizes - Abmessungen                                                                                                                                                                     |  | <b>REPÈRE</b><br>Item<br><b>1</b>                                                                                                                                                                                  |  | <b>REPERES</b><br>Mark<br><b>1</b>                                   |  | <b>ES</b>                                                                                                                                                  |  |
| <b>TRAITEMENT THERMIQUE SUR TOLE</b><br>Heat treatment on plate - Wärmebehandlung am blech<br><b>TREMPÉ + REVENU</b> |  | <b>TRAITEMENT THERMIQUE SUR COUPONS</b><br>Heat treatment on coupons - Wärmebehandlung des probencoupons<br><b>1/6 = 1/3 ext. 1/2 ép.</b><br><b>1/6 thick - 1/6 dicke</b>                                                                                                       |  | <b>1/6 = 1/3 ext. 1/2 ép.</b><br><b>1/6 thick - 1/6 dicke</b>                                                                                                                                                      |  | <b>1/6 = 1/3 ext. 1/2 ép.</b><br><b>1/6 thick - 1/6 dicke</b>        |  | <b>1/6 = 1/3 ext. 1/2 ép.</b><br><b>1/6 thick - 1/6 dicke</b>                                                                                              |  |
| <b>REPERES</b><br>Mark<br><b>HAUT</b>                                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>633</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>(5 mm sous charge) 3</b>                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>550°C</b> |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>378</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>PT</b>                                                                                  |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>PT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>amb.</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>amb. (r.t.) 580/700</b><br><b>UTS - RM</b>                                                              |  |
| <b>REPERES</b><br>Mark<br><b>HAUT</b>                                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>633</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>(5 mm sous charge) 3</b>                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>550°C</b> |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>378</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>PT</b>                                                                                  |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>PT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>amb.</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>amb. (r.t.) 580/700</b><br><b>UTS - RM</b>                                                              |  |
| <b>REPERES</b><br>Mark<br><b>HAUT</b>                                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>633</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>(5 mm sous charge) 3</b>                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>550°C</b> |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>378</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>PT</b>                                                                                  |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>PT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>amb.</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>amb. (r.t.) 580/700</b><br><b>UTS - RM</b>                                                              |  |
| <b>REPERES</b><br>Mark<br><b>HAUT</b>                                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>633</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>(5 mm sous charge) 3</b>                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>550°C</b> |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>378</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>PT</b>                                                                                  |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>PT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>amb.</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>amb. (r.t.) 580/700</b><br><b>UTS - RM</b>                                                              |  |
| <b>REPERES</b><br>Mark<br><b>HAUT</b>                                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT.</b><br>before rupture<br>durchm. vor versuch (mm)<br><b>10,0</b>                                                                                                                                    |  | <b>D'ESSAIS</b><br>Tests temperat.<br>Prüf-temperat.<br><b>amb.</b>  |  | <b>RESISTANCE (UTS)</b><br>Festigkeit<br>MPa<br><b>633</b>                                                                                                 |  |
| <b>REPERES</b><br>Mark<br><b>(5 mm sous charge) 3</b>                                                                |  | <b>PRELEVEM.</b><br>Location - Probenlage<br><b>MT</b>                                                                                                                                                                                                                          |  | <b>AVANT RUPT</b>                                                                                                                                                                                                  |  |                                                                      |  |                                                                                                                                                            |  |

## **APPENDIX 1.7**

[illegible]

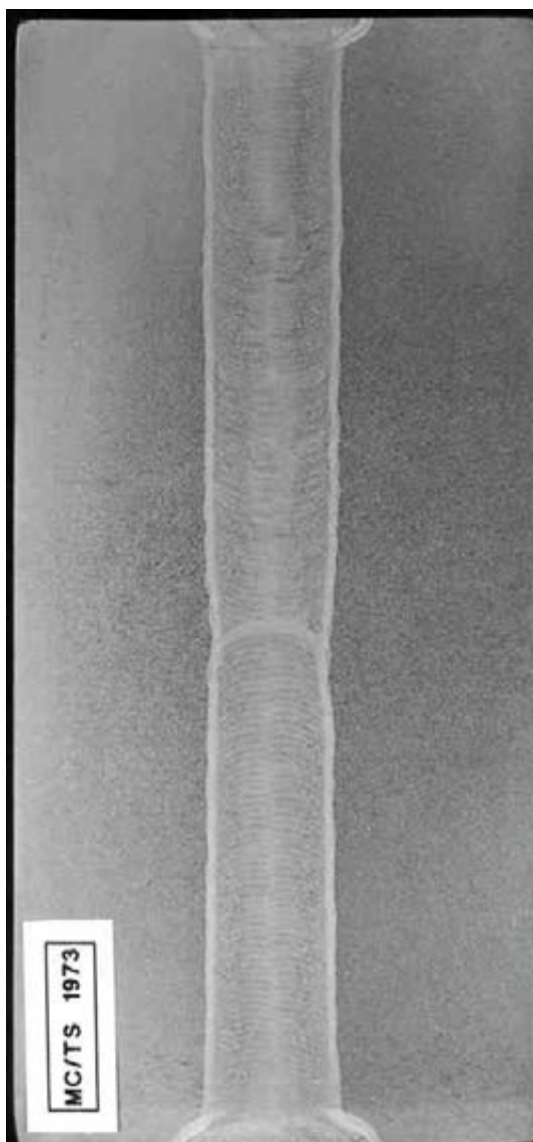
## APPENDIX 2

Chamfer shape



### **APPENDIX 3**

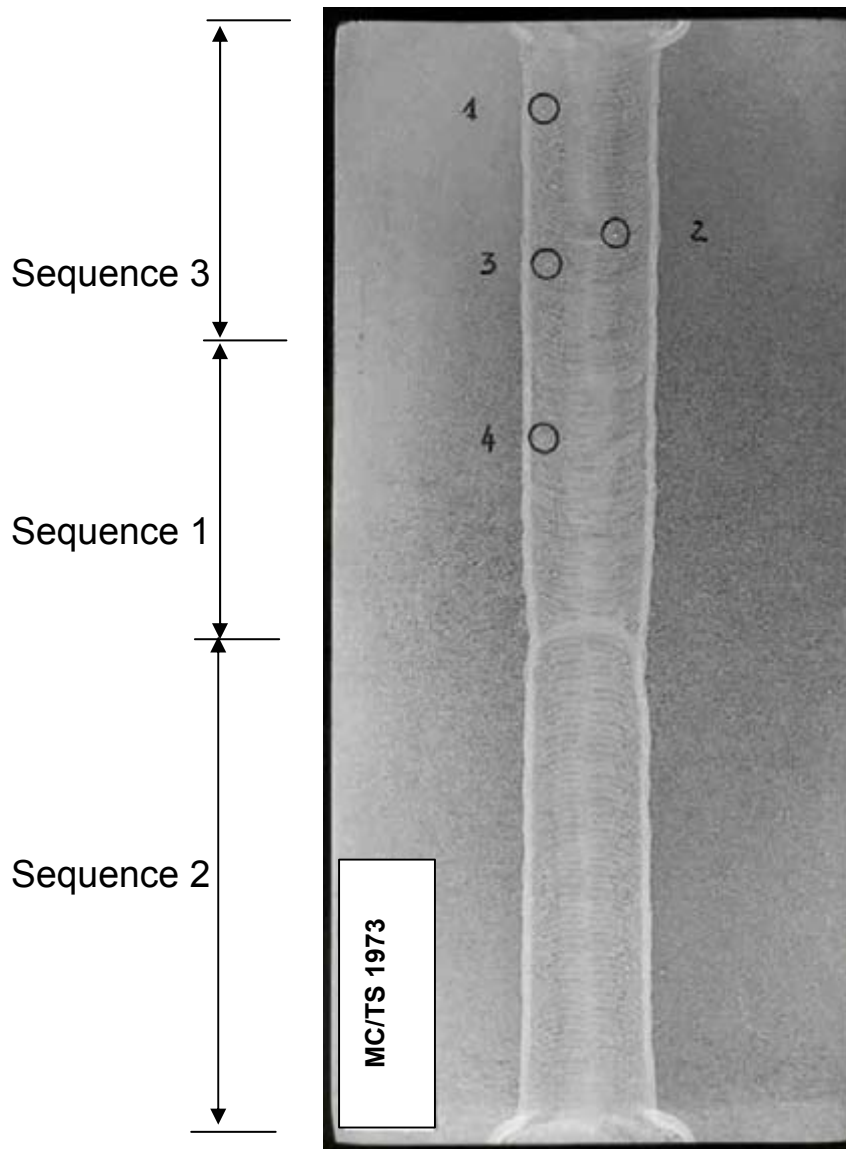
MCTS 1973 seam



## **APPENDIX 4**

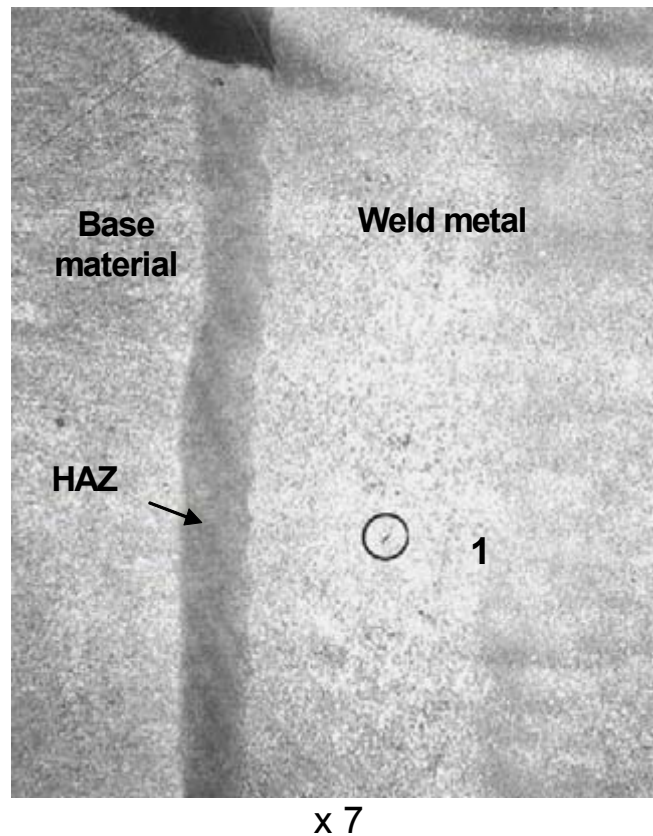
### MCTS 1973 seam

Location of the micrographic indications – cross section 2



## APPENDIX 5

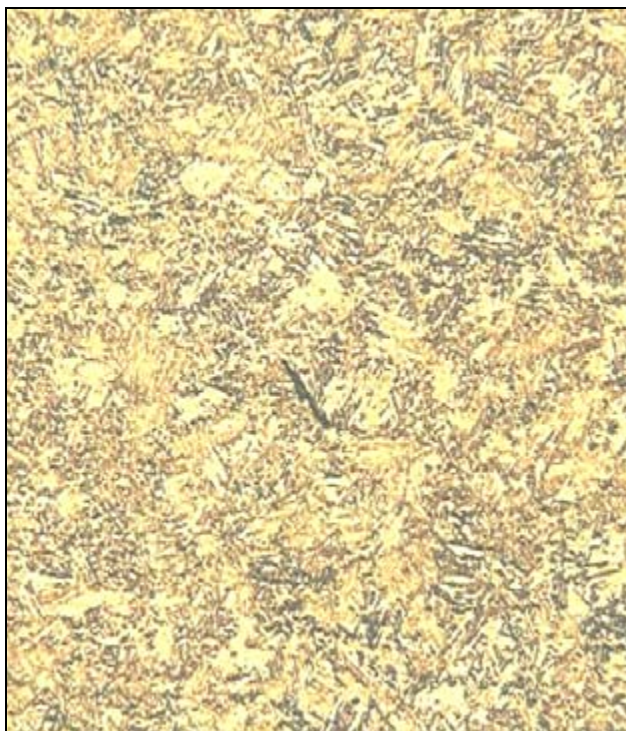
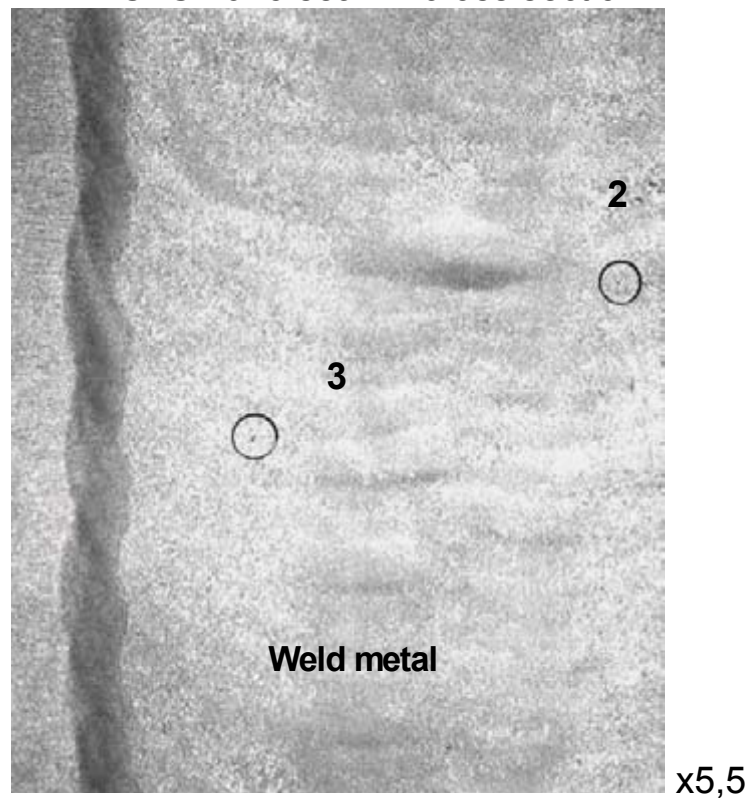
MCTS 1973 seam - cross section 2



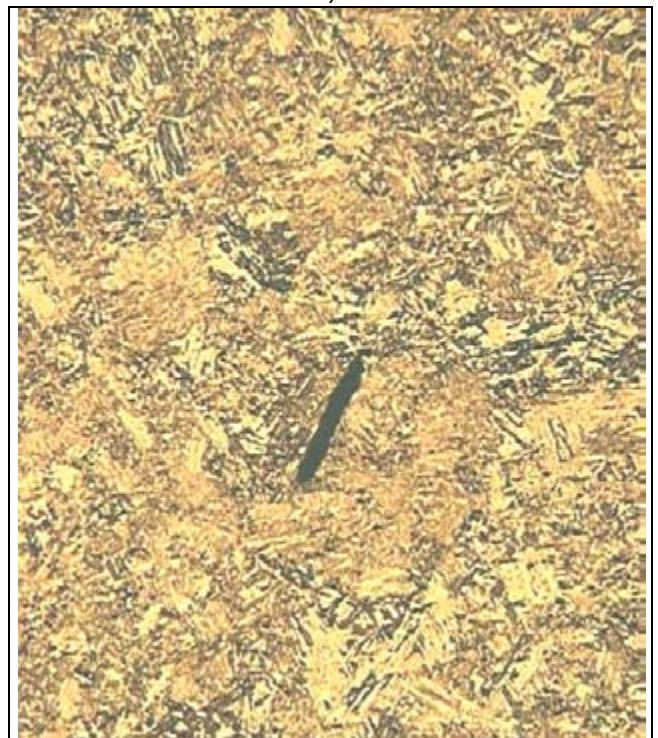
Indication n°1 length 225  $\mu\text{m}$  - x 100

## **APPENDIX 6**

MCTS 1973 seam - cross section 2



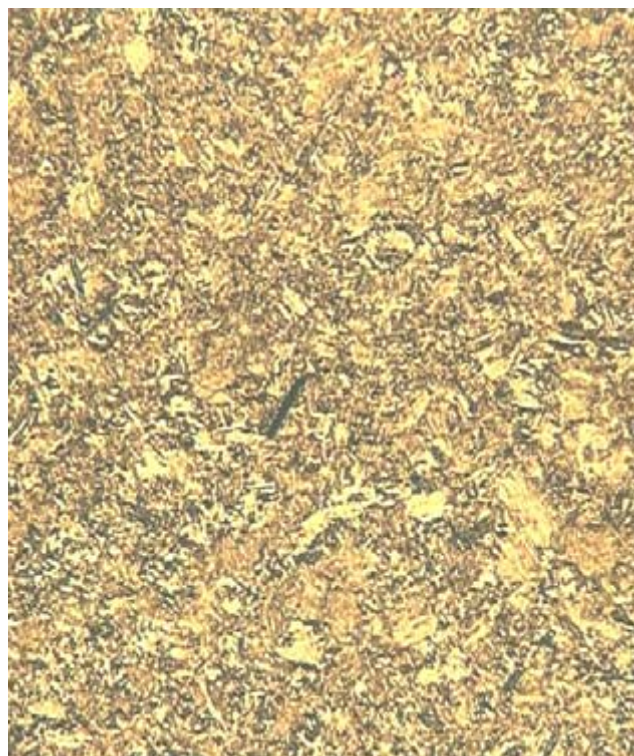
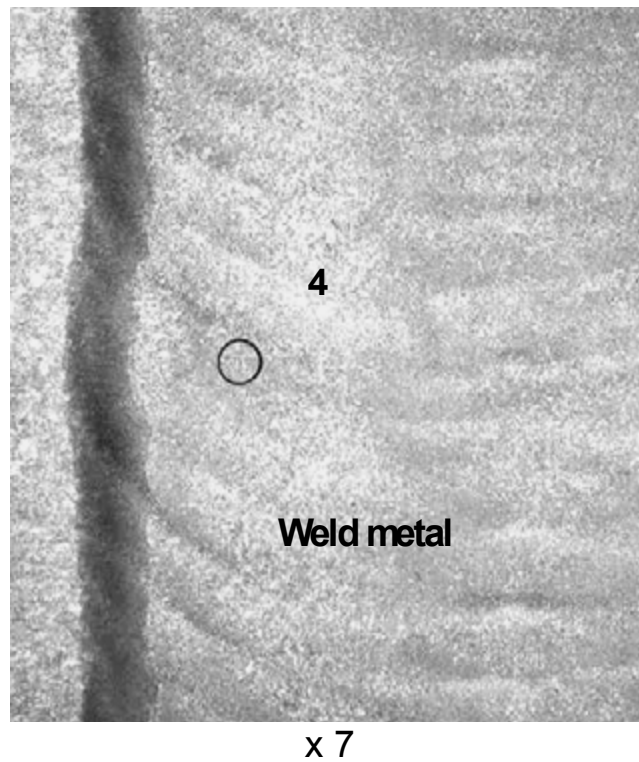
Indication n°2 - length 100µm  
x100



Indication n°3 - length 200µm x100

## **APPENDIX 7**

MCTS 1973 seam - cross section 2

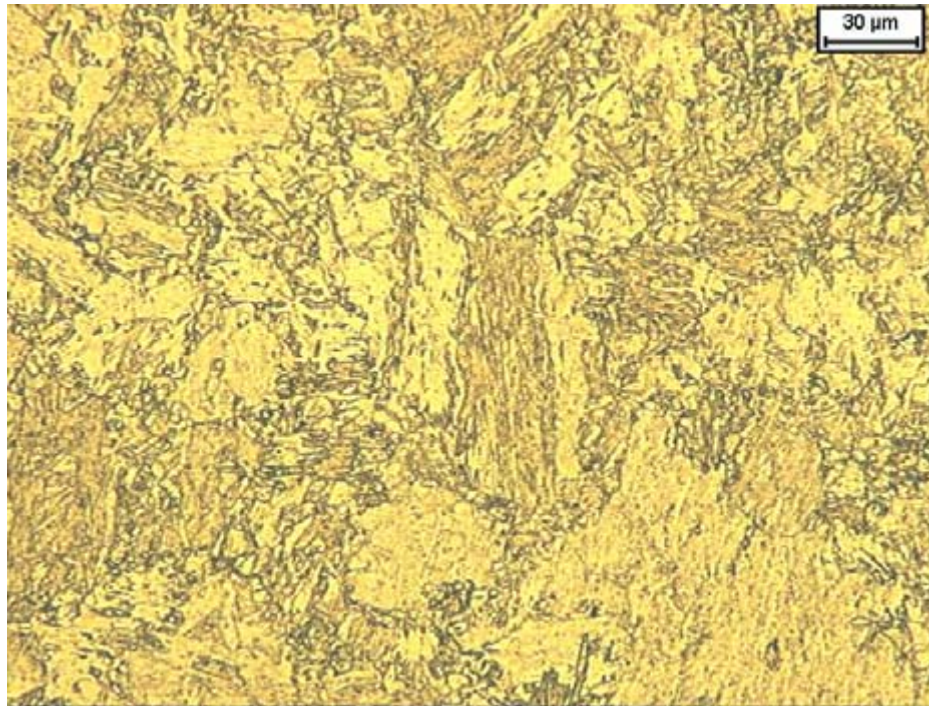


Indication n°4 length 75µm - x 100

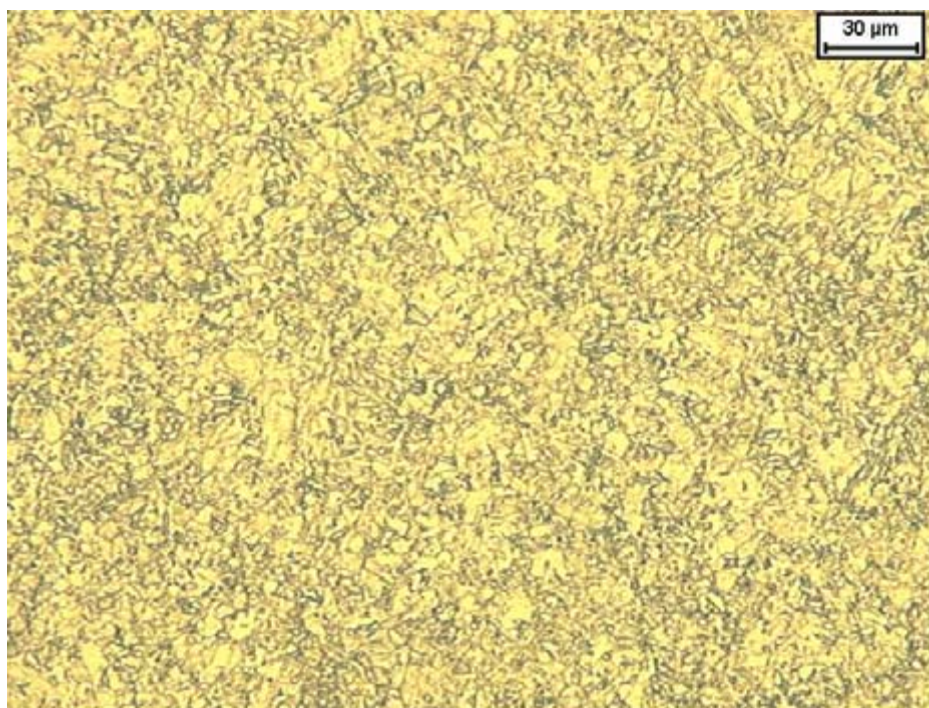
## **APPENDIX 8**

MCTS 1973 seam - cross section 1

micrographic examination- As welded condition



Weld metal - basaltic zone

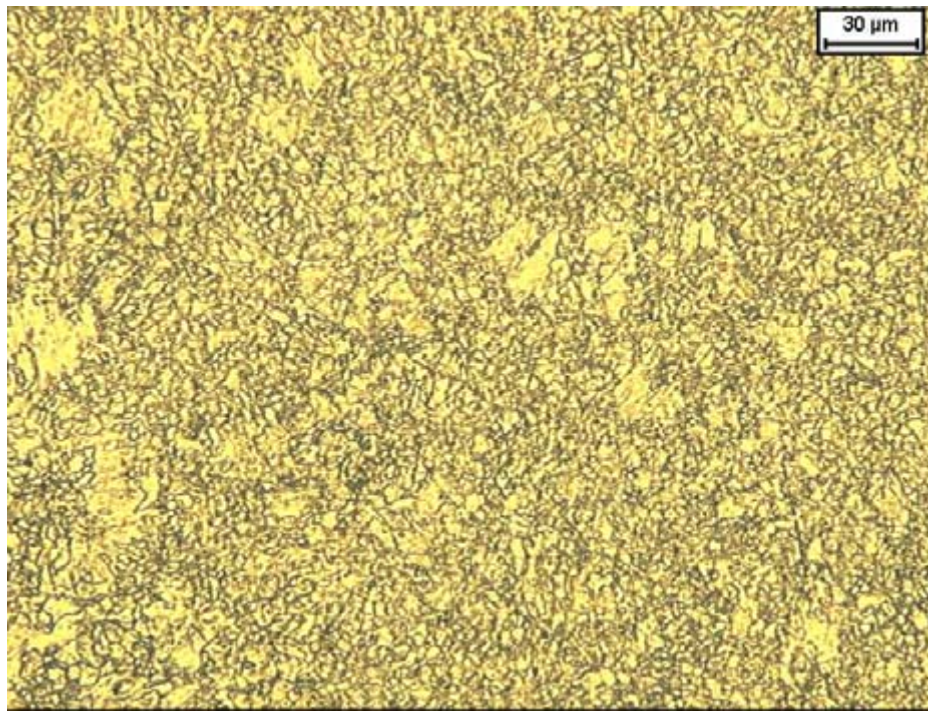


Weld metal – refined zone

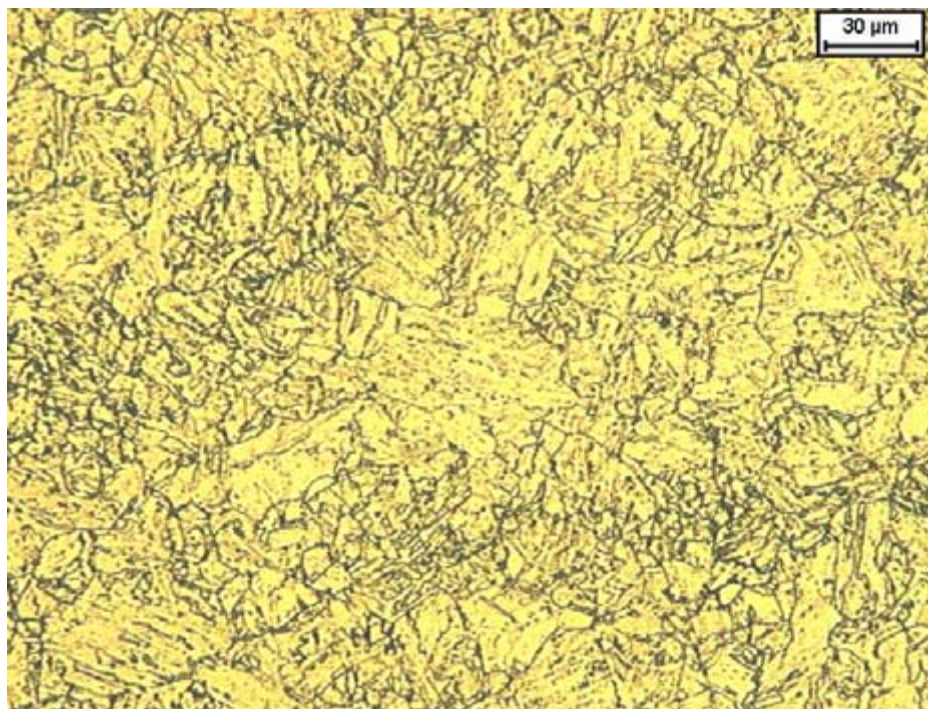
## **APPENDIX 9**

MCTS 1973 seam - cross section 1

micrographic examination- As welded condition



HAZ

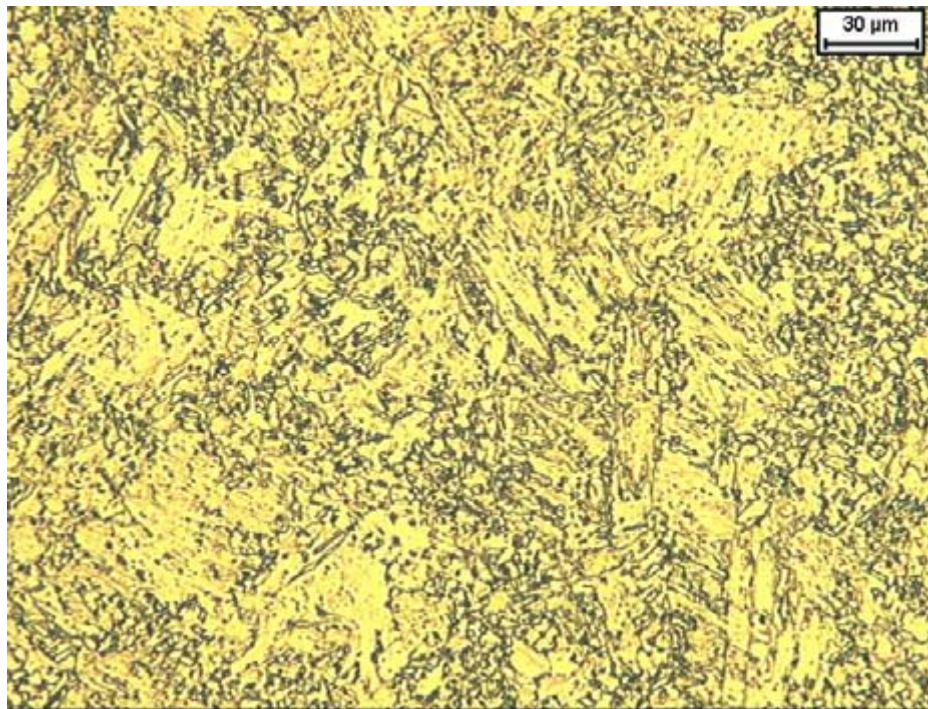


Base material

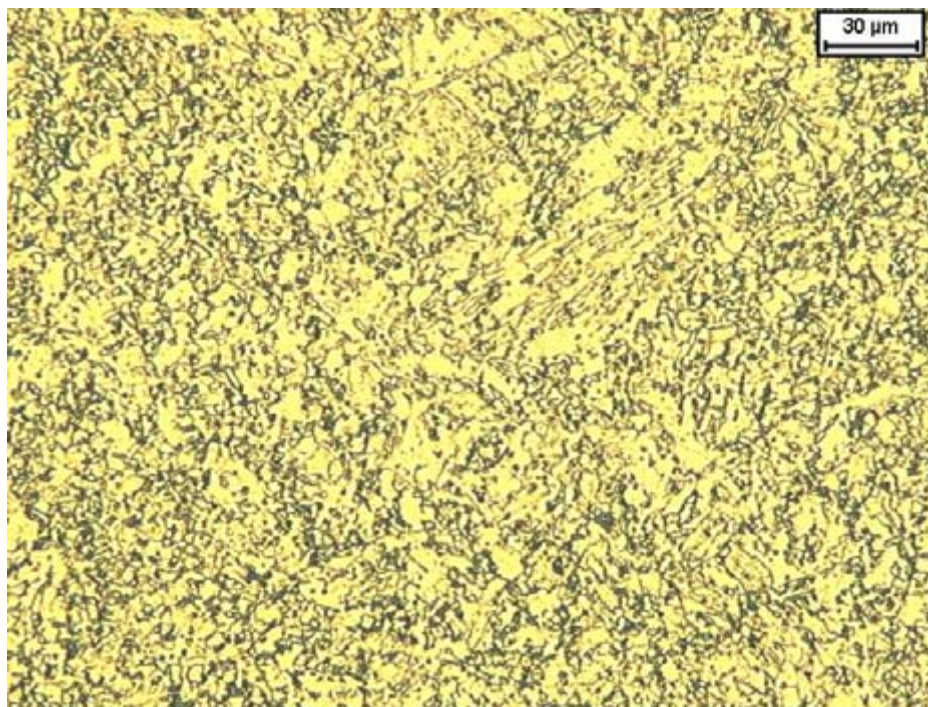
## **APPENDIX 10**

MCTS 1973 seam - cross section 3

micrographic examination- PWHT condition



Weld metal - basaltic zone

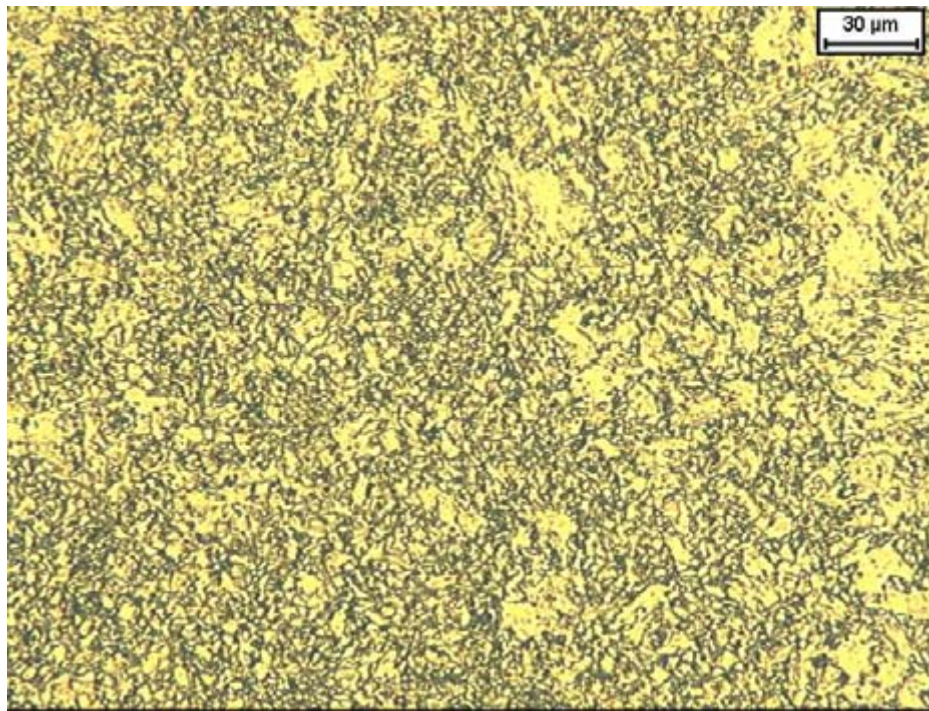


Weld metal- refined zone

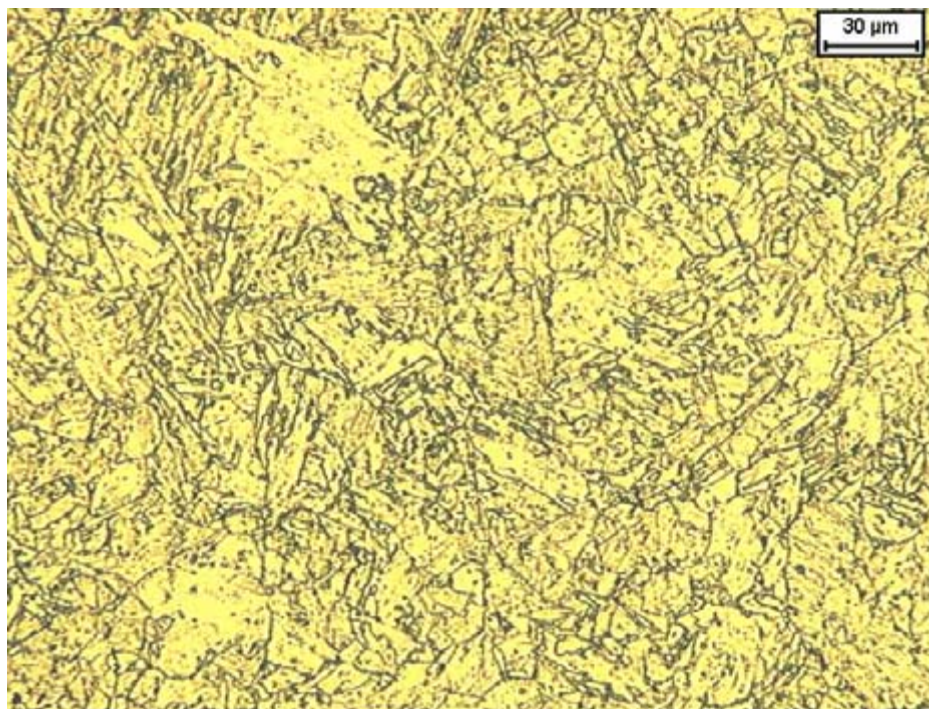
## **APPENDIX 11**

MCTS 1973 seam - cross section 3

micrographic examination- PWHT condition



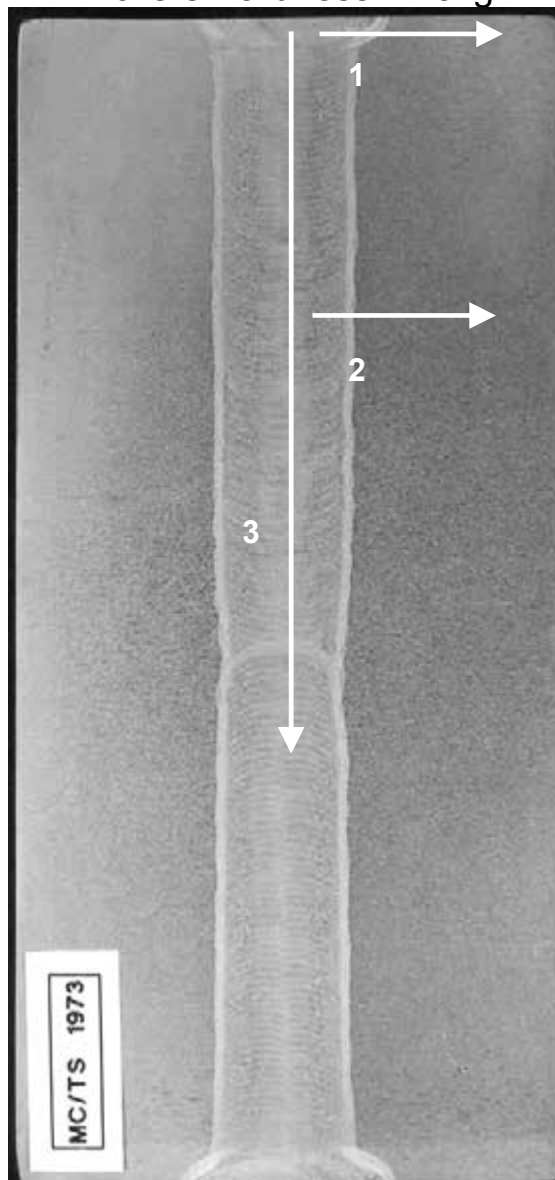
HAZ



Base material

## **APPENDIX 12**

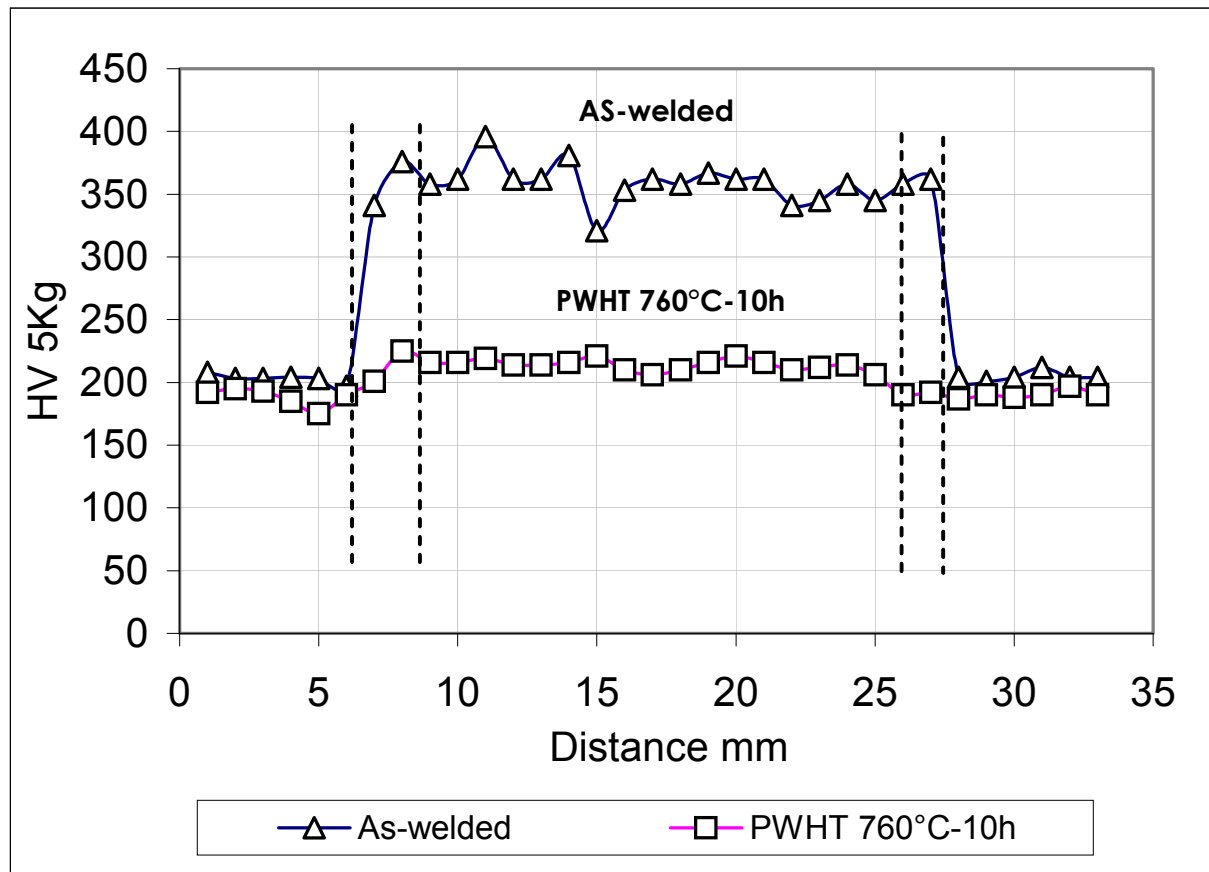
Vickers Hardness HV5kg



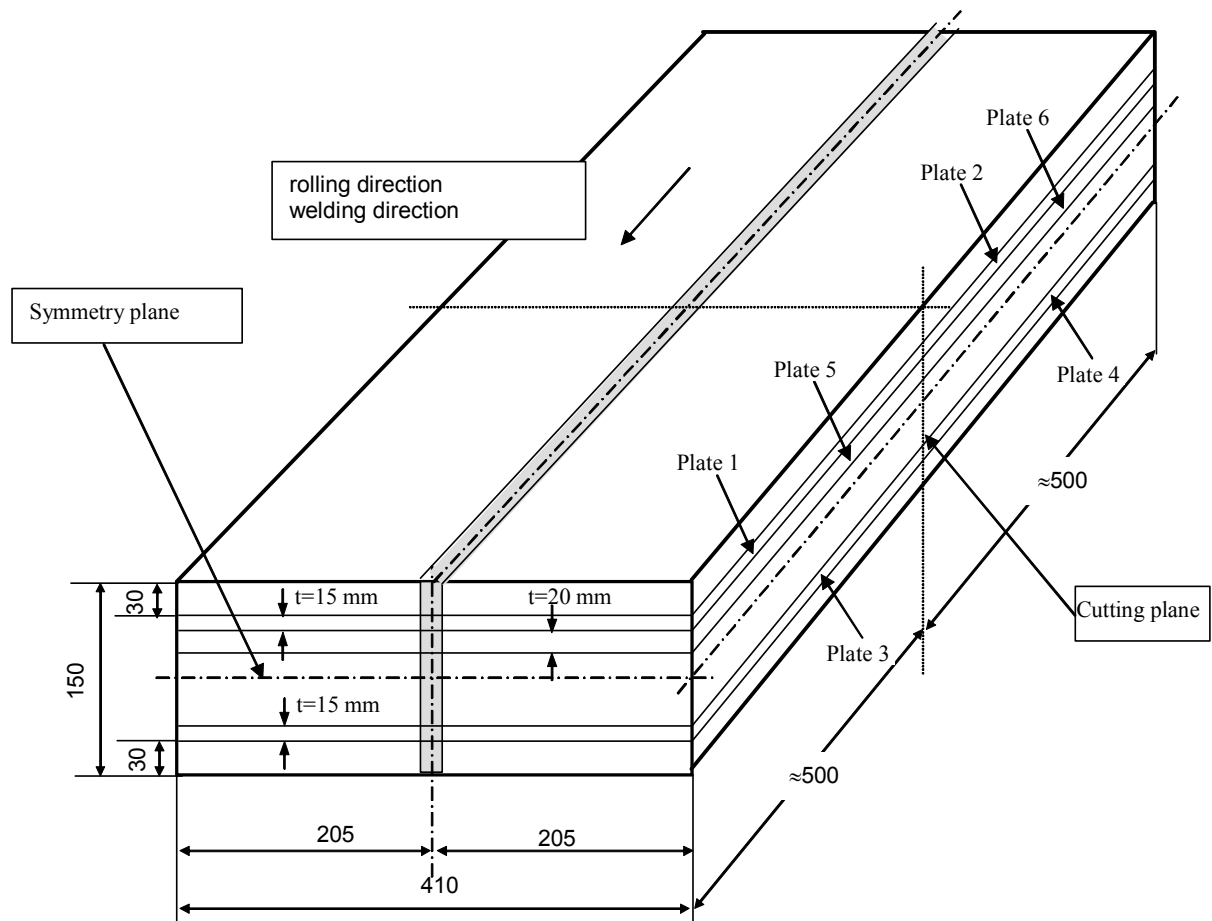
| Ligne | As-welded condition                                                                                                                                                                                                | PWHT 760°C-10h                                                                                                                                                                                                                |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | <u>base material</u> 208-203-203-204-203-197<br>ZAT 341-376<br><u>weld metal</u> 358-362-396-362-362-381-321-353-362-358-367-362-362-341<br><u>HAZ</u> 345-358-362-304-301<br><u>base material</u> 204-212-204-204 | <u>base material</u> 192-195-193-185-175<br><u>HAZ</u> 190-201<br><u>weld metal</u> 225-216-216-219-214-214-216-221-210-206-210-216-221-216-210-212<br><u>HAZ</u> 214-206-190-192<br><u>base material</u> 187-190-188-190-197 |
| 2     | <u>base material</u> 201-203-195<br><u>HAZ</u> 210-332-336<br><u>weld metal</u> 321-313-303                                                                                                                        | <u>base material</u> 201-201-195<br><u>HAZ</u> 183-192-227<br><u>weld metal</u> 206-210-221                                                                                                                                   |
| 3     | 349-341-313-293-310-293-303-306-362                                                                                                                                                                                | 212-210-216-214-221-221-232-219-219                                                                                                                                                                                           |

## APPENDIX 13

Hardness curve – location 2mm under the skin (line n°1)



## APPENDIX 14



## APPENDIX 14

### Identification and marking of the plates

