

THE EFFECT OF SUCCESSIVE REPAIRS ON THE WELDMENT QUALITY OF API 5L X 52 STEEL PIPES

B.Maamache¹, Y.Yahmi¹ et M.Bouabdellah²

1: Centre National de Recherche en Soudage et Contrôle, Division de Métallurgie et Mécanique, C.S.C,
PB 64 Route de dely brahim, Cheraga, Alger, maamache2002@yahoo.fr

2: ENSP, Métallurgie, ENSP El-Harrach, mabrouk.bouabdallah@mail.enp.edu.dz

ABSTRACT:

This work presents the results of multiple weld repairs in the same area in seamless API X-52 microalloyed steel pipe. Four conditions of shielded metal arcwelding repairs and one aswelded specimen of the girth weld were characterized to determine changes in the microstructure, grain size in the heat affected zone, and to evaluate their effect on the mechanical properties of the weld joints. The mechanical properties by means of tension tests. The results indicate that significant changes are not generated in the microstructural constituents of the heat affected zone. Grain growth in the heat affected zone at the specimen mid-thickness with the number of repairs was observed. A significant increase in the Vickers hardness of the heat affected zone occurred after the first repair and a gradual decrease in the Vickers hardness occurred as the number of repairs increases.

Keywords: Welding, Repair, Heat affected zone.

1 Introduction

When a defect is located in a weld by means of some nondestructive test, the weld should be repaired. Generally, the weld metal is removed by grinding and inspected to verify the effective removal of the defect in order to re-weld under a qualified welding procedure. In the qualification of welding procedures in accordance with API-1104 [1] and ASME Section IX [2] which are applicable standards to the welding of line pipes, the requirements to make weld repairs in areas previously repaired, indicate that the weld repair should be carried out with a qualified procedure, and the inspection personnel and welders should be qualified; however, these standards do not limit the number of times that can be repaired an area previously repaired. The only reference found in which the number of weld repairs in line pipe is limited is the offshore standard DNV-OS-F101 [3], Subsection G 300 Repair Welding, that states: "Weld seams may only be repaired twice in the same area". Most of the investigations in weld repairs are focused on studying the effect or distribution of residual stresses, and the great majority of these studies are based on simulation by finite element [4–5]. Few works have been found relating to weld repairs that evaluate changes or effects on the mechanical properties of the welds [6–8] and only few studies are about multiple repairs in girth welds of line pipes [7,8].

2 PRESENTATION OF THE ASSEMBLY WELDED

The material studied is API 5L X 52, pipe of 8 " and 14 mm of thickness, welded using SMAW process in 07 passes with E6010 and 7010 electrodes.

Procedures of repair consist in grinding the welded joint until a certain depth and repair welding. This operation is repeated three times. A radiographic control is required for each specimen, specimens with 1, 2 and 3 repair welding.

3 METALLOGRAPHIC CHARACTERIZATION

3.1 Macrographic observations

The macroscopic observations permit to reveal the different zones of the welded joint (*figure 1*).

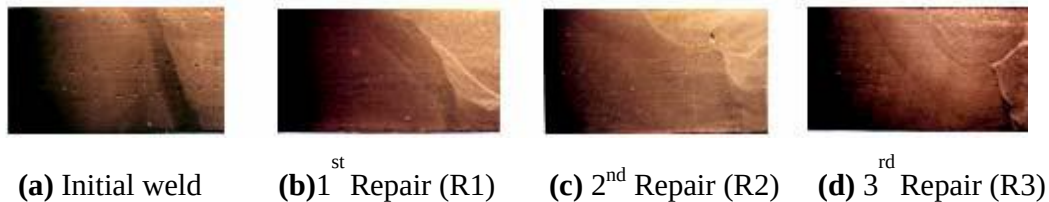


Figure 1 Micrographics of the initial and the repaired specimens

3.2 Micrographic observations

Using the different micrographies we try to analyze the transversal and depth microstructural evolution of the weldment specimens.

3.2.1 Depth structure evolution

- The grains elongated shape in the direction of the temperature gradient.
 - Progressive evolution in the ferrite shape according to the cooling speed: Widmanstätten structure. The last pass heat affects the previous passes structure. We observe therefore as follows:
 - Regeneration of the solidification structure.
 - The new grains formation of phase balance in fact ferrite and perlite which the shape becomes globular with a coalescence of the ferrite grains (figures 2. Sc, R3c).
- The last passes influence is very noticeable on the structure of the first passes (figures 2. Sd, R3d)

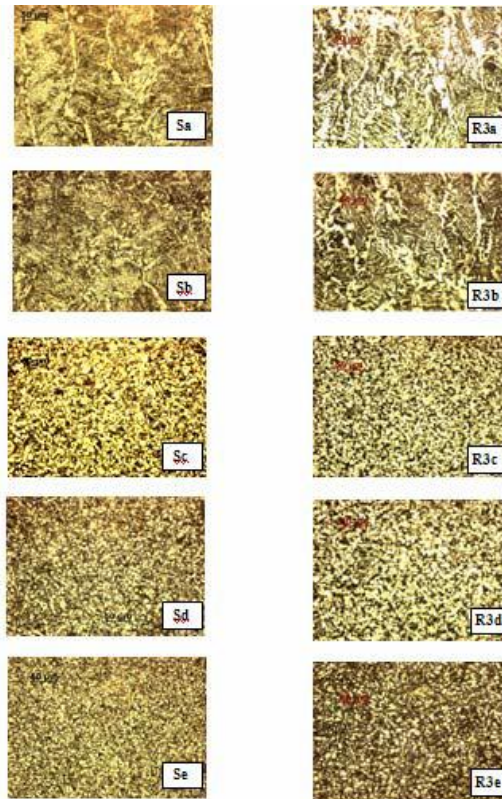


Figure 2. Depth structure evolution

3.2.2 Transverse structure evolution:

Alternate structure of ferrite and pearlite which is a characteristic of the rolling bands (figure 3.Sa). A progressive destruction of the rolling strip. A significant increasingly refinement of the grain Division of the ZAT which is characterized by a differentiation in the grains size with a clear discontinuity at the borders. The finest grain is located near the fusion zone; This phenomenon occurs because during the joint preparation for the repair the initial fusion zone has not been entirely eliminated and therefore the effect of the successive cycles of heating and cooling led to the formation of several thermal affected zones.

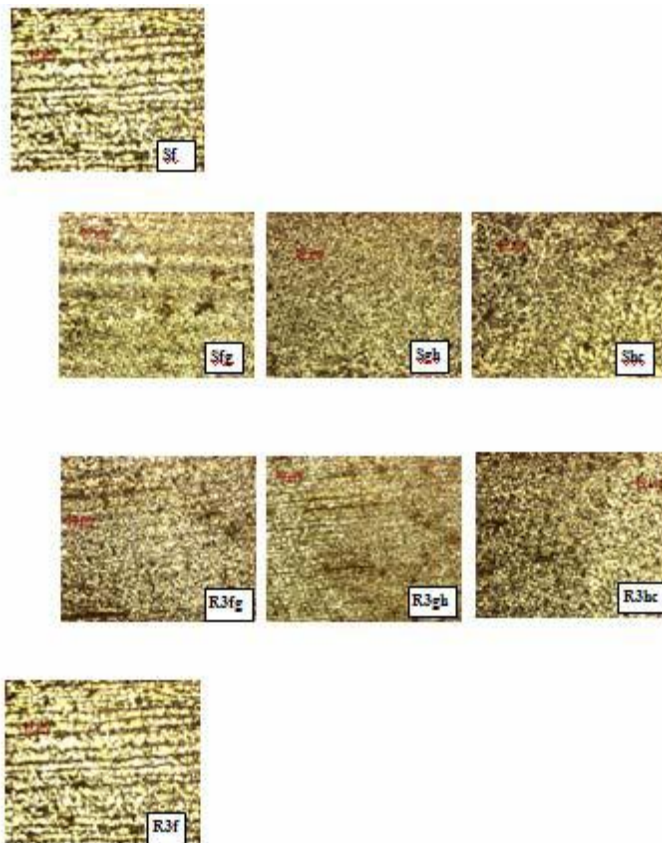


Figure 3: Transversal structure evolution

4 MECHANICAL BEHAVIOUR

4.1 Tensile tests

Table 1 - Tensile tests results

	MB	S1	R1	R2	R3
Ultimate Tensile σ_r (MPa)	525.13	498.70	488.33	539.61	433.08
Elongation (%)	23.18	15.85	19.54	18.85	12.98

The stress rupture remain higher than those recommended by the specification and are consequently satisfactory. It's the same for the elongation which remains acceptable. The caused observations and remarks are not at all valid for the third repair, the Ultimate Tensile σ_r is lower than what is recommended by specification (433.08 MPa instead of 455 MPa).

The same remark is to be emitted concerning the elongation which decreases of more than 5 %.

4.2 Hardness and microhardness

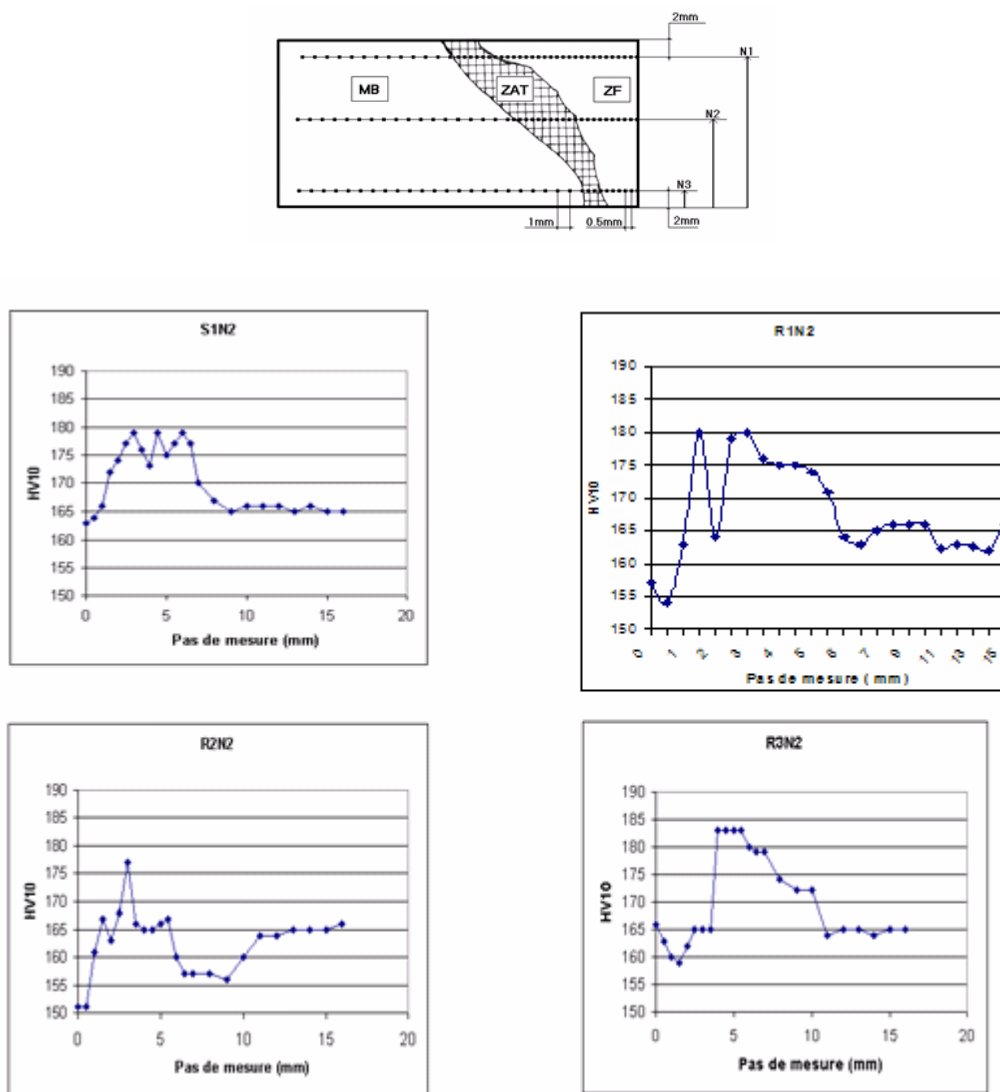


Figure 4. Fusion zone hardness measurements of different specimens

Filiations of hardness are carried out on specimen transverse sections. The step of filiatis is fixed at 0.5mm in the heat affected zone and the fusion zone, and 1 mm in the base metal MB (figure.4)

The HAZ hardness is higher than the one of the base metal, because of the high grains joints density.

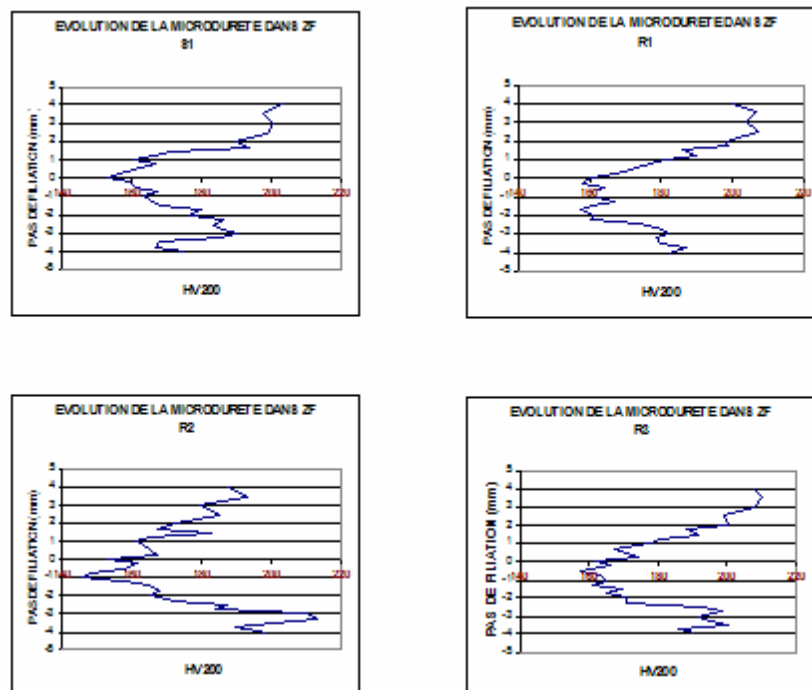


Figure 5. Heat affected zone hardness measurements of different specimens

The central part of the molten zone is characterized by a relatively low hardness compared with bottom and superior faces of the the joint corresponding respectively to the first pass and finish pass of the weldment. This observation was confirmed by a microhardnesses measurement done through the thickness direction of fusion zone (FZ) (*figure 5*). This can be explained by the weld multi pass effect where the previous passes undergo a softening of the structure (low hardness). [3]

5 CONCLUSIONS

Mechanical and microstructural evaluation in girth welds of seamless API X52 steel pipe with one, two, three SMAW repairs in the same area were studied. According to the results obtained, the mechanical properties satisfied the requirements of the different standards. We restrict our study to the main mechanical properties to note the effect of these repairs, it proves that we cannot indefinitely repair

because at each repair made corresponds a widening of the heat affected zone which is the most vulnerable area in the weldment. The number of the tests done doesn't permit to define the number of possible repairs, but it is clear that the number cannot be important because of the important change of the weldment quality.

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