# Parent Metal Cracking in a Combination Weld Tube

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Crack formation, due to improper preheat treatment, in combination welds of tubes, for superheater block assembly is analysed.

## I. Circumstances of the Failure :

Steel tubes, size 35×5.6 mm and specification 10CrMo 910 of DIN 17175 ($2\frac{1}{4}$Cr, 1%Mo steel) were welded with tubes 38×6 mm of CSN 415123.1 ($\frac{1}{2}$%Cr, $\frac{1}{2}$%Mo, $\frac{1}{4}$%V steel). The welding was carried out by arc welding process using CMB 83M electrode $\theta$2.5 mm (Rutile type—equivalent to E 8013 Bl). Before welding, the joints were supposed to have been preheated to temperature of 150-250°C by flame torch. After sometime, circumferential cracks parallel to the weld were observed at the Heat Affected Zone of the 10Cr Mo910 tube side (Fig. 1). One of the three failed samples was taken for detailed investigation.

## II. Investigation :

(a) *Chemical analysis* % :
(b) *Hardness Survey*


*Fig. 1. Photograph showing cracks in the heat affected zone. Mag : IX*

| *Sample* | *Chemical composition* % | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *C* | *Mn* | *Si* | *S* | *P* | *Cr* | *Mo* | *Sn* | *W* | *Ti* | *Sb* | *Al* |
| Parent Metal 10CrMo910 | .15 | .57 | .40 | .010 | .011 | 2.0 | <.94 | .03 | .02 | <.01 | <.01 | .015 |
| Weld Metal | ... | .49 | .27 | ... | ... | .66 | .98 | <.02* | ... | <.10 | <.01 | <.010 |

*Very fine traces.

Across the section, detailed hardness survey using a vickers diamond indentor was carried out at various zones of the welded piece (Ref. : Sketch-A)

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**HARDNESS HV 20**

| *Imp. No.* | *Position of Impression* | *Specimen from good portion* | *Specimen from cracked portion* |
|---|---|---|---|
| 1. | | 226 | 215 |
| 2. | | 232 | 215 |
| 3. | | 232 | 205 |
| 4. | Weld | 226 | 238 |
| 5. | | 232 | 232 |
| 6. | | 226 | 244 |
| 7. | | 232 | 257 |
| 8. | | 232 | 250 |
| 9. | | 386 | 340 |
| 10. | | 386 | 386 |
| 11. | Fusion zone (10CrMo910) | 392 | 386 |
| 12. | | 244 | 271 |
| 13. | | 250 | 271 |
| 14. | | 232 | 271 |
| 15. | | 183 | 179 |
| 16. | Parent Metal (10CrMo910) | 183 | 183 |
| 17. | | 187 | 183 |

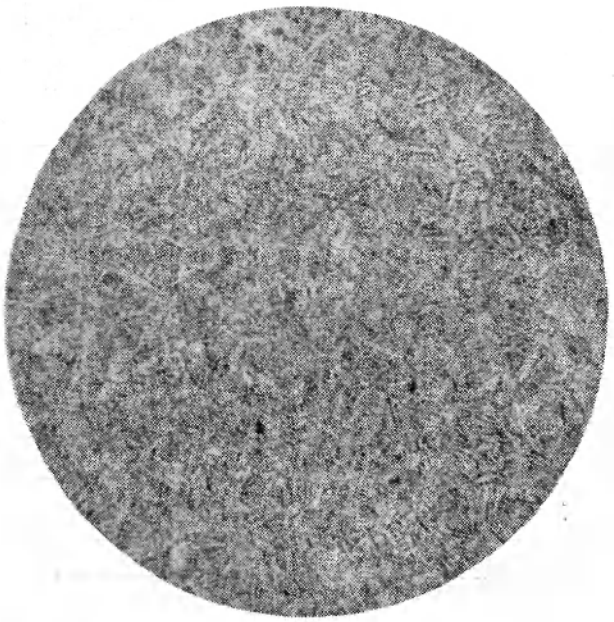
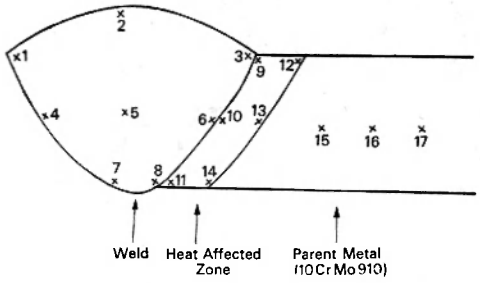


*Fig. 2. Microstructure in the heat affected zone of S. No. 576-Good portion Etchant : 3% Nital Mag : 125X*




*Sketch-A*

(c) *Micro examination (Etchant 3% Nital : Magnification :* 100X)

Two specimens (one from the good and the other from the cracked portion) were prepared, longitudinal to the axis of the tube and their cut sections were microscopically examined.

| *Sample No.* | *Position of specimen* | *Microstructure* | |
|---|---|---|---|
| 596 | Good portion | *Parent Metal* (10CrMo910) | Banded structure of fine ferrite+ pearlite. Grain size finer than ASTM 8. |
| | | *Weld* | Columnar structure over a limited area at the top+refined grains at other regions. |
| | | *Fusion zone* (10CrMo910) | Structure consists of Troostomartensite (Fig. 2). |
| | Failed portion | | Structure similar to that of good portion (Fig. 3) |

## III. Discussion of the result

The chemical analysis of the tube material and spectral analysis of the weld indicate that the recommended material and welding electrodes have been used. Hence posible deviation could have been due to the pre or post weld heat treatments. Since the failure has happened before post weld heat treatment, the only possible cause may be improper preheating. The microstructure consisting of Troosto martensite

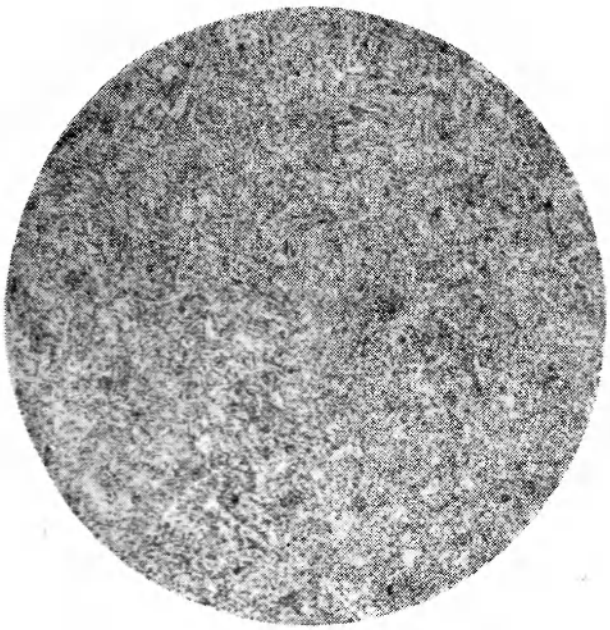


*Fig. 3. Microstructure of the fusion zone (PM + Weld) on S. No. 576-failed portion. Etchant ; 5% Nital. Mag : 125X*

and high hardness at the Heat Affected Zone confirms that internal stresses developed during the thermal transformation due to improper preheating temperature might have been one of the reasons for the heat affected zone cracking. The other possibility being the type of electrode used i.e. a rutile type electrode which is susceptible for hydrogen---cracking if proper precautions are not strictly adhered to.

Higher heat input using the thicker electrode and higher preheating temperature gives softer transformation zone, longer time for diffusion of the Hydrogen from the transformation zone and the weld metal by which risk due to Hydrogen cracking in weld and the transformation zone is minimised. The preheating given is not satisfactory for this type of electrode (i.e. Rutile) which has resulted with cracking in the heat affected zone.

## IV. Conclusion

The material used and the welding consumables are as per the requirements and set procedure. The troosto martensetic structure as revealed by the micro examination and high hardness values at the heat affected zone is due to insufficient preheating temperature and which in turn has aided the cold cracking by Hydrogen. This could have been avoided if a little more care had been taken to maintain proper preheat temperature.

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**Reference**

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