

TYPICAL REPORT
FURNACE FLOOR TUBE



SAFE CONTROL

M A T E R I A L T E K N I K

Member of Safe Control Group



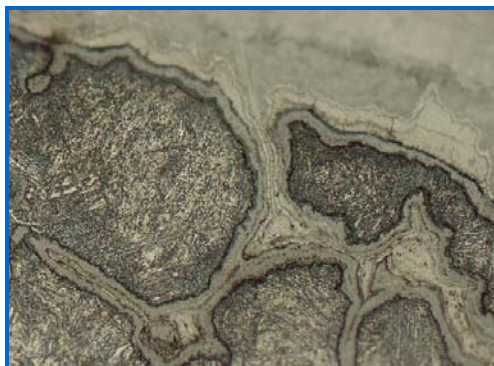
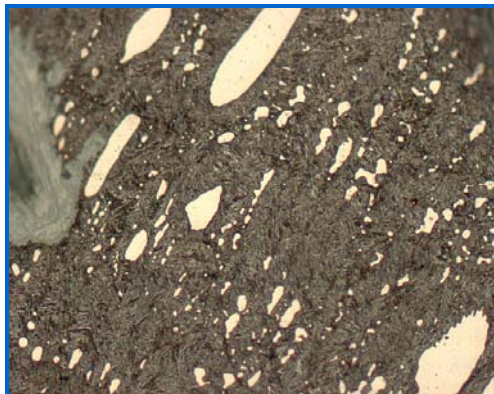
INVESTIGATION REPORT:

METALLOGRAPHIC INVESTIGATION OF FURNACE FLOOR TUBE #48 WITH LOCAL WALL THINNING; RECOVERY BOILER

REGISTRATION NUMBER: M013761

DATE: 2005-10-04

DEPARTMENT: METALLOGRAPHY





RAPPORT

utfärdad av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory



Beställare / Ordered by Safe Control Boiler Service AB Tillgängligheten 1 417 01 Göteborg	Orderdatum / Date of order 2005-09-12	Reg. nr. / Reg.No M013761
Er referens / Your reference Paul Praszkiar	Inlämningsdatum / Object (s) received 2005-09-12	Sidnr. / Page 1(9)
Ordernr. / Order number -	Rapportdatum / Date of report 2005-10-04	Vår referens / Our reference Lars Andersson

Investigation:	Metallographic investigation
Objects:	Furnace floor tube with local thinning from recovery boiler Ø 63 x 6.4 mm (measured)
Ocular examination:	See below on this page.
Macro- and microscopic investigation:	See page 2 and 3.
Hardness testing:	See page 3.
Photo pages:	Page 4 to 9.

"Laboratorier ackrediteras av Styrelsen för ackreditering och teknisk kontroll (SWEDAC) enligt svensk lag. Den ackrediterade verksamheten vid laboratoriet uppfyller kraven i SS-EN ISO/IEC 17 025 (2005). Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänner annat"

*Provningsresultaten i denna rapport avser endast provade objekt. Icke ackrediterade uppdrag markeras *.*

"Laboratories are accredited by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) under the terms of Swedish legislation. The accredited laboratory activities meet the requirements in SS-EN ISO/IEC 17 025 (2005). This report may not be reproduced other than in its full, except with the prior written approval of the issuing laboratory"

*The test results in this report refer only to tested objects. Investigations performed un-accredited is marked *.*



RAPPORT

utförd av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory



Teknisk instruktion / Technical instruction
Ocular examination, Macroscopic and
microscopic investigation

Objekt / Object
Tube with local wall thinning

Reg. nr. / Reg.No
M013761

Rapportdatum / Date of report
2005-09-27

Utfört av / Performed by
Lars Andersson

Sidnr. / Page
2(9)

Ocular examination:

We received one tube sample from furnace floor tube from recovery boiler . The tube sample had a length of about 65 mm with the dimension of \varnothing 63 x 6.4 mm (measured values). See fig.1 and 2 on page 4.

On gas-side towards furnace side we observed a limited region with local thinning (with a surface area of about 20×14.5 mm). See fig.3 on page 4.

Waterside surface on both furnace side and insulation side was covered by a thin layer of dark brown-coloured deposit/oxide. See fig.4 and 5 on page 5.

Macroscopic and microscopic investigation:

One cross section (parallel to tube axis) was cut out from the area with local thinning, for investigation. For location of the cross section, see fig.1 on page 4. The cross section was prepared and investigated in not etched and etched condition at magnification up to 800 \times . The cross section was etched with nital (etchant A.1 according to SIS-CEN/CR 12361:1996, similar to etchant 74 according to ASTM E 407-99).

Cross section

Wall thinning We observed an area with local wall thinning. The minimum wall thickness, in area with local thinning, was measured to 3.2 mm. See fig.6 on page 6.

Wall thickness in area with limited wall thinning was measured to 6.4 mm.

The wall thinning was calculated to 3.2 mm (which is equal to a 50 % reduction of the wall thickness).

Structure

In area with limited wall thinning: The structure consisted of fine lamellae pearlite in a matrix of ferrite, without remarks. See fig.17 on page 9.

At wall thinning: The structure showed a heat-affected zone (HAZ). See fig.7 on page 6.

Towards gas-side, in area with wall thinning, we observed a zone with different structure (structural change), probably because part of the tube towards gas-side had been melted. The structure in that zone had not been established, but the hardness indicates a hardening structure. See fig.10 on page 7.

Copper

We observed large amount of copper inclusions in the zone with different structure. In some areas we observed copper with intergranular extension in the heat affected zone (not the melted zone), indicating copper penetration. See fig.7 to 14 on page 6 to 9. Spectral analysis (x-ray spectra) established that the inclusions consisted of copper.



RAPPORT

utförd av ackrediterat laboratorium
REPORT issued by an Accredited Laboratory

**Teknisk instruktion / Technical instruction**

Macroscopic and microscopic
Investigation, Hardness testing

Objekt / Object

Tube with local wall thinning

Reg. nr. / Reg.No

M013761

Rapportdatum / Date of report

2005-09-27

Utfört av / Performed by

Lars Andersson

Sidnr. / Page

3(9)

Corrosion	We observed microstructural oriented corrosion (considered to be mainly intergranular) towards gas-side in area with wall thinning. See fig.15 and 16 on page 9. Spectral analysis (x-ray spectra) established presence of sulphur in the corrosion products.
Pit(-s)	Only superficial pits could be observed, with a depth up to 20 µm.
Oxides	Waterside surface was covered by a thin layer of protective oxide. The oxide layer had a thickness of about 5-10 µm. See fig.18 on page 9.

Hardness: HV10

Hardness test (HV10), according to SS-EN ISO 6507-1, had been made in three (3) areas. 1) In the zone enriched with copper and with a hardening structure (melted zone) in area with wall thinning. 2) In heat-affected zone (HAZ) in area with wall thinning. 3) In base metal in area with limited wall thinning.

1.	481 HV
2.	257 HV
3.	145 HV

*Den rapporterade utvidgade mätosäkerheten är baserad på en standardosäkerhet multiplicerad med täckningsfaktor, $k=2$, vilket för en normaldistribution motsvarar en sannolikhet med ca 95%.
Mätosäkerhetsberäkningarna är utförda i enlighet med EAL-G23, 1996 och GUM-ISO, 1995.*

*The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor, $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.
The uncertainty evaluation was carried out in accordance with EAL-G23, 1996 and GUM-ISO, 1995.*

Hårdheter HV / Hardness HV: 3.1 %

Signatur / Signature:

Teknisk instruktion / Technical instruction
Over-view pictures

Objekt / Object
Tube with local wall thinning

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.

-

Provningsutrustning / Testing equipment
SCM 54

Sidnr. / Page
4(9)

Provnin enligt / Testing according to

-

Provningsdatum / Testing date

2005-09-15

Utfört av / Performed by

Lars Andersson



Fig.1: Received tube sample with local wall thinning on furnace side. Location of cross section as in fig. above.



Fig.2: Same tube sample seen from insulation side.



Fig.3: Close-up view of area with local wall thinning.



Teknisk instruktion / Technical instruction
Over-view pictures

Objekt / Object
Tube with local wall thinning

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.

-

-

Provningsutrustning / Testing equipment
SCM 54

Sidnr. / Page
5(9)

Provning enligt / Testing according to

-

Provningsdatum / Testing date
2005-09-15

Utfört av / Performed by
Lars Andersson



Fig.4: Waterside surface, towards furnace side.



Fig.5: Waterside surface, towards insulation side.

Signatur / Signature:

Teknisk instruktion / Technical instruction
Macroscopic and microscopic
examination

Objekt / Object
Cross section

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.
SCMM1

Provningsutrustning / Testing equipment
SCM 9, SCM 48

Sidnr. / Page
6(9)

Provning enligt / Testing according to
SS-EN 1321

Provningsdatum / Testing date
2005-09-19

Utfört av / Performed by
Lars Andersson

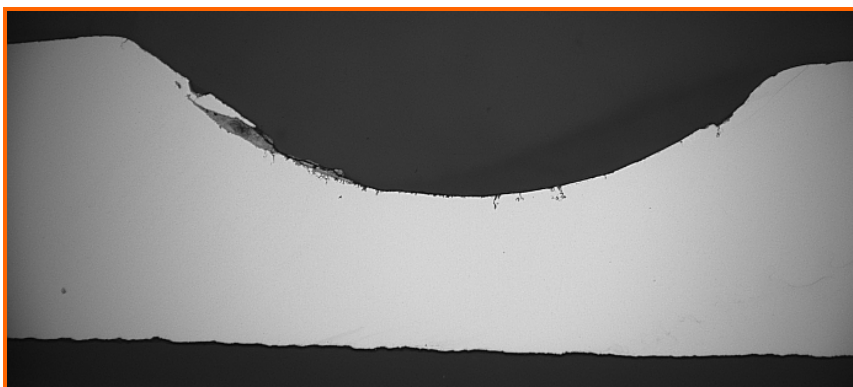


Fig.6: Cross section. Local wall thinning. Minimum wall thickness was measured to 3.2 mm. Not etched. 7 \times .

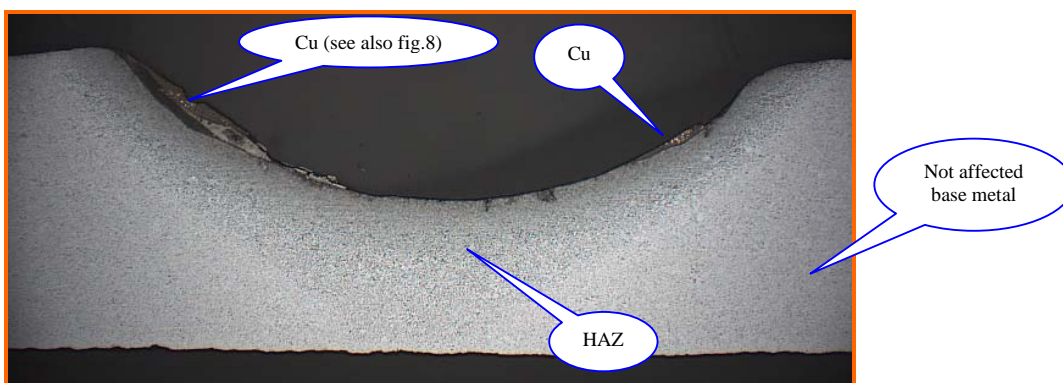


Fig.7: Same area as in fig.6, in etched condition. We observed a heat affected zone (HAZ) in the area where we observed local wall thinning. We observed occurrence of copper (Cu) towards gas-side. Nital. 7 \times .

Teknisk instruktion / Technical instruction
Macroscopic and microscopic
examination

Objekt / Object
Cross section

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.
SCMM1

Provningsutrustning / Testing equipment
SCM 10, SCM 47

Sidnr. / Page
7(9)

Provning enligt / Testing according to
SS-EN 1321

Provningsdatum / Testing date
2005-09-19

Utfört av / Performed by
Lars Andersson

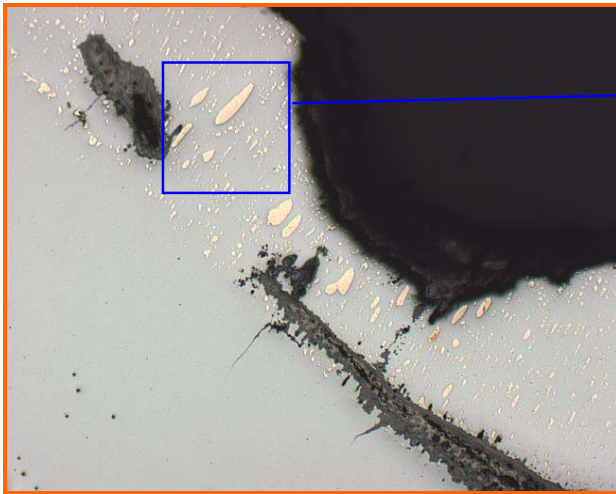


Fig.8: Cross section, towards surface in area with wall thinning. High concentration of copper (Cu). Not etched. 100 \times .

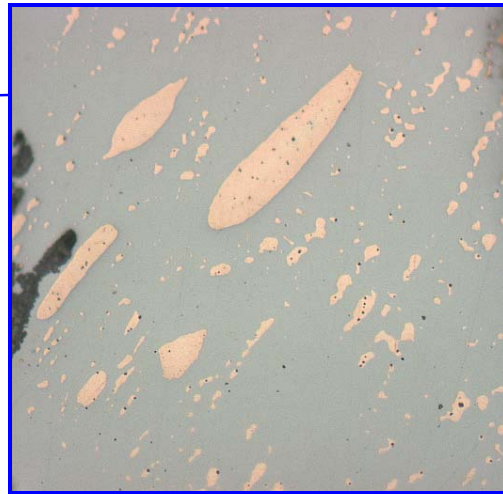


Fig.9: Area with copper (inclusions) at higher magnification. Not etched. 400 \times .

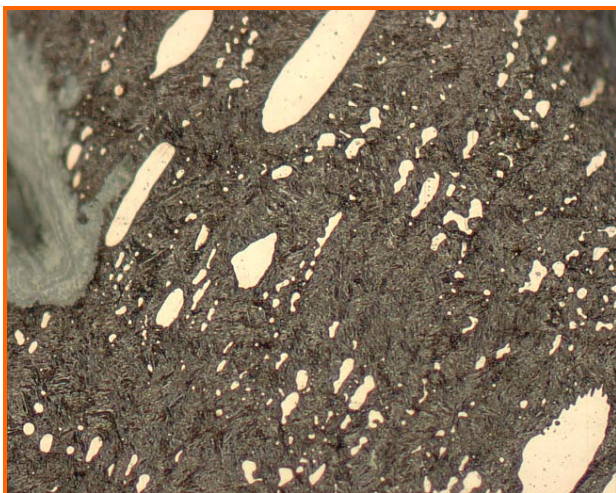


Fig.10: Same area as in fig.9, in etched condition. The structure consisted of a hardening structure (the hardness of the structure was measured to 481 HV). Nital. 400 \times .

Teknisk instruktion / Technical instruction
Macroscopic and microscopic
examination

Objekt / Object
Cross section

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.
SCMM1

Provningsutrustning / Testing equipment
SCM 10, SCM 47

Sidnr. / Page
8(9)

Provning enligt / Testing according to
SS-EN 1321

Provningsdatum / Testing date
2005-09-19

Utfört av / Performed by
Lars Andersson

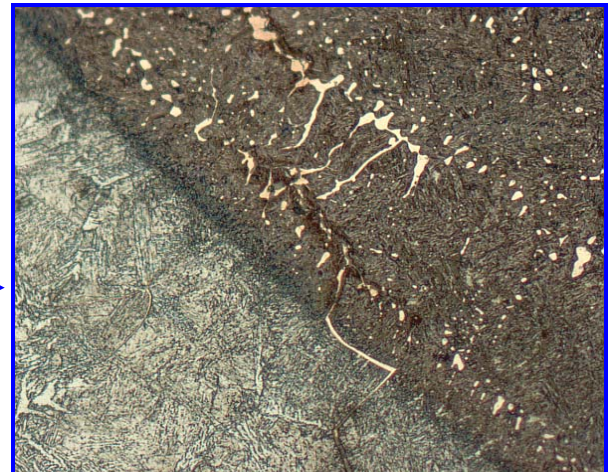
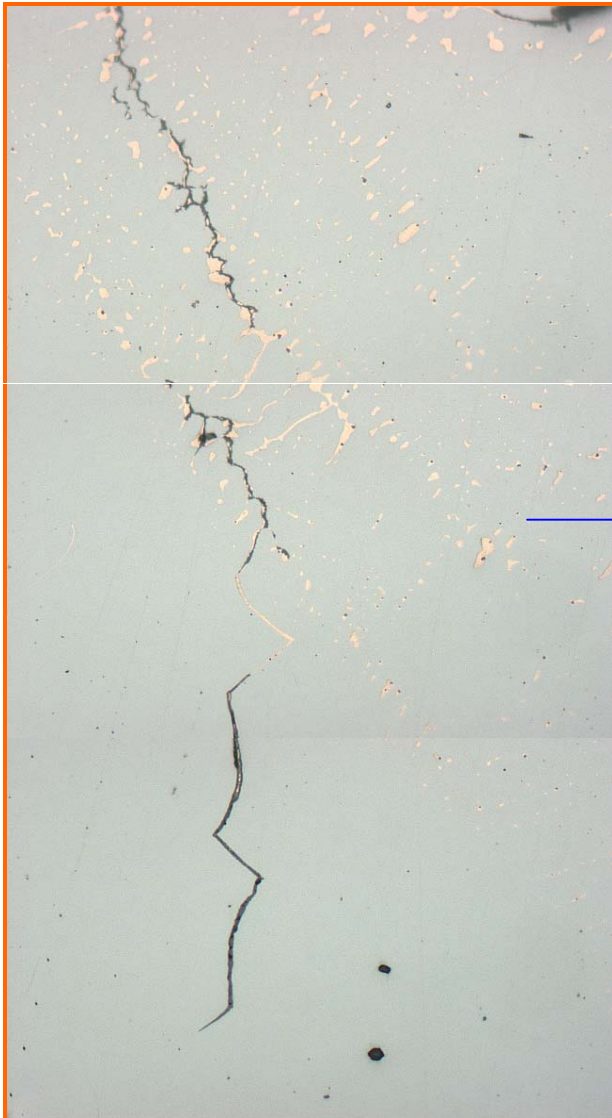


Fig.12: Part of area shown in fig.11, in etched condition.
Nital. 400×.

Fig.11 ¹⁾: Cracks (filled with oxides and copper). Not etched. 400×.
The cracks were mainly concentrated to areas with copper (inclusions).

¹⁾ Image composed by three micro photographs

Teknisk instruktion / Technical instruction
Macroscopic and microscopic
examination

Objekt / Object
Cross section

Reg. nr. / Reg.No
M013761

TI Dokumentnr./ TI Document no.
SCMM1

Provningstrustning / Testing equipment
SCM 10, SCM 47

Sidnr. / Page
9(9)

Provning enligt / Testing according to
SS-EN 1321

Provningsdatum / Testing date
2005-09-19

Utfört av / Performed by
Lars Andersson

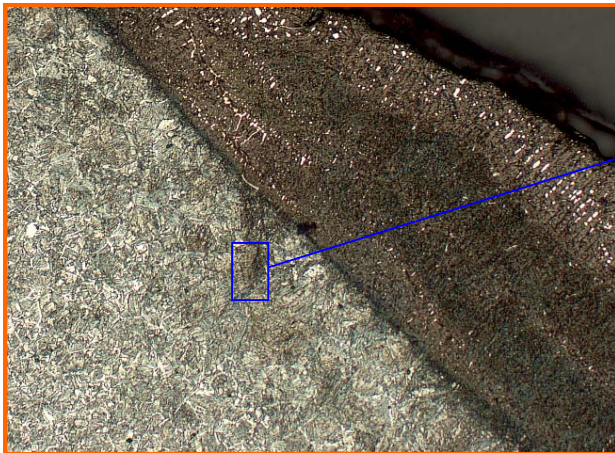


Fig.13: In area with wall thinning, gas-side. Nital. 100×.

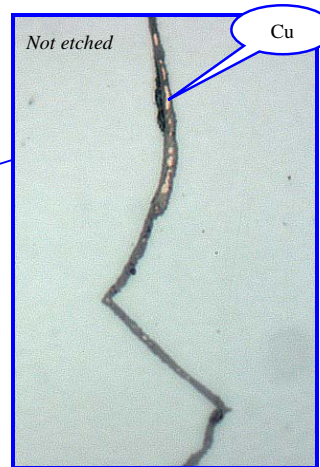


Fig.14: Part of crack (filled with oxide and copper). 800×.

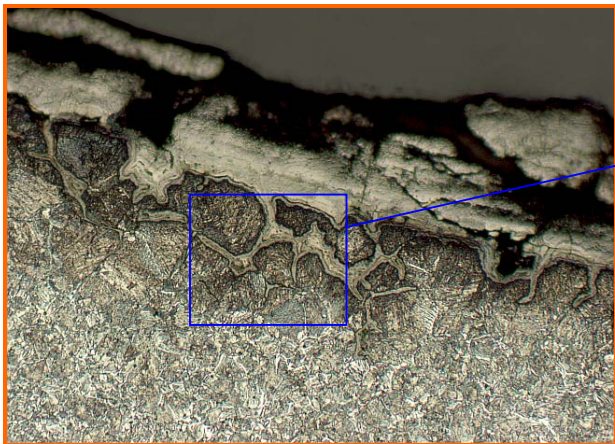


Fig.15: In area with wall thinning, gas-side. Nital. 100×.

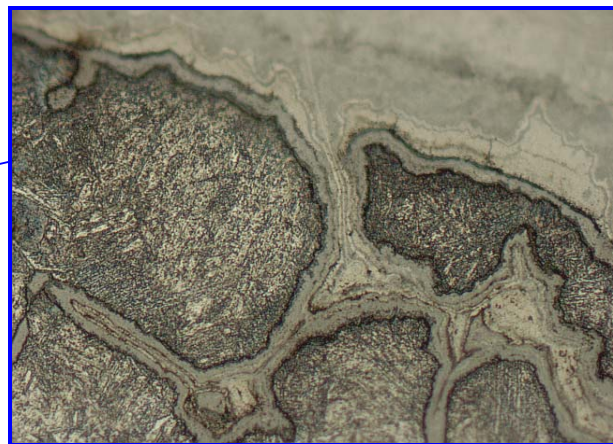


Fig.16: Part of area shown in fig.15, at higher magnification. Nital. 400×.

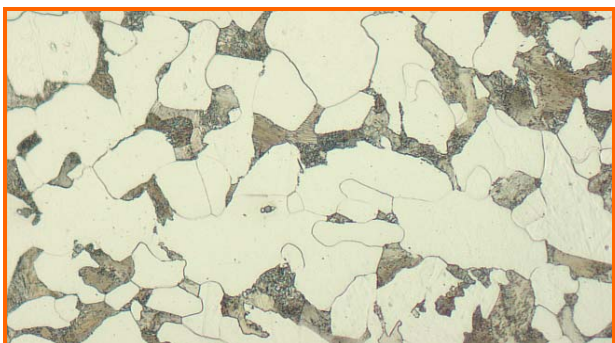


Fig.17: Base metal of ferrite and pearlite. Nital. 400×.

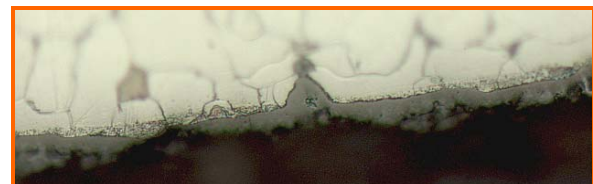


Fig.18: Towards waterside surface. Nital. 400×.