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WATER SOOTBLOWER EXPERIMENT IN THE BABCOCK & WILCOX KRAFT RECOVERY BOILER AT OY METSÄ-BOTNIA AB, KEMI MILLS

1. General

The principal objective of the water sootblowing experiment was to investigate the effect of sootblowing on the durability of superheater tubes of the recovery boiler in operating conditions. The efficiency of water sootblowing was also tested and on the basis of the results the operating values of the equipment were modified. The test results were also used for assessing energy savings achieved by water sootblowing. The experiment took about two years.

Water sootblowing in the boiler was continued after the actual experiment until 1990, after which the boiler became a stand-by boiler. The study was financed by the Ministry of Trade and Industry and the Finnish Recovery Boiler Committee.

2. Test boiler and sootblowing equipment

The water sootblowing tests were carried out on the B&W recovery boiler of Oy Metsä-Botnia Ab. The black liquor firing capacity of the boiler is approx. 450 t ds/day.

The steam sootblowers (4 pcs) of the superheater area were replaced by the water sootblowers designed by Tampella for this experiment. The cross section of the boiler and the location of the sootblowers are shown in Appendix 1, and the PI-diagram of the equipment in Appendix 2.

3. Results

3.1 Durability of superheater tubes and assessment of their operating life based on tube samples

3.1.1 Starting situation

The existing superheater tubes of the boiler were installed in December 1974, Appendices 3 and 4. The cold end of the superheater has been made of 15Mo3 ϕ 63.5 x 6.3 mm and the warmer end of 13CrMo 44 ϕ 63.5 x 6.3 mm. They are referred to as the original tubes in the following.

The water sootblowing experiment was started in June 1980. Two of the sootblowers were located between the areas of 15Mo3 tubes and 13CrMo 44 tubes so that the both areas were included in the experiment.

At the start of the experiment, 1 m long tube samples made of 15Mo3, 13 CrMo44 and SIS 2343 (2 samples of each material) were installed (Appendix 3).

Half of the samples were dismounted and examined after two years' use in summer 1982 and the remaining after four years' use in summer 1984.

Samples of the original tubes were taken and examined as follows:

- after three years' water sootblowing, in summer 1983
  1 pc of 13CrMo44

- after six years' water sootblowing, in autumn 1985
  1 pc of 13CrMo44 and 1 pc of 15Mo3

- after eight years' water sootblowing, in summer 1988
  1 pc of 13CrMo44

3.1.2 Results of the examination

- No changes in the microstructure could be detected compared with the unused material (examined from samples taken after two years' use).

- Toughness test made for SIS 2343 tube after two years' use, no differences when compared with the unused tube.

- Wall thickness measurements did not show any essential differences compared with other areas.

- Magnetic particle examinations with fluorescent liquid were made in the area of water sootblowing during sampling to the largest possible extent. Cracks were detected in the installed tubes for the first time in autumn 1986. In summer 1988 nearly all the tubes were cleaned along the sootblower at a height of ±0.5 m, from the side of the sootblower.

- No cracks were detected in tubes made of 15 Mo3.

- All examined tubes made of 13 CrMo44 had cracks. One of the worst tubes was taken as a sample. It seems that in furnace environment it is possible to detect cracks whose depth is at least 0.2...0.3 mm if the surface has been cleaned with an abrasive band.

- The Technical Research Centre of Finland (VTT) examined every sample for cracking with a stereoscopic microscope and cut sections by photographing.

  - Material SIS 2343, which was only used in the tube parts installed as samples.

    - After two years' use there were a lot of cracks on the outer surface, some of which had gone along the granular borders and some through grains.
      The biggest cracks detected were 0.1 mm deep.

    - After four years' use the maximum depth of cracks was approx. 0.25 mm. The cracks were sharper than with low alloy material.
      Since then no austenitic material has been used in the superheater.

  - Material 13CrMo44

    - After two years' use pits or very narrow cracks could be detected in the sample.

    - After three years' water sootblowing the original tube showed a dense network of crack begins when examined with a stereoscopic microscope and round-ended corrosion fatigue crack begins when examined with a light microscope.
      Maximum depth 0.1 mm

    - After four years' use the sample showed crack begins, which were rather wide and round-ended, several pieces per mm^2. Maximum depth 0.12 mm.

    - After six years' water sootblowing crack begins in the original tubes were detected. The cracks were filled with oxide and typical of corrosion fatigue breakage caused by thermal shocks. Their density in longitudinal sections was a few per mm and their maximum depth was 0.3 mm.

    - After eight years' sootblowing in summer 1988 the original tubes were examined and it was found out that cracks could be seen in magnetic particle examination, and one of the tubes with visible cracks was selected as a sample. In examinations the Technical Research Centre of Finland measured the maximum depth of a crack to be 0.3 mm, but because the surface had been cleaned with an abrasive band for crack inspection, it is probable that the maximum crack depth would have been approx. 0.4...0.5 mm.

- Material 15Mo3

  - After two years use some pits or very narrow cracks were detected and also some narrow cracks which had gone through grains.

  - After four years' use crack begins, rather wide and round-ended, several pcs/mm, were detected in the sample. The maximum depth was 0.1 mm at the point, where two indications were detected by magnetizing (no indications could be found in other parts and cracks were smaller there).

  - After six years' water sootblowing, 0.05 mm deep pits or grooves filled with oxide were detected in the original tube in autumn 1986. They were probably corrosion fatigue crack begins.

  - The subject material has not been examined since then.

- The cracked area was located outside the tube on the side of sootblowing so that cracks got smaller until they disappeared when turned 90 degrees from the line of the sootblower. No cracks were detected on the opposite side of the tube. The samples were at a height of ±0.5 m from the centre line of the sootblower (the tube length was about 1 m). The cracking was nearly equally strong on all parts of the samples.

- The internal surface of the tubes has not been inspected in the last few years, nor their microstructure, nor their toughness.

3.1.3 Conclusions

- Material SIS 2343 (austenitic) cracked most of all. The depth of cracks after four years' use (summer 1984) was 0.25 mm. The material in question is not suitable for superheaters to be cleaned by water sootblowing.

- Material 13CrMo44 (low alloy) cracked, but not very rapidly in the conditions under review. No other faults were detected. The latest inspection took place in summer 1988, at which time the water sootblowing had been used for about eight years. The surface touched by the water jet had cracked completely, which was detected by magnetic particle examination (some cracks/mm). The maximum depth of cracks was about 0.4...0.5 mm.

If the increase of the cracks were linear, they would reach the depth of 1 mm in about five years (1993; after 13 years of water sootblowing).

- Material 15Mo3 (low alloy) cracked less than 13CrMo44. No other faults were detected. The latest test took place in autumn 1986, at which time the maximum depth of the cracks detected was approx. 0.05 mm.
  In summer 1988 no cracks were detected in magnetic particle examination (probably the depth of the cracks was < 0.2 mm).

3.2 Efficiency of sootblowing

The operating values of the equipment at the beginning and end of the experiment and in the follow-up period were as follows:

	1980	1982	1983-90
Amount of water, l/s	0.65	0.9-1.0	1.5
Pressure, bar	NA	16-17	14-15
Operating time of sootblowers, min	5	7	7
Nozzles (2 pcs) ϕ mm	3.0	3.7	3
Inclination of nozzles, °	5	10	6

Unsalted water was used as sootblowing water, the temperature of which was about 20°C.

With the above operating values being effective, the superheater was cleaned 1-2 times a day.

After the renewal of the boiler in 1983 sootblowing was carried out 1-2 times a shift, on the basis of the flue gas pressure difference.

The sootblowing efficiency was followed by means of the temperature of superheated steam. Figure 1 shows the monthly temperature averages of superheated steam from the testing period. The temperature of superheated steam during water sootblowing was about 17°C (even 50°C, 1983-1990) higher than in steam sootblowing. The amount of water was about 20% of the amount of steam needed for sootblowing.

The amount of sootblowing water for the superheater was about 12 t/d less than the amount of sootblowing steam. The result of sootblowing was better with water than with steam.

The changes in the temperature of superheated steam during and after water sootblowing are shown in fig. 2.

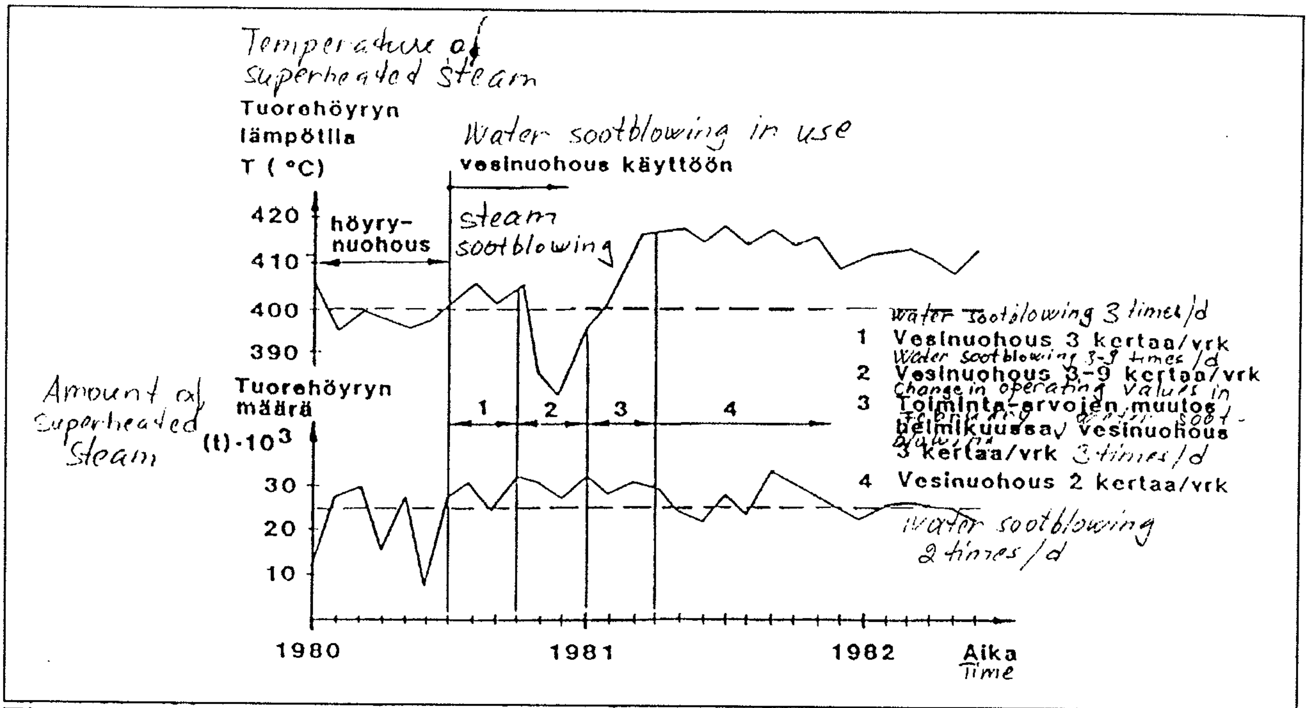


Fig. 1 Monthly averages of temperature and amount of superheated steam

3.3 Operating experience

It was detected in visual inspections that the areas which received the water jet were cleaned well. Some deposits remained on the opposite surfaces of the tubes.

During shutdowns the superheater was cleaned mechanically and the salt cake was easily removed from the surface of the superheater.

The wall tubes beneath the sootblowers are exposed to corrosion, because after the closing of the valve the water left in the lance drained from the sootblowers onto the tube surface outside the furnace.

The most usual operation faults of the sootblowers were:
- Wall boxes leaked
- Valves leaked and got stuck
- Although lubricated the drive chains in the sootblowers stretched and got stuck.

3.4 Operational safety

Water sootblowing did not cause any dangerous situations during the experiment and the follow-up period.

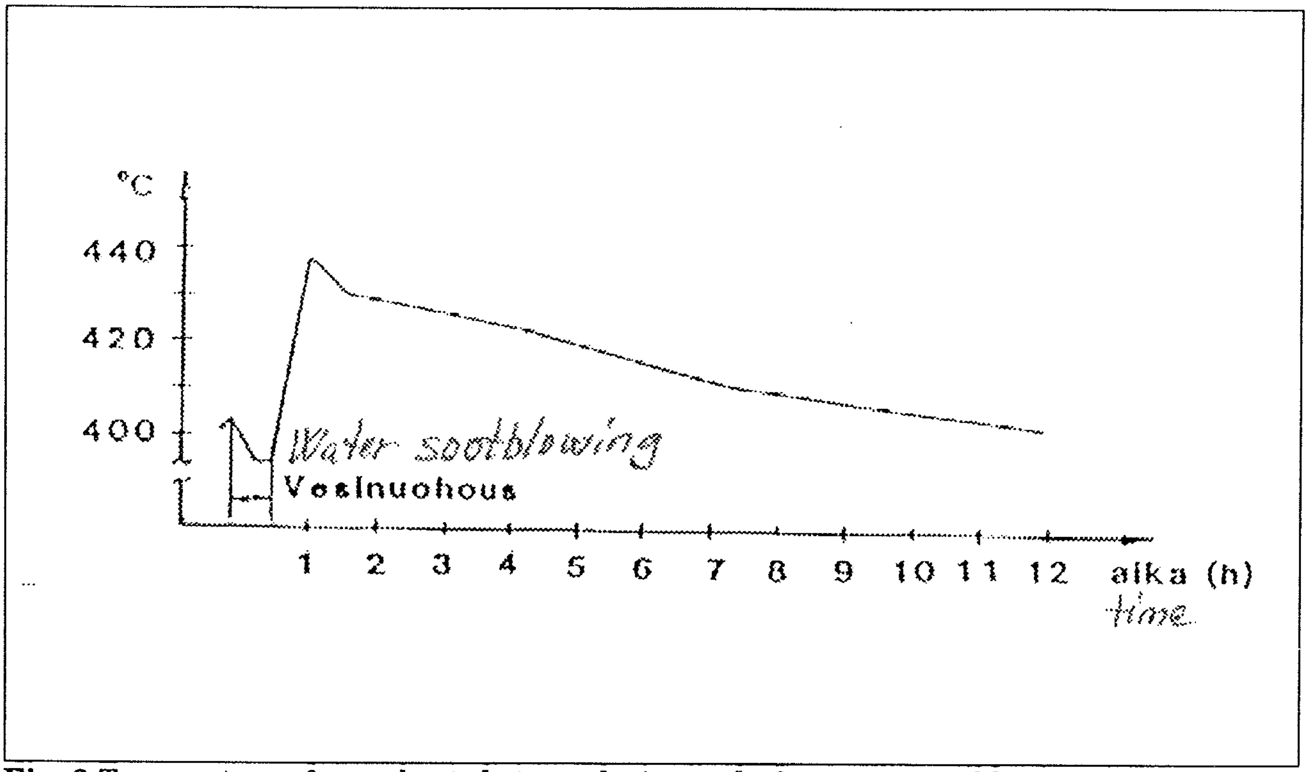


Fig. 2 Temperature of superheated steam during and after water sootblowing

3.5 Actual savings

3.5.1 Energy saving

Thanks to the increase in the boiler efficiency caused by lower steam consumption and the cleaner superheater, energy savings in Metsä-Botnia's B&W boiler were some 50-60 GJ/d (0.2 GJ/t ds)

3.5.2 Savings in money

Savings in money gained by means of water sootblowing must be estimated case by case, because the amount depends on several factors, such as process factors, price of an auxiliary boiler fuel, electricity price and the annual operation time of the boiler. In the case of Oy Metsä-Botnia Ab the annual savings by means of water sootblowing were estimated at FIM 460,000 (FIM 5/tds).

4. CONCLUSIONS

On the basis of the test results the water sootblowing of the superheaters was clearly more economical than steam sootblowing.

REFERENCES

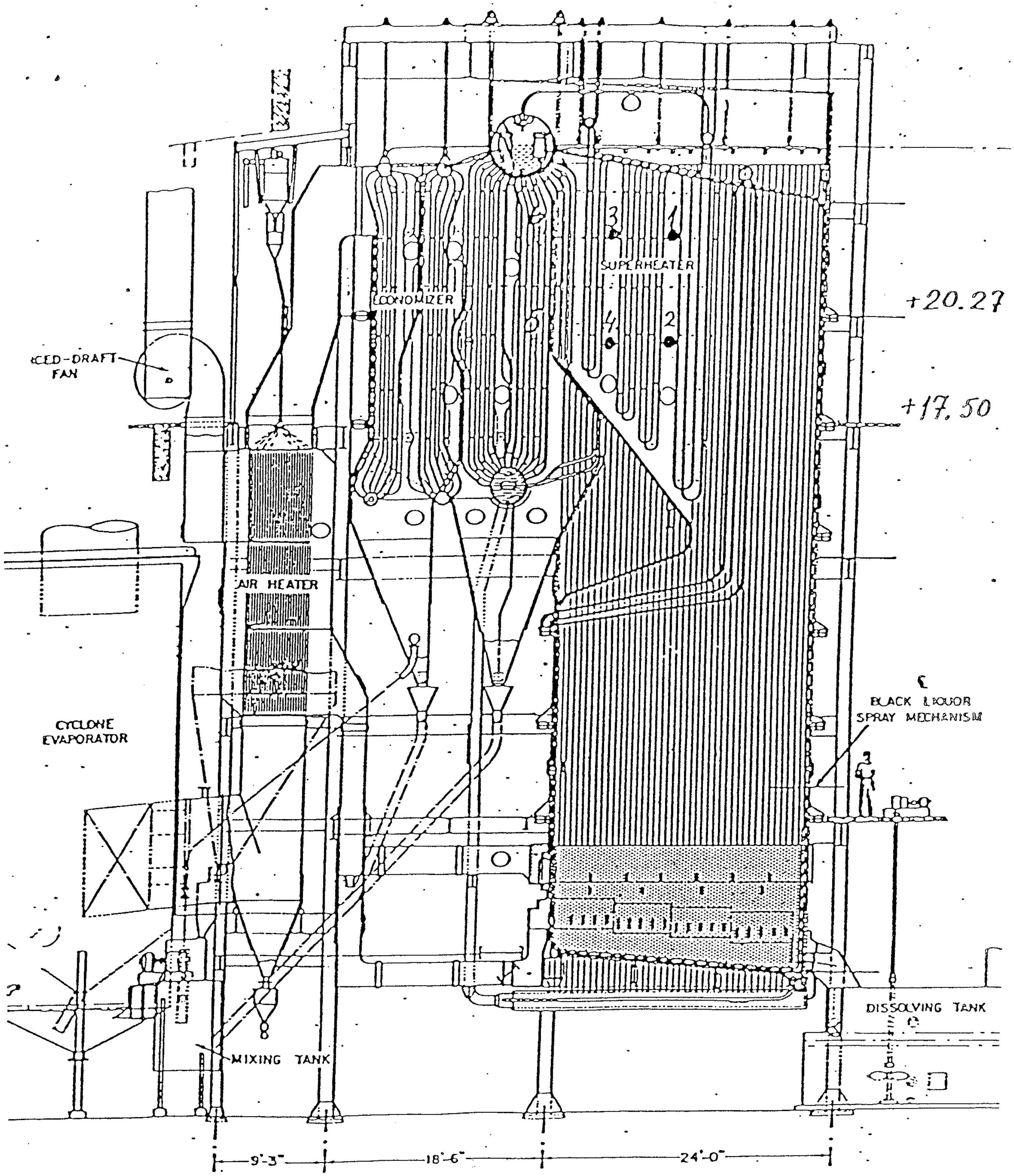
(1) E. Kinanen, Sootblowing tests using water on superheaters of a recovery boiler. Memos, inspection programme and inspection report (VK-91207-01...12), Ekono Oy/Finnish Recovery Boiler Committee, 17.10.1979...29.12.1982

(2) P Kittilä, B&W recovery boiler, superheater water sootblowing, tube resistance, assessment of service life on the basis of tube samples. Memo T732023/9/88, Oy Metsä-Botnia Ab, 9.9.1988.

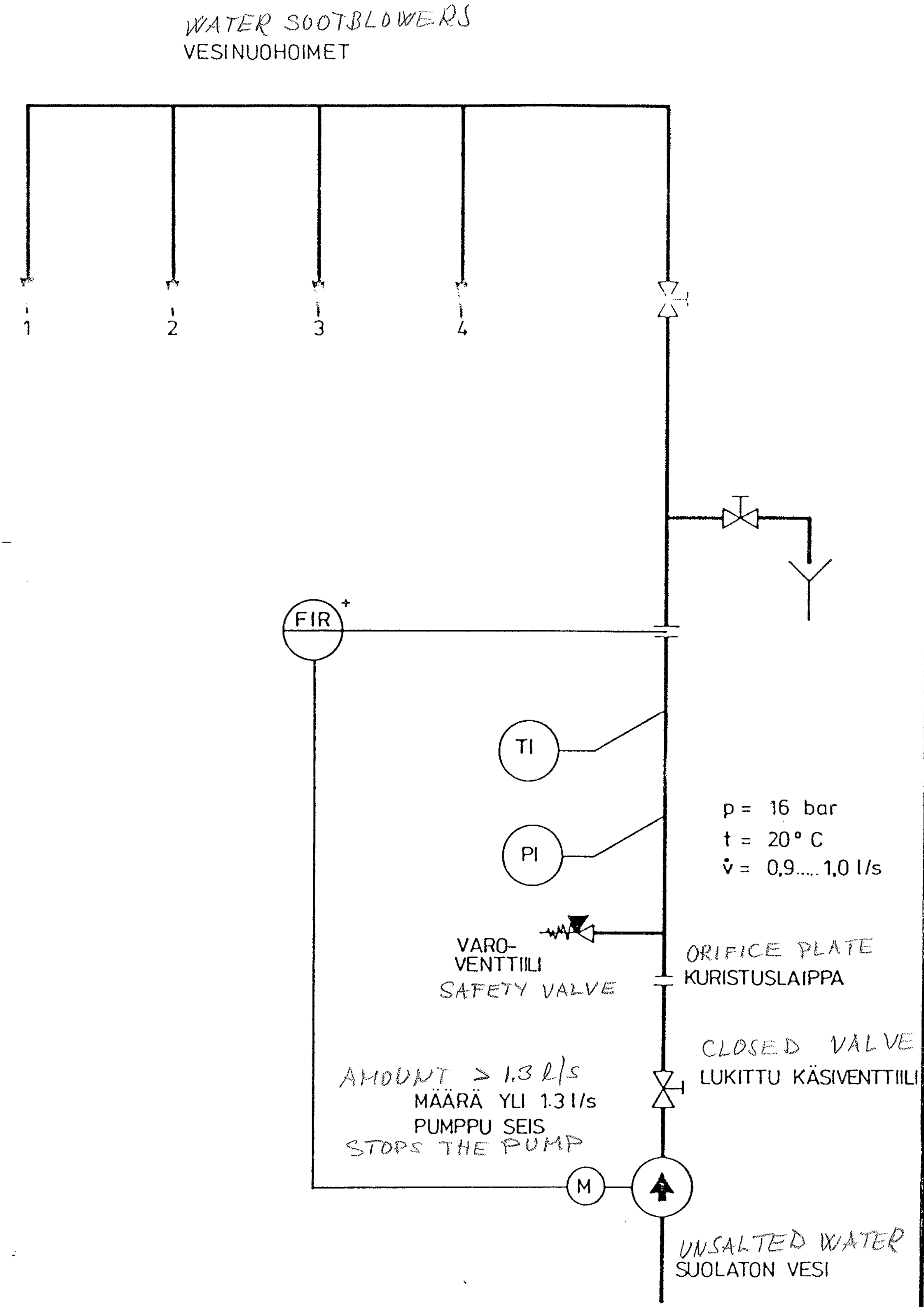
(3) Notes of the operating department of Oy Metsä-Botnia Ab during the water sootblowing experiment.

APPENDIX 1
LIITE 1

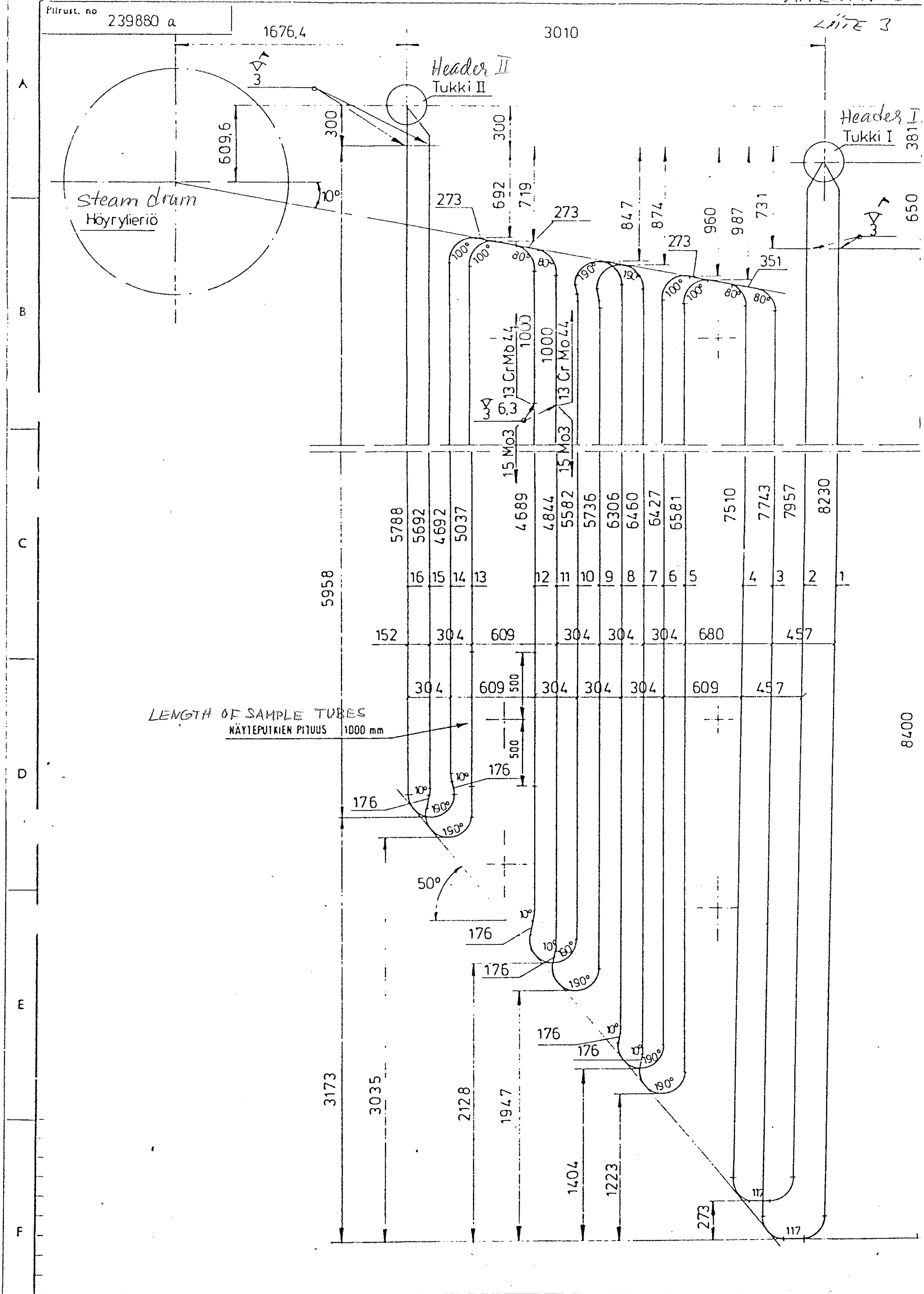
Water sootblowers Nos.
Vesinuohoimet n:o 1, 2, 3 ja 4



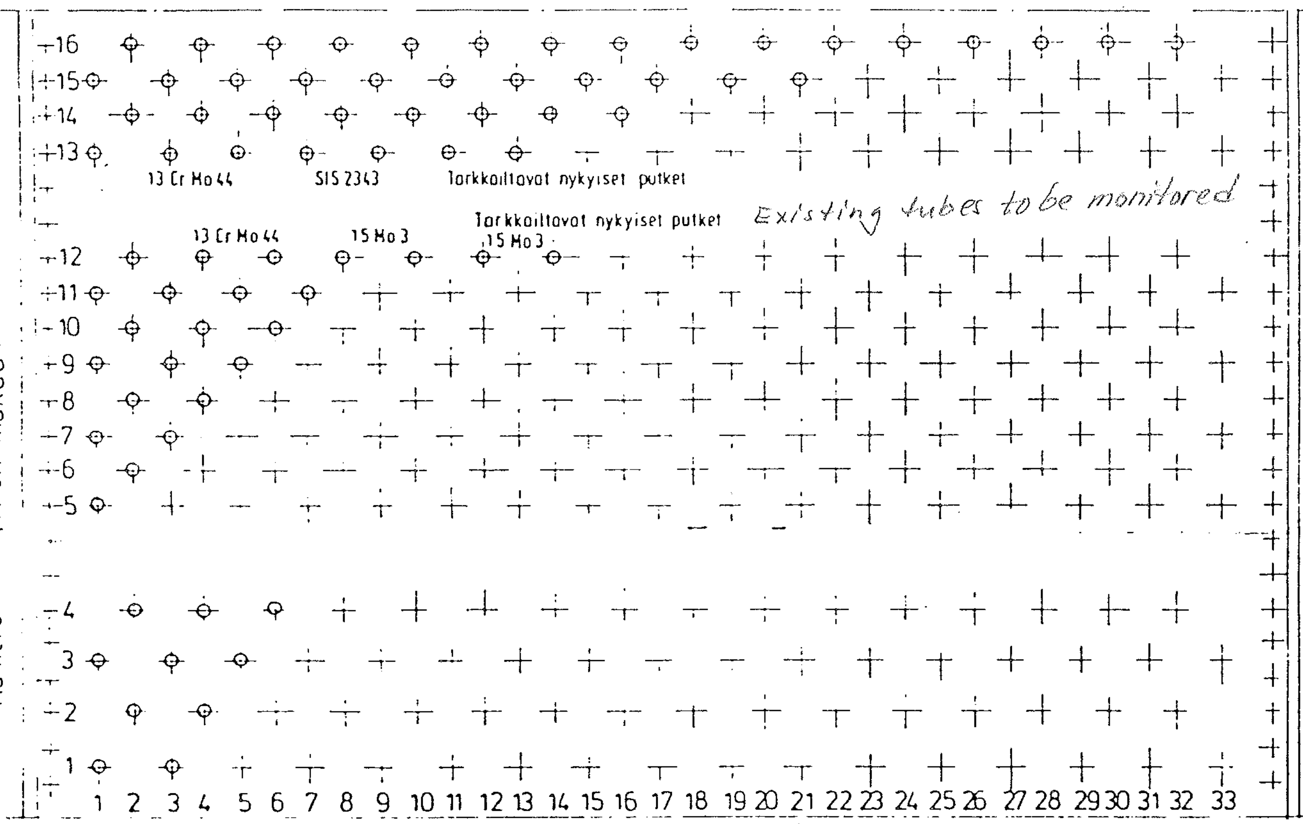
225 TON RECOVERY UNIT
A/B KEMI O/Y
KARIHAARA, FINLAND
B & W CONTRACT NO. S-9799



EKONO	KTM, VESINUOHOUSLAITTEISTON PERIAATEKAAVIO	VK-91207
		1982-12-21
		HGS/ ETK



Huomautuksia	Kohta	Muutos	Hyväks.	Päiv.	Piirt.



Numerointi elementtijonojen mukaan *Numbering according to component rows*

KATTILAN ETUPUOLI *FRONT END OF BOILER*

TUBE NUMBERING: First component row number and then line number
TUUBIEN NUMEROINTI: Ensin elementtijonon numero ja sitten rivin numero esim. tuubi 10/8 tarkoittaa elementtijonoa 10, rivi 8. *e.g. tube 10/8 means component line 10, row 8.*

BEND NUMBERING:
KÄYRIEN MERKINTÄ: esim. yläkäyrä 10/8-10 tarkoittaa että yläkäyrä on elementtijonossa 10 ja on 8-10 rivin välillä *e.g. upper bend 10/8-10 means that the upper bend is in component row 10 and between lines 8-10.*

Headers I and II

1. Tukit I ja II
   Measurements: Mitat: Φ 11 3/4" × 1" ≙ 298,45 × 25,4 mm
   Material: Materiaali: 106 B (hiiliteräs saumattomille putkille korkeisiin lämpötiloihin) *carbon steel for seamless tubes for high temperatures*
2. *Tubes, lines* Tuubit, rivit 1...12
   From header → Tukista lähtö
   Mitat: 2 1/2" × 0,0220" ≙ 63,5 × 5,589 mm
   Materiaali: SA-210 (ASTM-A-210-46), (keskihiilinenteräs saumattomiin kattila- ja tulistintuubeihin) *for seamless boiler and superheater tubes*
   Tuubit
   Mitat. Φ 63,5 × 6,3   Materiaali: 15 Mo 3/III
3. Tuubit, rivit 13...16
   Tukista lähtö
   Mitat: 2 1/2" × 0,240" ≙ 63,5 × 6,096 mm
   Materiaali: SA-213 (ASTM-A-213-46) (Ferriittinen tai austeniittinen seostettu teräs, saumattomiin kattila-tulistin- tai lämmönvaihdin tuubeihin. *Ferritic or austenitic alloyed steel for seamless tubes of boilers, superheaters or heat exchangers.*
   Tuubit
   Mitat: Φ 63,5 × 6,3   Materiaali: 13 Cr Mo 44/III
4. Tuubit hö-lieriöstä tulistimen I-tukkiin *Tubes from steam drum to header I of the superheater*
   Original: Number Alkuperäiset: Lukumäärä 14 kpl *14 pcs*
   Mitat: 3 1/4" × 0,180" ≙ 82,55 × 4,572 mm
   Materiaali: SA-178c (hiiliteräs hitsattuihin kattilatuubeihin) *carbon steel for welded boiler tubes*

Osa	Kpl	Esineen nimitys - Mitat	Piirust. No / Standardi	Osa	Aine / Toimitustila	Huomautuksia / Paino
Sohde	Liittyy Nimen		Piirt. 21 01 75	AVo/ARi		
Lokero 390	Osasto VO		Tark. / Hyv.			KEMI Oy

B&W KATTILAN TULISIJAN
TUKIT JA TUUBIT
HEADERS AND TUBES

239880 a

orvaa piir. no 237087