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# Test of technologies for flue gas cleaning and combustion improvement for existing residential wood burning appliances

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# Preface

The overall objective of the project with the Danish title "Afprøvning af teknologier til røggasrensning og/eller forbrændingsforbedring til eftermontering på eksisterende brændeovn- og brændekedel-installationer" is to evaluate and test technologies for flue gas cleaning and/or combustions improvements, which can be mounted on existing wood stoves and wood boilers.

Technologies to be incorporated in new stoves and boilers are not covered by this project.

Emissions from older wood stoves and wood boilers are in general higher, and often very much higher, than from new stoves/boilers. Consequently, the potential for emission reduction is much higher for older stoves and boilers than for new ones.

This is why the project mainly is aimed towards abatement technologies, which can be mounted on older existing wood stoves and wood boilers

The project has been carried out for the Danish Environmental Protection Agency by a consortium consisting of FORCE Technology, the Danish Technological Institute and the National Environmental Research Institute at Aarhus University.

# 1 Summary and conclusions

This project had the purpose to identify and test suitable technologies for flue gas cleaning and/or combustion improvement for use on existing wood stoves and boilers in Denmark on order to assess their efficiency regarding reduction of emission of the most important pollutants in wood smoke.

Five technologies were tested under controlled conditions in the laboratory, and subsequently the technologies were tested by mounting them on appropriate stoves in private homes.

The five tested technologies were:

1. Zumikon ESP[1] from Rüegg Cheminée AG, Schwiz.
2. Airbox ESP from Spartherm Feuerungstechnik GmbH, Germany.
3. CleanAir ESP from Applied Plasma Physics AS, Norway.
4. MoreCat Catalyst from MoreCat GmbH, Germany.
5. Ecoxy Retrofit System for old Stoves, from ECOXY AS, Norway.

The five technologies were first tested on a wood stove at the approved stove and boiler test facility of the Technological Institute (TI) in Aarhus. Only the three ESP devices were applicable for boilers, so only these devices were tested on the boiler.

The test results were compared with reference tests for the stove and boiler. Also a reference test with a modern Swan Eco Labelled stove was made for comparison.

The stove test period comprises the following phases: firing the stove, re-stoking twice with high performance, followed by re-stoking twice with reduced air. This stoking procedure is anticipated to be very similar to the daily use of a wood stove used for supplemental heating during late afternoon and evening.
The boiler was lighted up and re-stoked four times with high load only.

The test stove was a Morsø 1440, which is a convection wood stove for small rooms, which has been produced from 1990 to 2007. The wood boiler is an old Viadrus Hercules U22 bottom up combustion boiler from the Czech company Viadrus. The Swan Eco Labelled stove was an Epoca from the manufacture Rais AS.

The overall principle for the test was to measure and register the resulting pollution from the chimney in the environment, and especially the most correct figure for the contribution of particles to the ambient air. As condensables[2] will form particles when the flue gas is cooled down on its way through the chimney and when dispersed in the surrounding air, the emission measurements were made in a dilution tunnel. Several references are documenting, that the particle concentration measured in a dilution tunnel are

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[1] ESP = ElectroStatic Precipitator
[2] Condensables are unburned organic gaseous compounds from the combustion, which condense to liquid or solid particles by cooling of the flue gas.

between 2 and 10 times higher than when measured in the very hot flue gas in the chimney, due to condensation of condensables. The factor is low for optimal combustion conditions, but increases with more unfavourable combustion conditions, and it can be even higher than 10 by very bad combustion conditions.

Total PM[3], PN[4] particle size distribution (particle number in various size ranges), CO[5], VOC[6], PAH[7], PCDD/F[8] (dioxin) and odour was measured.

**Test results**

There is a comprehensive amount of results from the test, but only some of them are relevant for the evaluation of the emission reducing effect of the tested technologies. The relevant parameters are first of all the PM emission for all technologies, but it is most important for the three ESP's, which actively removes particles from the flue gas. The MoreCat catalyst should be able to reduce soot particles by catalytic combustion, but the main effect should be on the CO and OGC[9] emission (OGC is used synonymous with VOC). The Ecoxy Retrofit system should reduce the emission of particles, CO and OGC, by improving the combustion efficiency by introducing tertiary air

Additionally the emission of PAH, PCDD/F and odour is important for an evaluation of the potential reduction of toxic and carcinogenic compounds and the potential reduction of odour nuisances for neighbours.

## 1.1 General evaluation

The evaluation of the technologies is made with respect to the overall fact that according to the official used emission factors for stoves and boilers, the emission of particles, CO, VOC and PAH is on average at least 70 % and up to more than 90 % lower from the newest and most modern models compared to the oldest ones. Furthermore the consumption of wood is lower, because of higher efficiency. The emissions are reduced far less than this, by all the tested technologies, and none of them has an effect on both particles, CO, VOC and PAH.

In the attempt to give a better overview, the general evaluation of the tested technologies is made in relation to the different emission parameter separately.

**Total PM and soot particles**

The ESP technologies have no significant effect on the total PM emission, but some reducing effect on the emission of soot particles is visible from the colour of the plume of smoke and the filters used for sampling particulate matter. The best result was seen for the CleanAir ESP, where the colour of the filters from the PM measurements was light brown instead of black, eshowing that soot particles was removed very efficiently. It could also be seen from the field test that the soot particles in the plume of smoke clearly disappeared when the ESP was turned on.

[3] PM = Particulate Matter (measured in terms of mass)
[4] PN = Particle number (particle number measured in various size ranges)
[5] CO = Carbon monoxide
[6] VOC = Volatile Organic Compound (= OGC)
[7] PAH = Polycyclic Aromatic Hydrocarbon
[8] PCDD/F = PolyChlorinated DibenzoDioxin and dibenzoFuran
[9] OGC = Organic Gaseous Compound (= VOC)

The ESP technology is only capable of separating solid and liquid particles, and it has no effect on gaseous compounds. Although the soot emission is reduced significantly, then the emission of condensables is so big, that the reduction cannot be registered on the measurement of the total concentration of PM after cooling and condensation in the dilution tunnel. This is in good accordance with the 2 – 10 times higher result for PM measurement in dilution tunnel compared to chimney measurements, described in section 3.4 on page 25 ff.

### Ultra fine particles

None of the technologies has any significant reducing effect on the emission of ultra fine particles (particles smaller than 0.1µm in diameter) in terms of number. On the contrary there are strong indications that the ESP technology increases the emission of the number of ultra fine particles. This can be seen both in the laboratory tests and in the field test. The reason is very likely that when the large particles are removed and the flue gas subsequently is cooled down, the condensables will condense in the form of many ultra fine particles, instead of condensing on the larger particles and making them larger.

### Condensables

The three ESP devices have no effect on the emission of condensable (NMVOC[10]), except from the small part that has already condensed on the soot particles.

The MoreCat catalyst should be able to oxidize condensables, but the tests did not show any reduction. According to the MoreCat supplier, the reason could be a bad quality of the tested catalyst or it could be that the flue gas temperature was too low to start the catalytic oxidation.

The Ecoxy retrofit system should also be able to reduce the emission of condensables by improving the combustion, but the effect has not been large enough to be seen as a significant reduction of the condensables.

### PAH

There is no clear reduction of the PAH emission from any of the technologies. On the contrary there seems to be a small increase in the PAH emission by the ESP devices. Especially the CleanAir ESP gives a considerable increase in PAH concentration, even though it is the technology that clearly has the largest reduction in emission of soot particles, which usually contains the PAHs. A possible explanation for this apparently higher PAH emission is associated to the analysis procedure, where the PAH might be readily and completely extracted from a filter sample without soot particles, but only partly extracted from a filter with soot particles. It is recommended to investigate this possible problem with "increased" PAH emission, when removing the soot particles with an ESP.

The Swan wood stove has the lowest PAH emission, which is to be expected due to the more efficient combustion in a newer certified stove. The same is also expected for new boilers, which often have a very efficient combustion.

### PCDD/F

There was no effect on the emission of PCDD/F from any of the technologies.

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[10] NMVOC = Non-Methane Volatile Organic Compounds

### Odour

Odour is the main reason for most complaints on smoke nuisances, and there was no measurable effect from the MoreCat catalyst or the ESP technologies.

Some odour reduction by the MoreCat was expected, as it should reduce the VOC emission. It was not expected, that the ESP technologies would have any effect on the odour emission, as they only can remove particles, and the odour is normally gaseous compounds. It is also the experience of the manufacturer (APP) that the CleanAir ESP does not have any effect on the odour emission.

### Appearance and noise

None of the technologies will improve the looks of a wood stove or boiler, but some of them will be more disfiguring than others.

The Ecoxy retrofitting system is very neutral and only slightly visible and there is no noise from it. Its appearance will probably not keep anyone from using it.

The MoreCat catalyst is also very neutral in appearance, and it is not noisy at all. Even if it sits very visible just above the stove, most people will probably accept such a device in their living room.

The Zumikon ESP appears also quite neutral, but it has nevertheless a distinctive appearance with a box like a side pipe on the flue, and there is a 2 m long cable to the control box. Therefore the box must be located close to the stove, and it can be difficult to hide. Since some sparkling noise can come from the Zumikon, most people, and maybe especially the housewives, can be expected to be opposed to the presence of such a device in their living room. Most people would probably accept it, if it is mounted on a wood boiler, located in a basement, a scullery or an outbuilding.

The Airbox ESP is very large and heavy, and it will be highly visible and dominant on any wood stove, so it is expected that nobody will accept such one in their living room. Most people would probably accept if it is mounted on a wood boiler, located in a basement, scullery or an outbuilding.

CleanAir ESP appears quite big at close distance, but it does not look so big when it is mounted at the top of a chimney, so it will most probably be accepted by most people. However, there is some sparkling noise from it, which can be annoying inside the house close to the chimney, and this could be unacceptable for some people.

### Investment and maintenance cost

The total costs for installation and operation of the 5 tested technologies are especially difficult to predict for the three ESP, because the cost for installation depends on the actual condition, and because the cost for regularly cleaning of the CleanAir ESP depends on the necessary frequency, which again depends of how good the combustion is and how much the stove or boiler is used.

Installation costs and ongoing costs for some years for cleaning and maintenance of an ESP mounted on an existing old stove, will in many cases, be around the same level as for replacing it with a new approved type and possibly also a Swan Eco labelled model, which has significantly less emission for all the main pollutant, and not only for soot particles.

Replacing an old wood boiler with a new and more efficient one is much more expensive than replacing a wood stove, and also much more expensive than the cost for mounting and maintenance of an ESP, but for the environment and health effect, replacement is the best solution, as it reduces the emission of all main pollutant and not only the soot particles.

There are several benefits from replacing old wood stoves and -boilers with new, instead of installing an ESP:

- No extra work for regular inspection and cleaning of the ESP
- No extra cost for chimney sweeper inspection and cleaning
- No expenses for electricity and replacement of electrodes
- Higher efficiency, which means less firewood is needed to keep the same temperature
- Easier to fire and regulate the heat release
- Most new wood stoves have a modern and much more nice design than old ones

If considering installing any of the tested technologies on an older wood stove or –boiler installation, it is very important to involve all advantages and disadvantages, not only for the technology, but also for the alternative, to replace it with a new modern and much more effective one. There are obviously many disadvantages by all the technologies, especially the very limited effect on the total emission of all main pollutant, and it is very difficult to find any disadvantages by installing a new and modern stove or boiler, except for the relatively high cost for a new boiler.

## 1.2 Main conclusion

The main conclusion for the five tested technologies is made in relation to the aim of the project, which is:

- to evaluate and test technologies for flue gas cleaning and/or combustions improvements, which can be mounted on existing wood stoves and wood boilers

subject to the following conditions:

- existing wood stoves and boilers are mainly older appliances, which have much less efficient combustion than newer ones
- they have an substantial emission of condensables
- the emissions are measured in a dilution tunnel

All the technologies have a reducing effect on the emissions, but the efficiency is low or very low, depending on the compound.

A much more efficient way to reduce the emissions is to replace the older wood stove or boilers by new modern device, as new units have a documented much lower emission of all the pollutants CO, particles, condensables, PAH and most likely also odour.

Therefore it seems to be much more environmentally sustainable to work for a replacement of old wood stoves and boilers (older than 5 – 10 years) with new and more efficient ones, rather than trying to reduce the emissions from the incomplete combustion by installing an End of Line technology. It might only be possible to reduce the soot particle emission with the ESP technology and in some installations the CO and OGC emission with the catalyst technology.

The ESP technology seems to have the effect of increasing the emission of ultra fine particles in terms of number. In respect to health effects, ultra fine particles are of considerable concern. There was also found an indication that the measurable emission of PAH is increased by the ESP technology, which could mean an increased toxicity of the fine particles It is therefore strongly recommended to investigate this possible particle size distribution effect and potential PAH emission increase by the ESP, to clarify if the flue gas health effect is increased.

The overall conclusion is that the pollution from wood stoves and –boilers, older than 5-10 years, is reduced much more efficiently by replacing them with new approved ones, which for the stoves also could be Swan Eco labelled, rather than installing any of the tested technologies.

# 2 Sammenfatning og konklusion

Dette projekt havde til formål at identificere og afprøve egnede teknologier til røggasrensning og/eller forbedret forbrænding til eftermontering på eksisterende brændeovne og -kedler i Danmark, for at vurdere deres effektivitet med hensyn til reduktion af udledningen af de væsentligste forurenende stoffer i brænderøg.

Fem teknologier blev testet under kontrollerede forhold i laboratoriet, og efterfølgende blev nogle af dem testet ved at montere dem på passende brændeovne i private hjem.

De fem afprøvede teknologier var:
1. Zumikon ESP[11] fra Ruegg Cheminée AG, Schwiz.
2. Airbox ESP fra Spartherm Feuerungstechnik GmbH, Tyskland.
3. CleanAir ESP fra Applied Plasma Physics AS, Norge.
4. MoreCat Katalysator fra MoreCat GmbH, Tyskland.
5. Ecoxy Retrofit System til ældre brændeovne, fra ECOXY AS, Norge.

De fem teknologier blev først testet på en brændeovn på teststanden hos Teknologisk Institut (TI) i Århus. Det var kun de tre ESP filtre der blev testet på en kedel, for de to øvrige teknologier var ikke egnede til montering på kedler.

Testresultaterne blev sammenlignet med reference test for brændeovnen og kedlen. Der blev også gennemført en reference test med en moderne Svanemærket brændeovn til sammenligning.

Testene med brændeovn omfattede følgende faser: Optænding, genfyring to gange med høj ydeevne, efterfulgt af to gange genfyring med reduceret lufttilførsel. Denne fyrings procedure anses for at være meget lig den daglige brug af brændeovnen der er i mange husstande, hvor brændeovnen anvendes efter arbejdstid sidst om eftermiddagen og til sengetid om aftenen.
Kedlen blev tændt op og genfyret fire gange med høj belastning.

Test brændeovnen var en Morsø 1440, som er en konvektions brændeovn til mindre rum, som er produceret fra 1990 til 2007. Kedlen var en ældre VIADRUS Hercules U22 gennemforbrændings kedel fra den tjekkiske virksomhed VIADRUS. Den svanemærkede brændeovn var en Epoca fra Rais AS.

Det overordnede princip for testene var, at måle og registrere emissionen af forurenende stoffer fra skorstenen til det omgivende miljø, og især måle de mest korrekte tal for bidrag af partikler til den omgivende luft. Når røggassen afkøles på sin vej gennem skorstenen, kondenserer indholdet af kondenserbare stoffer[12] (bl.a. tjærestoffer) og danne partikler som spredes i den omgivende luft, og for at få de partikler med i målingerne, udførtes de i en fortyndingskanal. Flere referencer dokumenterer, at partikelkoncentration,

[11] ESP = ElectroStatic Precipitator = Elektrofilter
[12] Kondenserbare stoffer er uforbrændte organiske stoffer fra forbrændingen (VOC), som ved afkøling kondenserer til partikler.

målt i en fortyndingskanal, er mellem 2 og 10 gange højere, end hvis der måles i den varme røggas i skorstenen, på grund af kondensering af condensables. Faktoren er lav for optimal forbrænding, men stiger med mere ugunstige forbrændingsforhold, og den kan være endnu højere end 10 ved meget dårlig forbrænding.

Der blev udført målinger af PM[13], PN[14] partikelstørrelsesfordeling (partikelantal i forskellige størrelsesintervaller), CO[15], VOC[16], PAH[17], PCDD/F[18] (dioxin) og lugt.

**Testresultater**
Der er en omfattende mængde af resultaterne fra testen, men kun nogle af dem er relevante for evalueringen af den emissions reducerende effekt af de undersøgte teknologier. De relevante parametre er først og fremmest PM emissionen, som dog er specielt vigtig for de tre ESP filtre, som aktivt fjerner partikler fra røggassen. MoreCat katalysator skulle også kunne reducere emissionen af sodpartikler ved den katalytiske forbrænding, men hovedeffekten skulle være reduktion af CO og OGC[19] (OGC bruges synonymt med VOC). Ecoxy Retrofit systemet skulle reducere emissionen af både partikler, CO og OGC, fordi forbrændingens effektivitet skulle forbedres ved tilførsel af tertiær luft

Derudover er udledning af PAH, PCDD/F og lugt vigtigt for evaluering af potentialet for reduktion af giftige og kræftfremkaldende stoffer og reduktion af lugtgener for naboer.

## 2.1 Generel vurdering

Ifølge de officielt anvendte emissionsfaktorer for brændeovne og kedler, er udledningen af partikler, CO, VOC og PAH i gennemsnit mindst 70% og op til mere end 90% lavere fra de nyeste og mest moderne modeller i forhold til de ældste, og evalueringen af de testede teknologierne er lavet under hensyn til dette forhold. Desuden er forbruget af brænde lavere for nye brændeovne og kedler, på grund af deres højere virkningsgrad. Emissionerne er med alle de testede teknologier reduceret langt mindre end den reduktion der kan opnås med nye brændeovne og kedler. Desuden har ingen af teknologierne en reducerende effekt på både partikel, CO, VOC og PAH.

Den generelle evaluering af de testede teknologier foretages separat i forhold til de forskellige emissions parametre, i håbet om at give læseren et bedre overblik.

**Total PM og sodpartikler**
ESP teknologierne har ingen signifikant effekt på den samlede PM emission, men nogen reducerende effekt på emissionen af sodpartikler kan observeres, dels på røgfanens farve og på sværtningen af de filtre, der anvendes til prøvetagning af partikler. Det bedste resultat blev set for CleanAir ESP, hvor farven af filtrene fra PM målingerne var lys brun i stedet for sort, hvilket viser

[13] PM = Particulate Matter = total indhold af partikulært stof (masse).
[14] PN = Particle number = Partikel antal (antal partikel målt i forskellige størrelsesintervaller)
[15] CO = Carbon monoxide = kulilte
[16] VOC = Volatile Organic Carbon (= OGC)
[17] PAH = Polycyclic Aromatic Hydrocarbon
[18] PCDD/F = PolyChlorinated DibenzoDioxin and dibenzoFuran
[19] OCC = Organic Gaseous Compound (= VOC)

at sodpartiklerne er effektivt reduceret. I felt testen kunne det også tydeligt ses, at sodpartiklerne i røgfane forsvandt når ESP filteret blev tændt.

ESP filtrene er kun i stand til at udskille faste og flydende partikler, og det har ingen effekt på gasformige stoffer. Selvom emission af sod er reduceret betydeligt, så er udledningen af kondenserbare stoffer så stor, at sodreduktionen ikke kan registreres på målingen af den samlede koncentration af PM, som foretages efter afkøling og kondensering i fortyndingskanalen. Dette er i god overensstemmelse med det 2 - 10 gange højere resultat for PM måling i fortyndingskanal i forhold til måling i skorstenen, som beskrevet i afsnit 3.4 på side 25 ff.

Ultrafine partikler
Ingen af de testede teknologier har nogen signifikant reducerende effekt på emissionen af ultrafine partikler (antal partikler mindre end 0,1 µm i diameter). Tværtimod er der stærke tegn på, at ESP filtre kan øge udledningen af antallet af ultrafine partikler. Det kan ses både i laboratorieforsøgene og i felttesten. Årsagen er sandsynligvis, at når de store sodpartikler fjernes og røggassen efterfølgende køles ned, vil de kondenserbare stoffer kondensere i form af mange ultrafine partikler, i stedet for at kondensere på de større partikler og gøre dem større.

Kondenserbare stoffer
De tre ESP filtre har ingen effekt på udledningen af kondenserbare stoffer (NMVOC[20]), bortset fra den lille del, der allerede er kondenseret på sodpartikler hvor ESP filteret er monteret.

MoreCat katalysator skulle være i stand til katalytisk at oxidere CO og kondenserbare stoffer, men testene viste ingen reduktion. Ifølge MoreCat leverandøren, kan årsagen være en dårlig kvalitet af katalysatormassen i den testede enhed eller at røggastemperaturen bare har været for lav til at starte den katalytiske oxidation.

Ecoxy Retrofit system skulle være i stand til at reducere udledningen af kondenserbare stoffer ved at forbedre forbrændingen, men effekten har ikke været stor nok til at være en signifikant reduktion.

PAH
Ingen af de testede teknologier viser nogen klar reduktion af PAH emissionen. Tværtimod synes der at være en lille stigning i PAH udledningen med ESP filtrene. Især CleanAir ESP giver en betydelig stigning i PAH koncentration, selv om det er den teknologi, der klart har den største reduktion i udledning af sodpartikler, som normalt indeholder PAH'erne. En mulig forklaring på denne tilsyneladende stigning i PAH emissionen kan være relateret til analysen, hvor PAH kan være nem at opløse fuldstændigt fra et filter uden sodpartikler, hvor det måske kun delvist opløses fra et filter med sodpartikler. Det anbefales at undersøge dette mulige problem med "øget" PAH emissioner, når sodpartikler er fjernet med et ESP filter.

Den svanemærkede brændeovn har den laveste PAH emission, hvilket er forventeligt på grund af den mere effektive forbrænding i en nyere svanemærket brændeovn. Det samme forventes også at gælde for nye kedler, som ofte har en meget effektiv forbrænding.

[20] NMVOC = Non-Methane Volatile Organic Compounds

### PCDD / F

Der var ingen effekt på emissionen af PCDD/F fra nogen af de testede teknologier.

### Lugt

Lugt er den hyppigste årsag til klager over røggener, og der var ingen målbar effekt fra hverken MoreCat katalysatoren eller ESP filtrene.

Der var forventet nogen lugtreduktion over MoreCat katalysatoren, da den skulle kunne reducere VOC emissionen, som omfatter de lugtende stoffer. Det var ikke forventet, at ESP filtrene ville have nogen effekt på lugtemissionen, da de kun kan fjerne partikler, som ikke er årsag til lugten. Det er også den erfaring, som er oplyst fra leverandøren af CleanAir ESP, at den ikke har nogen effekt på lugtemissionen.

### Udseende og støj

Ingen af de testene teknologier er specielt kønne, så de vil ikke forbedre udseende af en brændeovn eller kedel, men nogle af dem er mere skæmmende end andre.

Ecoxy er meget neutral og kun lidt synlige fordi den er monteret på bagvæggen af brændkammeret, så dens udseende vil formentlig ikke holde nogen fra at benytte den.

MoreCat katalysator er også meget neutral i udseende, og den giver ingen støj, så selv om den sidder meget synligt i røgrøret lige over brændeovnen, vil de fleste nok kunne acceptere sådan en i stuen.

Zumikon ESP der monteres i røgrøret lige efter ovnen synes også ganske neutral, men den har alligevel et karakteristisk udseende med en stor udvækst på røret, og der er et 2 m langt kabel til kontrolboksen. Denne boks skal derfor være placeret tæt på ovnen, og den kan være svær at skjule. Der kan også være en del støj fra springende gnister, så man må forvente at de fleste mennesker, og måske især husmødre, ikke vil acceptere sådan en synlig anordning i deres stue. De fleste mennesker vil nok kunne acceptere, hvis den er monteret på en træfyret kedel, der er placeret i en kælder, et bryggers eller et udhus (hvis støjen ikke generer).

Airbox ESP er meget stor og tung, og den vil være meget synlig og dominerende på enhver brændeovn, så det må forventes, at ingen vil acceptere sådan en i deres stue. De fleste mennesker vil nok acceptere, hvis den er monteret på en træfyret kedel, der er placeret i en kælder, et bryggers eller i et udhus.

CleanAir ESP synes ganske stor på tæt afstand, men den ser ikke så stor ud, når den er monteret på toppen af en skorsten, så det vil sandsynligvis blive accepteret af de fleste mennesker. Der kan også være en del støj fra springende gnister, som kan være hørbart inde i huset tæt ved skorstenen, og det vil formodentlig være uacceptabelt mange steder.

### Investering og vedligeholdelsesomkostningerne

De samlede omkostninger til installation og drift af de 5 testede teknologier er vanskeligt at forudsige. Specielt vanskeligt er det for de tre ESP filtre, fordi omkostningerne til installation afhænger af de faktiske forhold hvor de skal installeres, og fordi omkostningerne til jævnligt rengøring, afhænger af den nødvendige hyppighed, som igen afhænger af hvor god forbrændingen er, og hvor meget ovnen eller kedlen bruges. Omkostningerne til rengøring vil specielt kunne være høje for CleanAir, fordi den skal renses fra taget.

Installationsomkostninger og løbende omkostninger i nogle år for rengøring og vedligeholdelse af en ESP monteret på en eksisterende brændeovn, vil i mange tilfælde være omkring samme niveau, som det vil koste at skifte til en ny og evt. svanemærket brændeovn, som har en betydeligt mindre emission af alle væsentlige forurenende stoffer.

Udskiftning af en ældre træfyret kedel med en ny og mere effektiv model er meget dyrere end at udskifte en brændeovn, og også meget dyrere end prisen for montering og vedligeholdelse af en ESP, men i forhold til den miljø- og sundhedsmæssig effekt, er udskiftning den bedste løsning, da det vil reducerer udslippet af alle de vigtigste forurenende stoffer, og ikke kun sodpartikler.

Der er flere fordele ved udskiftning af gamle brændeovne og- kedler med nye, i stedet for at installere en ESP:

- Intet ekstra arbejde for regelmæssig inspektion og rengøring af ESP
- Ingen omkostninger til ekstra skorstensfejer-inspektion og rengøring
- Ingen udgifter til el og udskiftning af elektroder
- Højere effektivitet, hvilket betyder mindre brændeforbrug til at opretholde den samme temperatur
- Lettere fyring og regulering af varmeafgivelsen
- De fleste nye brændeovne har et moderne og meget flottere design end de gamle

Hvis man overvejer at installere nogen af de testede teknologier på en ældre brændeovn eller -kedel, er det meget vigtigt at inddrage alle fordele og ulemper. Det gælder ikke kun for teknologien, men i høj grad også for alternativet, som er at skifte til en ny moderne og meget mere effektive brændeovn eller -kedel. Der er mange ulemper ved alle de testede teknologier, navnlig den meget begrænsede effekt på det samlede udslip af alle de væsentligste forurenende stoffer, og det er meget svært at finde ulemper ved at skifte til en ny og moderne brændeovn eller kedel, bortset fra de relativt høje omkostninger for installation af en ny kedel.

## 2.2 Hovedkonklusionen

Hovedkonklusionen for de fem testede teknologier er lavet i relation til formålet med projektet, som er:

- at evaluere og afprøve teknologier til røggasrensning og/eller forbrændingsforbedring, som kan monteres på eksisterende brændeovne og brændekedler

under følgende betingelser:

- eksisterende brændeovne og brændekedler er hovedsagelig ældre apparater, som har langt mindre effektiv forbrænding end nyere
- de har en betydelig udledning af kondenserbare stoffer
- emissionerne måles i en fortyndingskanal

Alle teknologier har en reducerende effekt på udledningen af forurenende stoffer, men effektiviteten er lav eller meget lav, afhængig af stoffet.

En langt mere effektiv måde at reducere emissionerne på er, at erstatte den ældre brændeovn eller -kedel med en ny moderne model, som har en dokumenteret meget lavere udledning af alle de væsentlige forurenende stoffer CO, partikler, kondenserbare stoffer (VOC), PAH og sandsynligvis også lugt.

Det synes derfor langt mere miljømæssigt bæredygtigt, at arbejde for en udskiftning af gamle brændeovne og -kedler (ældre end 5 - 10 år) med nye og mere effektive modeller, frem for at forsøge at reducere emissionerne ved at installere en renseteknologi. Det er tilsyneladende kun muligt, at reducere sod emissionen og ikke den totale partikelemission med ESP filtre, og i nogle installationer kan CO og OGC emission måske reduceres med katalysator teknologi.

ESP filtrene synes at have den virkning, at de øger udledningen af ultrafine partikler målt på antallet. Ud fra en sundhedsmæssig vurdering, er det emission af ultrafine partikler de giver anledning til mest bekymring. Der er også fundet en indikation på, at den målbare emission af PAH stiger ved anvendelse af ESP filter, hvilket kan betyde en øget toksicitet af de ultrafine partikler Det anbefales derfor, at undersøge denne mulige effekt på partikelstørrelsesfordelingen og den potentielle stigning i PAH emissionen ved anvendelse af ESP filtre, for at afklare, hvordan det påvirker røggassen sundhedsmæssige effekter.

Den overordnede konklusion er, at forureningen fra brændeovne og -kedler, ældre end 5-10 år, reduceres langt mere effektivt ved at erstatte dem med nye godkendte modeller, som for brændeovne også kan være svanemærkede, snarere end at installere nogen af de afprøvede teknologier.

# 3 Introduction and methodology

The purpose of this project has been to identify and test suitable technologies for flue gas cleaning and/or combustion improvement for use on existing wood stoves and boilers in Denmark in order to assess their efficiency regarding reduction of emission of the most important pollutants in wood smoke.

Selected technologies were tested in the laboratory under controlled conditions and some of these technologies were also tested in the field, by mounting them on appropriate stoves and/or boilers in one or more residential quarters in the heating season 2008/09. The field tests included a campaign with outdoor air quality measurements in order to assess the efficiency of one of the technologies.

Furthermore, the tests should try to clarify and describe advantages and disadvantages as well as possible problems with mounting, operation and maintenance of the technologies.

During the laboratory test in the first part of the project, it became clear that more laboratory tests than originally planned would be necessary to obtain a satisfactory evaluation of the technology performance. Consequently this part of the project was extended, and the field test part was reduced accordingly.

## 3.1 Principle for test

The overall principle for the test was to measure and register the resulting pollution in the environment around the chimney, and the potential for the technologies to be accepted and installed by ordinary wood stove and boiler owners.

This was done in two ways:

1. The test is made by using a dilution tunnel, as it will give the most correct result for the contribution of particles to the ambient air, as condensable gases will form particles when the flue gas is cooled throughout of the chimney. Therefore measuring in a dilution tunnel gives the best basis for an evaluation of the possible health impact from the particles in the flue gas.

2. The technologies are tested as if they were installed in a normal house, and no special efforts were taken to achieve the best possible performance of the technologies. People participating the field test was interviewed to give their opinion on the cost and appearance of the technology.

## 3.2 Project organization

The project is organized in the following sub tasks:

Sub task 1. Invitation of technologies by EU tender
Sub task 2. Selection of technologies for laboratory test
Sub task 3. Laboratory test
Sub task 4. Selection of technologies for field test
Sub task 5. Selection of houses for field test
Sub task 6. Field test, including outdoor air measuring at one site
Sub task 7. Evaluation and reporting

### 3.2.1 Sub task 1. Invitation of technologies

The project was started by an invitation to European producers and suppliers of products, methods or technologies for flue gas cleaning and/or combustion improvement which are suitable for after-mounting in or on existing wood stoves and wood boilers.

The invitation of technologies has officially taken place with the EU tender no. 2008/S 97-130806, where the whole text is only available in Danish. Attached is an English translation of the main parts of the EU Tender, containing a description of the background and purpose of the project (see Appendix 1).

The present material was also distributed directly to relevant companies and persons in Europe, which the consortium and/or the Danish Environmental Protection Agency knew or considered, could have an interest in the tender. The material was also distributed to everyone who applied with a request of more information about the tender, for instance on basis of the EU tender.

Written expression of interest in Danish or English as described in the EU tender should be delivered to the inviting company addressed below by mail or post on Thursday 26th of June 2008 at 12:00 AM, at the latest.

FORCE Technology
Att.: Project Manager Ole Schleicher
Park Allé 345
DK-2605 Brøndby
Email: osc@force.dk
Phone: +45 43 26 75 40
Cell phone: +45 22 69 75 40

Mr. Schleicher was also assisting with any questions regarding the project, expression of interest and the necessary documentation, by mail or phone.

Regarding the very short time limit, a short expression of interest was accepted, if the requested documentation was delivered by Friday 4th of July 2008 at the latest.

### 3.2.2 Sub task 2. Selection of technologies for laboratory test

Information's about the technologies and the manufacturer was collected, and further information was sought on the internet.

The applicability of the different technologies for mounting on typical Danish wood stove and wood boilers was evaluated based on knowledge about the typical installations in Denmark. The technologies should in general be applicable to the major part of the typical Danish installations. The criteria for being applicable for typical Danish installations, includes observing the Danish regulations for residential stove, boiler and chimney installations, and the regulations for electrical installations.

The technologies applying to participate in the project was evaluated in a meeting with the Danish EPA, and the technologies to be tested were selected. Five technologies were expected to be selected, as it was the number the project economy was based on, but the number was naturally depending of the number of technologies applying for attending the project. The number could be higher or lower as well, in return for an adjustment of the number of tests, measurements and analysis performed in the test.

### 3.2.3 Sub task 3. Laboratory test

The selected technologies for reduction of flue gas emissions were tested on a wood stove and a wood boiler, at the approved stove and boiler test facility of the Technological Institute (TI) in Aarhus.

The TI test centre is fully equipped to make test on wood stoves and small boilers for wood and pellets, according to the CEN standard EN 13240 and the Norwegian standards NS 3058 and NS 3059.

### 3.2.4 Sub task 4. Selection of technologies for field test

Based on the results of the laboratory test and an evaluation of the suitability for a general installation and use of the technologies in typical Danish wood stoves and boiler installations, technologies for field test were selected.

### 3.2.5 Sub task 5. Selection of houses for field test

The stove- or boiler installation in the participating households shall represent different types of installations regarding age, type, chimneys etc. The selected housing sector(s) shall be representative for common Danish living quarters, for instance single-family houses and terrace houses.

### 3.2.6 Sub task 6. Field test

In connection with the field test information was collected to describe:

1) Characterization of the combustion plants in the participating households, including:
    a) stove/boiler type and age
    b) chimney type and height
    c) fuel type, origin, moist content and consumption
2) The mounting process of the different technologies, including:
    a) technical challenges and solutions as well as the aesthetic consequences (inside and outside)
    b) financial costs for purchase and mounting
    c) reversibility of the installation
    d) other relevant conditions of importance for the mounting
3) The practical use, including:
    a) user-friendliness and operation stability
    b) resource consumption (for instance power consumption)
    c) waste generation and waste removal as well as possible environmental and working environmental influences of this, for

instance noise
   d) other relevant conditions of importance for the practical use of the technologies
4) Effect on air quality, including:
   a) measurement of air quality in an area with attached cleaning technology
   b) users' and neighbours' opinion of the air quality

### 3.2.7 Sub task 7. Evaluation and reporting

The test results, evaluation of the test results and evaluation of the applicability of the technologies to be mounted on typical Danish wood stove and boiler installations should be presented in a report in English (this report).

## 3.3 Particles from small scale wood combustion

The particulate emission from manual fired residential wood stoves and boilers is greatly influenced by the unsteady and incomplete combustion conditions which are always associated to manual firing.

The potential combustion efficiency is basically defined by the design, but it is also greatly affected by how the wood stove or boiler is operated and the size and quality of the firewood. It is well known, that the emission of particles from older stoves and boilers in general is much higher than from new modern ones, even if they are operated in the most optimal way.

There is also a clear difference in the particle mass emission, the particle distribution and the chemical composition, depending on the efficiency of the combustion. There is also varying concentration of particles in the flue gas, from the combustion zone, up through the chimney and the resulting contribution to the particle concentration in the surrounding air.

The particles basically consist of two different fractions: Unburned material (soot, tar and other organic compounds) and inorganic material (ash).

The amount of unburned material, which is the majority of the particle emission, is directly correlated to the combustion efficiency. It can be further divided in two fractions: Soot (inorganic carbon) and condensables (organic carbon).

Basically the soot consists of solid carbon, and it is formed right after the flames in the combustion chamber. The soot concentration is basically stable throughout the chimney, but the soot particles are growing by agglomeration and condensation of tar and condensables on the soot particles, when the flue gas is cooled down throughout the chimney. A part of the tar and condensable will also condense to form liquid droplets (which is inside the definition of particles). The organic condensed part of the particles is the main reason for the different concentration which can be measured, depending on the flue gas temperature up through the chimney and in the surrounding air.

The ash particles, which originate from the inorganic part of the wood, will always remain as by products from the combustion, regardless of the combustion efficiency. These particles can either be ash particles withdrawn from the ash layer by high enough flue gas flow, or evaporated inorganic salts which condense when the flue gas is cooled down. Formation and emission of ash particles is consequently affected by temperature and air/gas velocity (excess air) in the combustion zone.

The ash particle emission from manual fired wood stoves and boilers are in general a minor part of the particle emission. There is a tendency to have a slightly increased emission of ash particles from newer appliances with improved combustion, because of a higher combustion temperature, giving more evaporation of salts, and maybe also a higher withdraw of ash particles from the grate, because of smaller combustion chambers and higher flue gas flow.

### 3.4 Particle measuring procedures

Particle measurements on wood stoves and wood boilers can either be made directly in the chimney according to DIN+ and EN 13240, or in a dilution tunnel according to the Norwegian standard NS 3058/3059.

The concentration of particles measured according to these two procedures will not be the same, as higher concentrations will always be present in the dilution tunnel, and the difference can be relatively big. The reason is the condensables in the flue gas that will condense to liquid or solid particles, when the flue gas is cooled down.

Several investigations of the differences between measuring particle in the chimney and in a dilution tunnel have been summarized by Linda S. Bäfver[21]. The conclusion is that the concentration measured in the dilution tunnel can be 2 - 10 times higher than the one measured in the chimney, with the highest difference for appliances having less efficient combustion, and the lowest differences for the ones with more efficient combustion.

Older stoves and boilers have in general less efficient combustion compared to newer ones, which are designed for a much more efficient combustion. Today most of the wood stoves on the Danish market are eco labelled with the Swan, which means, that the emission of particles measured in a dilution tunnel is less than 5 g/kg wood. Older wood stoves, of which still many exist in Denmark, potentially have a particulate emission which is several times higher than the eco labelled ones.

In a Norwegian study referred by the Nordic Council of Ministers, the emission of particles from older stoves was around 30 g/kg wood[22]. In a Danish project the particulate emission was measured from several houses in Gundsømagle, and the emission was from 5 to 80 g/kg wood[23,24].

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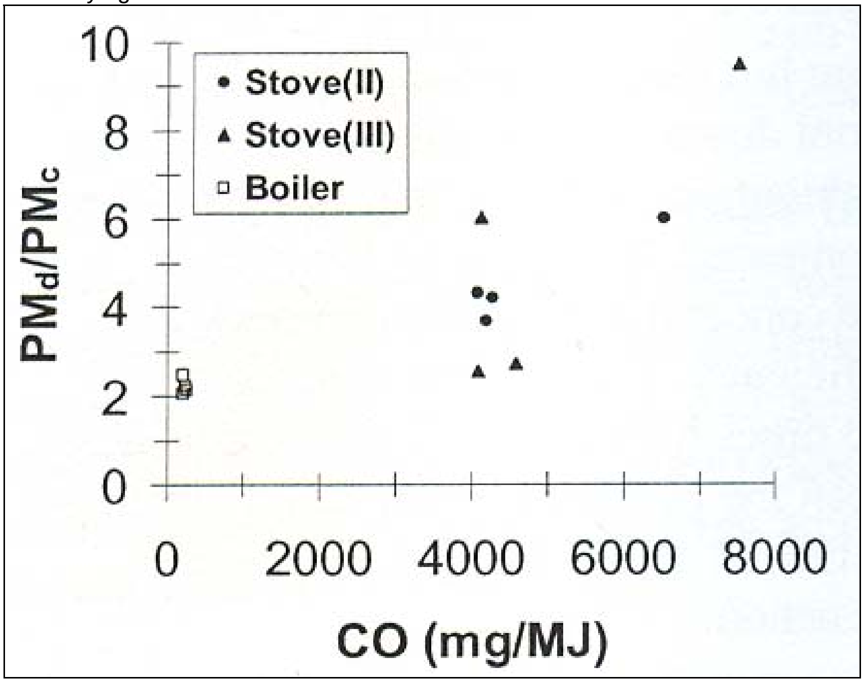
[21] Linda S. Bäfver. Particles from biomass combustion -Characteristics and influence of additives. Chalmers University of Technology. 2008. ISBN 978-91-7385-177-0.
[22] http://www.ecolabel.dk/presse/pressemeddelelser/Halveringafpartikleribraendeovne.htm
[23] Glasius M. Konggsgaard P. Stubkjær J. Rossana B. Hertel O. Ketzel M. Wåhlin P. Schleicher O. Palmgren F. Partikler og organiske forbindelser fra træfyring – nye undersøgelser af udslip og koncentrationer. Arbejdsrapport fra DMU nr. 235, 2007. http://www2.dmu.dk/Pub/AR235.pdf
[24] Glasius M. Vikelsøe J. Bossi R. Andersen H.V. Holst J. Johansen E. Schleicher O. Dioxin, PAH og partikler fra brændeovne. Arbejdsrapport fra DMU nr. 212, 2005. http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR212.pdf

The span of the differences between particle concentrations measured in the chimney and in a dilution tunnel referred to by Linda Bäfvel is shown in Figure 1. Test conditions for the Stove(II) test is burn rate II according to NS3058-1 (1.25 – 1.9 kg/h), and burn rate III (1.91 – 2.8 kg/h) for Stove(III). The actual burn rate was on average 1.5 and 2.2 kg/h respectively. Test conditions for the boiler were nominal load with an average burn rate of 9.9 kg/h.

Figure 1. Ratio of particles measured in dilution tunnel to measurements in the chimney against the CO concentration




The particulate emission per kg wood fuel measured in the dilution tunnel is 4.2 – 6.1 g/kg for Stove(II) and 5.3 – 8 g/kg for Stove(III), which is well below the Danish limit value for stoves of 10 g/kg. For the boiler, the average emission is 80 mg/Nm$^3$ at 10 % $O_2$, which is also well below the Danish limit value of 150 mg/Nm$^3$. There is no explanation on the stove and boiler type and age, but from the measured emissions, it is clear that they are modern types, with a potential of efficient combustion. Older stoves and boilers, with less potential for efficient combustion, and operated by ordinary people, without specific skills for optimal operation and efficient combustion, might have a much bigger emission of particles, especially from condensables. Consequently the differences between measurement in the chimney and dilution tunnel for older appliances could be bigger, and maybe even much bigger, than the factor 10.

The criteria for CO for the Swan eco labelling for stoves is less than 2.500 mg/m$^3$ at 13 % $O_2$, which is app. 1600 mg/MJ. Older stove can exceed the limit of 1 % CO in the voluntary Danish DS 887 certification from 1990, which is app. 8500 mg/MJ. This also indicates that for older stoves the particle concentration measured in a dilution tunnel could be even more than 10 times bigger compared to measurement in the chimney.

The differences in the two sampling points is also seen in the Danish wood Statutory Order for wood burners[25], which has different emission limit values for the two measuring points, as shown in Table 1.

The emission limit value for particulate emission from wood stoves and wood boilers is strongly connected to the sampling point, because the amount of particles in the flue gas depends on the temperature. This discrepancy can also be seen in the Danish Wood Burning Order, where an emission limit value is set for each of the two sampling point, and only one of them has to be fulfilled (see Table 1).

Table 1. Emission limit values and sampling points in the Danish Wood Burning Order

| Emission requirements for particles (upper limit) | Measuring principle | Testing method |
|---|---|---|
| 10 g/kg, and maximum emission of 20 g/kg in the individual testing intervals | Dilution tunnel | NS 3058-1 and NS 3058-2 (calculated according to NS 3059, class 1 or 2, depending on the size of the firing installation) or a similar standard for measuring particle emissions recognised in the EU, EFTA countries or Turkey. |
| 75 mg/Nm$^3$ at 13 % O2 | Chimney | Measuring method in accordance with DIN+, Zertifizierungsprogramm, Kaminöfen für feste Brennstoffe mit schadstoffarmer Verbrennung nach DIN EN 13240 or similar standard for measuring particle emissions recognised in the EU, EFTA countries or Turkey. |

The limit value of 10 g/kg measured in a dilution tunnel is equal to app. 826 mg/Nm³ at 13 % $O_2$ (12.1 Nm³ at 13 % $O_2$ flue gas/kg wood). This is 11 times more than the limit value of 75 mg/Nm³ at 13 % $O_2$ for measurements in the chimney.

The conclusion in the paper referred to by Linda Bäfvel is:

- The value of particle concentration measured in the dilution tunnel was between 2 and 10 times higher than the corresponding values measured in the chimney.
- The more unfavourable combustion conditions, the larger differences between the measurement methods were seen.
- At poor combustion conditions, repeated measurements at the same thermal output gave more scattered particle concentrations.
- The higher particle concentration measured in the dilution tunnel, compared with in the chimney, is due to organic tar compounds.

Measuring the particle emission in a dilution tunnel gives the best value for the contribution of particle to the ambient air, and thereby also the best basis for an evaluation of the possible health impact from the particles in the flue gas.

The conclusion for this project is:

1. Test shall be done by measuring in a dilution tunnel, as it gives the best figure for the contribution to the outdoor air pollution, and its potential health effect.

[25] Bekendtgørelse om regulering af luftforurening fra brændeovne og brændekedler samt visse andre faste anlæg til energiproduktion (Brændeovnsbekendtgørelsen). BEK nr. 1432 af 11/12/2007. An unofficial and not legal valid translation to English is available from: Statutory Order regulating air pollution from wood burners and boilers and certain other fixed energy-producing installations.

2. Newer wood stoves and boilers, with modern combustion technology, which are optimal fired to achieve an efficient combustion, might have a factor in the lower end of the 2 -10 span for particles measured in dilutions tunnel and in the chimney, and the best appliances might be around 2. Older appliances might be in the upper part of the 2-10 span, and the worst of them will probably be even higher than 10.
3. When measured in a dilution tunnel, technologies to reduce the particle emission by separation in the chimney are expected to be most efficient for new stoves and boilers having low emission of condensables and much less efficient for older ones having high emission of condensables.

The aim of the project is existing installations and the test and evaluation of the technologies must reflect this, by using older and widespread used stove and boiler for the test. They will consequently have less efficient combustion and high emission of condensables, and the relationship between particles measured in a dilution tunnel compared to the chimney, is expected to be in the higher end of the interval of 2-10, or maybe even higher than 10. This will influence the results of technologies to separate particles in the chimney.

# 4 Technologies

Eight technologies applied for participation in the project, and from an intensive evaluation of the technologies, three of them was found to be either outside the criteria for the project or didn't had any reliable or valid documentation for an reducing effect on the emission from residential wood stoves or boilers.

## 4.1 Technologies selected for laboratory test

The five technologies selected for the laboratory test is presented and described in the following paragraphs. Three of the technologies are **E**lectro**S**tatic Precipitators, which are consequently abbreviated to ESP in the rest of the report. The operating principle for ESP is, that the particles in the flue gas is electric charged, when passing a high voltage electrode (10 – 35 KV). After the electrode the particles will be attracted to any surface, and they will stick to the surface.

One is a catalyst and the last one is a retrofit system, which introduce tertiary combustion air.

### 4.1.1 Zumikon ESP

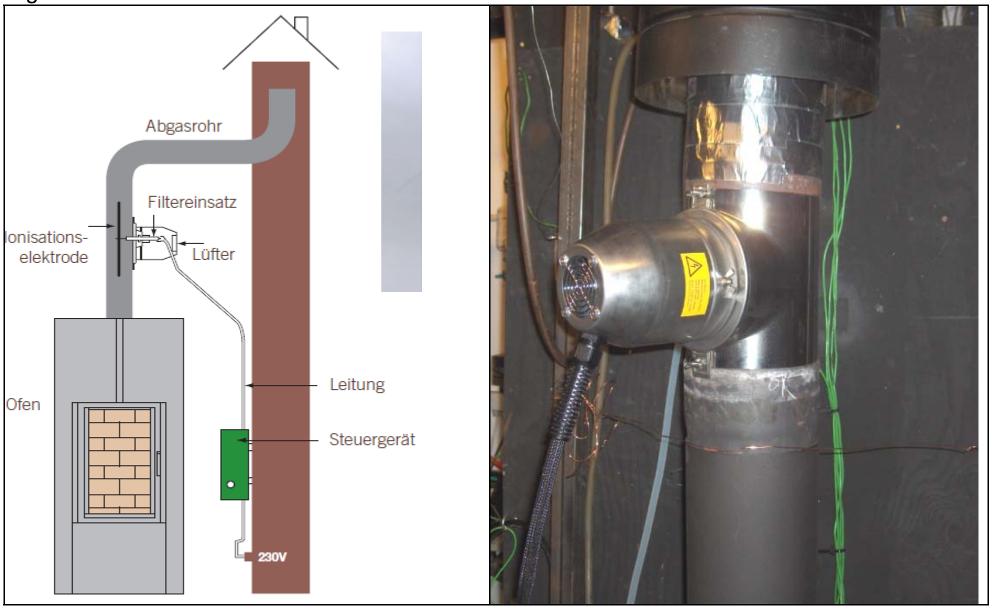
The Zumik®on ESP is manufactured by the company:

Rüegg Cheminée AG
Schwäntenmos 4
8126 Zumikon
Schweiz
www.ruegg-cheminee.com

The Zumikon ESP can be mounted anywhere in a steel flue in the chimney, but there shall be at least 1.5 m steel duct after the ESP, to ensure the precipitation of the charged particles.

The filter is powered by a voltage of approximately 10,000 Volt. There is practically no drop of pressure above the unit. The unit is relatively easy to install and does not occupy a lot of space in the room.

Figure 2. The Zumikon ESP




The filter is commercial available from several vendors in Switzerland and Germany for a price of app. € 960 (information from the company in 2008). Rüegg Cheminée AG is also offering courses for vendors and erectors.

A comprehensive amount of documentation of the particle reducing effect is available, e.g. field test of 18 units, where the particle removal efficiency was between 50 and 95 % for gravimetric measurements. A removal efficiency of 62 - 76 % for ultra fine particles measured with a particle counter is also reported.

The high voltage for the ESP is generated in a separate control box connected to the ESP with a 2 metre cable. The ESP is automatically turned on and off at a flue gas temperature of 50 °C.

It is recommended to have the ESP cleaned regularly by the chimneysweeper, and the frequency depends on the use of the stove and the combustion efficiency.

More detailed information and explanation of the function of the Zumikon is available from the homepage
www.ruegg-cheminee.com/ww/de/pub/produkte/partikelabscheider.htm

### 4.1.2 Airbox ESP

The Airbox ESP is manufactured by the company:

Spartherm Feuerungstechnik GmbH
Maschweg 38
D-49324 Melle
Germany
www.spartherm.com

The Airbox ESP can be mounted anywhere in the flue after stoves and boilers but it has to be indoor, as it is not constructed for outdoor placement, even though the left picture in Figure 3, which is from the manufactures brochure, is showing an outdoor placement. Because of the size and weight, it is most realistic to mount it directly on top of the stove or boiler.

Figure 3. The Airbox ESP

Documentation for the effect and efficiency on reduction of particle emission is sparingly, as final test has not yet been published. Spartherm has stated that test has been carried out, and the documentation will be presented shortly.

A flyer from the company's homepage claims, that the particle reduction is at least 60 % emission. A reduction of fine particles with 65-80 % was measured with a particle counter.

The Airbox is commercial available, and the price is app. € 1,400 (information from the company in 2008).

Spartherm has a Danish representative for sale of the wood stoves, which are the main product from the company, but the Airbox is apparently not marketed in Denmark.

The Airbox is installed on the stove or boiler flue exit. It can be mounted anywhere in the flue system, but this is limited by the relatively big size and weight.

The high voltage of app. 20,000 Volt for the ESP is generated in a control box mounted on the ESP. The ESP is automatically turned on and off at a flue gas temperature of 60 °C.

There is some drop of pressure over the unit, partly due to the several bending the flue has to pass and partly due to the cooling of the flue gas through the filter. By lighting up the fire the pressure drop can be reduced by turning a bypass damper, which then leads the flue gas direct up through the filter.

The Airbox ESP is relatively big and heavy, and it is more suitable for wood boilers than for wood stoves. It is recommended to be cleaned after each 100 running hours, and it can easily be done by the user in 15 minutes.

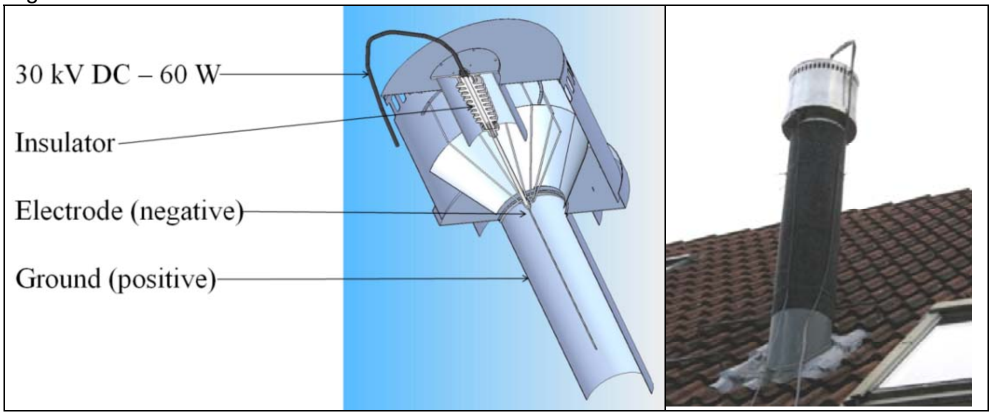
### 4.1.3 CleanAir Electrostatic Precipitator

The CleanAir ESP has been developed by the company:

Applied Plasma Physics AS
Bedriftsveien 25
4313 Sandnes
Norway
www.app.no

The CleanAir ESP has to be mounted on top of the chimney, by just lowering the pipe down into the chimney opening. The prototypes for the test had a pipe fitting for a 150 mm flue, which is the most common flue size in Denmark. The chimney and the pipe on the CleanAir shall fit to each other, and it can be a challenge to design a final version which fits to all sizes of chimneys.

Figure 4. The CleanAir ESP




APP is a company, which is specialized in power supplies and cold plasma technology for odour removal, which is sold worldwide.

A comprehensive amount of documentation on the performance of the ESP is available. The CleanAir has a cleaning efficiency of 85 - 99 % on PM 10 and PM 2.5. In a field test the CleanAir collected 4.4 kg particles during a two month test.

The CleanAir has been specially designed for mounting on the top of the chimney in existing installations. The operation period between inspection and cleaning is claimed to be two month.

The high voltage of up to app. 35,000 Volt to the ESP is generated in a separate control box, which in the tested version was connected to the ESP with an app. 10 metre cable. The control unit is very big, but this part is not fully developed and is expected to be somewhat more compact. The ESP is automatically turned on and off, when an elevated temperature in the flue is registered. There is no drop of pressure above the filter, since only a small electrode is inside the flue gas path.

The ESP is technically well developed and tested, but it has not yet been final designed for production and sale, and it is consequently not commercial available today.

The expected production price is app. 300 € for a large number production, but no information about expected sales price and installation cost are available. The electric power consumption is in the order of 0.1 kW.

### 4.1.4 MoreCat Catalyst

The moreCat catalyst has been developed, and is manufactured by the company:

MoreCat GmbH
Industriegelände Rossenray
Asdonkstraße 33
D-47475 Kamp-Lintfort
Deutschland
www.morecat.de

The catalyst system consists of a metal housing filled with catalyst, which is integrated into a standard, commercially available stove flue. This flue is installed as close as possible to the stove in order to achieve the optimal minimal operation temperature of the catalyst of approx. 350 °C. The system can be installed in a vertical or horizontal position. The system is easy to install and replaces the existing flue. The only visible thing in the installation is a small handle identical with a common flue gas damper. The actual catalyst unit is pushed into the opening in the mounted piece of flue gas tube where it then can be turned into vertical position (bypass) or into horizontal position, so that all the flue gas must pass through the catalyst material. The pressure loss over the catalyst is significant.

The moreCat is able to reduce the emission of soot particles and the gaseous compounds CO and hydrocarbons by catalytic oxidation. With an integrated filter an increased reduction of soot particles should be possible. It has to be operated manually by turning it into operation, when the flue gas temperature is high enough to make it work, and to turn it off again when refuelling or when ignite next time.

Figure 5. The moreCat catalyst

There is a comprehensive documentation made by the manufacturer and the University in Duisburg-Essen. Test of the catalyst shows efficiency on removal of soot/particles of 62-94 % with an integrated filter and app. 50 % for the catalyst alone. Up to 80 % odour reductions is possible. The tested version was without integrated soot filter, which will be available in short time according to the manufacturer.

The catalyst base material is metal, and it is more resistant against substances, which are poison for normal ceramic catalyst, e.g. sulphur, lead and sodium.

The moreCat is compact and very simple, and seems to be very easy to install directly on the stove flue gas exit, if the necessary length of flue is available.

The catalyst has to be cleaned regularly by the user, and at least every time the ash pan is emptied. The catalyst should just be removed from the flue and rinsed out with tap water. The catalyst lifetime should be at least two heating seasons.

The moreCat catalyst is relatively cheap, with a price of app. € 300 (information from 2008), but so far, the moreCat is only available for test purpose, and not for ordinary costumers for installation in private homes.

#### 4.1.5 Ecoxy Retrofit System for Old Stoves

The Ecoxy retrofit system for old stoves has been developed and is delivered by the company:

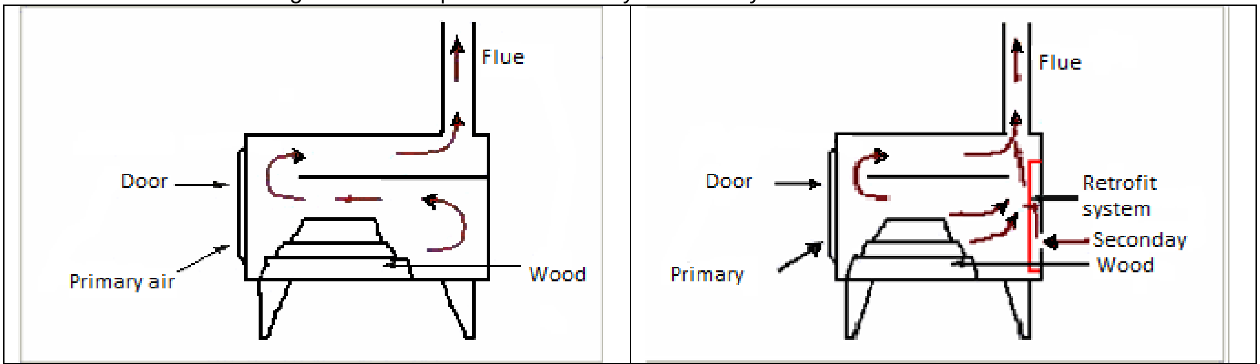
ECOXY AS
Sorgenfriveien 9
N-7037 Trondheim
Norweig
www.ecoxy.no

The retrofit system is a system to modernize old stoves, by installing a tertiary air supply, which improves the combustion efficiency. All most all new stoves have tertiary air supply. The system is a special plate which is mounted on the back wall of the combustion chamber, as can be seen in Figure 6.

Figure 6. The Ecoxy retrofit plate for tertiery air supply mounted in two old stoves

The principle for the Ecoxy retrofit system can be sees in Figure 7.

Figure 7. Principle for the Ecoxy retrofit system




| Old stove without the Ecoxy retrofit system | Old stove with the Ecoxy retrofit system installed |
|---|---|

According to the company homepage it is:

- easy to install
- reduces particulate matter up to 75 %
- improves the thermal efficiency by up to 20 %
- reduces the risk of stack fire

The product is very well documented, as field test has been accomplished for more than 99 wood stoves in Norway. It is potentially reducing the emission of particles, CO and OGC.

Laboratory test has shown a reduction of particle by 20-73 %, which strongly depending of the stove type. Field test shows a reduction of particles by 37 - 47 %.

The retrofit system can be mounted in wood stoves with a plain back wall in the combustion chamber. It is not suitable for boilers, because it is necessary to drill holes in the back wall, and it is normally impossible in a boiler.

The retrofit system is commercial available in Norway through a growing number of suppliers. When the retrofit system is installed, there are no extra costs for service or maintenance.

The price in Norway for the retrofit system is app. 250 € for the item itself, and 435 € with mounting included.

# 5 Laboratory test

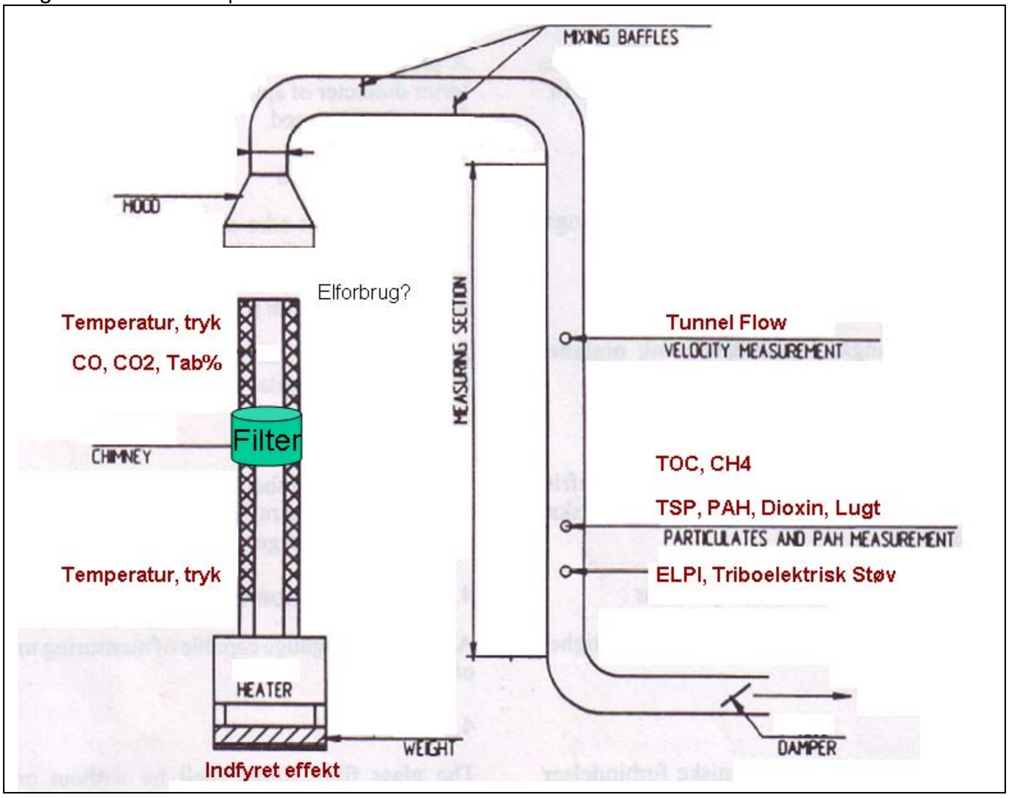
## 5.1 Laboratory test

Test of the five technologies for reduction of flue gas emissions has been tested on a wood stove and a wood boiler, at the approved stove and boiler test facility of the Technological Institute (TI) in Aarhus.

The TI test centre is fully equipped to make test on wood stoves and small boilers for wood and pellets, according to the CEN standard EN 13240 and the Norwegian standards NS 3058 and NS 3059.

Principe for the test stand with dilution tunnel and measuring points are shown in Figure 8.

Figure 8. Test set up




Measuring total PM direct in the chimney will give substantial lower emission (from 2 to almost 10 times lower), compared to measuring in the dilution channel, because particles will be formed by condensation processes when the flue gas is cooled down after leaving the chimney. It was decided to make the measurement in the dilution tunnel, as it will give the most realistic measure of the total particle emission to the environment.

Measuring with and without the technologies simultaneously was not possible, and therefore a first reference test without any technology was performed, and the test with technologies mounted was performed in exactly the same way. Nevertheless it is not possible to make exactly the same combustion and have exactly the same emissions, which therefore will vary, as it also can be seen on the variations for the repeated identical reference test. This deviation is also increased by the effect the technologies has on the chimney draught.

### 5.1.1 Stoking procedure

During testing it was the aim to achieve appropriate combustion conditions in the solid fuel stove; however, it was not quite identical with the type test stoking. It was also chosen to use Birch wood logs with bark, as it is the log type which is common used in wood stoves in Denmark. Normally logs without bark are used for test according to EN 13240 and spruce laths are used when testing according to NS 3058 and NS 3059 (Norwegian test).

The following stoking procedures were used for the stoves:

1. Ignition: Charge load of 1.6 kg small stickers and three fire lighters. Full open air supply and the door a little ajar during the first minutes.
2. Pre-test: Charge load of three pieces of 25 cm long firewood with a total weight of 1.8 kg, to achieve an entirely warm stove.
3. Nominal: Set for best possible emission, charge load of three pieces of 25 cm long firewood with a total weight of 1.8 kg.
4. Intermediate stage: Dampers scaled down to intermediate stage for low output. Charge load of two pieces of 25 cm long firewood with a total weight of 1.3 kg.
5. Reduced: Damper scaled down to low output. Charge load of two pieces of 25 cm long firewood with a total weight of 1.3 kg.

Figure 9. Small sticks for ignition and firewood with bark

The stoking procedure is expected to be quite similar to the procedure in a common household with a wood stove used for supplemental heating. Coming home from job in the late afternoon, the stove is lightened and fully charged two or three times to raise the temperature, and afterwards it is charged a couple of times with reduced load and air, to have a lower heat release into the warm room, and then it is time for going to bed.

However, three times of nominal charge were run on the reference stove.

The following stoking procedure was used for the wood boiler:

1. Ignition with charge load of 3.5 kg firewood. Full air and the door a little ajar at the beginning.
2. Pre-test. As nominal charge, but charge load 8-8.5 kg firewood to ensure that the stove was entirely warm.
3. Nominal 1. Set for best possible combustion with a charge load of 8 - 8.5 kg firewood.
4. Nominal 2. As for nominal 1.
5. Nominal 3. As for nominal 1.

During testing it was attempted to stoke reasonably in the wood boiler. The boiler was not filled entirely with firewood during the charges. The damper is open relatively much for the air to pass.

### 5.1.2 Dilution factor in dilution tunnel

The flow in the dilution tunnel was kept constant on app. 500 $m^3$/h. With the used combustion rates, the dilution factor for the tests is:

- Wood stoves at nominal load: 20 - 30 times
- Wood stoves at reduced load: 40 – 60 times
- Boiler: 6 – 8 times

### 5.1.3 Test set up

The tests are carried out in a test corner constructed with the purpose of executing accredited tests, e.g. according to the common European standard DS/EN 13240 and the Norwegian standard NS 3058/3059.

The appliance is mounted on a balance. Thus, it is possible to observe the burning activities continuously to determine the amount of wood being burned and when to carry out the next fuel load.

The chimney was placed directly upon the appliance, and pre-fabricated steel chimney components of 1 meter were applied. The appliance is placed free-standing in the room to ensure the stability of the weight. Above the chimney there is a cowl accumulating all the flue gas coming from the chimney. The cowl is placed in a way that does not give any extra draught in the chimney, i.e. there is only the natural draught in the chimney. Inside the cowl the flue gas is diluted with ambient air from the room, to a total flow of app. 500 $m^3$/h. From the cowl, the flue gas enters a dilution tunnel where flue gas/air velocity is constant during the entire combustion cycle. The particles are measured in the dilution tunnel, where they can be sampled isokinetic. The dilution tunnel compensates for varying flue gas flows which results in a more true mean value of emissions than direct measurement. Furthermore, the flue gas cooling in the dilution tunnel makes the amount of condensable particles increase.

The filter that was applied for sampling particles consists of two plane fibre filters in series. The temperature is measured between the two plane filters. When testing according to the Norwegian Standard NS 3058/3059, the temperature must not exceed 35°C. This temperature is important when it comes to determining whether condensable hydrocarbons are being accumulated on the filter or not.

### 5.1.4 Measuring program

As starting point, five technologies should be tested on the wood stove Morsø 1440 and on the wood boiler Viadrus.

First the units are tested without cleaning technologies, and hereafter with the cleaning technologies separately.

The following parameters were measured:

In the chimney:

- Continuous weighing of the fuel on scale
- Temperature before and after the cleaning technology
- Flue draught before and after the cleaning technology
- CO concentration (high and low concentration)
- $CO_2$ concentration

In the dilution tunnel:

- Air velocity (for calculation of the flow).
- OGC concentration (total OGC)
- NMVOC (calculated as total OGC minus $CH_4$, where $CH_4$ was measured by a FID measure after a Non Methane Cutter, which oxidizes all hydrocarbons except methane.
- Particles sampled on glass fibre filters at maximum 35°C according to NS 3058-2.
- Particle distribution with an ELPI instrument (see Appendix for details on the ELPI measurements)
- PAH and dioxin

The particle measurement is carried out on every second charge, i.e. ignition, nominal and reduced; the rest of the above-mentioned measurements are carried out continuously.

The dilution rate from the chimney to the dilution tunnel is calculated as an overall average value for each charge and test.

The dilution tunnel appears from the below photo.

Figure 10. Entire test rig with dilution tunnel

### 5.1.5 Test assembly

The test assembly has been identical for both the wood stoves and the wood boiler with the individual cleaning technologies. Natural chimney draught was used during all tests.

The ESPs Zumikon and Airbox and the moreCat catalyst are all installed in the flue within the first meter above the stove/boiler. The APP electro filter is mounted on the top of the chimney, and the Ecoxy is mounted on the back wall inside of the wood stove burning chamber.

## 5.2 Test Wood stoves and boiler

The wood stoves and boiler used for the test is presented her.

### 5.2.1 Morsø 1440 wood stove

The Morsø 1440[26] wood stove that was chosen for the tests is a very traditional and popular solid fuel stove, and probably the most sold wood stove in Denmark. The stove is a convection type for small rooms. It represents the typical wood stoves from about 1990, when the DS approval of wood stoves started in Denmark, and until about 2007, where the Danish wood stove order came into force, and the model was replaced with a more efficient one with tertiary air supply.

The primary air is lead up through the grate from the bottom of the stove and secondary air washing down the glass door, keeping it free from soot when the stove is correctly fired. The stove is not provided with tertiary air.

From an older type testing the following data was achieved for a Morsø 1440 wood stove:

- CO: 0.24% at 13% O2
- Efficiency: 77%
- Output: 5 kW
- Flue gas temperature: 335 °C.

Figure 11. Morsøe 14440 wood stove used for the test

Morsø 1440 can be used with wood, briquettes, coal or pet coke. The maximum load of wood logs is app. 2 kg/hour

[26] www.morsoe.co.uk/Produkter-3.aspx?M=eCom_Catalog&PID=&ProductID=PROD167

### 5.2.2 The Swan Eco labelled wood stove

The chosen Swan eco labelled stove is a Rais Epoca[27] which represents the newer stoves technology, with among other things has tertiary air supply for improved combustion. The stove has a nominal effect of 4.5 kW, but can be operated in the interval between 2 and 7 kW.

From the Swan testing, the data in Table 2 was achieved for Rais Epoca:

Table 2. Test results for Swan test of Rais Epoca wood stove

| Parameter | Test results |
|---|---|
| CO | 0.10 % at 13 % O2 |
| Efficiency | 76 % |
| Particle emission (NS 3058) | 2.58 g/kg wood |
| Flue gas temperature | 250 °C |

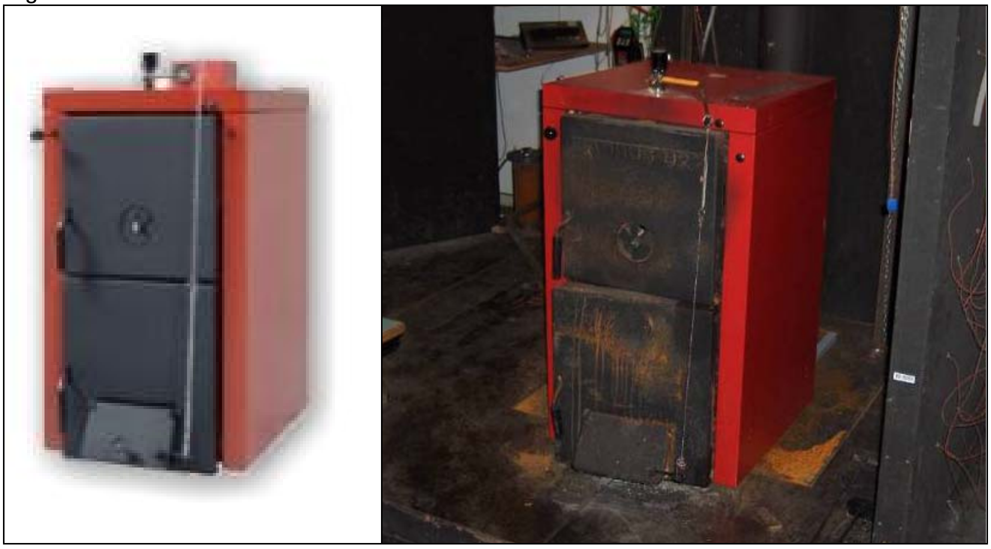
Figure 12. The Swan eco labelled Rais Epoca wood stove

### 5.2.3 Viadrus Hercules U22 wood boiler

The chosen wood boiler is a Viadrus Hercules U22 from Czech company Viadrus[28] which represents a very traditional up-draught boiler, which has been distributed a lot in Denmark.

[27] Type Epoca from the manufacture Rais AS, www.rais.dk
[28] www.viadrus.cz

Figure 13. Viadrus wood boiler



It is a universal cast iron boiler for hard coal, coke, wood and wooden briquettes can be used for houses as well as smaller structures with dead load or forced heating water circulation. The universality of this boiler lies in the possibility of adaptation from solid fuel to gas/liquid fuel and vice versa.

A newer version of the boiler is produced in several sizes with output from 11.7 up to 58.1 kW.

The combustion principle is a traditional up-draught, which is very common for older wood boilers in Denmark. The firewood is charged into the combustion chamber and the primary air is supplied up through the firewood. Secondary air is also supplied uppermost in the combustion chamber for combustion of the gasses.

Newer boilers do either have cross-draught, where the flames descend from the combustion chamber (the gasses are then after-burned in a second combustion chamber) or down-draft gasifying, where the gasses e.g. operates to the backside from the combustion chamber (and are also here being after-burned in a second combustion chamber).

The boiler has previously been tested and reported in a project for the Danish EPA[29]. In this test the data in the Table 3 was measured.

Table 3. Test results from 2007 for the Viadrus wood boiler

| Parameter | Value | Wood stove guideline mg/m3 (10% O2) |
|---|---|---|
| CO | 9 % | 5000 |
| Particle emission | 17,8 g/kg wood | 150 |
| OGC | - | 150 |
| Efficiency | 45,7 % | - |
| Flue gas temperature | 320 °C | - |

[29] Vurdering af brændekedlers partikelemission til luft i Danmark (“Assessment of Biofuel Boilers’ Particle Emission to the Air in Denmark”). Arbejdsrapport fra Miljøstyrelsen, No. 6, 2008:P.59. www2.mst.dk/Udgiv/publikationer/2008/978-87-7052-771-2/pdf/978-87-7052-772-9.pdf

## 5.3 Wood stove test

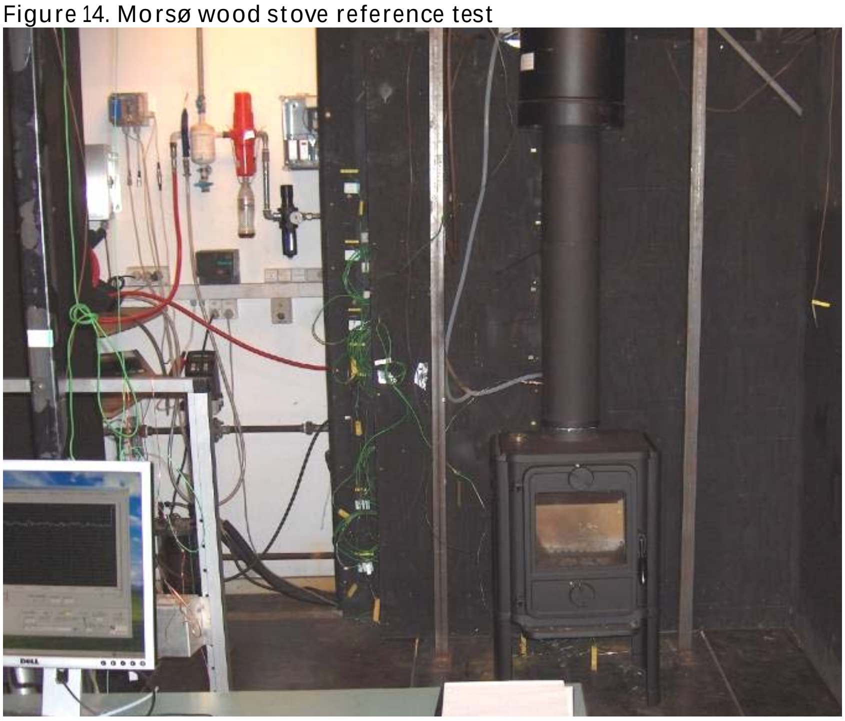
### 5.3.1 Morsø wood stove Reference test

The first measurement in 2008 included only one reference test, but three nominal charges was used where only two charges was used when testing the different technologies. This test was carried out according to the schedule without any problems.

Later on it was decided to make three more reference test to achieve a statistical more certain levels for the emission. These additional tests were carried out in September 2009.

At second attempt the pitot tube in the dilution tunnel was blocked, which was corrected in the results. In other respect, all three measurements succeeded without any problems.

Figure 14. Morsø wood stove reference test



#### 5.3.2 Morecat catalyst wood stove test

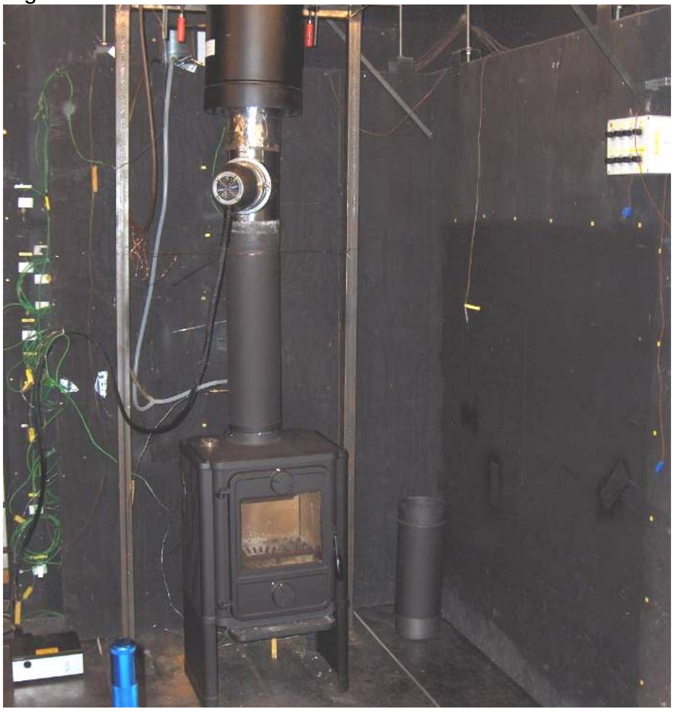
The measurement succeeded without problems.

Figure 15. Morsø wood stove with the Morecat catalyst

#### 5.3.3 Zumikon ESP wood stove test

Half way through the ignition, the red light and the on/off light on the control unit was blinking, indicating failures in the electro filter and/or the control unit. After charging the pre-test all four green lights went on, indicating that the unit is in normal operating again. Apparently the filter has been out of operation during the second half part of the ignition charge.

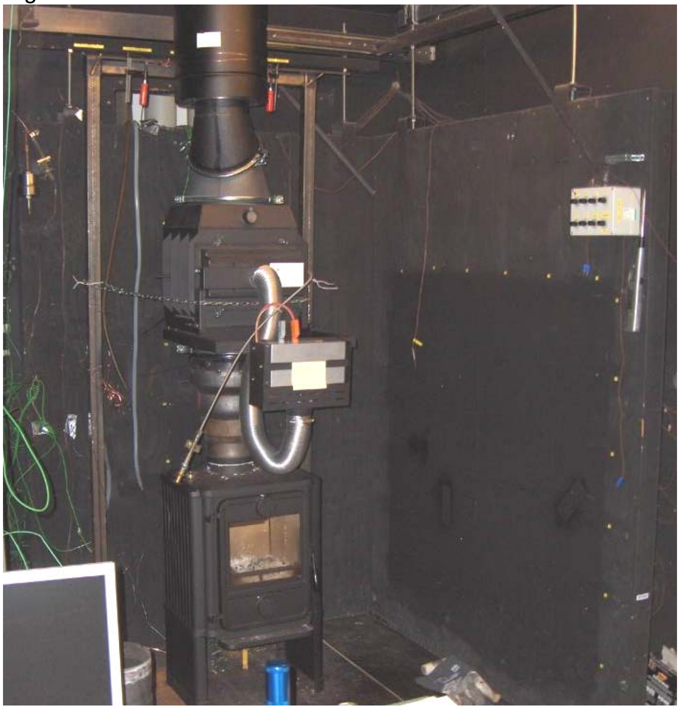
Figure 16. Morsø wood stove with the Zumikon ESP



### 5.3.4 Airbox ESP wood stove test

It was necessary to keep the door ajar a bit longer to get the fire started despite the fact that the filter was set in bypass. Five minutes after the ignition the bypass was closed. 15 minutes after the ignition, condensate was leaking from the filter.

Figure 17. Morsø wood stove with the Airbox ESP



The filter is pretty large and heavy, and it takes some time to heat this mass to the flue gas temperature, and therefore condensation of water occurs in the lightning period, where the flue gas has the highest content of water.

### 5.3.5 Ecoxy retrofit wood stove test

The measurement succeeded without problems.

### 5.3.6 CleanAir ESP wood stove test

In the test in 2008 the test with nominal load was skipped, because of problems with the filter in the boiler test, where the filter fell down due to the high temperature in the chimney (see clause 4.4.6 on page 52). Only the ignition and the reduced load test were accomplished in 2008. In 2009 the wood stove test was repeated with an improved mounting design, which could stand to high temperature.

The test in 2008 was carried out for the ignition, the intermediate stage to the reduced load and the reduced load, where the chimney temperatures are moderate, compared to nominal load.

The test in 2009 included the complete test program. In the first test in 2008, the PM measurements with plane filters were only made for each second charge, but for the 2009 test, it was measured for all charges.

Figure 18. Morsø wood stove with the CleanAir ESP

Due to a misunderstanding the filter was not turned ON during the Ignition and the Pre-test. It was not possible to repeat the whole test the same or any of the next days, and the test was then completed. The PAH and dioxin sampling, which should run or the entire test, was replaced when the filter was turned ON, giving one sample for the period with the ESP OFF and one sample for the period with the ESP ON.

Due to the lack of stability of the chimney with the CleanAir ESP on the top, the chimney was attached to the ceiling in the test corner. This does not have any influence on the measured values, except for the weighing of the wood fuel, which is done by weighing the total stove and chimney.

### 5.3.7 Swan eco labelled wood stove reference test

The test was carried through in 2009 and succeeded without problems.

## 5.4 Wood boiler test

### 5.4.1 Wood boiler reference test

NMVOC was not measured in the first test, due to problems with the measuring instruments. An extra test was performed, where all parameters, including the NMVOC, was measured.

Besides this problem, the measurement succeeded according to the test plan.

Figure 19. Viadrus wood boiler in normal position

### 5.4.2 MoreCat catalyst wood boiler test

Shortly after the first test was started, it was interrupted due to a dirty nozzle in the ELPI instrument, which had to be cleaned.

A new test was started, but this test was interrupted shortly after, due to a large pressure drop over the catalyst. The chimney draught was obviously way too low and flue gas was leaking from the boiler into the test hall.

It was realized, that the MoreCat catalyst is only suitable for wood stoves, and not for wood boilers, due to the larger amount of flue gas.

MoreCat has apparently constructed a larger catalyst, which should be more suitable for wood boilers with the higher flue gas flow compared to wood stoves.

Figure 20. Viadrus wood boiler with Morecat catalyst

### 5.4.3 Zumikon ESP wood boiler test

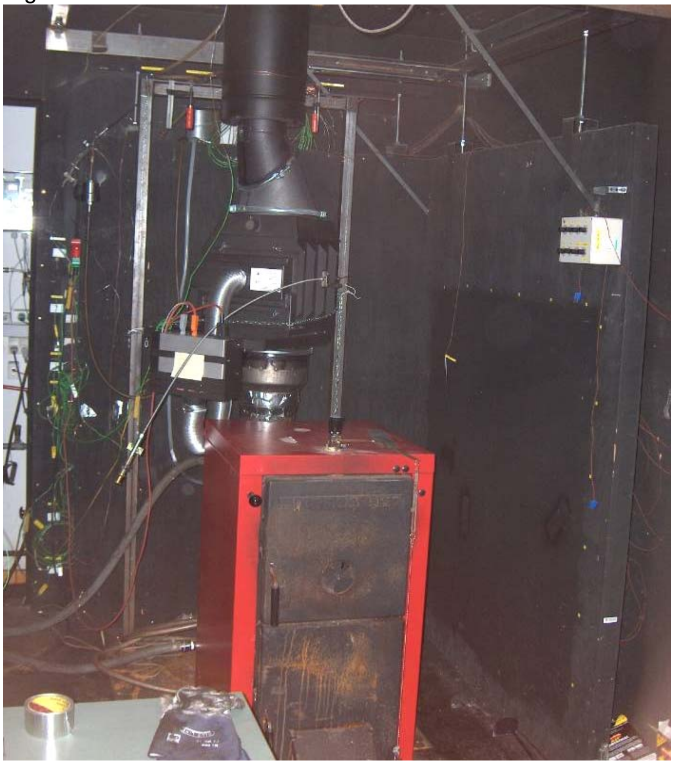
During the first charge approximately the red light in the control unit went on, indicating an electric short circuit and the power is automatically turned off. After almost 20 minutes the red light went off again and the filter operation was normal again. No other problem was observed during the test.

Figure21. Viadrus wood boiler with Zumikon ESP

### 5.4.4 Airbox ESP wood boiler test

There was noticed a little flue gas emission from the air valve on the boiler during this test, which is due to a small excess of pressure in the combustion chamber. Otherwise the measurements succeeded without problems.

Figure 22. Viadrus wood boiler with the Airbox ESP



### 5.4.5 Ecoxy retrofit wood boiler test

This combination is not possible, since the afterburner solely is for wood stoves. It cannot be mounted since it is necessary to drill holes into the backside of the stove, where boilers normally have cavities filled with water.

### 5.4.6 CleanAir ESP wood boiler test

During the first test in 2008, the test was interrupted shortly after the second charge. The filter was a prototype provided with a teflon ring between the chimney and the filter, which became more and more soft when the chimney temperature increased and finally the filter fell down from the chimney. The flue gas temperature just above the boiler was up to 450 °C during the ignition stage. Consequently the test could not be finished as planned and only data from the ignition stage and a few minutes from the first charge were available, but these data will not be used.

The manufacturer of the CleanAir ESP, Applied Plasma Physics AS, refused to improve the filter to stand the high temperature, because the filter is not suitable for such a high temperature, which is not normal according to their experience. The high temperature will cause a low efficiency, because fewer particles will be formed by condensation in the chimney, when the temperature in the is higher.

# 6 Test results

Many parameter and emissions has been measured during the test, and there is a comprehensive amount of results, but only some of them are relevant for the evaluation of the emission reducing effect of the tested technologies. The relevant parameters are first of all the PM emission for all technologies, but it is most important for the three ESP's, which actively removes particles from the flue gas. The moreCat catalyst should be able to reduce soot particles by catalytic combustion, but the main effect should be on the CO and OGC emission. The Ecoxy Retrofit system should reduce the emission of particles, CO and OGC, by the improved combustion efficiency.

Additionally the emission of PAH, PCDD/F and odour is important for an evaluation of the potential reduction of toxic and carcinogenic compounds and the potential reduction of odour nuisances for neighbours.

Only the main results for the relevant parameters are presented here, but all the test results for each test, charge and parameter can be seen in Appendix 3, except for the results for PAH, PCDD/F and odour, which are only presented here.

The method used is based on a type A evaluation, where the average and uncertainty for each test are compared with the reference test. The method is simplified as follows:

- The uncertainty for the repeated reference test is calculated for each of the parameters, and this uncertainty is assumed to be valid also for the technology-tests.
- The average weighted after the fuel load is calculated for all test and the uncertainty is added.
- The average including the uncertainty for the technology test is compared to average including the uncertainty for the reference test for each parameter, and if the uncertainty intervals are not overlapping, we have a significant deviation.

A detailed explanation of the method is given Appendix 4.

In the following paragraphs the main results for particles, CO and OGC will be shown, first for the wood stove test and after for the wood boiler.

In the last paragraphs the results for an extra test of the change in the particle distribution by an ESP, and the results for PAH, PCDD/F and odour is presented.

## 6.1 Main results for the wood stove test

The wood stove results will be shown in this order:

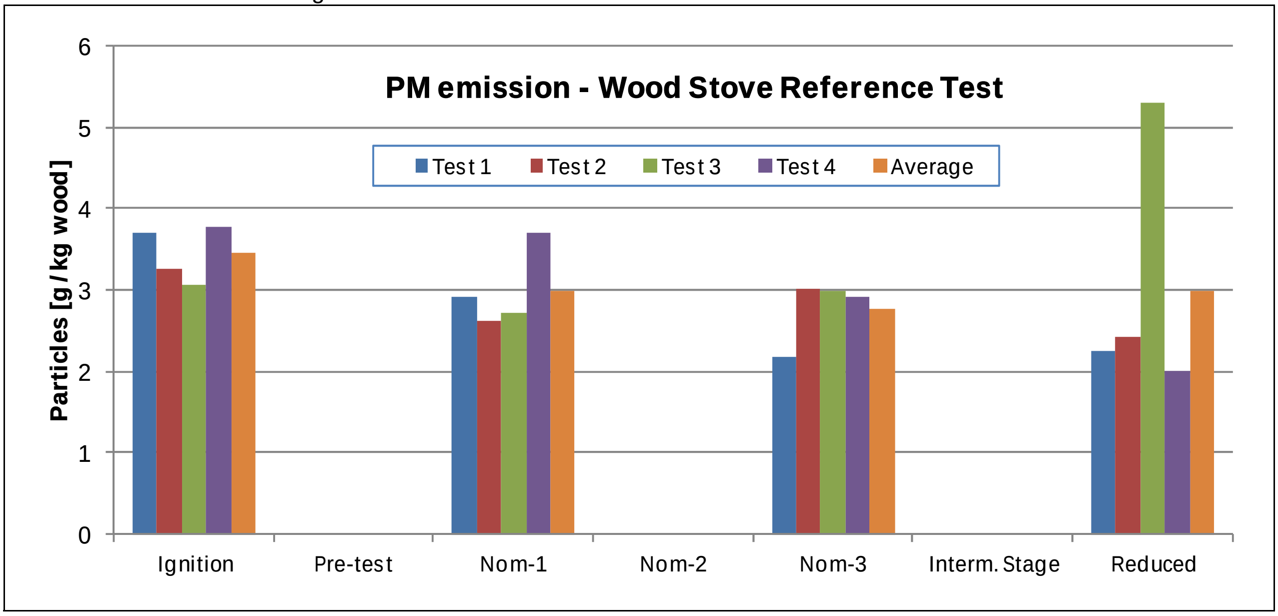
1. Results from the reference test
2. Results from test of the technologies
3. Statistical evaluation of results

## 6.2 Wood stove Reference test

Four reference tests were performed with the Morsø wood stove, to evaluate the repeatability for the emission of PM, CO and OGC, and to give a statistically better average value for comparison of the technology test.

The results for PM, PN[30] (particle number) and CO emission are shown in the next three figures. All results presented in the same type of diagrams can be seen in Appendix 5.

Figure 23. Total PM emission from the wood stove reference test




The total PM emission was only measured for every second charge, and consequently there are no values for the Pre-test, Nom-2 and Interm. Stage.

The variation in the PM emission seems to be reasonable low, when taking into account the big problems in making exactly reproduce able combustions and emission in a hand fired wood stove. Only the reduced charge for test 3 is way out of range of the other three test results, but it is also the most difficult charge to reproduce. The load is low and the air supply is reduced, and the temperature is low, and the result is problems in having an efficient combustion.

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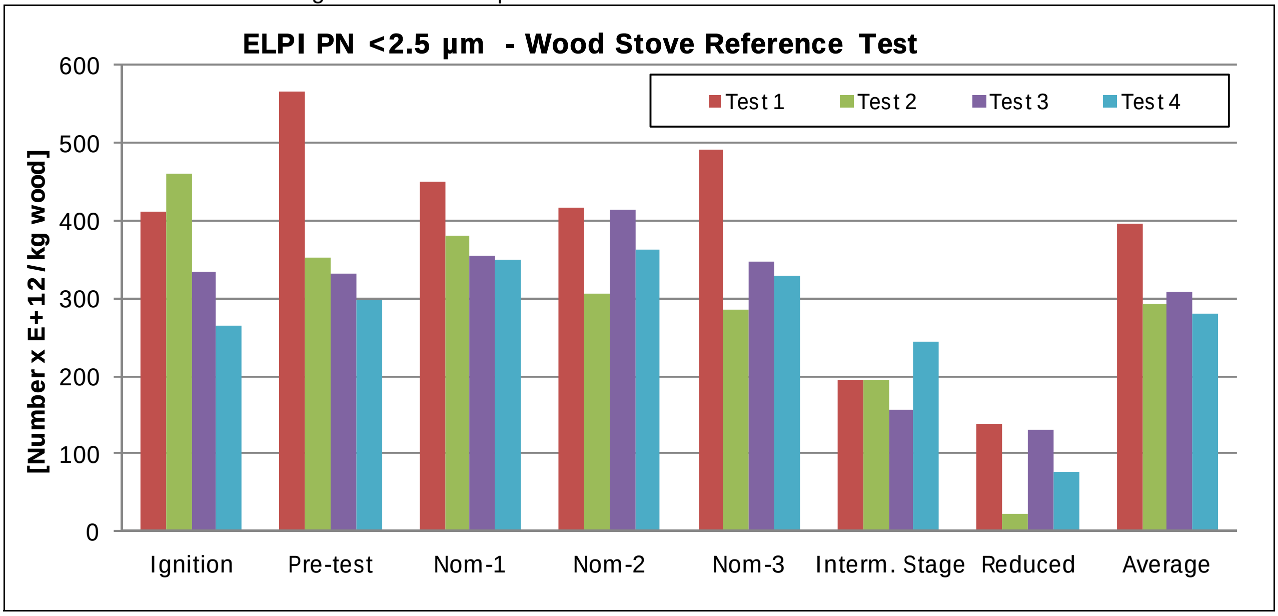
[30] Particle number concentration is measured with ELPI. Particles in the size range 0.028 -2.5 μm are counted, but mainly presented as PN < 2.5 μm.

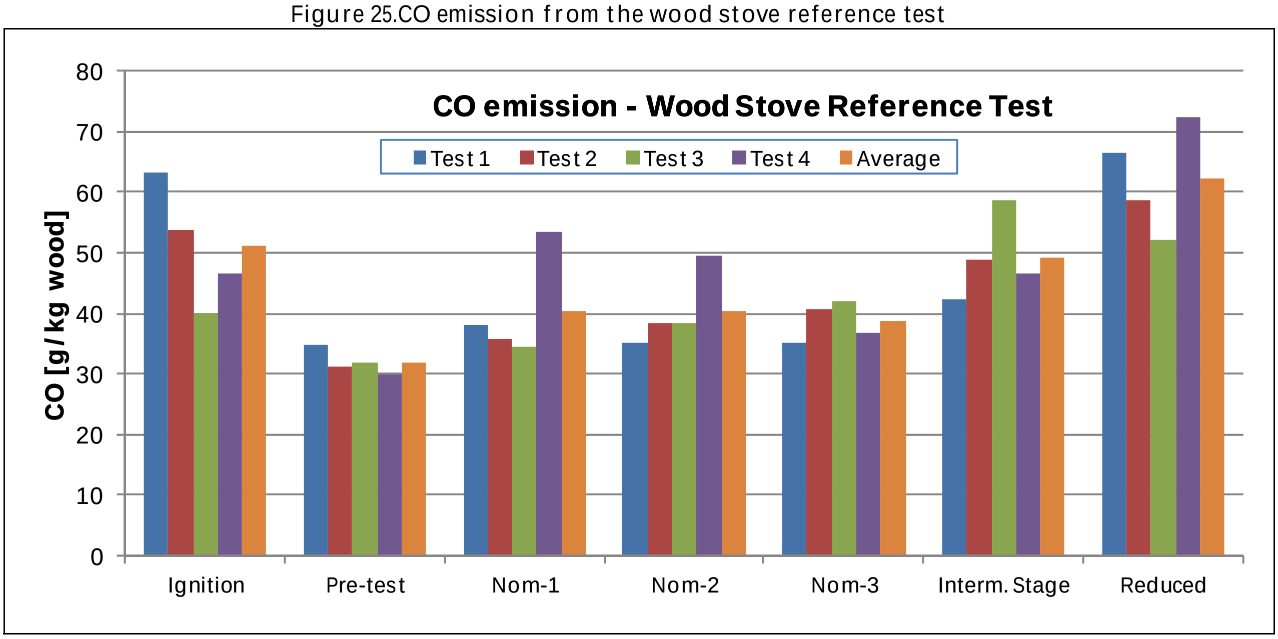
Figure 24. PN < 2.5 µm emission from the wood stove reference test




The variations in the emission in terms of particle number is much bigger than for the PM results, especially for the first test, Test 1, which was performed in 2008, where the other test was made in 2009.

Especially the Reduced charge for Test 2 seems to be way out of the range of the other three tests. On the other hand, the PM emission in Figure 23 does not show the same variation. The reason for this could be, that a substantial part of the particles is larger than 2.5 um, which is not included in $PM_{2.5}$. However, the low value could also be caused by some not discovered problem in the ELPI measurement system.

Figure 25.CO emission from the wood stove reference test




The variations in the CO emission seems to be quite low, taking into account the big problems in making exactly reproducible combustions and emission in a hand fired wood stove.

The relatively limited variations in the emission from the reference test indicate a good repeatability for the emissions from repeated firings. It is however not possible to achieve exactly the same firing conditions when testing the technologies, as they inevitable will have an impact on these conditions. MoreCat, Zumikon and Airbox ESPs will more or less reduce the chimney draught and the Ecoxy will increase the amount of combustion air. When comparing the average reference test results with the technology test results, it is however necessary to remember, that the reference test might be different from the actual conditions. It is however considered to be the most correct way to evaluate the technologies, in relation to install them on existing chimneys and stoves.

## 6.3 Wood Stove Technology test

For evaluation of the emission reduction by replacing an older stove with a new Swan eco labelled wood stove, the technology test was supplemented with an extra test with a Rais Epoca wood stove, which has the Swan ECO labelled.

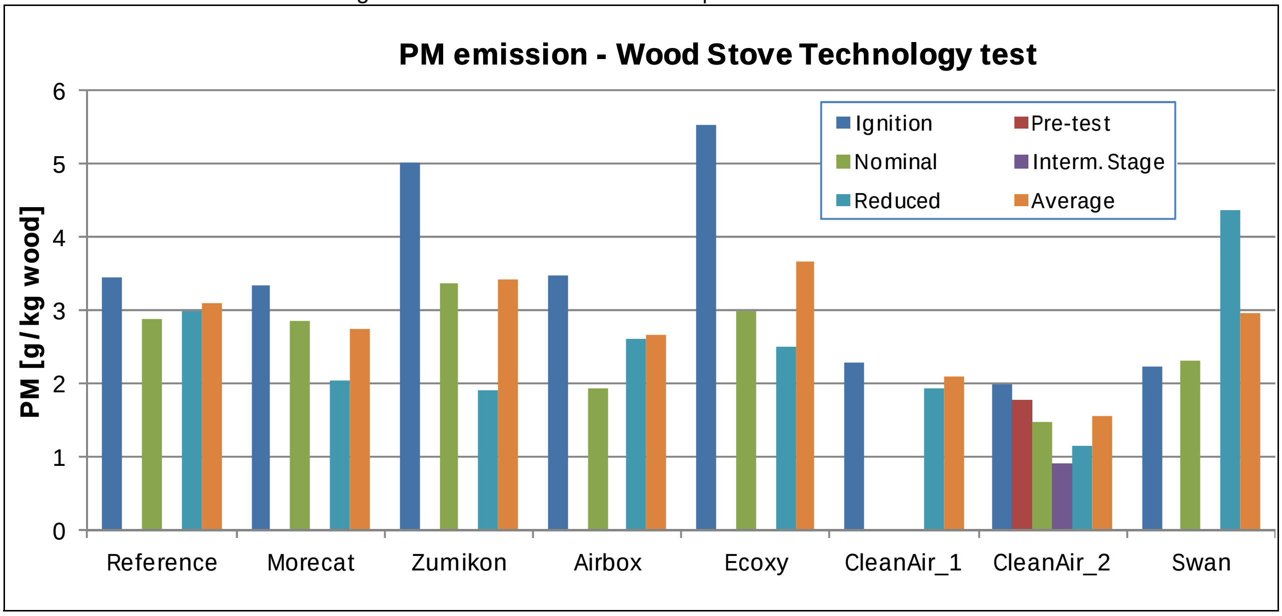
Table 4. Average emission factors for wood stove test

| Technology/Parr. | PM g/kg wood | CO g/kg wood | OGC g/kg wood | NMVOC g/kg wood |
|---|---|---|---|---|
| Reference | 3.1 | 45 | 4.6 | 3.1 |
| Zumikon ESP | 3.4 | 52 | 7.8 | 5.5 |
| Airbox ESP | 2.7 | 60 | 6.5 | 4.5 |
| CleanAir ESP | 1.5 | 41 | 4.1 | 3.9 |
| MoreCat catalyst | 2.7 | 29 | 5.9 | 3.2 |
| Ecoxy afterburner | 3.7 | 37 | 4.7 | 3.2 |
| Swan Eco labelled stove | 3.0 | 24 | 3.6 | 2.4 |

As for the reference test, the total PM emission was only measured for every second charge, and consequently there are no values for the Pre-test, Nom-2 and Interm.Stage, except for the CleanAir_2, which was re-tested in 2009.

The test results for the most relevant parameter is the PM emission

Figure 26. PM emission from wood stove technology test. The Reference test is average of the four reference tests performed

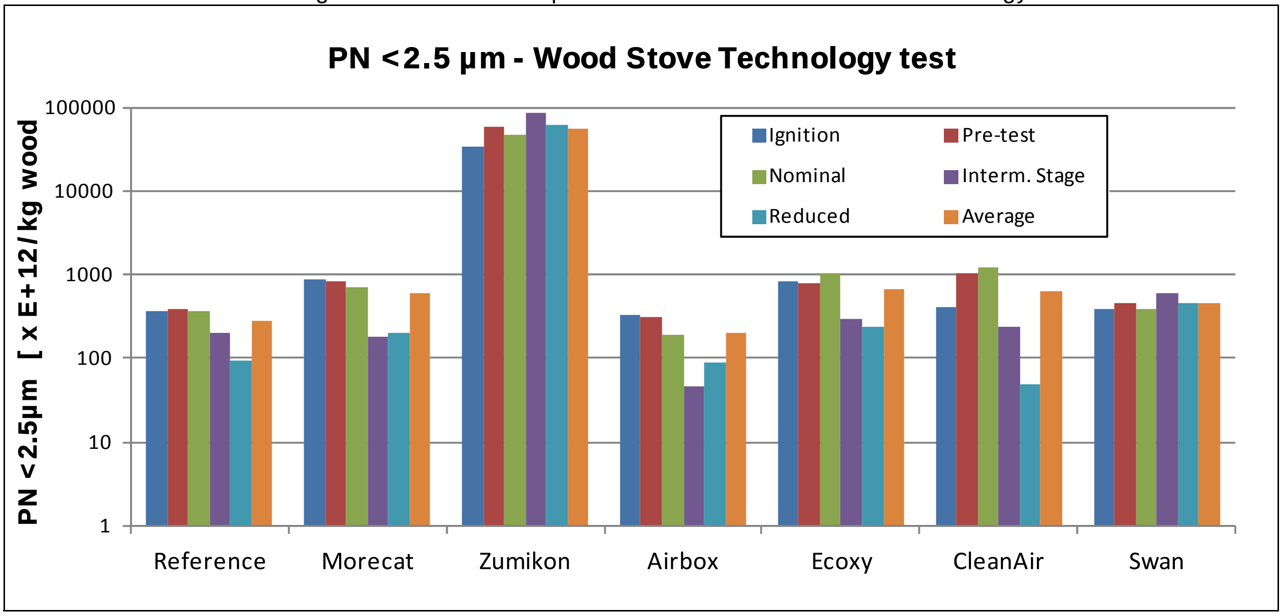



There is apparently no clear reduction of the PM emission for any of the technologies, except for the CleanAir, where some reduction seems more evident.

The particle distribution measured with the ELPI instrument showed clearly, that the main part of the particles in terms of number are ultra fine particles (less than 0.1 µm i diameter). Some of these results are presented her, and more results can be seen in Appendix 5.

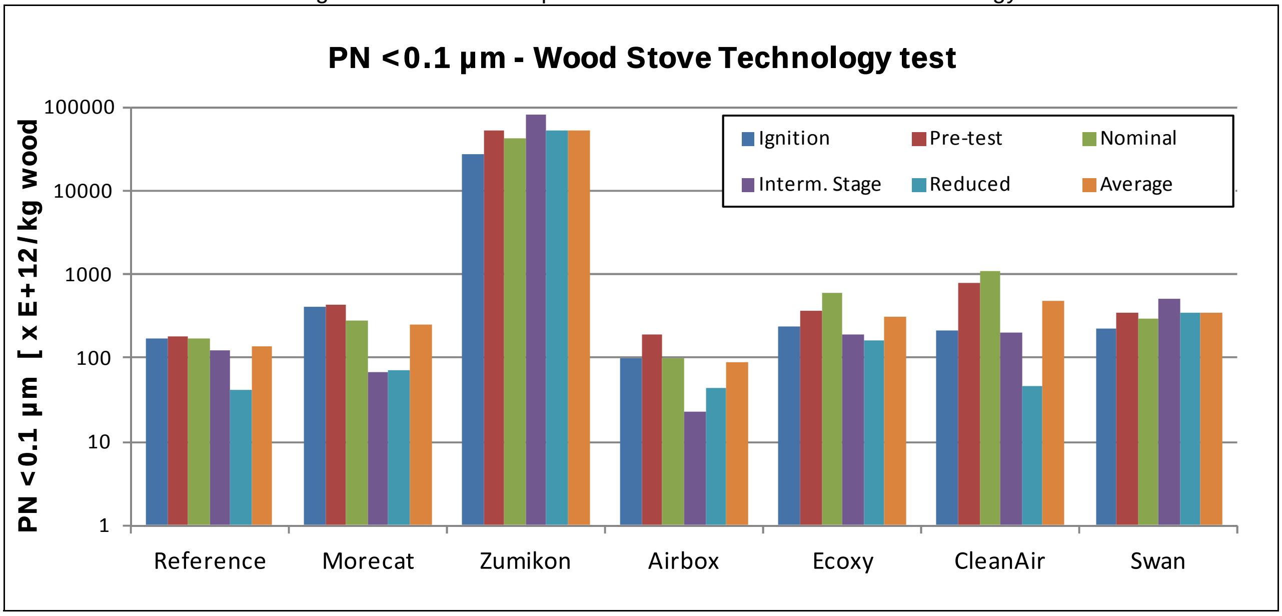
The test results for PN < 2.5 µm in Figure 27 shows a very high number of particles for the Zumikon ESP compared to the other tests.

Figure 27. ELPI PN < 2.5 µm emission from wood stove technology test




This very high number of particles are associated to the ultra fine particles, which can be seen Figure 28, where the PN < 0.1 µm are shown.

Figure 28. ELPI PN <0.1µm emission from wood stove technology test without Zumikon




There is apparently a very big increase in the emission of PN < 0.1 µm for the Zumikon ESP, but there is apparently also some increase for the other technologies, including the new Swan stove, but it is difficult to see in the figure, as the number is a logarithmic scale. Only the Airbox seems to have a lower PN < 0.1 µm emission than the reference test. The PN < 0.1 µm particles are so small, that their weight contribution to the total PM mass is minimal, which means, that there is no connection between the PN < 0.1 µm and the total PM mass, which is seen by comparing the PN < 0.1 µm in Figure 28 with the PM in Figure 26.

The CO emission in Figure 29 and the OGC emission in Figure 30 are showing a bigger variation in the emissions than the reference test, which could be caused by an influence on the combustion conditions from the technologies. The figures indicate that the combustion conditions from the technology tests are not exactly the same as for the reference test.

Figure 29. CO emission from wood stove technology test. The CleanAir_1 results are without the pre-test and nominal loads, and the CleanAir_2 is the full re-test in 2009.

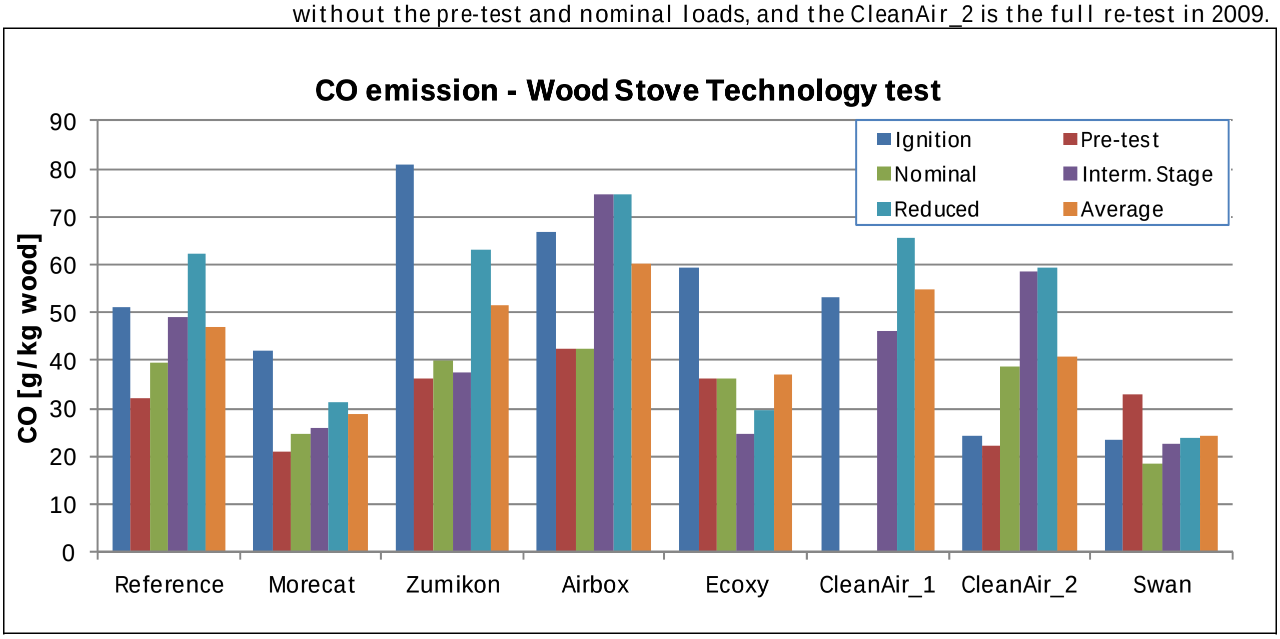
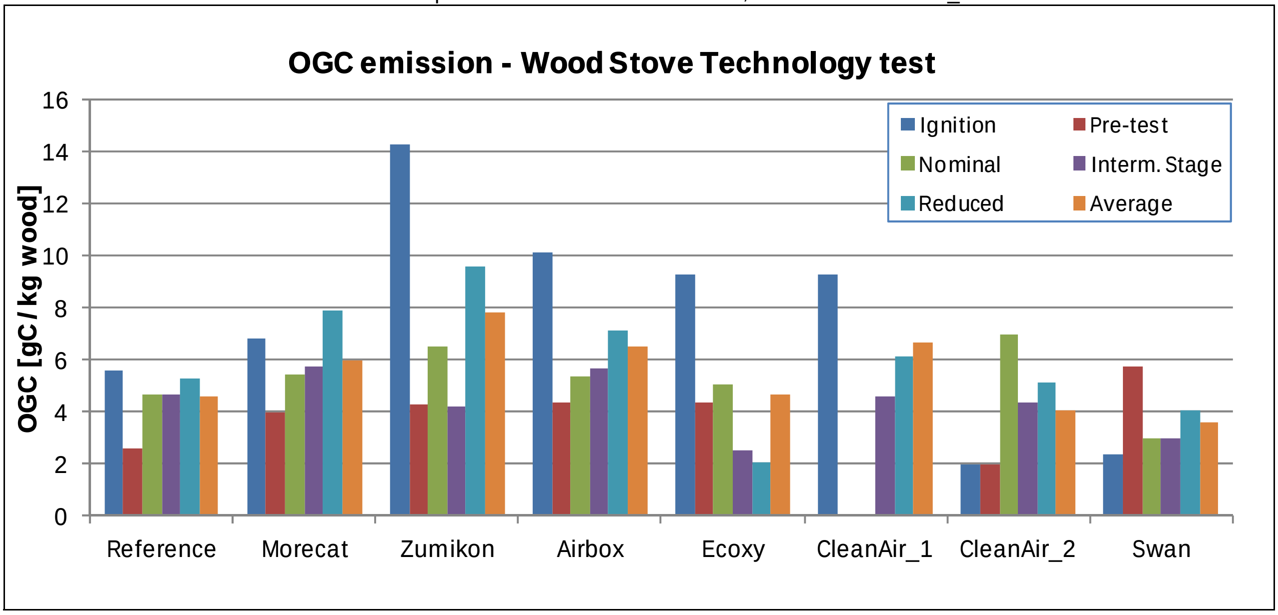


Figure 30. OGC emission from wood stove technology test. The CleanAir_1 results are without the pre-test and nominal loads, and the CleanAir_2 id the full re-test in 2009.

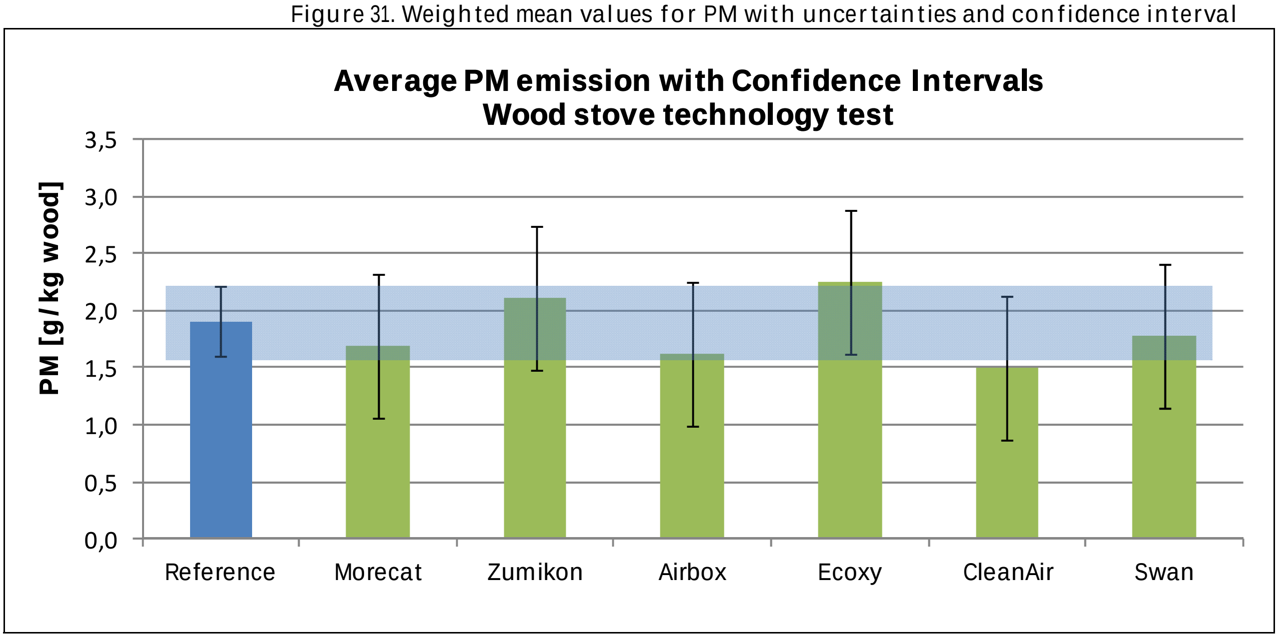



## 6.4 Wood stove statistical evaluation

The main results for the wood stove test in terms of weighted average emission factors for all tests for each technology with the calculated uncertainty and confidence interval according to the type A statistical evaluation explained in Appendix 4 are shown in the next figures.

The ELPI particle distribution measurement by the number of particles seems to be greatly affected by some of the technologies, and the differences in the number of particles is so big, that it can only be seen in a diagram with a logarithmic scale. Furthermore it is not possible to show the uncertainty correct in a logarithmic diagram and consequently no diagram with the uncertainty is shown.

Figure 31. Weighted mean values for PM with uncertainties and confidence interval

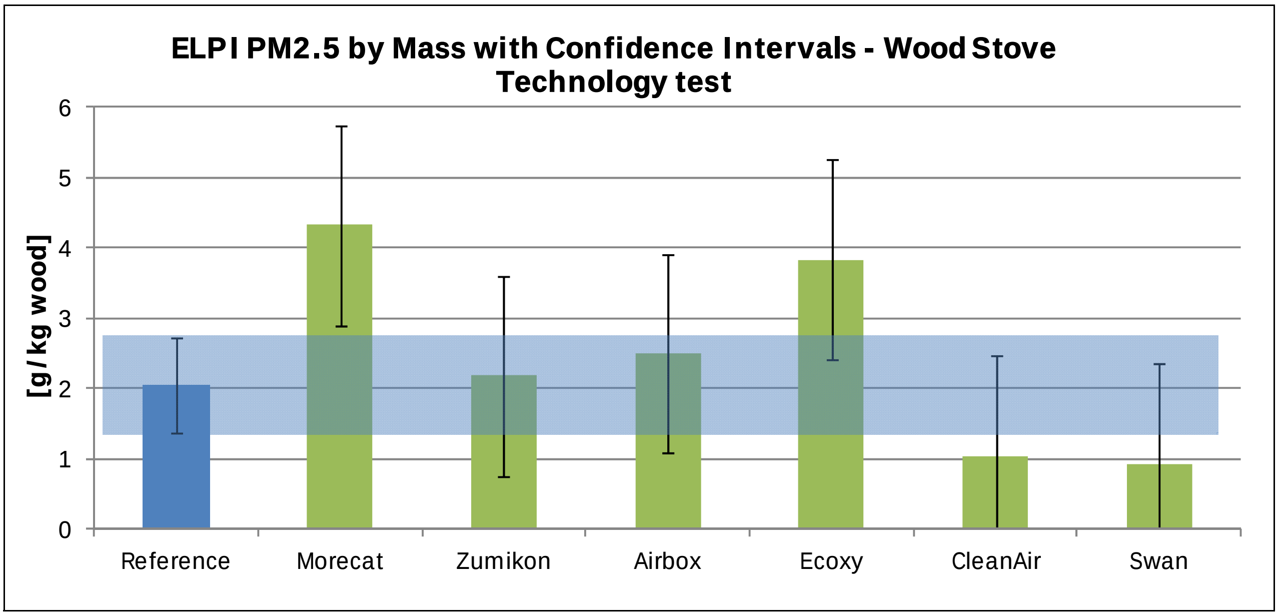


None of the tested technologies has a significant reduction of PM and surprisingly not the eco labelled Swan stove either.

There is probably a reduction of the PM emission for the CleanAir ESP, but it is very weak.

Based on the particle distribution measured with the ELPI, values for $PM_{2.5}$ (concentration in terms of mass) can be calculated, subjected to certain assumptions (spherical particles, a density of 1 $g/cm^3$). Such results are shown in Figure 32.

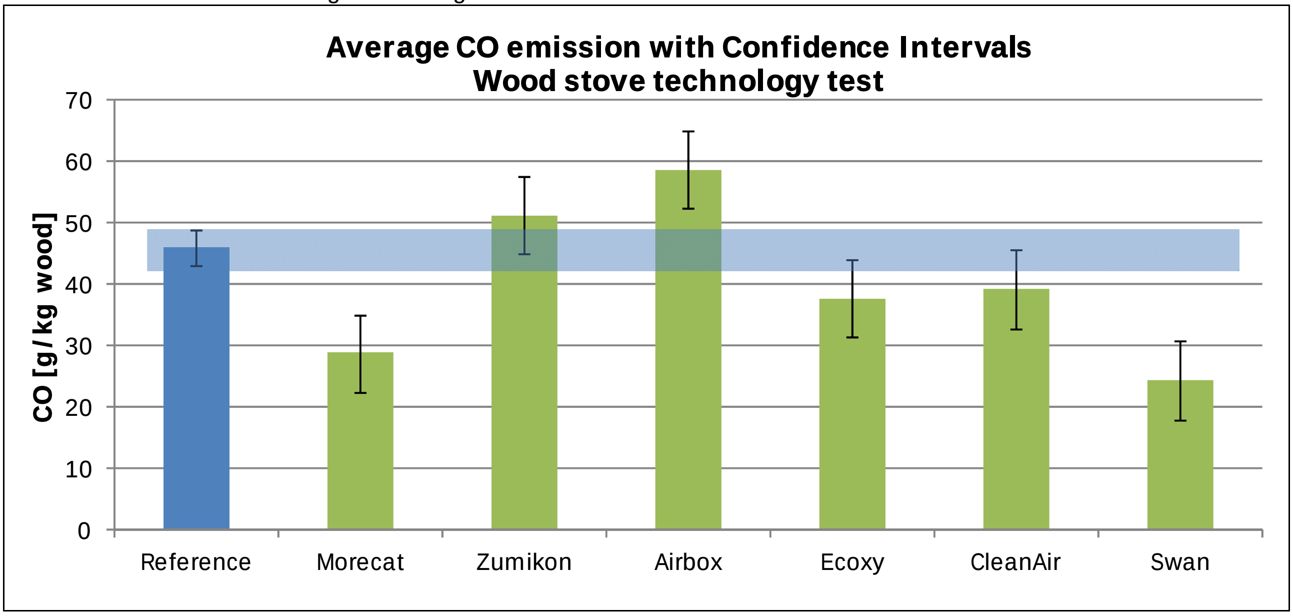
Figure 32. Average calculated $PM_{2.5}$ based on ELPI measurements with uncertainties and confidence interval




There is a significant increase in the calculated $PM_{2.5}$ based on ELPI measurement for the moreCat catalyst, and a probably reduction for the CleanAir ESP and the Swan Eco labelled stove. This is not in agreement with the results for the PM measurement in Figure 26. Since the ELPI $PM_{2.5}$ is calculated values, they are considered to be much more uncertain than the PM measured by the standard reference method, and consequently no certain conclusion can be drawn.

The results for the CO measurements are shown in Figure 33.

Figure 33.Weighted mean values for CO uncertainties and confidence interval



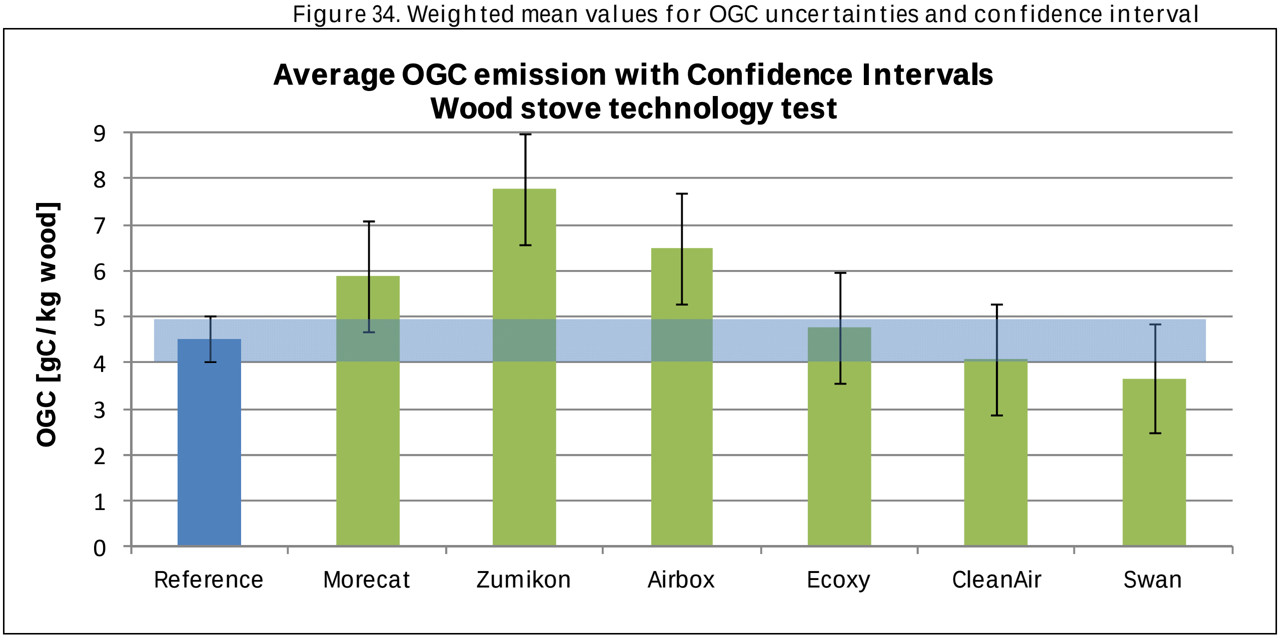

The test with MoreCat and the Swan stove has a significant lower emission of CO, and the Airbox has a significant higher emission of CO. The test with Ecoxy and CleanAir 09 has a probable lower emission of CO.

This is believed to be:

- The moreCat catalyst is capable to reduce some of the CO by oxidizing it to $CO_2$.
- The Swan Eco labelled stove has a more efficient combustion, and consequently a lower CO emission.
- The Airbox has a negative effect on the combustion efficiency, which increases the CO emission, caused by a reduced chimney draught.
- The Ecoxy has a better combustion, caused by the increased supply of combustion air.

The results for the OGC measurements are shown in Figure 34.

Figure 34. Weighted mean values for OGC uncertainties and confidence interval



The Zumikon and Airbox has a significant and the MoreCat has a probably higher emission of OGC, which is believed to caused by a slightly negative effect on the combustion efficiency from a slightly reduced chimney draught. This effect could possibly have been avoided, by opening the air supply a little bit more, to compensate for the reduced chimney draught. By looking at the results for the single charges in Figure 30, it is obviously that it is only a few of the charges that are causing the high value for the average.

## 6.5 Wood Boiler test

The main average results in emissions factors in grams per kg wood from the wood boiler test is shown in Table 5

Table 5. Average emission factors for all the wood boiler tests

| Technology | PM g/kg | CO g/kg | OGC g/kg | NMVOC g/kg |
|---|---|---|---|---|
| Reference | 2.42 | 38 | 4.3 | 3.2 |
| Zumikon | 1.83 | 36 | 4.4 | 3.3 |
| Airbox | 2.59 | 40 | 5.3 | 3.5 |
| CleanAir* | 2,2 | 26 | 1,5 | 1,2 |

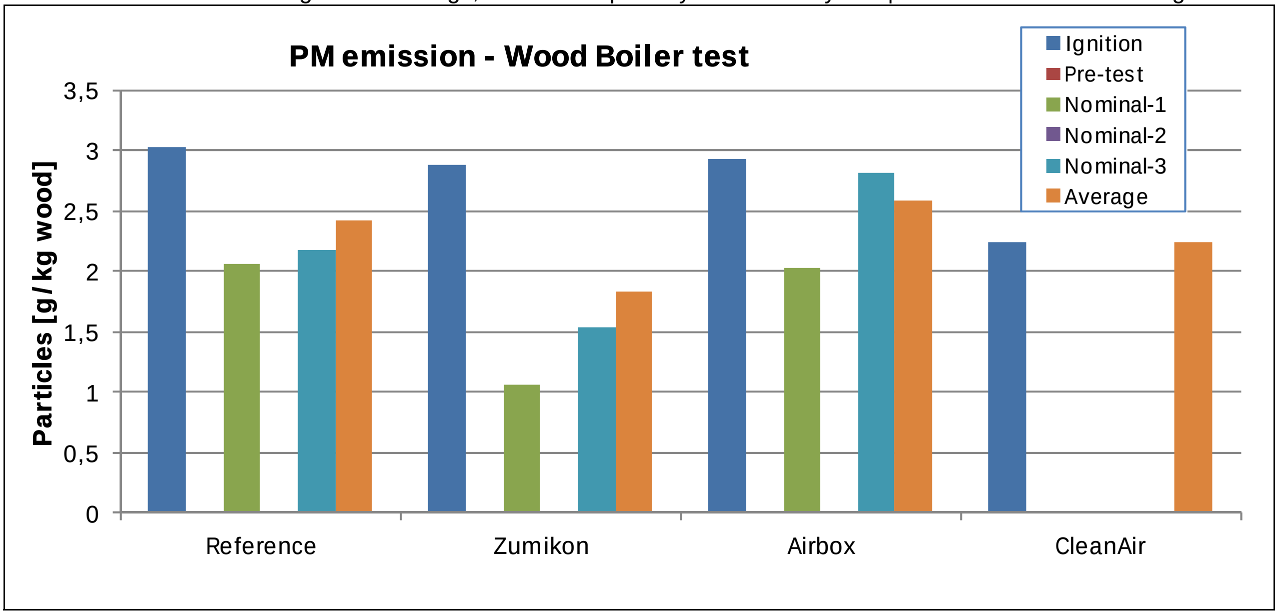
*Values for CleanAir are only for the ignition charge, and they are consequently not directly comparable with the other figurers, which are averages for all charges.

As only one reference test was performed, and the Ecoxy and MoreCat are not applicable for boilers, all the results can be presented in one diagram per parameter.

The test of the CleanAir ESP was aborted after the ignition charge, as the filter felt down from its placement on top of the chimney.

The PM emission for each test is shown in Figure 35.

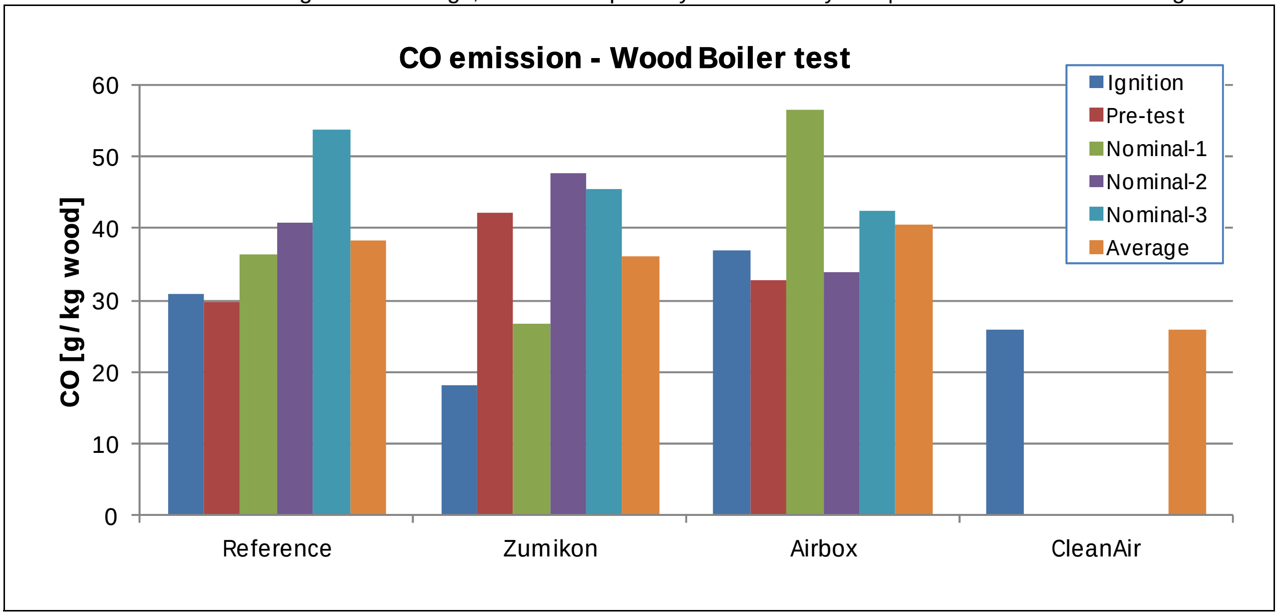
Figure 35. PM emissions from wood boiler test. Values for CleanAir are only for the ignition charge, and consequently not directly comparable with the other figurers



Only the Zumikon ESP seems to have some reducing effect on the PM emission.

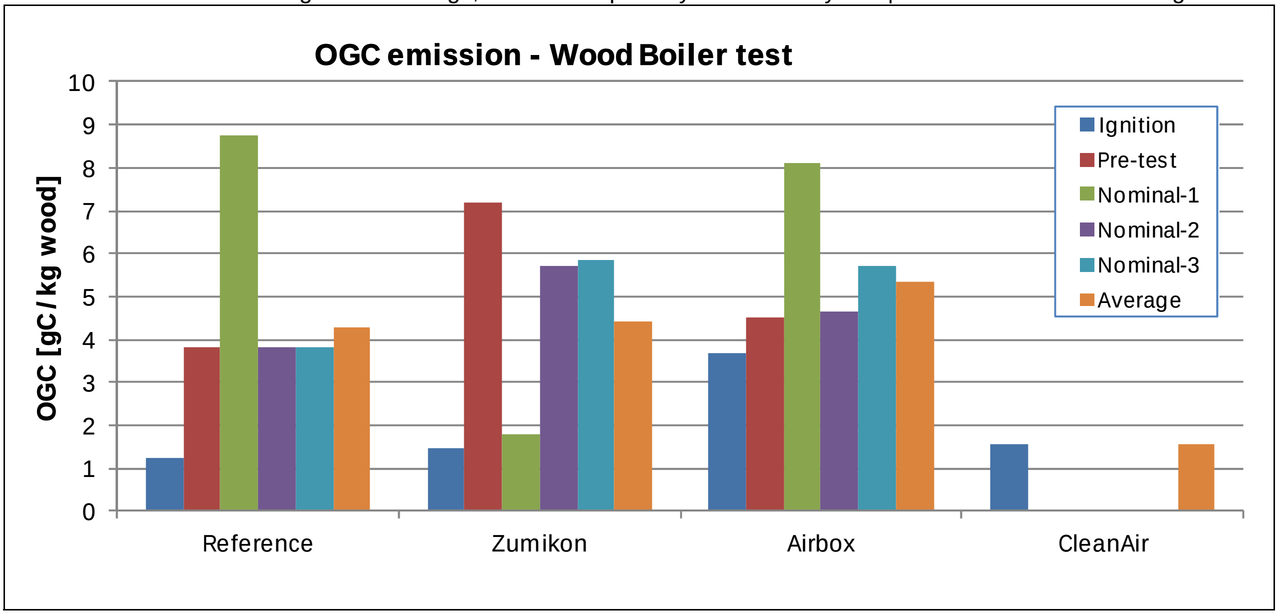
The CO emission in Figure 36 for the Zumikon an Airbox is showing a different and more varying patterns than the reference test, indication that the combustion conditions has not been exactly the same as for the reference test.

Figure 36. CO emissions from wood boiler test. The CleanAir value is only for the ignition charge, and consequently not directly comparable with the other figurers




The OGC emission in Figure 37 for the Zumikon an Airbox is showing a different and more varying patterns than the reference test, which supports the indication from the CO emissions, that the combustion conditions has not been exactly the same as for the reference test.

Figure 37. OGC emissions from wood boiler test. The CleanAir value is only for the ignition charge, and consequently not directly comparable with the other figurers

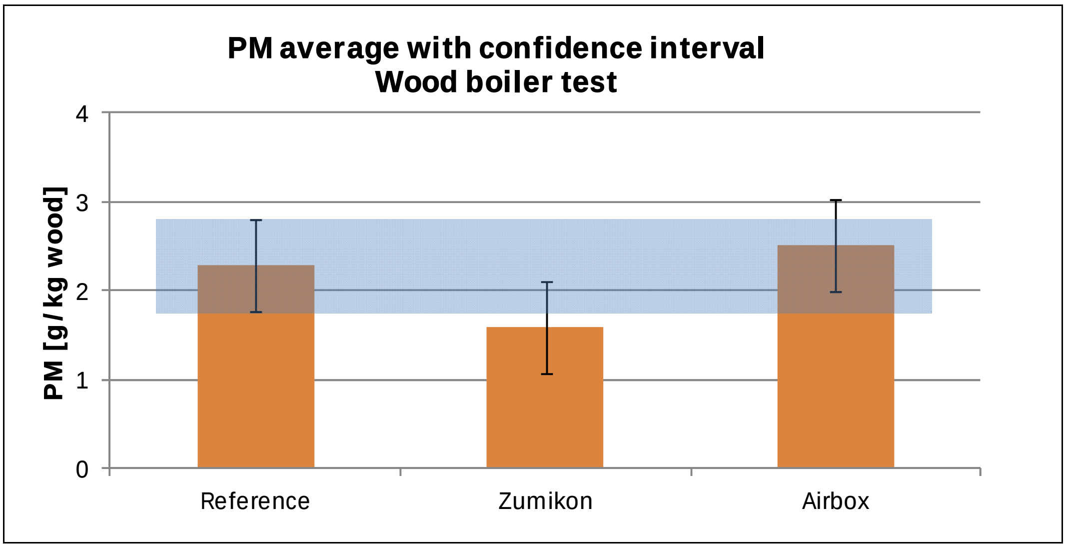


## 6.6 Wood Boiler statistical evaluation

The main results for the wood boiler test in terms of weighted average emission factors for all tests for each technology with the calculated uncertainty and confidence interval according to the type A statistical evaluation explained in Appendix 4 are shown in the next figures.

The CleanAir ESP is not included in this statistical evaluation, because leak of date, as the boiler test in 2008 was stopped, when the filter fell down in the beginning of the Pre-test phase (see clause 4.4.6 on page 52). In 2009 the Clean Air ESP test was repeated, but only for the wood stove.

Figure 38. Average PM emission with uncertainty confidence interval for the wood boiler test




The Zumikon has a probably lower emission of PM, while there is no difference in the emission of CO or OGC for any of the technologies.

Figure 39. CO emission from wood boiler test

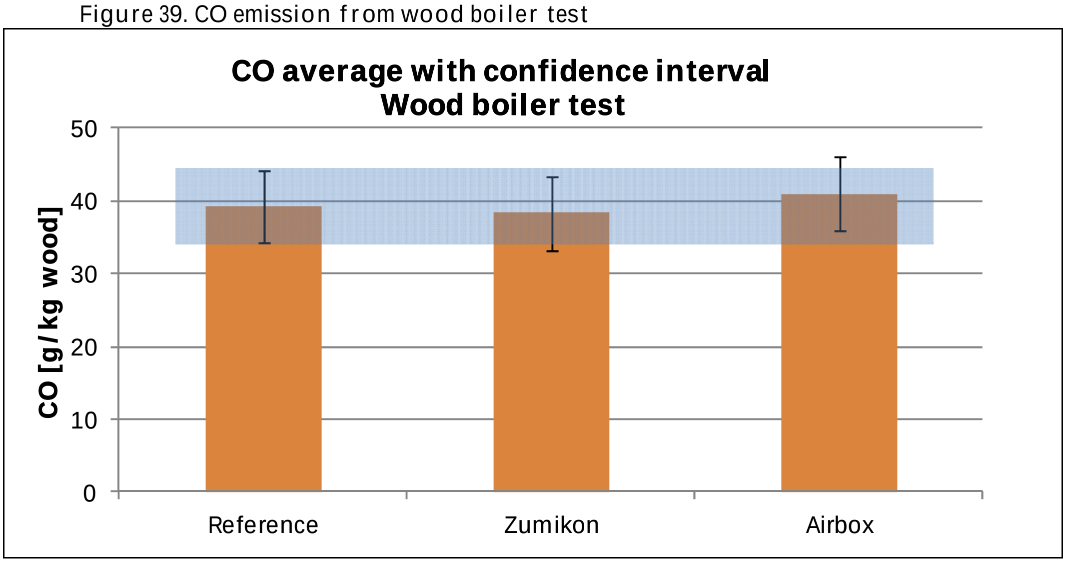
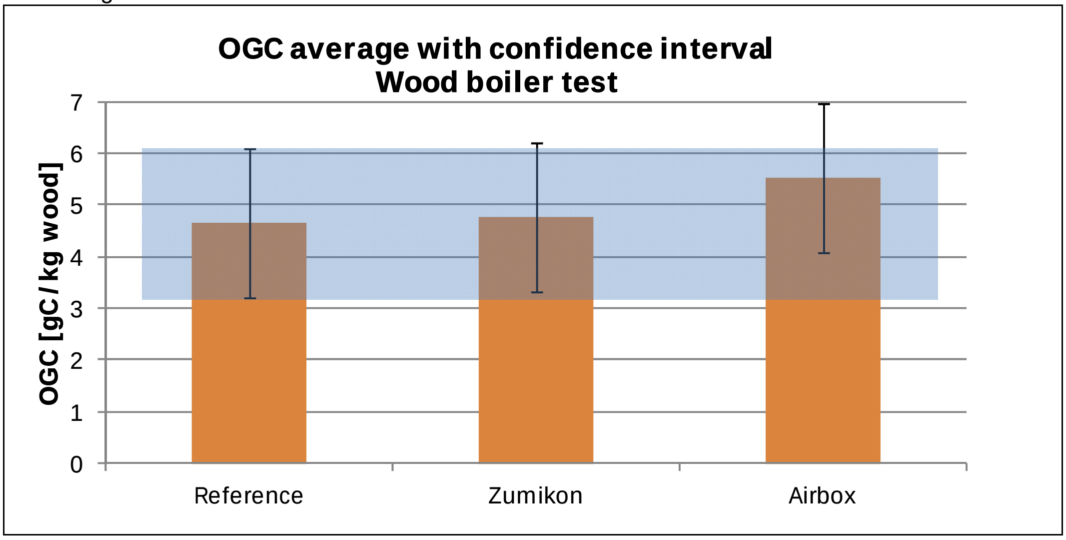


Figure 40. OGC emission from wood boiler test




## 6.7 Assessment of Main Results

There is obviously an effect on the combustion conditions when installing any of the tested technologies, which makes the comparison to a reference test more unreliable. However, it would be expected from any technology to reduce emissions when mounting on existing and often old appliances, that a considerable reduction in the emission could be registered, despite a minor differences in combustions conditions.

### 6.7.1 Effects on combustion conditions

The Zumikon and the Airbox has a small blower, taking up to 5 $m^3$/h air from the room into the ESP, apparently for cooling the electrode and to prevent depositions on the insulation, which otherwise could cause electrical short cut. This air will be mixed with the flue gas, and be exhausted through the chimney. The chimney draught will be reduced by this addition of room air, partly because it will reduce the temperature in the chimney, partly because it interrupt's the upward movement of the flue gas, and partly because the chimney draught has to take out the extra volume. This result in reduced combustion efficiency compared to the reference test, and causes potentially increased emissions. If the chimney is well insulated and high enough to have a surplus draught, the negative effect can be compensated by opening the air supply a little bit more.

Additionally the Airbox is big and heavy, which cools down the flue gas and thereby reduces the chimney draught. The flue gas also has to change directions inside the ESP, which causes a pressure loss, and a demand for a little more chimney draught.

The CleanAir ESP is mounted on the top of the chimney, and it has no blower installed. The temperature is anticipated to be low enough for the thermal stability of the components, and the electrode bushing is designed to avoid depositions, which otherwise could cause electrical short cut. However, the flue gas has to change direction through the ESP, which gives a slightly decrease in the chimney draught. APP claims' that the ESP will increase the chimney draught, and it might be correct, because during the test it was observed, that with the ESP turned off some flue gas was leaking from the bottom of the ESP, and when the ESP was turned on it disappeared.

The moreCat catalyst will reduce the chimney draught considerable, as it will cause a pressure loss of 5 – 7 Pa, and it is recommended by the producer to have a high chimney or to install a chimney fan.

The Ecoxy retrofit system has only a positive effect on the combustion efficiency, as it constantly will supply tertiary combustion air to the stove.

### 6.7.2 Zumikon ESP evaluation

The PM measurements does not show any significant reduction compared to Reference for the Wood stove test, but some reduction is apparent for the boiler test.

The ELPI measurements shows an increase in the number of small particles < 2,5 µm. Calculated to mass by a density of 1, shows a reduction for the stove, but not for the boiler.

The colour of the filters for the PM measurements, does not show any reduction in the black colour for the boiler test, but for the stove test the filter from the reduced load was light brown, where all the other filters was black, just as the filters from the reference tests. The flue gas flow is lower for the stove than for the boiler, and as the ESP efficiency also depend on the velocity, the highest efficiency are expected for the stove with the lowest velocity, and the flow is also the lowest for the reduced test.

Figure 41. The Zumikon ESP after one day stove test and one day boiler test.

The inside of the Zumikon shows an increased soot deposition on the inside of the flue after the electrode, which can be seen as a thicker layer of deposition in the upper part of the flue in Figure 41. It is an open question, how much of these soot particles would have been deposited in the chimney, if the ESP was not there.

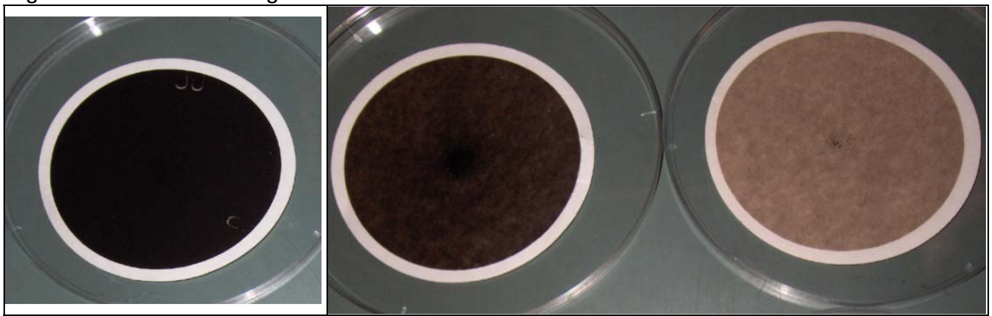
### 6.7.3 Airbox ESP evaluation

There is no significant reduction of the particle emission compared to the Reference test, except for a possible small reduction for the stove at nominal load.

The ELPI measurements shows a slightly reduction of the number of particles < 2.5 µm, and a significant reduction in the mass of particles < 2.5 µm calculated with a density of 1.

The colour of the filters for the PM measurement indicates some reduction of the soot particle emission, especially for the stove test, which is shown in Figure 42.

Figure 42. PM measuring filters from the Airbox stove test



From the left: ignition, nominal and reduced

All filters from the reference test are black, as the first filter from ignition in Figure 42. It is obviously from the colour that the black soot particles are reduced in the stove test, leaving the brownish condensables. The lower efficiency for the ignition could either be due to a more incomplete combustion when igniting a cold stove or boiler, or due the fact, that it takes some minutes before the Airbox is automatically turned on, when registering the increasing temperature in the flue. The same is not seen for the boiler test, where all the filters were just as black as the reference test. There might be some reduction in soot particle emission, but not enough to see it on the black colour. The flue gas flow is lower for the stove than for the boiler, and as the ESP efficiency also depend on the velocity, the highest efficiency are expected for the stove with the lowest velocity.

The big mass of the filter, which cools down the flue gas as well as the introduced cooling air, will reduce the chimney draught. Combined with the pressure loss in the filter, it apparently results in a different combustion with less combustion air and consequently less effective combustion, compared to the Reference test. This could be the reason for the general slightly higher emission values for CO and OGC compared to the reference test (if they are not just reflecting common variations in the combustion conditions). The particulate emission could also have been increased by the less efficient combustion, which means that the Airbox could be more efficient regarding particle reduction, than the test shows, if it is operated in the most optimal way. A test with the Airbox turned on and off periodically could have disclosed this, but it was not a part of the test plan, and it would also provide an alteration of the control box, to be able to turn off only the ESP and leave the fan running.

A while after the test was performed, the Airbox was opened to be inspected and to evaluate the soot deposits inside. The depositions were surprisingly very thick, as seen in Figure 43. It was not inspected before the test, and when seeing these thick depositions after two days test, it is obvious to think that most of these deposits must have been there when receiving the unit. It could be the reason for the poor test results.

Figure 43. Airbox opened with the 8 electrode visible for cleaning after the test

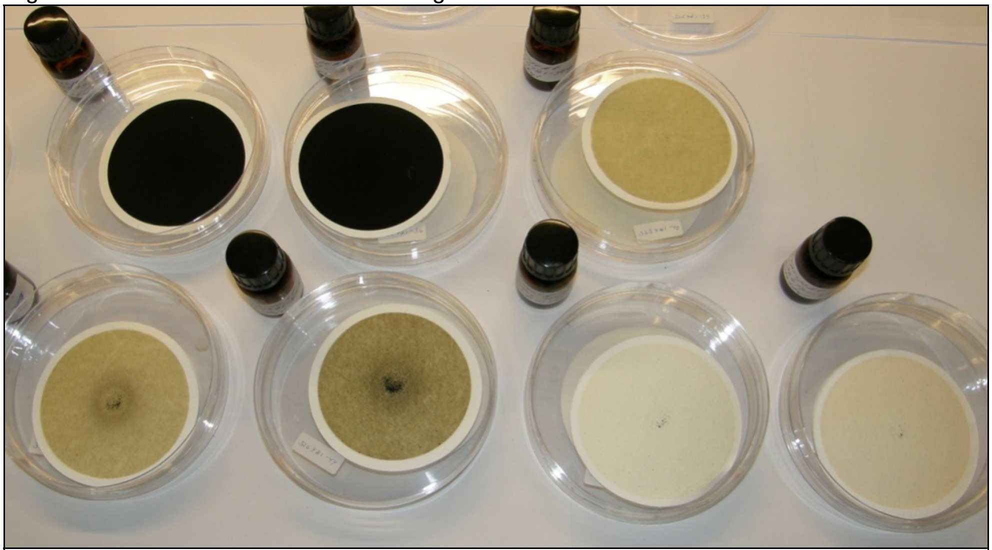
If the Airbox was clean when the test started, and the thick soot layer is coming from only two days of operation, then it must be pretty efficient, but it is not what the measurement are showing.

### 6.7.4 CleanAir ESP evaluation

All tests could not be carried out, because of a problem with a piece of Teflon between the chimney top and the CleanAir, which could not stand the high temperatures during the test. During the boiler test in the pre-test period right after the ignition, the CleanAir felt down from the chimney top, because of to high temperature, which softened the Teflon. The boiler test could consequently not be accomplished. In the following stove test, the nominal load test was skipped, because of the high flue gas and chimney temperatures, and only ignition and reduced load test was performed. However, the stove test was repeated in its full extend the following year, as the steering committee judged that it would be of great value for the project to have these test results. The CleanAir could be the most efficient ESP, because it is placed in the top of the chimney, where the flue gas temperature is lower, and more condensables has condensed to form particles.

The test shows a significant reduction of the particle emission in the wood stove test, but also a probable increase in the NMVOC emission. There was no significant reduction of particle emission from the boiler, but apparently a less significant decrease in OGC and NMVOC.

Figure 44. Picture of the PM measuring filters from the 2009 wood stove CleanAir test



The order of the filters are the same order as the firing order, which mean from the top to the left starts with Ignition, Pre-test, Nominal 1 and in the next row from the left is Nominal 2, Nominal 3, Intermediate stage and Reduced load.

From the colour on the filters seen in Figure 44 it is very clear to see the effect on the particle emission. The two first filters are black from soot, but they are from the period where the CleanAir ESP by a mistake was not turned on. It obviously to see from the colour of the rest of the filters, where the ESP is on, that it removes almost all the soot particles from the flue gas. The brownish colour on these filters are made by the collected condensables, which apparently from the PM results contributes to the main part of the weight of the particle emission. There are a growing number of bigger black particles on the first three soot free filters, and it is a strong indication of either a falling efficiency after start up, or that agglomerated particles are released from its deposition. The two last filters from the reduced load test are less coloured, which might be due to the reduced load which apparently emits les PM and OGC. There is a clear and increasing deposition of bigger soot particles in the centre of the filters, especially for the nominal test, which could either be due to rapid decrease of ESP efficiency, or due to the release of bigger soot particles from the growing soot layer in the ESP.

The ELPI measurements shows a big increase in the number of particles, but the mass of $PM_{2,5}$ calculated by the density of 1, shows a significant reduction.

### 6.7.5 MoreCat catalyst evaluation

The pressure drop over the catalyst reduces the chimney draught, and affects thereby the combustions compared to the reference condition. The stove test was performed, but apparently with a reduced rate of combustion air and consequently less efficient combustion. The boiler test could not be performed, because of a too high pressure drop, as the flue gas flow from the boiler is much bigger than from the stove. Later a larger version for small boilers should be available.

The test showed a significant reduction of the CO emission compared to the Reference test, but there was no significant effect on the emission of OGC, NMVOC or particles. The effect of the moreCat should especially be seen on the OGC and NMVOC emission (OGC includes NMVOC).

The colour of the filters for the PM measurements does not show any visible differences from the reference test.

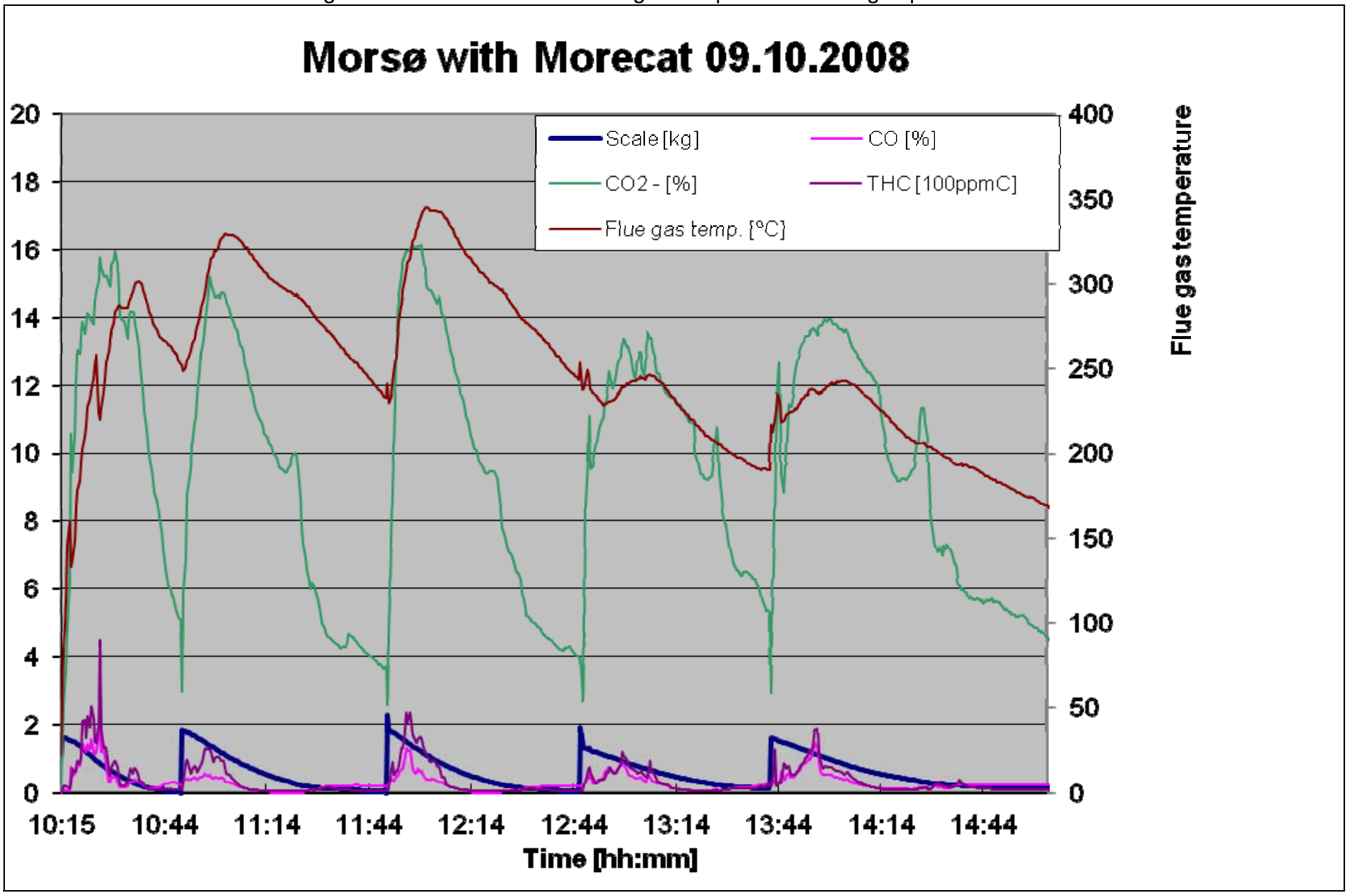
The company MoreCat has later on explained, that the tested catalyst was of a poor quality. As a result of the presence of oxidized metals on the surface the precious metal doesn't stick properly on the total surface of the support metal, which could be a reason for the poor performance on OGC reduction in the tests.

The reason for the lack of OGC reduction could also be a too low flue gas temperature to achieve the catalytic oxidation of the hydrocarbons.

MoreCat claims, that "to oxidize soot particles a starting temperature of at least 350 °C is required. To start the CO and OGC oxidation a temperature of app. 270 to 300 °C is necessary. If the temperature remains too low during firing the surface of the catalyst will be gradually covered with soot what decreases its performance. An operation temperature of at least 350 °C is then required to free the surface from this layer of soot".

According to the flue gas temperature during the test showed in Figure 45, the temperature of 350 °C is only nearly reached in the nominal charge (the third temperature maximum) and the soot deposition from the ignition and pre-firing has consequently not been oxidized, which decreases the performance. The temperature has only been above 270 °C part time of the three first charges, but it is below 250 °C for the reduced test, where no effect can be expected.

Figure 45. MoreCat test - flue gas temperature and gas parameters

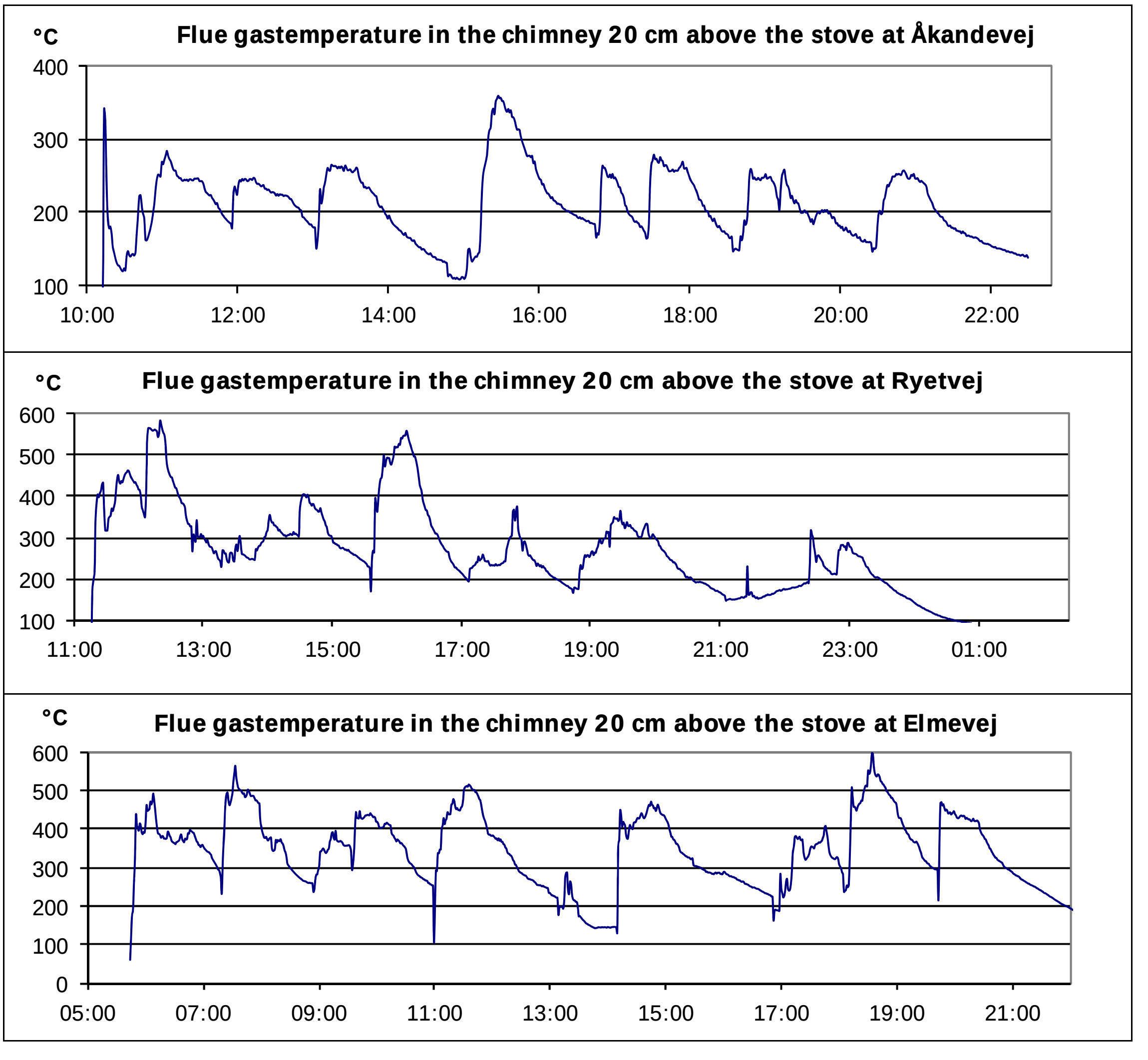


It is not possible to make out, if the reason for the lack of efficiency is due to the too low flue gas temperature or the poor quality of the catalyst.

The flue gas temperature in many Danish stoves will have a too low flue gas temperature to fulfil the temperature requirement to achieve a good efficiency with a moreCat catalyst.

The next diagram shows the flue gas temperature measured in the chimney 20 cm above the wood stoves in three random chosen houses. The temperature has been measured during 1½ week, and the figures show one representative day from this period.

Figure 46. Flue gas temperature measured in the chimney 20 cm above three random chosen wood stoves




The stove in the first diagram is not suitable for the moreCat, as the flue gas temperature in general is below 270 - 300 °C, and soot depositions will not be oxidized, as the temperature hardly gets above 350 °C.

The stove in the middle diagram could probably achieve some effect from a moreCat, as the temperature is above 300 °C most of the time during the day, and the temperature is high enough to oxidize soot in several periods. But during the three last charges in the evening, it is les suitable, as the temperature is lower, probably caused by a more smouldering combustion.

The stove in the lower diagram seems most suitable for the moreCat, as the temperature most of the time is high enough to start hydrocarbon and soot oxidation. This stove is probably operated better than the other two stoves, with more efficient combustion and less emission.

It is a paradox, that the need for an emission reduction is greatest for the stoves where a moreCat is less applicable.

#### 6.7.6 Ecoxy Retrofit System evaluation

This technology could only be tested with the stove, because it could not be mounted in the boiler.

CO and OGC/NMVOC emission are significantly lower at reduced combustion, which most likely is caused by the supply of tertiary combustion air. There is no significant effect on the PM emission.

Increased combustion rate was observed especially in the lightning phase, which apparently gives a small increase of the particle emission.

The colour of the filters for the PM measurements does not show any visible differences for the ignition and nominal load, but the filter from the reduced load was light brownish, where it was light black in the reference test. The effect from the extra supply of tertiary air is apparently better at the reduced load, but the effect is not big enough to be seen on the measured parameters.

The Ecoxy retrofit system has among others been tested on a Jøtul 600 wood stove, which seems to be very much alike, the Morsø stove, used in this project. It is a typical and widespread used stove in Norway, and more than one million units have been produced since 1940. The tests showed a particle emission reduction of 60 – 80 %.

Jøtul 600 – old model


Jøtul F 602 – the new version of Jøtul 600

We believe that it might be possible to achieve better results with the Ecoxy retrofit system, if it is tested with the most optimal regulation of the air supply, instead of just the same setting as used for the entire test in this project.

### 6.7.7 Swan eco labelled stove

The eco labelled wood stove has the lowest emission factor of all test, for CO, OGC and NMVOC. The CO decrease is very significant. Decrease in PM is existing but not significant; however, this is due to a high value in the reduced load test.

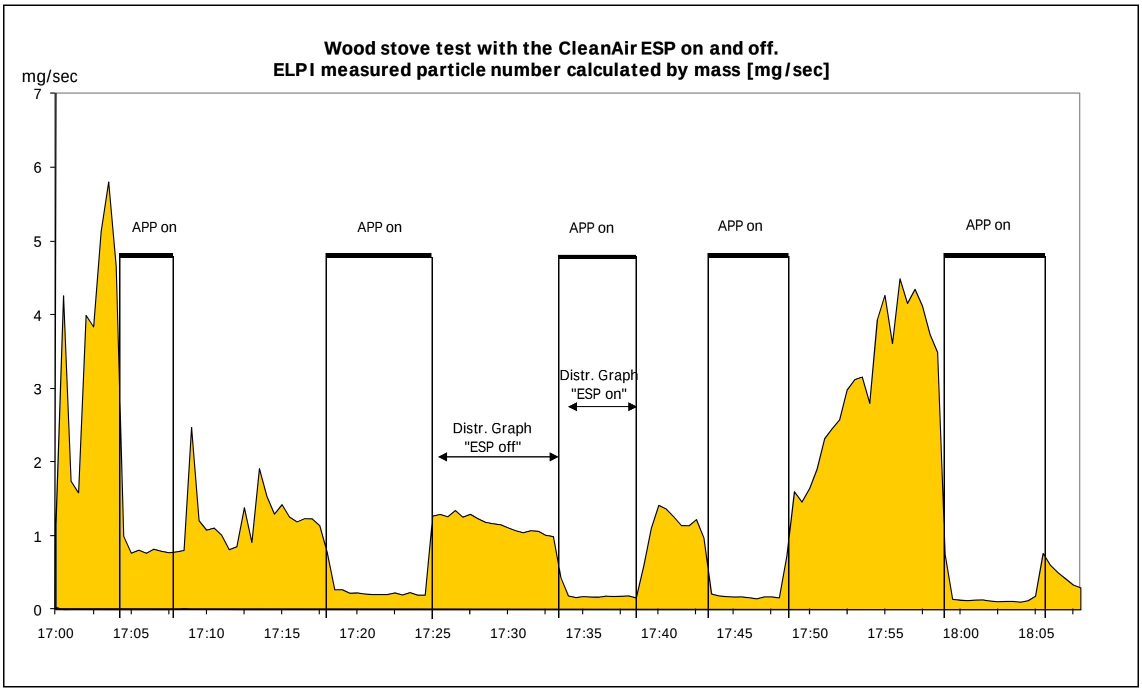
## 6.8 Fine particles influenced by ESP

In some of the tests with ESP it was seen that the number of fine particles < 2.5 µm was increasing, when the larger particles was removed by the ESP. To verify this, a special test was planned, where the CleanAir filter was turned on and off, and the effect on the particle number and size distribution was measured directly with the ELPI.

This test was performed immediately after the normal test, with a refuelling as a nominal load with three logs of app. 2 kilo wood. The CleanAir was then turned on and off with app. five to ten minutes interval. The logs were loaded at 17:00 and at 17:53 the secondary air supply was closed, and the fire began to make a heavy smoke.

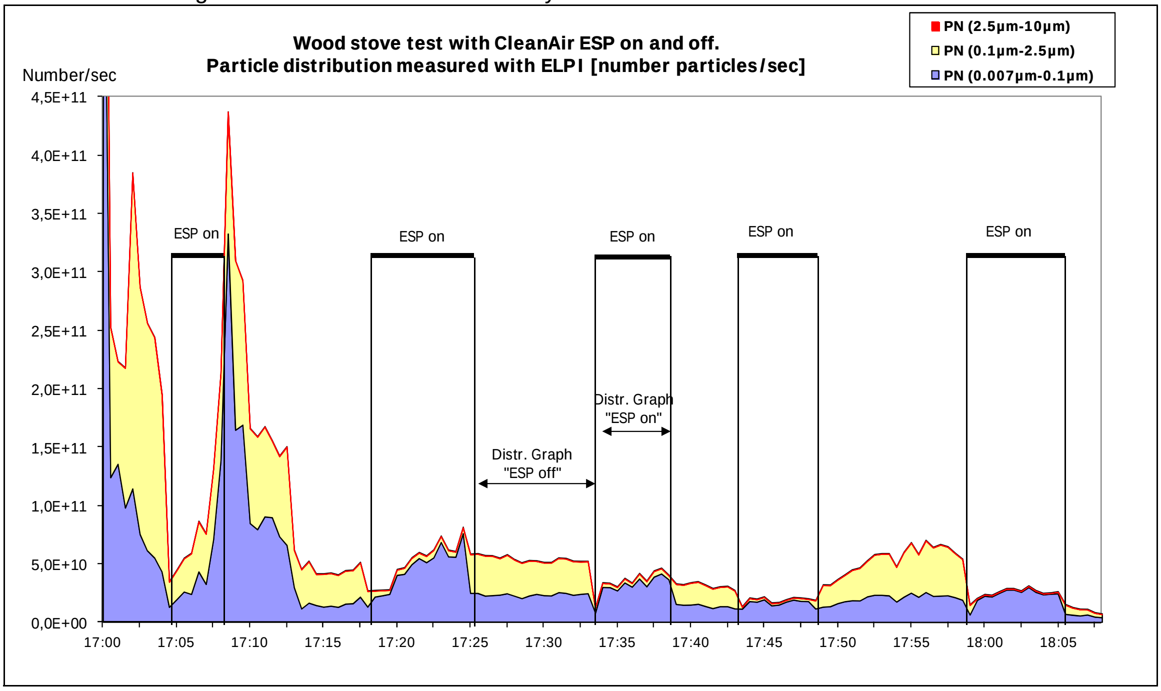
The results are shown in Figure 47 and Figure 48.

Figure 47. Particle distribution by mass, calculated for a density 1 g/ccm, for the CleanAir ESP on / off




There is a very clear reducing effect on the ELPI measured particle distribution number calculated by mass in Figure 47.

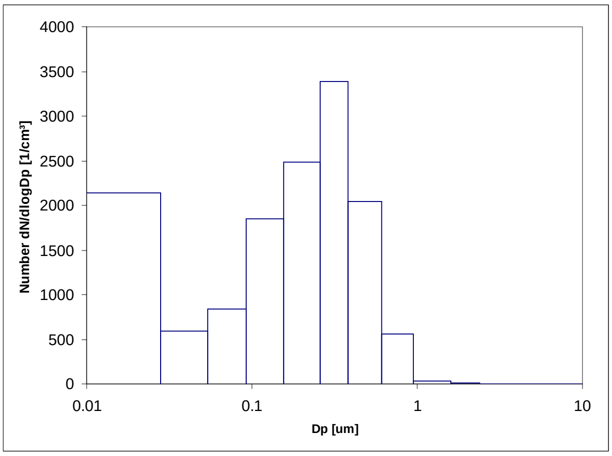
Figure 48. Particle distribution by number with the CleanAir ESP on and off



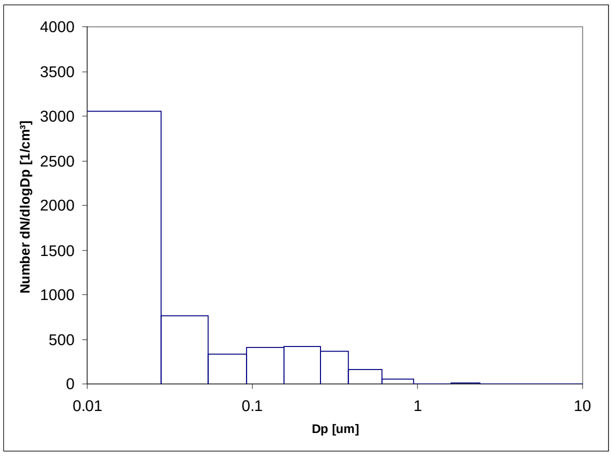

The particle distribution by number in Figure 48 does not show the same big reduction in the total number of particles, as for the calculated mass in Figure 47, but there is a clear effect on the particle size distribution. The ESP has a big reducing effect on the number of particle > 0.1 µm, but it seems to have the opposite effect on the number of fine particle < 0.1 µm. This is not so clear during the first minutes after the refuelling, but it is evident in the last 4 on/off's. The yellow area representing the number of particle > 0.1 µm is reduced to a very low value, when the ESP is on, and in the same periods the number of particles < 0.1 µm is increased, compared to the periods with the ESP off.

The changes in particle distribution and the big increase in particles smaller than 0.1 µm are also very visible in Figure 49.

Figure 49. particle size distribution with the ESP turned on and off.




ESP off




ESP on

The explanation for the increased number of ultra fine particles by the ESP is believed to be, that normally condensables will condense on the larger particles and make them bigger when the flue gas is cooled down, and if the bigger particles are removed by an ESP, the condensables will rather condense to form fine particles, which are < 0.1 µm.

If ESP's in general increases the number of ultra fine particles when reducing the number of larger particles this it is very problematic, because the particles < 0.1 µm is the most health effecting part of the particles. This possible effect will probably not be seen, if the reduction of particles is measured directly in the very hot flue gas in the chimney, before and after the ESP, and therefore we take it as an extra reason for always measuring in a dilution tunnel.

It is recommended to investigate this possible particle size distribution effect by the ESP, to clarify if, and how much, the flue gas health effect risk is increased or reduced, when the larger particles are removed by the ESP.

## 6.9 PAH and PCDD/F emission

PAHs and PCDD/Fs (dioxins and furans) were measured from one sample collected during the whole test from ignition to reduced load, and consequently it is not possible to make statistical evaluation of the uncertainty.

The emission factors for PAH and PCDD/F emission per kg wood, was calculated from the measured concentration in the sample, the total amount of wood burned and the total volume of diluted flue gas in the dilution tunnel during the sampling period.

### 6.9.1 PAH emission

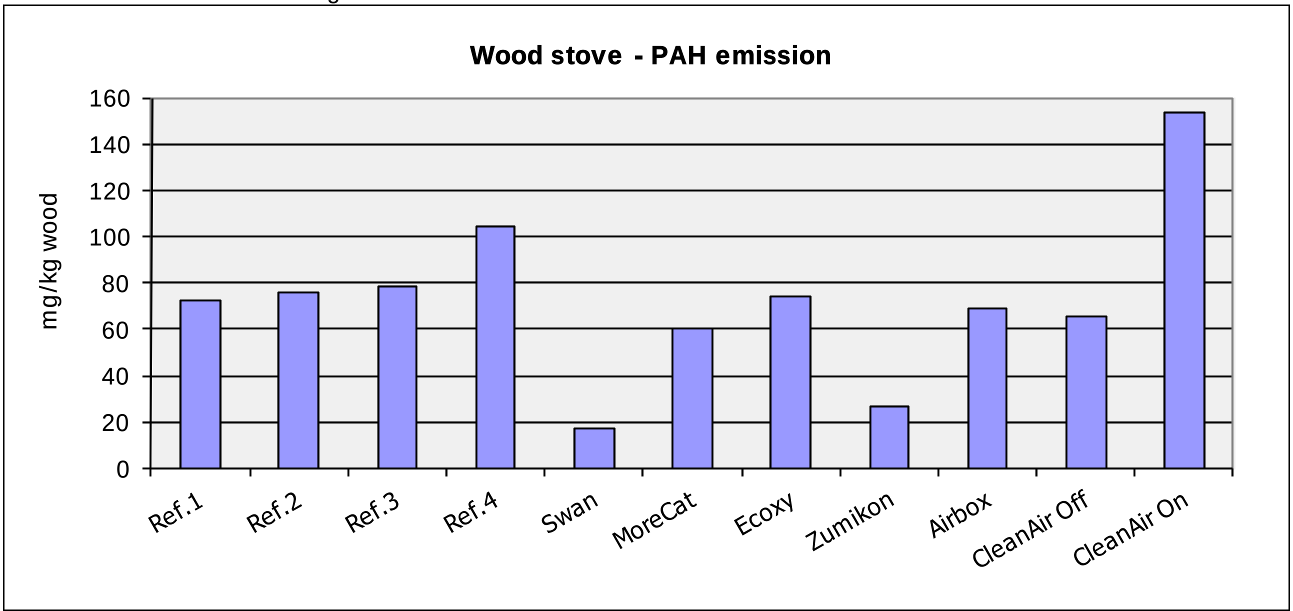
The 16 EPA PAH except naphthalene was analyzed together with 6 additional PAH compounds. All twenty-one analyzed PAH are showed in Table 6. The six additional PAH, besides the 15 EPA PAH is marked with greyish cells.

Table 6. Analyzed PAH

| | | |
|---|---|---|
| Acenaphthylen | Benz(a)anthracen | Benzo(ghi)perylen |
| Acenaphthen | Chrysen | Dibenzothiofen |
| Fluoren | Benzo(b)fluoranthen | 2-Methylphenanthren |
| Phenanthren | Benzo(k)fluoranthen | 3,6 Dimethylphenanthren |
| Anthracen | Benzo(a)pyren | Triphenylen |
| Fluoranthen | Indeno(1,2,3-cd)pyren | Benzo(e)pyren |
| Pyren | Dibenz(a,h)anthracen | Perylen |

The PAH emission factors, as the sum of the measured compounds, can be seen in Figure 50 for the wood stove test, and in Figure 51 for the wood boiler test.

Figure 50. PAH emission factors for the wood stove test



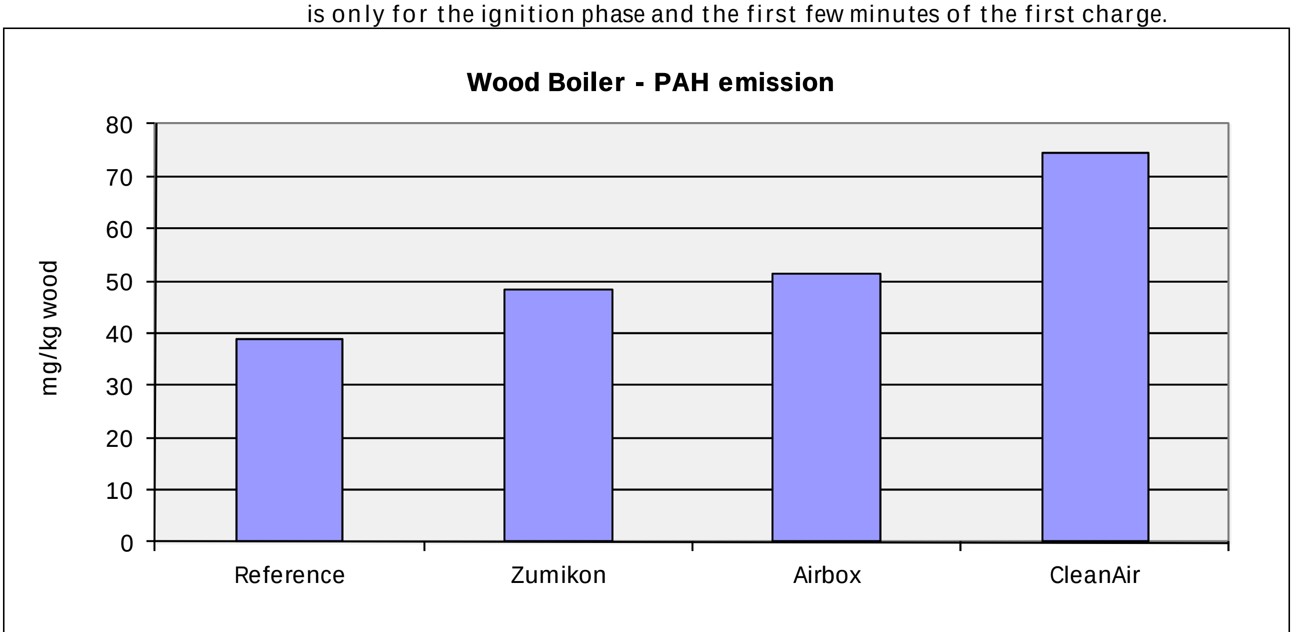

The “CleanAir off” test includes the ignition and the first charge, where the ESP mistakenly was off, and the “CleanAir on” is the rest of the test, where the ESP was turned on.

The Swan wood stove has the lowest PAH emission, which also is expected from the more efficient combustion in a newer certified stove.

The Zumikon test has almost as low PAH emission as the Swan stove and the CleanAir has the highest emission, which is nearly the double of the reference test. With only one sample for each technology, it is impossible to make clear conclusions, but there is a tendency to a small reduction of the emission by all of the technologies, except for the CleanAir.

The PAH emissions from the wood boiler test is shown in Figure 51.

Figure 51. PAH emission factors from the wood boiler test. The value for the CleanAir is only for the ignition phase and the first few minutes of the first charge.



There is no indication of any positive effect on reduction of the PAH emission from the wood boiler with any of the three tested ESP. In contradiction the values more indicate an increase in the PAH emission when using ESP. The highest value is seen for the CleanAir ESP in the wood stove test, which also showed the most efficient reduction of particles.

#### *6.9.1.1 Discussion of PAH emission*

The PAH is normally associated to the soot particles, and when reducing the soot particles, the PAH is expected to be reduced too.

The higher value for the CleanAir in both the stove and boiler tests is strange, especially when comparing with the filters from the stove test in Figure 44, where it is clear to see, that the soot particles are efficiently removed by the ESP.

A thesis for the higher PAH emission for CleanAir could be, that PAH is readily and completely extracted from the filter without soot particles, but only partly extracted from the filter with soot particles. It is well known, that some compounds, e.g. PCDD/F and heavy metals needs a strong chemical treatment to be fully extracted from flue gas samples, but such a treatment would degrade the PAH's, and therefore the ISO/DIS standard for PAH analysis only demands extraction with organic solvents[31]. It is also well known, that when analysing samples of volatile organic compounds collected on activated carbon, only a certain part of the sampled organics can be extracted from the activated carbon, and soot particles has some of the same properties as activated carbon. It could mean, that when removing the soot particles with an ESP, the small particles formed afterwards by condensation could keep a higher concentration of PAH, which is more readily available for health risk, because it is not strongly adsorbed to the bigger soot particles, which are segregated in the nose by respiration, where the small particles can go deep into the lungs. This is only a thesis, but it would be very important for the evaluation of the ESP technology for small scale appliances if there is something in it. Therefore it is strongly recommended to investigate this possible problem with "increased" PAH emission, when removing the soot particles with an ESP.

The Swan wood stove has the lowest PAH emission, which also is expected from the more efficient combustion in a newer certified stove.

### 6.9.2 PCDD/F emission

PCDD/F is a widespread term for two groups of cyclic organic chlorinated compounds, the 75 different polychlorinated dibenzo-p-dioxins (PCDD) and the 135 different polychlorinated dibenzo-furans (PCDF). Often they are also named "dioxin and furans" or only "dioxins". In this report we will use the name PCDD/F.

Only 17 of the 210 PCDD/Fs  is considered to be toxic, and these 17 are analyzed and the concentration is multiplied with a toxicity factor for each of them, and summarize to one concentration with the unit I-TEQ (International

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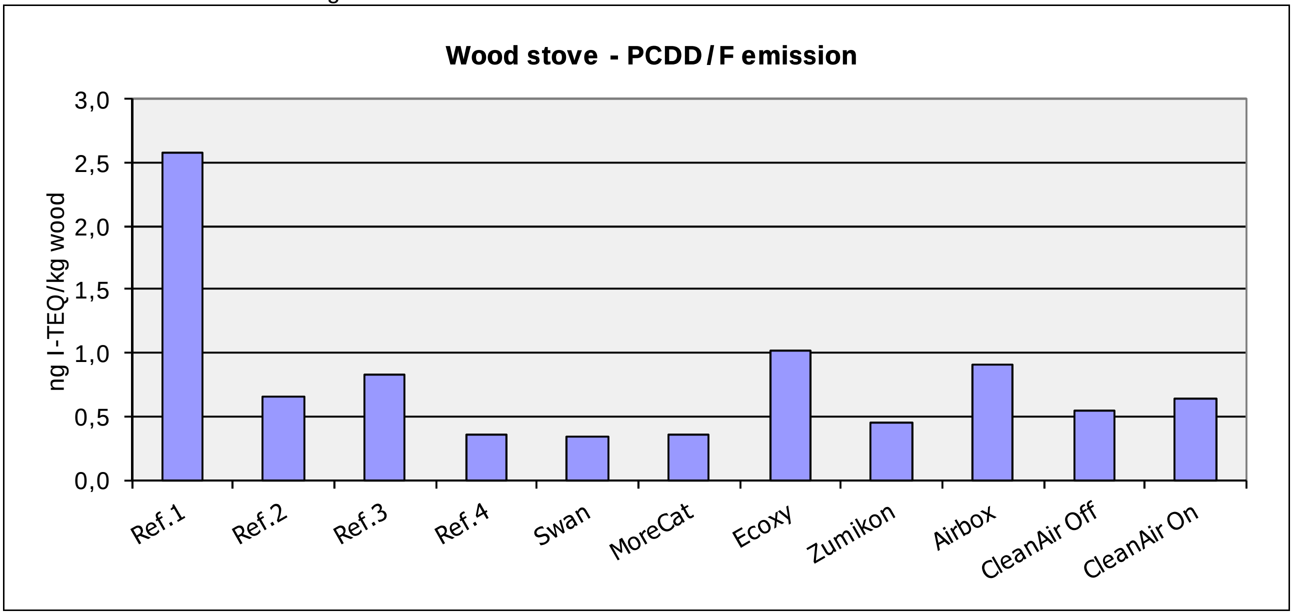
[31] ISO/DIS 11338-2: 2003. Stationary source emissions – Determination of gas and particle-phase polycyclic aromatic hydrocarbons. Part 2: Sample preparation, clean-up and determination.

Toxic EQuivalent). PCCD/F are sampled and analyzed according to the CEN standard EN 1948 part 1-3[32].

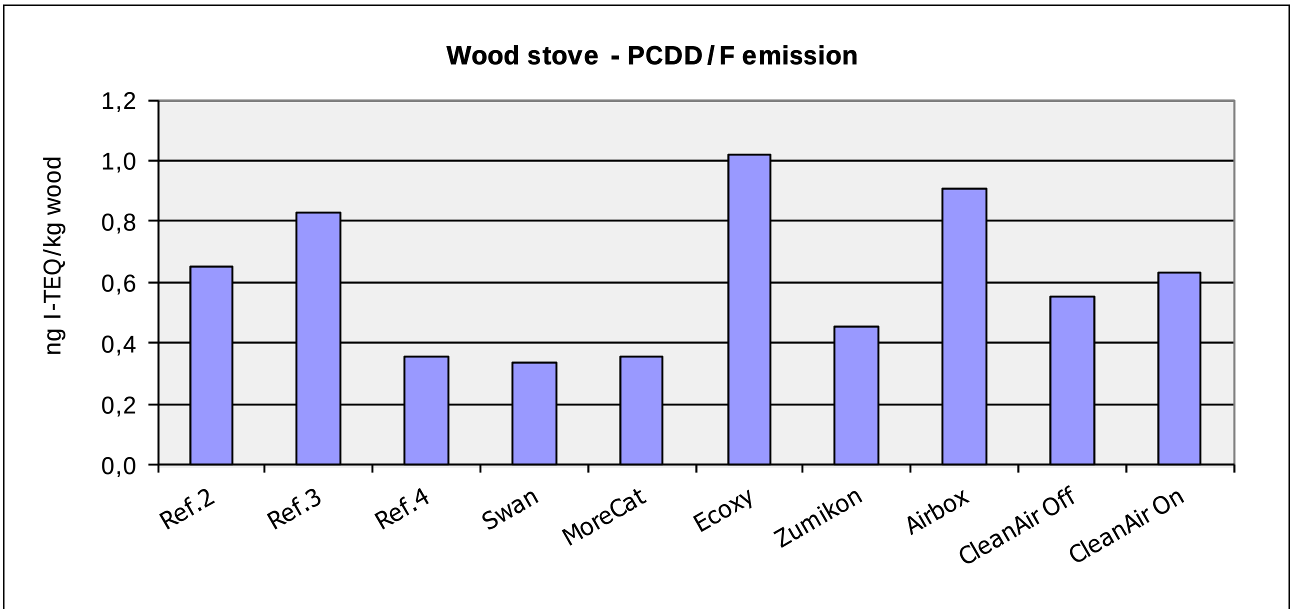
The measured emissions of PCDD/F can be seen in Figure 52 and Figure 53 for the wood stove test and in Figure 54 for the wood boiler test.

Figure 52. PCDD/F emission factors for the wood stove test




The first reference test, Ref.1, was performed during the first series of laboratory test in 2008, and the three next during the second series of test in 2009. The Ref. 1 test might not be representative for the PCDD/F emission, and if removed, it is easier to see the variations between the other measurements, as shown in Figure 53.

Figure 53. PCDD/F emission factors for the wood stove test without the very high reference test 1.

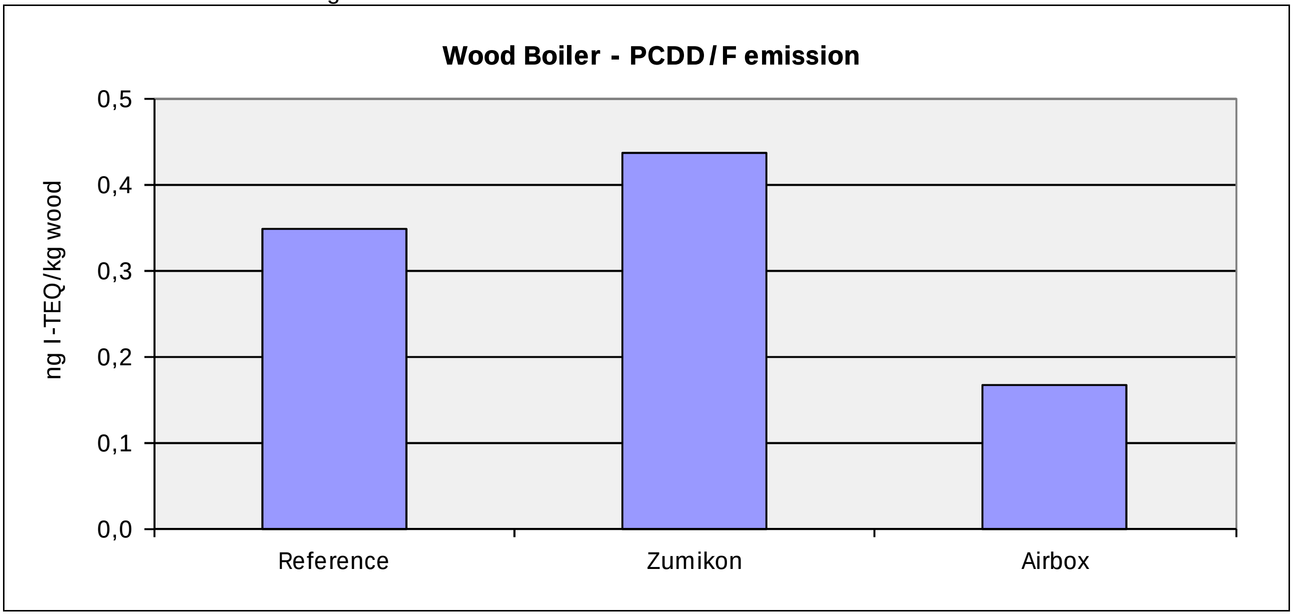



[32] EN 1948-1:2006, Stationary source emissions - Determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs. Part 1: Sampling, Part 2: Extraction and clean-up, and Part 3: Identification and quantification.

There is a big variation in the PCDD/F emission, even for the four reference test, and all the technology test is within the variation for the reference test. Only the Swan stove is slightly lower than the lowest reference test, but the MoreCat is almost as low.

PCDD/F could not be analysed for the CleanAir sample, because of some disturbance in the sample, which could not be removed by the clean up procedure. The other results are shown in Figure 54.

Figure 54. PCDD/F emission factors from the wood boiler test.




The PCCD/F emissions from the wood boiler test seems in general to be lower than from the wood stove test, but the number of test and samples is too low to give more than an indication of the emission level.

#### *6.9.2.1 Discussion of PCDD/F emission*

PCDD/F is not formed in the combustion process, but on the deposited soot particles in the area where the flue gas temperature is mainly in the interval from 450 °C to 400 °C[33]. The PCDD/F formation is catalysed by cupper from chloride and aromatic hydrocarbon precursors formed in the combustions zone. The formed PCDD/F evaporates to the flue gas from the soot particles, and some of it might condense on particles when the flue is cooling down.

The PCDD/F emission from the boiler could possibly be lower than from the stove, because the flue gas might be cooled down below the critical temperature window of 450 °C to 400 °C where the PCDD/F is formed more efficient and faster than for the wood stove.

As the flue gas in general is below 400 °C where the technologies are installed, the PCDD/F formation is not influenced by the technologies, except for the Ecoxy, which might improve the combustion enough to change the FCDD/F formation. It is not clear whether an improved combustion in a wood stove or

[33] Emissionskortlægning for decentral kraftvarme 2008 – Energinet.dk Miljøprojekt nr. 07/1882. Delrapport 5. Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme, 2006. Faglig rapport fra DMU nr. 781, 2010.

boiler is causing a reduced or an increased PCDD/F formation. The results are varying too accidental to give any clarification of this.

Depending on the temperature, the PCDD/F is partly in the gas phase and partly condensed on the surface of the particles. Based on this the ESPs should be able to reduce the PCDD/F emission by removing soot particles, but the test does not show any general tendency for that. This lack of efficiency could be that the main part of the PCDD/F is associated to the fine particles, and they are not reduced by any of the technologies.

The overall conclusion is that none of the technologies are capable of reducing the PCDD/F emission significantly.

### 6.10 Odour emission

Odour nuisances are the most common reason for neighbour complaining about domestic wood stoves and boilers. Odour is normally related to gaseous compounds, and no reduction can normally be expected, if only the particle emission is reduced. Consequently no reduction in the odour emission are expected by using the ESP technology, but some reduction is possible by using the MoreCat catalyst and the Ecoxy retrofit, as they should cause a better combustion of the gaseous compounds.

To discover the effect on the emission of odour by the technologies, some samples of the diluted flue gas was collected from some of the tests. The samples for odour test were collected in special plastic bags, and the odour concentration was determined at the FORCE Technology Odour Laboratory, according to the CEN standard EN 13725:2003[34].

Odour samples are spot sampling of app. 10-15 litres, which are withdrawn during a period of app. 5 minutes.

Most samples from both the wood stove and the wood boiler were taken during the first reference test, to achieve knowledge about the level and the variations during the different combustions stages.

Samples for odour measurement was only taken for the wood stove test with the MoreCat catalyst and the APP filter, as they were anticipated have the highest potential to reduce the odour emission. The catalyst because the odour compounds could be oxidised, and the CleanAir ESP because it is situated in the top of the chimney, where more of the gaseous compounds could be condensed on the particles which are removed in the filter

For the wood boiler samples only were taken when testing the Airbox ESP. This is mainly because of the size of the unit, which only makes it realistic to install it on wood boilers.

The results of the odour measurement are presented in Table 7 and Table 8.

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[34] CEN standard EN 13725:2003 Air quality - Determination of odour concentration by dynamic olfactometry.

Table 7. Measured odour emissions in Odour Units from the wood stove tests

| Sampling start time | Technology: | Reference | MoreCat | CleanAir |
|---|---|---|---|---|
| | Combustion stage | OU/sec | OU/sec | OU/sec |
| 09:36 | Ignition-start | 272 | - | 332 |
| 09:45 | Ignition-start | 90 | - | - |
| 10:05 | Ignition-mid | 76 | - | 181 |
| 11:04 | Charge1-start | 154 | 460 | - |
| 11:11 | Charge1-start | 92 | - | - |
| 11:48 | Charge1-mid | 22 | - | - |
| 12:46 | Charge2-start | 62 | - | - |
| 15:02 | LowCharge-start | 283 | 308 | 345 |
| 15:54 | LowCharge-mid | 25 | 364 | 140 |
| 16:44 | Low air supply | 311 | - | - |
| 16:52 | Low-Low air supply | 1 556 | - | - |

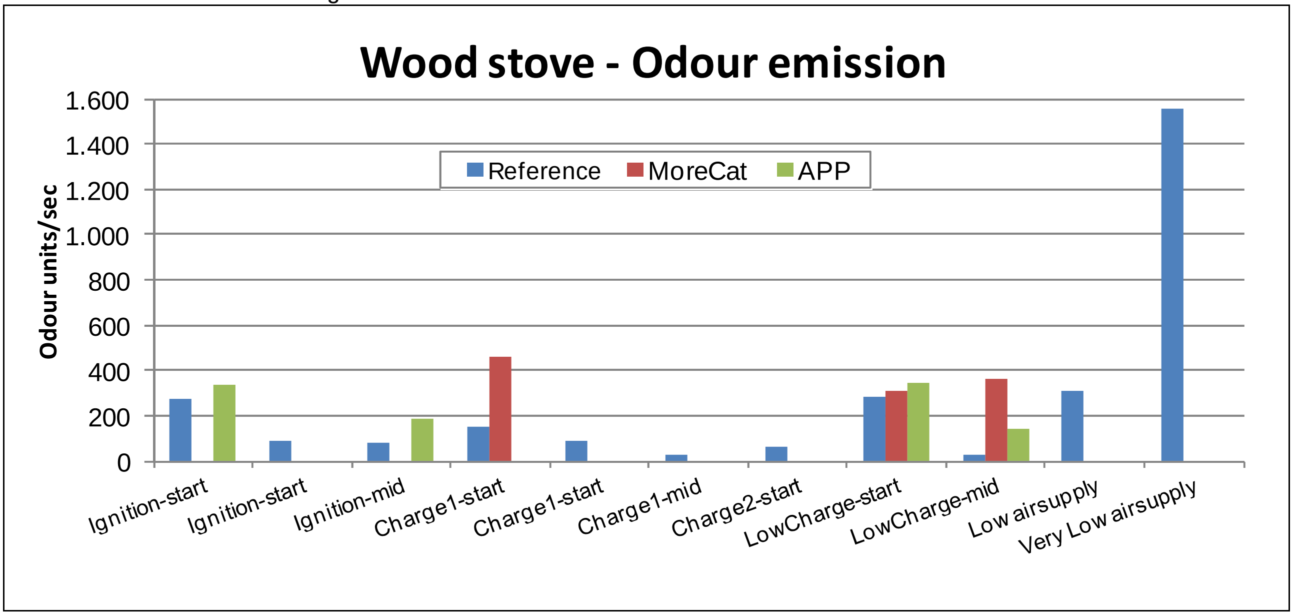
Notice that the last measurements called Low-Low air supply, is made with a very low air supply to imitate an "overnight firing" where the stove is filled up with logs, and the air supply is reduced to only maintain a slow smouldering with very few flames, and a very high emission of unburned gasses (hydrocarbons/OGC). A considerable increase in odour emission was expected and also found for these conditions, and the results documents, that such "overnight firing" should never be practiced.

Table 8. Measured odour emission in Odour Units from the wood boiler

| Sampling start time | Technology: | Reference | Airbox |
|---|---|---|---|
| | Combustion stage | OU/sec | OU/sec |
| 10:17 | Ignition-start | 241 | 986 |
| 10:25 | Ignition-start | 126 | 571 |
| 10:41 | Prefiring1 | 1 862 | - |
| 11:06 | Prefiring2 | 479 | 571 |
| 11:50 | Charge1-start | 1 963 | 2 096 |
| 11:57 | Charge1-start | 236 | 1 188 |
| 12:14 | Charge1-mid1 | 157 | 391 |
| 12:33 | Charge1-mid2 | 314 | 545 |

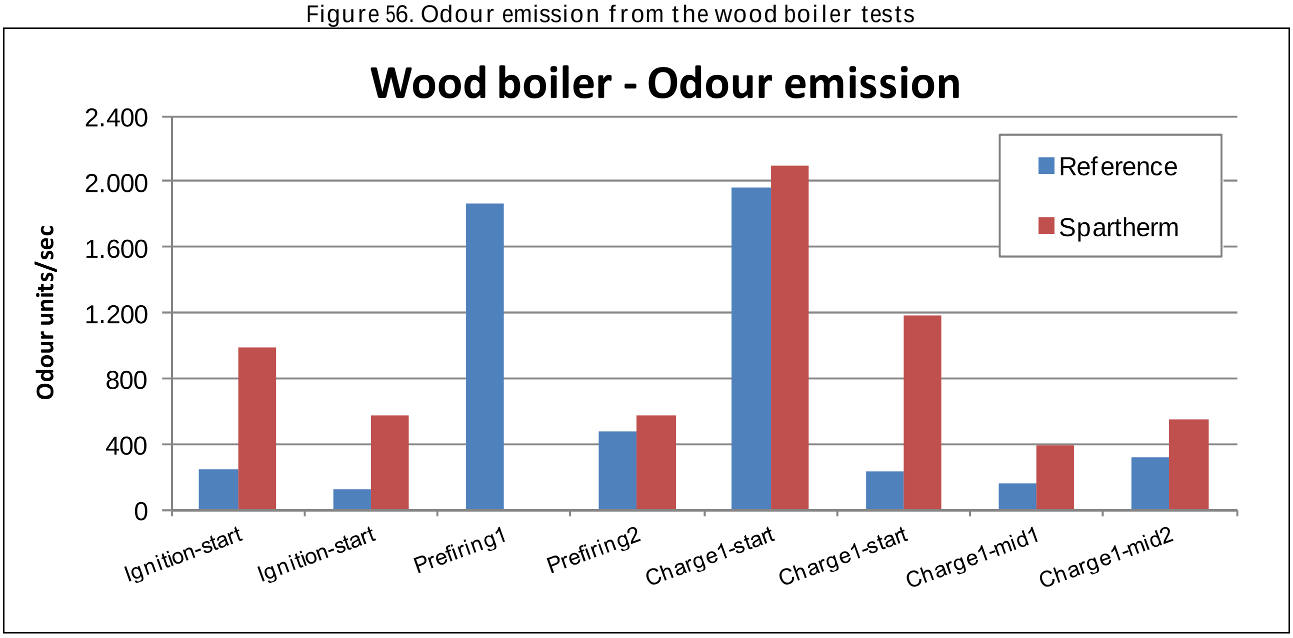
The odour emissions are also presented in diagrams in Figure 55 and Figure 56.

Figure 55. Odour emission from the wood stove tests




There is a great variation in the measured odour emissions, even within short time for the same charge, which probably are strongly connected to variations in the actual combustion conditions. It seems to be impossible to make reproducible and directly comparable odour measurements for different firing conditions.

Figure 56. Odour emission from the wood boiler tests




An odour emission has normally to be reduced by at least 70 – 90 % to achieve a perceptible improvement of the odour level in the surroundings.

The odour measurements clearly demonstrate that none of the technologies seems to have any essential effect on the odour emission. This is in agreement with information from APP, that the CleanAir ESP apparently has no effect on the odour emission.

The consequence is that none of the tested technologies can be used on stove or boiler installation, to reduce or prevent odour nuisances.

# 7 Field test

Based on the results of the laboratory test and an evaluation of the suitability for a general installation and use of the technologies in typical Danish wood stoves and boiler installations, technologies for field test should be selected.

The wood stoves and wood boilers of the participating households should represent different types regard to the age, type, chimneys etc. The selected housing sector(s) should be representative for common Danish residential areas, for instance single-family houses and terrace houses.

During the laboratory test in the first part of the project, it became clear that more laboratory tests than originally planned would be necessary to obtain a satisfactory evaluation of the technologies. Consequently this part of the project was extended, while the field test part was reduced accordingly.

It was also realized, that a field test of some of the technologies would be problematic, either because of problems in finding installations where they could be easily installed, or because of conflicts with the Danish rules for approval of chimney installations.

Consequently the planned test in ordinary Danish houses was reduced, but the test with measurement of the ambient air quality was unchanged.

Before the decision of reducing the field tests was taken, the search for test houses had already started. It was decided to find volunteer house owners with older wood stoves or wood boilers in the town Værløse near Copenhagen, by requesting for volunteers in the local free distributed weekly paper.

More than 40 house owners responded by mail or phone, and they were all contacted by phone for a short interview about their stove or boiler, concerning the type, age, chimney, firing habits, type of firewood and the consumption. Most of the respondents had a wood stove, but some of the stoves were found to be too new to fit to the project on testing technologies on older stoves and boilers.

## 7.1 Revised field test plan

The field tests included a campaign with outdoor air quality measurements in order to assess the efficiency of one of the technologies. In the revised field test plan, this part was unchanged, but for the rest of the field test it was agreed to include what was possible to do inside the remaining budget.

The resulting field test plan includes:

- One Zumikon ESP was tested on a stove for a period of two month.
- Five CleanAir ESPs was tested on row houses in Slåenbækken, and the effect on the outdoor air quality was measured.
- One MoreCat catalyst was tested by a chimney sweeper on his wood stove.

The Ecoxy retrofit system was tested on five houses in Værløse.
It was also the intention to make a test with the Airbox ESP on a boiler, but it was not possible to find a boiler where it could be readily mounted without bigger alterations.

The next sections are giving a more detailed description of the field test and its results.

### 7.1.1 Airbox ESP

The Airbox is relatively big and heavy, and because of its appearance, it is not realistic to use it on top of typical Danish wood stoves, which are free-standing steel stoves with a visible flue connection to a brick chimney or a steel chimney on top of the stove. It is anticipated, that hardly no housewives would accept such an installation in the living room.

The Airbox is more suitable for wood boilers, which normally are placed in a cellar or in a separate utility room, but usually they have only very short pipe connection to a brick chimney, and no space for an Airbox. Most of the nearly 100 000 wood boilers in Denmark are connected to a brick or concrete chimney, which originally was build for the old heating system with a boiler fired with coal, coke or oil. However, some of the wood boilers are installed with a steel chimney, and some of them are anticipated to have enough space to install an Airbox ESP, but it is only an assumption.

None of the houses with a wood boiler in Værløse could have an Airbox installed, and even with the help from the chimney sweeper in three other districts, it was not possible to find any boiler, where the Airbox could be installed.

It might be possible to install the Airbox when installing new boilers, but as new boilers have lower emissions than older ones, the incitement to install it will be very low.

The cost for an Airbox is of app. 1200 € will not stimulate people to buy it voluntarily, especially not if they have just spend 4 – 7000 € for a new and less polluting boiler.

### 7.1.2 Zumikon ESP

The Zumikon filter was tested on one wood stove with water-tank connected to the central heating system. The stove is placed in a study in the basement. The house has an oil fired boiler for the central heating system, but the oil consumption is very low, due to a rather constant firing in the stove.

Figure 57. Stove before and after installing the Zumikon ESP

The user's experience from the first days of operation was primarily a relatively high sparkling noise from the ESP. If the stove was placed in the living room and not in the basement, the noise would be clearly unacceptable.

In Denmark free standing wood stoves with visible flue and chimney are common, and it seems that it is most common to have the flue and chimney hidden behind an interior in Switzerland and Germany. In such installations the noise from the filter is less audible in the living room, and therefore possibly insignificant. If the boiler is located in a boiler room or utility room, noise will probably not pose a problem, unless living or sleeping rooms are situated right next to it.

In Denmark, stoves are typically freestanding units in the living room, with visible chimney, especially for installations with a steel chimney, and here the Zumikon ESP would be very visible, and could be highly annoying when sparkling. Many stoves have only a short flue from the back into a brick chimney, which is too short to mount a Zumikon ESP. Furthermore it is recommended to have a steel flue of at least 1.5 metre after the ESP, to obtain the best separation of particles, and it will not be available for the majority of the brick chimney installations in Denmark. All most all the wood boilers in Denmark are brick chimney installations, and the same is a big part of the wood stove installations.

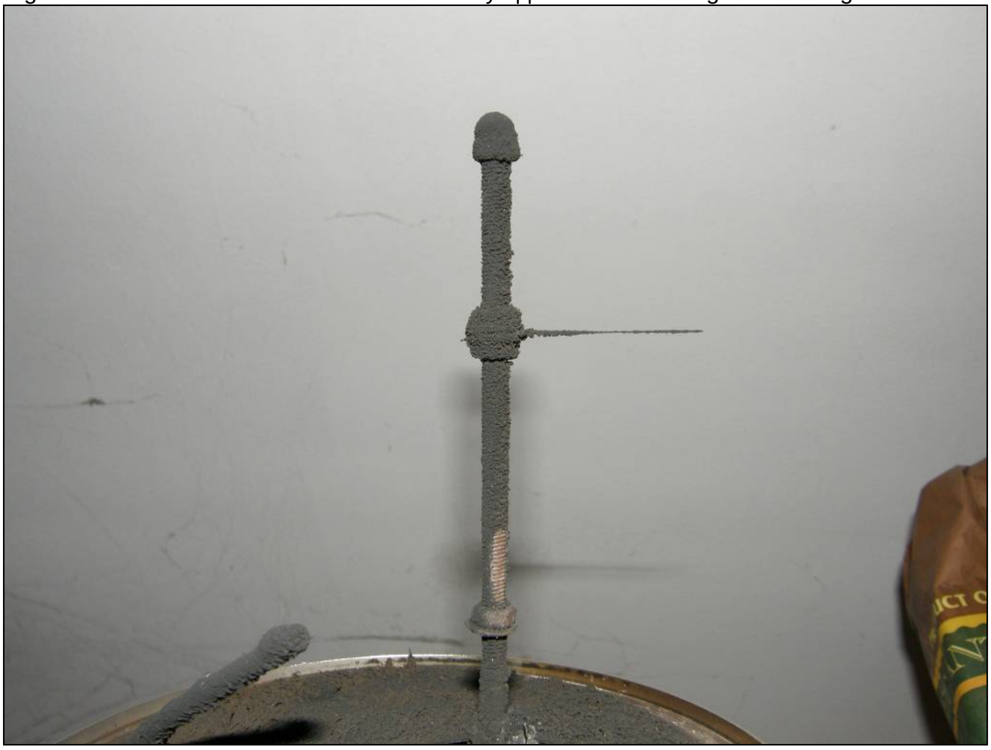
The initial assessment is that because of the noise from the Zumikon ESP, it is inapplicable for common occurring stoves in Denmark. The appearance of the ESP alone is also expected to prevent many people, especially housewives, from installing it in their living room.

The chimneysweeper has inspected and cleaned the flue regularly during the test period. He found a significant layer of soot depositions in the flue right after the filter, after only one week of operation. However he believes that some of this soot probably would be deposited further up the chimney if the filter was not there. From his judgement the ESP retain soot particles, which otherwise would be emitted through the chimney.

The user dismantled the filter unit after six weeks of operation because of malfunctioning. Most of the approx. 25 cm long electrode was missing, probably burned away by sparkling, so only app. 5 cm remained. The built in fan in the filter was also malfunctioning, and it was possibly destroyed by a too high flue temperature.

It is obviously that a Zumikon ESP can't stand unusual high flue gas temperature and it has to be cleaned regularly.

Figure 58. The Zumikon electrode with only app. 5 cm remaining of the original 25 cm



The test conditions have probably been extreme, but it clearly demonstrates, that the ESP can't just be installed on every stove with good result. It is necessary to evaluate the appliance and the firing conditions and habits, to judge if the Zumikon is suitable for installation. It is obviously also necessary that the user has some basic understanding of the functioning of the ESP, and are capable of judging its condition, to clean it regularly and to change the electrode.

### 7.1.3 CleanAir ESP

The CleanAir filter was tested on four houses in the village Slåenbækken near Hillerød in the northern part of Zeeland. The test included outdoor air quality measurements in the near vicinity, as described in section 6.2 on page 91.

### 7.1.4 MoreCat catalyst

There is a potential risk for the MoreCat catalyst to be partly or totally blocked by soot and char deposits, if not always operated correct, and in worst case the CO rich flue gas could enter the room, and poisoning the occupants.

According to the Danish Building Regulation[35], the flue shall have a free opening of at least 175 cm2 (= diameter of 15 cm) if the opening of the stove/fireplace is not greater than 2,500 cm² (= common stoves). If a damper is installed, it must have a free opening of at least 20 $cm^2$ in closed position.

According to this regulation, it is probably not legal to install a moreCat catalyst on stoves in Denmark. The catalyst seems to have a total fee passage area of more than 20 $cm^2$, when it is new and clean, but it cannot directly be compared to a damper, because of the much larger pressure drop through the catalyst, compared to the free opening in a damper. The free passage in the catalyst will also be reduces by soot and char depositions, which gives a risk of total blockage and consequently a risk of CO poisoning from CO rich flue gas leaking into the room. Under these circumstances it could not be justified to let ordinary people test the catalyst in their homes.

Subsequently the More Cat catalyst has been extended with a safety facility to prevent potential problems in case of a poor chimney draught. A small device automatically turns the catalyst to bypass position at flue gas temperatures below approx. 250 °C. This will reduce the risk for blockage of the flue, and reduce the risk for CO poisoning, but still it does not strictly fulfil the exact requirement of an opening of at least 20 $cm^2$ in closed position in the Danish Building Regulation.

Because of this potential CO poisoning risk, and the conflict with the Danish Building Regulation, the project team could not take the responsibility to let ordinary people test the MoreCat catalyst. Instead a test was done by a chimney sweeper master, which was fully aware of the CO poisoning risk and the conflict with the Building Regulation. The catalyst was tested in his home, on a newer wood stove with steel chimney mounted on top of the stove and directly up in the air. But it came never in full operation, because the pressure loss over the catalyst was more than the chimney could deliver. After the fire was lighted up and a heavy fire was achieved, the MoreCat was activated, and then the fire was readily stifling, because of insufficient chimney draught. After several trials, he gave up and dismantled the MoreCat, with the conclusion, that it is not suitable for Danish wood stoves and chimneys. He also remarked, that it might also be potential CO poisoning dangerous, if the chimney is blocked, and CO rich flue gas is leaking to the living room.

Many brick or concrete chimneys are higher than most steel chimneys (4.5 - 7 m), but their chimney draught might not be larger, because of more heat loss, which means lower temperature and consequently less chimney draught. Furthermore there might be more pressure loss in the bending connection between the stove and chimney.

The MoreCat manufacturer was asked about this problem with insufficient chimney draught and answered:

***Dear Mr. Schleicher,***
***The required chimney draught for wood burning in a specific type of stove depends on many factors such as way of firing, weather condition, design of stove and chimney. First of all the chimney draught has to overcome the pressure loss of the stove and the chimney and secondly approx. 5 - 7 Pa pressure loss caused by the catalyst. In windy weather and high temperature differences (frosty weather)***

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[35] The Danish Building Regulation is published by the Danish Enterprise and Construction Authority at: http://www.ebst.dk/file/155699/BR10_ENGLISH.pdf

***a chimney with only 3.5 m may satisfy to feed the fire with sufficient oxygen. For example: pressure drop of a wood stove: 10 Pa, pressure drop of the catalyst in operation: 7 Pa, required draught of the chimney approx. 20 Pa. We believe however, based on praxis and on physical assumptions, that 3.5 m is too low to fire in other conditions.***

***As a result of a poor draught and a lack of oxygen in the stove the emission of CO and CxHy will be relatively high. The installation of a catalyst will not improve such bad firing conditions or lower the emissions of a stove in case the stove lacks an appropriate input of oxygen and in this case the temperature of the off gas is insufficient. In case of a poor draught and lack of oxygen we advice customers to improve the chimney (insulation, forced draught, extension. etc). By judging the colour and the motion of the flames you can definitely conclude if the draught and the oxygen level are sufficient. Until the draught is improved we will advise against the installation of a catalyst because the catalyst needs oxygen and a minimum operation temperature. If these basic conditions aren't fulfilled the catalyst will not oxidize the soot particles. These soot particles will eventually cover the active surface of the catalyst and until the catalyst has reached a minimum temperature of approx 350 °C the efficiency will remain low.***

***The experiences of our customers with a catalyst, having a good draught, are very positive. In our practice we experience however that in many cases the installation and the quality of stoves and the chimney and lust but not least the understanding of the customers is inadequate. In general, simply selling a catalyst to lower the emissions of their stoves won't be enough. From our experience we learn that it probably will be better to visit the customer, to inspect the stove and the chimney, to measure the off gas temperature and to advice the customer on burning wood and to judge if the installation of a catalyst makes sense. As we mentioned before, for instance well instructed chimney sweepers or local dealers could do this work.***

The MoreCat manufacturer has also been asked which flue gas temperature is necessary for the catalyst to function properly, and the answer was:

***This depends on the composition of the off gas. To oxidize soot particles a starting temperature of at least 350 °C is required. For some other combinations a starting temperature of approx. 270 to 300 °C will be fine. If the temperature remains too low during firing, the surface of the catalyst will be gradually covered with soot what decreases its performance. An operation temperature of at least 350 °C is then required to free the surface from this layer of soot.***

It can be concluded, that the MoreCat catalyst is not suitable to just buy and install on any wood stoves, as there is several conditions that has to be fulfilled, to achieve a proper operation and reduction of the emission of CO, OGC and soot particles. Also the stove user has to be aware of the functioning and temperature demand, and operate it accordingly.

### 7.1.5 Ecoxy Retrofit System

The Ecoxy plate was tested by mounting it in five older wood stoves in usual houses. One person from the company Ecoxy came to mount them, but only succeed to mount one of them. The other five stoves were larger than the common size in the company hometown Stavanger in Norway, and he did not bring the largest version.

Subsequently Ecoxy has sent five of the largest version of the retrofit system, and they where mounted by a technician from a stove store. The mounting was not as easy as anticipated, as according to the instructions from Ecoxy, the firebricks should be removed where the Ecoxy plate should be mounted. This was also the reason, why it could not be mounted on one the stoves, as the firebricks could not easily be removed, because they were apparently glued to the steel plate by fireclay.

The mounting time was 1½ hours for three of the stoves and one hour for the last one. The technician wondered why he had to install the Ecoxy plate instead of just drilling some holes through the firebricks and steel plate on the backside of the stove burning chamber, as it would give exactly the same result, and it would be easier, faster and cheaper. He also pointed out, that potential problems with the regulation of the combustion air supply could arise, when mounting the Ecoxy plate in older not tight stoves, as the new tertiary air supply cannot be regulated or closed. It could especially be a problem in the warmer periods of the heating season, where the need of heat is low, and the stove heat yield is reduced by reducing the air supply. Furthermore in the coldest period, the extra air supply could cause a very vigorous combustion with very high temperature, which could damage the stove.

#### *7.1.5.1 Ecoxy test 1*

The wood stove is a rather big and old Rais wood stove from 1980. An app. 3.5 meter high steel chimney is mounted directly from the top of the stove.

Figure 59. Rais stove from 1980 and the Ecoxy plate mounted inside on the back wall

The stove is used daily after work and in weekends from November to March/April. Only beach logs are burned, which has been stored for drying for 2-3 years in a woodshed. The consumption is 3 - 4 $m^3$/year.

The owner is very positive, as he has experienced two main improvements: It is easier to light the fire, and the combustion is better.

The wood is burning faster but more efficient, because the chimney draught is better. When re fuelling on embers the combustions start readily even with closed door, which it could not before.

Lightning is different and easier now, as the fire starts readily, and the door has only to be kept ajar at the very beginning, where it needed much more air access previously.

Previous problems with flue gas leakage to the living room, when opening the wood stove doors has disappeared, as the chimney draught is improved.

Apparently the consumption of firewood has increased a little bit, but it is acceptable because of the overall improvement of the stove operation and performance.

#### 7.1.5.2 Ecoxy test 2

Old stove of unknown type, without glass in the door.

The inside of the stove has a black layer of soot, which indicates a not so efficient combustion.

#### 7.1.5.3 Ecoxy test3

The Ecoxy plate was mounted by Ecoxy in the Handöl 10 stove from 1995.

Figure 60. Handöl 10 stove and the Ecoxy plate mounted inside on the back wall

The stove is used daily and delivers most of the heating of 15 years old well insulated 140 $m^2$ house. Only app. 500 $m^3$ natural gas is used yearly for heating and warm water.

The owner is not content with the performance of the Ecoxy, because:

- The combustion temperature has been reduced because of more heat losses, where the firebrick has been removed to install the Ecoxy plate.
- The flue has changed direction, so it cannot keep the glass in the doors clean.
- The fire wood consumption has increased, because more heat is lost through the chimney.

The six edged baffle plate was bended during the mounting of the Ecoxy plate, to allow some of the flue gas to enter the chimney directly, which was pointed out by the user to be the main reason for the poor performance.

The Ecoxy plate was removed in August 2009 at the owner’s request.

#### 7.1.5.4 *Ecoxy test 4*

The stove is app. ten years old, and it is used almost every evening from November to April. The firewood is birch logs, and wood scraps of pine, teak and mahogany from a cabinetmaker workshop.

The owner has not noticed some improvements after the Ecoxy plate was installed.

- He often sees small blue flames out of the holes in the Ecoxy plate.
- He might be using a little bit less wood than before the Ecoxy was mounted.
- He has less soot on the glass doors, so they are not cleaned so often as before.

All together he is satisfied with the performance of the Ecoxy plate.

#### 7.1.5.5 *Ecoxy test 5*

The stove is a Rais from 1985 connected to a brick chimney.

The owner has not registered any improvements or any differences from before the Ecoxy plate was installed.

## 7.2 Outdoor air quality measurements

The effect of the APP filters on the outdoor air quality near emitting wood stoves was tested in a partly isolated estate called Slåenbække n with twenty non-detached houses densely arranged in 6 blocks with very small lots. The twenty houses were built around 1980 and are located in the southern corner of a larger district with more scattered detached houses in the village Ny Hammersholt near the town Hillerød. In the directions to the south and west there is open land. To the east there are houses with wood stoves in a distance of more than 300 m.

In Slåenbækken there are seven wood stoves. Four of them are close to each other in two neighbouring blocks, and all of these are regularly used in the winter time as supplement for electrical heating. The chimneys are marked no. 3, 4, 5, and 9 (= as the house numbers) in. The four woodstoves are of different age; some were installed shortly after the houses were built, and one is of a quite new type with tertiary air supply. All the stoves are fired exclusively with dried firewood. The other three woodstoves in the estate were not included in the study. They are located in the more distant southern part of the area, and only one of them seemed to be used regularly.

The four chimneys are placed in rather low positions on the roofs (Figure 62). Because the top of the chimneys are below the ridge it was anticipated that the passage between the two blocks has a channelling effect in a wide interval of southern wind directions.

A monitoring station was placed on the shared parking area belonging to the estate close to the four wood stove chimneys and close to the passage between the blocks. Two wind sectors are indicated in Figure 61. When the wind blows from sector I it is anticipated that smoke from chimney 9 may be detected at the monitoring station, while it is unlikely that smoke can be detected for winds outside the sector. Similarly, the wind sector II covers chimneys 3-5 and is slightly wider.

Figure 61. Map showing the relative position of the chimneys and the monitoring station. Two wind sectors are indicated. When the wind blows from sector I or II it is anticipated that smoke from chimney 9 or 5-4-3 may be detected at the monitoring station.

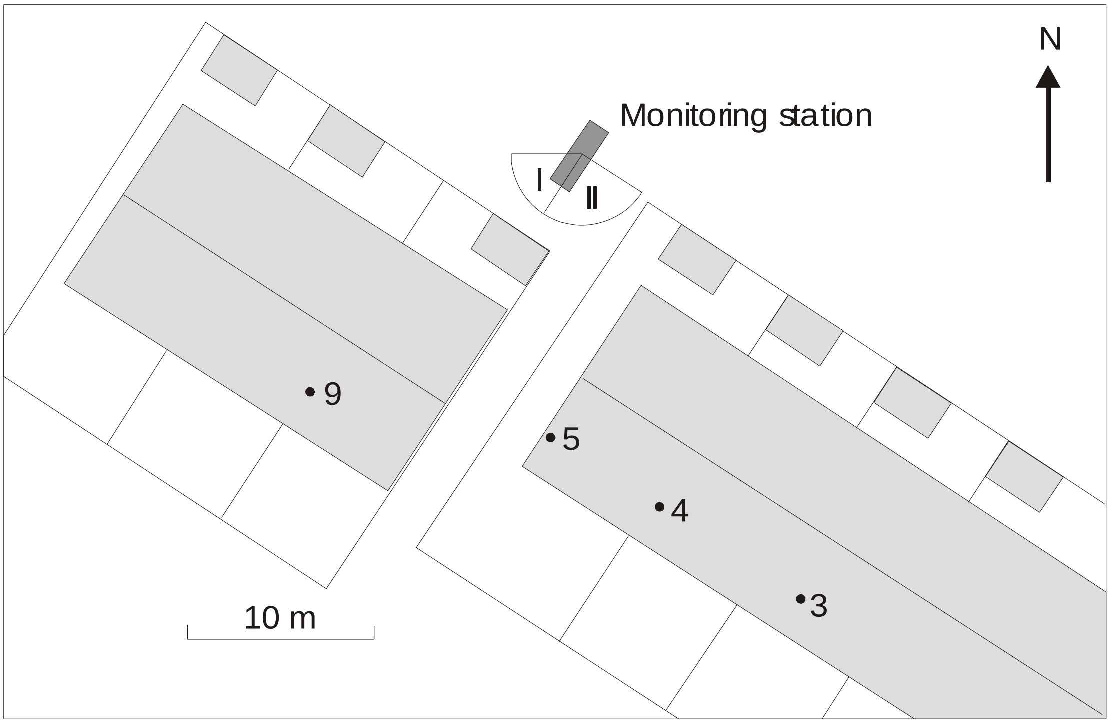


Figure 62. Photo showing the four chimneys mounted with APP electrostatic filters. The high voltage units were placed at ground level on the garden terraces below the chimneys.

According to the agreement with the residents the campaign should begin in the middle of January 2009 and it should be finished after eight weeks.

Measurements of ambient air pollution were performed during the scheduled period from 15.01.2009 to 12.03.2009. The measurements comprised $PM_{2.5}$ concentration measurements, particle size distributions including integrated values of particle number concentration (N) and volume concentration (V), soot concentration (light absorption), and carbon monoxide with CO. Due to technical problems there are some periods with missing data (Table 9). During the last two weeks of the campaign $PM_{10}$ samples were collected each day from 18:00 until the next day at 18:00. The 24-hour samples were later analysed in the laboratory for elemental carbon (EC) and organic carbon (OC).

Table 9. Periods with missing data

| Parameter/equipment | Period | Duration |
|---|---|---|
| $PM_{2.5}$ | 15.01 - 22.01 | 7 days |
| DMPS | 05.02 - 11.02 | 9 days |
| Soot | 03.02 - 25.02 | 22 days |

There is a rural monitoring station (Lille Valby, abbreviated LVBY) located 27 km to the Southwest of Slåenbækken. All available data from LVBY for the same components in the same period are used for comparison. Wind direction data are also from LVBY.

The particle measurements of $PM_{2.5}$ were carried out using TEOM instruments (Tapered Element Oscillating Microbalance, Rupprecht and Patashnick, NY, USA) operated at 50 °C to dry the aerosol. The elevated temperature results in loss of volatile compounds (especially ammonium nitrate), and in general $PM_{2.5}$ values obtained with TEOM are lower than results obtained with standard gravimetric methods (Hitzenberger et al., 2004[36]; Hauck et al., 2004[37]). Ammonium nitrate is not directly emitted by wood stoves. However, some unknown losses of other volatile compounds from the woodstoves may still influence the $PM_{2.5}$ results. The data were averaged for each half-hour.

The particle size distributions (10-700 nm) were measured with a Differential Mobility Particle Sizer (DMPS) using a Vienna type Differential Mobility Analyser (Winklmayr et al., 1991[38]) coupled to a Condensation Particle Counter (TSI 3010) and employing a re-circulating flow system (Jokinen and Makela, 1997[39]). The scanning time for each size spectrum was 2 min, using alternating up- and down-scans. By integrating over the particle size distribution the total particle number and particle volume in the range 10-700 nm was calculated assuming spherical particles with geometrical diameters equal to the mobility diameter for the volume calculation. The data were averaged for each half-hour.

[36] Hitzenberger, R., Berner, A., Galambos, Z., Maenhaut, W., Cafmeyer, J., Schwarz, J., Müller, K., Spindler, G., Wieprecht, W., Acker, K., Hillamo, R., Mäkelä, T., 2004. Intercomparison of methods to measure the mass concentration of the atmospheric aerosol during INTERCOMP2000 – influence of instrumentation and size cuts. Atmospheric Environment 38, 6467-6476.
[37] Hauck, H., Berner, A., Gomiscek, B., Stopper, S., Puxbaum, H., Kundi, M., Preining, O., 2004. On the equivalence of gravimetric PM data with TEOM and beta-attenuation measurements. Journal of Aerosol Science 35, 1135-1149.
[38] Winklmayr, W., Reischl, G. P., Lindner, A. O., Berner, A., 1991. A New Electromobility Spectrometer for the Measurement of Aerosol Size Distributions in the Size Range from 1 to 1000 nm. Journal of Aerosol Science 22, 289-296.
[39] Jokinen, V., Makela, J.M., 1997. Closed-loop arrangement with critical orifice for DMA sheath/excess flow system. Journal of Aerosol Science 28, 643-648.

Half-hourly averages of CO were measured with API M300 monitors using infrared absorption.

The light absorption by particles collected on a filter was measured by custom built Particulate Soot Absorption Photometers (PSAP) following the design described in Bond at al. (1999). The PSAP measures the absorption of light using green light, 550 nm, passing through a glass fibre filter (Pallflex E70-2075W) that is continuously loaded with particles collected from ambient air. Several laboratory tests and calibrations have been performed (Andersen, 2006[40]) showing a reliable performance of the instruments. The light absorption coefficient (optical attenuation per length in ambient air) is measured in 15-minute intervals and averages are calculated for half-hour intervals. If needed, the light absorption coefficient can be converted to a soot mass concentration dividing by an absorption cross section per unit mass of $7.5 \pm 1.2\ m^2g^{-1}$ recommended in the review of Bond et al.[41], or by the value of $12.7\ m^2g^{-1}$ originating from an inter calibration with a Ambient Carbon Particle Monitor (ACPM R&P inc.) at a street location in Copenhagen (Andersen, 2006). It should be noted, however, that such conversion refers to the mass of soot exclusively. $PM_{2.5}$ comprises other compounds than soot; therefore the listed factors cannot be used to quantify $PM_{2.5}$

Atmospheric $PM_{10}$ aerosols were sampled on 47 mm prefired quartz fibre filters using a low-volume-sampler (Leckel, SEQ47/50) operating at $2.3\ m^3h^{-1}$, which provided time-integrated samples of 24 hours. The filter face velocity was $55.5\ cms^{-1}$ in order to reduce positive artefacts, i.e. absorption of volatile organic compounds (VOCs) to the particle phase. Moreover, the samples were obtained according to the quartz-behind-quartz method (QBQ) in which a tandem filter setup is applied. Under the simplified assumption that VOCs adsorb equally to the front and back filter, this positive artifact is compensated for by subtraction of the organic carbon from the back filter (McDow et al.[42] The carbonaceous fraction was quantified by a thermal/optical instrument (Sunset Laboratory, CA) as elemental carbon (EC) and organic carbon (OC), according to the EUSAAR 2 protocol.

The four APP filters were mounted on the chimneys on 12.02, exactly 4 weeks after the start of the measurements. After an initial period from 12.02 to 15.02 in which the high voltage on the filters was turned on all the time, the filters were turned off until Monday 16.02 18:00 when a 3½-weeks period with a scheduled on/off sequence began. From this point of time the filters were turned on in 24h periods according to the schedule:

Periods with the filters on:
Monday 18:00 – Tuesday 18:00
Wednesday 18:00 – Thursday 18:00
Friday 18:00 – Saturday 18:00

The filters were turned off during the remaining time. The four high voltage modules were powered in parallel using the same power cord from a 230 V

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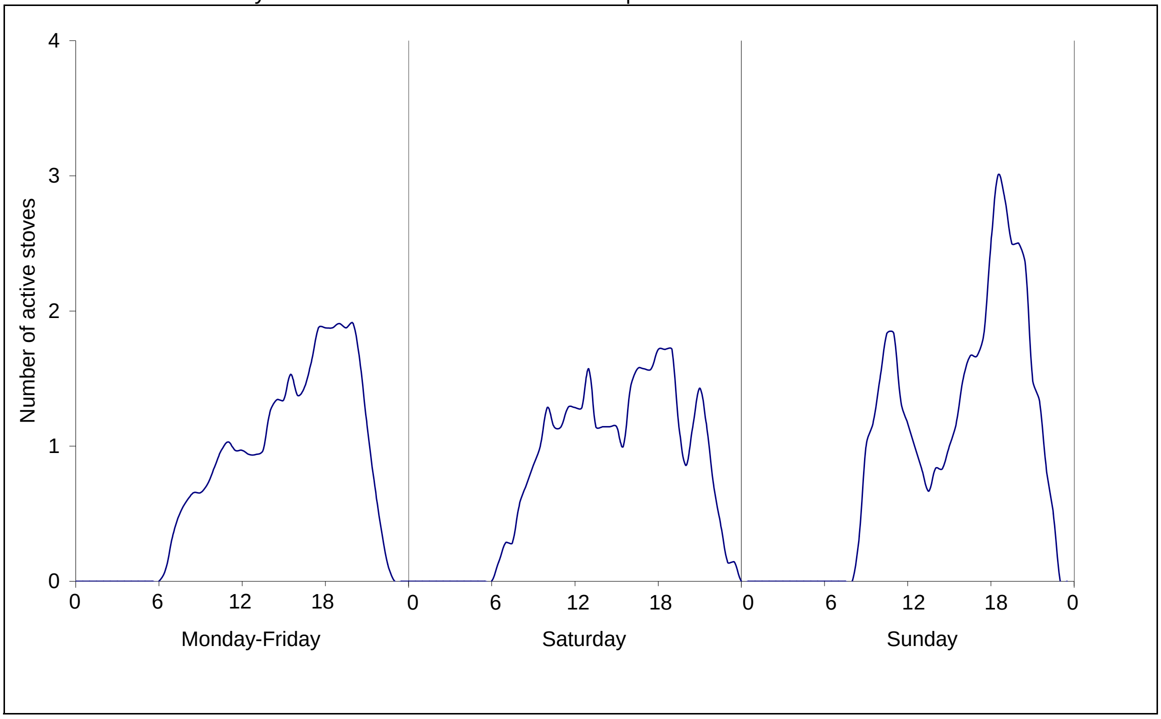
[40] Andersen, P. (2006). Measurement of particulate carbon in relation to traffic and validation of a Particulate Soot Absorption Photometer (PSAP). MSc thesis. University of Southern Denmark and National Environmental Research Institute, Roskilde, Denmark.
[41] Bond, T.C., Bergstrom, R.W., 2006. Light absorption by carbonaceous particles: An investigative review. Aerosol Science and Technology 40, 27-67.
[42] McDow, S. R., Huntzicker, J. J., 1990. Vapor adsorption artifact in the sampling of organic aerosol: face velocity effects. Atmos. Environ. 24A, 2563–2571.

point with a single programmable on/off timer in the monitoring station. 18:00 was chosen as a proper time for switching the filters on and off, because a high firing activity was expected at this time of day.

## 7.3 Measured data

The residents in the houses began the detailed reporting of their wood stove firing on 29.01.2009 and continued during six weeks until the end of the campaign. The average number of active wood stoves for the same hour is shown in Figure 63 as function of time for all weekdays, Saturdays and Sundays respectively.

Figure 63. The average number of active stoves as function of time during all weekdays and weekends in the six weeks period 29.01.2009 – 14.03.2009.




Averages of ambient air concentration have been calculated for PM2.5, carbon monoxide, particle number, soot, and particle volume for simultaneous half-hour measurements in Slåenbækken and at the rural background station LVBY (Table 10 to Table 14). No measurements of EC and OC are available from LVBY. The averages from Slåenbækken are shown in Table 15.

The data have been classified according to two criteria:

- A half-hourly value is characterized as 'selected' when at least one of the wood stoves is active, while the wind direction is within the same sector as the chimney (I for chimney 9, II for chimneys 3-5, see Figure 63). Thus, for 'selected' data there is a potential impact of the wood stoves on air quality.
- Each half-hourly value is characterized according to the status of the APP filter: ON or OFF.

As a result, four groups of data appear in the tables.

The calculated increment in the tables is the value at Slåenbække minus the value at Lille Valby. The simultaneously measured size distributions were classified in the same way, and the average distributions are shown in Figure 64.

Table 10. Average of $PM_{2.5}$ in $\mu g/m^3$ for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station). 'Count' is the number of values used for each average calculation.

| Filters | Selected | PM2.5 | PM2.5_LVBY | Increment | Count |
|---|---|---|---|---|---|
| OFF | No | 10.31 | 10.57 | -0.26 | 1130 |
| OFF | Yes | 17.23 | 14.51 | 2.73 | 167 |
| ON | No | 9.88 | 9.94 | -0.06 | 526 |
| ON | Yes | 11.52 | 8.45 | 3.07 | 75 |

Table 11. Averages of CO in ppm for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station).

| Filters | Selected | CO | CO_LVBY | Increment | Count |
|---|---|---|---|---|---|
| OFF | No | 0.240 | 0.225 | 0.015 | 457 |
| OFF | Yes | 0.321 | 0.237 | 0.084 | 69 |
| ON | No | 0.287 | 0.259 | 0.029 | 339 |
| ON | Yes | 0.395 | 0.250 | 0.145 | 77 |

Table 12. Averages of total particle number in the size range (6-700 nm) in unit of particles per $cm^3$ for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station).

| Filters | Selected | N | N_LVBY | Increment | Count |
|---|---|---|---|---|---|
| OFF | No | 3255 | 3056 | 199 | 801 |
| OFF | Yes | 5885 | 4077 | 1808 | 91 |
| ON | No | 3267 | 3042 | 225 | 413 |
| ON | Yes | 6138 | 4223 | 1915 | 72 |

Table 13. Averages of soot (light absorption coefficient) in $Mm^{-1}$ for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station).

| Filters | Selected | Soot | Soot_LVBY | Increment | Count |
|---|---|---|---|---|---|
| OFF | No | 4.38 | 1.55 | 2.82 | 477 |
| OFF | Yes | 9.62 | 2.31 | 7.31 | 68 |
| ON | No | 3.22 | 1.45 | 1.76 | 183 |
| ON | Yes | 10.43 | 0.95 | 9.47 | 47 |

Table 14. Averages of total particle volume in the size range 6-700 nm in units of $\mu m^3 cm^{-3}$ for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station).

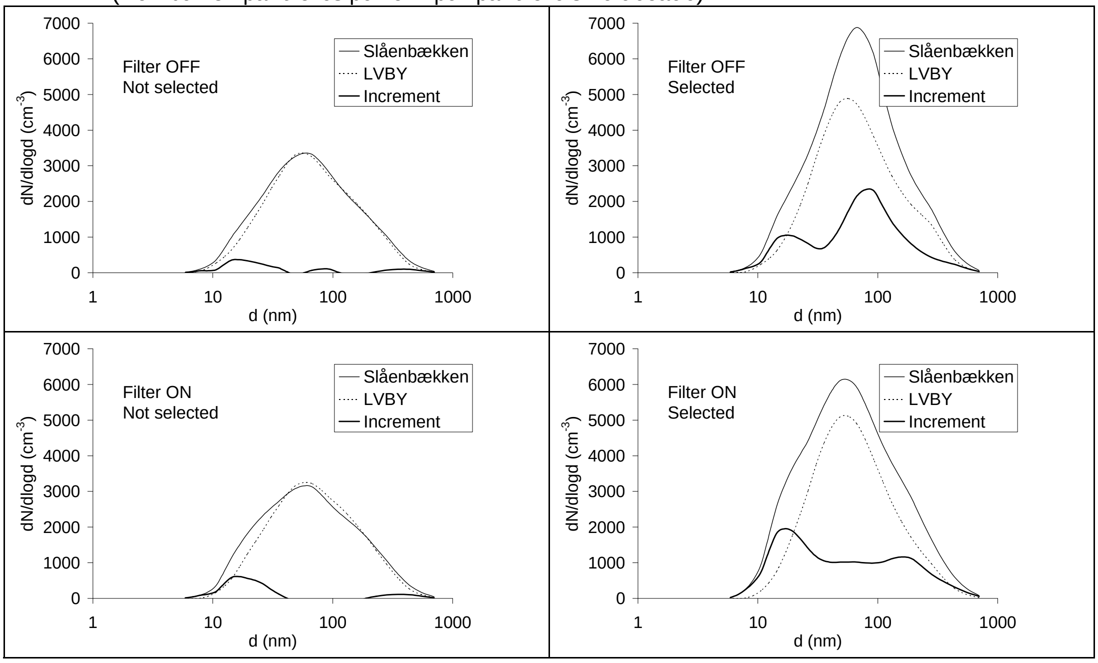
| Filters | Selected | V | V_LVBY | Increment | Count |
|---|---|---|---|---|---|
| OFF | No | 7.70 | 6.27 | 1.44 | 801 |
| OFF | Yes | 13.78 | 9.04 | 4.74 | 91 |
| ON | No | 8.32 | 6.77 | 1.56 | 413 |
| ON | Yes | 13.51 | 7.02 | 6.48 | 72 |

Table 15. Averages of EC and OC in units of $\mu g m^{-3}$ for four groups of data (the 24-hour value is used as a constant approximation for all the half-hour values in each 24-

hour interval), classified according to the state of the filters and to the status for 'selection' ('Yes' for selected half-hours, when firing occurs upwind of the monitoring station). Count is the number of half-hours in each average calculation.

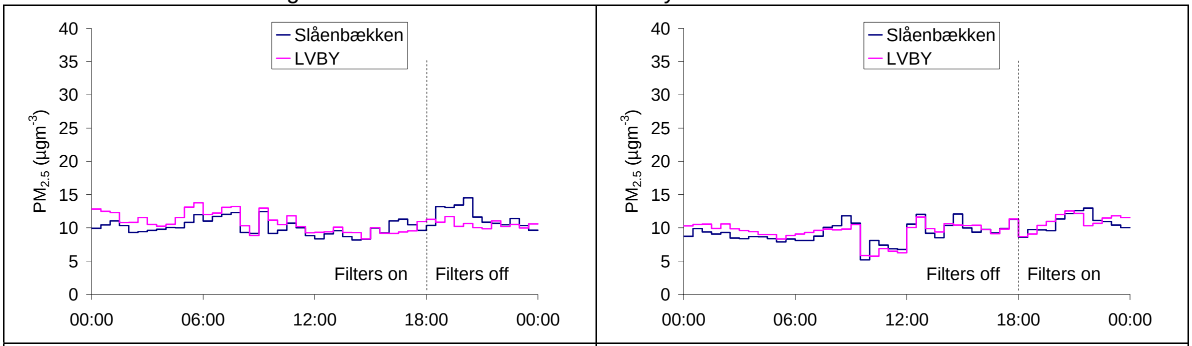
| Filters | Selected | EC | OC | Count |
|---|---|---|---|---|
| OFF | No | 0.63 | 3.43 | 308 |
| OFF | Yes | 0.72 | 3.42 | 49 |
| ON | No | 0.60 | 3.15 | 238 |
| ON | Yes | 0.60 | 2.29 | 29 |

Figure 64. Averages of particle size distributions for four groups of data (half-hours), classified according to the state of the filters and to status for 'selection' (half-hours are selected, if firing in at least one of the four stoves occurs upwind of the monitoring station). dN/dlogd is the differential particle number concentration (number of particles per $cm^3$ per particle size decade).



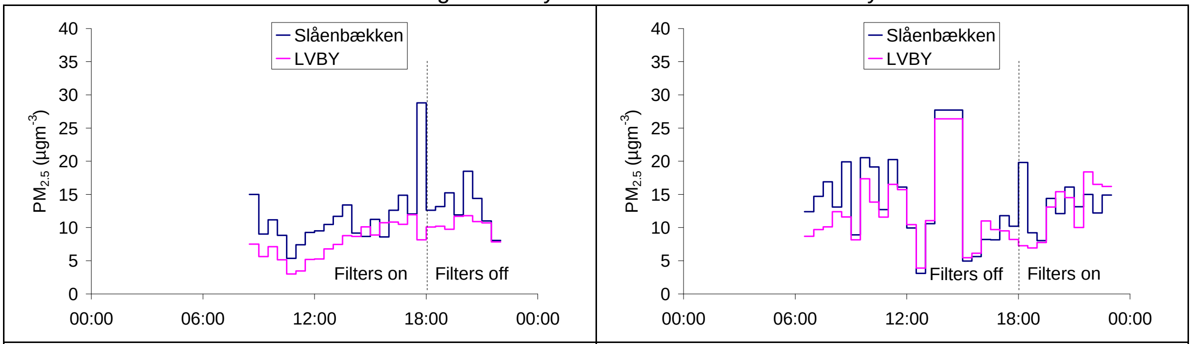

In order to highlight whether changes in concentrations occur around 18:00, Figure 65 and Figure 66 show averages of half-hourly measurements of $PM_{2.5}$ as a function of time of day. The graphs are based on data from days when the filters were either turned on or off at 18:00. Figure 65 is based on half-hours that are not among the 'selected' data, while Figure 66 is based on 'selected' half-hours (when at least one of the wood stoves was fired and the chimney was in the appropriate wind sector). Thus, the number of measurements underlying each point on the graph varies, as indicated in the figure text.

Figure 65. Simultaneous measurements at Slåenbækken and at LVBY when no increments were expected, either because the wood stoves were not fired, or because all active wood stoves were outside their corresponding upwind sector. Each value is an average of between 5 and 11 half-hourly measurements.




| Days when the filters were turned off at 18:00 | Days when they were turned on at 18:00 |
|---|---|

Figure 66. Simultaneous measurements at Slåenbækken and at LVBY when some increment could be expected, because at least one wood stove was active within the current upwind sector. The results are very sensitive to single extreme values, because each value is an average of only between 1 and 4 half-hourly measurements.




| Days when the filters were turned off at 18:00 | Days when they were turned on at 18:00 |
|---|---|

## 7.4 Discussion

The calculated increments in Table 10 to Table 14 and Figure 64 show that the grouping of the data according to the periods with an active stove upwind (Selected = 'Yes') and the rest of the time is reasonable. Due to the long distance (27 km) between the two monitoring sites the increment cannot be regarded as a precise indicator of the local stove emissions at Slåenbækken, but the numbers for all the measured variables in the tables clearly show that the increments are significantly larger in the periods with an active stove upwind. The data are also grouped according to the on/off status of the filters. However, almost no effect of this can be seen. Only in Figure 64 there seems to be a clear difference in the size distribution of the increment for the selected data: The shape has changed from a distribution with a dominating mode at 80-100 nm when the filter is off to a distribution with a dominating mode at 10-20 nm when the filters are on. This agrees very well with the increased emission of $PM_{0.1}$ measured in the laboratory test of the ESP technologies.

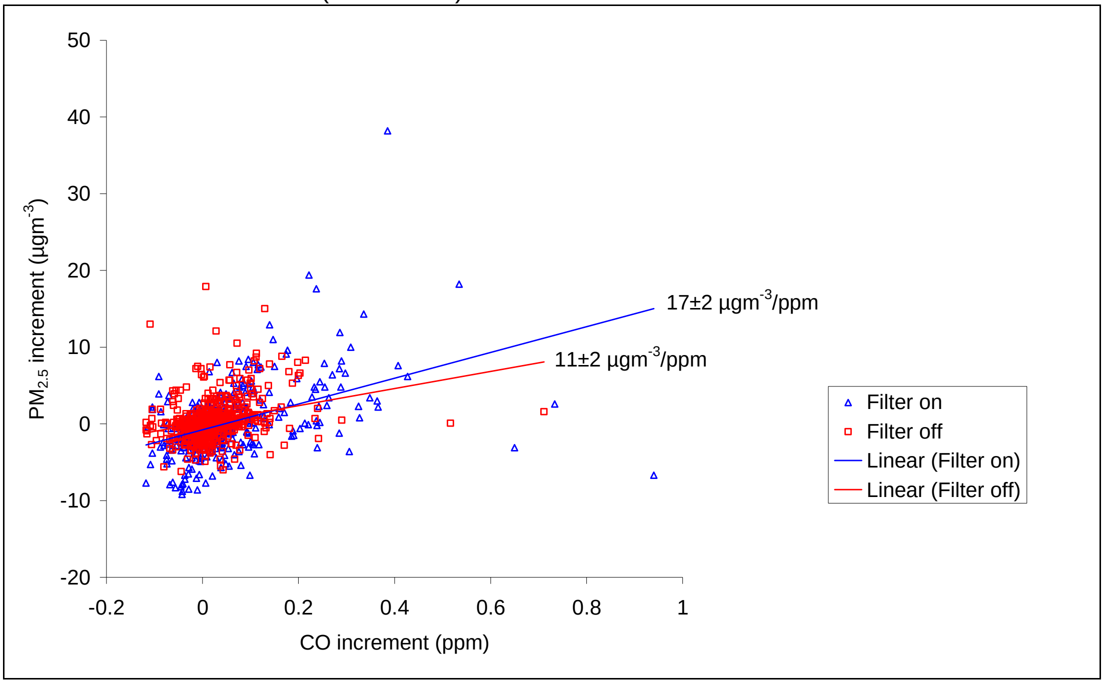
For EC and OC no background measurements were available for comparison (Table 15). No significant difference of the average concentration can be seen between selected half-hours and not selected half-hours while the filters were turned off. This indicates that the contributions from the chimneys are so small compared with the general background level in Slåenbækken that no conclusions based upon the values in the table about the efficiency of the filters can be made.

18:00 was chosen as a proper time for switching the filters on and off because a high firing activity was expected at this time of day. Figure 63 shows that this expectation was indeed fulfilled. Figure 65 shows as expected that the status shift had no effect on the $PM_{2.5}$ concentration at 18:00 when there was no firing in upwind direction. However, Figure 66 shows the same lack of effect for situations when the status shift was expected to be detectable. On the contrary the shift seems to have the opposite effect of what was expected. This is probably due to random fluctuations that are not smoothed away because the average calculation is based on very few (one to four) half-hourly measurements.

As the large variation observed in Figure 66 indicates, the effect of the filters on the smoke emissions detected by the difference between the average concentrations of the pollutants at the two monitoring stations may be obscured by random fluctuations of the local dispersion at Slåenbækken and by local concentration fluctuations at the background site. The long length of the campaign (8 weeks) was chosen to minimize the influence of the random fluctuation on the averages. For the $PM_{2.5}$ measurements, favourable downwind conditions for the test of the smoke cleaning effect only occurred during 75+167 = 242 half-hours (see Table 10). This is a very short time compared with the total length of the campaign (2688 half-hours).

The CO emission should not be affected by the filters, and the dispersion effect on CO should be almost the same as for the particles. The use of the CO increment as a tracer for the detectable firing activity together with the $PM_{2.5}$ increment in a scatter plot (Figure 67) will eliminate the effect of the local dispersion fluctuations, and the correlation and slope of the regression line will not be affected by possible constant offset errors in the data at both sites. If the filters have a substantial cleaning effect on the particles, such an effect should be revealed by a smaller slope of the regression line for $PM_{2.5}$ as function of CO for points with the filter turned on. However, it can be seen

Figure 67. Scatter plot showing the PM2.5 increment as function of the CO increment. The regression lines were calculated including all the data (both selected and not selected) in situations when the filters were turned on (blue colour) and when they were turned off (red colour).



from the slopes in Figure 67 that such an effect of the filters is not observed. On the contrary the filters seem to have the opposite effect of what was expected, although the difference between 17±2 $\mu gm^{-3}/ppm$ and 11±2 $\mu gm^{-3}/ppm$ is not significant.

After one month of operation with the CleanAir ESP active three days a week, they were dismantled, and the photos of the inside of the ESP shown in Figure 68 were taken. They clearly show differences in the depositions. The oily surface of the deposits in photo no 1 is caused by condensed tar, which gives a greasy and difficult to remove deposition, while the depositions in photo no 3 is dry and easy to brush of.

Figure 68. The CleanAir ESP after one month of operation, where they were active three days a week

Photo 1. Andersen stove from 2000. Fired with dry firewood and wood briquettes.

Photo 2. Contura stove from 2003. Fired with dry ash firewood and cut up wood pallets.

Photo 3. Westfire 5 stove. Fired with elm, poplar and willow from a nearby grove.

Photo 4. Andersen stove from 1999. Mostly fired with branches and twigs from a cottage.

From the pictures is evident that the depositions can be more or less difficult to remove and to clean the electrodes satisfactorily, and dirty electrode covered with deposits is less efficient than clean ones.

The participants were interviewed about their experience from the test and their meaning about the filter.

House A has a Contura 510 wood stove from 2003. The stove is normally in use from the beginning of October, and more heavily from the middle of November until March or April. Dry ash firewood from a forest district and some very dry used cut up wood pallets is used. The wood pallets are used first, because it is most dry. The firewood is kept in a shed, and it is stored in the house for a week before it is used. The firewood consumption is approximately 2 $m^3$ per year.

Would consider buying a filter if it is efficient and the price is reasonable, which is considered to be approximately € 300 including installation. If it is really effective, it may well cost more!

The ESP was sparkling at the beginning, but that decreased and almost disappeared during the following days.

The filter's appearance is OK, if it does not become larger.

House B has a Westfire 5 wood stove. The stove is used daily after working time. The firewood is elm, poplar, willow, etc. which are cut down by the owner in the small area of forest that belongs to the built up area. The other residents don't want to have the hassle of sawing and splitting.

Will immediately only buy a filter if it is demanded for by the authorities. They think a cost of 3 – 500 € will be a reasonable price.

There was a crackling sound during listening and the Bank from the filter at the beginning, but it was not annoying. It was less gradually and gave the impression of less efficiency. There were no genes from the ESP, but no visible effect either.

OK with cleaning once a year by the chimney sweeps, but not more often, because it will cost extra.

The CleanAir is not a beautification, so it should be smaller, and it should fall better into the stack appearance by having a black colour, instead of the stainless steel look.

House C and D have the same Andersen wood stove from 1999 and 2000 respectively. The people living in house C are retired, so they will normally use the wood stove the whole day and evening.

The firewood comes from their cottage, and much of it is branches and twigs. Back in the year 2000 they asked a wood stove dealer if they could buy a filter for the wood stove, but it was not possible.

They think an acceptable price for a filter depends on the efficiency, but up to 700 € considered to be fair. If it costs as much as 1300 - 1600 €, it would be reasonable with a public subsidies of perhaps 1000 € to reward environmental initiatives.

They have not experienced any problems or impact on the stove combustion or performance. The think the filter looked very big, when it was on the ground, but it does not look so big, when it is mounted on top of the chimney.

## 7.5 Conclusion – field test

The test of the filters was performed during only 4 weeks instead of the planned 8 weeks, and this has reduced the amount of useful data, and thus the significance of the test results.

The length of the campaign was chosen to minimize the influence of random fluctuation on the averages, but only in very short periods there were favourable downwind conditions during wood stove firing with the filters turned on (75 half-hours for the $PM_{2.5}$ measurements out of a total of 2688 half-hours in the campaign). Most of the time (87%) with simultaneous $PM_{2.5}$ measurements at Slåenbækken and LVBY detection of the local emissions was not possible, either because there was no woodstove firing or because the emissions were outside the favourable wind sectors.

In an alternating way during the 4 weeks the filters were turned on in half of the time and turned off in the rest of the time.

The 'selected data' (defined by the criteria that upwind firing occurred in at least one of the four houses in the predefined wind sectors) showed clearly enhanced increments compared with the rest of the data. This proves that the 'selected data' represent wood smoke signals from the four houses that are significantly larger than the noise due to the fluctuations of the background concentrations at the two monitoring sites.

A comparison of 'selected data' for which the filters were turned on with the 'selected data' for which the filters were turned off can therefore be used to test the efficiency of the filters. An indication of a positive effect of the filters should be that the increments of either $PM_{2.5}$, particle number, particle volume or soot with the filters turned on were clearly smaller than the increments with the filters turned off. A more specific indication should be that the average $PM_{2.5}$/CO ratio obtained by regression analysis was significantly smaller when the filters were turned on than when the filters were turned off. Neither of these reductions was observed, so a cleaning effect of the filters has not proved by the measurements during the campaign.

The only observed possible effect of the filters was a change of the average particle size distribution, so the distribution with a dominating mode at 80-100 nm when the filters were turned off changed to a distribution with a dominating mode at 10-20 nm when the filters were turned on - i.e., with the filters on there were more ***very*** small particles and fewer of the slightly larger particles.

# 8 Discussion and evaluation

Since the authorities began to regulate industrial emissions in the $70^{th}$, a common practice has been developed for the sequence of actions to reduce emissions, which are:

1) Process optimization was the first tool to minimize emissions, by optimizing it in relation to the emissions, e.g. optimizing a combustion process to minimizing the CO and particulate emission.
2) Substitution, where environmentally harmful substances and the emission of these, are replaced by other substances, which gives less emission or less harmful emissions.
3) Cleaner technologies, where a part of, or the entire process, is carried out in a different way or with more modern equipment that has a smaller emission.
4) End of Line technology, where the emissions are reduced in a separate process, e.g. a scrubber, a filter etc. This should only be applied, if emissions are not reduced sufficiently by the first three steps.

This principle is also relevant for handling the emissions from wood stoves and wood boilers, especially the older ones, which have considerable emissions of particles, tar and unburned gases. If these older appliances should be brought down to an emission level close to the level of modern appliances, the following considerations can be made, in relation to the above four points for industrial emissions.

### 8.1.1 Process optimization

It is not possible to optimize the combustion process in older appliances to achieve combustion as effective as in the newer appliances, because the newer ones are based on entirely new and improved design principles.

The newer stoves have, e.g. smaller combustion chamber and a much improved management of pre-heated combustion air, which usually also include tertiary air supply.

The best new boilers have downdraught gasification and control the heat release with a fan, which is far more effective compared to the old bottom up combustion in old boiler.

The Ecoxy retrofit system improves old stoves with tertiary air supply, resulting in some improvement of combustion, but it is only a slight improvement, which is far from bringing the combustion efficiency in older stoves to the level of the new and modern ones.

There is a systematic provision of information from authorities, chimney sweeps and media to get people to fire correctly and use proper and dry firewood in their stoves and boilers.

Process optimization by proper firing with dry firewood, can minimize the emissions from older wood stove and -boilers but the emissions will still be much higher, than from newer wood stoves and boilers.

### 8.1.2 Substitution

It is only possible to substitute the fuel used, but it's not the fuel that is causing the high emissions from older plants, although a lousy fuel obviously can cause even more emissions than a better one. Even if firing with the best fuel - clean dry firewood with the recommended thickness of approx. 8 cm - the emissions from older wood stoves and -boilers, will still be much larger than from new ones.

As mentioned for Process optimization, there is a systematic provision of information from authorities, chimney sweeps and media to get people to fire properly and use properly, dry fire wood, and provide information on what are not allowed as fuel, for example waste, demolition wood and used wood pallets.

Substitution, in the sense of using only proper and dry firewood, is a realistic way to achieve a substantial reduction in emissions from older wood stoves and boilers, but the emissions will still be much higher than from newer stove and boilers.

### 8.1.3 Cleaner technology

Cleaner technology for both stoves and wood boilers has been developed for many years, and especially during the last 10 years, and even more within the last 5 years, the combustion techniques has been improved and the emissions of particulates, CO and OGC is significant lower than from older appliances.

Cleaner technologies can be easily introduced by replacing older wood stove or boiler with new ones, that at least meets the emission requirements in the Danish Wood Stove Order[43], or even better is Eco labeled with the Swan, where the requirements are even stricter.

The effect of replacing old furnaces with new ones can be seen from the emission factors for wood stoves and boilers used for estimating the total yearly emission of PM, NMVOC, dioxin and PAHs in Denmark, required by the NEC directive[44].

The Environmental Project No. 1324 from 2010 presents a proposal for revised emissions factors for wood stoves and boilers with different ages[45]. The proposed emission factors are shown in the next two tables, with the highest emission factor for each group set to index 100. The achieved lower emission by replacing an old stove or boiler with a new one, can readily be seen, e.g. as percentage of the oldest one. The total number of stoves and boilers of the different age-groups are included in the tables to demonstrate

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[43] Statutory Order regulating air pollution from wood burners and boilers and certain other fixed energy-producing installations. Only available from www.mst.dk. Direct link.

[44] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants

[45] Iversen, J. Henriksen, T C. Dreyer, S. Emissioner fra træfyrede brændeovne og –kedler. Miljøprojekt Nr. 1324, 2010.

the potential for emission reduction by switching from old to new stove and boilers.

Table 16. Age depending emission factor index for wood stoves

| Wood stoves | Age | Number in 2008 | PM Index | NMVOC Index | PAH-4[1)] Index | Dioxin Index |
|---|---|---|---|---|---|---|
| Old stoves | → 1990 | 134 100 | 100 | 100 | 100 | 100 |
| DS-887 approved stoves[2)] | 1990 - 2005 | 189 800 | 100 | 83 | 100 | 100 |
| Complying with Order 2008[3)] | 2005 → | 134 500 | 75 | 21 | 35 | 38 |
| Swan labelled or equivalent | 2005 → | 52 400 | 29 | 10 | 18 | 19 |

[1)] Valid for four PAH, but the relationship is presumable fairly the same for the 16 EPA PAH.
[2)] Withdrawn Danish Standard: DS 887:2000. Solid fuel stove for room heating - Part 1: Requirements, and Part 2: Test methods-
[3)] Danish Wood Stove order

Table 17. Age depending emission factor index for wood boilers

| Wood boilers | Age | Heat storage vessel | Number in 2008 | PM Index | NMVOC Index | PAH-4[1)] Index | Dioxin Index |
|---|---|---|---|---|---|---|---|
| Old boilers | → 1980 | No | 7 400 | 100 | 100 | 100 | 100 |
| | | Yes | 9 500 | 54 | 40 | 20 | 100 |
| New boilers | 1980 → | No | 11 400 | 13 | 25 | 12 | 60 |
| | | Yes | 19 700 | 7 | 10 | 6 | 60 |

[1)] Valid for four PAH, but the relationship is presumable fairly the same for the 16 EPA PAH.

The total number of stoves and boilers in the tables are respectively 511 000 and 48 000. The figures are based on a study conducted by the Technological Institute in 2005. Other studies show that there is up to 700 000 stoves and almost 100 000 wood-burning boilers in Denmark, but according to a counting made by the Danish Chimney Sweeps Association, the total number of stoves and - boilers are just around 600 000.

It is evident that there is enormous potential for reduction of the emission of all four pollutants, by replacing older wood stoves and boilers with new ones. The emissions of CO are not included in the tables, because there are no demands for reporting the emissions of CO, but the CO emission will also decrease when the combustion is improved and the emission of PAH and NMVOC is reduced.

Additionally the actual emission reduction will be greater, because the heat efficiency is also higher in the new stove and boilers, and thus they consume less firewood to give the same amount of heat. This is presumed to further reduce the emissions with 10 – 30 %, but maybe it can be reduced by up to 40 - 50%, if a very low efficient stove or boiler is replaced by a new and much more efficient one.

The table's shows, that only app. 10 % of the wood stoves, and 40 % of the boilers are of the most efficient types with the lowest emissions. And the emission factors shows, that replacing all older stoves, even some of them complying with the Order 2008, with ones meeting the Swan Eco Label requirements will reduce the emissions much more than any of the tested technologies is able to. And it is without giving any extra work and/or costs for maintenance and cleaning.

By handling the emissions from stoves and boilers as is the common practice for industrial emissions, it is obvious that replacing old ones with new ones is the only environmental sustainable way to reduce the emissions. This applies obviously only to older stoves and boilers, but it is also the majority of the number, which contributes with an even bigger part of the total emission.

If the emission of especially soot particles from the new and most efficient stoves and - boilers should be reduced further, then the ESP technology could be a useful technology, which will probably work better and be easier to clean, because particles from an efficient combustion is more dry and less sticky, because the smoke contains much less condensables.

However, there may be stoves which cannot simply be replaced with new ones, for example historical stoves from before 1940, which are exempt from the requirements in the Stove Order 2008. There may be other stoves which are expensive to replace, for example masonry stoves, for which it could be desirable to install an End of Line technology to purifying the smoke, but it is a very small proportion of the total number of stoves in Denmark.

### 8.1.4 End of Line Technologies

End of Line Technologies for flue gas cleaning for industrial combustion plants with continuous supply of homogeneous fuel and control of combustion is well known and proven technology. The smoke from the combustion is much cleaner than from small hand-fired plants, and the smoke composition and temperature is fairly constant, which normal is crucial for the operation and performance of an End of Line technology.

For manually-fired stoves and boilers, the situation is very different, because of the discontinuous operation, with very large variations in combustion conditions and thus also in the temperature and content of soot, condensables and unburned gases. New plants with more efficient combustion will have slight variations in emissions and will have a relatively low content of condensables and thus limited condensation. Therefore, the soot particles are relatively dry and much easier to handle, than the sticky particles that typically come from older plants with high emission of condensables.

The properties of the particles and the condensation of tar put very high demands to the performance of the technology and for regular cleaning and maintenance. General proven technologies for flue gas cleaning at industrial combustions plants are:

- Cyclones
- Bag Filters
- ESP (Electro Static Precipitators)
- Scrubbers (flue gas condensation)

**Cyclones and bag filters** are not directly applicable to stoves and wood boilers, due to large pressure drop that requires a fan, high price for the bag filter and problems of rapid clogging of the filter material with soot and tar. However, there are probably newer boilers equipped with a flue gas blower, which has a kind of cyclone for separating large particles.

**ESP and scrubber technologies** are more suitable for wood stoves and boilers, due to a low or no pressure loss, and no risk of clogging.

Scrubbers is more suitable for boilers as they require some space, water supply, drainage, and not least a blower, because the flue gas is cooled down, which reduces or destroy the chimney draught. Due to the cooling of the flue gas, a part of the condensables will condensate, and can be washed out of the smoke in flounder. No scrubbers are tested in this project.

The ESP technology is provisionally the most promising technology. Several manufacturers are working seriously to develop and market them in Germany, Austria and Switzerland. Fairly good cleaning efficiencies is achieved for particles, but it is measured just before and after the ESP, and it's probably measured for newer stoves, boilers and pellet boilers, from which the emission of condensables which forms particles when the smoke is cooled down is low or very low compared to older stoves and boilers. The ESP is only effective against particles and droplets and it has no effect against condensables on vapor form.

The ESP technology works by electrical charging the particles with one or more electrodes that are imprinted with a negative DC voltage of 10 kV (kilovolt). The voltage creates an electric field which ionizes the gas, whereby the particles are negatively charged, and they are repelled by the field and moves across the gas flow towards the precipitation plates, which typically is the flue gas pipe, which therefore must be made of steel. When the particles meet the precipitation plates, they release their electric charge, but as the layer of particles increases, it decreases the ESP efficiency. In industrial plants the collected dust is removed automatically on a regular basis, e.g. by shaking the precipitation plates, whereby the particle falls down into the filter base funnel from where it is recovered. The small ESP developed for stoves and boilers do not have such an automated cleaning system, so they must be cleaned manually and the required frequency depends on the amount of particles emitted from the actual stove or boiler. It is therefore evident that the older plants with high emissions of particles require more frequent cleaning than new plants with low particle emissions. Effective performance can be difficult in plants with poor combustion, where tar can be condensed as an oily layer that is difficult to remove (see e.g. Figure 68 Picture 1). Operation of ESP is expected to be much easier and more effective on new stove and boilers with efficient combustion and low emission of condensables.

For the assessment of ESP it is considered to be very important to distinguish between flue gas from new or old installations, where the latter can give problems with condensables. In this project, only flue gas from an older stove and boiler are tested, and they have a significant greater emission of condensables than normally seen from newer appliances. Therefore the evaluations only apply to older appliances, as there might be a much better performance for newer appliances having more optimal combustion, including pellet stove and pellet boilers.

The tests do not show any or only a minor reduction of the particle emission measured in a dilution tunnel. The best results shows an efficient removal of the black soot, which is clearly visible on the filters for measuring particle concentration, which changes color from black to brownish, when the ESP is turned on.

There are great differences in the results for the three tested ESP. There could not be seen or measured any significant reduction in the particle emission for the Airbox ESP, but it could be due to the fact, that the filter has apparently been used previously without being cleaned. The efficiency has probably been greatly reduced due to a thick deposition of soot on both electrodes and depositions plates. This was first discovered some time after all test was completed.

The results for Zumikon is somewhat better than Airbox and the best results was achieved for the CleanAir, probably because it is mounted on top of the chimney where the flue temperature is lower and maybe also because the electrode size and length gives a longer retention time in the electric field, and therefore a longer time to separate the particles. None of the ESP provides any measurable reduction of particles, measured in the dilution tunnel, which is attributed to the relatively poor combustion, which gives a large amount of particles by condensation when the flue gas is cooled down after leaving the chimney.

### 8.1.5 Catalyst

Catalytic combustion is never used for cleaning the flue gas from industrial boilers, because the combustion normally is so efficient, that the emission of condensables is so low, that it is not relevant to reduce. The flue gas temperature will also be too low for the catalytic process, which normally requires at least 300 °C to operate. Catalysts are used in some wood stoves, e.g. in United States. The catalysts are normally embedded in the stove, where it is easier to achieve the required temperature to start the catalytic oxidation.

The use of a catalyst requires some attention from the user, because he has to turn the catalyst on and off depending of the temperature, by a flue gas bypass valve. The catalyst also has to be replaced after some years, depending on the load. The catalyst can also be destroyed if burning contaminated wood. A catalyst is therefore not a technology that just always works, and it is recommended only to persons who are prepared and able to give the necessary attention to make it work properly.

The results of the test with MoreCat catalyst demonstrates clearly that it cannot just be mounted on every wood stove, because it requires an extra large chimney draught, which very few chimneys in Denmark are able to deliver. Furthermore the flue gas temperature in many stoves is too low to start the catalytic oxidation. To increase the chimney draught a fan can be mounted on top of the chimney, but then the total cost will be in the same as for replacing the stove with a new and most modern type.

MoreCat catalyst can also be used on newer wood stoves, which has a lower emission of CO and condensables than the older ones, but it is foreseen to be even more difficult to find stoves which have the required flue gas temperature to start the catalytic oxidation.

## 8.2 General evaluation

There are a lot of results and information, which is relevant to include in a general evaluation of the tested technologies, and in the attempt to give a better overview, the evaluation it is made in relation to the different emission parameter separately.

### 8.2.1 Total PM and soot particles

The ESP technologies have no significant effect on the total PM emission, but some reducing effect on the emission of soot particles is visible from the colour of the plume of smoke and the filters used for sampling particulate matter. The best result was seen for the CleanAir ESP, where the colour of the filters from the PM measurements was light brown instead of black, showing that soot particles was removed very efficiently. It was also be seen from the field test, that the soot particles in the plume of smoke clearly disappeared when the ESP was turned on.

The ESP technology is only capable of separating solid and liquid particles, and it has no effect on gaseous compounds. Although the soot emission is reduced significantly, then the emission of condensables is so big, that the reduction cannot be registered on the measurement of the total concentration of PM after cooling and condensation in the dilution tunnel. This is in good accordance with the 2 – 10 times higher result for PM measurement in dilution tunnel compared to chimney measurements, described in section 2.4 on page 25 ff.

### 8.2.2 Ultra fine particles – $PM_{0.1}$

None of the technologies has any significant reducing effect regarding reduction of the number of ultra fine particles (particles smaller than 0.1 µm). On the contrary, there are strong indications, that the ESP technologies increased emission of ultra fine particles, which can be seen both in the laboratory tests and in the field test. The reason is very likely that when the large particles are removed, then the condensables will condense as many ultra fine particles, instead of condensing on the larger particles and make them larger.

### 8.2.3 Condensables

None of the ESP's had any effect at all on the emission of condensables (NMVOC), except from a small part, which might have condensed on the soot particle.

The catalyst MoreCat should be able to oxidize condensables, but the tests did not show any reduction. According to the MoreCat supplier, the reason could be a bad quality of the catalyst or it could be that the flue gas temperature was too low to start the catalytic oxidation.

The Ecoxy retrofit system should also be able to reduce the emission of condensables by improving the combustion, but the effect has not been high enough to see a significant reduction of the condensables.

### 8.2.4 PAH

There is apparently no significant reduction of PAH emission from any of the technologies. There seem to be a small increase for the boilers and a slight reduction for the stoves. The CleanAir ESP gives a considerable increase in PAH concentration, even though it is the technology that clearly has the largest reduction of emissions of soot particles, which usually contains the PAHs. By a mistake the CleanAir ESP was not switched on during the ignition and pre test, and two PAH measurements were therefore performed, for the parts with the ESP on and off respectively. The figures shows a doubling in the PAH emissions when the ESP is turned on.

A thesis for this higher PAH emission with the CleanAir ESP turned on, is associated to the analytical procedure, where the PAH might be readily and completely extracted from the filter without soot particles, but only partly extracted from the filter with soot particles. It is well known, that some compounds, e.g. PCDD/F and heavy metals needs a strong chemical treatment to be fully extracted from flue gas samples, where the they are strongly associated to the particles, but such a treatment would degrade the PAH 's, and therefore the ISO/DIS standard for PAH analysis only demands extraction with organic solvents[46].

It is also well known, that when analysing samples of volatile organic compounds collected on activated carbon, only a part of the sampled organics can be extracted from the activated carbon and soot particles and has some of the same properties as activated carbon. It could mean, that when removing the soot particles with an ESP, the small particles formed afterwards by condensation could keep a higher concentration of PAH, which is more readily available for health risk, because it is not strongly adsorbed to the bigger soot particles. The bigger particles are segregated in the nose by respiration, where the small particles can go deep into the lungs. This is only a thesis, but it would be very important for an overall evaluation of the ESP technology used for older wood stove and –boilers, if it is correct. Therefore it is strongly recommended to investigate this possible problem with "increased" PAH emission, when removing the soot particles with an ESP.

The Swan Eco labelled wood stove has the lowest PAH emission, which also is expected from the more efficient combustion in a newer certified stove. The same is also expected for the new boiler, which can be even more efficient combustion than newer certified stoves.

The most efficient way to reduce the PAH emission from older stoves and most likely also older boilers, is apparently to replace them with new modern certified, and preferable Swan Eco labelled ones.

### 8.2.5 PCDD/F

None of the technologies seems to have any reducing effect on the emission of PCDD/F (dioxins and furans).

PCDD/F is formed on the surface of soot particles where the flue gas temperature is in the range of 450 ° C to 400 ° C. The formed dioxin evaporates again from the soot particles and condenses on the particles when the flue gas is further cooled down.

There is a relatively large variation in the measured dioxin emissions, but it has also been seen in previous wood stove measurements, especially in the Gundsømagle projects[47,48], so the variations are more likely caused by the

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[46] ISO/DIS 11338-2: 2003. Stationary source emissions – Determination of gas and particle-phase polycyclic aromatic hydrocarbons. Part 2: Sample preparation, clean-up and determination.

[47] Glasius M. Konggsgaard P. Stubkjær J. Rossana B. Hertel O. Ketzel M. Wåhlin P. Schleicher O. Palmgren F. Partikler og organiske forbindelser fra træfyring – nye undersøgelser af udslip og koncentrationer. Arbejdsrapport fra DMU nr. 235, 2007. http://www2.dmu.dk/Pub/AR235.pdf

incineration process and variations in the firewood used, rather than an effect from the tested technologies. The Swan Eco Labelled stove has the lowest PCDD/F emission, but there are too few measurements to conclude if the stove type always has a lower dioxin emission. Several references, e.g. in a project for the Danish EPA in 2000 shows that the dioxin emission is greater from a good combustion in a stove, and significantly lower from a poor combustion. The reason is believed to be, that with the higher temperature in the good combustion, more of the inorganic compounds, (e.g. chlorine and cupper) which enhance the formation of dioxins, are brought into the flue gas, where the dioxins are formed in the area where the flue gas temperature is 400-450 °C. The newer stoves have high combustion temperatures, but the more efficient combustion will also cause a considerable less quantity of organic substances in the flue gas, and thereby the formation of dioxin should be reduced.

The two subsequent measurements with the CleanAir ESP respectively off and on, strongly indicate that removal of the large soot particles does not provide an equivalent reduction in PCDD/F emissions.

### 8.2.6 Odour

Odour is the reason for most complaints on smoke nuisances, but there was no measurable effect on the odour emission from the MoreCat catalyst or any of the ESP technologies.

It was not expected, that the ESP technologies would have any effect on the odour emission, as they only can remove particles, and the odour is normally gaseous compounds. It is also APP's experience, that the CleanAir ESP does not have any effect on the odour emission.

It was expected that the MoreCat catalyst would have some effect on the odour emission, because the catalyst should oxidise some of the condensables (NMVOC), but as the NOVOC was not reduced in the test, the odour was neither. According to the MoreCat supplier, the reason could be a bad quality of the catalyst or it could be that the flue gas temperature was too low to start the catalytic oxidation. With the correct quality of catalyst, and the appropriate high flue gas temperature, the MoreCat might have had a reducing effect on the odour emission, but the temperature would not be high enough in the ignition phase, where the odour emission is the highest. Even if the MoreCat is able to reduce the odour emission, then it is not a suitable technology to solve smoke odour nuisance problems, as it requires a very high stack or a fan to operate properly. Additionally it is doubtfully if it can reduce the odour emission enough to avoid nuisances, even if it is operated correctly by a conscientiousness user.

No test of the odour emission was performed with the Ecoxy, but in relation to the slightly improved combustion from the extra air supply, it is expected to cause a slightly reduced odour emission, but not enough to solve smoke nuisance problems.

There was like wise made no odour measurements in the test of the Swan Eco labelled stove, but as the Swan stoves has a significant better combustion than

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[48] Glasius M. Vikelsøe J. Bossi R. Andersen H.V. Holst J. Johansen E. Schleicher O. Dioxin, PAH og partikler fra brændeovne. Arbejdsrapport fra DMU nr. 212, 2005. http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR212.pdf

old ones, it is expected to have an equivalent lower odour emission. There are also several odour nuisance problems that have been solved, by replacing an old stove with a new Swan labelled model.

### 8.2.7 Mounting and service

Mounting and maintenance of all the five technologies is relatively easy if their requirements are met. However, there are several conditions which could complicate the mounting and maintenance, and thereby increase the costs.

By mounting a MoreCat ore a Zumikon on a stove with a top mounted steel chimney going vertical up through the roof, the chimney has to be raised to dismantle the pipe, so the device can be mounted. If the steel chimney is fixed to a rafter in a closed roof construction, some of the tiles must be dismantled in order to loosen up the chimney, so it can be raised.

Houses with multiple floors and/or high roof slope usually have a brick chimney. The chimney sweeper normally sweeps it from a clean-out door at the bottom of the chimney, and where appropriate also from one on the loft. Such chimneys are rarely swept from the roof for safety reasons. If a CleanAir ESP, which has to be cleaned regularly from the roof, is mounted on such a chimney, there must be established steps on the roof up to the chimney, and two men is needed for both mounting and cleaning, because one is needed to secure the ladder, while the other climbs to the chimney.

All houses where the chimneys are swept from the roof should be equipped with roof steps, but it is the chimney sweeper who decides whether it is necessary or not. If a CleanAir ESP has to be cleaned several times during the winter, it is expected that the chimney sweepers to a greater extent will demand steps mounted on all types of roofs, because the ESP has to be cleaned regularly, also if there is ice or snow on the roof.

### 8.2.8 Appearance and noise

None of the technologies will smarten up a wood stove or boiler, but some of them will disfigure more and others.

The Ecoxy retrofitting system is very neutral and only slightly visible and there is no noise from it. Its appearance will probably not keep anyone from using it.

The MoreCat catalyst is also very neutral in appearance, and it is not noisy at all. Even if it sits very visible just above the stove, it will most likely that most people can accept such on in their living room.

The Zumikon ESP appears also quite neutral, but it has nevertheless a distinctive appearance with a large tuber on the flue, and there is a 2 m long cable to the control box, which must therefore be located close to the stove, and therefore it can be difficult to hide. Since some sparkling noise can come from the Zumikon, most people, and maybe especially the housewives, is expected to oppose to have such one installed in their living room. Most people would probably accept it, if it is mounted on a wood boiler, located in a basement, scullery or in an outbuilding.

The Airbox ESP is very large and heavy, and it will be highly visible and dominant on any wood stove, so it is not expected that anybody will accept such one in their living room. Most would probably accept, if it is mounted on a wood boiler, located in a basement, scullery or an outbuilding.

CleanAir ESP is quite big in a close look, but it doesn't look so much like when it is mounted at the top of a stack, so it will most probably be accepted by most people. However, there is some sparkling noise from it, which can be annoying inside the house close to the chimney, and it could be unacceptable for many people.

#### 8.2.9 Investment and maintenance cost

The total costs for installation and operation of the 5 tested technologies are especially difficult to predict for the three ESP, because the cost for installation depends on the actual condition, and because the cost for regularly cleaning of the CleanAir ESP depends on the necessary frequency, which again depends of how good the combustion is and how much the stove or boiler is used.

The Ecoxy is the least expensive technology, as in Norway can be obtained for 250 € for the device and for 435 € including installation. There are no additional expenses for cleaning.

The MoreCat has also a relatively low price of 300 €, with an expected price for mounting of approximately 100 €, but it can be much higher, if a steel chimney is fixed and cannot easily be elevated to dismantle the flue gas pipes. In addition, replacement of the catalyst itself approximately every second or third year has a price of approximately 200 €. The cleaning is carried out by the user, so here is no extra cost.

The Zumikon and Airbox ESP is relatively easy to install, and they can probably be mounted by a wood stove seller or the chimney sweeper for between 100 and 300 €, provided that it can be connected to an existing socket for electricity. Regularly cleaning of the filters is expected to be done by the user. However, there may be a requirement to carry out regular chimney sweeps inspection, cleaning of the filter and especially the whole chimney, where more soot will be deposit. We therefore anticipate 2-4 visits a year by the chimney sweeper, a price which a little higher than the normal for chimney sweeping.

The price for a CleanAir is not known, but APP expects a cost price of approximately 300 € by large mass production, but by comparing to the prices for Zumikon and Airbox (960 € and 1400 €), we expect a sales price in the level of 1000 €. The costs for installation will in many installations be higher or much higher than for the other technologies, partly because of the additional outdoor electricity installation to be made by an authorized electrician, and partly because of the extra cost and precautions to be taken when installing it on house with several floors or very high roof slope. In many cases the installation cost could be as expensive as the filter, which is around 1000 €. A new Swan Eco labelled stove can be bought and installed for less than 2000 €, and much more emission reduction would be attained.

The necessary cleaning frequency depends on the operating time and combustion efficiency, but we expect it to be done by the chimney sweeper at least 2 – 4 times in the heating season. The cost may be significantly larger than the normal chimney sweeping, especially for houses with several floors, where two persons are needed, so that one can secure the ladder.

The residents who tested the CleanAir ESP in Slåenbækken, was prepared to pay from 300 € and up to 600 € including mounting for an ESP, if it is really effective, and there are no large annual costs for cleaning. The real expected cost is thus far higher than the amount these residents are ready to pay. In addition, their condition, that the filter must be really effective, cannot be documented by the tests.

Installation costs and ongoing costs for cleaning and maintenance of an ESP, will in many cases, be in the same level as the replacement of an old stove with a new and modern approve type and possibly also Swan Eco labelled model, which has significantly less emission for all the main pollutant, and not only for soot particles.

Replacing an old wood boiler with a new and more efficient one are much more expensive than replacing a wood stoves, and also much more expensive than the cost for mounting and maintenance of an ESP, but for the environment and health effect, replacement is the best solution, as it reduces the emission of all main pollutant and not only the soot.

There are several benefits from replacing old wood stoves and -boilers with new, instead of installing an ESP:

- no extra work for regular inspection and cleaning of the ESP
- no extra cost for chimney sweeper inspection and cleaning
- no expenses for electricity and replacement of electrodes
- higher efficiency, which means less firewood is needed to keep the same temperature
- easier to fire and regulate the heat release
- many wood stoves has a modern and nice design

If considering installing any of the tested technologies on an older wood stove or –boiler installation, it is very important to involve all advantages and disadvantages, not only for the technology, but also for the alternative, to replace it with a new modern and much more effective one. There are obviously many disadvantages by all the technologies, especially the very limited effect on the total emission of all main pollutant, and it is very difficult to find any disadvantages by installing a new and modern stove or boiler, except for the relatively high cost for a new boiler.

## 8.3 Main conclusion

The overall conclusion for the five tested technologies, in relation to the aim of the project, which is:

- to evaluate and test technologies for flue gas cleaning and/or combustions improvements, which can be mounted on existing wood stoves and wood boilers

subject to the following conditions

- existing wood stoves and boilers are mainly older appliances, which have much less efficient combustion than newer ones
- they have an substantial emission of condensables

- the emissions are measured in a dilution tunnel

All the technologies have a reducing effect on the emissions, but the efficiency is low or very low, depending on the compound.

A much more efficient way to reduce the emissions is to replace the older wood stove or boilers by new modern devices, as new units have a documented much lower emissions of all the pollutants CO, particles, condensables, PAH and most likely also odour.

It is also believed, that especially the ESP technology will perform much better with less problems, if used on newer installations with efficient combustion and less condensables, where the soot particles are more dry and easier to handle.

It seems to be much more environmentally sustainable to work for a replacement of old wood stoves and boilers (older than 5 – 10 years) with new and more efficient ones, rather than trying to reduce the emissions from the incomplete combustion by installing an End of Line technology. It might only be possible to reduce the soot particle emission with the ESP technology and in some installations the CO and OGC emission with the catalyst technology.

The ESP technology seems to have the effect of increasing the emission of ultra fine particles in terms of number. In respect to health effects, ultra fine particles are of considerable concern. The explanation for this is believed to be that normally condensables will condense on the larger particles and make them bigger when the flue gas is cooled down. If the bigger particles are removed by an ESP the condensables will instead tend to condense to form ultra fine particles, which are $< 0.1$ µm.

This increase of the number of ultra fine particles when reducing the $PM_{2.5}$ are of considerable concern and it is strongly recommended to investigate this possible particle size distribution effect by the ESP, to clarify if, and how much, the flue gas health effect is increased or reduced, when the larger particles are removed by the ESP.

The overall conclusion is that the pollution from wood stoves and –boilers, older than 5-10 years, will be reduced much more by a replacement with new and more efficient ones, e.g. Swan Eco labelled stoves, rather than installing any of the tested technologies. The cost for a new stove will for many installations be roughly the same or only a somewhat higher than for installing an ESP, while the cost will be much higher for replacing a boiler. Compared to the environmental benefits from the much lower emissions from a new stove or boiler; it seems to more than justify a probably higher cost.

# 9 Appendix

Appendix 1. EU tender and letter

Appendix 2. ELPI

Appendix 3. Combustion diagrams

Appendix 4. Type A statistical evaluation

Appendix 5. Emission data in diagrams

Appendix 6. Laboratory test data

# EU Tender and Letter

Next 12 pages is a copy of a letter describing the invitation to participate in the test, and an Extract of EU tender 2008/S 97-130806.

FORCE TECHNOLOGY

To Whom It May Concern:

Brøndby, 11-06-2008

**INVITATION TO TEST – Filters or other technologies for reduction of flue gas nuisances from wood stoves and wood boilers are hereby invited to a national test**

The consortium consisting of FORCE Technology, Danish Technological Institute and the National Environmental Research Institute carries out the project "Test of technologies for flue gas cleaning and/or combustion improvement for after-mounting on existing wood stove and wood boiler installations" for the Danish Environmental Protection Agency.

### Purpose

The project has the purpose to identify and test suitable technologies for flue gas cleaning and/or combustion improvement for use on existing wood stoves and boilers in Denmark with regard to clarify their efficiency regarding reduction of the discharge of the most important pollutants in the wood smoke.

Selected technologies will be tested in the laboratory under controlled conditions and the technologies which manage best in the laboratory tests will be tested through mounting on stoves and boilers in one or more residential quarters in the heating season 2008/09.

Furthermore, the tests will try to clarify and describe advantages and disadvantages as well as possible problems with mounting, operation and maintenance of the filters.

### Invitation of technologies

The project is started by inviting technologies from producers and suppliers which can be after-mounted on wood stoves and boilers and reduce the pollution. The most promising technologies will be tested in the laboratory under controlled conditions. The technologies which manage best in the laboratory tests will be mounted on stoves and boilers in one or more Danish residential quarters in the heating season 2008/09.

The invitation of technologies has officially taken place with the EU tender no. 2008/S 97-130806 where the whole text is only available in Danish. Attached is an English translation of the main parts of the EU Tender, and this letter supplement it with more description of background and purpose of the project.

The present material is distributed directly to relevant companies and persons in Europe, which the consortium and/or the Danish Environmental Protection Agency know or think, might have an interest in the tender. The material is also distributed to everyone who might apply with a request of more information about the tender, for instance on basis of the EU tender.

### Expression of interest

Written expression of interest in Danish or English as described in the enclosed copy of the EU tender shall be delivered to the inviting company addressed below by mail or post Thursday 26 June 2008 at 12.00 AM at the latest, to:

FORCE TECHNOLOGY

FORCE Technology
Att.: Project Manager Ole Schleicher
Park Allé 345
DK-2605 Brøndby
Email: osc@force.dk
Phone: +45 43 26 75 40
Cell phone: +45 22 69 75 40

Mr. Schleicher will also assist you with any questions regarding the project, expression of interest and the necessary documentation, so don't hesitate to mail or phone.

Regarding the very short time limit, a short expression of interest will be accepted, if the requested documentation will be delivered by Friday 4 July 2008 at the latest.

Everyone who has products, methods or technologies for flue gas cleaning and/or combustion improvement which are suitable for after-mounting in or on existing wood stoves and wood boilers are invited to show their interest.

**Project**
The combustion plant of the participating households shall represent different types of combustion plants with regard to the age, type (wood stoves/wood boilers), chimneys etc. of the installation. The selected housing sector(s) shall be representative for common Danish living quarters, for instance single-family houses and terrace houses.

In connection with the test, systematic emission measurements will be carried out and information will be collected to describe:

1) The cleaning efficiency of the technologies (emission reduction) through measurement in the cooled flue gas in a dilution tunnel with regard to:
   a) particles ($PM_{10}$, $PM_{2.5}$, $PM_{0.1}$ and TSP)
   b) VOC, NMVOC, PAH, dioxins
   c) $O_2$, CO and temperature are measured continuously during all the measurements
2) Characterization of the combustion plants in the participating households, including:
   a) stove/boiler type and age
   b) chimney type and height
   c) fuel type, origin, moist content and consumption
3) The mounting process of the different technologies, including:
   a) technical challenges and solutions as well as esthetic consequences (inside and outside)
   b) financial costs for purchase and mounting
   c) reversibility of the installation
   d) other relevant conditions of importance for the mounting
4) The practical use, including:
   a) user-friendliness and operation stability
   b) resource consumption (for instance power consumption)
   c) waste generation and waste removal as well as possible environmental and working environmental influences of this, for instance noise
   d) other relevant conditions of importance for the practical use of the technologies
5) Effect on air quality, including:
   a) measurement of air quality in an area with attached cleaning technology
   b) users' and neighbours' opinion of the air quality

The laboratory tests take place in October-November 2008 and the field trial will take place in the heating season 2008-09, i.e. from December 2008 to April 2009.

If you are a potential supplier of the mentioned type of technology we hope that this project has your interest and we look forward to a positive expression of interest. If you do not want to participate or your technology is outside the criteria we would still like to hear from you with a description of the technology so we can gather broad knowledge on potential technologies for reduction of the emissions from wood stoves and boilers.

Possible questions can be directed to the undersigned at e-mail osc@force.dk or phone +45 2269 7540.

Sincerely yours
FORCE Technology

Ole Schleicher
Project Manager

Energy, Climate and Environment

Enclosure: Copy of EU tender no. 208/S 97-130806 (in Danish)
English extract of the main parts of the EU Tender

## Extract of EU tender 2008/S 97-130806

# INVITATION TO TEST – Filters or other technologies for reduction of flue gas nuisances from wood stoves and wood boilers are hereby invited to a national test

### II.1.5) Short description of the contract or the purchase/s

Producers and dealers of flue gas cleaning technologies and/or technologies for combustion improvement, intended for wood stoves and wood boilers, are invited to make their products available for free systematic test in a laboratory and possible additional medium scale field trial in one or more delimited residential quarters in Denmark.

The wanted products must be especially suitable for after-mounting in existing wood stoves or wood boilers, without a need for substantial technical intervention. It is a precondition that the products are made available free of charge and as basis they can be expected to be returned after the conclusion of the test unless the wood stove/boiler is not easily re-established to original condition at the disassembling.

Test of 1-2 pieces of the technology in laboratory is expected to take place from week 40-2008.

The laboratory test shall ensure that selected technologies are tested for their cleaning efficiency towards essential pollution parameters, including particles as well as the influence on the efficiency, pressure loss etc.

Furthermore, the laboratory test shall ensure that only technologies which both have a reasonable cleaning efficiency, operating stability and ability of after-mounting are subsequently used in the field trial even if at first a supplier is selected to participation in a laboratory test.

Dependent on the results of the laboratory test, focus in the field trial is expected to be on measurement of CO, TOC, Odour, the particle fractions PM10, PM2.5 and PM0 and PM0.1 and TSP.

Delivery of a number of 5-10 pieces for use in the field trial has to take place in week 47-2008 at the latest. The field trial is expected to take place from December 2008 to and including April 2009.

Final report on the test is expected to be published about at the turn of the year 2009/10.

### III.2) CONDITIONS OF PARTICIPATION
### III.2.1) The financial actors' personal situations

Everybody who has products, methods or technologies for flue gas cleaning and/or combustion improvement which are suitable for after-mounting in or on existing wood stoves and wood boilers is invited to express their interest.

Products, methods or technologies which are assumed to be built-in as a part of the production process of new wood stoves and boilers cannot participate in the present project which solely includes products, methods or technologies which can be after-mounted in or on existing wood stoves and wood boilers.

The attention is drawn to the fact that the purpose of the project is to examine:

1. Whether such products, methods or technologies are on the market which can be after-mounted in or on existing wood stoves and wood boilers.

2. At testing in a laboratory test to demonstrate their efficiency especially concerning reduction of the emission of health damaging substances, including particles and fine particles, CO, TOC, NMVOC, PAH, Dioxin and odour.

3. At testing in field trial at mounting in a number of ordinary houses with existing wood stoves or wood boilers, to test their functionality regarding reduction of CO, TOC, odour, the particle fractions $PM_{10}$, $PM_{2.5}$ and $PM_{0.1}$ and TSP, besides demonstration of mounting costs, operation stability, need of maintenance, as well as users' and neighbours' experience of the effect.

The project is concluded with a publication of a report but does not automatically lead to a pre- qualification process with the aim of purchase of the tested objects.

### III.2.2) Economical and financial capacity

The participants must be able to deliver products or technologies which are tested and which within a short time frame are expected to be made available on the market in volume and in technological and commercial condition.

Possible references to other tests as well as possible test reports or test results are requested to be delivered together with the expression of interest.

It is requested that the products, the methods, the technologies and their mounting and use must keep all valid Danish requirements of safety, including among others the building regulations, the power current regulation and other safety legislation related to fire, explosion and electricity.

It is especially important that the operation of these products, methods and technologies do not imply any increased risk for discharge of combustion products, as for example CO due to unintentional blocking of the flue or other conditions impairing the conditions related to person safety at the user.

### IV.1.2) Limitation of the number of financial actors who will be invited to give offer or to participate

Planned number of financial actors *OR* planned minimum number 3 and *if so*, maximum number Objective criteria for selection of the limited number of candidates:

In unprioritized order

- Possible existing documentation of the efficiency of the method or the product.
- Possible references documenting the supplier's technical and financial capacity and capability.
- Applicability for after-mounting in existing wood stoves, boilers, smoke pipes or chimneys without a need for substantial technical intervention.
- The technological and commercial availability of the method or the product.
- The supplier's ability and possibility to deliver and service products in Denmark.
- The length of the operation period between cleaning and maintenance.
- Estimated price for future users, purchase and installation as well as operation and maintenance.

### IV.3.4) Time-limit for receipt of tenders or requests to participate

Date: 26/06/2008
Time: 12:00

### IV.3.5) Deadline for dispatch of invitations to make an offer or to participate to selected candidates

Date: 11/07/2008

### IV.3.6) Language(s) in which tenders or requests to participate may be drawn up:

Danish and English

**DK-Brøndby: research and experimental development services**

**2008/S 97-130806**

**CONTRACT NOTICE**

**Services**

**SECTION I: CONTRACTING AUTHORITY**

I.1) **NAME, ADDRESSES AND CONTACT POINT(S):**
FORCE Technology, Park Allé 345, Contact: Force Technology, Attn: Ole Schleicher, DK-2605 Brøndby. Tel. (45) 43 26 75 40. E-mail: osc@force.dk.
**Internet address(es)**:
General address of the contracting authority: www.forcetechnology.com/en.
**Further information can be obtained at:** As in above-mentioned contact point(s).
**Specifications and additional documents (including documents for competitive dialogue and a dynamic purchasing system) can be obtained at:** As in above-mentioned contact point(s).
**Tenders or requests to participate must be sent to:** As in above-mentioned contact point(s).

II.1) **DESCRIPTION**

II.1.6) **Common procurement vocabulary (CPV):**
73100000.

**Description:**
Research and experimental development services.

**SECTION IV: PROCEDURE**

IV.3) **ADMINISTRATIVE INFORMATION**

IV.3.3) **Conditions for obtaining specifications and additional documents or descriptive document**
Time limit for receipt of requests for documents or for accessing documents: 20.6.2008 - 12:00.

IV.3.4) **Time-limit for receipt of tenders or requests to participate:**
26.6.2008 - 12:00.

IV.3.6) **Language(s) in which tenders or requests to participate may be drawn up:**
Danish. English.

**DK-Brøndby: Forskning og eksperimentel udvikling**

**2008/S 97-130806**

**UDBUDSBEKENDTGØRELSE**

**Tjenesteydelsesaftale**

**DEL I: ORDREGIVENDE MYNDIGHED**

I.1) **NAVN, ADRESSER OG KONTAKT(ER):**
FORCE Technology, Park Allé 345, Kontakt: Force Technology, Att. Ole Schleicher, DK-2605 Brøndby. Tlf. (45) 43 26 75 40. E-post: osc@force.dk.
**Internetadresse(r)**:
Overordnet internetadresse for den ordregivende myndighed: www.forcetechnology.com/en.
**Yderligere oplysninger kan fås ved henvendelse til:** Se under kontakt(er) ovenfor.
**Specifikationer og yderligere dokumenter (herunder dokumenter vedrørende den konkurrenceprægede dialog og et dynamisk indkøbssystem) kan fås ved henvendelse til:** Se under kontakt(er) ovenfor.
**Bud eller ansøgninger om deltagelse skal sendes til:** Se under kontakt(er) ovenfor.

I.2) **DEN ORDREGIVENDE MYNDIGHEDS ART OG HOVEDAKTIVITET(ER):**
Andet: GTS Institut.
Miljø.
Den ordregivende myndighed køber på vegne af andre ordregivende myndigheder: nej.

**DEL II: KONTRAKTENS GENSTAND**

II.1) **BESKRIVELSE**

II.1.1) **Den ordregivende myndigheds betegnelse for kontrakten:**
INVITATION TIL AFPRØVNING - Filtre eller andre teknologier til begrænsning af røggener fra brændeovne og brændekedler inviteres hermed til national afprøvning.

II.1.2) **Kontrakttype og udførelses- eller leveringssted:**
Tjenesteydelser.
Tjenesteydelseskategori: nr. 27.
Hovedudførelsessted: Teknologisk Institut, Vedvarende Energi og Transport, Kongsvangs alle 29, 8000 Århus C, Danmark (samt efterfølgende feltforsøg på en endnu ikke udvalgt lokation).
NUTS-kode: DK0.

II.1.3) **Bekendtgørelsen vedrører:**
En offentlig kontrakt.

II.1.4) **Oplysninger om rammeaftalen:**

II.1.5) **Kortfattet beskrivelse af kontrakten eller indkøbet/ene:**
Producenter og forhandlere af røgrensningsteknologier og/eller teknologier til forbrændingsforbedring, beregnet til brændeovne og brændekedler, inviteres til at stille deres produkter til rådighed for vederlagsfri systematisk afprøvning i et laboratorium og eventuel efterfølgende medium skala feltforsøg i et eller flere afgrænsede beboelseskvarterer i Danmark. De ønskede produkter skal være specielt velegnede til eftermontage i bestående brændeovne og brændekedler, uden behov for væsentlige tekniske indgreb. Produkterne forudsættes stillet til rådighed uden beregning og kan som udgangspunkt påregnes tilbagelevet efter forsøgets afslutning,

medmindre brændeovn/kedel ikke let lader sig reetablere til oprindelig stand ved demonteringen. Test af 1-2 stk i laboratorium forventes at finde sted fra uge 40-2008 Laboratorietesten skal sikre at de udvalgte teknologier testes for deres rensningseffektivitet overfor væsentlige forureningsparametre, herunder partikler, samt indvirkningen på virkningsgrad, tryktab mv. Laboratorietesten skal endvidere sikre, at kun teknologier der både har en rimelig rensningseffektivitet, driftsstabilitet og eftermonterbarhed efterfølgende anvendes i feltforsøget. Der er således ikke garanti for deltagelse i feltforsøget, selvom en leverandør i første omgang bliver udvalgt til deltagelse i laboratorietest. Afhængig af resultaterne af laboratorietesten, forventes der i feltforsøget fokus på måling af CO, TOC, Lugt, Partikelfraktionerne PM10, PM2,5 og PM0,1 og TSP. Levering af et antal på 5-10 stk til brug for feltforsøget skal ske senest i uge 47-2008. Feltforsøget forventes at findes sted fra December 2008 til og med April 2009. Endelig rapport over forsøget forventes at udkomme omkring årsskiftet 2009/10.

II.1.6) **CPV-Klassifikation (Common Procurement Vocabulary):**
73100000 - E020 - E050.

II.1.7) **Er dette udbud omfattet af WTO-aftalen om offentlige indkøb:**
Nej.

II.1.8) **Opdeling i delaftaler:**
Nej.

II.1.9) **Alternative tilbud vil blive taget i betragtning:**
Ja.

II.2) **ORDRENS MÆNGDE ELLER OMFANG**

II.2.1) **Samlet mængde eller omfang:**
Op til 10 eksemplarer pr produkt/teknologi, fordelt med 1-2 stk til laboratorietest i uge 40-2008 og 5-10 stk til brug for feltforsøget med levering senest uge 47-2008 Udbuddet er alene en invitation til at præsentere og lade afprøve produkter og teknologier til røgrensning og/eller forbrændingsforbedring. I det af udbuddet omfattede projekt indgår IKKE tilbud eller forpligtelser om køb af produkter eller teknologier, hverken som en del af afprøvningen eller efterfølgende.
Anslået værdi ekskl. moms:
mellem 1 000,00 og 6 000,00 DKK.

II.2.2) **Optioner:**
Nej.

II.3) **KONTRAKTENS VARIGHED ELLER FRIST FOR DENS OPFYLDELSE:**
Periode i måneder: 6 (fra tildeling af kontrakten).

**DEL III: JURIDISKE, ØKONOMISKE, FINANSIELLE OG TEKNISKE OPLYSNINGER**

III.1) **BETINGELSER I KONTRAKTEN**

III.1.1) **Sikkerhedsstillelse og garantier, som forlanges:**

III.1.2) **De vigtigste finansierings- og betalingsvilkår og/eller henvisning til relevante bestemmelser herom:**

III.1.3) **Retlig form, som kræves af den sammenslutning af økonomiske aktører, ordren tildeles:**

III.1.4) **Andre særlige vilkår, som gælder for opfyldelse af kontrakten:**
Nej.

III.2) **BETINGELSER FOR DELTAGELSE**

III.2.1) **De økonomiske aktørers personlige forhold, herunder krav om optagelse i erhvervs- eller handelsregister:**

Oplysninger og formaliteter, som er nødvendige for at vurdere, om kravene er opfyldt: Alle, der har produkter, metoder eller teknologier til røgrensning og/eller forbrændingsforbedring, som er egnede til eftermontering i eller på bestående brændeovne og brændekedler, opfordres til at give deres interesse tilkende. Produkter, metoder eller teknologier, der forudsættes indbygget som en del af fremstillingsprocessen af nye brændeovne og -kedler kan ikke deltage i nærværende projekt, der alene omhandler produkter, metoder eller teknologier der kan eftermonteres i eller på bestående brændeovne og brændekedler. Der gøres opmærksom på, at formålet med projektet er at undersøge: 1. om der findes sådanne produkter, metoder, eller teknologier på markedet, der kan eftermonteres i eller på bestående brændeovne og brændekedler 2. ved afprøvning i laboratorietest at eftervise deres nyttevirkning med særlig henblik på nedbringelse af udledning af sundhedsskadelige stoffer, herunder partikler og fine partikler, CO, TOC, NMVOC, PAH, Dioxin og lugt 3. ved afprøvning i feltforsøg ved montage i et antal almindelige huse med eksisterende brændeovne eller brændekedler, at afprøve deres funktionalitet med henblik på reduktion af CO, TOC, lugt, partikelfraktionerne PM10, PM2,5 og PM0,1 og TSP, foruden eftervisning af montageomkostninger, driftsstabilitet, behov for vedligeholdelse, samt brugeres og naboers oplevelse af effekten. Projektet afsluttes med udgivelse af en rapport, men leder ikke automatisk over i en prækvalifikationsproces med sigte på indkøb af de afprøvede genstande.

III.2.2) **Økonomisk og finansiel kapacitet:**

III.2.3) **Teknisk kapacitet:**

Oplysninger og formaliteter, som er nødvendige for at vurdere, om kravene er opfyldt: Deltagerne skal være i stand til at levere produkter eller teknologier der er afprøvede og som indenfor en kortere tidshorisont forventes at kunne gøres tilgængelige på markedet i volumen og i teknologisk og kommerciel modnet stand. Eventuelle referencer til andre forsøg, så vel som eventuelle afprøvningsrapporter eller afprøvningsresultater ønskes leveret sammen med interessetilkendegivelsen. Det fordres at produkterne, metoderne, teknologierne og deres montering og brug skal overholde alle gældende danske sikkerhedskrav, herunder bl.a. bygningsreglementet, stærkstrømsbekendtgørelsen og øvrig sikkerhedslovgivning relateret til brand, eksplosion og elektricitet. Det lægges især vægt på at driften af disse produkter, metoder og teknologier ikke indebærer forøget risiko for udstrømning af forbrændingsprodukter som eksempelvis CO grundet uvarslet tilstopning eller andre forhold og derved forringer de personsikkerhedsmæssige forhold hos brugeren.

III.2.4) **Reserverede kontrakter:**

Nej.

III.3) **SPECIFIKKE VILKÅR FOR TJENESTEYDELSESKONTRAKTER**

III.3.1) **Udførelse af tjenesteydelsen er forbeholdt en bestemt profession:**

Nej.

III.3.2) **Juridiske personer bør anføre navn og faglige kvalifikationer for de medarbejdere, der skal udføre kontrakten:**

Nej.

## DEL IV: PROCEDURER

IV.1) **TYPE PROCEDURE**

IV.1.1) **Type procedure:**

Konkurrencepræget dialog.

IV.1.2) **Begrænsning af det antal økonomiske aktører, som vil blive opfordret til at afgive tilbud eller deltage:**

Planlagt minimum antal: 3.

Objektive kriterier for valg af det begrænsede antal kandidater: I uprioriteret rækkefølge: - Eventuel eksisterende dokumentation for metodens eller produktets nyttevirkning. - Eventuelle referencer der dokumenterer tilbyderens tekniske og økonomisk kapacitet og kapabilitet - Egnethed for eftermontage i bestående brændeovne, -kedler, røgrør eller skorstene uden behov for væsentlige tekniske indgreb, - Løsningens teknologiske og kommercielle modenhed - Udbyderens evne og mulighed for at levere og servicere produkter i Danmark - Længden af driftsperioden mellem renholdelse og vedligehold - Anslået pris for kommende brugere, såvel anskaffelse og installation som drift og vedligehold.

IV.1.3) **Reduktion af antallet af økonomiske aktører i forbindelse med forhandlingerne eller dialogen:**
Anvendelse af etapeopdelt procedure for gradvist at reducere det antal løsninger, der skal drøftes, eller tilbud, der skal forhandles ja.

IV.2) **TILDELINGSKRITERIER**

IV.2.1) **Tildelingskriterier:**
Det økonomisk mest fordelagtige bud vurderet på grundlag af de kriterier, der er anført i specifikationerne, opfordringen til at afgive bud eller til at forhandle eller i det beskrivende dokument.

IV.2.2) **Der vil blive anvendt elektronisk auktion:**
Nej.

IV.3) **ADMINISTRATIVE OPLYSNINGER**

IV.3.1) **Sagsnummer hos den ordregivende myndighed:**
MST-523-00068.

IV.3.2) **Forudgående offentliggørelser om samme kontrakt:**
Nej.

IV.3.3) **Vilkår for adgang til specifikationer og yderligere dokumenter eller beskrivende dokumenter**
Frist for modtagelse af anmodninger om dokumenter eller for adgang til dokumenter: 20.6.2008 - 12:00.
Skal der betales for dokumenterne: nej.

IV.3.4) **Frist for modtagelse af bud eller ansøgninger om deltagelse:**
26.6.2008 - 12:00.

IV.3.5) **Frist for afsendelse af opfordringer til at afgive bud eller at deltage til udvalgte kandidater:**
11.7.2008.

IV.3.6) **Sprog, der må benyttes ved afgivelse af bud eller ansøgninger om deltagelse:**
Dansk. Engelsk.

IV.3.7) **Minimumsperiode, i hvilken den bydende er forpligtet af sit bud:**

IV.3.8) **Fremgangsmåden ved åbning af bud:**

## DEL VI: SUPPLERENDE OPLYSNINGER

VI.1) **ER DER TALE OM GENTAGNE OFFENTLIGE INDKØB:**
Nej.

VI.2) **VEDRØRER KONTRAKTEN ET PROJEKT/PROGRAM, DER FINANSIERES AF FÆLLESSKABSMIDLER?:**
Nej.

VI.3) **YDERLIGERE OPLYSNINGER:**
Yderligere oplysninger om projektet, herunder projektbeskrivelse og tidsplan kan fås ved henvendelse til: Ole Schleicher FORCE Technology Park Allé 345 2605 Brøndby Telefon (45) 43 26 75 40 Email: osc@force.dk.

VI.4) **KLAGEPROCEDURER**

VI.4.1) **Organ med ansvar for klageprocedurerne:**
Klagenævnet for Udbud, Erhvervs- og Selskabsstyrelsen, Kampmannsgade 1, DK-1780 København V. Tlf. (45) 33 30 76 21. Internetadresse (URL): www.klfu.dk. Fax (45) 33 30 77 99.

VI.4.2) **Indgivelse af klager:**

Præcise oplysninger om frister for indgivelse af klager: Der er ingen lovbestemte frister for indgivelse af klager til Klagenævnet for udbud. Senest samtidig med indgivelse af klage til Klagenævnet, skal klager skriftligt underrette ordregiver om den påståede overtrædelse og om, at klagen indbringes for nævnet. Der er klageadgang til konkurrencestyrelsen inden undertegnelse af kontrakt. Derefter henvendelse til Klagenævn for Udbud, Erhvervs- og Selskabsstyrelsen, Kampmandsgade 1, 1780 København V, Telefon (45) 33 30 76 21, hjemmeside www.klfu.dk.

VI.4.3) **Tjeneste, hvor der kan indhentes oplysninger om indgivelse af klager:**
Konkurrencestyrelsen, Nyropsgade 30, DK-1780 København V. E-post: ks@ks.dk. Tlf. (45) 72 26 80 00. Internetadresse (URL): http://www.ks.dk/. Fax (45) 33 32 61 44.

VI.5) **DATO FOR AFSENDELSE AF DENNE BEKENDTGØRELSE:**
20.5.2008.

# ELPI Measuring Principle

ELPI is the abbreviation of Electrical Low-Pressure Impactor.

The ELPI is measuring the particle distribution on line in real time in 13 stages

Sampling wood smoke in the dilutions tunnel is performed through a dilution system comprising of a hot dilution step (dilution factor approx. 1:10) followed by an optional cold dilution step (total dilution factor approx. 1:100). An ejection type diluter is used.

Dry, HEPA filtered pressurized air is added as dilution air to both diluters, ensuring that the water content in the diluted gas will be well below a dew point of about 5 °C. The dilution ratio was determined before each measurement in FORCE Technology's laboratory by means of a certified mixture of propane, and subsequent measurement of the concentration of propane in the diluted gas. A partial volume of the diluted sample gas is transported to the ELPI at ambient temperature via ELPI's sampling system.

The sampling system is shown in Figure 8 and Figure 9. The effect of non-isokinetic sampling is rather small for particles < 2500 nm, however isokinetic sampling was sought in this project. An in-stack pre-separator (cyclone) for separation of particles > 10 µm was used. Heated probes and heated stainless steel, flexible tubes were used for transporting the undiluted flue gas to the diluter.

Figure 1. Setup for sampling and dilution of particles from wood stoves for measuring fine particles with ELPI . ges.  Adapted from /ii/.

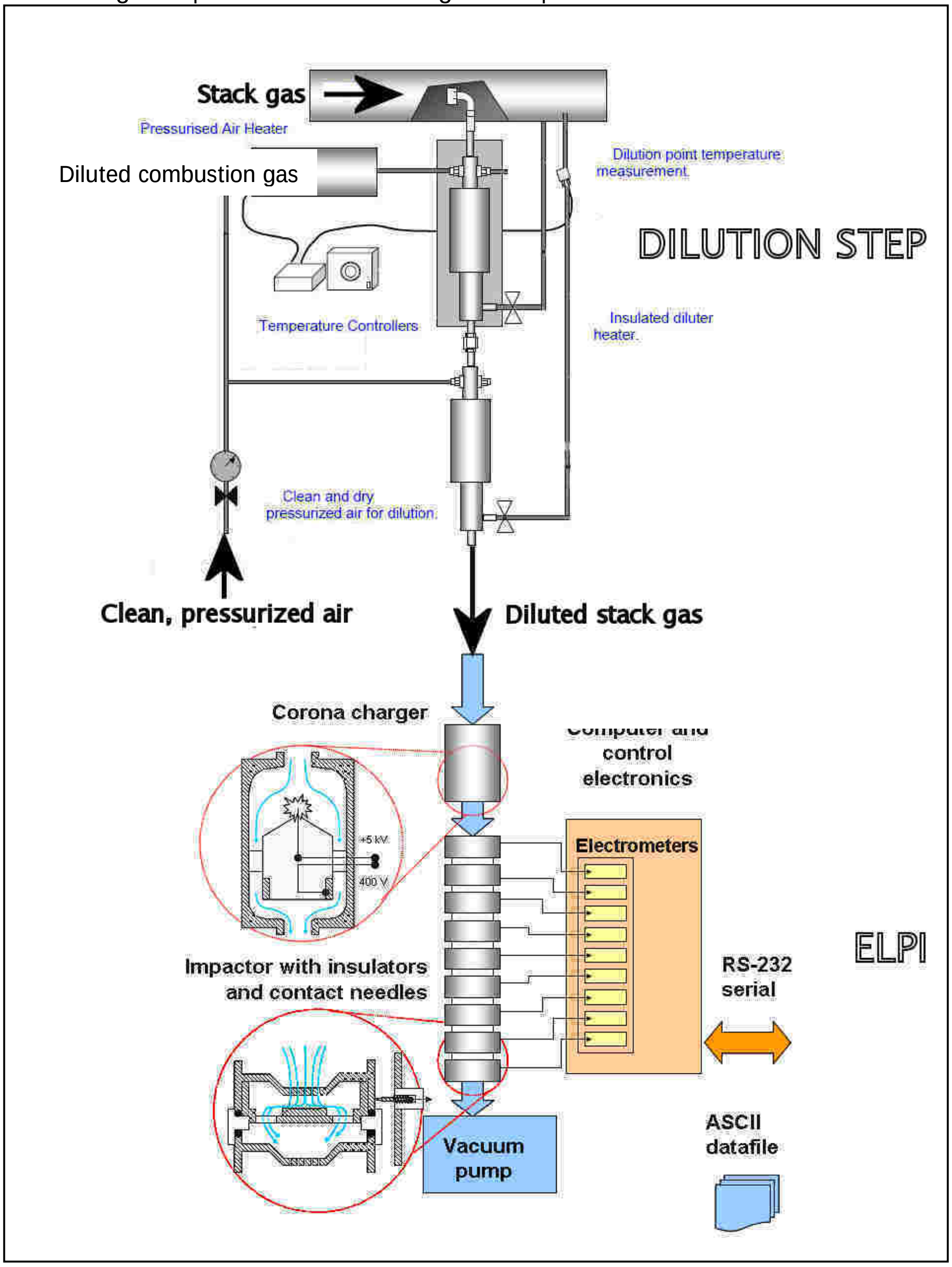


Figure 2. Sampling of particles in wood smoke with ELPI at TI's test plant in Aarhus.

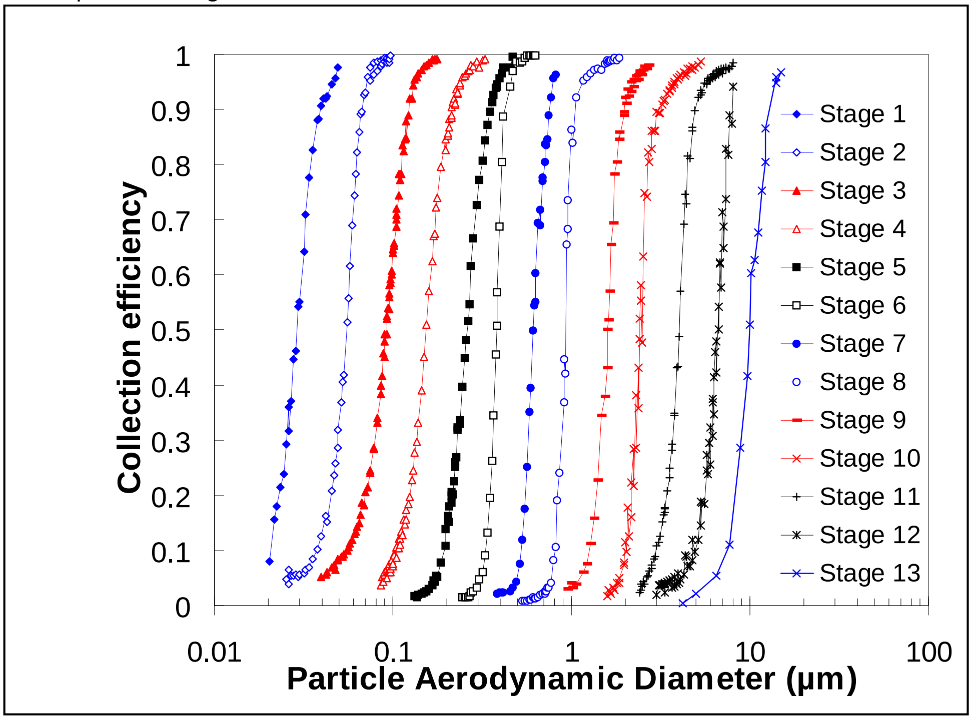
The specified ranges for collection of particles with the specific ELPI impactor used are shown in Table 5.

Table 1. Cut size for ELPI defined on the basis of aerodynamic diameter /[i]/.

| Impactor stage | Collected particles, dia. interval (nm) | Real-time measurement (CHP Emission Survey Project) | SEM analysis (this project) |
|---|---|---|---|
| Filter | 7 - 28 | + | - |
| 1 | 28 - 54 | + | + |
| 2 | 54 - 92 | + | + |
| 3 | 92 - 155 | + | + |
| 4 | 160 - 260 | + | + |
| 5 | 260 - 380 | + | + |
| 6 | 380 - 610 | + | + |
| 7 | 610 - 950 | + | + |
| 8 | 950 - 1590 | + | + |
| 9 | 1600 - 2400 | + | + |
| 10 | 2400 - 4000 | + | + |
| 11 | 4000 - 9900 | + | - |
| 12 | > 9900 | - | - |

The collection efficiency for the individual impactor stages is shown in Figure 10. Ideally, the collection efficiency curve should be vertical for each stage, so that any particle size would be found on one specific impactor stage only. However, this is not the case in any impactor, and particles will to some extend be collected on two or more subsequent stages.

Figure 3. Collection efficiencies as a function of aerodynamic diameter for the impactor stages of ELPI /[ii]/.




ELPI measures the size distribution continuously through the electrometers. It measures the current created from the particles passing through the individual impactor stages. ELPI uses conversion factors made from calibrations to convert the measured current to a number concentration. In order to convert the number distribution result into a mass distribution result, the total mass concentration in ELPI is achieved after assuming some physical properties of the sample aerosol. A density must be given for each type of particles.

In addition, a correction algorithm is used in ELPI to correct for the diffusion losses in the upper stages of the impactor where applied. A filter stage measures the particles below 30 nm. The diffusion loss for these very small particles at the upper stages of the impactor can add significantly to the normally small number concentrations measured e.g. above 2.5 µm. The correction algorithm uses the particle number at the filter stage and corrects for these particles' diffusion loss in the upper impactor stages. This correction reduces the overestimation of mass in the upper stages.

---

[i] Dekati data sheet for ELPI impactor # 2420.

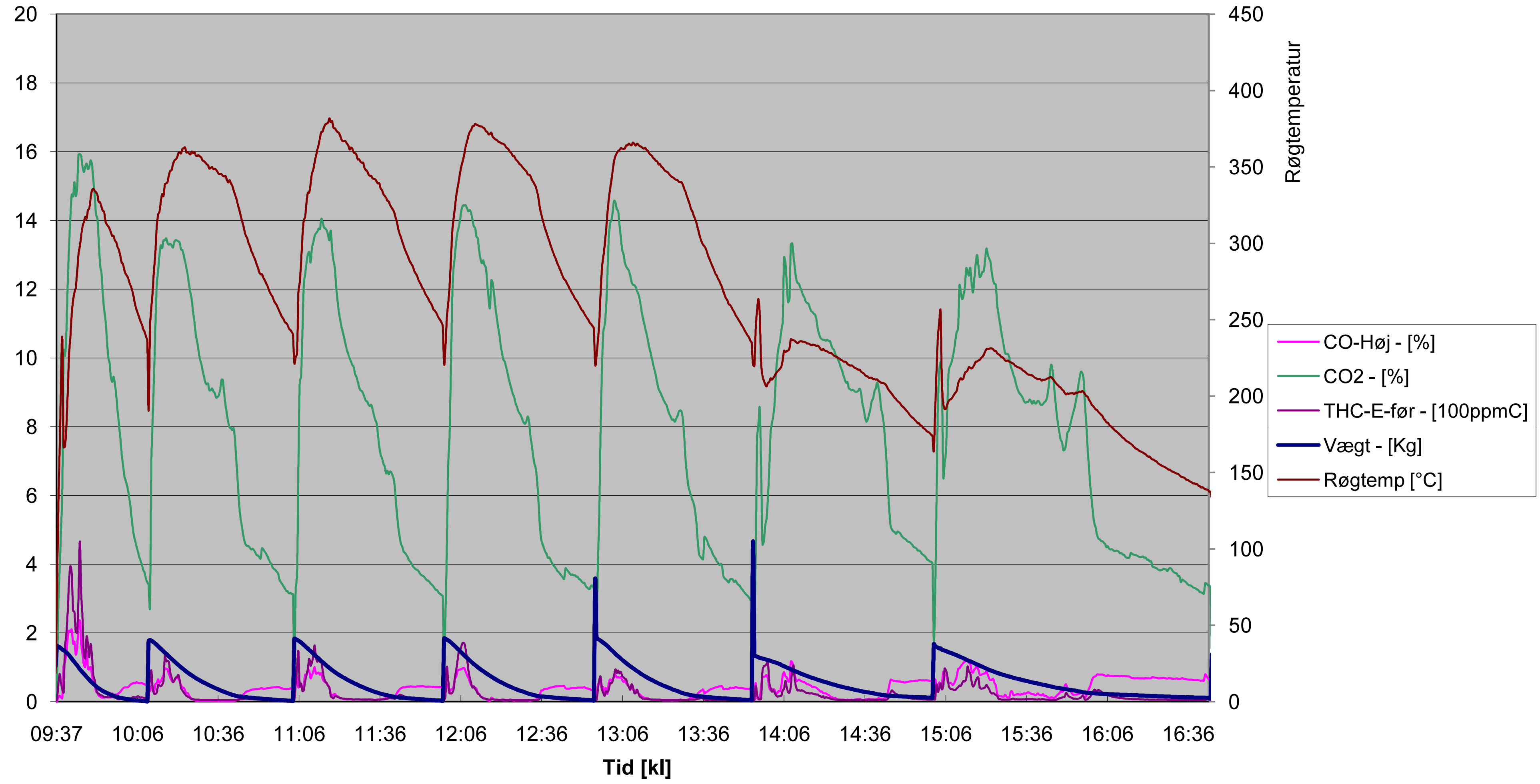
[ii] Marjamäki, M. (2000). Performance evaluation of the electrical low-pressure impactor (ELPI). J. Aerosol Sci. Vol. 31, No. 2, pp. 249-261.

# Combustion diagrams

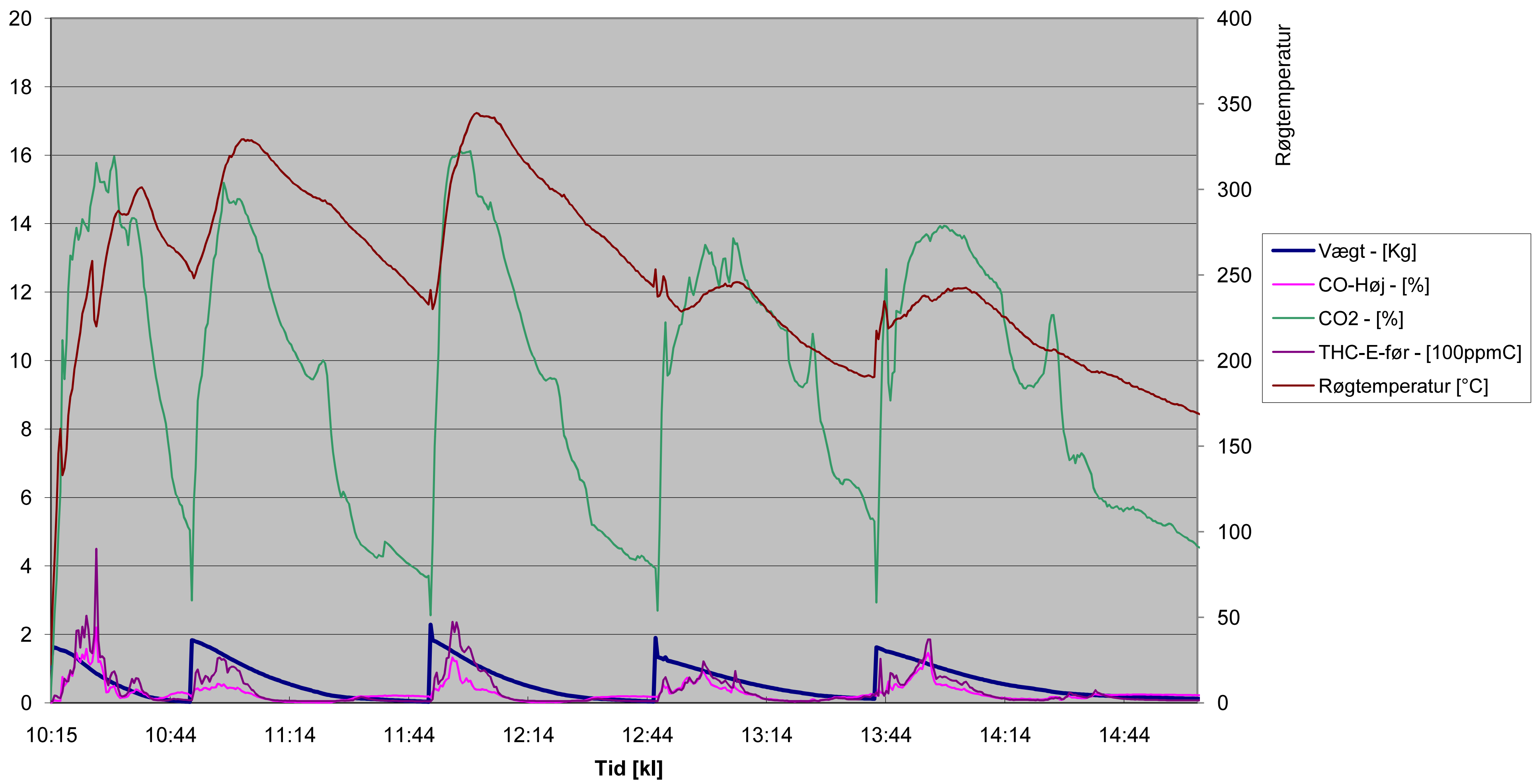
The next 17 pages contain combustion diagrams for the test, showing the:

- concentration of CO, $CO_2$ and OGC (= THC)
- the flue gas temperature.
- weight (vægt) of the wood logs showing the wood burning rate (the stove/boiler is placed on a weight, where data is recorded).

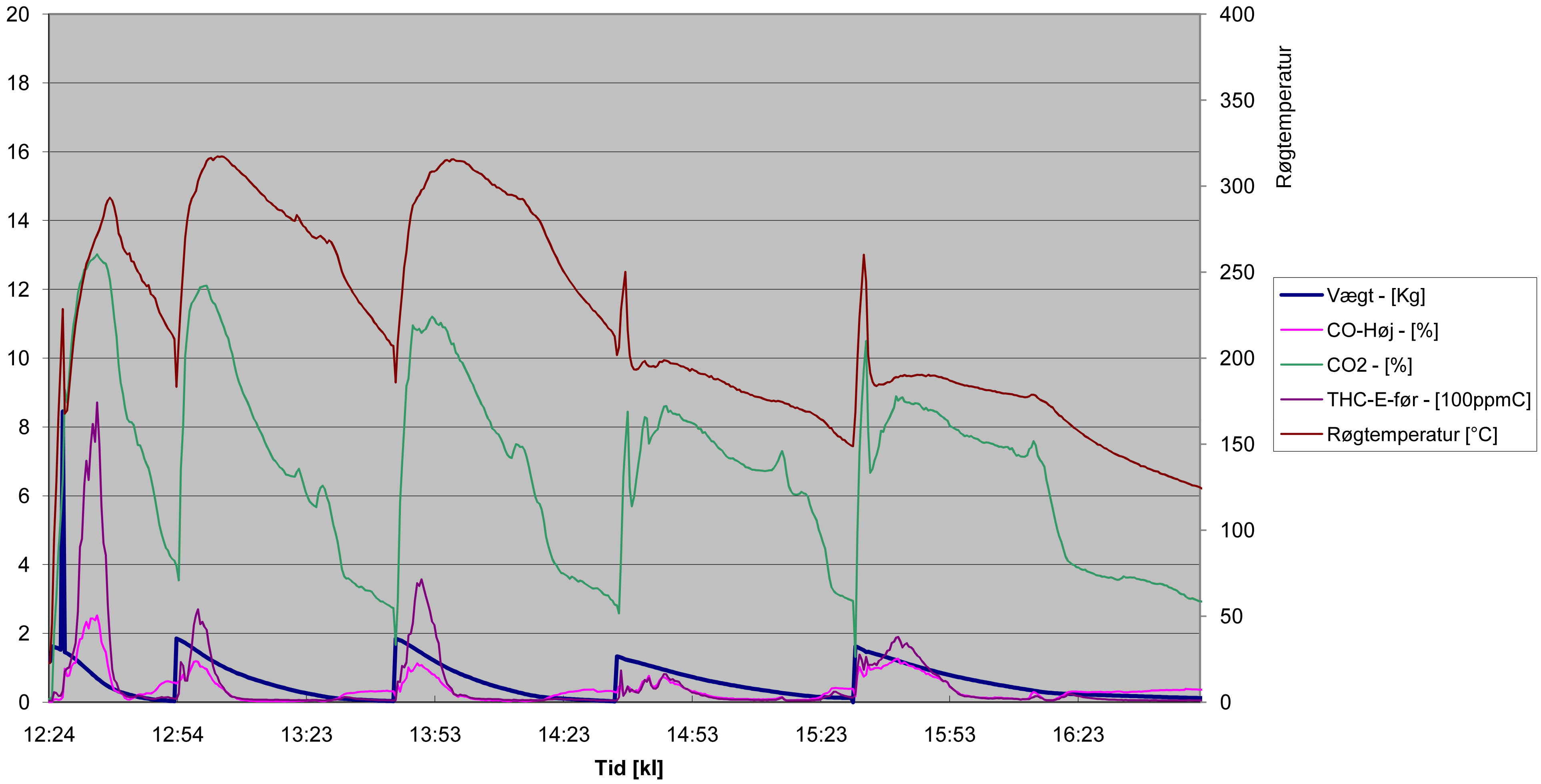
## Morsø Ingen rensning 07.10.2008



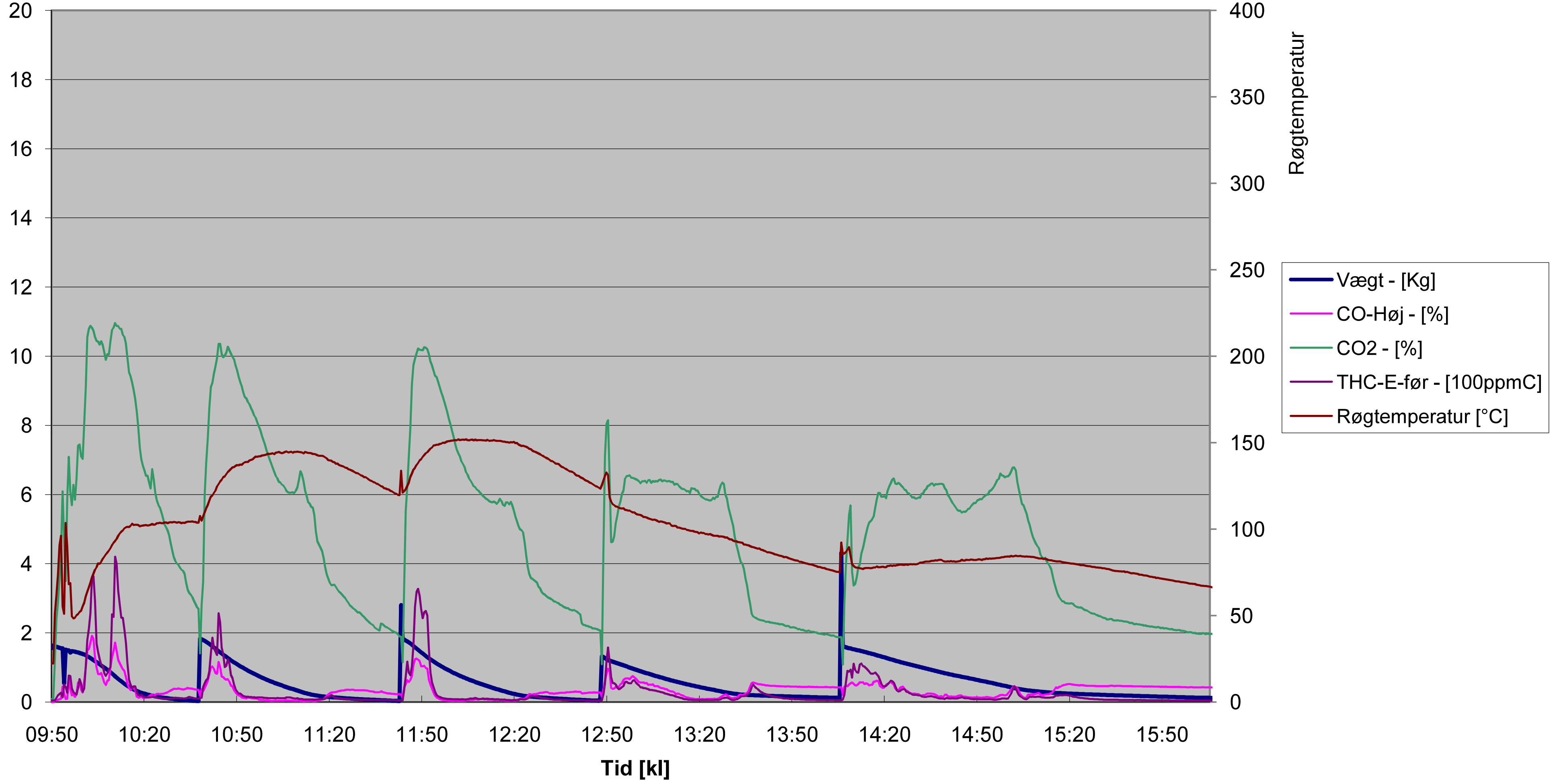
# Morsø med Morecat 09.10.2008



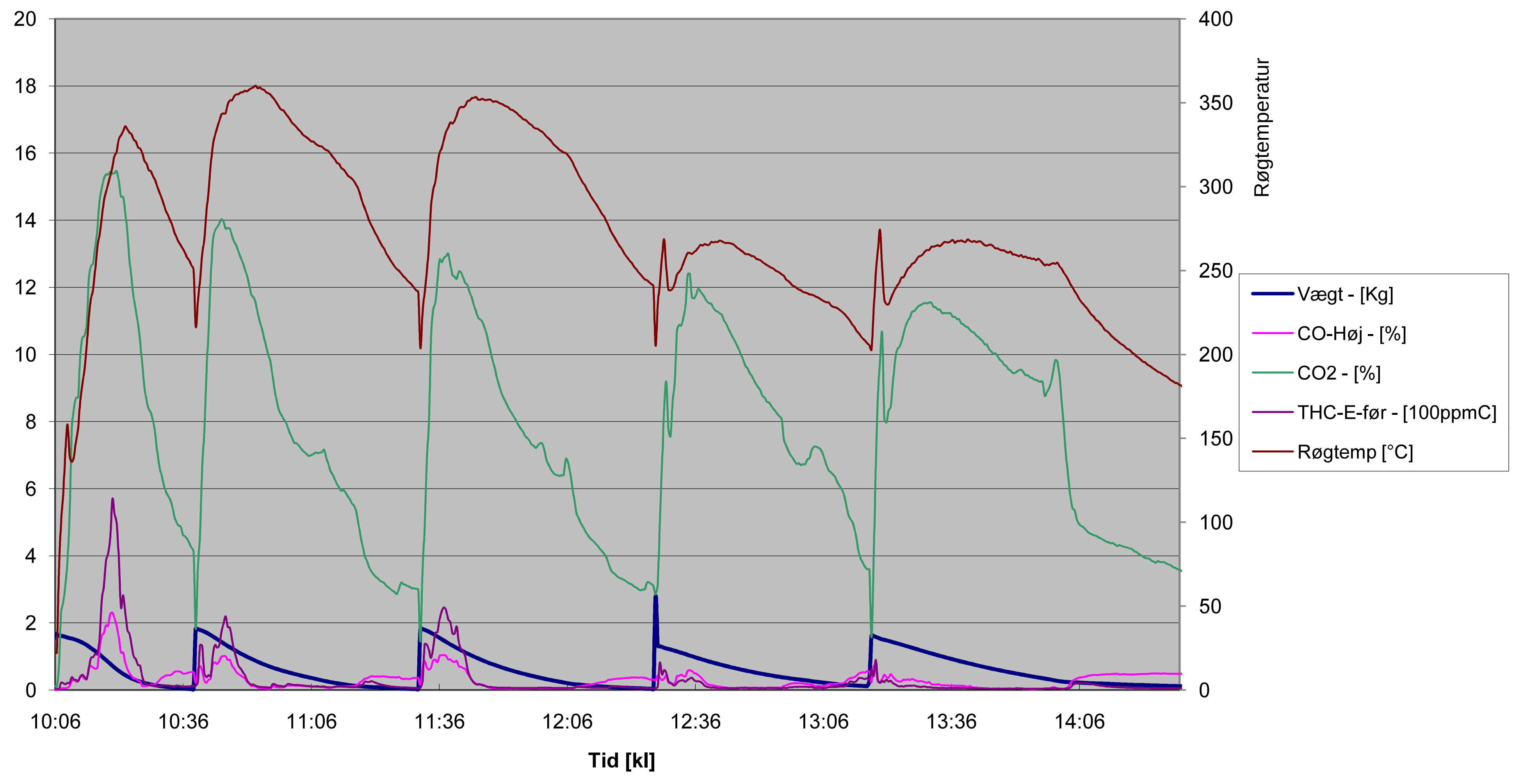
# Morsø med Rüegg 08.10.2008



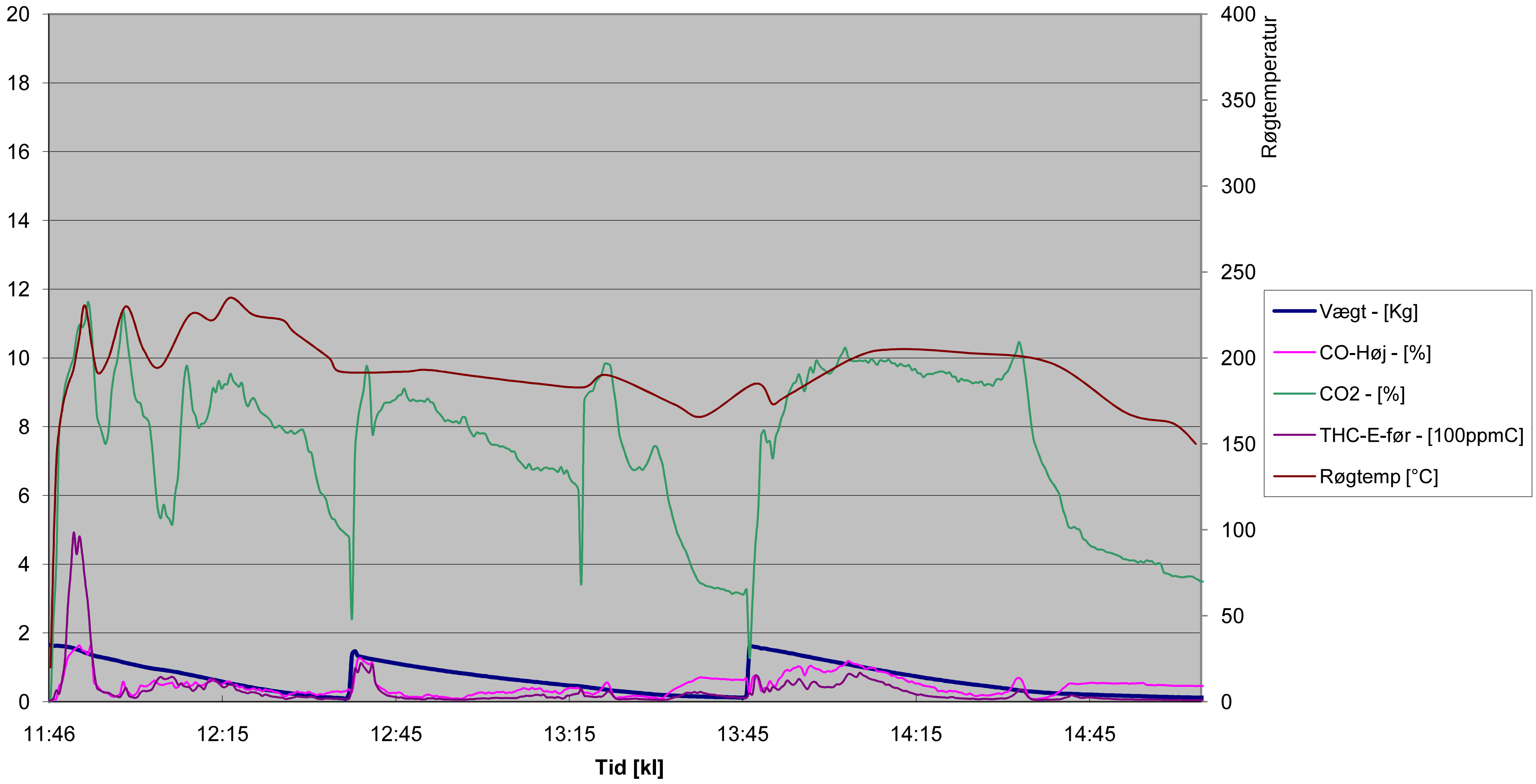
# Morsø med Sparterm 14.10.2008

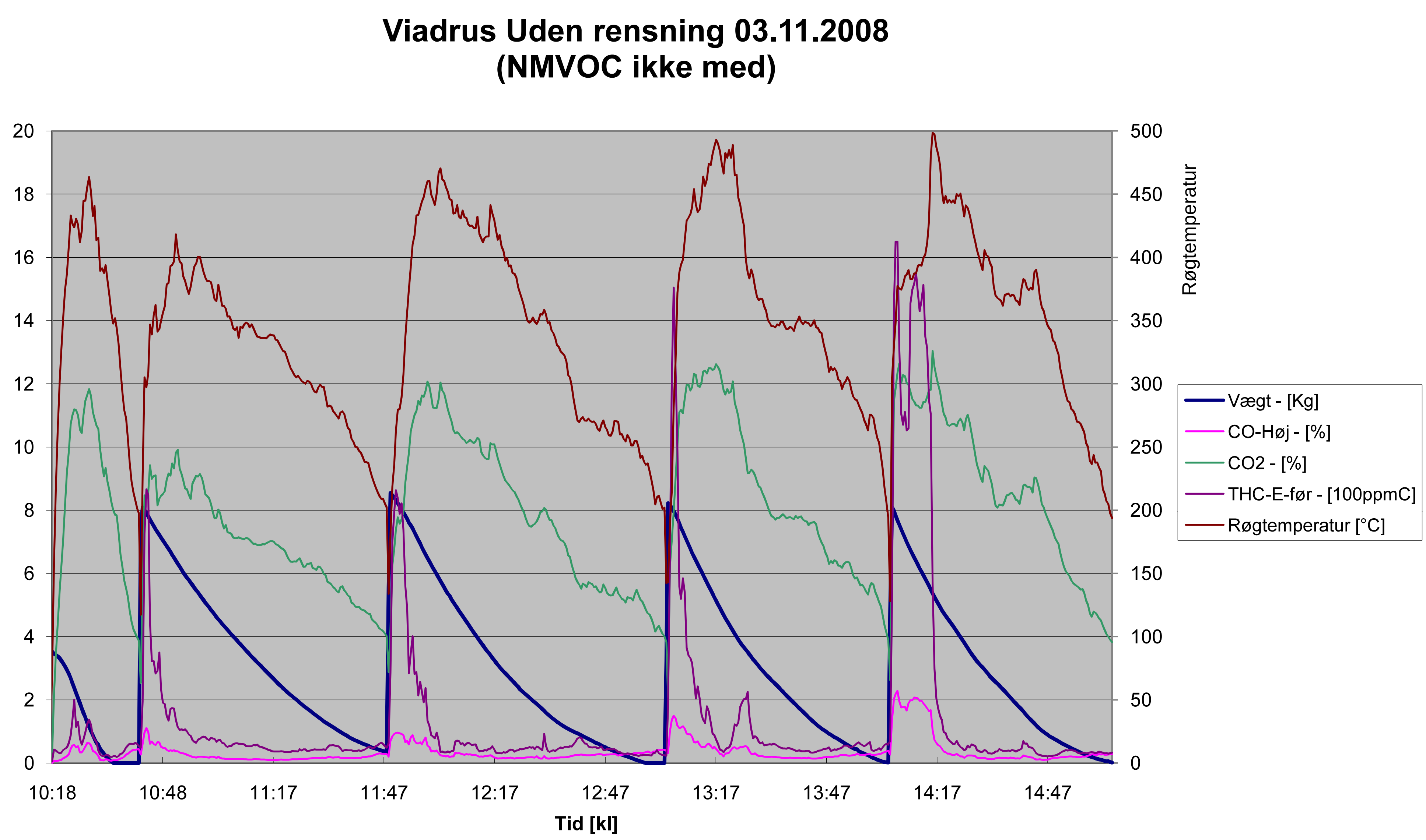


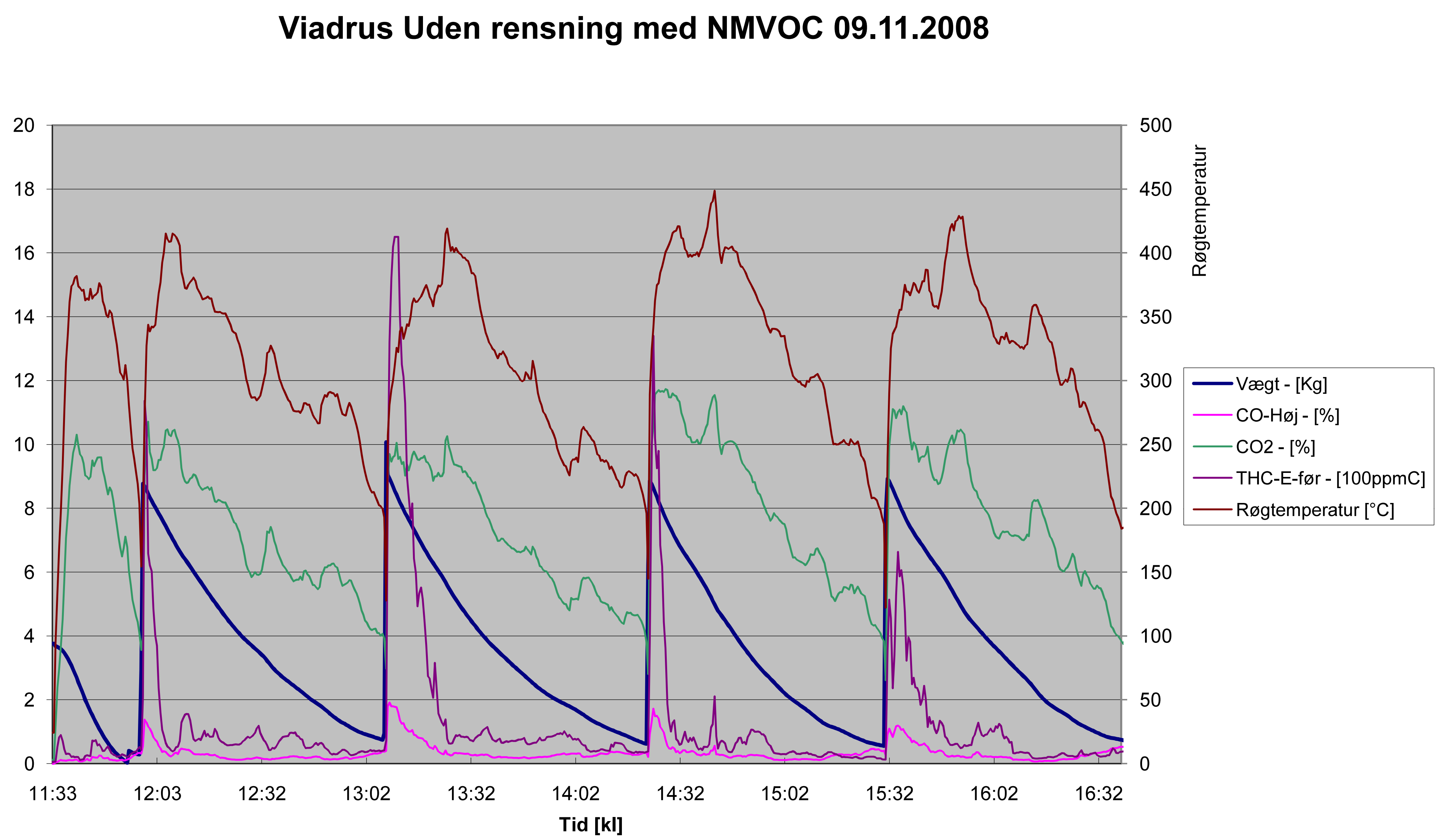
## Morsø med Ecoxy 15.10.2008



## Morsø med APP 13.11.2008
**(Røgtemperatur målt manuelt)**

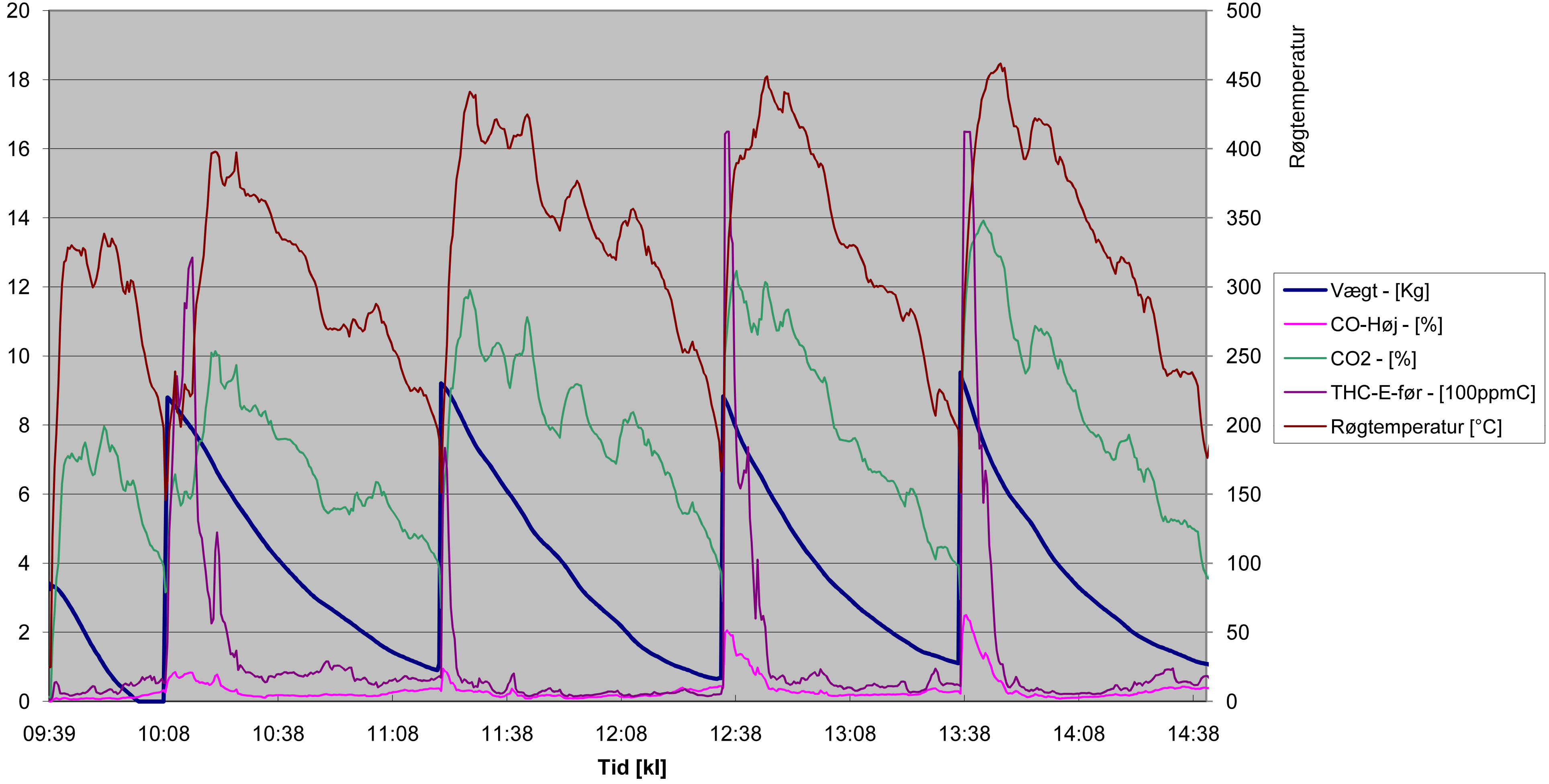



Viadrus Uden rensning 03.11.2008
(NMVOC ikke med)
20
18
16
14
12
10
8
6
4
2
0
500
450
400
350
300
250
200
150
100
50
0
Røgtemperatur
10:18
10:48
11:17
11:47
12:17
12:47
13:17
13:47
14:17
14:47
Tid [kl]
Vægt - [Kg]
CO-Høj - [%]
CO2 - [%]
THC-E-før - [100ppmC]
Røgtemperatur [°C]

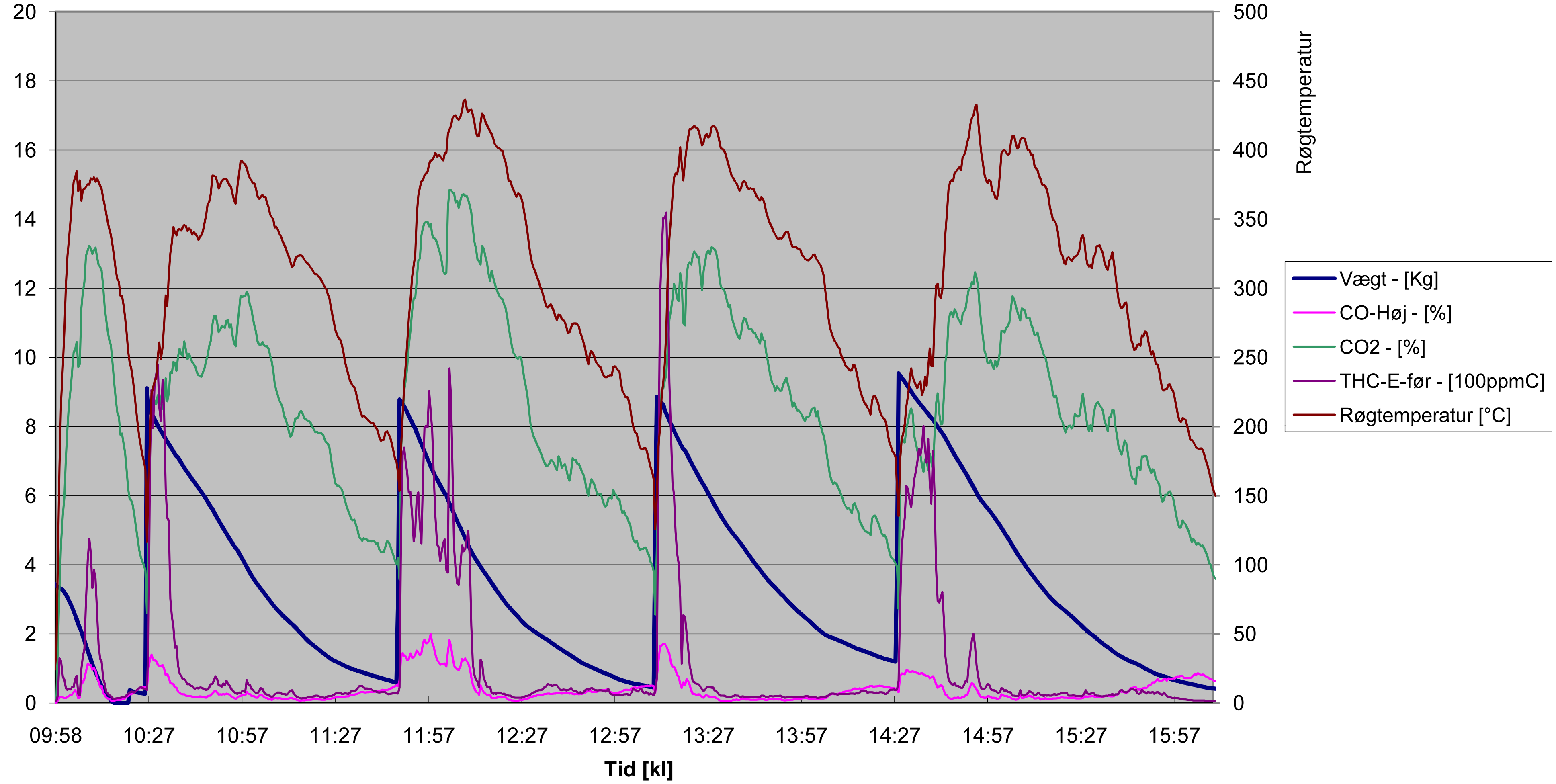


Viadrus Uden rensning med NMVOC 09.11.2008
20
18
16
14
12
10
8
6
4
2
0
500
450
400
350
300
250
200
150
100
50
0
Røgtemperatur
11:33
12:03
12:32
13:02
13:32
14:02
14:32
15:02
15:32
16:02
16:32
Tid [kl]
Vægt - [Kg]
CO-Høj - [%]
CO2 - [%]
THC-E-før - [100ppmC]
Røgtemperatur [°C]

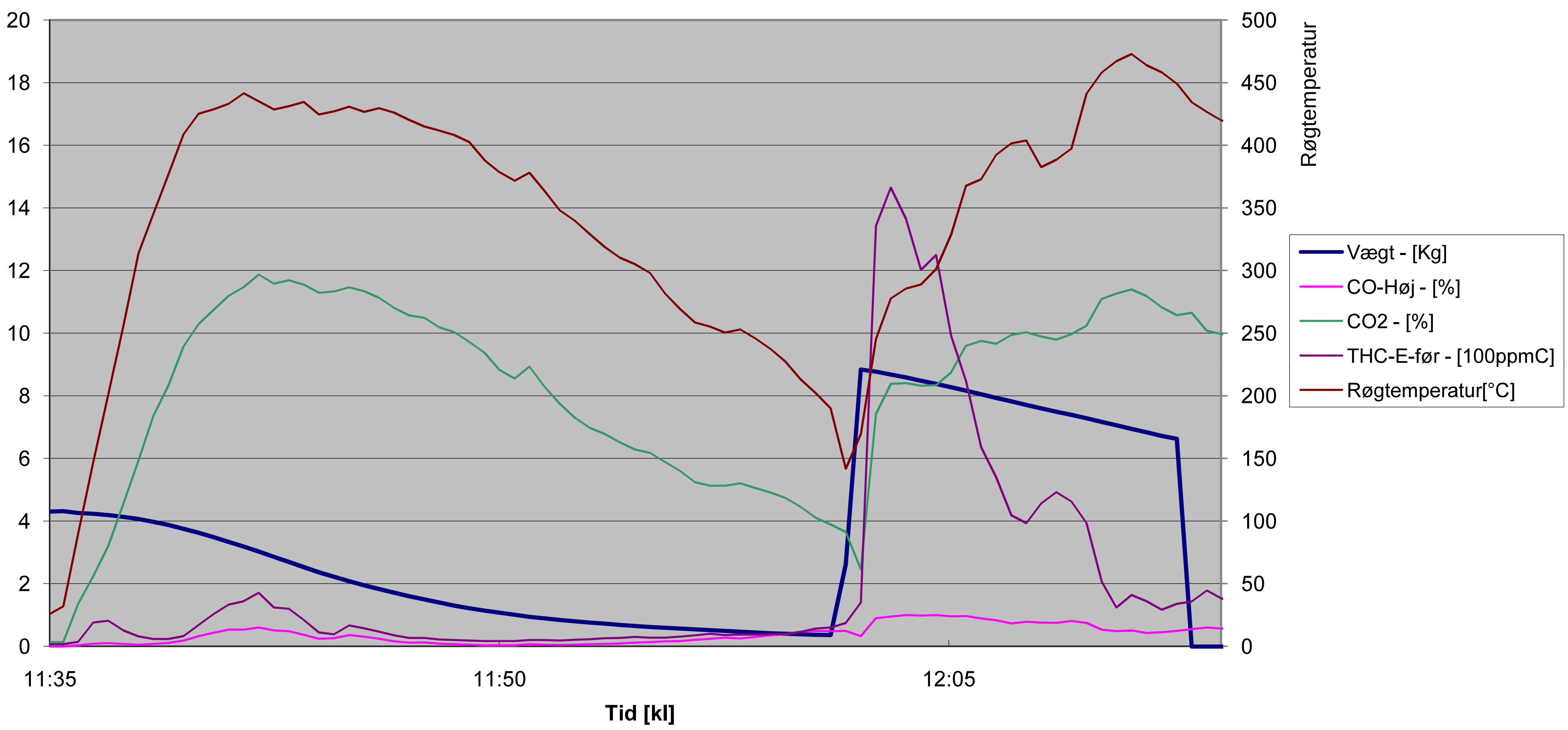
## Viadrus med Rüegg 07.11.2008

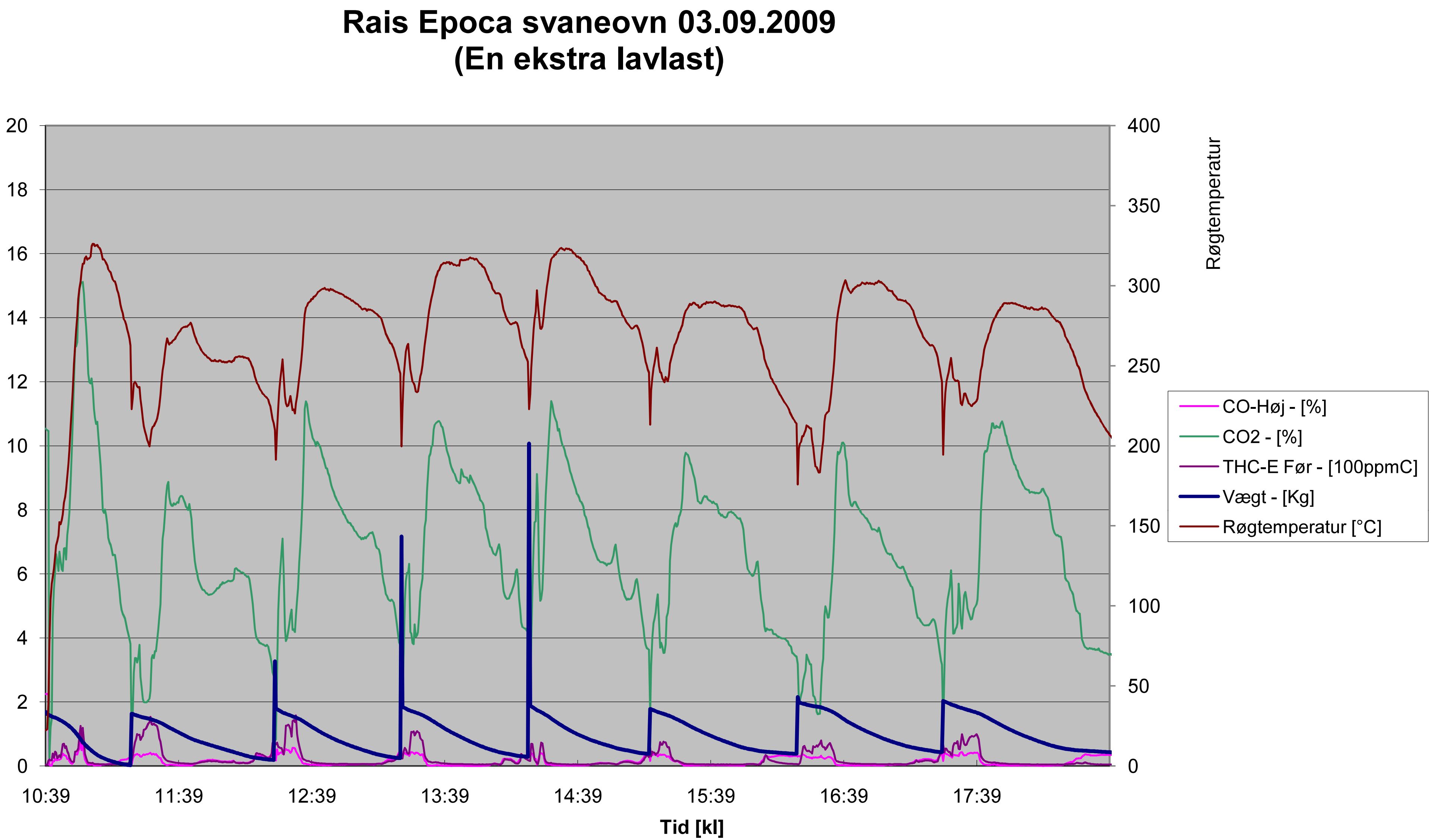


# Viadrus med Sparterm 11.11.2008

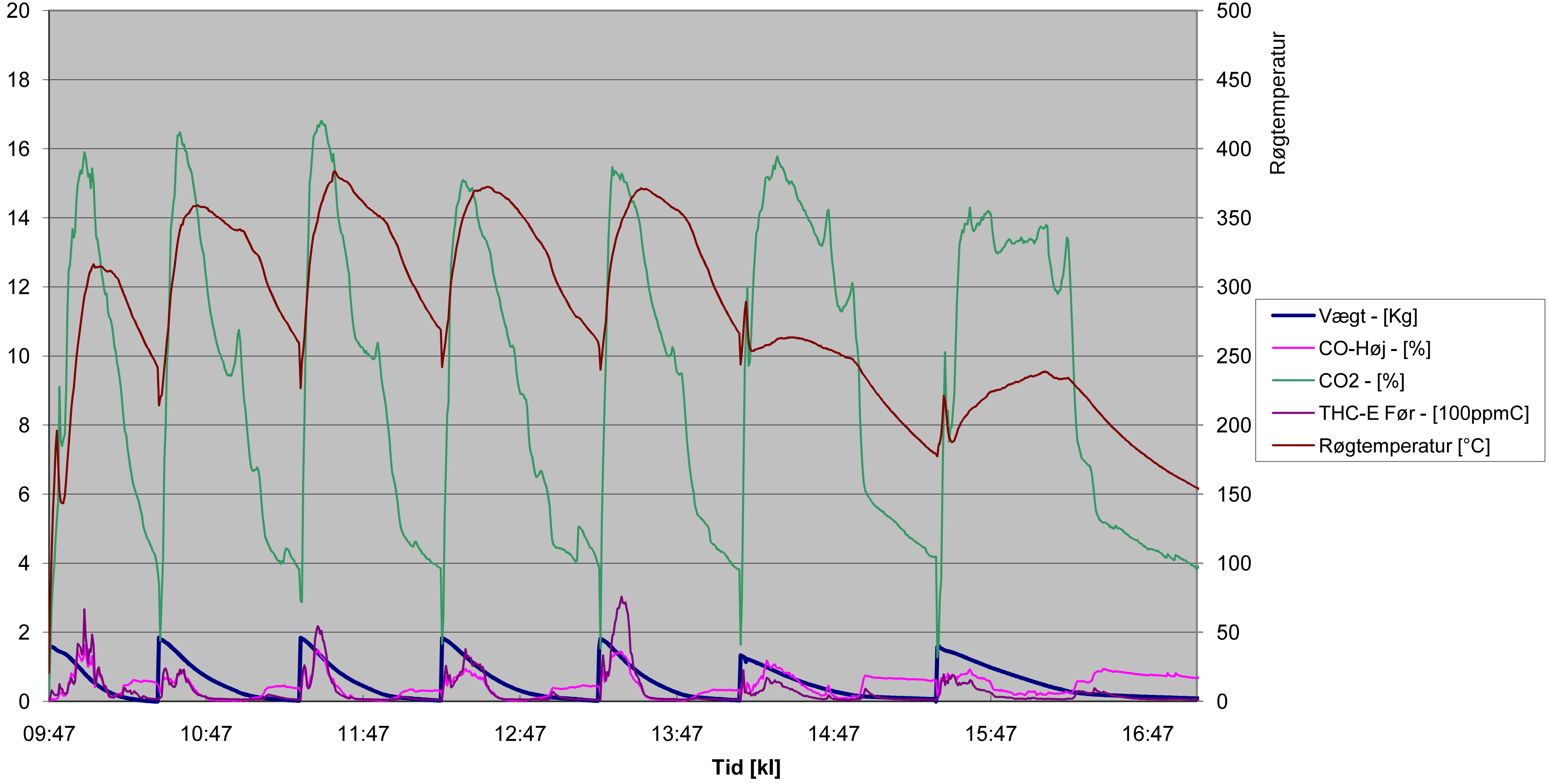


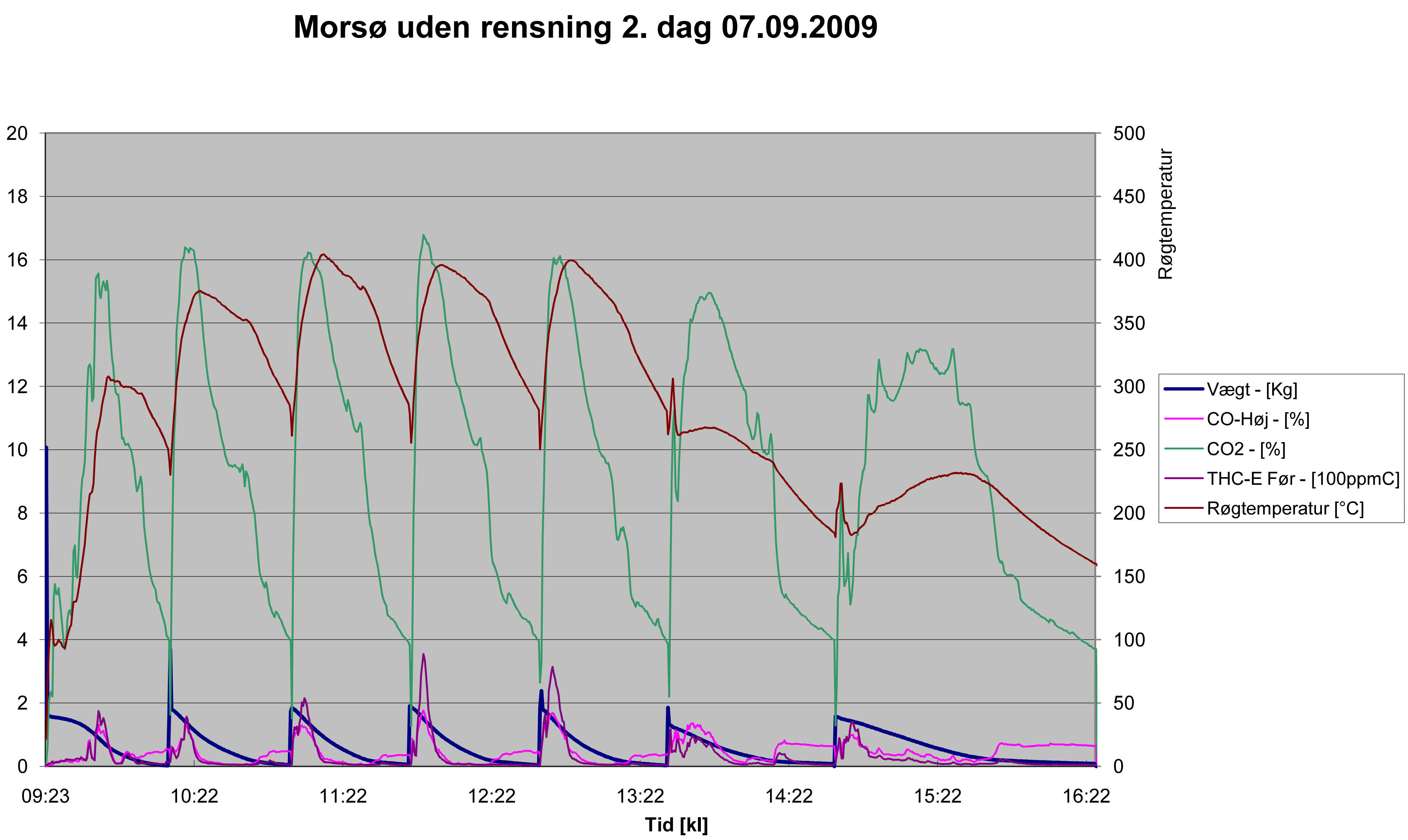
# Viadrus med APP 12.11.2008



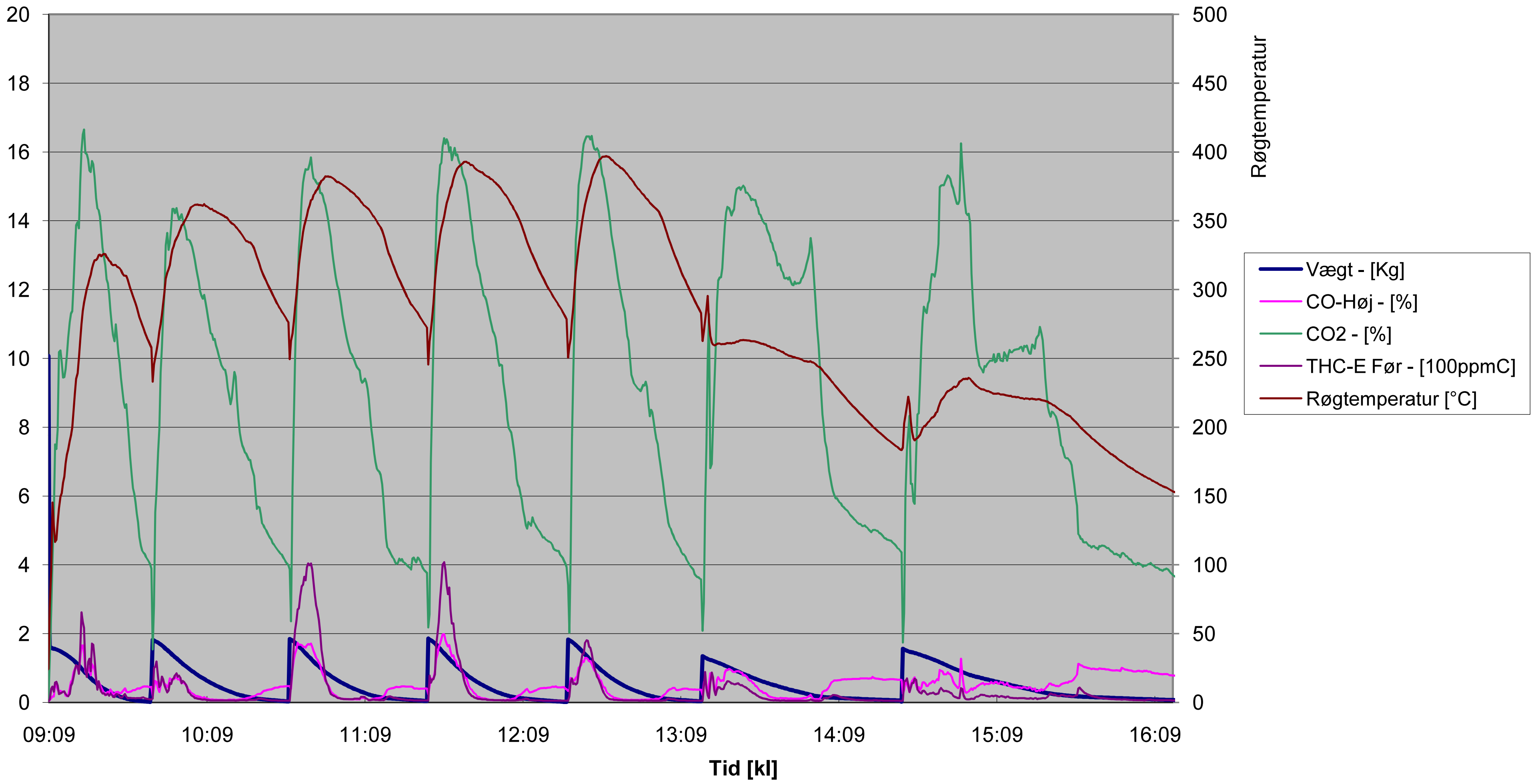

Rais Epoca svaneovn 03.09.2009
(En ekstra lavlast)
20
18
16
14
12
10
8
6
4
2
0
400
350
300
250
200
150
100
50
0
Røgtemperatur
10:39
11:39
12:39
13:39
14:39
15:39
16:39
17:39
Tid [kl]
CO-Høj - [%]
CO2 - [%]
THC-E Før - [100ppmC]
Vægt - [Kg]
Røgtemperatur [°C]

## Morsø uden rensning 1. dag 04.09.2009

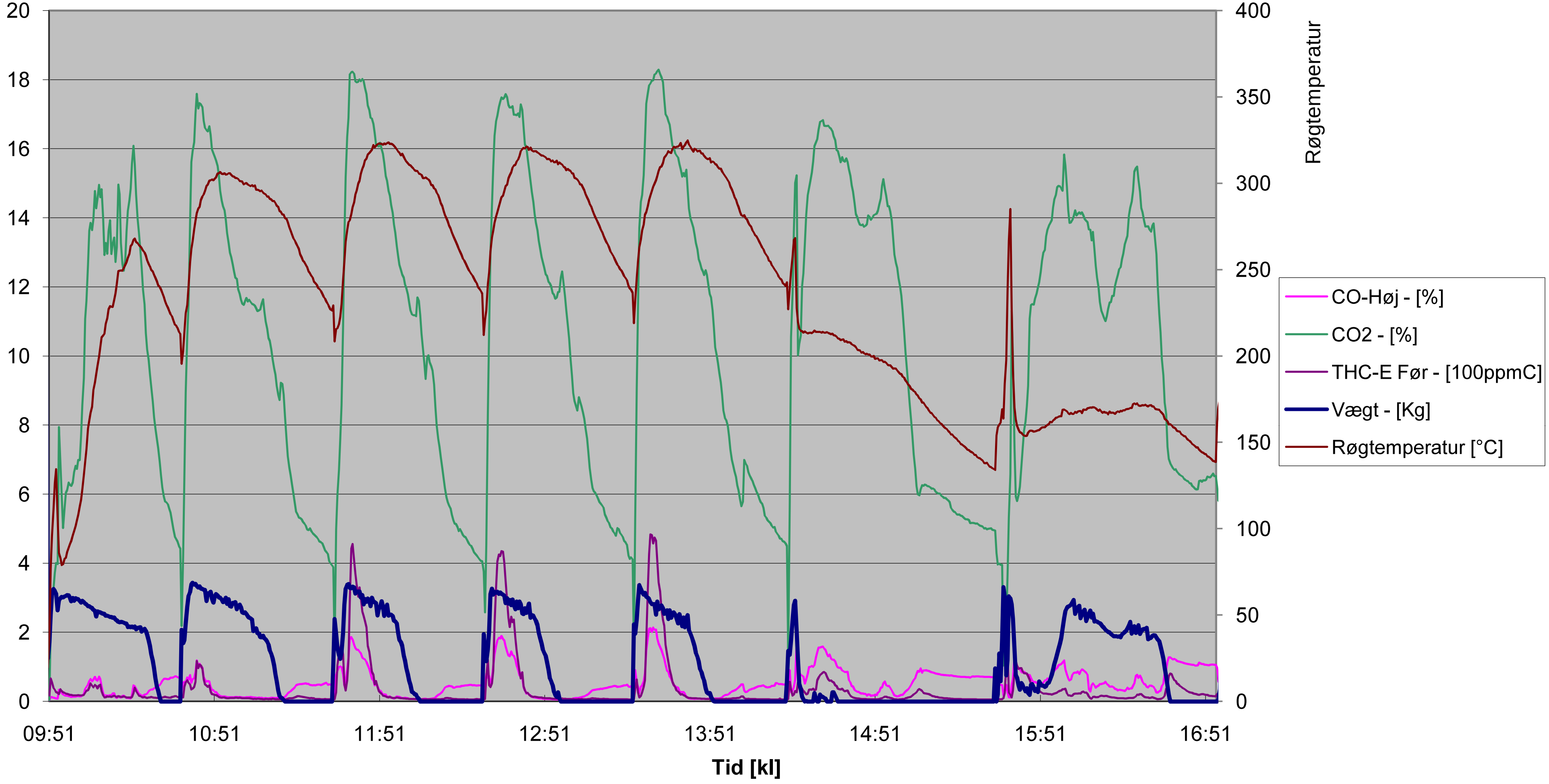



Morsø uden rensning 2. dag 07.09.2009
20
18
16
14
12
10
8
6
4
2
0
500
450
400
350
300
250
200
150
100
50
0
Røgtemperatur
Vægt - [Kg]
CO-Høj - [%]
CO2 - [%]
THC-E Før - [100ppmC]
Røgtemperatur [°C]
09:23
10:22
11:22
12:22
13:22
14:22
15:22
16:22
Tid [kl]

# Morsø uden rensning 3. dag 08.09.2009



## Morsø med APP 30.09.2009



# 1 Statistical Evaluation

The uncertainty of each measurement was evaluated from a Type A method according to the Joint Committee for Guides in Metrology; "Evaluation of measurement data — Guide to the expression of uncertainty in measurement"; JCGM 100:2008[1].

The Type A method involves a repetitive measurement of each parameter. In this case the reference test of the Morsø 1440 stove was repeated 4 times. From the 4 sets of measurements the standard deviation (STDEV) of each parameter was calculated. The uncertainty of each parameter was the evaluated as:

$$u = K \cdot s$$

Where:
u = uncertainty
K = 2 (The standard coverage factor corresponding to 95.45% confidence level)
s = STDEV (standard deviation)

The STDEV is defined as:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}}$$

Where:
n = the number of repeated measurements during reference test (n=4)
$x_i$ = the measured parameter during reference test (e.g. CO [g/kg])
$\bar{x}$ = the average of 4 measurements during reference test (e.g. CO [g/kg])

Example for the calculation of the uncertainty for CO measured during ignition phase:

| Measurement no. | CO emission |
|---|---|
| Reference 1 | 63.38 g/kg |
| Reference 2 | 53.92 g/kg |
| Reference 3 | 40.15 g/kg |
| Reference 4 | 46.71 g/kg |
| Average $\bar{x}$ | 51.04 g/kg |

The uncertainty u is then calculated according to the equation:

[1] http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf
http://www.bipm.org/en/publications/guides/gum.html

$$u = 2 \cdot \sqrt{\frac{(63.38-51.04)^2+(53.92-51.04)^2+(40.15-51.04)^2+(46.71-51.04)^2}{4-1}}$$
$$= 19.93\ g/kg$$

Similarly uncertainties for all measurement parameters (e.g. CO, OGC, NMVOC, PM etc.) during all load cases (i.e. ignition, pre-test, nominal, transition and reduced combustion) were calculated.

When a certain load case is repeated more than once the uncertainty is further reduced.

$$u = \frac{K \cdot s}{\sqrt{n}}$$

Where:
n = the number of repeated measurements

This is the case for the following test;

- Gas measurements on Morsø at nominal output (n=3)
- Particle measurements on Morsø at nominal output (n=2)
- Gas measurements on Swan stove at nominal output (n=3)
- Particle measurements on Swan stove at nominal output (n=2)
- Gas and particle measurements on APP2008 (n=3)

Remaining test were done only once (n=1).

### 1.1 Calculation of weighted average with uncertainties

To provide a summarizing result with much less uncertainty than individual measurements, the weighted average of all load cases was computed.

This was done with respect to the fuel consumed in each load case.

Table 1. Wood consumption

| Charge | Wood burned |
|---|---|
| Ignition | 1.6 kg |
| Pre-test | 1.8 kg |
| Nominal | 1.8 kg |
| Transition | 1.3 kg |
| Reduced | 1.5 kg |
| Total | 8.0 kg |

Thus the weighted average W of 5 load cases X is:

$$W = \frac{x_1 \cdot 1.6 + x_2 \cdot 1.8 + x_3 \cdot 1.8 + x_4 \cdot 1{,}3 + x_5 \cdot 1{,}5}{8.0}$$

Where:
$x_i$ is the measured parameter during any phase of a reference or product test, and:

$x_1$ is the ignition phase
$x_2$ is the pre-test phase
$x_3$ is the nominal phase
$x_4$ is the transition phase
$x_5$ is the reduced output phase

The uncertainty of W was calculated according to the general formula for combined uncertainty.

$$u_W = \sqrt{\sum_{1}^{5} \left( \frac{\partial W}{\partial x} \cdot u_x \right)^2}$$

Thus a general expression of the uncertainty of W is

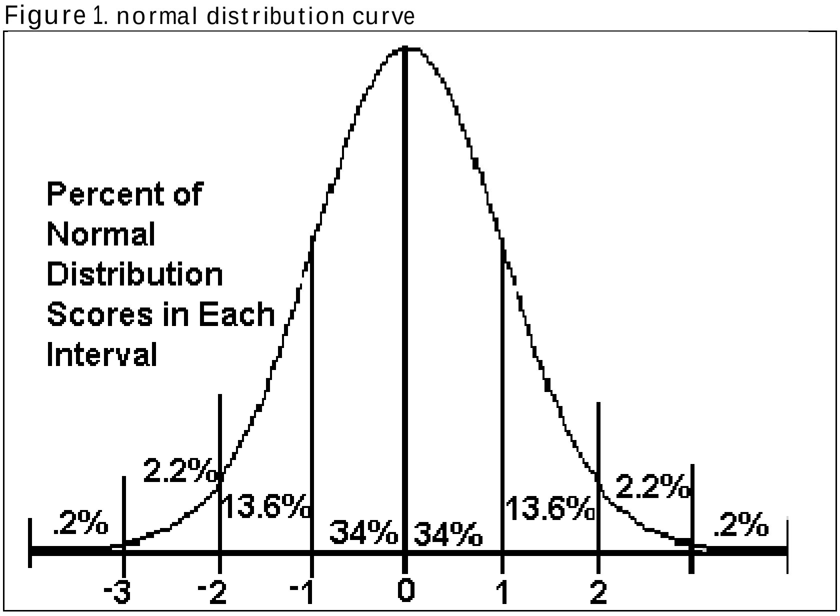
$$u_W = \sqrt{(0.2 \cdot u_{x1})^2 + (0.225 \cdot u_{x2})^2 + (0.225 \cdot u_{x3})^2 + (0.1625 \cdot u_{x4})^2 + (0.1875 \cdot u_{x5})^2}$$

The combined uncertainty of W is roughly $\sqrt{\frac{1}{5}}$ = 45% of the uncertainty on a single measurement x.

### 1.2 Confidence interval

The calculated weighted mean value plus or minus the uncertainty is referred to the ***confidence interval***. No matter how wide the confidence interval, the measured value is still the best estimate of the true value. The probability of the true value being close to the limits of the confidence interval is very low. From the normal distribution curve (Figure 19) there is a 68% percent probability that the true value lies within half the width of the confidence interval. Therefore two confidence intervals may overlap slightly and still make sensible data.

Figure 1. normal distribution curve



## 1.3 Significant change:

When the confidence intervals of two comparable values do not intersect at all (e.g. CO for MoreCat and the Reference stove) this is recorded as a ***significant change***. This is because there is practically no probability that the two values could be identical. The change is therefore quite certain.

## 1.4 Probable change:

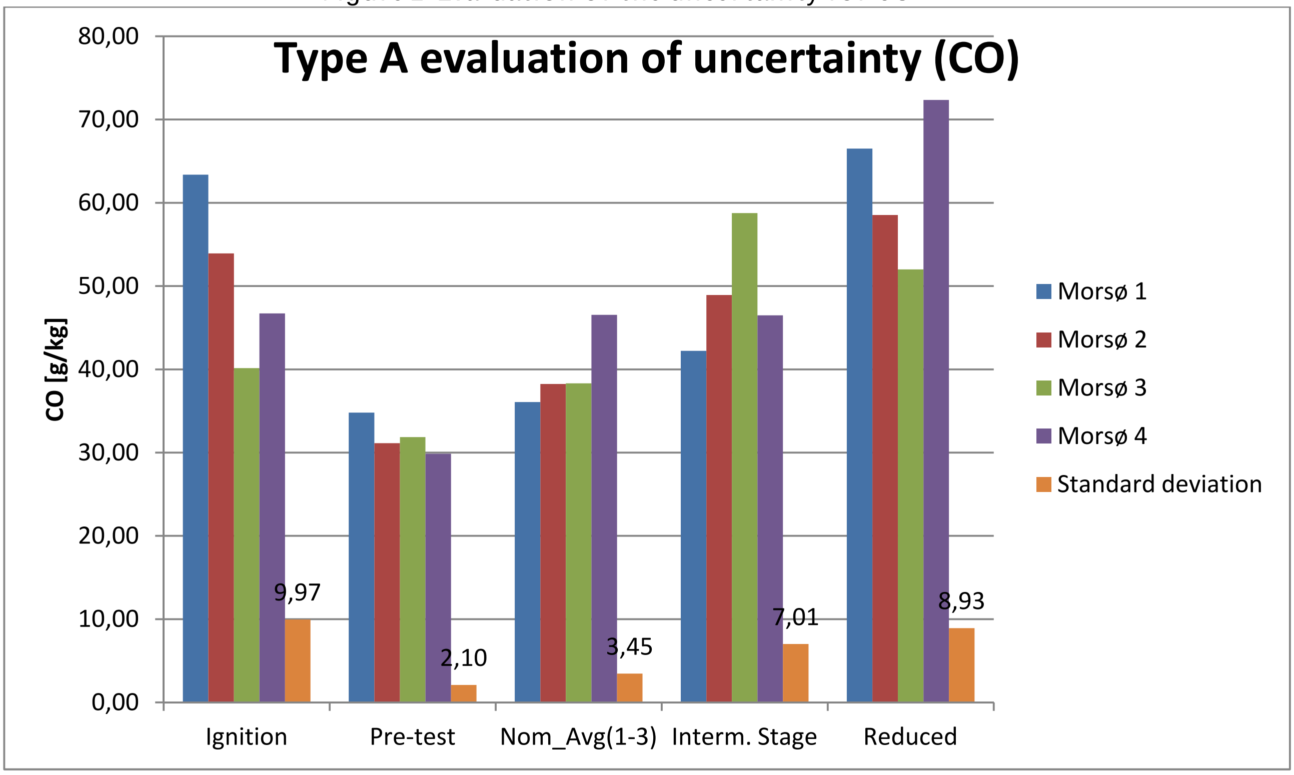
When the confidence intervals overlap, but the value of each measurement is outside the confidence interval of the other (e.g. CO for Ecoxy) this is regarded as a ***probable change***. This is because there is little probability that the values could be identical or switched around. Therefore the change is quite likely, but not proved.

## 1.5 No measurable change:

When the confidence intervals overlap, and the value of one measurement is inside the confidence interval of the other (e.g. CO for Zumikon) this is regarded as ***no measurable change.*** This is because there too much probability that the values could be identical or switched around. Therefore the change is not proved.

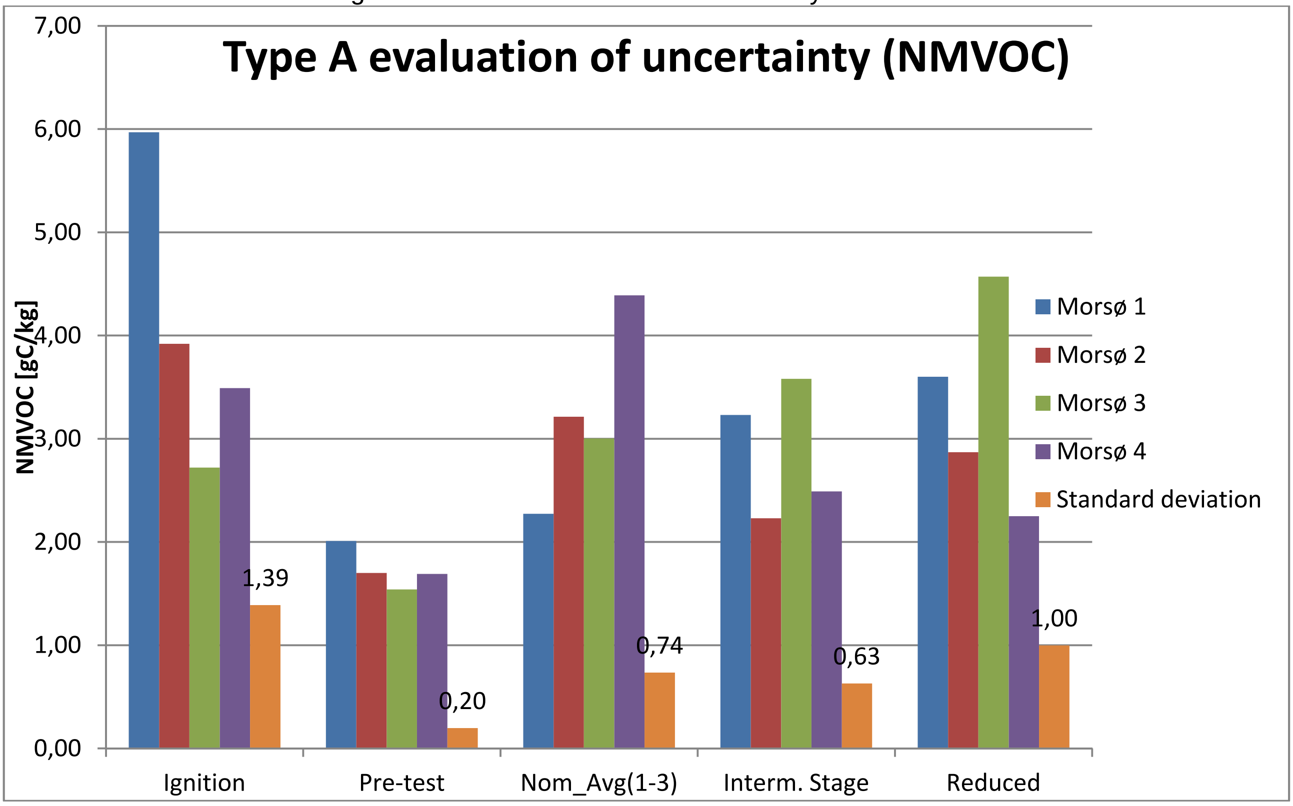
The results for the determination of CO, OGC, NMVOC and PM in grams per kilo woof burned from the four reference test on the Morsø 1440 wood stove is shown in the next four figures, together with the standard deviation calculated according to section 4.1.

Figure 2. Evaluation of the uncertainty for CO



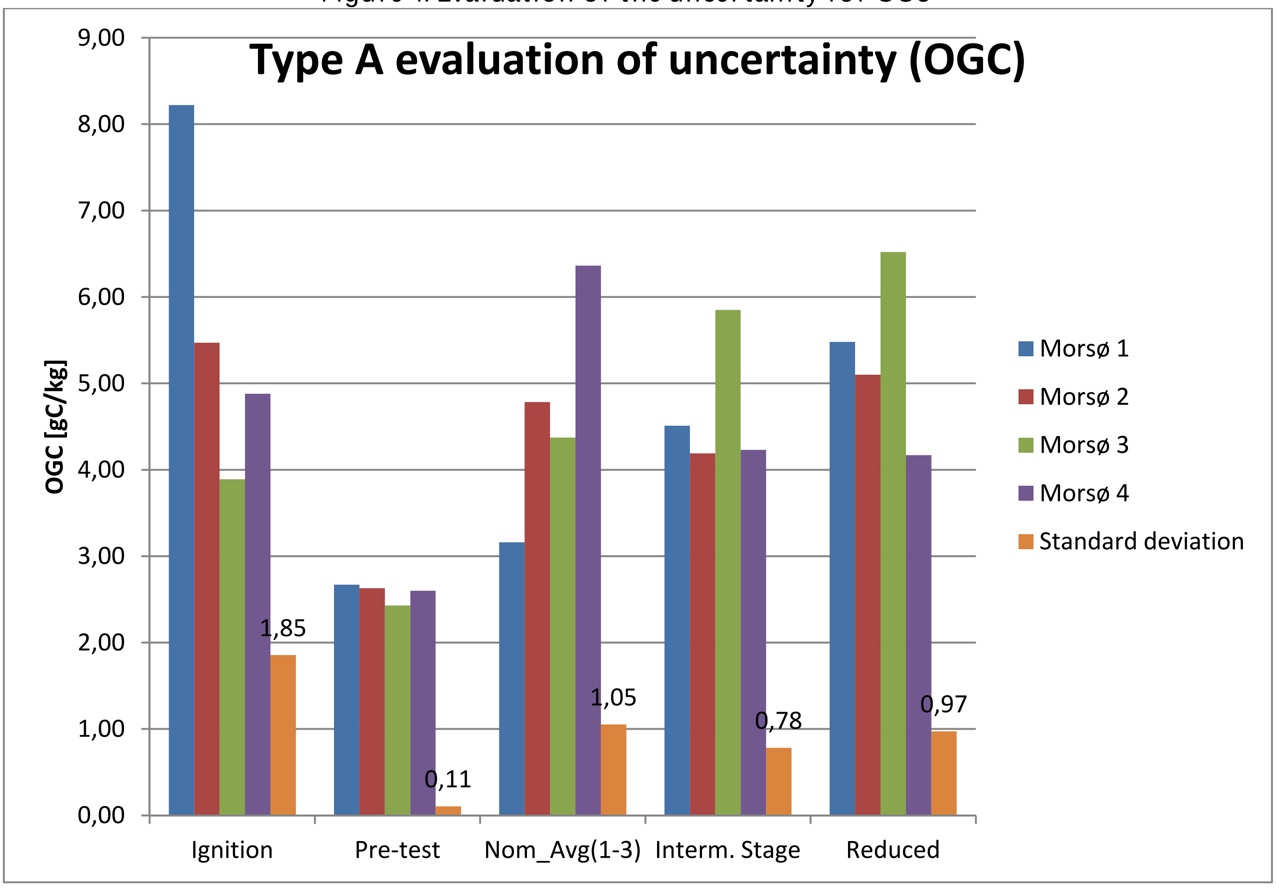

There is a very reasonable repeatability of CO on Morsø 1440.

Figure 3. Evaluation of the uncertainty for NMVOC



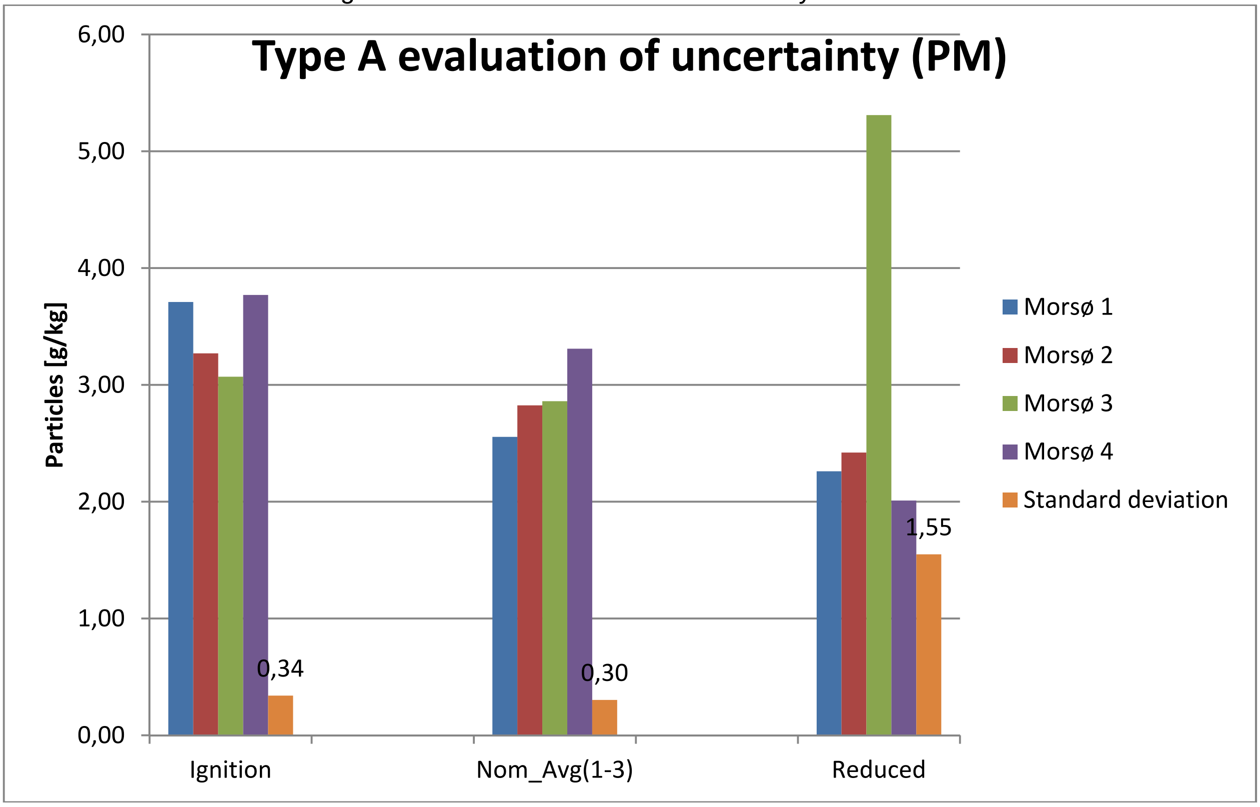

There is a rather reasonable repeatability of NMVOC, with a few deviations.

Figure 4. Evaluation of the uncertainty for OGC



Rather reasonable repeatability of OGC, with a few deviations though.

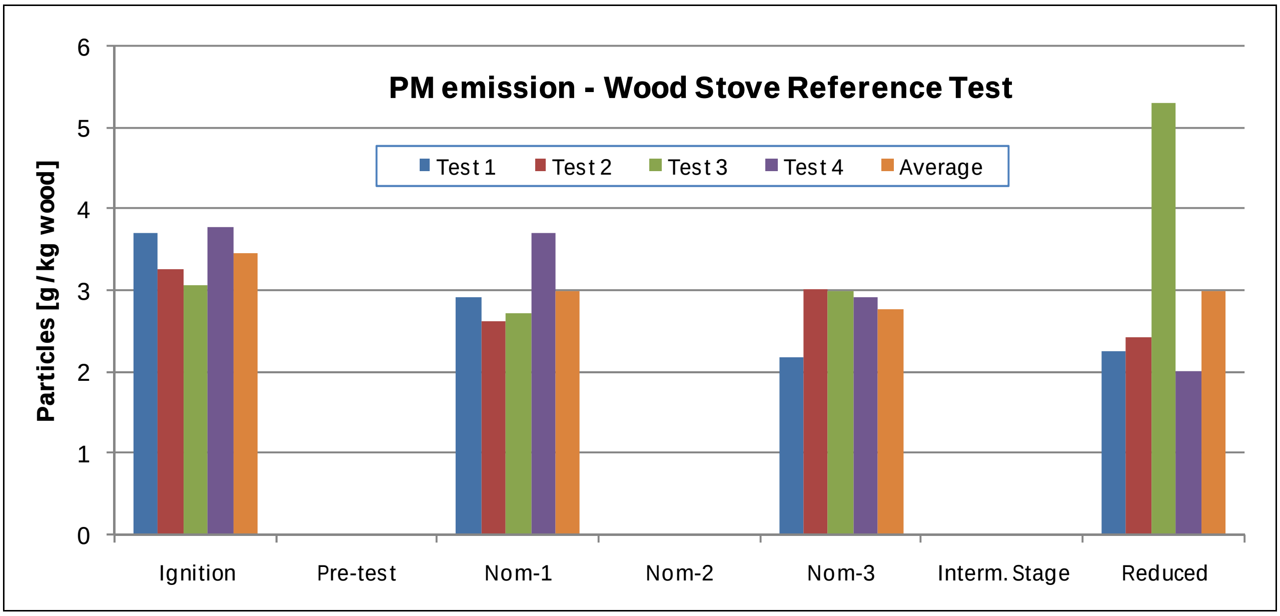
Figure 5. Evaluation of the uncertainty for TSP

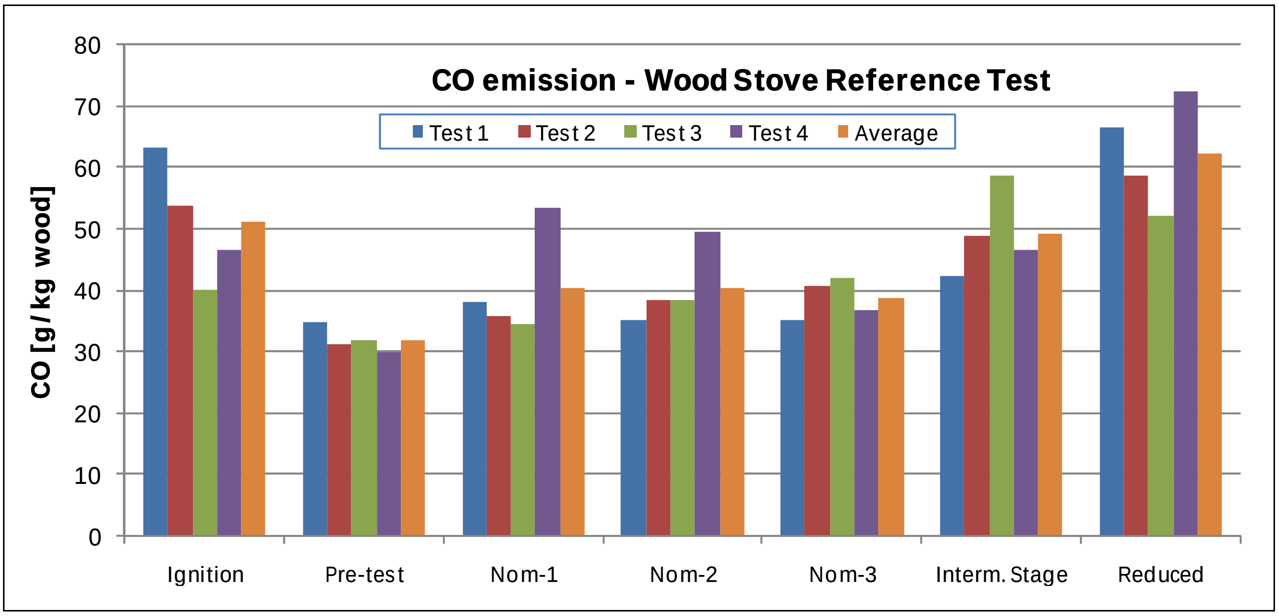


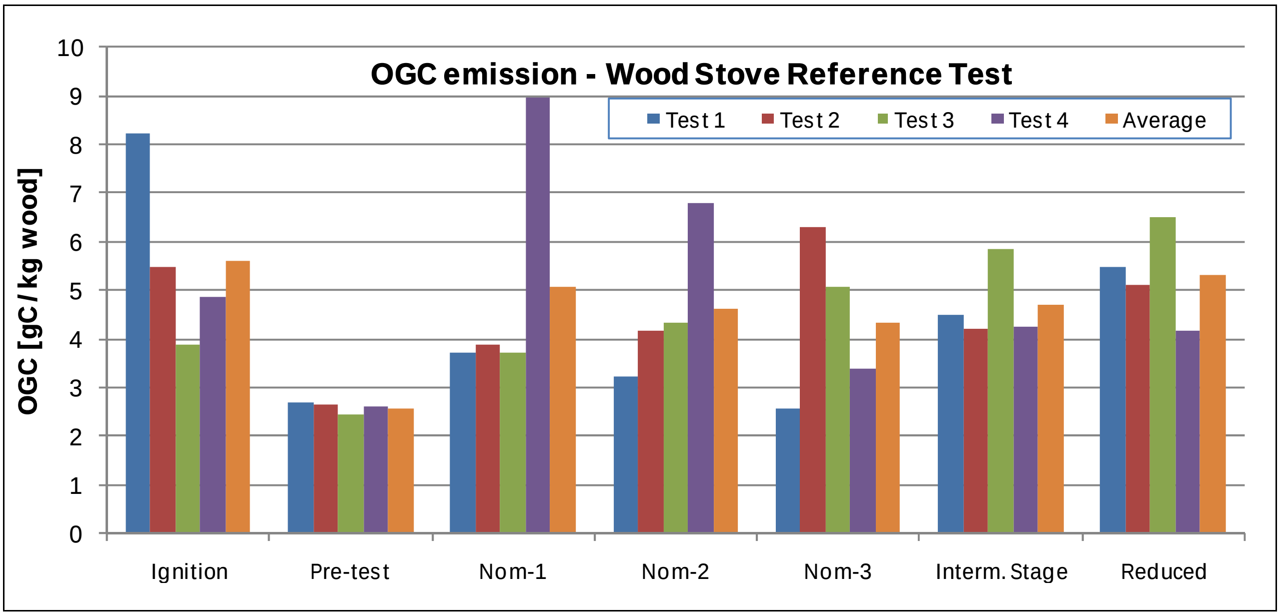

There is a reasonable repeatability for the emission of particles from the Morsø 1440 wood stove reference test, except for the reduced load, where there is a large deviation for the third test.

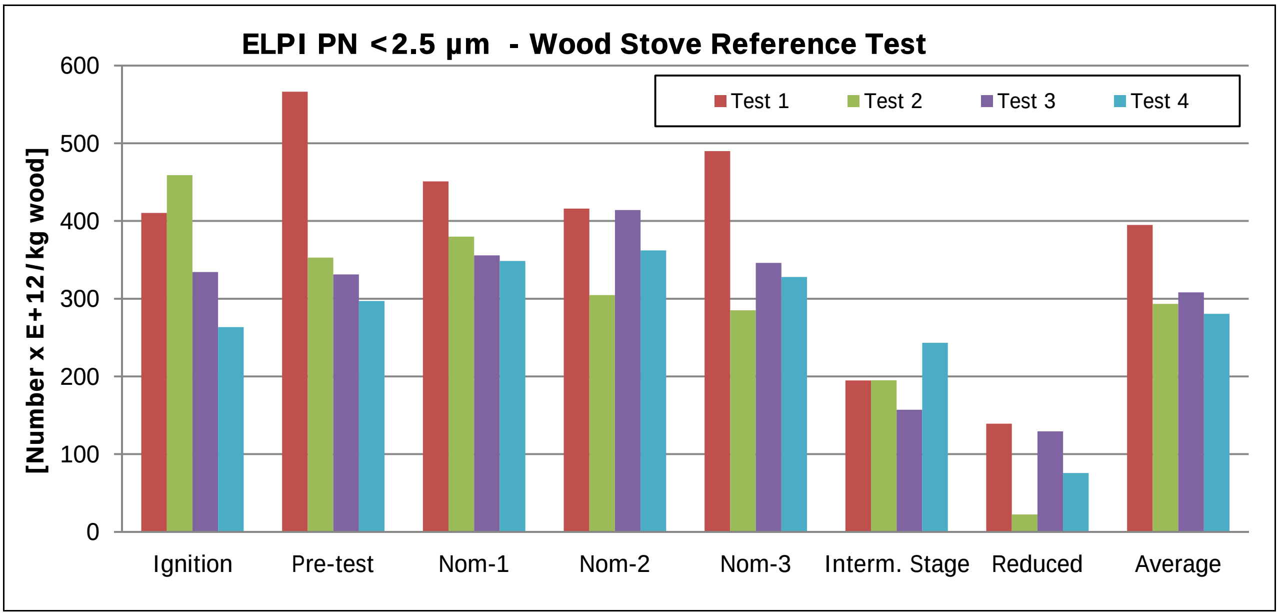
# Emission data diagrams

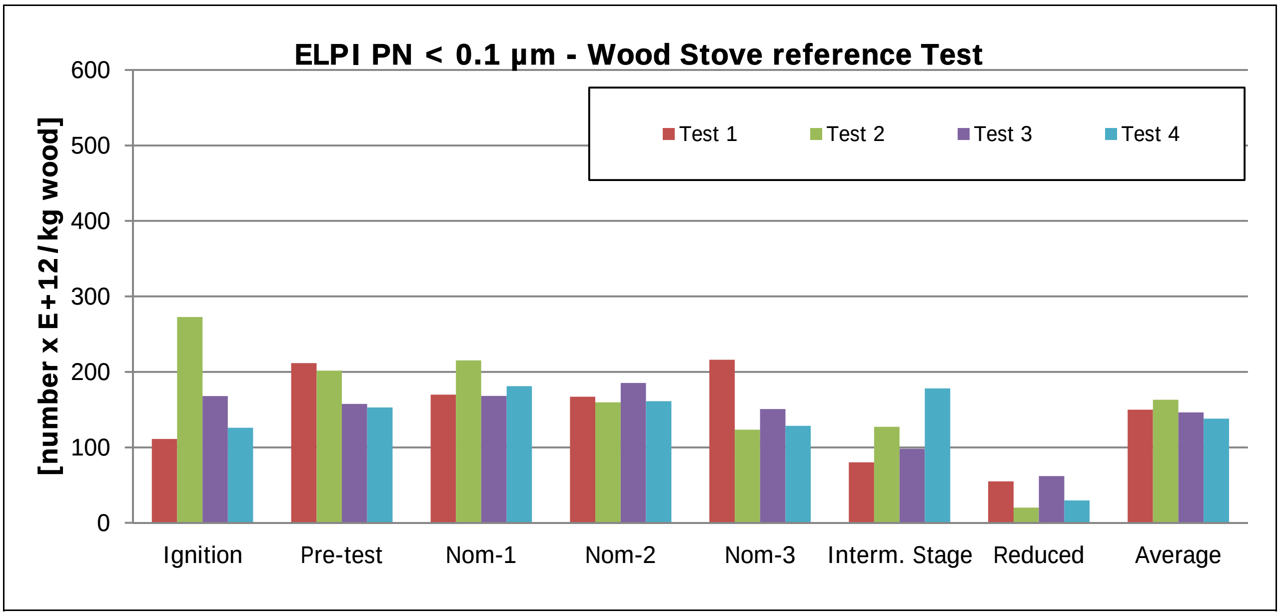
The most important measured emissions are shown in the following diagrams.

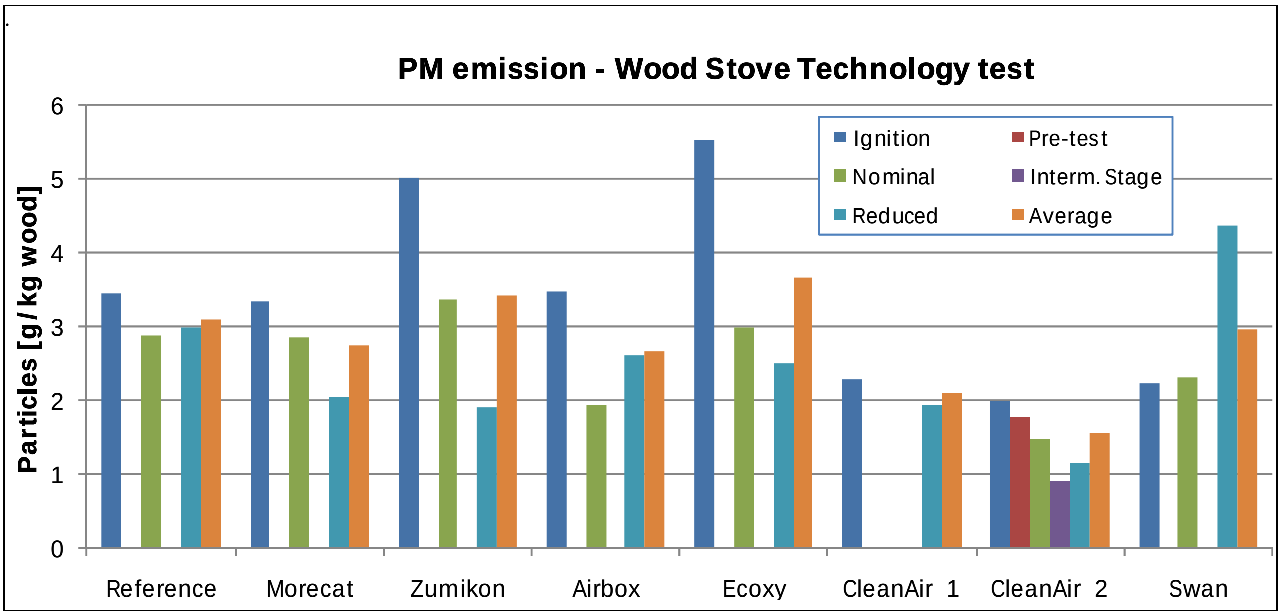


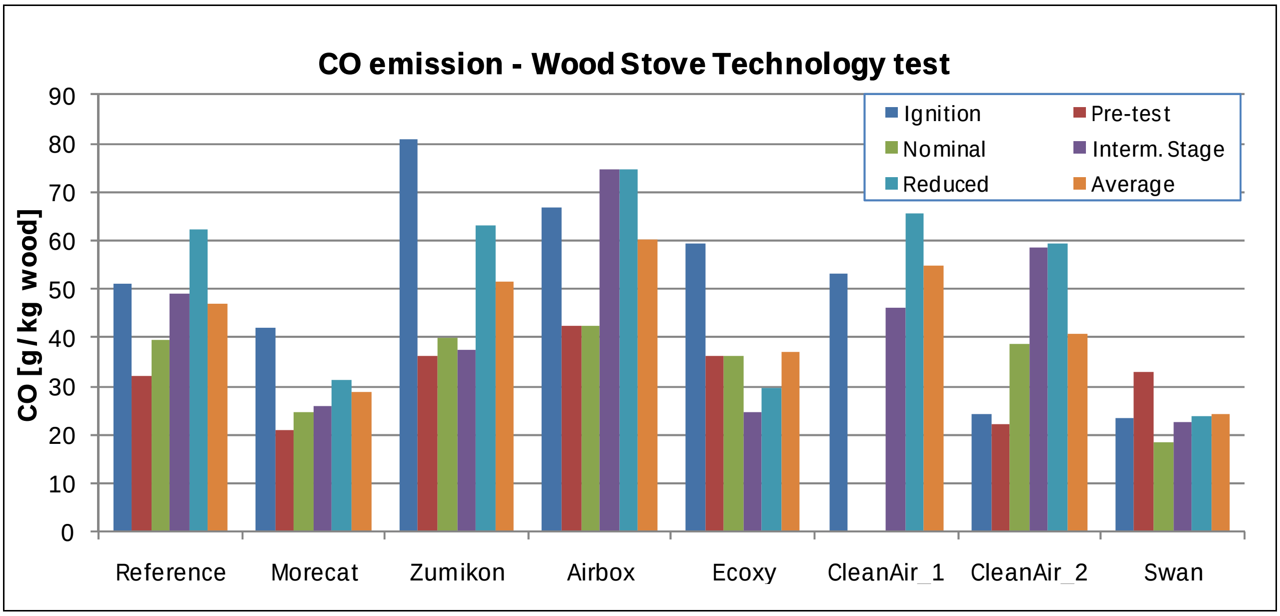



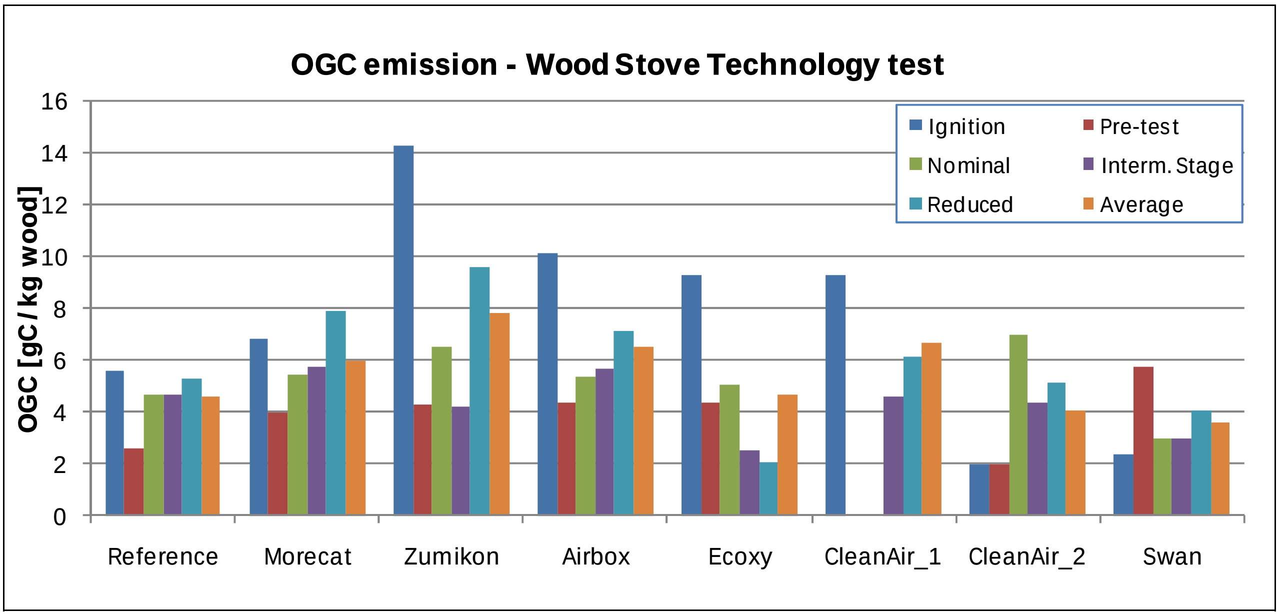

OGC emission - Wood Stove Reference Test
Test 1
Test 2
Test 3
Test 4
Average
OGC [gC/kg wood]
10
9
8
7
6
5
4
3
2
1
0
Ignition
Pre-test
Nom-1
Nom-2
Nom-3
Interm. Stage
Reduced

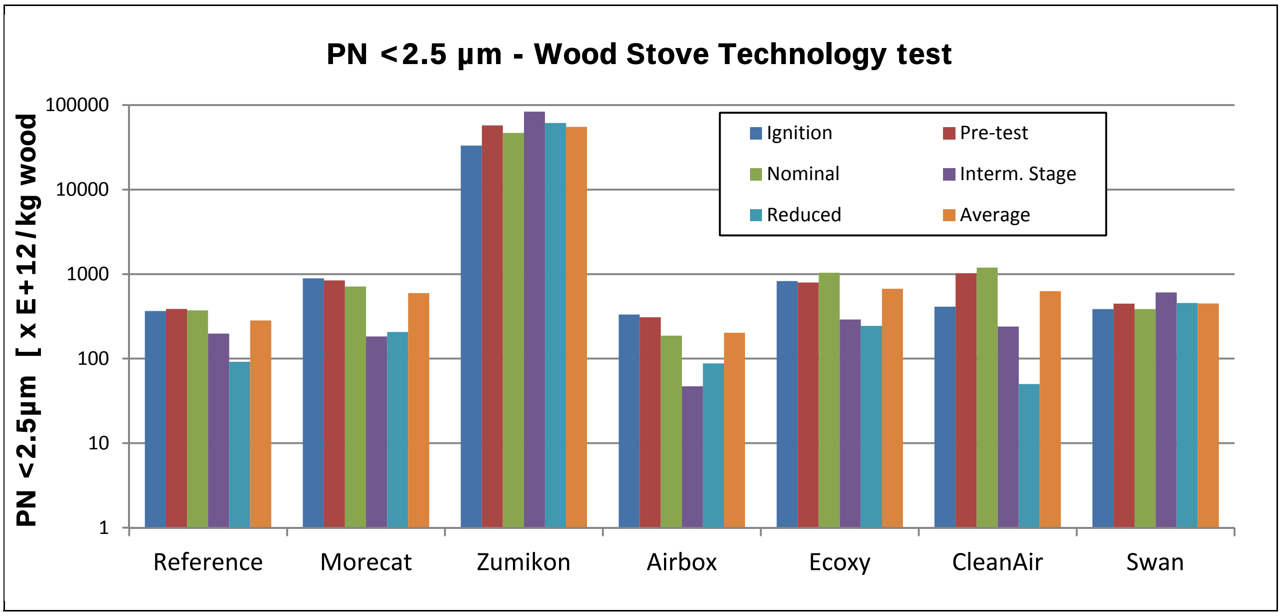

ELPI PN <2.5 µm - Wood Stove Reference Test
Test 1
Test 2
Test 3
Test 4
[Number x E+12/kg wood]
600
500
400
300
200
100
0
Ignition
Pre-test
Nom-1
Nom-2
Nom-3
Interm. Stage
Reduced
Average

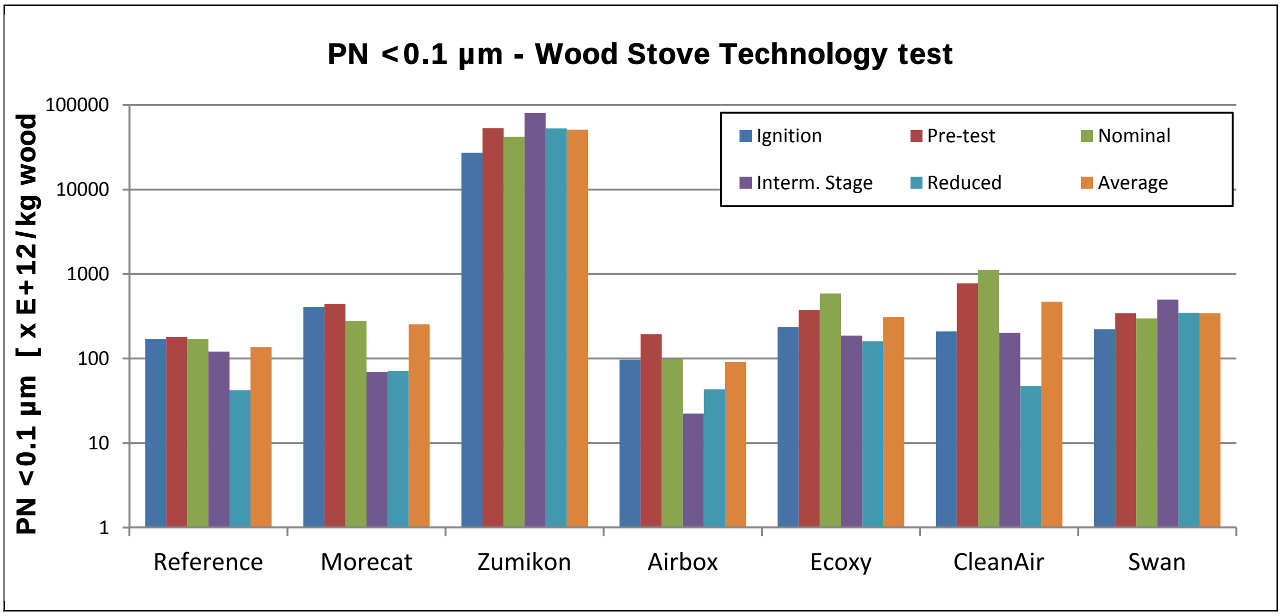

ELPI PN < 0.1 µm - Wood Stove reference Test
Test 1
Test 2
Test 3
Test 4
[number x E+12/kg wood]
600
500
400
300
200
100
0
Ignition
Pre-test
Nom-1
Nom-2
Nom-3
Interm. Stage
Reduced
Average

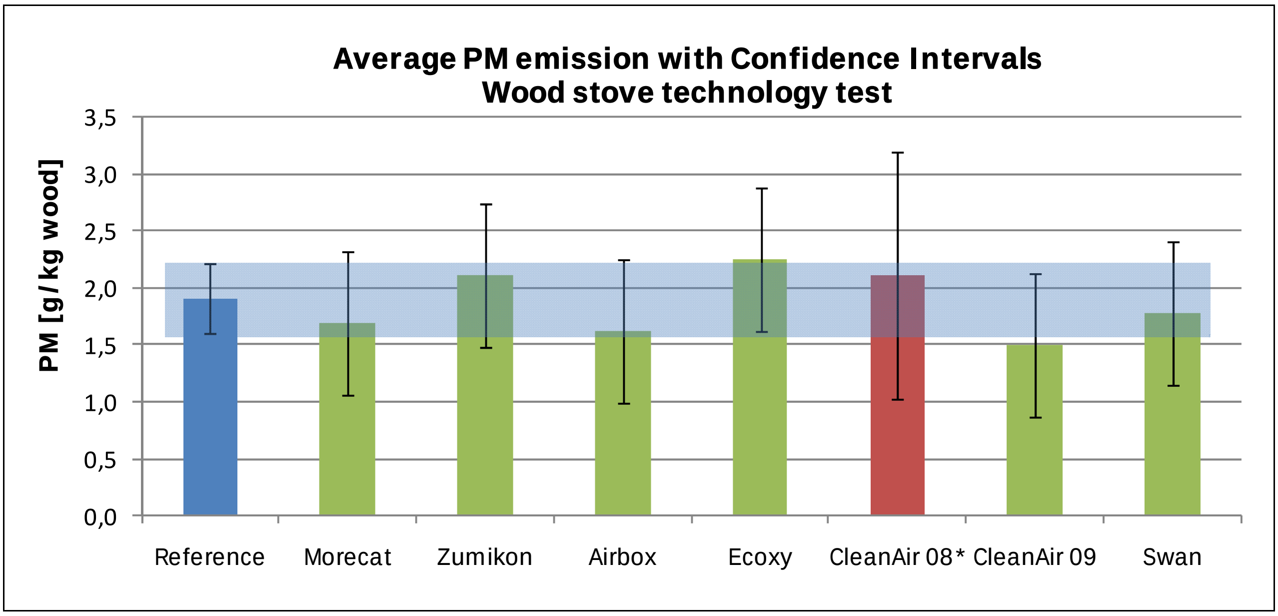

PM emission - Wood Stove Technology test
Particles [g/kg wood]
0
1
2
3
4
5
6
Ignition
Pre-test
Nominal
Interm. Stage
Reduced
Average
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir_1
CleanAir_2
Swan

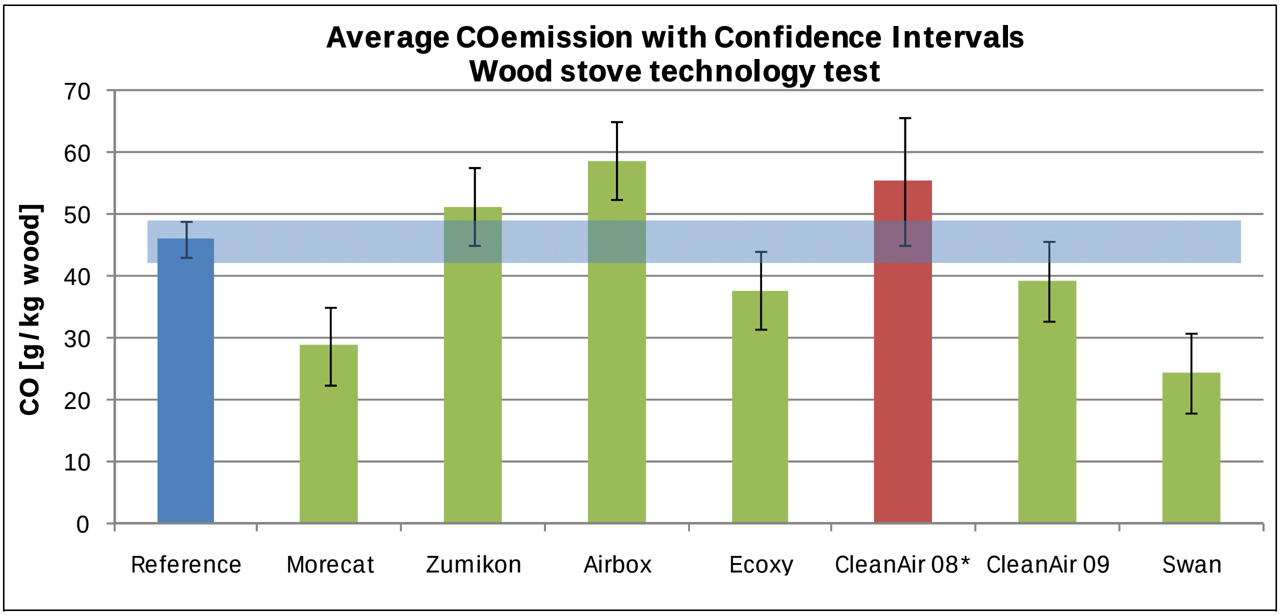

CO emission - Wood Stove Technology test
CO [g/kg wood]
0
10
20
30
40
50
60
70
80
90
Ignition
Pre-test
Nominal
Interm. Stage
Reduced
Average
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir_1
CleanAir_2
Swan

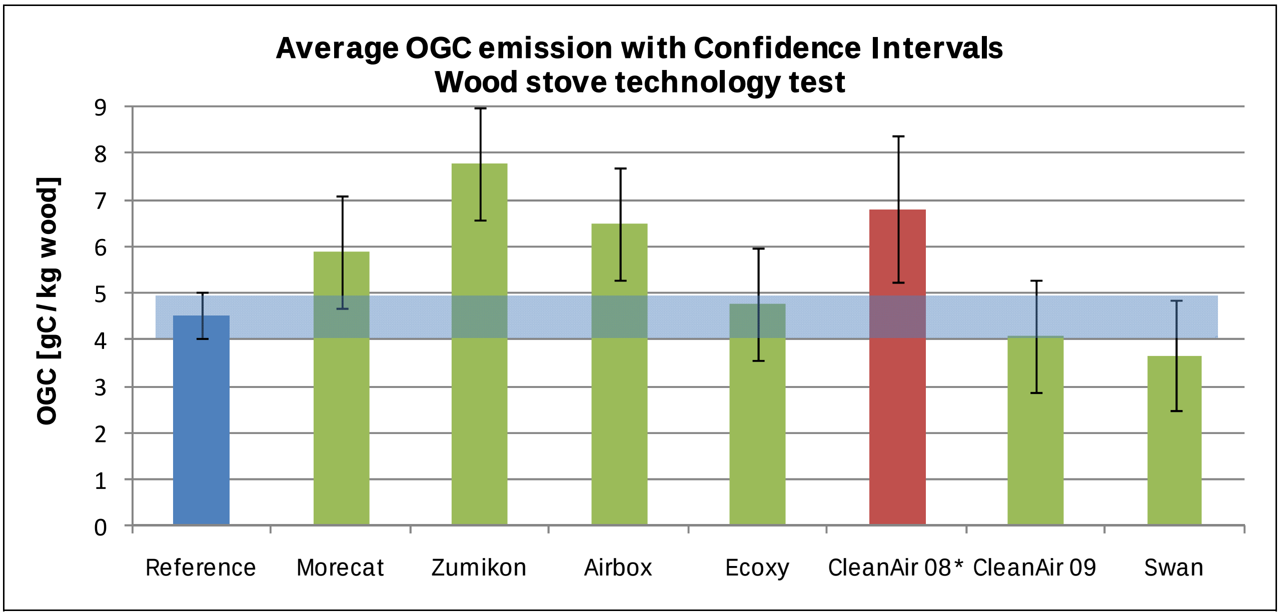

OGC emission - Wood Stove Technology test
OGC [gC/kg wood]
0
2
4
6
8
10
12
14
16
Ignition
Pre-test
Nominal
Interm. Stage
Reduced
Average
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir_1
CleanAir_2
Swan

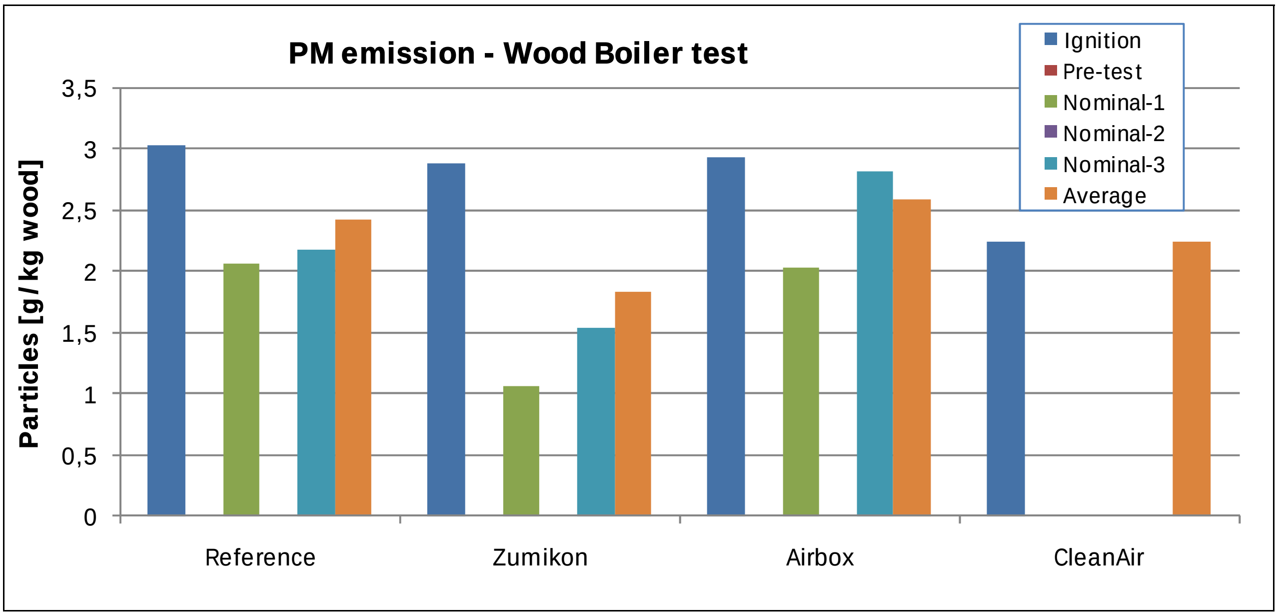

PN <2.5 µm - Wood Stove Technology test
PN <2.5µm [ x E+12/kg wood
100000
10000
1000
100
10
1
Ignition
Pre-test
Nominal
Interm. Stage
Reduced
Average
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir
Swan

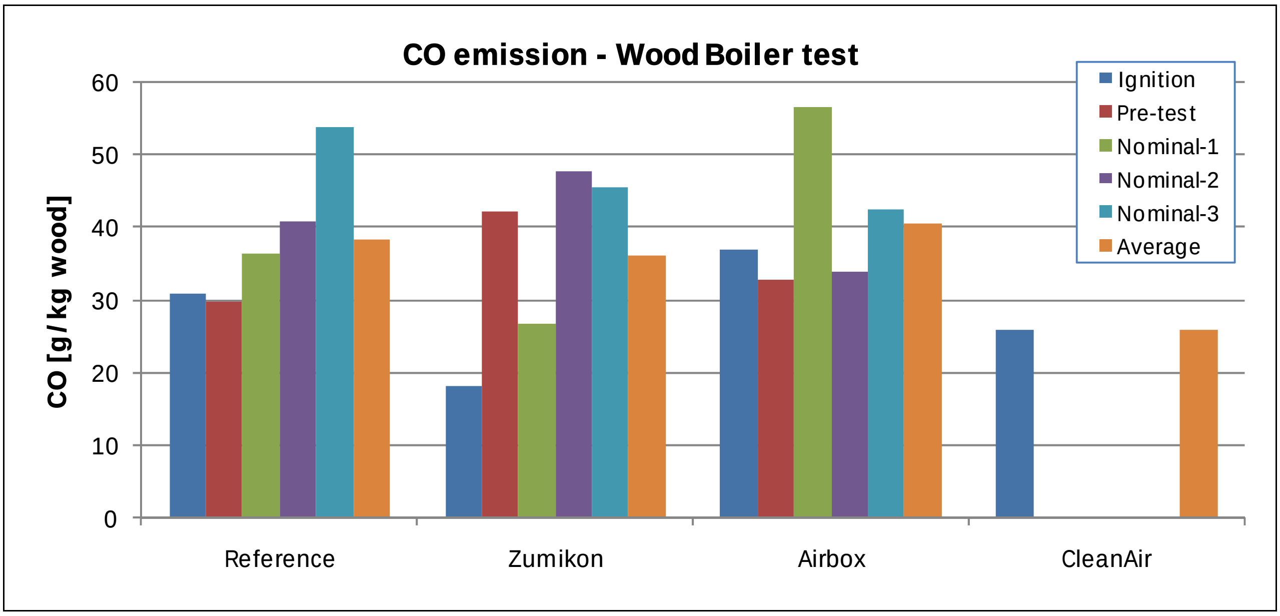

PN <0.1 µm - Wood Stove Technology test
PN <0.1 µm [ x E+12/kg wood
100000
10000
1000
100
10
1
Ignition
Pre-test
Nominal
Interm. Stage
Reduced
Average
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir
Swan

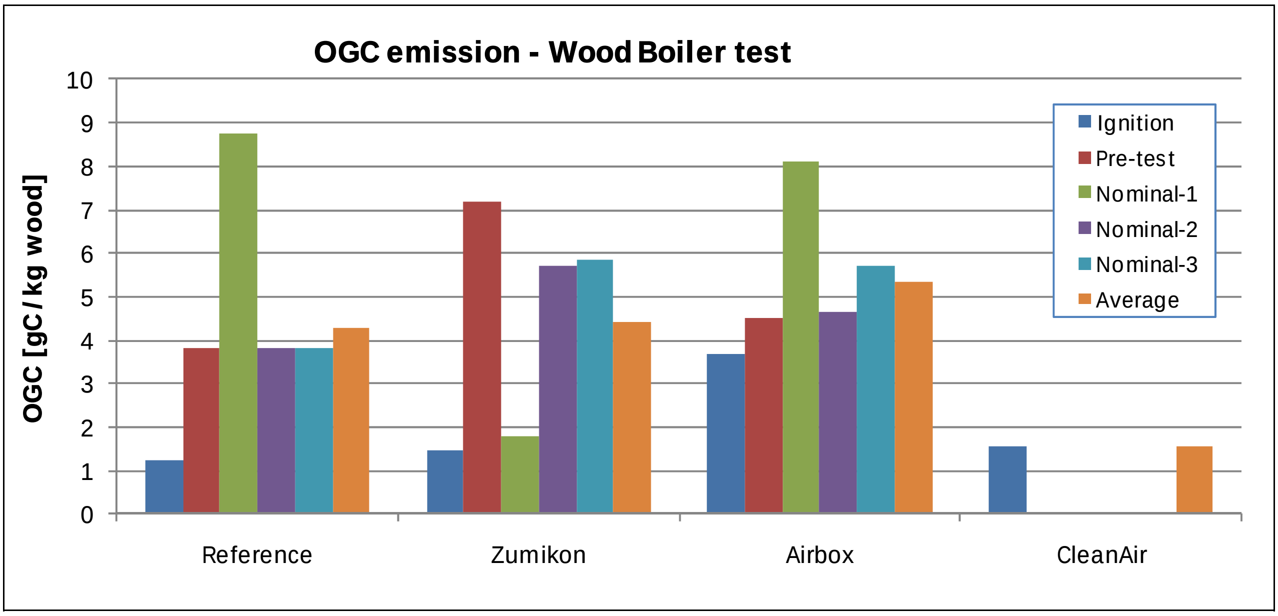

Average PM emission with Confidence Intervals
Wood stove technology test
PM [g/kg wood]
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir 08*
CleanAir 09
Swan

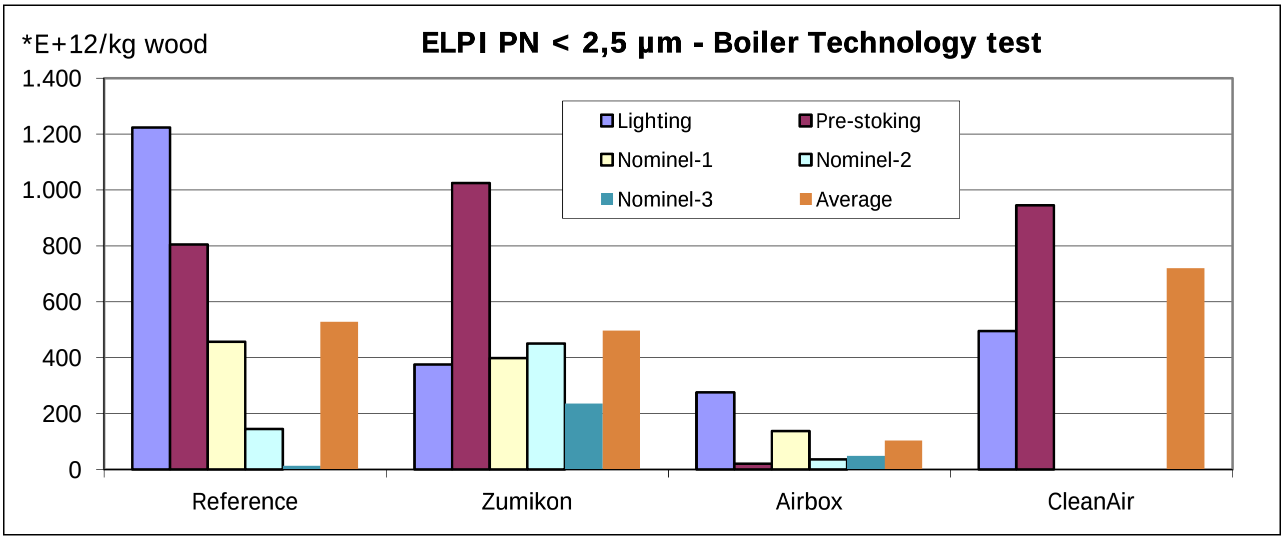

Average COemission with Confidence Intervals
Wood stove technology test
CO [g/kg wood]
70
60
50
40
30
20
10
0
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir 08*
CleanAir 09
Swan

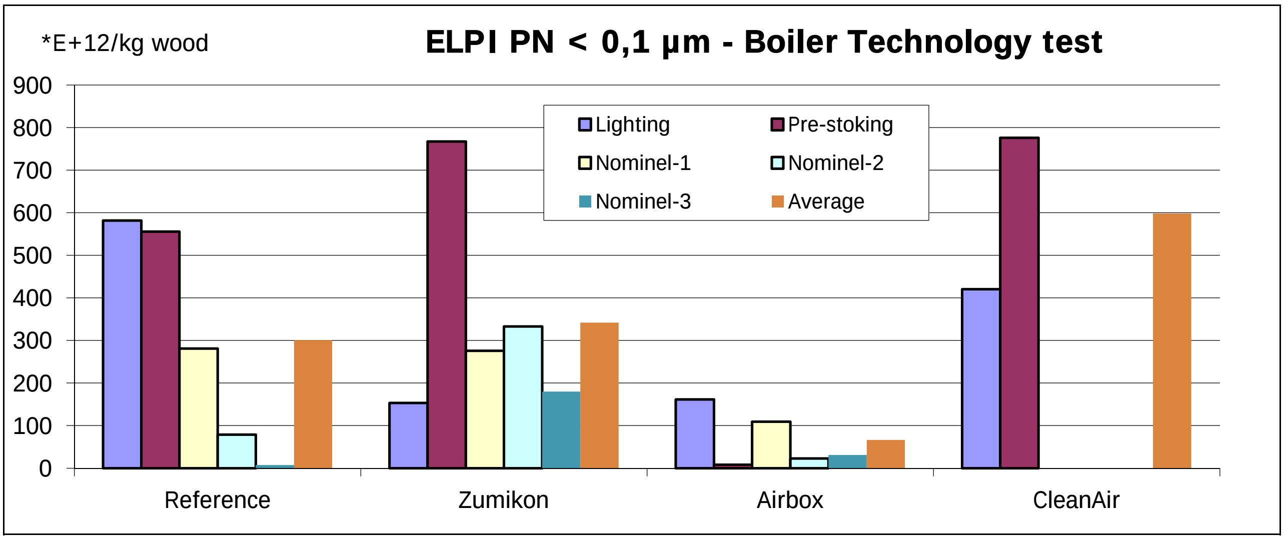

Average OGC emission with Confidence Intervals
Wood stove technology test
OGC [gC/kg wood]
9
8
7
6
5
4
3
2
1
0
Reference
Morecat
Zumikon
Airbox
Ecoxy
CleanAir 08*
CleanAir 09
Swan

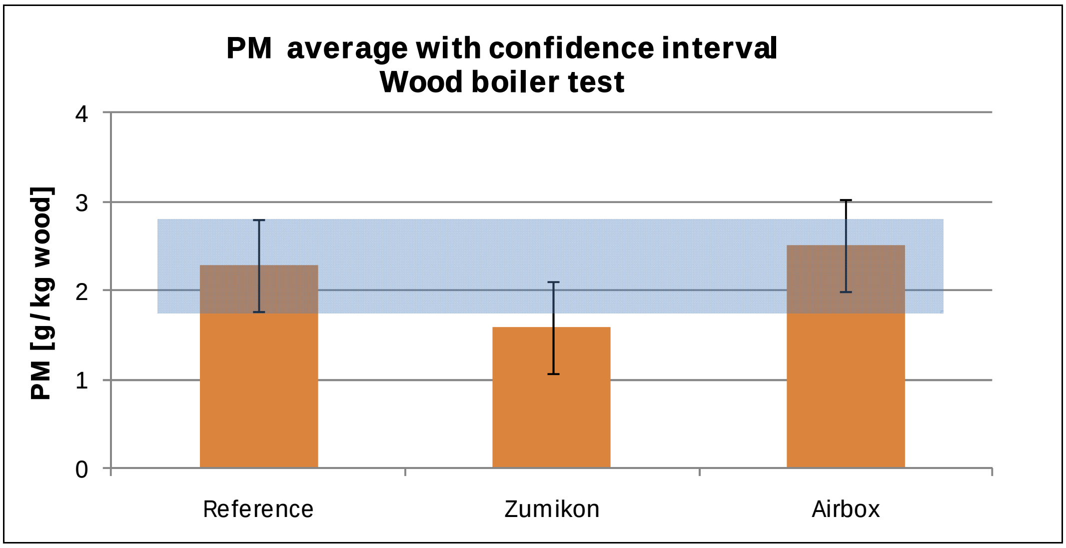

PM emission - Wood Boiler test
Particles [g/kg wood]
3,5
3
2,5
2
1,5
1
0,5
0
Reference
Zumikon
Airbox
CleanAir
Ignition
Pre-test
Nominal-1
Nominal-2
Nominal-3
Average

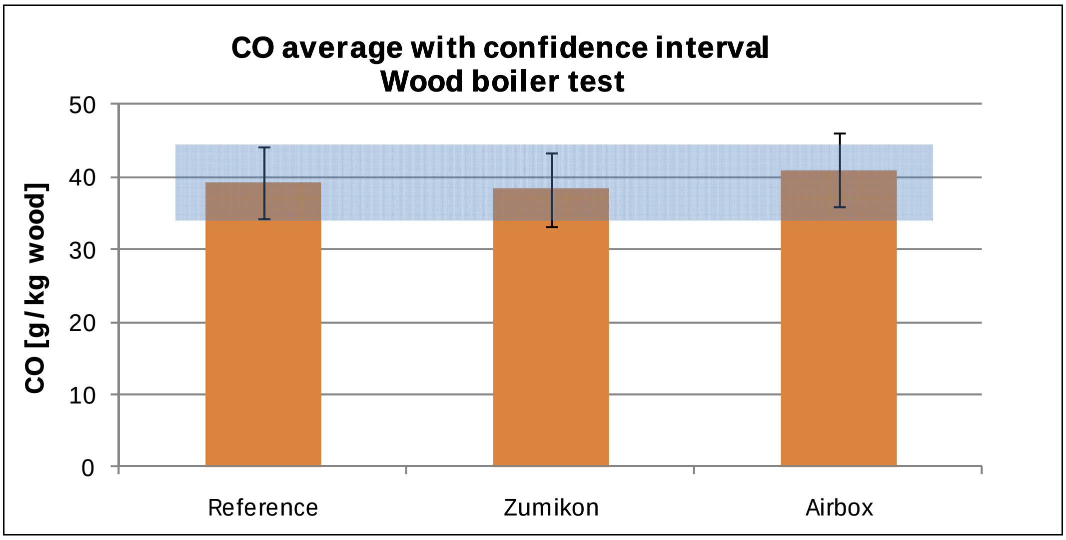

CO emission - Wood Boiler test
CO [g/kg wood]
60
50
40
30
20
10
0
Reference
Zumikon
Airbox
CleanAir
Ignition
Pre-test
Nominal-1
Nominal-2
Nominal-3
Average

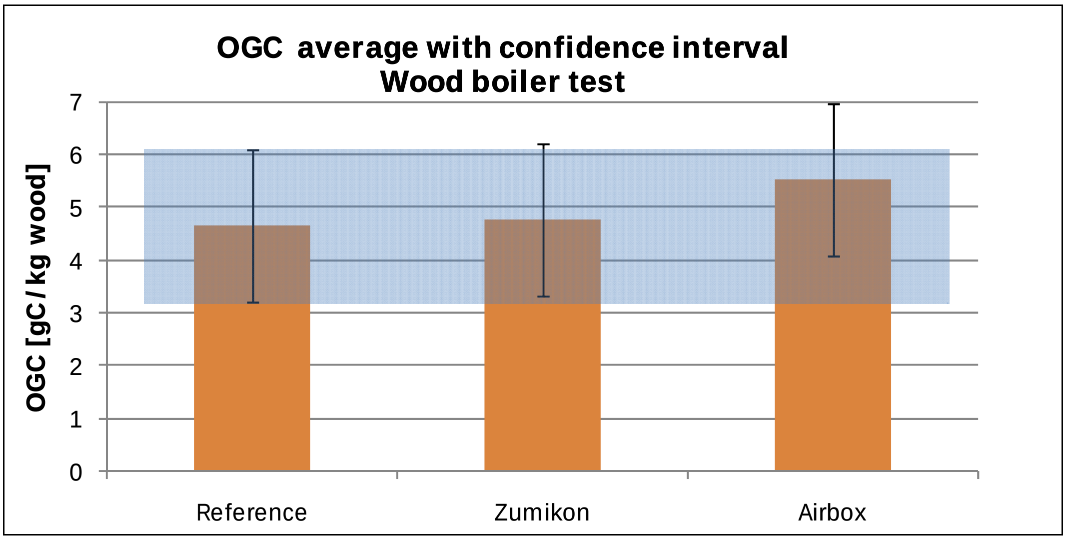

OGC emission - Wood Boiler test
OGC [gC/kg wood]
10
9
8
7
6
5
4
3
2
1
0
Reference
Zumikon
Airbox
CleanAir
Ignition
Pre-test
Nominal-1
Nominal-2
Nominal-3
Average


*E+12/kg wood
ELPI PN < 2,5 µm - Boiler Technology test
1.400
1.200
1.000
800
600
400
200
0
Lighting
Pre-stoking
Nominel-1
Nominel-2
Nominel-3
Average
Reference
Zumikon
Airbox
CleanAir


*E+12/kg wood
ELPI PN < 0,1 µm - Boiler Technology test
900
800
700
600
500
400
300
200
100
0
Lighting
Pre-stoking
Nominel-1
Nominel-2
Nominel-3
Average
Reference
Zumikon
Airbox
CleanAir


PM average with confidence interval
Wood boiler test
PM [g/kg wood]
0
1
2
3
4
Reference
Zumikon
Airbox


CO average with confidence interval
Wood boiler test
CO [g/kg wood]
0
10
20
30
40
50
Reference
Zumikon
Airbox


OGC average with confidence interval
Wood boiler test
OGC [gC/kg wood]
0
1
2
3
4
5
6
7
Reference
Zumikon
Airbox

# Laboratory test data

Detailed measurement data as averages for each test cycle is found on the next 44 pages.

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | Optænding |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,8 | [%] |
| CO2 beregnet i tunnel | 0,440 | [%] |
| CO målt i skorsten | 0,70 | [%] |
| CO beregnet i skorsten | 0,55 | [% ved 13% O2] |
| CO beregnet i skorsten | 5527 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6908 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4278 | [mg/MJ] |
| CO udslip | 63,38 | [g/kg (indfyret)] |
| THC målt i tunnel | 87 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 24 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 63 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1952 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 534 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1418 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 651 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 403 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 5,97 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 896 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 555 | [mgC/MJ] |
| OGC beregnet i skorsten | 8,22 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 711 | [Nl (Tør)] |
| Opsamlet mængde partikler | 11,5 | [mg] |
| Partikulær udslipsandel | 8,34 | [g/h] |
| Justeret partikulær udslipsandel | 10,59 | [g/h] |
| Justeret partikulær udslipsandel | 4,47 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 405 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 251 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,71 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 313 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 274 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 19 | [Pa] |
| Træk efter enhed | 19 | [Pa] |
| Temperatur midt i tunnel | 30 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 8,9 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 8,9 | [kW] |
| Middelhastighed i tunnel | 5,05 | [m/s] |
| Virkningsgrad | 76 | [%] |
| Røggasflow i tunnel | 514810 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 181 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,08 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,20 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 22,3 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 2,85 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,37 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,56 | [timer] |
| Måling start | 07-10-2008 09:37:00 | [Dato/Tid] |
| Måling stop | 07-10-2008 10:10:41 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | Forfyring |

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,0 | [%] |
| CO2 beregnet i tunnel | 0,318 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,29 | [% ved 13% O2] |
| CO beregnet i skorsten | 2942 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3677 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2350 | [mg/MJ] |
| CO udslip | 34,81 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 5 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 15 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 510 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 126 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 384 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 212 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 136 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,01 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 282 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 180 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,67 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 347 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 313 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 21 | [Pa] |
| Træk efter enhed | 21 | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 23 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,8 | [kW] |
| Middelhastighed i tunnel | 5,03 | [m/s] |
| Virkningsgrad | 70 | [%] |
| Røggasflow i tunnel | 503218 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 252 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,01 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,11 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,00 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,66 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,90 | [timer] |
| Måling start | 07-10-2008 10:10:41 | [Dato/Tid] |
| Måling stop | 07-10-2008 11:04:40 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 1-Nominel

| | | |
|---|---|---|
| $CO_2$ målt i skorsten | 8,1 | [%] |
| $CO_2$ beregnet i tunnel | 0,309 | [%] |
| CO målt i skorsten | 0,34 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% $O_2$] |
| CO beregnet i skorsten | 3231 | [ppm ved 13% $O_2$] |
| CO beregnet i skorsten | 4039 | [mg/$Nm^3$ (Tør) ved 13% $O_2$] |
| CO udslip | 2571 | [mg/MJ] |
| CO udslip | 38,10 | [g/kg (indfyret)] |
| THC målt i tunnel | 27 | [ppm $CH_4$ ækv.] |
| $CH_4$ målt i tunnel | 8 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i tunnel | 20 | [ppm $CH_4$ ækv.] |
| THC beregnet i skorsten | 714 | [ppm $CH_4$ ækv.] |
| $CH_4$ beregnet i skorsten | 199 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 514 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 282 | [mgC/$Nm^3$ (Tør) ved 13%$O_2$] |
| NMVOC beregnet i skorsten | 180 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,66 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 392 | [mgC/$Nm^3$ (Tør) ved 13%$O_2$] |
| OGC beregnet i skorsten | 250 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,70 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1143 | [Nl (Tør)] |
| Opsamlet mængde partikler | 8,9 | [mg] |
| Partikulær udslipsandel | 3,94 | [g/h] |
| Justeret partikulær udslipsandel | 5,68 | [g/h] |
| Justeret partikulær udslipsandel | 3,52 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 309 | [mg/$Nm^3$ (Tør) ved 13%$O_2$] |
| Justeret partikulær udslipsandel | 197 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,92 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 358 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 320 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 21 | [Pa] |
| Træk efter enhed | 22 | [Pa] |
| Temperatur midt i tunnel | 37 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,6 | [kW] |
| Middelhastighed i tunnel | 5,07 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 505336 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 259 | [$Nm^3$/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,91 | [$Nm^3$/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,01 | [$Nm^3$/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 26,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,95 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,62 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,92 | [timer] |
| Måling start | 07-10-2008 11:04:40 | [Dato/Tid] |
| Måling stop | 07-10-2008 12:00:00 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 2-Nominel

| | | |
|---|---|---|
| $CO_2$ målt i skorsten | 8,0 | [%] |
| $CO_2$ beregnet i tunnel | 0,307 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,30 | [% ved 13% $O_2$] |
| CO beregnet i skorsten | 2959 | [ppm ved 13% $O_2$] |
| CO beregnet i skorsten | 3698 | [mg/$Nm^3$ (Tør) ved 13% $O_2$] |
| CO udslip | 2363 | [mg/MJ] |
| CO udslip | 35,00 | [g/kg (indfyret)] |
| THC målt i tunnel | 23 | [ppm $CH_4$ ækv.] |
| $CH_4$ målt i tunnel | 7 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i tunnel | 17 | [ppm $CH_4$ ækv.] |
| THC beregnet i skorsten | 612 | [ppm $CH_4$ ækv.] |
| $CH_4$ beregnet i skorsten | 170 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 443 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 245 | [mgC/$Nm^3$ (Tør) ved 13%$O_2$] |
| NMVOC beregnet i skorsten | 157 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,32 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 340 | [mgC/$Nm^3$ (Tør) ved 13%$O_2$] |
| OGC beregnet i skorsten | 217 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,21 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/$Nm^3$ (Tør) ved 13%$O_2$] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 362 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 317 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 21 | [Pa] |
| Træk efter enhed | 21 | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,5 | [kW] |
| Middelhastighed i tunnel | 5,02 | [m/s] |
| Virkningsgrad | 70 | [%] |
| Røggasflow i tunnel | 499366 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 262 | [$Nm^3$/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,03 | [$Nm^3$/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,13 | [$Nm^3$/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 26,1 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,91 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,58 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,94 | [timer] |
| Måling start | 07-10-2008 12:00:00 | [Dato/Tid] |
| Måling stop | 07-10-2008 12:56:30 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 3-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,7 | [%] |
| CO2 beregnet i tunnel | 0,298 | [%] |
| CO målt i skorsten | 0,30 | [%] |
| CO beregnet i skorsten | 0,30 | [% ved 13% O2] |
| CO beregnet i skorsten | 2968 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3710 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2370 | [mg/MJ] |
| CO udslip | 35,11 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 5 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 13 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 475 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 134 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 341 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 195 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 125 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,84 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 272 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 174 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,57 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1216 | [Nl (Tør)] |
| Opsamlet mængde partikler | 6,4 | [mg] |
| Partikulær udslipsandel | 2,62 | [g/h] |
| Justeret partikulær udslipsandel | 4,05 | [g/h] |
| Justeret partikulær udslipsandel | 2,64 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 232 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 148 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,19 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 359 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 310 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 21 | [Pa] |
| Træk efter enhed | 21 | [Pa] |
| Temperatur midt i tunnel | 37 | [°C] |
| Temperatur i filter | 31 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,3 | [kW] |
| Middelhastighed i tunnel | 5,00 | [m/s] |
| Virkningsgrad | 70 | [%] |
| Røggasflow i tunnel | 496993 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 269 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,35 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,44 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 26,0 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,85 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,54 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,97 | [timer] |
| Måling start | 07-10-2008 12:56:30 | [Dato/Tid] |
| Måling stop | 07-10-2008 13:54:45 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: Overgang

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,3 | [%] |
| CO2 beregnet i tunnel | 0,185 | [%] |
| CO målt i skorsten | 0,39 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3594 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4493 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2850 | [mg/MJ] |
| CO udslip | 42,23 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 6 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 895 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 254 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 641 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 344 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 218 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,23 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 480 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 305 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,51 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 278 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 210 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 17 | [Pa] |
| Træk efter enhed | 17 | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,8 | [kW] |
| Middelhastighed i tunnel | 4,95 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 502377 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 432 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,65 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,76 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 44,8 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,16 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,96 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,12 | [timer] |
| Måling start | 07-10-2008 13:54:45 | [Dato/Tid] |
| Måling stop | 07-10-2008 15:01:50 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,3 | [%] |
| CO2 beregnet i tunnel | 0,135 | [%] |
| CO målt i skorsten | 0,55 | [%] |
| CO beregnet i skorsten | 0,58 | [% ved 13% O2] |
| CO beregnet i skorsten | 5820 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 7275 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4490 | [mg/MJ] |
| CO udslip | 66,52 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 6 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 12 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 993 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 340 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 653 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 394 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 243 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,60 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 600 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 370 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,48 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 2084 | [Nl (Tør)] |
| Opsamlet mængde partikler | 4,6 | [mg] |
| Partikulær udslipsandel | 1,13 | [g/h] |
| Justeret partikulær udslipsandel | 2,01 | [g/h] |
| Justeret partikulær udslipsandel | 2,72 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 247 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 152 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,26 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 250 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 188 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 30 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 2,9 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 2,9 | [kW] |
| Middelhastighed i tunnel | 4,99 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 509094 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 571 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,58 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,67 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 54,0 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 0,89 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,74 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,69 | [timer] |
| Måling start | 07-10-2008 15:01:50 | [Dato/Tid] |
| Måling stop | 07-10-2008 16:43:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Morecat
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 11,3 | [%] |
| CO2 beregnet i tunnel | 0,446 | [%] |
| CO målt i skorsten | 0,52 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3590 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4488 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2845 | [mg/MJ] |
| CO udslip | 42,16 | [g/kg (indfyret)] |
| THC målt i tunnel | 71 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 22 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 48 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1781 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 565 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1216 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 493 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 312 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,63 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 722 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 458 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,78 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 703 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,7 | [mg] |
| Partikulær udslipsandel | 7,07 | [g/h] |
| Justeret partikulær udslipsandel | 9,22 | [g/h] |
| Justeret partikulær udslipsandel | 4,01 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 354 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 225 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,33 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 361 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 296 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 241 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | 16 | [Pa] |
| Temperatur midt i tunnel | 30 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 9,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 9,3 | [kW] |
| Middelhastighed i tunnel | 5,02 | [m/s] |
| Virkningsgrad | 82 | [%] |
| Røggasflow i tunnel | 511077 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 184 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,30 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,43 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,3 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 2,77 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,30 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,58 | [timer] |
| Måling start | 09-10-2008 10:15:05 | [Dato/Tid] |
| Måling stop | 09-10-2008 10:49:45 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Morecat
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,7 | [%] |
| CO2 beregnet i tunnel | 0,291 | [%] |
| CO målt i skorsten | 0,20 | [%] |
| CO beregnet i skorsten | 0,17 | [% ved 13% O2] |
| CO beregnet i skorsten | 1744 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2180 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1414 | [mg/MJ] |
| CO udslip | 20,96 | [g/kg (indfyret)] |
| THC målt i tunnel | 27 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 16 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 803 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 330 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 473 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 243 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 157 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,33 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 412 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 267 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,96 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 385 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 327 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 280 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | 18 | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,6 | [kW] |
| Middelhastighed i tunnel | 5,04 | [m/s] |
| Virkningsgrad | 76 | [%] |
| Røggasflow i tunnel | 503910 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 282 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,42 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,52 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 29,9 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,79 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,49 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,00 | [timer] |
| Måling start | 09-10-2008 10:49:45 | [Dato/Tid] |
| Måling stop | 09-10-2008 11:50:01 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Morecat
Prøvning: Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,5 | [%] |
| CO2 beregnet i tunnel | 0,313 | [%] |
| CO målt i skorsten | 0,25 | [%] |
| CO beregnet i skorsten | 0,21 | [% ved 13% O2] |
| CO beregnet i skorsten | 2051 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2563 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1656 | [mg/MJ] |
| CO udslip | 24,54 | [g/kg (indfyret)] |
| THC målt i tunnel | 40 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 16 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 23 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1196 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 493 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 703 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 334 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 216 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,20 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 568 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 367 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,44 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1152 | [Nl (Tør)] |
| Opsamlet mængde partikler | 8,6 | [mg] |
| Partikulær udslipsandel | 3,76 | [g/h] |
| Justeret partikulær udslipsandel | 5,46 | [g/h] |
| Justeret partikulær udslipsandel | 3,44 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 299 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 193 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,86 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 400 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 329 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 288 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | 19 | [Pa] |
| Temperatur midt i tunnel | 37 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,0 | [kW] |
| Middelhastighed i tunnel | 5,04 | [m/s] |
| Virkningsgrad | 76 | [%] |
| Røggasflow i tunnel | 502279 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 263 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,70 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,81 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 30,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,91 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,59 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,94 | [timer] |
| Måling start | 09-10-2008 11:50:01 | [Dato/Tid] |
| Måling stop | 09-10-2008 12:46:30 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Morecat
Prøvning: Overgang

| | | |
|---|---|---|
| CO2 målt i skorsten | 10,0 | [%] |
| CO2 beregnet i tunnel | 0,229 | [%] |
| CO målt i skorsten | 0,28 | [%] |
| CO beregnet i skorsten | 0,22 | [% ved 13% O2] |
| CO beregnet i skorsten | 2165 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2706 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1748 | [mg/MJ] |
| CO udslip | 25,89 | [g/kg (indfyret)] |
| THC målt i tunnel | 31 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 17 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1329 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 589 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 739 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 335 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 217 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,21 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 602 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 389 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,76 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 338 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 264 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 216 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | 16 | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,8 | [kW] |
| Middelhastighed i tunnel | 5,02 | [m/s] |
| Virkningsgrad | 83 | [%] |
| Røggasflow i tunnel | 507140 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 361 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,29 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,42 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 43,5 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,41 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,17 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,92 | [timer] |
| Måling start | 09-10-2008 12:46:30 | [Dato/Tid] |
| Måling stop | 09-10-2008 13:42:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Morecat
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,2 | [%] |
| CO2 beregnet i tunnel | 0,181 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,26 | [% ved 13% O2] |
| CO beregnet i skorsten | 2626 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3283 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2107 | [mg/MJ] |
| CO udslip | 31,22 | [g/kg (indfyret)] |
| THC målt i tunnel | 33 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 22 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 12 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1701 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 1103 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 598 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 291 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 187 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,77 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 827 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 531 | [mgC/MJ] |
| OGC beregnet i skorsten | 7,86 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1654 | [Nl (Tør)] |
| Opsamlet mængde partikler | 4,3 | [mg] |
| Partikulær udslipsandel | 1,32 | [g/h] |
| Justeret partikulær udslipsandel | 2,29 | [g/h] |
| Justeret partikulær udslipsandel | 2,47 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 215 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 138 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,05 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 317 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 255 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 203 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 32 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,8 | [kW] |
| Middelhastighed i tunnel | 4,99 | [m/s] |
| Virkningsgrad | 83 | [%] |
| Røggasflow i tunnel | 504563 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 452 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,84 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,95 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 51,1 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 1,12 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,93 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,34 | [timer] |
| Måling start | 09-10-2008 13:42:00 | [Dato/Tid] |
| Måling stop | 09-10-2008 15:02:20 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Rüegg |
| Prøvning: | Optænding |

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,6 | [%] |
| CO2 beregnet i tunnel | 0,510 | [%] |
| | | |
| CO målt i skorsten | 0,80 | [%] |
| CO beregnet i skorsten | 0,72 | [% ved 13% O2] |
| CO beregnet i skorsten | 7209 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 9011 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 5469 | [mg/MJ] |
| CO udslip | 81,02 | [g/kg (indfyret)] |
| | | |
| THC målt i tunnel | 181 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 52 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 129 | [ppm CH4 ækv.] |
| | | |
| THC beregnet i skorsten | 3047 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 882 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 2165 | [ppm CH4 ækv.] |
| | | |
| NMVOC beregnet i skorsten | 1127 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 684 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 10,13 | [gC/kg (indfyret)] |
| | | |
| OGC beregnet i skorsten | 1586 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 962 | [mgC/MJ] |
| OGC beregnet i skorsten | 14,26 | [gC/kg (indfyret)] |
| | | |
| Udsuget gasvolumen | 583 | [Nl (Tør)] |
| Opsamlet mængde partikler | 16,7 | [mg] |
| Partikulær udslipsandel | 14,30 | [g/h] |
| Justeret partikulær udslipsandel | 16,56 | [g/h] |
| Justeret partikulær udslipsandel | 6,05 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 558 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 339 | [mg/MJ] |
| Justeret partikulær udslipsandel | 5,02 | [g/kg (indfyret)] |
| | | |
| Røggastemperatur før enhed | 328 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 230 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 18 | [Pa] |
| Træk efter enhed | 18 | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 28 | [°C] |
| | | |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| | | |
| Totalydelse | 10,4 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 10,4 | [kW] |
| | | |
| Middelhastighed i tunnel | 4,95 | [m/s] |
| Virkningsgrad | 77 | [%] |
| | | |
| Røggasflow i tunnel | 498732 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 151 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,99 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,10 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 16,8 | [gg] |
| | | |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 3,30 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,74 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| | | |
| Måletid | 0,48 | [timer] |
| Måling start | 08-10-2008 12:24:20 | [Dato/Tid] |
| Måling stop | 08-10-2008 12:53:20 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Rüegg |
| Prøvning: | Forfyring |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 0,347 | [%] |
| | | |
| CO målt i skorsten | 0,28 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3073 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3841 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2450 | [mg/MJ] |
| CO udslip | 36,30 | [g/kg (indfyret)] |
| | | |
| THC målt i tunnel | 36 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 25 | [ppm CH4 ækv.] |
| | | |
| THC beregnet i skorsten | 719 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 217 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 502 | [ppm CH4 ækv.] |
| | | |
| NMVOC beregnet i skorsten | 316 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 202 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,99 | [gC/kg (indfyret)] |
| | | |
| OGC beregnet i skorsten | 454 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 289 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,29 | [gC/kg (indfyret)] |
| | | |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| | | |
| Røggastemperatur før enhed | 375 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 267 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | 20 | [Pa] |
| Temperatur midt i tunnel | 39 | [°C] |
| Temperatur i filter | 26 | [°C] |
| | | |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| | | |
| Totalydelse | 6,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,2 | [kW] |
| | | |
| Middelhastighed i tunnel | 4,91 | [m/s] |
| Virkningsgrad | 71 | [%] |
| | | |
| Røggasflow i tunnel | 485360 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 229 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,39 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,48 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 20,1 | [gg] |
| | | |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,12 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,76 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| | | |
| Måletid | 0,85 | [timer] |
| Måling start | 08-10-2008 12:53:20 | [Dato/Tid] |
| Måling stop | 08-10-2008 13:44:20 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Rüegg |
| Prøvning: | Nominel |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 0,339 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,34 | [% ved 13% O2] |
| CO beregnet i skorsten | 3397 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4246 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2698 | [mg/MJ] |
| CO udslip | 39,97 | [g/kg (indfyret)] |
| THC målt i tunnel | 54 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 40 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1111 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 287 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 825 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 516 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 328 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,85 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 695 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 442 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,54 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1044 | [Nl (Tør)] |
| Opsamlet mængde partikler | 10,9 | [mg] |
| Partikulær udslipsandel | 5,13 | [g/h] |
| Justeret partikulær udslipsandel | 7,08 | [g/h] |
| Justeret partikulær udslipsandel | 4,04 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 356 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 226 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,36 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 380 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 270 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | 20 | [Pa] |
| Temperatur midt i tunnel | 41 | [°C] |
| Temperatur i filter | 33 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,2 | [kW] |
| Middelhastighed i tunnel | 5,01 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 491751 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 233 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,25 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,34 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 20,7 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,11 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,75 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,86 | [timer] |
| Måling start | 08-10-2008 13:44:20 | [Dato/Tid] |
| Måling stop | 08-10-2008 14:35:40 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Rüegg |
| Prøvning: | Overgang |

| | | |
|---|---|---|
| CO2 målt i skorsten | 6,5 | [%] |
| CO2 beregnet i tunnel | 0,222 | [%] |
| CO målt i skorsten | 0,27 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3153 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3942 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2514 | [mg/MJ] |
| CO udslip | 37,25 | [g/kg (indfyret)] |
| THC målt i tunnel | 23 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 15 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 664 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 224 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 439 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 296 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 189 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,79 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 447 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 285 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,22 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 303 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 176 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | 16 | [Pa] |
| Temperatur midt i tunnel | 35 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,6 | [kW] |
| Middelhastighed i tunnel | 4,96 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 497662 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 356 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 12,15 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 11,22 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 29,3 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,40 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,16 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,93 | [timer] |
| Måling start | 08-10-2008 14:35:40 | [Dato/Tid] |
| Måling stop | 08-10-2008 15:31:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Rüegg
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 6,0 | [%] |
| CO2 beregnet i tunnel | 0,171 | [%] |
| CO målt i skorsten | 0,43 | [%] |
| CO beregnet i skorsten | 0,55 | [% ved 13% O2] |
| CO beregnet i skorsten | 5504 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6880 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4262 | [mg/MJ] |
| CO udslip | 63,15 | [g/kg (indfyret)] |
| THC målt i tunnel | 41 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 13 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 28 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1440 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 446 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 994 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 722 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 448 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,63 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 1047 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 648 | [mgC/MJ] |
| OGC beregnet i skorsten | 9,61 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1658 | [Nl (Tør)] |
| Opsamlet mængde partikler | 4,0 | [mg] |
| Partikulær udslipsandel | 1,21 | [g/h] |
| Justeret partikulær udslipsandel | 2,13 | [g/h] |
| Justeret partikulær udslipsandel | 2,30 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 208 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 129 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,91 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 283 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 161 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,6 | [kW] |
| Middelhastighed i tunnel | 4,97 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 501371 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 448 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 12,76 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 11,83 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 35,1 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 1,12 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,93 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,34 | [timer] |
| Måling start | 08-10-2008 15:31:20 | [Dato/Tid] |
| Måling stop | 08-10-2008 16:52:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Sparterm
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 0,308 | [%] |
| CO målt i skorsten | 0,53 | [%] |
| CO beregnet i skorsten | 0,58 | [% ved 13% O2] |
| CO beregnet i skorsten | 5839 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 7299 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4503 | [mg/MJ] |
| CO udslip | 66,71 | [g/kg (indfyret)] |
| THC målt i tunnel | 77 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 21 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 56 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1761 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 488 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1273 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 800 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 494 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 7,32 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 1107 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 683 | [mgC/MJ] |
| OGC beregnet i skorsten | 10,12 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 961 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,7 | [mg] |
| Partikulær udslipsandel | 5,18 | [g/h] |
| Justeret partikulær udslipsandel | 7,13 | [g/h] |
| Justeret partikulær udslipsandel | 4,20 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 381 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 235 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,48 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 211 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 85 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 6 | [Pa] |
| Træk efter enhed | 8 | [Pa] |
| Temperatur midt i tunnel | 28 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 7,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 7,5 | [kW] |
| Middelhastighed i tunnel | 4,99 | [m/s] |
| Virkningsgrad | 89 | [%] |
| Røggasflow i tunnel | 512462 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 250 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,01 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,09 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 22,7 | [gg] |
| Charge mængde | 1,59 | [kg] |
| Brændselsforbrug (indfyret) | 2,05 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,70 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,78 | [timer] |
| Måling start | 14-10-2008 09:51:40 | [Dato/Tid] |
| Måling stop | 14-10-2008 10:38:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Sparterm
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 5,5 | [%] |
| CO2 beregnet i tunnel | 0,256 | [%] |
| CO målt i skorsten | 0,26 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3627 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4534 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2873 | [mg/MJ] |
| CO udslip | 42,56 | [g/kg (indfyret)] |
| THC målt i tunnel | 28 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 7 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 20 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 597 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 160 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 437 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 342 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 217 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,21 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 467 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 296 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,39 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 259 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 128 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 10 | [Pa] |
| Træk efter enhed | 12 | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,6 | [kW] |
| Middelhastighed i tunnel | 4,95 | [m/s] |
| Virkningsgrad | 83 | [%] |
| Røggasflow i tunnel | 499187 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 304 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 14,03 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 13,08 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 21,6 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,64 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,36 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,09 | [timer] |
| Måling start | 14-10-2008 10:38:20 | [Dato/Tid] |
| Måling stop | 14-10-2008 11:44:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Sparterm
Prøvning: Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 5,5 | [%] |
| CO2 beregnet i tunnel | 0,258 | [%] |
| CO målt i skorsten | 0,26 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3623 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4528 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2869 | [mg/MJ] |
| CO udslip | 42,51 | [g/kg (indfyret)] |
| THC målt i tunnel | 34 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 23 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 724 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 225 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 499 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 395 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 250 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,71 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 573 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 363 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,38 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1320 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,2 | [mg] |
| Partikulær udslipsandel | 2,00 | [g/h] |
| Justeret partikulær udslipsandel | 3,24 | [g/h] |
| Justeret partikulær udslipsandel | 2,32 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 205 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 130 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,93 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 259 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 136 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 10 | [Pa] |
| Træk efter enhed | 12 | [Pa] |
| Temperatur midt i tunnel | 34 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,7 | [kW] |
| Middelhastighed i tunnel | 5,05 | [m/s] |
| Virkningsgrad | 82 | [%] |
| Røggasflow i tunnel | 506803 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 302 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 14,20 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 13,24 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 21,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,68 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,40 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,07 | [timer] |
| Måling start | 14-10-2008 11:44:00 | [Dato/Tid] |
| Måling stop | 14-10-2008 12:48:15 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Sparterm
Prøvning: Overgang

| | | |
|---|---|---|
| CO2 målt i skorsten | 4,4 | [%] |
| CO2 beregnet i tunnel | 0,149 | [%] |
| CO målt i skorsten | 0,38 | [%] |
| CO beregnet i skorsten | 0,66 | [% ved 13% O2] |
| CO beregnet i skorsten | 6602 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 8252 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 5048 | [mg/MJ] |
| CO udslip | 74,78 | [g/kg (indfyret)] |
| THC målt i tunnel | 22 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 13 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 650 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 278 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 372 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 360 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 220 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,27 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 629 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 385 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,70 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 176 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 89 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 7 | [Pa] |
| Træk efter enhed | 9 | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,4 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,4 | [kW] |
| Middelhastighed i tunnel | 4,89 | [m/s] |
| Virkningsgrad | 84 | [%] |
| Røggasflow i tunnel | 496532 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 499 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 16,77 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 15,79 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 29,7 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,00 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,83 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,30 | [timer] |
| Måling start | 14-10-2008 12:48:15 | [Dato/Tid] |
| Måling stop | 14-10-2008 14:06:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Sparterm
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 4,2 | [%] |
| CO2 beregnet i tunnel | 0,111 | [%] |
| CO målt i skorsten | 0,36 | [%] |
| CO beregnet i skorsten | 0,66 | [% ved 13% O2] |
| CO beregnet i skorsten | 6604 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 8255 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 5047 | [mg/MJ] |
| CO udslip | 74,77 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 6 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 774 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 236 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 538 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 548 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 335 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,96 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 788 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 482 | [mgC/MJ] |
| OGC beregnet i skorsten | 7,14 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 2471 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,4 | [mg] |
| Partikulær udslipsandel | 1,10 | [g/h] |
| Justeret partikulær udslipsandel | 1,97 | [g/h] |
| Justeret partikulær udslipsandel | 3,15 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 288 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 176 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,61 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 148 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 72 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 6 | [Pa] |
| Træk efter enhed | 7 | [Pa] |
| Temperatur midt i tunnel | 30 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 2,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 2,7 | [kW] |
| Middelhastighed i tunnel | 4,92 | [m/s] |
| Virkningsgrad | 86 | [%] |
| Røggasflow i tunnel | 502351 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 667 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 17,63 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 16,63 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 37,9 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 0,75 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,62 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,99 | [timer] |
| Måling start | 14-10-2008 14:06:20 | [Dato/Tid] |
| Måling stop | 14-10-2008 16:06:00 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ecoxy |
| Prøvning: | Optænding |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,3 | [%] |
| CO2 beregnet i tunnel | 0,476 | [%] |
| CO målt i skorsten | 0,62 | [%] |
| CO beregnet i skorsten | 0,52 | [% ved 13% O2] |
| CO beregnet i skorsten | 5167 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6459 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4017 | [mg/MJ] |
| CO udslip | 59,51 | [g/kg (indfyret)] |
| THC målt i tunnel | 107 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 29 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 78 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 2100 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 572 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1528 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 735 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 457 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,77 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 1010 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 628 | [mgC/MJ] |
| OGC beregnet i skorsten | 9,31 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 649 | [Nl (Tør)] |
| Opsamlet mængde partikler | 18,6 | [mg] |
| Partikulær udslipsandel | 14,62 | [g/h] |
| Justeret partikulær udslipsandel | 16,86 | [g/h] |
| Justeret partikulær udslipsandel | 6,65 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 599 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 372 | [mg/MJ] |
| Justeret partikulær udslipsandel | 5,52 | [g/kg (indfyret)] |
| Røggastemperatur efter ovn | 339 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 257 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk efter enhed | 18 | [Pa] |
| Temperatur midt i tunnel | 32 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 9,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 9,7 | [kW] |
| Middelhastighed i tunnel | 5,04 | [m/s] |
| Virkningsgrad | 77 | [%] |
| Røggasflow i tunnel | 510136 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 167 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,50 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,62 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 19,6 | [gg] |
| Charge mængde | 1,61 | [kg] |
| Brændselsforbrug (indfyret) | 3,06 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,54 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,52 | [timer] |
| Måling start | 15-10-2008 10:07:40 | [Dato/Tid] |
| Måling stop | 15-10-2008 10:39:10 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ecoxy |
| Prøvning: | Forfyring |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,4 | [%] |
| CO2 beregnet i tunnel | 0,323 | [%] |
| CO målt i skorsten | 0,29 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3053 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3816 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2435 | [mg/MJ] |
| CO udslip | 36,08 | [g/kg (indfyret)] |
| THC målt i tunnel | 34 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 10 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 23 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 771 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 234 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 537 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 319 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 204 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,02 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 459 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 293 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,34 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur efter ovn | 373 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 304 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk efter enhed | 21 | [Pa] |
| Temperatur midt i tunnel | 39 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,8 | [kW] |
| Middelhastighed i tunnel | 5,09 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 504463 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 247 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,75 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,84 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 23,0 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,04 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,69 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,88 | [timer] |
| Måling start | 15-10-2008 10:39:10 | [Dato/Tid] |
| Måling stop | 15-10-2008 11:32:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ecoxy
Prøvning: Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,3 | [%] |
| CO2 beregnet i tunnel | 0,314 | [%] |
| CO målt i skorsten | 0,29 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3055 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3819 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2437 | [mg/MJ] |
| CO udslip | 36,10 | [g/kg (indfyret)] |
| THC målt i tunnel | 38 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 10 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 28 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 881 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 237 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 644 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 389 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 248 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,68 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 532 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 339 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,03 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1116 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,2 | [mg] |
| Partikulær udslipsandel | 4,11 | [g/h] |
| Justeret partikulær udslipsandel | 5,88 | [g/h] |
| Justeret partikulær udslipsandel | 3,60 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 316 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 202 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,99 | [g/kg (indfyret)] |
| Røggastemperatur efter ovn | 376 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 304 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk efter enhed | 21 | [Pa] |
| Temperatur midt i tunnel | 40 | [°C] |
| Temperatur i filter | 32 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,5 | [kW] |
| Middelhastighed i tunnel | 5,05 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 498184 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 253 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,91 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,00 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 23,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,97 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,63 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,91 | [timer] |
| Måling start | 15-10-2008 11:32:00 | [Dato/Tid] |
| Måling stop | 15-10-2008 12:26:50 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ecoxy
Prøvning: Overgang

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,2 | [%] |
| CO2 beregnet i tunnel | 0,247 | [%] |
| CO målt i skorsten | 0,22 | [%] |
| CO beregnet i skorsten | 0,21 | [% ved 13% O2] |
| CO beregnet i skorsten | 2073 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2592 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1676 | [mg/MJ] |
| CO udslip | 24,83 | [g/kg (indfyret)] |
| THC målt i tunnel | 15 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 5 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 9 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 492 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 179 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 313 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 169 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 110 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,62 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 266 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 172 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,55 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur efter ovn | 332 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 239 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk efter enhed | 18 | [Pa] |
| Temperatur midt i tunnel | 34 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,9 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,9 | [kW] |
| Middelhastighed i tunnel | 5,03 | [m/s] |
| Virkningsgrad | 78 | [%] |
| Røggasflow i tunnel | 505892 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 329 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,90 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,01 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 33,2 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,54 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,28 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,84 | [timer] |
| Måling start | 15-10-2008 12:26:50 | [Dato/Tid] |
| Måling stop | 15-10-2008 13:17:30 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ecoxy
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,9 | [%] |
| CO2 beregnet i tunnel | 0,202 | [%] |
| CO målt i skorsten | 0,25 | [%] |
| CO beregnet i skorsten | 0,25 | [% ved 13% O2] |
| CO beregnet i skorsten | 2475 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3094 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1989 | [mg/MJ] |
| CO udslip | 29,47 | [g/kg (indfyret)] |
| THC målt i tunnel | 10 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 5 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 5 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 386 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 185 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 201 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 113 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 72 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,07 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 216 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 139 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,06 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1468 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,6 | [mg] |
| Partikulær udslipsandel | 1,92 | [g/h] |
| Justeret partikulær udslipsandel | 3,13 | [g/h] |
| Justeret partikulær udslipsandel | 3,00 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 262 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 168 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,49 | [g/kg (indfyret)] |
| Røggastemperatur efter ovn | 324 | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 233 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk efter enhed | 18 | [Pa] |
| Temperatur midt i tunnel | 34 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,0 | [kW] |
| Middelhastighed i tunnel | 4,99 | [m/s] |
| Virkningsgrad | 78 | [%] |
| Røggasflow i tunnel | 502406 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 400 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,17 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,27 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 39,3 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 1,26 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,04 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,19 | [timer] |
| Måling start | 15-10-2008 13:17:30 | [Dato/Tid] |
| Måling stop | 15-10-2008 14:29:10 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,1 | [%] |
| CO2 beregnet i tunnel | 0,271 | [%] |
| CO målt i skorsten | 0,48 | [%] |
| CO beregnet i skorsten | 0,46 | [% ved 13% O2] |
| CO beregnet i skorsten | 4575 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5719 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3582 | [mg/MJ] |
| CO udslip | 53,07 | [g/kg (indfyret)] |
| THC målt i tunnel | 61 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 13 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 48 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1815 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 395 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1420 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 780 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 488 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 7,23 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 997 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 624 | [mgC/MJ] |
| OGC beregnet i skorsten | 9,25 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1053 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,4 | [mg] |
| Partikulær udslipsandel | 2,79 | [g/h] |
| Justeret partikulær udslipsandel | 4,26 | [g/h] |
| Justeret partikulær udslipsandel | 2,75 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 246 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 154 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,28 | [g/kg (indfyret)] |
| Røggastemperatur i skorsten | 205 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 24 | [°C] |
| Temperatur i filter | 21 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,1 | [kW] |
| Middelhastighed i tunnel | 5,24 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 543970 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 291 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,76 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,86 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 29,8 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 1,87 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,55 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,85 | [timer] |
| Måling start | 13-11-2008 11:46:20 | [Dato/Tid] |
| Måling stop | 13-11-2008 12:37:30 | [Dato/Tid] |

# Måleresultater

| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | APP |
| Prøvning: | Overgang |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 0,164 | [%] |
| CO målt i skorsten | 0,36 | [%] |
| CO beregnet i skorsten | 0,40 | [% ved 13% O2] |
| CO beregnet i skorsten | 3960 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4950 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3126 | [mg/MJ] |
| CO udslip | 46,31 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 11 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 777 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 323 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 454 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 286 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 181 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,68 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 490 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 309 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,58 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur i skorsten | 182 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 26 | [°C] |
| Temperatur i filter | 21 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,7 | [kW] |
| Middelhastighed i tunnel | 5,26 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 544167 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 480 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,28 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,37 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 42,6 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,13 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,94 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,15 | [timer] |
| Måling start | 13-11-2008 12:37:30 | [Dato/Tid] |
| Måling stop | 13-11-2008 13:46:20 | [Dato/Tid] |



# Måleresultater

| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | APP |
| Prøvning: | Lavlast |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,5 | [%] |
| CO2 beregnet i tunnel | 0,164 | [%] |
| CO målt i skorsten | 0,55 | [%] |
| CO beregnet i skorsten | 0,57 | [% ved 13% O2] |
| CO beregnet i skorsten | 5719 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 7149 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4417 | [mg/MJ] |
| CO udslip | 65,44 | [g/kg (indfyret)] |
| THC målt i tunnel | 25 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 16 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1134 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 414 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 719 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 425 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 262 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,89 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 669 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 414 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,13 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1665 | [Nl (Tør)] |
| Opsamlet mængde partikler | 3,9 | [mg] |
| Partikulær udslipsandel | 1,27 | [g/h] |
| Justeret partikulær udslipsandel | 2,21 | [g/h] |
| Justeret partikulær udslipsandel | 2,32 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 211 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 130 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,93 | [g/kg (indfyret)] |
| Røggastemperatur i skorsten | 180 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 26 | [°C] |
| Temperatur i filter | 24 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,8 | [kW] |
| Middelhastighed i tunnel | 5,24 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 540546 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 471 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,36 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,45 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 45,5 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 1,15 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,95 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,31 | [timer] |
| Måling start | 13-11-2008 13:46:20 | [Dato/Tid] |
| Måling stop | 13-11-2008 15:04:50 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | Optænding | |
| CO2 målt i skorsten | 8,0 | [%] |
| CO2 beregnet i tunnel | 1,445 | [%] |
| CO målt i skorsten | 0,27 | [%] |
| CO beregnet i skorsten | 0,26 | [% ved 13% O2] |
| CO beregnet i skorsten | 2594 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3243 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2079 | [mg/MJ] |
| CO udslip | 30,80 | [g/kg (indfyret)] |
| THC målt i tunnel | 58 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 1 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 57 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 321 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 7 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 314 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 175 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 112 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,66 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 179 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 115 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,70 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 467 | [Nl (Tør)] |
| Opsamlet mængde partikler | 24,0 | [mg] |
| Partikulær udslipsandel | 24,81 | [g/h] |
| Justeret partikulær udslipsandel | 26,16 | [g/h] |
| Justeret partikulær udslipsandel | 3,64 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 318 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 204 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,02 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 342 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 58 | [°C] |
| Temperatur i filter | 37 | [°C] |
| Vandflow | 811 | [l/h] |
| Temperatur fremløb | 58,6 | [°C] |
| Temperatur retur | 46,2 | [°C] |
| Totalydelse | 24,0 | [kW] |
| Vandside ydelse | 11,7 | [kW] |
| Rum ydelse | 12,4 | [kW] |
| Middelhastighed i tunnel | 5,18 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 482707 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 56 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,11 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,21 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,5 | [gg] |
| Charge mængde | 3,42 | [kg] |
| Brændselsforbrug (indfyret) | 8,67 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 7,19 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,39 | [timer] |
| Måling start | 03-11-2008 10:18:00 | [Dato/Tid] |
| Måling stop | 03-11-2008 10:41:40 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | Forfyring | |
| CO2 målt i skorsten | 6,9 | [%] |
| CO2 beregnet i tunnel | 1,256 | [%] |
| CO målt i skorsten | 0,22 | [%] |
| CO beregnet i skorsten | 0,25 | [% ved 13% O2] |
| CO beregnet i skorsten | 2507 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3134 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2009 | [mg/MJ] |
| CO udslip | 29,77 | [g/kg (indfyret)] |
| THC målt i tunnel | 93 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | -20 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 113 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 510 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | -111 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 620 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 395 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 253 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,76 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 325 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 208 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,08 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 316 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 65 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | 819 | [l/h] |
| Temperatur fremløb | 66,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 20,5 | [kW] |
| Vandside ydelse | 14,6 | [kW] |
| Rum ydelse | 5,9 | [kW] |
| Middelhastighed i tunnel | 5,23 | [m/s] |
| Virkningsgrad | 66 | [%] |
| Røggasflow i tunnel | 478700 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 63 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,56 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,64 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,5 | [gg] |
| Charge mængde | 8,47 | [kg] |
| Brændselsforbrug (indfyret) | 7,54 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,26 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,12 | [timer] |
| Måling start | 03-11-2008 10:41:40 | [Dato/Tid] |
| Måling stop | 03-11-2008 11:49:00 | [Dato/Tid] |

# Måleresultater

Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen
Prøvning: 1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,8 | [%] |
| CO2 beregnet i tunnel | 1,110 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3096 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3869 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2463 | [mg/MJ] |
| CO udslip | 36,49 | [g/kg (indfyret)] |
| THC målt i tunnel | 104 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 90 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 735 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 97 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 638 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 361 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 230 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,40 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 416 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 265 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,92 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1510 | [Nl (Tør)] |
| Opsamlet mængde partikler | 36,1 | [mg] |
| Partikulær udslipsandel | 11,27 | [g/h] |
| Justeret partikulær udslipsandel | 13,58 | [g/h] |
| Justeret partikulær udslipsandel | 2,50 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 220 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 140 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,07 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 336 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 68 | [°C] |
| Temperatur i filter | 43 | [°C] |
| Vandflow | 824 | [l/h] |
| Temperatur fremløb | 69,0 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 18,1 | [kW] |
| Vandside ydelse | 17,4 | [kW] |
| Rum ydelse | 0,7 | [kW] |
| Middelhastighed i tunnel | 5,20 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 471235 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 72 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,20 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,30 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 7,1 | [gg] |
| Charge mængde | 8,19 | [kg] |
| Brændselsforbrug (indfyret) | 6,55 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,43 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,25 | [timer] |
| Måling start | 03-11-2008 11:49:00 | [Dato/Tid] |
| Måling stop | 03-11-2008 13:04:00 | [Dato/Tid] |



# Måleresultater

Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen
Prøvning: 2-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,4 | [%] |
| CO2 beregnet i tunnel | 1,419 | [%] |
| CO målt i skorsten | 0,38 | [%] |
| CO beregnet i skorsten | 0,35 | [% ved 13% O2] |
| CO beregnet i skorsten | 3465 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4331 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2744 | [mg/MJ] |
| CO udslip | 40,66 | [g/kg (indfyret)] |
| THC målt i tunnel | 142 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 108 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 34 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 839 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 640 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 199 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 106 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 67 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 0,99 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 445 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 282 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,18 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 351 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 71 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | 827 | [l/h] |
| Temperatur fremløb | 69,9 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 22,9 | [kW] |
| Vandside ydelse | 18,2 | [kW] |
| Rum ydelse | 4,6 | [kW] |
| Middelhastighed i tunnel | 5,17 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 464467 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 56 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,53 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,63 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,9 | [gg] |
| Charge mængde | 8,35 | [kg] |
| Brændselsforbrug (indfyret) | 8,24 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,84 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,01 | [timer] |
| Måling start | 03-11-2008 13:04:00 | [Dato/Tid] |
| Måling stop | 03-11-2008 14:04:50 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen
Prøvning: 3-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,7 | [%] |
| CO2 beregnet i tunnel | 1,385 | [%] |
| CO målt i skorsten | 0,53 | [%] |
| CO beregnet i skorsten | 0,47 | [% ved 13% O2] |
| CO beregnet i skorsten | 4650 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5813 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3630 | [mg/MJ] |
| CO udslip | 53,78 | [g/kg (indfyret)] |
| THC målt i tunnel | 286 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 118 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 168 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1806 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 743 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1063 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 543 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 339 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 5,02 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 922 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 576 | [mgC/MJ] |
| OGC beregnet i skorsten | 8,53 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1194 | [Nl (Tør)] |
| Opsamlet mængde partikler | 39,9 | [mg] |
| Partikulær udslipsandel | 15,64 | [g/h] |
| Justeret partikulær udslipsandel | 17,83 | [g/h] |
| Justeret partikulær udslipsandel | 2,63 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 236 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 147 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,18 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 357 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 73 | [°C] |
| Temperatur i filter | 47 | [°C] |
| Vandflow | 826 | [l/h] |
| Temperatur fremløb | 71,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 22,7 | [kW] |
| Vandside ydelse | 19,6 | [kW] |
| Rum ydelse | 3,2 | [kW] |
| Middelhastighed i tunnel | 5,24 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 467923 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 57 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,05 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,17 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,3 | [gg] |
| Charge mængde | 8,11 | [kg] |
| Brændselsforbrug (indfyret) | 8,18 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,79 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,99 | [timer] |
| Måling start | 03-11-2008 14:04:50 | [Dato/Tid] |
| Måling stop | 03-11-2008 15:04:18 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen (NMVOC)
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,5 | [%] |
| CO2 beregnet i tunnel | 1,286 | [%] |
| CO målt i skorsten | 0,15 | [%] |
| CO beregnet i skorsten | 0,15 | [% ved 13% O2] |
| CO beregnet i skorsten | 1503 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 1879 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1221 | [mg/MJ] |
| CO udslip | 18,09 | [g/kg (indfyret)] |
| THC målt i tunnel | 37 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 28 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 216 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 53 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 163 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 96 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 62 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 0,93 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 127 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 83 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,22 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 312 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 52 | [°C] |
| Temperatur i filter | 23 | [°C] |
| Vandflow | 792 | [l/h] |
| Temperatur fremløb | 57,1 | [°C] |
| Temperatur retur | 46,2 | [°C] |
| Totalydelse | 23,4 | [kW] |
| Vandside ydelse | 10,0 | [kW] |
| Rum ydelse | 13,4 | [kW] |
| Middelhastighed i tunnel | 5,47 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 519336 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 63 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,84 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,93 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,8 | [gg] |
| Charge mængde | 3,36 | [kg] |
| Brændselsforbrug (indfyret) | 8,23 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,83 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,41 | [timer] |
| Måling start | 09-11-2008 11:33:40 | [Dato/Tid] |
| Måling stop | 09-11-2008 11:58:10 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen (NMVOC)
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 1,132 | [%] |
| CO målt i skorsten | 0,28 | [%] |
| CO beregnet i skorsten | 0,30 | [% ved 13% O2] |
| CO beregnet i skorsten | 3048 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3810 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2427 | [mg/MJ] |
| CO udslip | 35,96 | [g/kg (indfyret)] |
| THC målt i tunnel | 104 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 26 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 78 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 643 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 158 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 485 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 304 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 193 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,87 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 403 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 257 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,80 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 307 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 61 | [°C] |
| Temperatur i filter | 24 | [°C] |
| Vandflow | 805 | [l/h] |
| Temperatur fremløb | 66,8 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 20,2 | [kW] |
| Vandside ydelse | 14,9 | [kW] |
| Rum ydelse | 5,3 | [kW] |
| Middelhastighed i tunnel | 5,53 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 511171 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 70 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,30 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,38 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,2 | [gg] |
| Charge mængde | 8,47 | [kg] |
| Brændselsforbrug (indfyret) | 7,30 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,06 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,16 | [timer] |
| Måling start | 09-11-2008 11:58:40 | [Dato/Tid] |
| Måling stop | 09-11-2008 13:08:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Ingen (NMVOC)
Prøvning: 1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,0 | [%] |
| CO2 beregnet i tunnel | 1,021 | [%] |
| CO målt i skorsten | 0,43 | [%] |
| CO beregnet i skorsten | 0,47 | [% ved 13% O2] |
| CO beregnet i skorsten | 4664 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5830 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3640 | [mg/MJ] |
| CO udslip | 53,93 | [g/kg (indfyret)] |
| THC målt i tunnel | 219 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 54 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 165 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1511 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 373 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1138 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 711 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 444 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,58 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 944 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 590 | [mgC/MJ] |
| OGC beregnet i skorsten | 8,74 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 297 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 16 | [Pa] |
| Temperatur midt i tunnel | 62 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | 807 | [l/h] |
| Temperatur fremløb | 67,9 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 18,7 | [kW] |
| Vandside ydelse | 15,9 | [kW] |
| Rum ydelse | 2,7 | [kW] |
| Middelhastighed i tunnel | 5,54 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 510789 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 76 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,06 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,15 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,9 | [gg] |
| Charge mængde | 8,36 | [kg] |
| Brændselsforbrug (indfyret) | 6,70 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,56 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,25 | [timer] |
| Måling start | 09-11-2008 13:08:20 | [Dato/Tid] |
| Måling stop | 09-11-2008 14:23:15 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Viadrus U22 |
| Rensningsenhed: | Ingen (NMVOC) |
| Prøvning: | 2-Nominel |

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,1 | [%] |
| CO2 beregnet i tunnel | 1,147 | [%] |
| CO målt i skorsten | 0,34 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3239 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4048 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2572 | [mg/MJ] |
| CO udslip | 38,11 | [g/kg (indfyret)] |
| THC målt i tunnel | 105 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 31 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 74 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 736 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 216 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 521 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 287 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 182 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,70 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 405 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 258 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,81 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 329 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 17 | [Pa] |
| Temperatur midt i tunnel | 66 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | 813 | [l/h] |
| Temperatur fremløb | 70,2 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 20,5 | [kW] |
| Vandside ydelse | 18,3 | [kW] |
| Rum ydelse | 2,3 | [kW] |
| Middelhastighed i tunnel | 5,57 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 507241 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 70 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,91 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,01 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 7,0 | [gg] |
| Charge mængde | 8,26 | [kg] |
| Brændselsforbrug (indfyret) | 7,28 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,04 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,13 | [timer] |
| Måling start | 09-11-2008 14:23:15 | [Dato/Tid] |
| Måling stop | 09-11-2008 15:31:20 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Viadrus U22 |
| Rensningsenhed: | Ingen (NMVOC) |
| Prøvning: | 3-Nominel |

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,8 | [%] |
| CO2 beregnet i tunnel | 1,182 | [%] |
| CO målt i skorsten | 0,34 | [%] |
| CO beregnet i skorsten | 0,33 | [% ved 13% O2] |
| CO beregnet i skorsten | 3329 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4161 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2641 | [mg/MJ] |
| CO udslip | 39,13 | [g/kg (indfyret)] |
| THC målt i tunnel | 109 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 31 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 78 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 721 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 207 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 514 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 291 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 184 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,73 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 407 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 259 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,83 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i skorsten | 328 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i skorsten | 17 | [Pa] |
| Temperatur midt i tunnel | 64 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | 812 | [l/h] |
| Temperatur fremløb | 69,1 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 21,1 | [kW] |
| Vandside ydelse | 17,2 | [kW] |
| Rum ydelse | 3,9 | [kW] |
| Middelhastighed i tunnel | 5,55 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 508397 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 67 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,16 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,26 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,6 | [gg] |
| Charge mængde | 8,40 | [kg] |
| Brændselsforbrug (indfyret) | 7,54 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,26 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,11 | [timer] |
| Måling start | 09-11-2008 15:31:20 | [Dato/Tid] |
| Måling stop | 09-11-2008 16:38:10 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Rüegg | |
| Prøvning: | Optænding | |
| CO2 målt i skorsten | 6,1 | [%] |
| CO2 beregnet i tunnel | 1,110 | [%] |
| CO målt i skorsten | 0,12 | [%] |
| CO beregnet i skorsten | 0,15 | [% ved 13% O2] |
| CO beregnet i skorsten | 1520 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 1900 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1235 | [mg/MJ] |
| CO udslip | 18,29 | [g/kg (indfyret)] |
| THC målt i tunnel | 39 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 31 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 213 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 46 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 167 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 120 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 78 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,15 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 153 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 99 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,47 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 600 | [Nl (Tør)] |
| Opsamlet mængde partikler | 21,4 | [mg] |
| Partikulær udslipsandel | 17,38 | [g/h] |
| Justeret partikulær udslipsandel | 19,46 | [g/h] |
| Justeret partikulær udslipsandel | 3,47 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 299 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 194 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,88 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 284 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 201 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 51 | [°C] |
| Temperatur i filter | 35 | [°C] |
| Vandflow | 862 | [l/h] |
| Temperatur fremløb | 55,0 | [°C] |
| Temperatur retur | 46,8 | [°C] |
| Totalydelse | 18,5 | [kW] |
| Vandside ydelse | 8,2 | [kW] |
| Rum ydelse | 10,4 | [kW] |
| Middelhastighed i tunnel | 5,11 | [m/s] |
| Virkningsgrad | 67 | [%] |
| Røggasflow i tunnel | 487157 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 72 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 13,16 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 12,22 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,5 | [gg] |
| Charge mængde | 3,32 | [kg] |
| Brændselsforbrug (indfyret) | 6,76 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,61 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,49 | [timer] |
| Måling start | 07-11-2008 09:39:40 | [Dato/Tid] |
| Måling stop | 07-11-2008 10:09:10 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Rüegg | |
| Prøvning: | Forfyring | |
| CO2 målt i skorsten | 6,7 | [%] |
| CO2 beregnet i tunnel | 1,140 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3611 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4513 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2855 | [mg/MJ] |
| CO udslip | 42,29 | [g/kg (indfyret)] |
| THC målt i tunnel | 199 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 42 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 157 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1164 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 247 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 917 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 604 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 382 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 5,66 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 766 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 485 | [mgC/MJ] |
| OGC beregnet i skorsten | 7,18 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 289 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 205 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 59 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | 818 | [l/h] |
| Temperatur fremløb | 65,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 19,5 | [kW] |
| Vandside ydelse | 13,7 | [kW] |
| Rum ydelse | 5,8 | [kW] |
| Middelhastighed i tunnel | 5,20 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 483304 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 69 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,80 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,87 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 5,8 | [gg] |
| Charge mængde | 8,44 | [kg] |
| Brændselsforbrug (indfyret) | 7,02 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,82 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,20 | [timer] |
| Måling start | 07-11-2008 10:09:10 | [Dato/Tid] |
| Måling stop | 07-11-2008 11:21:20 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Rüegg | |
| Prøvning: | 1-Nominel | |
| CO2 målt i skorsten | 8,1 | [%] |
| CO2 beregnet i tunnel | 1,160 | [%] |
| CO målt i skorsten | 0,24 | [%] |
| CO beregnet i skorsten | 0,22 | [% ved 13% O2] |
| CO beregnet i skorsten | 2242 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2802 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1803 | [mg/MJ] |
| CO udslip | 26,71 | [g/kg (indfyret)] |
| THC målt i tunnel | 50 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 38 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 347 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 80 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 267 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 146 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 94 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,40 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 190 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 122 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,81 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1495 | [Nl (Tør)] |
| Opsamlet mængde partikler | 16,7 | [mg] |
| Partikulær udslipsandel | 5,26 | [g/h] |
| Justeret partikulær udslipsandel | 7,22 | [g/h] |
| Justeret partikulær udslipsandel | 1,29 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 112 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 72 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,07 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 337 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 231 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | 16 | [Pa] |
| Temperatur midt i tunnel | 66 | [°C] |
| Temperatur i filter | 44 | [°C] |
| Vandflow | 817 | [l/h] |
| Temperatur fremløb | 69,4 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 19,0 | [kW] |
| Vandside ydelse | 17,5 | [kW] |
| Rum ydelse | 1,5 | [kW] |
| Middelhastighed i tunnel | 5,18 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 471005 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 70 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,99 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,09 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 7,0 | [gg] |
| Charge mængde | 8,28 | [kg] |
| Brændselsforbrug (indfyret) | 6,76 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,61 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,22 | [timer] |
| Måling start | 07-11-2008 11:21:20 | [Dato/Tid] |
| Måling stop | 07-11-2008 12:34:50 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Rüegg | |
| Prøvning: | 2-Nominel | |
| CO2 målt i skorsten | 8,1 | [%] |
| CO2 beregnet i tunnel | 1,261 | [%] |
| CO målt i skorsten | 0,43 | [%] |
| CO beregnet i skorsten | 0,41 | [% ved 13% O2] |
| CO beregnet i skorsten | 4089 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5111 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3214 | [mg/MJ] |
| CO udslip | 47,61 | [g/kg (indfyret)] |
| THC målt i tunnel | 173 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 49 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 125 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1116 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 314 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 802 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 439 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 276 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,09 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 610 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 384 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,69 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 329 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 225 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 65 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | 815 | [l/h] |
| Temperatur fremløb | 69,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 22,1 | [kW] |
| Vandside ydelse | 17,4 | [kW] |
| Rum ydelse | 4,6 | [kW] |
| Middelhastighed i tunnel | 5,40 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 493057 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 63 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,76 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,86 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,4 | [gg] |
| Charge mængde | 8,17 | [kg] |
| Brændselsforbrug (indfyret) | 7,85 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,51 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,04 | [timer] |
| Måling start | 07-11-2008 12:34:50 | [Dato/Tid] |
| Måling stop | 07-11-2008 13:37:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Rüegg
Prøvning: 3-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,7 | [%] |
| CO2 beregnet i tunnel | 1,245 | [%] |
| CO målt i skorsten | 0,44 | [%] |
| CO beregnet i skorsten | 0,39 | [% ved 13% O2] |
| CO beregnet i skorsten | 3891 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4864 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3066 | [mg/MJ] |
| CO udslip | 45,42 | [g/kg (indfyret)] |
| THC målt i tunnel | 175 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 52 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 123 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1220 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 362 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 857 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 441 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 278 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,11 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 627 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 395 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,85 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1299 | [Nl (Tør)] |
| Opsamlet mængde partikler | 25,1 | [mg] |
| Partikulær udslipsandel | 9,59 | [g/h] |
| Justeret partikulær udslipsandel | 11,88 | [g/h] |
| Justeret partikulær udslipsandel | 1,85 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 164 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 104 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,54 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 338 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 226 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | 15 | [Pa] |
| Temperatur midt i tunnel | 66 | [°C] |
| Temperatur i filter | 44 | [°C] |
| Vandflow | 817 | [l/h] |
| Temperatur fremløb | 70,6 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 22,1 | [kW] |
| Vandside ydelse | 18,7 | [kW] |
| Rum ydelse | 3,4 | [kW] |
| Middelhastighed i tunnel | 5,45 | [m/s] |
| Virkningsgrad | 69 | [%] |
| Røggasflow i tunnel | 496286 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 64 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,19 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,30 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 7,0 | [gg] |
| Charge mængde | 8,25 | [kg] |
| Brændselsforbrug (indfyret) | 7,74 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,42 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,07 | [timer] |
| Måling start | 07-11-2008 13:37:20 | [Dato/Tid] |
| Måling stop | 07-11-2008 14:41:20 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Viadrus U22
Rensningsenhed: Sparterm
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,8 | [%] |
| CO2 beregnet i tunnel | 1,105 | [%] |
| CO målt i skorsten | 0,36 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3132 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3914 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2493 | [mg/MJ] |
| CO udslip | 36,93 | [g/kg (indfyret)] |
| THC målt i tunnel | 96 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 38 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 58 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 772 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 306 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 466 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 236 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 150 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,22 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 390 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 249 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,68 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 579 | [Nl (Tør)] |
| Opsamlet mængde partikler | 21,0 | [mg] |
| Partikulær udslipsandel | 18,65 | [g/h] |
| Justeret partikulær udslipsandel | 20,64 | [g/h] |
| Justeret partikulær udslipsandel | 3,53 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 311 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 198 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,93 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 306 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 163 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 8 | [Pa] |
| Træk efter enhed | 9 | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | 798 | [l/h] |
| Temperatur fremløb | 57,9 | [°C] |
| Temperatur retur | 46,8 | [°C] |
| Totalydelse | 21,1 | [kW] |
| Vandside ydelse | 10,3 | [kW] |
| Rum ydelse | 10,8 | [kW] |
| Middelhastighed i tunnel | 5,17 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 514280 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 73 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,13 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,24 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 8,0 | [gg] |
| Charge mængde | 3,33 | [kg] |
| Brændselsforbrug (indfyret) | 7,04 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,85 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,47 | [timer] |
| Måling start | 11-11-2008 09:58:30 | [Dato/Tid] |
| Måling stop | 11-11-2008 10:26:50 | [Dato/Tid] |

# Måleresultater

Fyringsanlæg: Viadrus U22
Rensningsenhed: Sparterm
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,2 | [%] |
| CO2 beregnet i tunnel | 0,964 | [%] |
| CO målt i skorsten | 0,30 | [%] |
| CO beregnet i skorsten | 0,28 | [% ved 13% O2] |
| CO beregnet i skorsten | 2770 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3462 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2213 | [mg/MJ] |
| CO udslip | 32,78 | [g/kg (indfyret)] |
| THC målt i tunnel | 103 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 29 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 74 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 879 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 250 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 629 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 339 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 217 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,21 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 474 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 303 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,49 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 297 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 190 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 8 | [Pa] |
| Træk efter enhed | 11 | [Pa] |
| Temperatur midt i tunnel | 45 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | 815 | [l/h] |
| Temperatur fremløb | 65,6 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 18,1 | [kW] |
| Vandside ydelse | 13,9 | [kW] |
| Rum ydelse | 4,2 | [kW] |
| Middelhastighed i tunnel | 5,23 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 507063 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 84 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,76 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,87 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 8,6 | [gg] |
| Charge mængde | 8,22 | [kg] |
| Brændselsforbrug (indfyret) | 6,07 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,04 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,35 | [timer] |
| Måling start | 11-11-2008 10:26:50 | [Dato/Tid] |
| Måling stop | 11-11-2008 11:48:05 | [Dato/Tid] |



# Måleresultater

Fyringsanlæg: Viadrus U22
Rensningsenhed: Sparterm
Prøvning: 1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,2 | [%] |
| CO2 beregnet i tunnel | 0,940 | [%] |
| CO målt i skorsten | 0,58 | [%] |
| CO beregnet i skorsten | 0,49 | [% ved 13% O2] |
| CO beregnet i skorsten | 4888 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6111 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3805 | [mg/MJ] |
| CO udslip | 56,37 | [g/kg (indfyret)] |
| THC målt i tunnel | 184 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 75 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 109 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1803 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 735 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1069 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 519 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 323 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,79 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 877 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 546 | [mgC/MJ] |
| OGC beregnet i skorsten | 8,09 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1676 | [Nl (Tør)] |
| Opsamlet mængde partikler | 32,6 | [mg] |
| Partikulær udslipsandel | 9,78 | [g/h] |
| Justeret partikulær udslipsandel | 12,08 | [g/h] |
| Justeret partikulær udslipsandel | 2,44 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 220 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 137 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,03 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 310 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 198 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 7 | [Pa] |
| Træk efter enhed | 11 | [Pa] |
| Temperatur midt i tunnel | 49 | [°C] |
| Temperatur i filter | 36 | [°C] |
| Vandflow | 818 | [l/h] |
| Temperatur fremløb | 67,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 17,8 | [kW] |
| Vandside ydelse | 15,6 | [kW] |
| Rum ydelse | 2,2 | [kW] |
| Middelhastighed i tunnel | 5,24 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 502993 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 84 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,60 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,72 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 9,8 | [gg] |
| Charge mængde | 8,16 | [kg] |
| Brændselsforbrug (indfyret) | 5,96 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 4,94 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,37 | [timer] |
| Måling start | 11-11-2008 11:48:05 | [Dato/Tid] |
| Måling stop | 11-11-2008 13:10:20 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Sparterm | |
| Prøvning: | 2-Nominel | |
| CO2 målt i skorsten | 8,9 | [%] |
| CO2 beregnet i tunnel | 1,039 | [%] |
| CO målt i skorsten | 0,33 | [%] |
| CO beregnet i skorsten | 0,29 | [% ved 13% O2] |
| CO beregnet i skorsten | 2866 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3583 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2287 | [mg/MJ] |
| CO udslip | 33,88 | [g/kg (indfyret)] |
| THC målt i tunnel | 115 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 34 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 80 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 984 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 293 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 691 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 346 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 221 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,28 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 493 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 315 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,67 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 312 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 197 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 7 | [Pa] |
| Træk efter enhed | 11 | [Pa] |
| Temperatur midt i tunnel | 50 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | 817 | [l/h] |
| Temperatur fremløb | 66,2 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 19,3 | [kW] |
| Vandside ydelse | 14,6 | [kW] |
| Rum ydelse | 4,7 | [kW] |
| Middelhastighed i tunnel | 5,24 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 501749 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 78 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,07 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,18 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 8,6 | [gg] |
| Charge mængde | 8,37 | [kg] |
| Brændselsforbrug (indfyret) | 6,44 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 5,35 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,30 | [timer] |
| Måling start | 11-11-2008 13:10:20 | [Dato/Tid] |
| Måling stop | 11-11-2008 14:28:20 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Viadrus U22 | |
| Rensningsenhed: | Sparterm | |
| Prøvning: | 3-Nominel | |
| CO2 målt i skorsten | 8,3 | [%] |
| CO2 beregnet i tunnel | 0,797 | [%] |
| CO målt i skorsten | 0,39 | [%] |
| CO beregnet i skorsten | 0,36 | [% ved 13% O2] |
| CO beregnet i skorsten | 3632 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4540 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2871 | [mg/MJ] |
| CO udslip | 42,53 | [g/kg (indfyret)] |
| THC målt i tunnel | 109 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 34 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 76 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1143 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 351 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 792 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 423 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 267 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,96 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 611 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 386 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,72 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 2077 | [Nl (Tør)] |
| Opsamlet mængde partikler | 48,7 | [mg] |
| Partikulær udslipsandel | 11,59 | [g/h] |
| Justeret partikulær udslipsandel | 13,91 | [g/h] |
| Justeret partikulær udslipsandel | 3,39 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 301 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 190 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,82 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 300 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | 191 | [°C ved 20° rumtemperatur] |
| Træk før enhed | 7 | [Pa] |
| Træk efter enhed | 11 | [Pa] |
| Temperatur midt i tunnel | 49 | [°C] |
| Temperatur i filter | 37 | [°C] |
| Vandflow | 821 | [l/h] |
| Temperatur fremløb | 65,3 | [°C] |
| Temperatur retur | 50,9 | [°C] |
| Totalydelse | 14,6 | [kW] |
| Vandside ydelse | 13,7 | [kW] |
| Rum ydelse | 0,9 | [kW] |
| Middelhastighed i tunnel | 5,15 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 494291 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 100 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,58 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,68 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 10,4 | [gg] |
| Charge mængde | 8,31 | [kg] |
| Brændselsforbrug (indfyret) | 4,94 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 4,10 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 1,68 | [timer] |
| Måling start | 11-11-2008 14:28:20 | [Dato/Tid] |
| Måling stop | 11-11-2008 16:09:20 | [Dato/Tid] |

# Måleresultater

Fyringsanlæg: Viadrus U22
Rensningsenhed: APP
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,9 | [%] |
| CO2 beregnet i tunnel | 1,308 | [%] |
| CO målt i skorsten | 0,22 | [%] |
| CO beregnet i skorsten | 0,22 | [% ved 13% O2] |
| CO beregnet i skorsten | 2168 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2710 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1746 | [mg/MJ] |
| CO udslip | 25,87 | [g/kg (indfyret)] |
| THC målt i tunnel | 48 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 37 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 288 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 67 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 221 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 124 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 80 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,19 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 162 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 104 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,54 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 526 | [Nl (Tør)] |
| Opsamlet mængde partikler | 16,8 | [mg] |
| Partikulær udslipsandel | 16,01 | [g/h] |
| Justeret partikulær udslipsandel | 18,18 | [g/h] |
| Justeret partikulær udslipsandel | 2,70 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 235 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 151 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,24 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | - | [°C ved 20° rumtemperatur] |
| Røggastemperatur i røgrør | 334 | [°C ved 20° rumtemperatur] |
| Træk før enhed | - | [Pa] |
| Træk i røgrør | 15 | [Pa] |
| Temperatur midt i tunnel | 52 | [°C] |
| Temperatur i filter | 34 | [°C] |
| Vandflow | 804 | [l/h] |
| Temperatur fremløb | 58,3 | [°C] |
| Temperatur retur | 46,7 | [°C] |
| Totalydelse | 22,7 | [kW] |
| Vandside ydelse | 10,8 | [kW] |
| Rum ydelse | 11,9 | [kW] |
| Middelhastighed i tunnel | 5,27 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 501254 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 62 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 10,24 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 9,34 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 6,0 | [gg] |
| Charge mængde | 3,47 | [kg] |
| Brændselsforbrug (indfyret) | 8,11 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 6,73 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,815 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 17 | [%] |
| Måletid | 0,43 | [timer] |
| Måling start | 12-11-2008 11:36:30 | [Dato/Tid] |
| Måling stop | 12-11-2008 12:02:10 | [Dato/Tid] |



# Måleresultater

Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,3 | [%] |
| CO2 beregnet i tunnel | 0,445 | [%] |
| CO målt i skorsten | 0,21 | [%] |
| CO beregnet i skorsten | 0,19 | [% ved 13% O2] |
| CO beregnet i skorsten | 1950 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2437 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1575 | [mg/MJ] |
| CO udslip | 23,54 | [g/kg (indfyret)] |
| THC målt i tunnel | 25 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 17 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 463 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 141 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 321 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 172 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 111 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,66 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 247 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 160 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,38 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 703 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,9 | [mg] |
| Partikulær udslipsandel | 3,90 | [g/h] |
| Justeret partikulær udslipsandel | 5,64 | [g/h] |
| Justeret partikulær udslipsandel | 2,67 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 231 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 150 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,24 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 251 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 32 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 8,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 8,1 | [kW] |
| Middelhastighed i tunnel | 4,60 | [m/s] |
| Virkningsgrad | 77 | [%] |
| Røggasflow i tunnel | 465218 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 184 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,84 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,95 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 18,7 | [gg] |
| Charge mængde | 1,59 | [kg] |
| Brændselsforbrug (indfyret) | 2,52 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,11 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,63 | [timer] |
| Måling start | 03-09-2009 10:40:40 | [Dato/Tid] |
| Måling stop | 03-09-2009 11:18:30 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 5,4 | [%] |
| CO2 beregnet i tunnel | 0,254 | [%] |
| CO målt i skorsten | 0,19 | [%] |
| CO beregnet i skorsten | 0,28 | [% ved 13% O2] |
| CO beregnet i skorsten | 2756 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3445 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2205 | [mg/MJ] |
| CO udslip | 32,94 | [g/kg (indfyret)] |
| THC målt i tunnel | 35 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 24 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 744 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 227 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 517 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 417 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 267 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,98 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 600 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 384 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,74 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 241 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 15 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 35 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,2 | [kW] |
| Middelhastighed i tunnel | 4,59 | [m/s] |
| Virkningsgrad | 68 | [%] |
| Røggasflow i tunnel | 459480 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 311 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 14,71 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 13,75 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 21,1 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 1,48 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,24 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,08 | [timer] |
| Måling start | 03-09-2009 11:18:30 | [Dato/Tid] |
| Måling stop | 03-09-2009 12:23:30 | [Dato/Tid] |

## Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: 1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,1 | [%] |
| CO2 beregnet i tunnel | 0,296 | [%] |
| CO målt i skorsten | 0,16 | [%] |
| CO beregnet i skorsten | 0,18 | [% ved 13% O2] |
| CO beregnet i skorsten | 1774 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2218 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1437 | [mg/MJ] |
| CO udslip | 21,47 | [g/kg (indfyret)] |
| THC målt i tunnel | 27 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 18 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 655 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 227 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 428 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 264 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 171 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,56 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 404 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 262 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,91 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1069 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,4 | [mg] |
| Partikulær udslipsandel | 4,07 | [g/h] |
| Justeret partikulær udslipsandel | 5,84 | [g/h] |
| Justeret partikulær udslipsandel | 4,14 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 358 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 232 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,46 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 265 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,1 | [kW] |
| Middelhastighed i tunnel | 4,65 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 463419 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 275 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,41 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,49 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,1 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 1,69 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,41 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,95 | [timer] |
| Måling start | 03-09-2009 12:23:30 | [Dato/Tid] |
| Måling stop | 03-09-2009 13:20:15 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: 2-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,3 | [%] |
| CO2 beregnet i tunnel | 0,294 | [%] |
| CO målt i skorsten | 0,14 | [%] |
| CO beregnet i skorsten | 0,14 | [% ved 13% O2] |
| CO beregnet i skorsten | 1447 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 1809 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1177 | [mg/MJ] |
| CO udslip | 17,58 | [g/kg (indfyret)] |
| THC målt i tunnel | 22 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 547 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 194 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 354 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 214 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 139 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,08 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 331 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 215 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,22 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 280 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 17 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,0 | [kW] |
| Middelhastighed i tunnel | 4,66 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 463347 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 278 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,22 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,31 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,8 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 1,67 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,39 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,96 | [timer] |
| Måling start | 03-09-2009 13:20:15 | [Dato/Tid] |
| Måling stop | 03-09-2009 14:18:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: 3-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 7,2 | [%] |
| CO2 beregnet i tunnel | 0,314 | [%] |
| CO målt i skorsten | 0,12 | [%] |
| CO beregnet i skorsten | 0,13 | [% ved 13% O2] |
| CO beregnet i skorsten | 1301 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 1627 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1060 | [mg/MJ] |
| CO udslip | 15,84 | [g/kg (indfyret)] |
| THC målt i tunnel | 13 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 7 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 6 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 293 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 150 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 143 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 88 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 57 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 0,86 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 180 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 117 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,75 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1025 | [Nl (Tør)] |
| Opsamlet mængde partikler | 2,6 | [mg] |
| Partikulær udslipsandel | 1,17 | [g/h] |
| Justeret partikulær udslipsandel | 2,07 | [g/h] |
| Justeret partikulær udslipsandel | 1,40 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 120 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 78 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,17 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 286 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 17 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 37 | [°C] |
| Temperatur i filter | 31 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,2 | [kW] |
| Middelhastighed i tunnel | 4,64 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 461641 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 261 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,42 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,50 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 22,8 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 1,77 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,48 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,90 | [timer] |
| Måling start | 03-09-2009 14:18:00 | [Dato/Tid] |
| Måling stop | 03-09-2009 15:12:05 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: Overgang

| | | |
|---|---|---|
| CO2 målt i skorsten | 6,4 | [%] |
| CO2 beregnet i tunnel | 0,218 | [%] |
| CO målt i skorsten | 0,15 | [%] |
| CO beregnet i skorsten | 0,19 | [% ved 13% O2] |
| CO beregnet i skorsten | 1876 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2344 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1518 | [mg/MJ] |
| CO udslip | 22,67 | [g/kg (indfyret)] |
| THC målt i tunnel | 15 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 8 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 446 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 224 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 222 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 153 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 99 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,48 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 306 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 198 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,96 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 257 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,7 | [kW] |
| Middelhastighed i tunnel | 4,62 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 461558 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 369 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 12,68 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 11,75 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 29,1 | [gg] |
| Charge mængde | 1,39 | [kg] |
| Brændselsforbrug (indfyret) | 1,25 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,04 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,12 | [timer] |
| Måling start | 03-09-2009 15:12:05 | [Dato/Tid] |
| Måling stop | 03-09-2009 16:19:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Epoca Svaneovn
Rensningsenhed: Ingen
Prøvning: Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 6,8 | [%] |
| CO2 beregnet i tunnel | 0,225 | [%] |
| CO målt i skorsten | 0,17 | [%] |
| CO beregnet i skorsten | 0,20 | [% ved 13% O2] |
| CO beregnet i skorsten | 1958 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2447 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1582 | [mg/MJ] |
| CO udslip | 23,63 | [g/kg (indfyret)] |
| THC målt i tunnel | 21 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 5 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 16 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 648 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 165 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 483 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 310 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 201 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,00 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 417 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 269 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,02 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1434 | [Nl (Tør)] |
| Opsamlet mængde partikler | 12,0 | [mg] |
| Partikulær udslipsandel | 3,86 | [g/h] |
| Justeret partikulær udslipsandel | 5,59 | [g/h] |
| Justeret partikulær udslipsandel | 5,21 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 451 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 292 | [mg/MJ] |
| Justeret partikulær udslipsandel | 4,36 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 251 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 31 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,9 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,9 | [kW] |
| Middelhastighed i tunnel | 4,62 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 461597 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 360 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 11,86 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 10,94 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 30,4 | [gg] |
| Charge mængde | 1,59 | [kg] |
| Brændselsforbrug (indfyret) | 1,28 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,07 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,24 | [timer] |
| Måling start | 03-09-2009 17:24:25 | [Dato/Tid] |
| Måling stop | 03-09-2009 18:38:55 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 1-dag-Optænding |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,3 | [%] |
| CO2 beregnet i tunnel | 0,388 | [%] |
| CO målt i skorsten | 0,56 | [%] |
| CO beregnet i skorsten | 0,46 | [% ved 13% O2] |
| CO beregnet i skorsten | 4617 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5771 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3609 | [mg/MJ] |
| CO udslip | 53,92 | [g/kg (indfyret)] |
| THC målt i tunnel | 51 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 36 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1217 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 344 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 873 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 420 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 263 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,92 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 585 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 366 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,47 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 786 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,1 | [mg] |
| Partikulær udslipsandel | 5,48 | [g/h] |
| Justeret partikulær udslipsandel | 7,47 | [g/h] |
| Justeret partikulær udslipsandel | 3,91 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 350 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 219 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,27 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 255 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 7,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 7,3 | [kW] |
| Middelhastighed i tunnel | 4,66 | [m/s] |
| Virkningsgrad | 77 | [%] |
| Røggasflow i tunnel | 473399 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 207 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,61 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,73 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,1 | [gg] |
| Charge mængde | 1,59 | [kg] |
| Brændselsforbrug (indfyret) | 2,29 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,91 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,70 | [timer] |
| Måling start | 04-09-2009 09:48:15 | [Dato/Tid] |
| Måling stop | 04-09-2009 10:30:00 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 1-dag-Forfyring |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,1 | [%] |
| CO2 beregnet i tunnel | 0,361 | [%] |
| CO målt i skorsten | 0,31 | [%] |
| CO beregnet i skorsten | 0,26 | [% ved 13% O2] |
| CO beregnet i skorsten | 2600 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3251 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2083 | [mg/MJ] |
| CO udslip | 31,13 | [g/kg (indfyret)] |
| THC målt i tunnel | 22 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 558 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 197 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 361 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 178 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 114 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,70 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 275 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 176 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,63 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 314 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 18 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,0 | [kW] |
| Middelhastighed i tunnel | 4,52 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 452021 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 227 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,02 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,13 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,99 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,66 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,90 | [timer] |
| Måling start | 04-09-2009 10:30:00 | [Dato/Tid] |
| Måling stop | 04-09-2009 11:24:15 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 1-dag-1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,5 | [%] |
| CO2 beregnet i tunnel | 0,372 | [%] |
| CO målt i skorsten | 0,37 | [%] |
| CO beregnet i skorsten | 0,30 | [% ved 13% O2] |
| CO beregnet i skorsten | 2994 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3743 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2387 | [mg/MJ] |
| CO udslip | 35,66 | [g/kg (indfyret)] |
| THC målt i tunnel | 34 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 23 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 862 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 281 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 581 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 275 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 175 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,62 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 408 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 260 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,89 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1015 | [Nl (Tør)] |
| Opsamlet mængde partikler | 8,3 | [mg] |
| Partikulær udslipsandel | 3,64 | [g/h] |
| Justeret partikulær udslipsandel | 5,32 | [g/h] |
| Justeret partikulær udslipsandel | 3,15 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 276 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 176 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,63 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 329 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 19 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,1 | [kW] |
| Middelhastighed i tunnel | 4,49 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 445656 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 220 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,63 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,75 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,5 | [gg] |
| Charge mængde | 1,81 | [kg] |
| Brændselsforbrug (indfyret) | 2,02 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,69 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,89 | [timer] |
| Måling start | 04-09-2009 11:24:15 | [Dato/Tid] |
| Måling stop | 04-09-2009 12:17:50 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 1-dag-2-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,7 | [%] |
| CO2 beregnet i tunnel | 0,323 | [%] |
| CO målt i skorsten | 0,37 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3243 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4054 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2578 | [mg/MJ] |
| CO udslip | 38,51 | [g/kg (indfyret)] |
| THC målt i tunnel | 32 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 21 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 856 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 298 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 558 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 286 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 182 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,71 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 438 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 278 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,16 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 320 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 19 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 5,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 5,3 | [kW] |
| Middelhastighed i tunnel | 4,50 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 446712 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 251 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,29 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,41 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 27,0 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 1,78 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,49 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,01 | [timer] |
| Måling start | 04-09-2009 12:17:50 | [Dato/Tid] |
| Måling stop | 04-09-2009 13:18:25 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 1-dag-3-Nominel |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,2 | [%] |
| CO2 beregnet i tunnel | 0,360 | [%] |
| CO målt i skorsten | 0,41 | [%] |
| CO beregnet i skorsten | 0,34 | [% ved 13% O2] |
| CO beregnet i skorsten | 3426 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4282 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2716 | [mg/MJ] |
| CO udslip | 40,58 | [g/kg (indfyret)] |
| THC målt i tunnel | 53 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 17 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 37 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1367 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 433 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 935 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 454 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 288 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,31 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 665 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 422 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,30 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1010 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,5 | [mg] |
| Partikulær udslipsandel | 4,29 | [g/h] |
| Justeret partikulær udslipsandel | 6,09 | [g/h] |
| Justeret partikulær udslipsandel | 3,61 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 318 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 202 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,02 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 324 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 19 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 30 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,0 | [kW] |
| Middelhastighed i tunnel | 4,59 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 455909 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 226 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,82 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,93 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,6 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,02 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,69 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,89 | [timer] |
| Måling start | 04-09-2009 13:18:25 | [Dato/Tid] |
| Måling stop | 04-09-2009 14:11:50 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 1-dag-Overgang |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,9 | [%] |
| CO2 beregnet i tunnel | 0,185 | [%] |
| CO målt i skorsten | 0,53 | [%] |
| CO beregnet i skorsten | 0,42 | [% ved 13% O2] |
| CO beregnet i skorsten | 4164 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5205 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3275 | [mg/MJ] |
| CO udslip | 48,93 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 10 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 980 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 458 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 522 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 238 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 150 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,23 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 446 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 281 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,19 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 230 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 32 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,5 | [kW] |
| Middelhastighed i tunnel | 4,50 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 455178 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 439 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,20 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,33 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 53,5 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,04 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,87 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,25 | [timer] |
| Måling start | 04-09-2009 14:11:50 | [Dato/Tid] |
| Måling stop | 04-09-2009 15:27:00 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 1-dag-Lavlast |

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,9 | [%] |
| CO2 beregnet i tunnel | 0,158 | [%] |
| CO målt i skorsten | 0,58 | [%] |
| CO beregnet i skorsten | 0,50 | [% ved 13% O2] |
| CO beregnet i skorsten | 5037 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6297 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3918 | [mg/MJ] |
| CO udslip | 58,54 | [g/kg (indfyret)] |
| THC målt i tunnel | 19 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 11 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1092 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 478 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 614 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 308 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 192 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,87 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 549 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 341 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,10 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1896 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,2 | [mg] |
| Partikulær udslipsandel | 1,27 | [g/h] |
| Justeret partikulær udslipsandel | 2,21 | [g/h] |
| Justeret partikulær udslipsandel | 2,90 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 261 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 162 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,42 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 199 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,1 | [kW] |
| Middelhastighed i tunnel | 4,54 | [m/s] |
| Virkningsgrad | 81 | [%] |
| Røggasflow i tunnel | 461457 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 506 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,95 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,07 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 56,5 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 0,91 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,76 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,64 | [timer] |
| Måling start | 04-09-2009 15:27:00 | [Dato/Tid] |
| Måling stop | 04-09-2009 17:05:40 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 2-dag-optænding |

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,5 | [%] |
| CO2 beregnet i tunnel | 0,328 | [%] |
| CO målt i skorsten | 0,37 | [%] |
| CO beregnet i skorsten | 0,34 | [% ved 13% O2] |
| CO beregnet i skorsten | 3387 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4233 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2688 | [mg/MJ] |
| CO udslip | 40,15 | [g/kg (indfyret)] |
| THC målt i tunnel | 30 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 9 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 21 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 779 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 234 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 544 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 286 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 182 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,72 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 410 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 260 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,89 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 930 | [Nl (Tør)] |
| Opsamlet mængde partikler | 8,1 | [mg] |
| Partikulær udslipsandel | 4,10 | [g/h] |
| Justeret partikulær udslipsandel | 5,87 | [g/h] |
| Justeret partikulær udslipsandel | 3,67 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 324 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 206 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,07 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 223 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 29 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,3 | [kW] |
| Middelhastighed i tunnel | 4,60 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 470908 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 246 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,55 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,66 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,8 | [gg] |
| Charge mængde | 1,58 | [kg] |
| Brændselsforbrug (indfyret) | 1,91 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,60 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,82 | [timer] |
| Måling start | 07-09-2009 09:23:35 | [Dato/Tid] |
| Måling stop | 07-09-2009 10:13:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 2-dag-forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,7 | [%] |
| CO2 beregnet i tunnel | 0,396 | [%] |
| CO målt i skorsten | 0,34 | [%] |
| CO beregnet i skorsten | 0,27 | [% ved 13% O2] |
| CO beregnet i skorsten | 2664 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3329 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2132 | [mg/MJ] |
| CO udslip | 31,86 | [g/kg (indfyret)] |
| THC målt i tunnel | 22 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 549 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 201 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 348 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 161 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 103 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,54 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 254 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 163 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,43 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 334 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 37 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,6 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,6 | [kW] |
| Middelhastighed i tunnel | 4,58 | [m/s] |
| Virkningsgrad | 73 | [%] |
| Røggasflow i tunnel | 456709 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 208 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,46 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,58 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,6 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,20 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,84 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,82 | [timer] |
| Måling start | 07-09-2009 10:13:00 | [Dato/Tid] |
| Måling stop | 07-09-2009 11:02:15 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 2-dag-1-Nominel

| | | |
|---|---|---|
| CO2 målt i skorsten | 10,1 | [%] |
| CO2 beregnet i tunnel | 0,399 | [%] |
| CO målt i skorsten | 0,38 | [%] |
| CO beregnet i skorsten | 0,29 | [% ved 13% O2] |
| CO beregnet i skorsten | 2893 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3616 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2309 | [mg/MJ] |
| CO udslip | 34,50 | [g/kg (indfyret)] |
| THC målt i tunnel | 35 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 24 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 871 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 270 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 602 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 270 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 172 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,57 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 391 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 249 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,73 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 905 | [Nl (Tør)] |
| Opsamlet mængde partikler | 8,4 | [mg] |
| Partikulær udslipsandel | 4,33 | [g/h] |
| Justeret partikulær udslipsandel | 6,15 | [g/h] |
| Justeret partikulær udslipsandel | 3,25 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 285 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 182 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,72 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 353 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,7 | [kW] |
| Middelhastighed i tunnel | 4,70 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 467030 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 207 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,19 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,31 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,26 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,89 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,80 | [timer] |
| Måling start | 07-09-2009 11:02:15 | [Dato/Tid] |
| Måling stop | 07-09-2009 11:50:05 | [Dato/Tid] |

## Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 2-dag-2-Nominel | |
| CO2 målt i skorsten | 9,6 | [%] |
| CO2 beregnet i tunnel | 0,370 | [%] |
| CO målt i skorsten | 0,40 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3242 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4053 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2577 | [mg/MJ] |
| CO udslip | 38,50 | [g/kg (indfyret)] |
| THC målt i tunnel | 37 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 12 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 26 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 968 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 305 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 662 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 311 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 197 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,95 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 454 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 289 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,31 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 346 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,1 | [kW] |
| Middelhastighed i tunnel | 4,58 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 454564 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 221 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,53 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,65 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,9 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,06 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,72 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,88 | [timer] |
| Måling start | 07-09-2009 11:50:05 | [Dato/Tid] |
| Måling stop | 07-09-2009 12:42:35 | [Dato/Tid] |

## Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 2-dag-3-Nominel | |
| CO2 målt i skorsten | 9,4 | [%] |
| CO2 beregnet i tunnel | 0,377 | [%] |
| CO målt i skorsten | 0,43 | [%] |
| CO beregnet i skorsten | 0,35 | [% ved 13% O2] |
| CO beregnet i skorsten | 3547 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4434 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2808 | [mg/MJ] |
| CO udslip | 41,96 | [g/kg (indfyret)] |
| THC målt i tunnel | 45 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 31 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1128 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 354 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 774 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 369 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 233 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,49 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 537 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 340 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,08 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 983 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,7 | [mg] |
| Partikulær udslipsandel | 4,49 | [g/h] |
| Justeret partikulær udslipsandel | 6,33 | [g/h] |
| Justeret partikulær udslipsandel | 3,59 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 318 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 201 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,00 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 346 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 38 | [°C] |
| Temperatur i filter | 31 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,2 | [kW] |
| Middelhastighed i tunnel | 4,58 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 454592 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 216 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,62 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,74 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,0 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,11 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,76 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,86 | [timer] |
| Måling start | 07-09-2009 12:42:35 | [Dato/Tid] |
| Måling stop | 07-09-2009 13:33:55 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 2-dag-Overgang | |
| CO2 målt i skorsten | 9,5 | [%] |
| CO2 beregnet i tunnel | 0,202 | [%] |
| CO målt i skorsten | 0,62 | [%] |
| CO beregnet i skorsten | 0,51 | [% ved 13% O2] |
| CO beregnet i skorsten | 5056 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 6320 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3933 | [mg/MJ] |
| CO udslip | 58,76 | [g/kg (indfyret)] |
| THC målt i tunnel | 28 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 11 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 17 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1332 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 517 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 815 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 385 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 239 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,58 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 629 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 391 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,85 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 236 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,8 | [kW] |
| Middelhastighed i tunnel | 4,53 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 459739 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 397 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,42 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,54 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 47,2 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,16 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,97 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,12 | [timer] |
| Måling start | 07-09-2009 13:33:55 | [Dato/Tid] |
| Måling stop | 07-09-2009 14:41:20 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 2-dag-Lavlast | |
| CO2 målt i skorsten | 8,5 | [%] |
| CO2 beregnet i tunnel | 0,130 | [%] |
| CO målt i skorsten | 0,49 | [%] |
| CO beregnet i skorsten | 0,44 | [% ved 13% O2] |
| CO beregnet i skorsten | 4440 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5550 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3481 | [mg/MJ] |
| CO udslip | 52,00 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 6 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1330 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 397 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 933 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 488 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 306 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,57 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 695 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 436 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,52 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 2002 | [Nl (Tør)] |
| Opsamlet mængde partikler | 11,2 | [mg] |
| Partikulær udslipsandel | 2,57 | [g/h] |
| Justeret partikulær udslipsandel | 3,99 | [g/h] |
| Justeret partikulær udslipsandel | 6,35 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 567 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 355 | [mg/MJ] |
| Justeret partikulær udslipsandel | 5,31 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 198 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 2,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 2,5 | [kW] |
| Middelhastighed i tunnel | 4,53 | [m/s] |
| Virkningsgrad | 81 | [%] |
| Røggasflow i tunnel | 460150 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 613 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,38 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,49 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 65,3 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 0,75 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,63 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,73 | [timer] |
| Måling start | 07-09-2009 14:41:20 | [Dato/Tid] |
| Måling stop | 07-09-2009 16:25:10 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 3-dag-Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 10,0 | [%] |
| CO2 beregnet i tunnel | 0,422 | [%] |
| CO målt i skorsten | 0,52 | [%] |
| CO beregnet i skorsten | 0,40 | [% ved 13% O2] |
| CO beregnet i skorsten | 3968 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4960 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3126 | [mg/MJ] |
| CO udslip | 46,71 | [g/kg (indfyret)] |
| THC målt i tunnel | 49 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 14 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 35 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1153 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 330 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 823 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 370 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 233 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 3,49 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 519 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 327 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,88 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 741 | [Nl (Tør)] |
| Opsamlet mængde partikler | 11,1 | [mg] |
| Partikulær udslipsandel | 7,12 | [g/h] |
| Justeret partikulær udslipsandel | 9,28 | [g/h] |
| Justeret partikulær udslipsandel | 4,50 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 400 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 252 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,77 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 258 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 8,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 8,0 | [kW] |
| Middelhastighed i tunnel | 4,68 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 475472 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 193 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,11 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,24 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 23,8 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 2,47 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,06 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,65 | [timer] |
| Måling start | 08-09-2009 09:10:05 | [Dato/Tid] |
| Måling stop | 08-09-2009 09:49:00 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 3-dag-Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,0 | [%] |
| CO2 beregnet i tunnel | 0,363 | [%] |
| CO målt i skorsten | 0,29 | [%] |
| CO beregnet i skorsten | 0,25 | [% ved 13% O2] |
| CO beregnet i skorsten | 2492 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3115 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1999 | [mg/MJ] |
| CO udslip | 29,87 | [g/kg (indfyret)] |
| THC målt i tunnel | 22 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 14 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 547 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 191 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 355 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 176 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 113 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,69 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 271 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 174 | [mgC/MJ] |
| OGC beregnet i skorsten | 2,60 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 321 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 19 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 36 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,2 | [kW] |
| Middelhastighed i tunnel | 4,67 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 465699 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 226 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,10 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,21 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,9 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,06 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,72 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,87 | [timer] |
| Måling start | 08-09-2009 09:49:00 | [Dato/Tid] |
| Måling stop | 08-09-2009 10:41:25 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 3-dag-1-Nominel | |
| CO2 målt i skorsten | 9,1 | [%] |
| CO2 beregnet i tunnel | 0,359 | [%] |
| CO målt i skorsten | 0,54 | [%] |
| CO beregnet i skorsten | 0,46 | [% ved 13% O2] |
| CO beregnet i skorsten | 4581 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5727 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3582 | [mg/MJ] |
| CO udslip | 53,51 | [g/kg (indfyret)] |
| THC målt i tunnel | 77 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 23 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 54 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1938 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 573 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1365 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 675 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 422 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,30 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 958 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 599 | [mgC/MJ] |
| OGC beregnet i skorsten | 8,95 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 996 | [Nl (Tør)] |
| Opsamlet mængde partikler | 12,2 | [mg] |
| Partikulær udslipsandel | 5,65 | [g/h] |
| Justeret partikulær udslipsandel | 7,66 | [g/h] |
| Justeret partikulær udslipsandel | 4,44 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 397 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 248 | [mg/MJ] |
| Justeret partikulær udslipsandel | 3,71 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 333 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 39 | [°C] |
| Temperatur i filter | 31 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,0 | [kW] |
| Middelhastighed i tunnel | 4,65 | [m/s] |
| Virkningsgrad | 70 | [%] |
| Røggasflow i tunnel | 461213 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 223 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,85 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,97 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,07 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,73 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,87 | [timer] |
| Måling start | 08-09-2009 10:41:25 | [Dato/Tid] |
| Måling stop | 08-09-2009 11:33:40 | [Dato/Tid] |

# Måleresultater



| | | |
|---|---|---|
| Fyringsanlæg: | Morsø 1440 | |
| Rensningsenhed: | Ingen | |
| Prøvning: | 3-dag-2-Nominel | |
| CO2 målt i skorsten | 9,5 | [%] |
| CO2 beregnet i tunnel | 0,361 | [%] |
| CO målt i skorsten | 0,52 | [%] |
| CO beregnet i skorsten | 0,42 | [% ved 13% O2] |
| CO beregnet i skorsten | 4219 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 5273 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3313 | [mg/MJ] |
| CO udslip | 49,49 | [g/kg (indfyret)] |
| THC målt i tunnel | 58 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 18 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 40 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1527 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 482 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1045 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 494 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 310 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,63 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 721 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 453 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,77 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 338 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 40 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,0 | [kW] |
| Middelhastighed i tunnel | 4,61 | [m/s] |
| Virkningsgrad | 71 | [%] |
| Røggasflow i tunnel | 454512 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 224 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,50 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,62 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 26,4 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,03 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,70 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,89 | [timer] |
| Måling start | 08-09-2009 11:33:40 | [Dato/Tid] |
| Måling stop | 08-09-2009 12:27:00 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 3-dag-3-Nominel |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,6 | [%] |
| CO2 beregnet i tunnel | 0,385 | [%] |
| CO målt i skorsten | 0,38 | [%] |
| CO beregnet i skorsten | 0,31 | [% ved 13% O2] |
| CO beregnet i skorsten | 3081 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3851 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2453 | [mg/MJ] |
| CO udslip | 36,65 | [g/kg (indfyret)] |
| THC målt i tunnel | 30 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 10 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 20 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 759 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 254 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 505 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 236 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 150 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,24 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 354 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 226 | [mgC/MJ] |
| OGC beregnet i skorsten | 3,37 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 966 | [Nl (Tør)] |
| Opsamlet mængde partikler | 9,3 | [mg] |
| Partikulær udslipsandel | 4,36 | [g/h] |
| Justeret partikulær udslipsandel | 6,18 | [g/h] |
| Justeret partikulær udslipsandel | 3,48 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 305 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 195 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,91 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 344 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 20 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 41 | [°C] |
| Temperatur i filter | 33 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 6,3 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 6,3 | [kW] |
| Middelhastighed i tunnel | 4,61 | [m/s] |
| Virkningsgrad | 72 | [%] |
| Røggasflow i tunnel | 453378 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 213 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,50 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,63 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 25,1 | [gg] |
| Charge mængde | 1,79 | [kg] |
| Brændselsforbrug (indfyret) | 2,13 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,78 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,84 | [timer] |
| Måling start | 08-09-2009 12:27:00 | [Dato/Tid] |
| Måling stop | 08-09-2009 13:17:35 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | Ingen |
| Prøvning: | 3-dag-3-Overgang |

| | | |
|---|---|---|
| CO2 målt i skorsten | 9,7 | [%] |
| CO2 beregnet i tunnel | 0,180 | [%] |
| CO målt i skorsten | 0,49 | [%] |
| CO beregnet i skorsten | 0,39 | [% ved 13% O2] |
| CO beregnet i skorsten | 3946 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4933 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 3112 | [mg/MJ] |
| CO udslip | 46,49 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 7 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 11 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 966 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 397 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 569 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 265 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 167 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,49 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 449 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 283 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,23 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | #I/T | [Nl (Tør)] |
| Opsamlet mængde partikler | #I/T | [mg] |
| Partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/h] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | #I/T | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | #I/T | [mg/MJ] |
| Justeret partikulær udslipsandel | #I/T | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 232 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 16 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,4 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,4 | [kW] |
| Middelhastighed i tunnel | 4,58 | [m/s] |
| Virkningsgrad | 80 | [%] |
| Røggasflow i tunnel | 462459 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 451 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 8,40 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 7,52 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 53,6 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,03 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,86 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,27 | [timer] |
| Måling start | 08-09-2009 13:17:35 | [Dato/Tid] |
| Måling stop | 08-09-2009 14:33:45 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: Ingen
Prøvning: 3-dag-3-Lavlast

| | | |
|---|---|---|
| CO2 målt i skorsten | 8,2 | [%] |
| CO2 beregnet i tunnel | 0,179 | [%] |
| CO målt i skorsten | 0,67 | [%] |
| CO beregnet i skorsten | 0,63 | [% ved 13% O2] |
| CO beregnet i skorsten | 6323 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 7904 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 4843 | [mg/MJ] |
| CO udslip | 72,35 | [g/kg (indfyret)] |
| THC målt i tunnel | 18 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 8 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 10 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 843 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 388 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 455 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 246 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 150 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 2,25 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 455 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 279 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,17 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1977 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,0 | [mg] |
| Partikulær udslipsandel | 0,97 | [g/h] |
| Justeret partikulær udslipsandel | 1,78 | [g/h] |
| Justeret partikulær udslipsandel | 2,41 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 220 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 135 | [mg/MJ] |
| Justeret partikulær udslipsandel | 2,01 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 196 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 14 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 31 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 2,9 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 2,9 | [kW] |
| Middelhastighed i tunnel | 3,79 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 384850 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 436 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 9,49 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 8,60 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 45,9 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 0,88 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,74 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,70 | [timer] |
| Måling start | 08-09-2009 14:33:45 | [Dato/Tid] |
| Måling stop | 08-09-2009 16:15:50 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: Optænding

| | | |
|---|---|---|
| CO2 målt i skorsten | 10,9 | [%] |
| CO2 beregnet i tunnel | 0,446 | [%] |
| CO målt i skorsten | 0,28 | [%] |
| CO beregnet i skorsten | 0,20 | [% ved 13% O2] |
| CO beregnet i skorsten | 2005 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2507 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1619 | [mg/MJ] |
| CO udslip | 24,19 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 2 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 18 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 485 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 44 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 441 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 185 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 119 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,78 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 203 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 131 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,96 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 703 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,0 | [mg] |
| Partikulær udslipsandel | 3,30 | [g/h] |
| Justeret partikulær udslipsandel | 4,90 | [g/h] |
| Justeret partikulær udslipsandel | 2,38 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 206 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 133 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,99 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 199 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 10 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 28 | [°C] |
| Temperatur i filter | 23 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 8,7 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 8,7 | [kW] |
| Middelhastighed i tunnel | 4,52 | [m/s] |
| Virkningsgrad | 85 | [%] |
| Røggasflow i tunnel | 464210 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 188 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,73 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,86 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,4 | [gg] |
| Charge mængde | 1,60 | [kg] |
| Brændselsforbrug (indfyret) | 2,47 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,06 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,65 | [timer] |
| Måling start | 30-09-2009 09:55:29 | [Dato/Tid] |
| Måling stop | 30-09-2009 10:34:29 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: Forfyring

| | | |
|---|---|---|
| CO2 målt i skorsten | 11,9 | [%] |
| CO2 beregnet i tunnel | 0,483 | [%] |
| CO målt i skorsten | 0,28 | [%] |
| CO beregnet i skorsten | 0,18 | [% ved 13% O2] |
| CO beregnet i skorsten | 1842 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 2302 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 1490 | [mg/MJ] |
| CO udslip | 22,26 | [g/kg (indfyret)] |
| THC målt i tunnel | 21 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 2 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 20 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 525 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 42 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 483 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 186 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 121 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 1,80 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 203 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 131 | [mgC/MJ] |
| OGC beregnet i skorsten | 1,96 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 850 | [Nl (Tør)] |
| Opsamlet mængde partikler | 5,7 | [mg] |
| Partikulær udslipsandel | 2,96 | [g/h] |
| Justeret partikulær udslipsandel | 4,48 | [g/h] |
| Justeret partikulær udslipsandel | 2,11 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 183 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 118 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,77 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 284 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 33 | [°C] |
| Temperatur i filter | 25 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 8,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 8,5 | [kW] |
| Middelhastighed i tunnel | 4,42 | [m/s] |
| Virkningsgrad | 81 | [%] |
| Røggasflow i tunnel | 445901 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 176 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,14 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,28 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 24,6 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,54 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 2,12 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,71 | [timer] |
| Måling start | 30-09-2009 10:40:59 | [Dato/Tid] |
| Måling stop | 30-09-2009 11:23:29 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: 1. charge

| | | |
|---|---|---|
| CO2 målt i skorsten | 11,5 | [%] |
| CO2 beregnet i tunnel | 0,406 | [%] |
| CO målt i skorsten | 0,47 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3181 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3976 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2530 | [mg/MJ] |
| CO udslip | 37,80 | [g/kg (indfyret)] |
| THC målt i tunnel | 65 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 2 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 64 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1845 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 46 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1799 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 718 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 457 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,83 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 736 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 469 | [mgC/MJ] |
| OGC beregnet i skorsten | 7,00 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 933 | [Nl (Tør)] |
| Opsamlet mængde partikler | 4,9 | [mg] |
| Partikulær udslipsandel | 2,35 | [g/h] |
| Justeret partikulær udslipsandel | 3,70 | [g/h] |
| Justeret partikulær udslipsandel | 2,03 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 178 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 113 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,70 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 286 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 34 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 7,2 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 7,2 | [kW] |
| Middelhastighed i tunnel | 4,46 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 447976 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 205 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,27 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,41 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 28,2 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,18 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,83 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,82 | [timer] |
| Måling start | 30-09-2009 11:35:59 | [Dato/Tid] |
| Måling stop | 30-09-2009 12:25:29 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: 2. charge

| | | |
|---|---|---|
| CO2 målt i skorsten | 11,4 | [%] |
| CO2 beregnet i tunnel | 0,406 | [%] |
| CO målt i skorsten | 0,47 | [%] |
| CO beregnet i skorsten | 0,32 | [% ved 13% O2] |
| CO beregnet i skorsten | 3170 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 3962 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2522 | [mg/MJ] |
| CO udslip | 37,67 | [g/kg (indfyret)] |
| THC målt i tunnel | 67 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 1 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 66 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1885 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 41 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1844 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 740 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 471 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 7,04 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 756 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 481 | [mgC/MJ] |
| OGC beregnet i skorsten | 7,19 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 938 | [Nl (Tør)] |
| Opsamlet mængde partikler | 4,1 | [mg] |
| Partikulær udslipsandel | 1,95 | [g/h] |
| Justeret partikulær udslipsandel | 3,17 | [g/h] |
| Justeret partikulær udslipsandel | 1,74 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 153 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 97 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,46 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 288 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 35 | [°C] |
| Temperatur i filter | 28 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 7,1 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 7,1 | [kW] |
| Middelhastighed i tunnel | 4,45 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 446747 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 205 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,31 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,45 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 28,0 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,18 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,82 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,82 | [timer] |
| Måling start | 30-09-2009 12:30:29 | [Dato/Tid] |
| Måling stop | 30-09-2009 13:19:59 | [Dato/Tid] |

# Måleresultater



Fyringsanlæg: Morsø 1440
Rensningsenhed: APP
Prøvning: 3. charge

| | | |
|---|---|---|
| CO2 målt i skorsten | 11,4 | [%] |
| CO2 beregnet i tunnel | 0,427 | [%] |
| CO målt i skorsten | 0,50 | [%] |
| CO beregnet i skorsten | 0,34 | [% ved 13% O2] |
| CO beregnet i skorsten | 3394 | [ppm ved 13% O2] |
| CO beregnet i skorsten | 4242 | [mg/Nm3 (Tør) ved 13% O2] |
| CO udslip | 2692 | [mg/MJ] |
| CO udslip | 40,22 | [g/kg (indfyret)] |
| THC målt i tunnel | 66 | [ppm CH4 ækv.] |
| CH4 målt i tunnel | 1 | [ppm CH4 ækv.] |
| NMVOC beregnet i tunnel | 65 | [ppm CH4 ækv.] |
| THC beregnet i skorsten | 1777 | [ppm CH4 ækv.] |
| CH4 beregnet i skorsten | 36 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 1741 | [ppm CH4 ækv.] |
| NMVOC beregnet i skorsten | 696 | [mgC/Nm3 (Tør) ved 13%O2] |
| NMVOC beregnet i skorsten | 442 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 6,60 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 711 | [mgC/Nm3 (Tør) ved 13%O2] |
| OGC beregnet i skorsten | 451 | [mgC/MJ] |
| OGC beregnet i skorsten | 6,74 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 963 | [Nl (Tør)] |
| Opsamlet mængde partikler | 3,8 | [mg] |
| Partikulær udslipsandel | 1,64 | [g/h] |
| Justeret partikulær udslipsandel | 2,75 | [g/h] |
| Justeret partikulær udslipsandel | 1,53 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 135 | [mg/Nm3 (Tør) ved 13%O2] |
| Justeret partikulær udslipsandel | 86 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,28 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 288 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 13 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 35 | [°C] |
| Temperatur i filter | 29 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 7,0 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 7,0 | [kW] |
| Middelhastighed i tunnel | 4,15 | [m/s] |
| Virkningsgrad | 79 | [%] |
| Røggasflow i tunnel | 416351 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 194 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,27 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,41 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 26,7 | [gg] |
| Charge mængde | 1,80 | [kg] |
| Brændselsforbrug (indfyret) | 2,14 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,79 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 0,84 | [timer] |
| Måling start | 30-09-2009 13:24:59 | [Dato/Tid] |
| Måling stop | 30-09-2009 14:15:29 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | APP |
| Prøvning: | Overgang |

| | | |
|---|---|---|
| $CO_2$ målt i skorsten | 10,6 | [%] |
| $CO_2$ beregnet i tunnel | 0,192 | [%] |
| CO målt i skorsten | 0,69 | [%] |
| CO beregnet i skorsten | 0,50 | [% ved 13% $O_2$] |
| CO beregnet i skorsten | 5031 | [ppm ved 13% $O_2$] |
| CO beregnet i skorsten | 6289 | [mg/Nm3 (Tør) ved 13% $O_2$] |
| CO udslip | 3916 | [mg/MJ] |
| CO udslip | 58,50 | [g/kg (indfyret)] |
| THC målt i tunnel | 20 | [ppm $CH_4$ ækv.] |
| $CH_4$ målt i tunnel | 1 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i tunnel | 19 | [ppm $CH_4$ ækv.] |
| THC beregnet i skorsten | 1093 | [ppm $CH_4$ ækv.] |
| $CH_4$ beregnet i skorsten | 49 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 1043 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 448 | [mgC/Nm3 (Tør) ved 13%$O_2$] |
| NMVOC beregnet i skorsten | 279 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,17 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 469 | [mgC/Nm3 (Tør) ved 13%$O_2$] |
| OGC beregnet i skorsten | 292 | [mgC/MJ] |
| OGC beregnet i skorsten | 4,36 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1360 | [Nl (Tør)] |
| Opsamlet mængde partikler | 1,4 | [mg] |
| Partikulær udslipsandel | 0,47 | [g/h] |
| Justeret partikulær udslipsandel | 0,98 | [g/h] |
| Justeret partikulær udslipsandel | 1,07 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 97 | [mg/Nm3 (Tør) ved 13%$O_2$] |
| Justeret partikulær udslipsandel | 60 | [mg/MJ] |
| Justeret partikulær udslipsandel | 0,90 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 176 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 9 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 30 | [°C] |
| Temperatur i filter | 27 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 3,8 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 3,8 | [kW] |
| Middelhastighed i tunnel | 4,53 | [m/s] |
| Virkningsgrad | 85 | [%] |
| Røggasflow i tunnel | 461369 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 422 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,67 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,80 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 55,1 | [gg] |
| Charge mængde | 1,30 | [kg] |
| Brændselsforbrug (indfyret) | 1,09 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 0,91 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,19 | [timer] |
| Måling start | 30-09-2009 14:23:29 | [Dato/Tid] |
| Måling stop | 30-09-2009 15:35:00 | [Dato/Tid] |

# Måleresultater



| | |
|---|---|
| Fyringsanlæg: | Morsø 1440 |
| Rensningsenhed: | APP |
| Prøvning: | Lavlast |

| | | |
|---|---|---|
| $CO_2$ målt i skorsten | 11,1 | [%] |
| $CO_2$ beregnet i tunnel | 0,220 | [%] |
| CO målt i skorsten | 0,74 | [%] |
| CO beregnet i skorsten | 0,51 | [% ved 13% $O_2$] |
| CO beregnet i skorsten | 5109 | [ppm ved 13% $O_2$] |
| CO beregnet i skorsten | 6386 | [mg/Nm3 (Tør) ved 13% $O_2$] |
| CO udslip | 3970 | [mg/MJ] |
| CO udslip | 59,31 | [g/kg (indfyret)] |
| THC målt i tunnel | 27 | [ppm $CH_4$ ækv.] |
| $CH_4$ målt i tunnel | 1 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i tunnel | 26 | [ppm $CH_4$ ækv.] |
| THC beregnet i skorsten | 1350 | [ppm $CH_4$ ækv.] |
| $CH_4$ beregnet i skorsten | 45 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 1305 | [ppm $CH_4$ ækv.] |
| NMVOC beregnet i skorsten | 535 | [mgC/Nm3 (Tør) ved 13%$O_2$] |
| NMVOC beregnet i skorsten | 333 | [mgC/MJ] |
| NMVOC beregnet i skorsten | 4,97 | [gC/kg (indfyret)] |
| OGC beregnet i skorsten | 553 | [mgC/Nm3 (Tør) ved 13%$O_2$] |
| OGC beregnet i skorsten | 344 | [mgC/MJ] |
| OGC beregnet i skorsten | 5,14 | [gC/kg (indfyret)] |
| Udsuget gasvolumen | 1396 | [Nl (Tør)] |
| Opsamlet mængde partikler | 2,3 | [mg] |
| Partikulær udslipsandel | 0,76 | [g/h] |
| Justeret partikulær udslipsandel | 1,44 | [g/h] |
| Justeret partikulær udslipsandel | 1,39 | [g/kg (tørstof)] |
| Justeret partikelkoncentration i skorsten | 125 | [mg/Nm3 (Tør) ved 13%$O_2$] |
| Justeret partikulær udslipsandel | 78 | [mg/MJ] |
| Justeret partikulær udslipsandel | 1,16 | [g/kg (indfyret)] |
| Røggastemperatur før enhed | 155 | [°C ved 20° rumtemperatur] |
| Røggastemperatur efter enhed | - | [°C ved 20° rumtemperatur] |
| Træk før enhed | 8 | [Pa] |
| Træk efter enhed | - | [Pa] |
| Temperatur midt i tunnel | 29 | [°C] |
| Temperatur i filter | 26 | [°C] |
| Vandflow | - | [l/h] |
| Temperatur fremløb | - | [°C] |
| Temperatur retur | - | [°C] |
| Totalydelse | 4,5 | [kW] |
| Vandside ydelse | 0,0 | [kW] |
| Rum ydelse | 4,5 | [kW] |
| Middelhastighed i tunnel | 4,48 | [m/s] |
| Virkningsgrad | 86 | [%] |
| Røggasflow i tunnel | 458545 | [Nl/h] |
| Røggasvolumen, fugtig i tunnel | 369 | [Nm3/kg (indfyret)] |
| Røggasvolumen, fugtig i skorsten, beregnet | 7,31 | [Nm3/kg (indfyret)] |
| Røggasvolumen, tør i skorsten, beregnet | 6,45 | [Nm3/kg (indfyret)] |
| Fortyndingsgrad fra skorsten til tunnel | 50,5 | [gg] |
| Charge mængde | 1,50 | [kg] |
| Brændselsforbrug (indfyret) | 1,24 | [kg (indfyret)/h] |
| Brændselsforbrug (tørstof) | 1,04 | [kg (tørstof)/h] |
| Brændværdi (Hn) | 14,940 | [MJ/kg (indfyret)] |
| Vandindhold i brændet | 16 | [%] |
| Måletid | 1,21 | [timer] |
| Måling start | 30-09-2009 15:42:30 | [Dato/Tid] |
| Måling stop | 30-09-2009 16:55:00 | [Dato/Tid] |