Emission Testing of wood fired stoves or fireplaces

Standards and Test Procedures in Australia/New Zealand, Europe and North America

- Introduction
  Definition, Categories, Impact
- Test Procedures & Standards
  ‚AUS/NZ, Europe, USA/CAN
- Example
  inset appliance with various tests
- Conclusion

SPARTHERM®
Feuerungstechnik

Spartherm Main Site:
Melle, Germany

Fireplace Inserts,
wood stoves

Definition

Small wood fired appliances:

Common names:
wood stoves, tiled stoves, fireplaces,
and many more

Standardisation:
room heaters, inset appliances, inserts,
wood heaters, fireplaces

Intended use:
living room heating and decoration

Typical features:
- manually fed with batches of cord wood,
- natural chimney draught,
- manually controlled by user,
- operation without electric power

free standing

inbuilt

Impact of wood combustion

Table 2-16: Lot 15 appliances sales and stock (2007)

Appliance type		sales	stock
indirect heating appliances	manually fuelled boilers	250 400	6 433 000
	automatically fuelled boilers	62 600	1 412 000
direct heating appliances	open fireplaces	850 000	16 000 000
	closed fireplaces / inserts	849 100	16 139 000
	stoves	1 306 700	25 901 000
	cookers	464 200	7 594 000

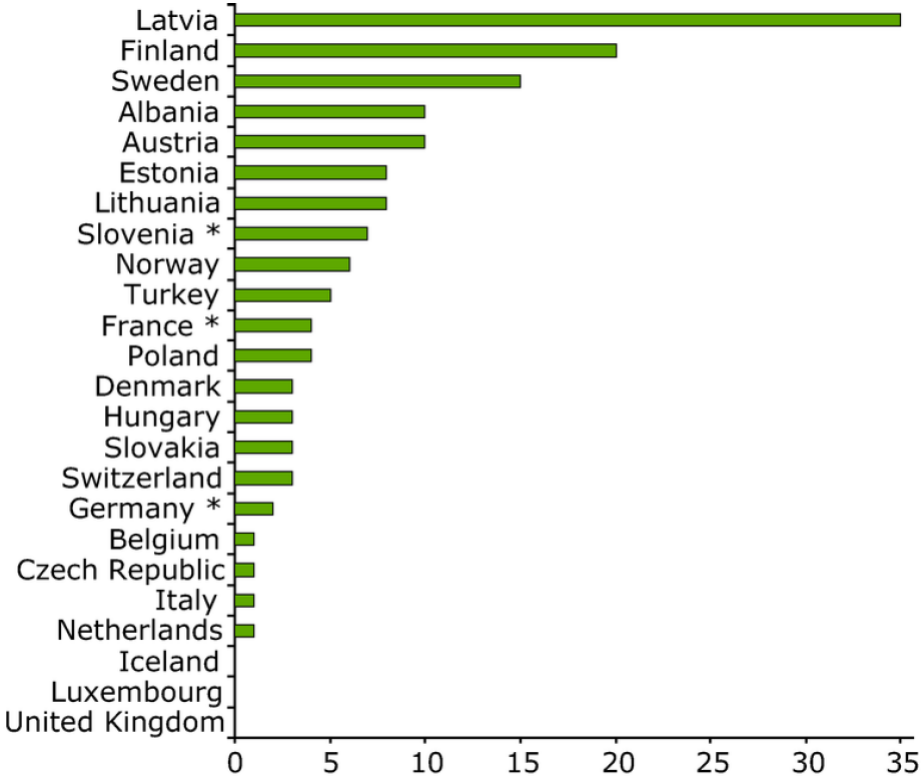
~73 Mio.

Ecodesign, Lot 15: Solid fuel small combustion installations, Preparatory Study (2009)
Task 2: Economic and Market Analysis

Impact of wood combustion

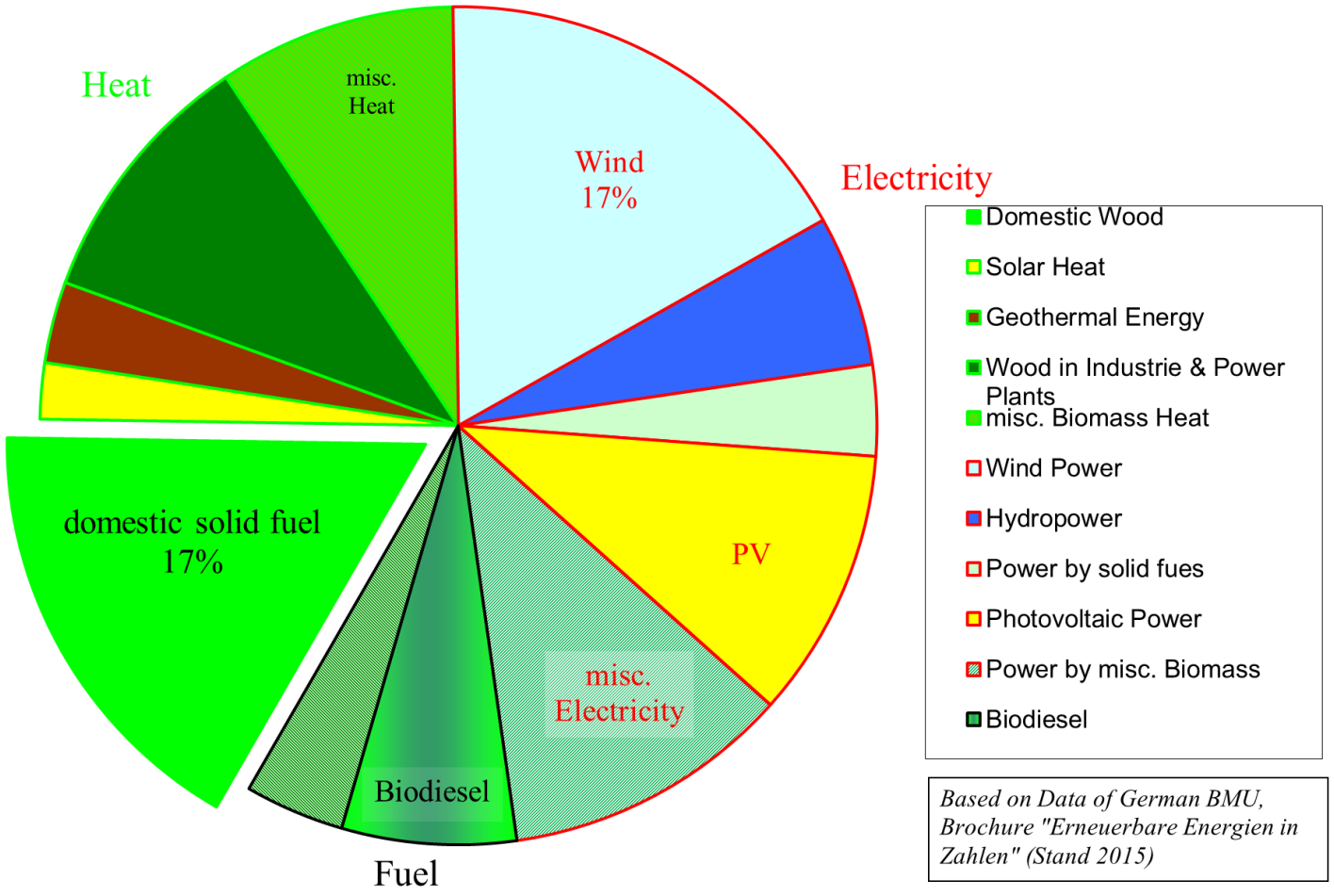
Contribution of wood energy to total energy consumption, 2005

* 2000 values were used for France, Germany and Slovenia



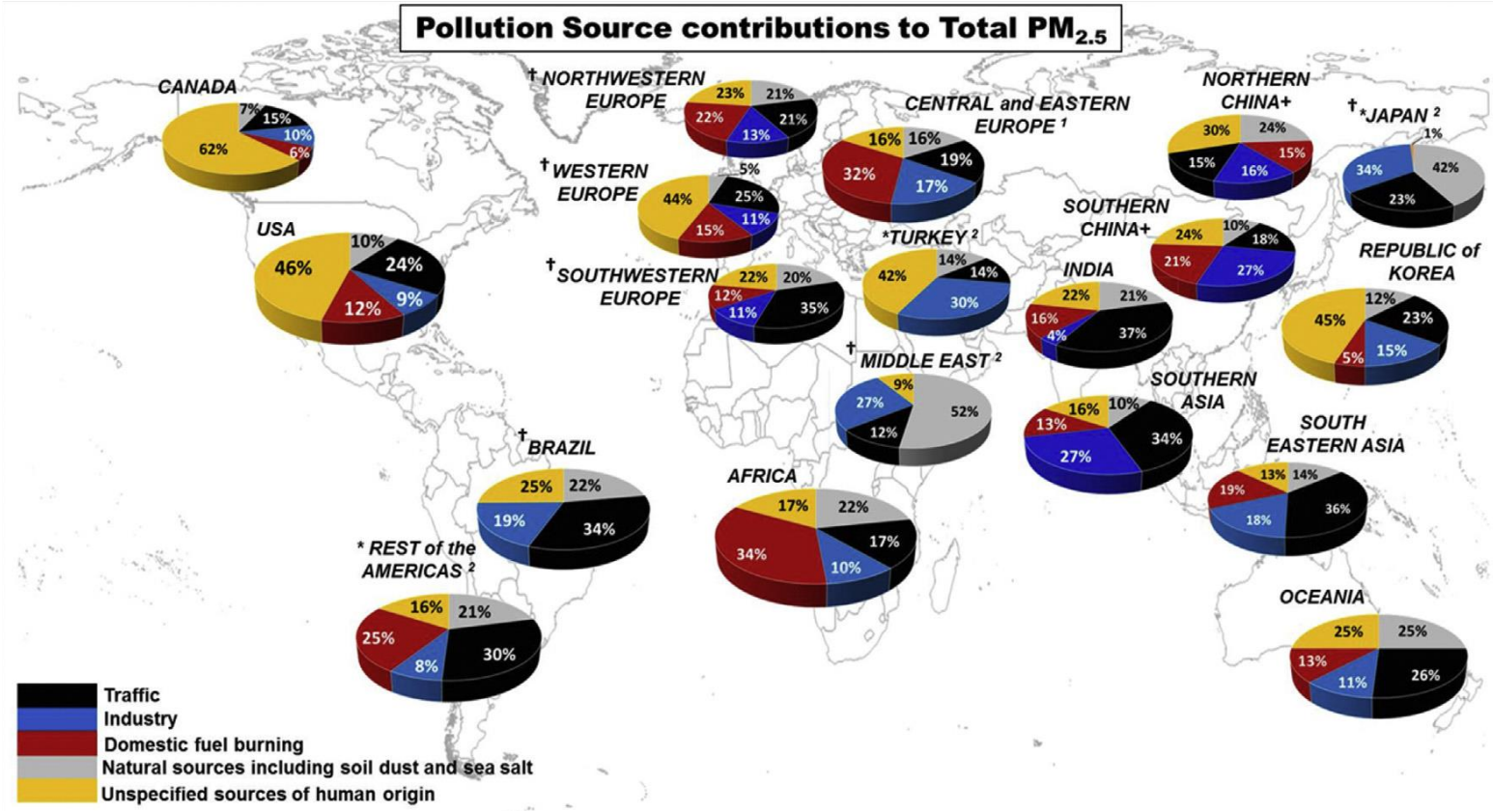
Impact of wood combustion

2014: 336 TWh Renewable Energy in Germany



Based on Data of German BMU, Brochure "Erneuerbare Energien in Zahlen" (Stand 2015)

Impact of wood combustion

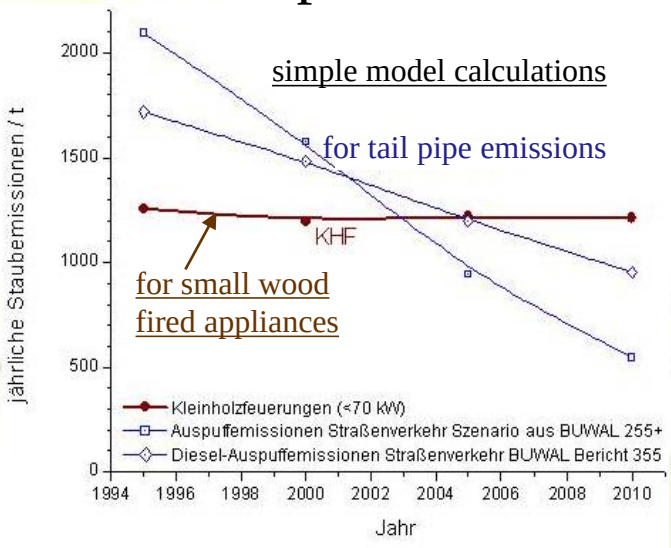


Problem: Emissions of small wood fired appliances, **locally major source of particulates in ambient air**

Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level (2015) Karagulian, F.; Belis, C.A.; Dora, C.F.C.; Prüss-Ustün, A.M.; Bonjour, S.; Adair-Rohani, H.; Amann, M. Atmospheric Environment, pp. 475-483

Impact of wood combustion

Retrospective view



V. Schmatloch, J.Brenn,
4. Kolloquium Klein-Holzfeuerungen 2004

→Stricter requirements for small wood fired appliances

→Standardisation work

Impact of wood combustion

Requirements or Regulation

national / regional / local based on type tests and upcoming market surveillance
Efficiency / Particulates / CO / NOx / OGC

NZ: no general national requirements
requirements in „urban areas“ (premises >20ha)
depending on local council (0,5g/kg to 1,5g/kg particulates)

USA: EPA requirements for „wood heaters“,
application differs depending on state or county
no requirements for „fireplaces“, exemption for decorative or single burn rate units

EU: general requirements scheduled for 2022
presently different regulations in some member states

UK: no general requirements
Clean Air Act → Smoke Control areas (smokeless fuels or exempt appliances)

D: National requirements on Efficiency, gaseous and particulate emissions, exemption for „open fireplaces“

CH: National requirements on Efficiency, gaseous and particulate emissions, exemption for „open fireplaces“

No: National requirements on Particulates, exemption for large appliances

Test Procedures

Basic objectives of type tests

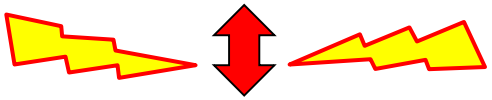
- Fire Safety
- Heating Performance
- Efficiency
- Emissions (CO, PM, NO_x, C_nH_m/OGC/VOC)
- Test of compliance with declared performance and with requirements
  → Certification

Procedures for

Standardised Characterisation

Comparison of different models

at



„realistic“ operating conditions

Test Procedures

Measurement method

setup/sampling, principle/technology

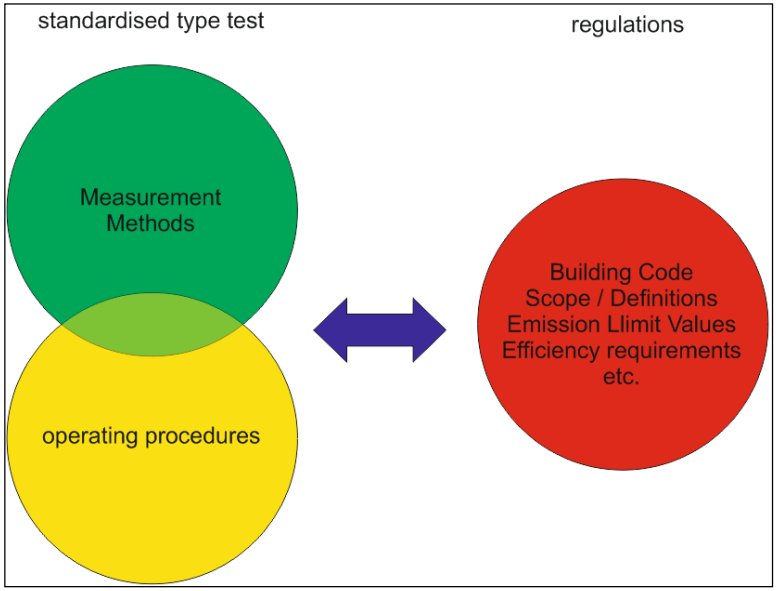
Appliance operation

chimney, fuel, loading combustion air, ignition, raking

→ full load / part load or burn rates

Regulation

limit values, allowed fuels



Test Procedures, PM sampling systems

Particulate Emissions

Solid particles and condensibles

Possible approach

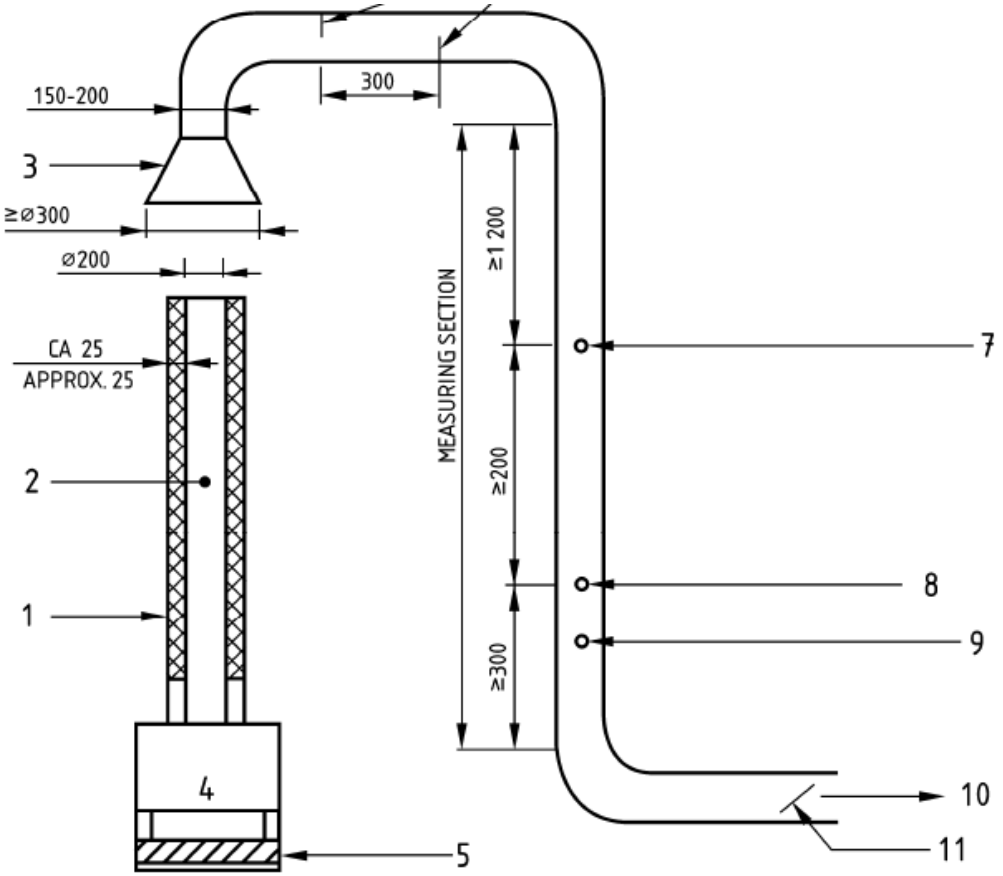
A) Simulation of chimney conditions,
→ condensibles for model conditions
full flow dilution tunnel

B) Measurements of flue gas components
→ solid particles and condensibles separately
Heated Filter and FID

General objective:

lower type test emissions → reduced ambient air pollution

Test Procedures, PM sampling systems

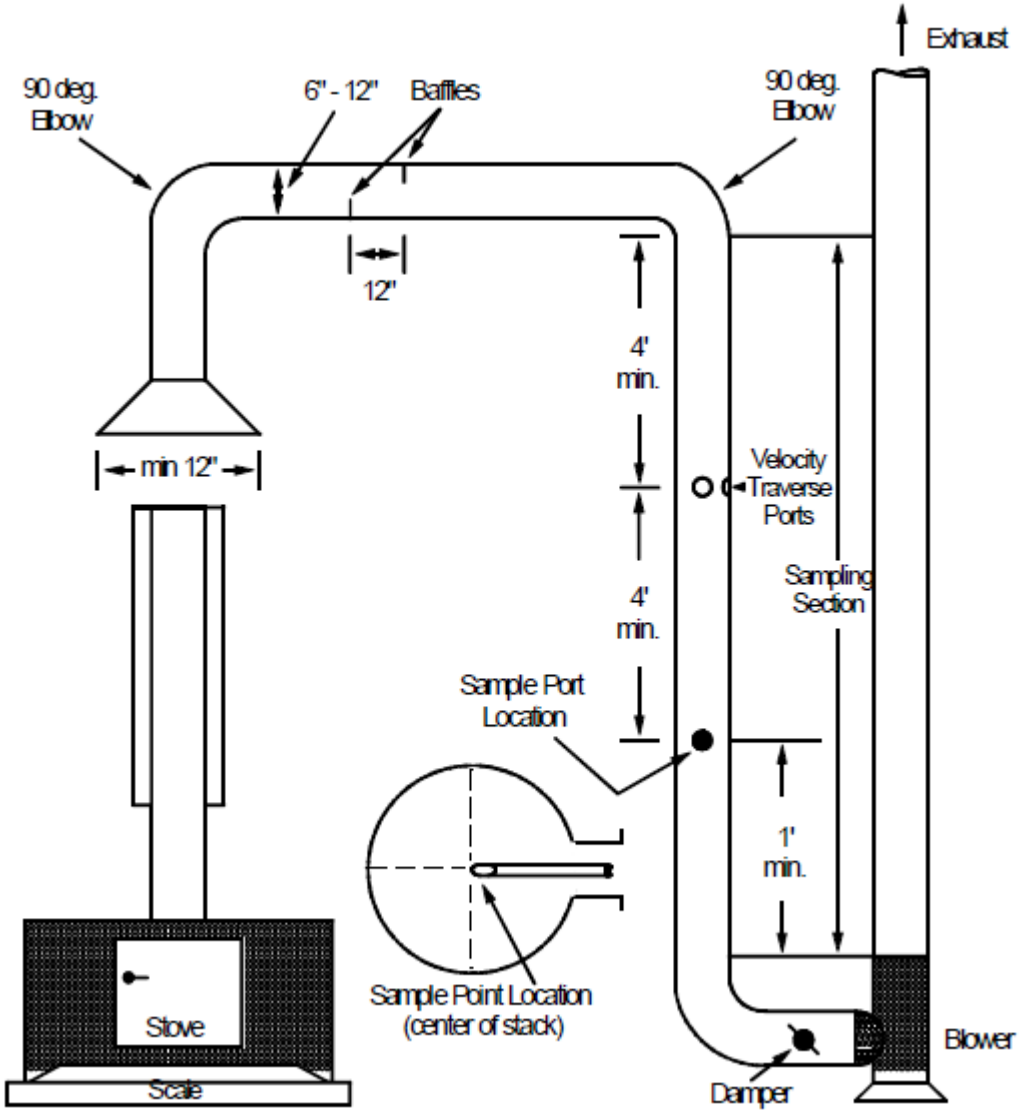


Legende

1	Isolierung	7	Geschwindigkeitsmessung
2	Schornstein	8	Partikel- und PAK-Messung
3	Abgastrichter	9	CO- und CO_2-Messung
4	Heizgerät	10	Sonde
5	Waage	11	Klappe
6	Verwirbelungsplatten		

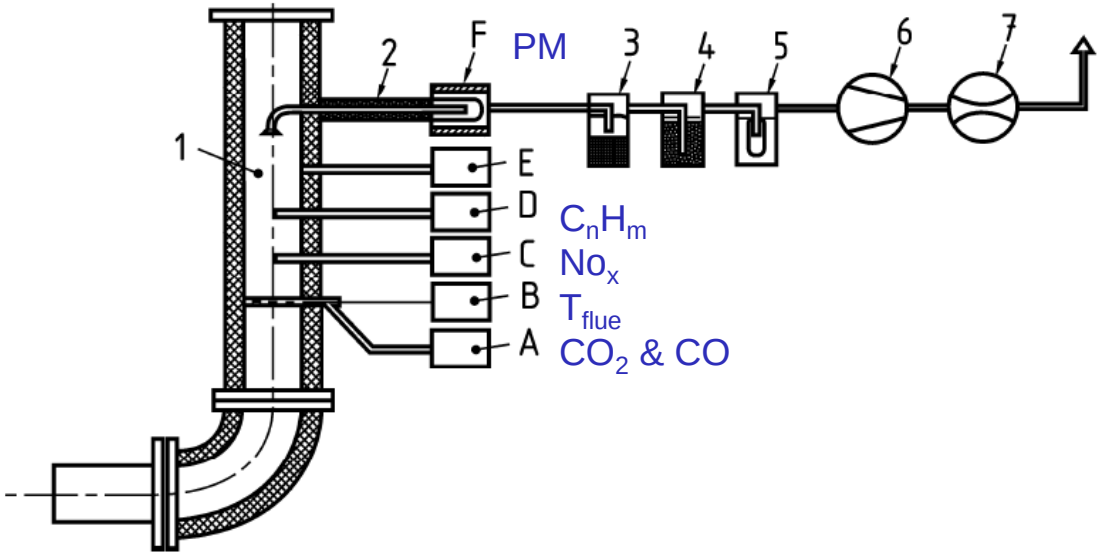
According to TS15883

Test Procedures, PM sampling systems



According to CSA B415

Test Procedures, PM sampling systems



Legende

1 Messstrecke
2 Gas-Probeentnahmesonde und Leitung für die Partikelmessung (wärmeisoliert)
3 Wasserabscheider
4 Kieselgel-Filter
5 Extrafein-Filter
6 Pumpe
7 Gas-Durchflussmengenmesser

A CO_2- und CO-Messung
B Abgastemperatur t_a-Messung
C NO_x-Messung
D C_nH_m-Messung
E Förderdruck-Messung
F Partikelfilter (off-line gravimetrische Messung)

According to TS15883

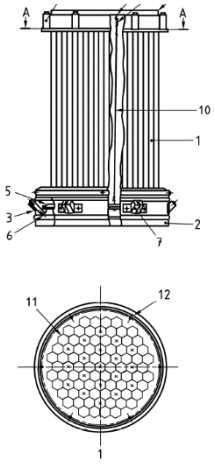
Test Procedures, PM sampling systems

Collection of particulates

Filters, most common material diameter

Aus „Feinstaubbildung in Holzfeuerungen“,
N.Klippel, T. Nussbaumer,
9. Holzenergie-Symposium 2006

UK alternative methode: ESP



According to TS15883

Test Procedures, operation and handling

General approach

A) Operating conditions fixed by standard

B) Operation according to user instructions („intended use“)

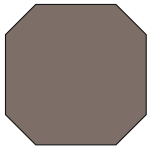
Various parameters:

- Fuel load – mass / position / geometry
- Air setting
- Poking / Raking
- Refueling

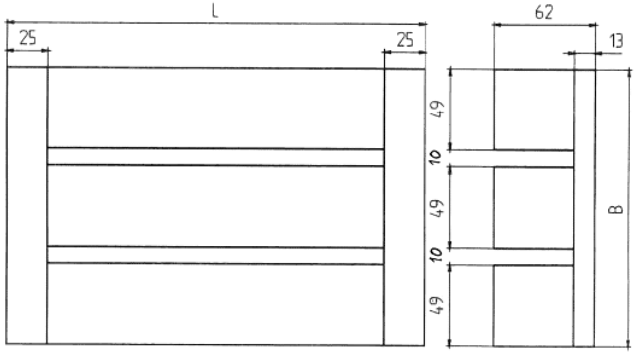
Test Procedures, operation and handling

Examples for Fuel load – mass and geometry

AUS/NZ: Mass according to Volume as determined by „125mm cube method“, $L_f=P_d \cdot 0.165 \cdot V/(1-M/100)$, premanufactured fuel (octagonal crosssection) piled without fixation



No: Mass according to Volume (112±11)kg/m^3
crib wood made of pieces (49mm square crosssection) stitched together with defined with spacers



According to NS 3058

Test Procedures, operation and handling

Examples for Fuel load – mass and geometry

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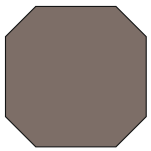


Test Procedures, operation and handling

Examples for fuel load – mass and geometry

EN – European standards: cord wood
fuel loading according to user instructions

Broschure Holzenergie Schweiz
Publikation-Nr. 315 - 2007/10 – 400
www.holzenergie.ch · www.energie-schweiz

Test Procedures, operation and handling

Burn rate / Nominal heat output

EPA (USA) – four given burn rates required

BURN RATE CATEGORIES
[Average kg/hr (lb/hr), dry basis)

Category 1	Category 2	Category 3	Category 4
< 0.80 (< 1.76)	0.80 to 1.25 (1.76 to 2.76)	1.25 to 1.90 (2.76 to 4.19)	Maximum burn rate

According to EPA

NS 3058 (No)
Similar to EPA,
but four burn rates from below 1.25kg/h to >2.80kg/h possible

AUS/NZ: low, medium and high burn rates required

EN - European standards:
Nominal heat output according to user instructions
Standard requirements on minimum burn time → fuel load

Test Procedures, operation and handling

Number of tests

AUS/NZ: one valid test for each burn rate

USA/CAN: one valid test for each burn rate

No: one valid test for each burn rate

UK: two burn rates with 5 valid test runs

EN: one burn rate, 2 to3 vaild test runs

Test Procedures

Overview of selected specifics

	AUS/NZ	EN	No	USA/CAN
Test setup	calor. Room	test stand	test stand	test stand
Sampling	FFDT	HF[1]	FFDT	FFDT
Exhaust system	defined chimney	fixed draught	defined chimney	defined chimney
Burn rate	standard	user instr.	standard	standard
# of burn rates	3 (1) [2]	1 [4]	4 (2) [3]	4 (1) [2]
Fuel load	fbV*	user instr.	fbV*	fbV*
Raking/Adjusting	while starting	no	while starting	while starting
Fuel type	constr.	Cord wood	constr.	constr.
Bark	no	yes	no	no

1 - additonal OGC measurement optional, 2 – „fixed burn rate units“, 3 – large units with restricted air setting
4 – additional part load optional, *-mass of fuel load calculated by volume of firebox

Test Results

Low Emission Woodburners

Brand and Model	Emissions (mg/MJ)	Emission Factor (g/kg)	Efficiency (%)	Type	Water Heater	Authorisation Number
Spartherm Varia 2L 80h-P7	73.2	0.96	65.9	Built-in	None	168071
Spartherm Varia 2R 80h-P7	73.2	0.96	65.9	Built-in	None	168072
Spartherm Varia ASh-P8	72.8	0.99	67	Built-in	None	167168
Spartherm Varia AS-P8	72.8	0.99	67	Built-in	None	167167
Spartherm Varia Bh-P7	70.5	0.92	65	Built-in	None	167169

Excerpt of the „Authorised Solid Fuel Burners“ list,
Canterbury Regional Council, NZ

Test Results

Appliance name	Manufacturer	England	Wales	Scotland	Northern Ireland
Spartherm Arte U-50h – P3, Spartherm Arte U-90h – P3 and Spartherm Arte U-70h – P3 insert stoves	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2014 No. 294
Spartherm Linear cassette model S 600 P3 inset stove	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2014 No. 294
Spartherm Linear Cassette XS500 –P3 insert stove	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2014 No. 294
Spartherm Mini 2LRh-4S P3, Spartherm Mini 2L-4S P3, and Spartherm Mini 2R-4S P3 wood-burning inset roomheaters	Spartherm Feuerungstechnik GmbH, Maschweg 38, S-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2014 No. 294
Spartherm Passo S-P3, Spartherm Passo M-P3 and Spartherm Passo L-P3 10kW wood-burning stoves	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	No	View detailed information	SR 2015 No. 406
Spartherm Stovo S, M and L Wood burning stoves	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2013 No. 292
Spartherm Varia ASh2L – P3, Spartherm Varia ASh2R – P3, Spartherm Varia ASh2L X – P3, and Spartherm Varia ASh2R X – P3 wood-burning inset roomheaters	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	SI 2015 No.1513	View detailed information	SR 2014 No. 294
Stovo L-plus – P3 4.7kW wood burning stove	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	No	View detailed information	SR 2015 No. 406
Stovo S-plus – P3 4.7kW wood burning stove	Spartherm Feuerungstechnik GmbH, Maschweg 38, D-49324 Melle, Germany	View detailed information	No	View detailed information	SR 2015 No. 406

Excerpt of the list of Exempt Appliances for use in Smoke Control Areas, DEFRA, UK

Test Results

Overview for one model

Varia 2L / 2R 80h	**AUS/NZ**	**EN**	**No**
Efficiency / %	65.9	80.2	na
Particulate emission / g/kg	0.96 g/kg	na	3.2
Particulate emission / g/h	na	na	10.4
Particulate emission / mg/m^3	na	23,7	na
Particulate emission / mg/MJ	73.2	16	na
Burn rate kg/h	na	na	3.28
NHO kW	11.56-12.93	10.4 / 16.0	na
Test Fuel Load / kg	6.9	4.22*	3.88

* - 2 batches

Test Results

Particulate emissions, four models compared

according to tests results in AUS/NZ, EU, No

	Limit Value	Varia AS	Varia B	Varia 2L80	Varia AFD
AUS / NZ g/kg	NZ:0.5/1.0/1.5/(4) AUS: 1.5/2.5	0.99 (burn rate 2.7kg/h)	0.92 (burn rate 3.1kg/h)	0.96 (burn rate 4.9kg/h)	0.96 (burn rate 4.2kg/h)
EU	40 mg/m^3 foreseen	19 (burn rate 2.7kg/h)[1]	21 (burn rate 3.1kg/h) [1]	24 (burn rate 2.8kg/h)[1,2]	19 (burn rate 3.5kg/h) [1]
No	10 g/kg	0.93 (burn rate 4.2kg/h)	not tested	3.16 (burn rate 3.3kg/h)	3.48 (burn rate 4.1kg/h)

1 – average over 2 burn cycles 2 – at NHO 10.4kW, higher NHO test available

Conclusion

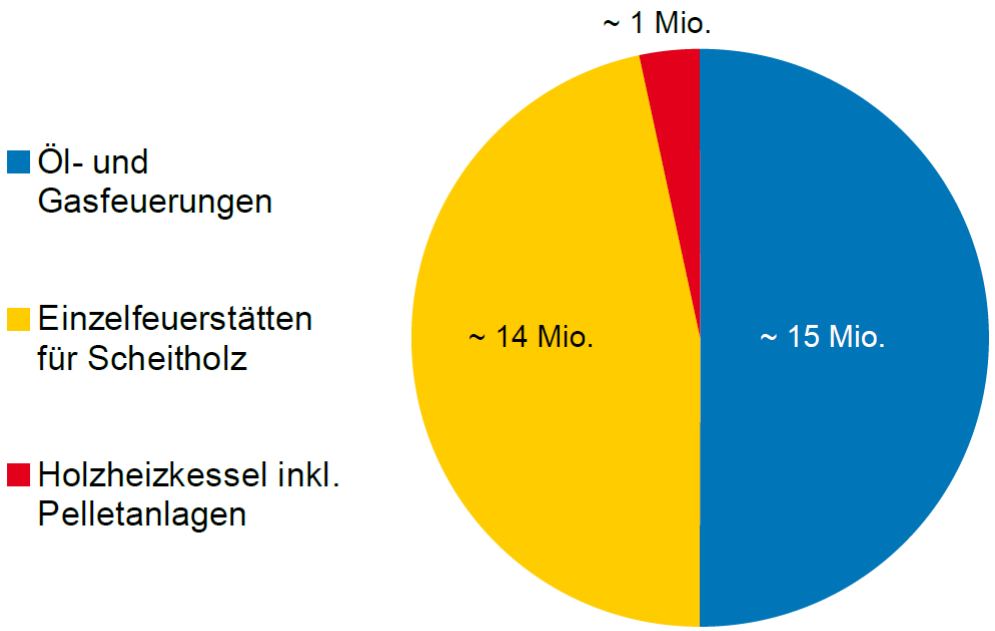
Large Variety of Appliances
Different National situations & habits
→
Different national requirements on emissions
Various Test Standards / different concepts

Proposal for Single European Test method:
EN PME (see poster 22)

„Real Life not yet standardised“

Thank you for your patience!

Impact of wood combustion



Quelle: BMU, Novelle der 1. Bundesimmissionsschutzverordnung (1. BImSchV) Fragen und Antworten, 5/2009

EMISSIONSGRENZWERTE UND VERBRENNUNGSVERBOTE IN DEUTSCHLAND
Tim Froitzheim, Referent Ofen- und Luftheizungsbau, Erneuerbare Energien, KOK 2014

Test Results

SPARTHERM® Feuerungstechnik

Stammdaten

Eintrag vom	07.10.2013
Hersteller	Spartherm Feuerungstechnik GmbH
Modell	Varia AS 11,0kW - A1
Nennwärmeleistung [kW]	11
Dauerbrandfeuerstätte	–
Norm der Typprüfung	DIN EN 13229
Prüfjahr	2013
Prüfstelle	RRF Rhein-Ruhr-Feuerstättenprüfstelle GmbH
Prüfstellennummer	2
Nummer des Prüfberichts	RRF – 29 13 3201

Abgaswerte

	Holz
Abgas Massenstrom [g/s]	9.5
Abgastemperatur [°C]	340
Notwendiger Förderdruck [Pa]	12

weitere wichtige Geräteeigenschaften

Eignung zur Mehrfachbelegung[1]	✓
Anschlußmöglichkeit an das Zentralheizsystem	–
Bauaufsichtliche Zulassung für den raumluftunabhängigen Betrieb	–

[1] Bei raumluftabhängigem Betrieb kann die Feuerstätte zur Mehrfachbelegung geeignet sein (siehe Installationsanleitung).

Hiermit bestätigt der HKI Industrieverband e.V. im Auftrag des Herstellers die Einhaltung der jeweiligen Anforderung* gemäß 1.BImSchV. Der Typprüfbericht der Feuerstätte liegt dem HKI Industrieverband e.V. vor.

* Bei grünem Haken wird die 1. Stufe der 1.BImSchV erfüllt, bei gelben Haken wird die Übergangsregelung der 1.BImSchV erfüllt und bei rotem Strich wird die 1.BImSchV nicht erfüllt.

Bewertung von Emissionsdaten und Wirkungsgrad Holz

Norm DIN EN 13229: Kamineinsätze (geschlossene Betriebsweise)	**Bewertung**	
D - 1.BImSchV	✓ Bestandsschutz	Details Erklärung
A - Österreichische Vereinbarung gemäß Art.15a B-VG	✓	Details
CH - Schweizer Luftreinhalteverordnung	✓	Details

http://cert.hki-online.de/geraete

Impact of wood combustion

Kat.	Anlagengruppe	Jahr			Veränderung	
		2014	2013	1990	2014/2013	2014/1990
A	Einzelraumheizungen (A): Anlagenkategorie 1 bis 6	539'039	545'116	537'525	-1.1%	0.3%
B	Gebäudeheizungen (B): Anlagenkategorie 7 bis 11b	56'175	60'612	152'673	-7.3%	-63.2%
C	Automatische Feuerungen (C): Anlagenkategorie 12a bis 18	8'192	7'791	2'250	5.1%	264.1%
D	Spezialfeuerungen (D): Anlagenkategorie 19 und 20	94	93	49	1.1%	91.8%
Total	Total, alle Anlagenkategorien	603'500	613'612	692'497	-1.6%	-12.9%
Total	Total ohne KVA (Kat. 20)	603'470	613'582	692'471	-1.6%	-12.9%

Tabelle 2.1 Veränderung des Anlagenbestandes nach Gruppen

Schweizerische Holzenergiestatistik
Erhebung für das Jahr 2014, BFE, Schweiz

Impact of wood combustion

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