Part 3 LABTQ /LABNET. Technical experience with testing ECO design parameters

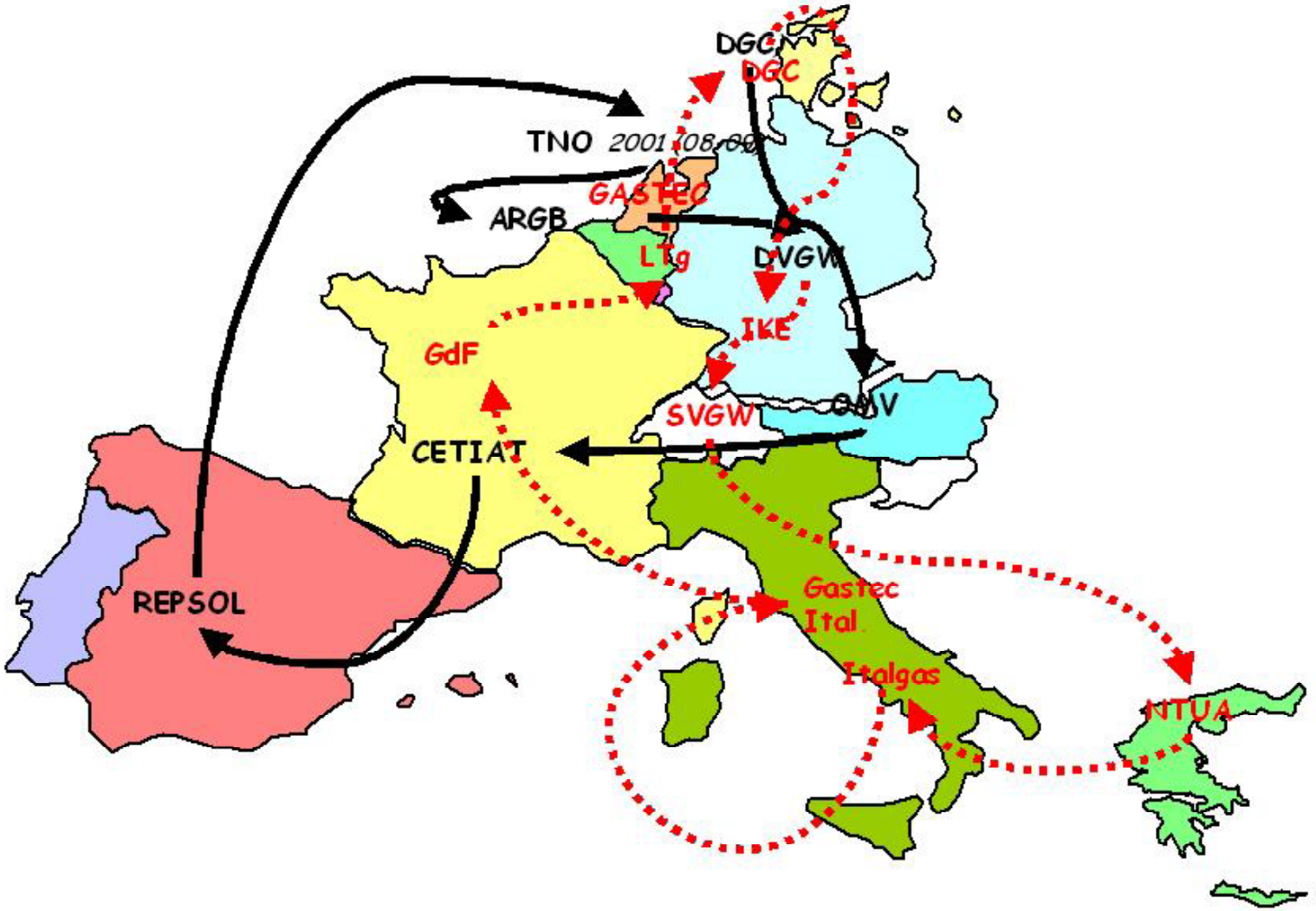
20 years of Round Robin test on boilers.
Measurement state of the art (DGC)

→**INTERCOMPARISONS (efficiency, emissions)**

→**Good Laboratory Practise documents**

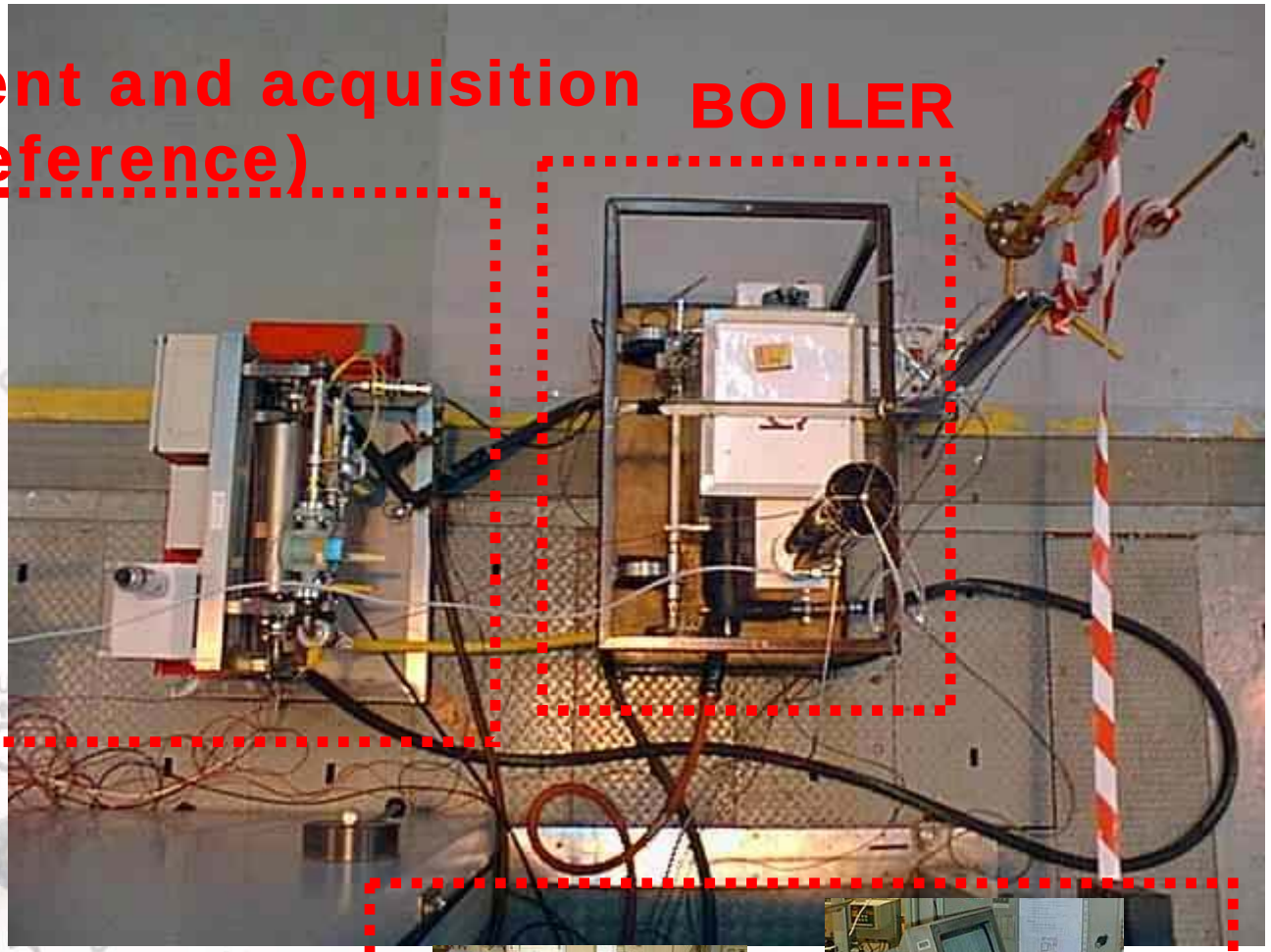
→**Investigations**

Inter-comparison WHAT IS IT? = Circulating the same appliance through labs



Measurement and acquisition module (reference)

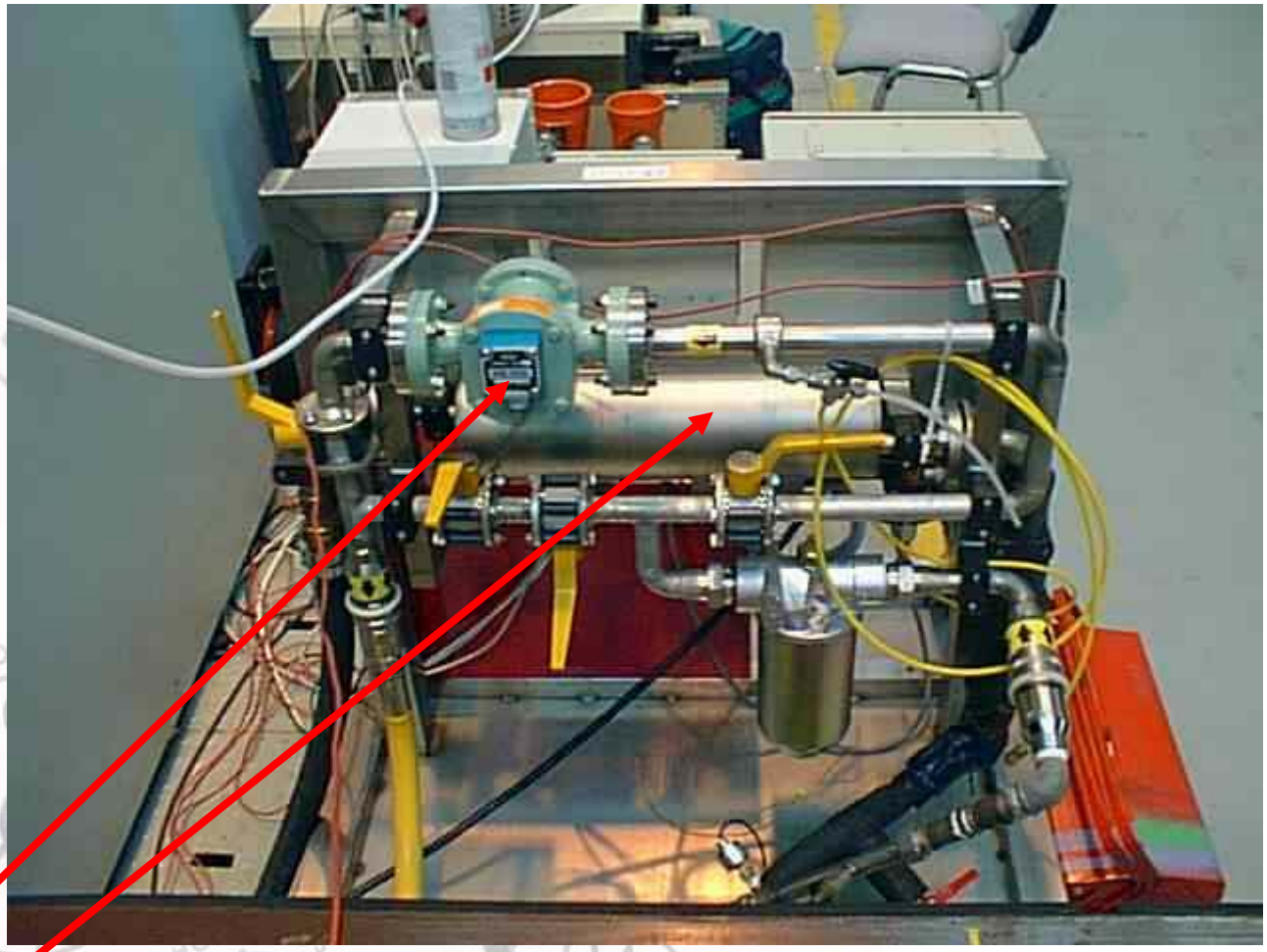
BOILER



- Efficiency
- T water in
- T water out
- Water flow
- Gas flow
- Gas pressure

etc..

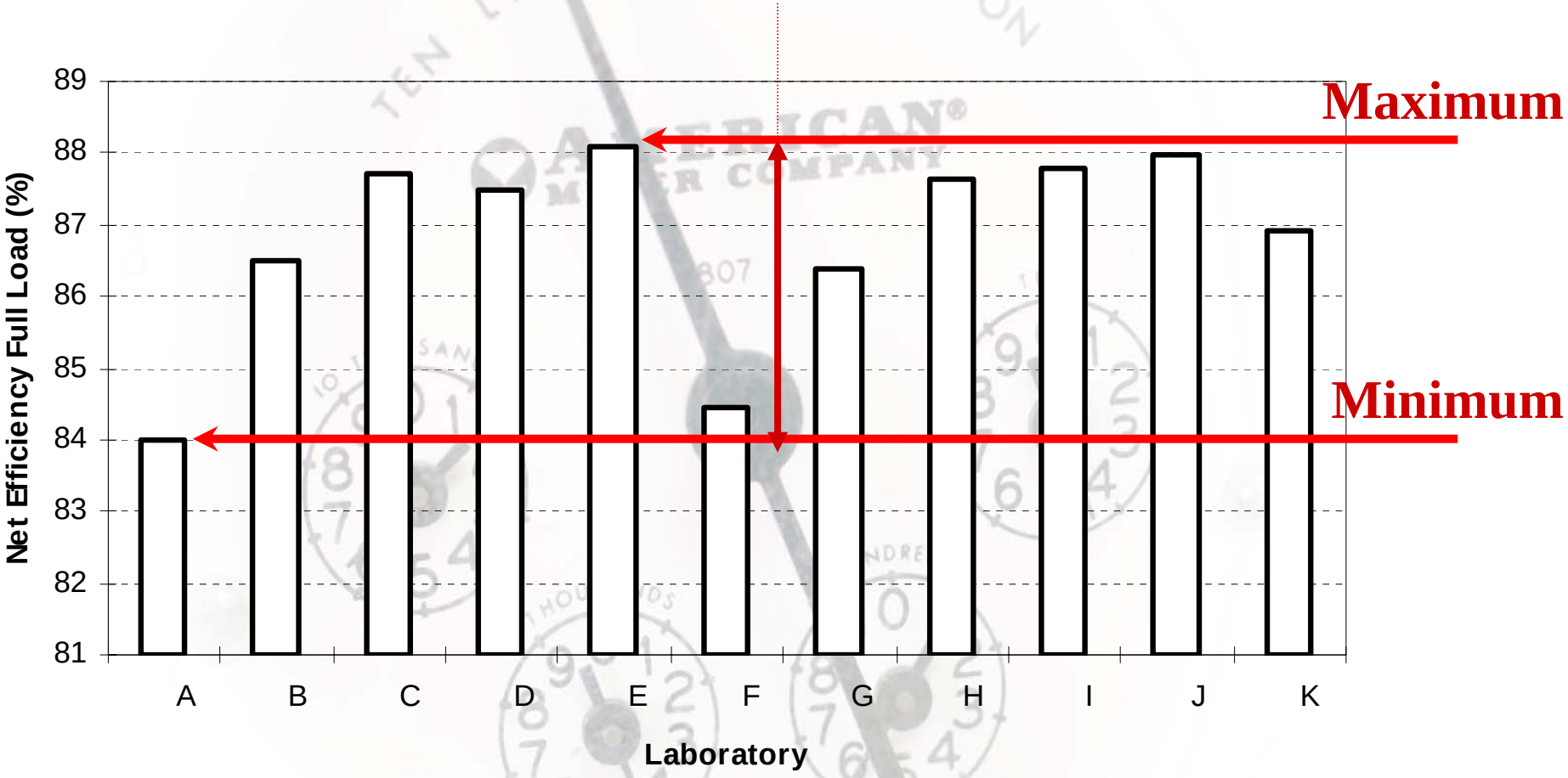
Measurement and acquisition (laboratory)



Water flow **Danfoss**
Water temp. **FR & Co. Pt 100 1/10-DIN**
Gas volume **OVAL GAL 53 5m3/h + convert.**
Gas temp. **FP & Co. Pt 100 1/10-DIN**
Gas pressure **JUMO 4 AP 30**
Air temp. **FP & Co. Pt 100 1/10-DIN**

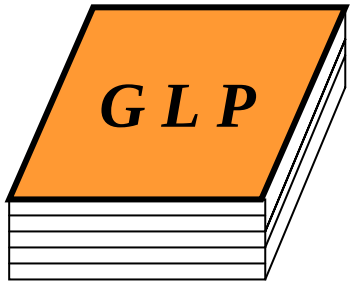
Reproducibility
R = 4.5% rel.

INTERCOMPARISON 1991



The **reproducibility (R)** is the value, below which the absolute difference between two single test results obtained with the same method on identical test material, under different conditions (different operators, different apparatus, different laboratories, and different time) may be expected to lie with a specified probability of 95% (ISO 5725).

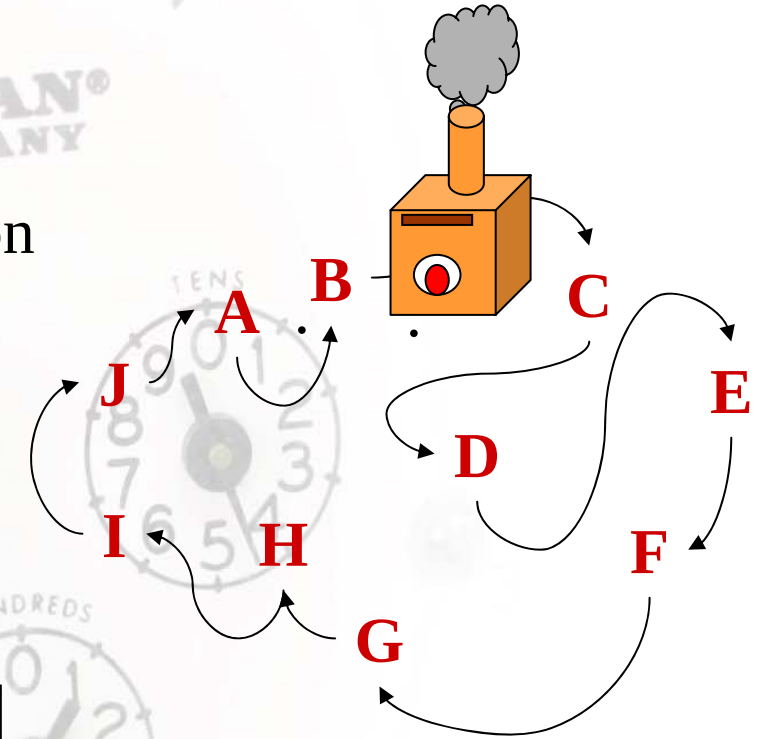
WP1 GLP Efficiency (GLP document)

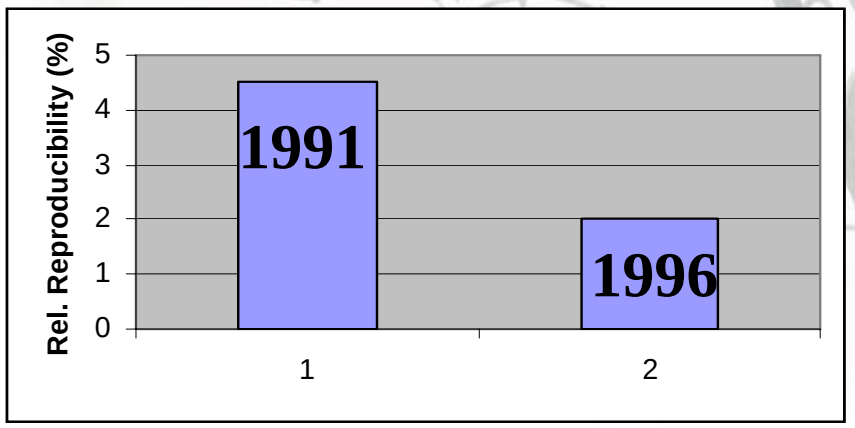


Good Laboratory Practice Document (G.L.P.)

Boiler Efficiency Intercomparison

Improved Interlaboratory Reproducibility





LAB EXPERIENCE BASED ON WIDE RANGE OF COMMON ACTIVITIES
As for ex:

- **WP1 GLP Efficiency** (GLP document)
- **WP2 GLP NOx CO** (GLP document)
- **WP3 Intercomparison** (Gas & fuel oil boilers)
- **WP5 Uncertainty calculation**
- **WP7 New procedures, methods**
- **WP10 Electric consumption of appliances**
- **WP13 On site test of efficiency**
- **WP14 On site test of emissions**

WP5 Uncertainty calculation

GAS FLOW

						Rel.	Abs.		
Value measured	0,621		m3/h					U (2k) (%)	% of total
		Distribution	Distribution	factor	factor (2k)	U (2k)	U (2k)		
1. Error of the calib.	Method	A	Normal	1,00	1	*0,2400*	*0,0000*	**0,24**	**18,4**
	Repeatability	B	Rect. Sym.	0,58	2	*0,1155*	*0,0000*	**0,12**	**4,3**
	Calibr curve	C	Rect. Non sym.	0,29	2	*0,1963*	*0,0000*	**0,20**	**12,3**
2. Drift between calib.		B	Rect. Sym.	0,58	2	*0,2309*	*0,0000*	**0,23**	**17,1**
3. Random drift		0		0,00	0	*0,0000*	*0,0000*	**0,00**	**0,0**
4. Resolution		C	Rect. Non sym.	0,29	2	*0,0000*	*0,0006*	**0,09**	**2,8**
5. Influence param.	Temperature	B	Rect. Sym.	0,58	2	*0,0000*	*0,0001*	**0,02**	**0,1**
	Pression	B	Rect. Sym.	0,58	2	*0,0000*	*0,0000*	**0,00**	**0,0**
	Humidity	B	Rect. Sym.	0,58	2	*0,0000*	*0,0000*	**0,00**	**0,0**
	Other	B	Rect. Sym.	0,58	2	*0,0000*	*0,0000*	**0,00**	**0,0**
6. Linearity		C	Rect. Non sym.	0,29	2	*0,3753*	*0,0000*	**0,38**	**45,0**
7. Hysterisis		C	Rect. Non sym.	0,29	2	*0,0000*	*0,0000*	**0,00**	**0,0**
8. Repeatability		A	Normal	1,00	1	*0,0000*	*0,0000*	**0,00**	**0,0**
9. Other		0		0,00	0	*0,0000*	*0,0000*	**0,00**	**0,0**
10. Meth. and proc.		A	Normal	1,00	1	*0,0000*	*0,0000*	**0,00**	**0,0**
11. Hardware		A	Normal	1,00	1	*0,0000*	*0,0000*	**0,00**	**0,0**
12. Unc. on corrections		A	Normal	1,00	1	*0,0000*	*0,0000*	**0,00**	**0,0**
13. Representativity		A	Normal	1,00	1	*0,0000*	*0,0000*	**0,00**	**0,0**

FULL LOAD & PART LOAD EFFICIENCY

Calculation based on the measure of T1, T2

Overall uncertainty, calculated according the GLP efficiency

$$\frac{V(q_{v,g})}{q_{v,g}^2}+\frac{V(P_g)}{(Pg+P_{atm})^2}+\frac{V(P_{atm})}{(Pg+P_{atm})^2}+\frac{V(T_g)}{(T_g+T_N)^2}+\frac{V(H_{iv})}{H_{iv}^2}$$

	Value	U (2k) abs	U rel %	Variance	Unit		Formula	% of total	U (2k) %	
Heat Input: Qm										
q vg	0,621	0,00	0,6	3,01E-06	m3/h		7,82E-06	24,0	0,6	**Ai**
Pg	1026	9,49	0,9	2,25E+01	mbars		2,14E-05	65,8	0,9	**Bi**
Patm (1)	1005	9,30	0,9	2,16E+01	mbars		0,00E+00	0,0	0,0	**Ci**
Tg	23,1	0,16	0,7	6,63E-03	deg. C		7,56E-08	0,2	0,1	**Di**
TN	273,0		0,0	0,00E+00	deg. C			0,0	0,0	**Ei**
Hi	35,88	0,13	0,4	4,18E-03	MJ/m3	(0°C, 1013 mba	3,25E-06	10,0	0,4	**Fi**
Qm	6,192				kW					
						TOTAL Inp.	3,25E-05	100,0	**1,1** %	

Ai = $\frac{V(q_{v,g})}{q_{v,g}^2}$ **Bi =** $\frac{V(P_g)}{(Pg+P_{atm})^2}$ **Di =** $\frac{V(T_g)}{(T_g+T_N)^2}$ **Ei =** $\frac{V(P_{atm})}{(Pg+P_{atm})^2}$ **Fi =** $\frac{V(H_{iv})}{H_{iv}^2}$

(1) In this case Patm is NOT taken into account as Pg is absolute

$$\frac{V(q_{v,w})}{q_{v,w}^2}+B_w^2\frac{V(T_w)}{\rho_w^2}+\frac{V(p_w)}{\rho_w^2}+\frac{V(\Delta T)}{\Delta T^2}$$

$$\frac{V(q_{v,w})}{q_{v,w}^2}+B_w^2\frac{V(\overline{T_w})}{\overline{\rho_w}^2}+\frac{V(\overline{\rho_w})}{\overline{\rho_w}^2}+\frac{V(T_1)+V(\overline{T_2})}{(\overline{T_2}-T_1)^2}+\frac{V(H_1)+V(\overline{H_2})}{C_p^2(\overline{T_2}-T_1)^2}$$

	Value	U (2k) abs	U rel %	Variance	Unit		Formula	% of total	U (2k) %	
Heat output: Qout										
qv,w	722,92	4,10		4,19E+00	kg/h	Flow	8,02E-06	2,1	0,6	**Ao**
Tw	46,64	0,16		6,63E-03		T/d	1,49E-09	0,0	0,0	**Bo**
pw (T1)	989,6	0,20		9,79E-03		d	1,00E-08	0,0	0,0	**Co**
dT	6,15	0,09		2,02E-03	deg. C	dT				
T1	46,64	0,16		6,63E-03	deg. C	T1/T2	3,50E-04	93,6	3,7	**Fo**
T2	52,79	0,16		6,63E-03	deg. C	H	1,61E-05	4,3	0,8	**Go**
Cp (2)	4180			0,00E+00	J/kg.C					
Bw (3)	0,47			0,00E+00	kg/m3.C					
H(T1)	195177	137		4,67E+03	J/kg					
H(T1+dT)	220875	155		5,98E+03	J/kg					
Q out	5,114				kW					
						TOTAL out.	3,74E-04	100,0	**3,9** %	

Ao = $\frac{V(q_{v,w})}{q_{v,w}^2}$ **Bo =** $B_w^2\frac{V(T_w)}{\rho_w^2}$ **Co =** $\frac{V(p_w)}{\rho_w^2}$ **Fo =** $\frac{V(T_1)+V(\overline{T_2})}{(\overline{T_2}-T_1)^2}$

Go = $\frac{V(H_1)+V(\overline{H_2})}{C_p^2(\overline{T_2}-T_1)^2}$

Simplifications for U calculation

(2) Cp is in the expression of the water enthalpy: H = Cp.T

(3) Bw is in the expression of the water density: pw = Aw + Bw.T

OVERALL VARIANCE

Qm	6,192	kW	3,254E-05	
Qout	5,114	kW	3,745E-04	

Total Uncertainty	***FULL LOAD 60/80 pure CH4***	4,07E-04	**4,0** %	The uncertainty is related to the test data given at the page "Test DATA"

WHAT IS THE ACTUAL SITUATION FOR THE PARAMETERS NEEDED FOR ECODESIGN?

BOILER

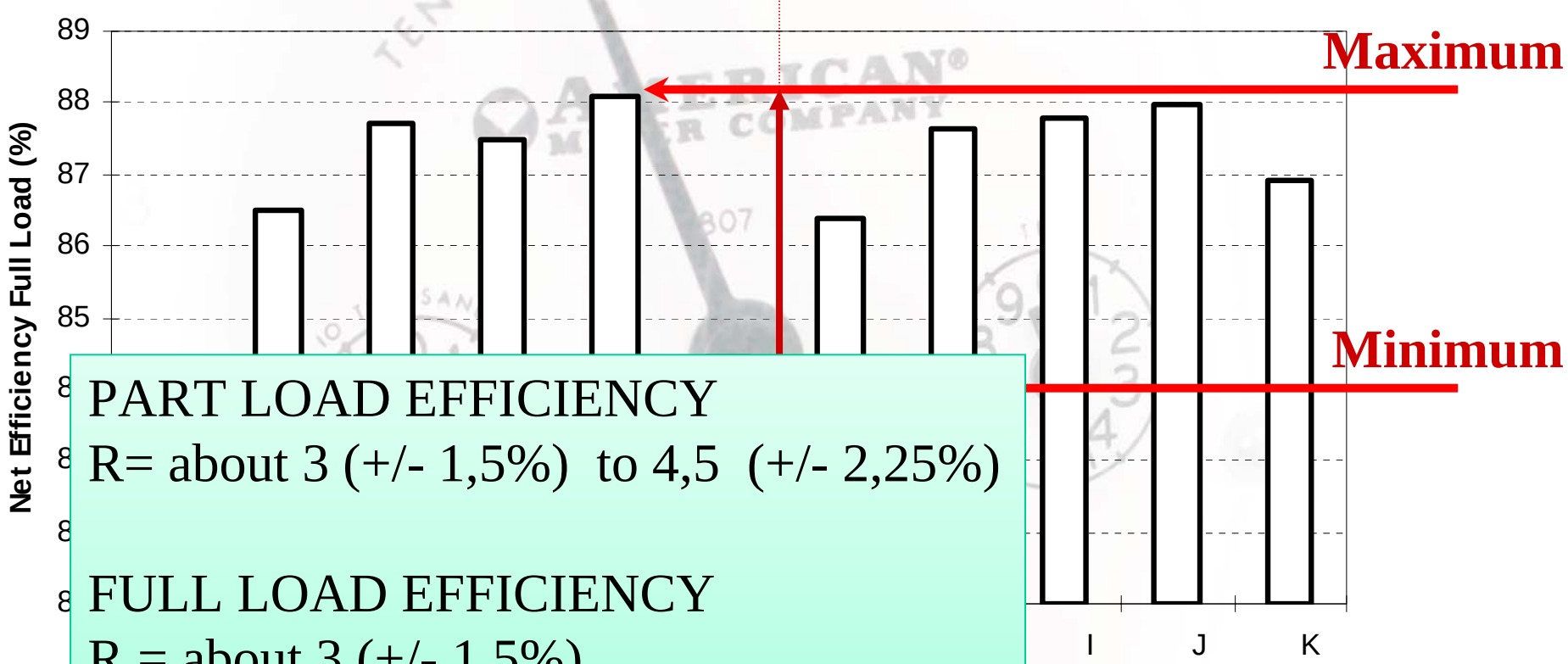
- Full load efficiency
- Part load efficiency
- NOx
- Standby loss
- Electricity consumption

HOT WATER APPLIANCES

- Hot water efficiency
- Other parameter= same as above

Reproducibility
R = 4.5% rel.

INTERCOMPARISON 1991

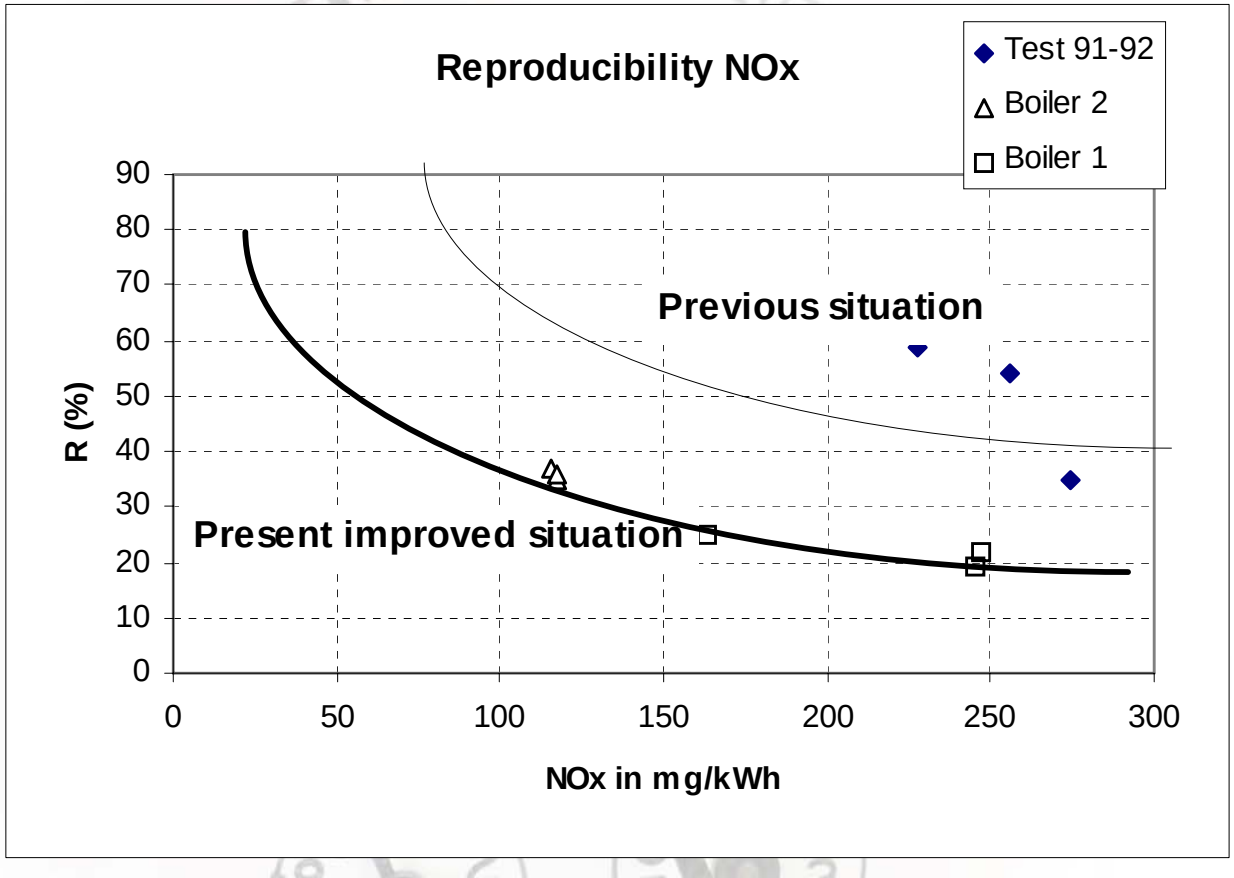


PART LOAD EFFICIENCY
R= about 3 (+/- 1,5%) to 4,5 (+/- 2,25%)

FULL LOAD EFFICIENCY
R = about 3 (+/- 1,5%)

STANBY LOSSES
(+/- 50%?)

WP2 GLP NOx CO (GLP document)



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Improvement of Interlaboratory Reproducibility for NOx and CO Measurements

WHAT IS THE ACTUAL SITUATION FOR THE PARAMETERS NEEDED FOR ECODESIGN? **(tested during RRTs)**

BOILER

- Full load efficiency **+/- 1,5 % Rel**
- Part load efficiency **+/- 2 % Rel**

- NOx **+/- 20 % Rel** **(at the limit proposed)**
- Standby loss **+/- 50 % Rel (?)**
- Electricity consumption **(?)**

HOT WATER APPLIANCES

- Hot water efficiency **(?)**
- Other parameter= same as above

Part 3 LABTQ /LABNET. Technical experience with testing ECO design parameters

3) Hot water production, what accuracy to expect? (DGC)

Report

Source:

HOT WATER PRODUCTION:
ESTIMATION OF THE UNCERTAINTIES

DGC August 1999

EXAMPLE OF U CALCULATION DK TAP

UNCERTAINTY/ERROR:	TYPE	VALUE estimation		VALUE % of eff. Random	Syst. (*)
Repeatability of the system	Random	5 %	?	5 0	
Repeatability of measurements	Random	2 %		2.0	
Influence of heat content balance	Random	0 12 kWh		0 8	
Water temperature influence	Systematic	-7.70 % on eff Tap			-6.3
Uncertainty meters	Random	2 2 % on eff		2 2	
Influence of ambient temperature	Systematic	12.88 % on SEY			2.4
Influence of tank real temperature	Random	5 % on eff	?	5 0	
Non identified influences/errors	Random	5 % on eff	?	5.0	
Tolerance on ennergy tapped	Random	0 1 kWh		0 8	
Tolerance on tapping starting point	Random	5 %	?	5 0	
TOTAL				10.5	3.8
		Option 1 NO CORRECTION	U=	14.3 % rel.	
		Option 2 CORRECTION	U=	10.7 % rel.	

(*) A negative error will have the effect of decreasing the efficiency given

Lessons for CEN 13203 testing

For instantaneous appliances some of the U factor will not apply → better accuracy, but experiments also shows that worse case are obtained with small tapping.