

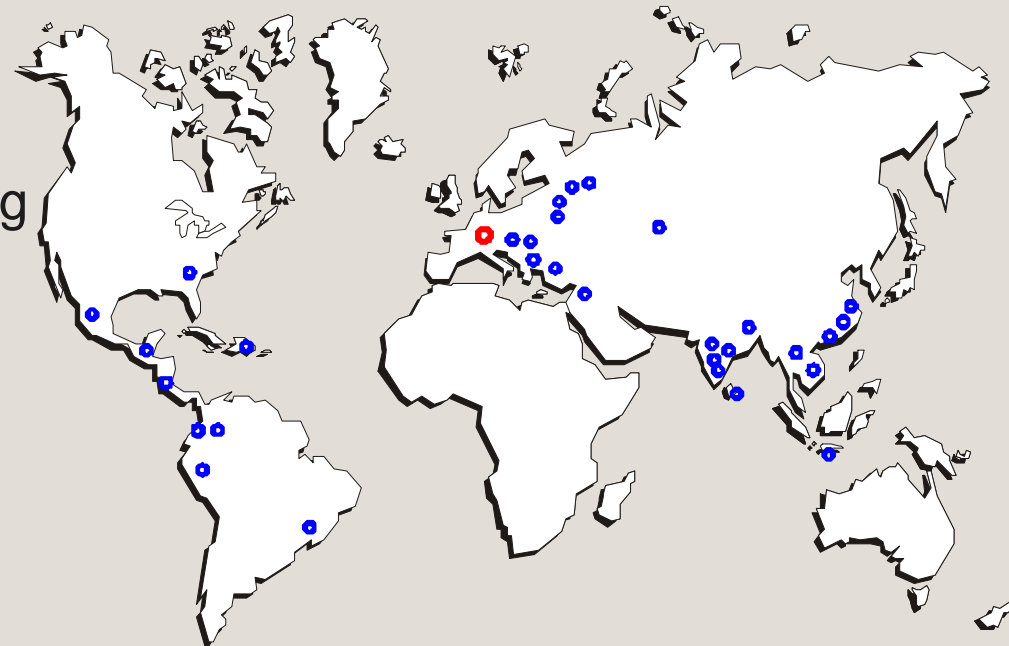
# ICC – Meeting Copenhagen, May 17, 2013

Florian Girmond, Hohenstein Institute



## HOHENSTEIN INSTITUTE

- Private institute for research, testing, consulting and inspections
- Non-profit research institute
- Family operated in third generation
- Technical academy: vocational and advanced training
- Total about 500 employees at the headquarters in Bönningheim and in around 30 contact offices globally



## Compression Tests

- Compression Tests since about 50 years
- Hohenstein Measurement System HOSY since 1982
- Exclusive Institute for Tests according to/following RAL-GZ 387/DIN 58133
- Standardisation national/international



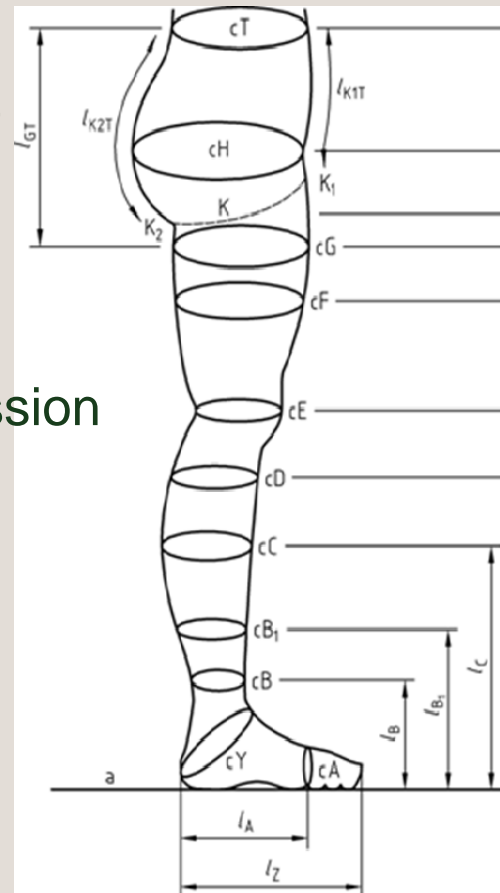
## Technical Equipment – HOSY (Hohenstein Measurement System)

- No. of axes/sections: 20
- Width of section: 5 cm
- Maximum length 100 cm
- Range of girths (min/max): 10/110 cm
- Results for compression: kPa and/or mmHg



## Definitions acc. to RAL-GZ 387/1 – required / given

- Sizes – informations about
  - a. lengths
  - b. girths
- Compression class
- Characteristics of compression (residual pressure)
- no definitions for stiffness



Compression Class	Definition	Compression [kPa] <sup>a</sup>	Compression [mmHg] <sup>b</sup>
I	mild/soft	2,4 - 2,8	18 – 21
II	medium	3,1 - 4,3	23 – 32
III	strong	4,5 - 6,1	34 – 46
IV	very strong	≥ 6,5	≥ 49

a 1 kPa = 7,5 mmHg  
b 1 mmHg = 0,133 kPa

Compression class	Residual pressure related to B [%]		
	Position B <sub>1</sub>	Position C	Position F or G
I	70 - 100	50 - 80	20 - 60
II	70 - 100	50 - 80	20 - 50
III	70 - 100	50 - 70	20 - 40
IV	70 - 100	50 - 70	20 - 40

Source: RAL-GZ 387/1

# Measurement Preparations



Reference size 1: 4  
2: 14s

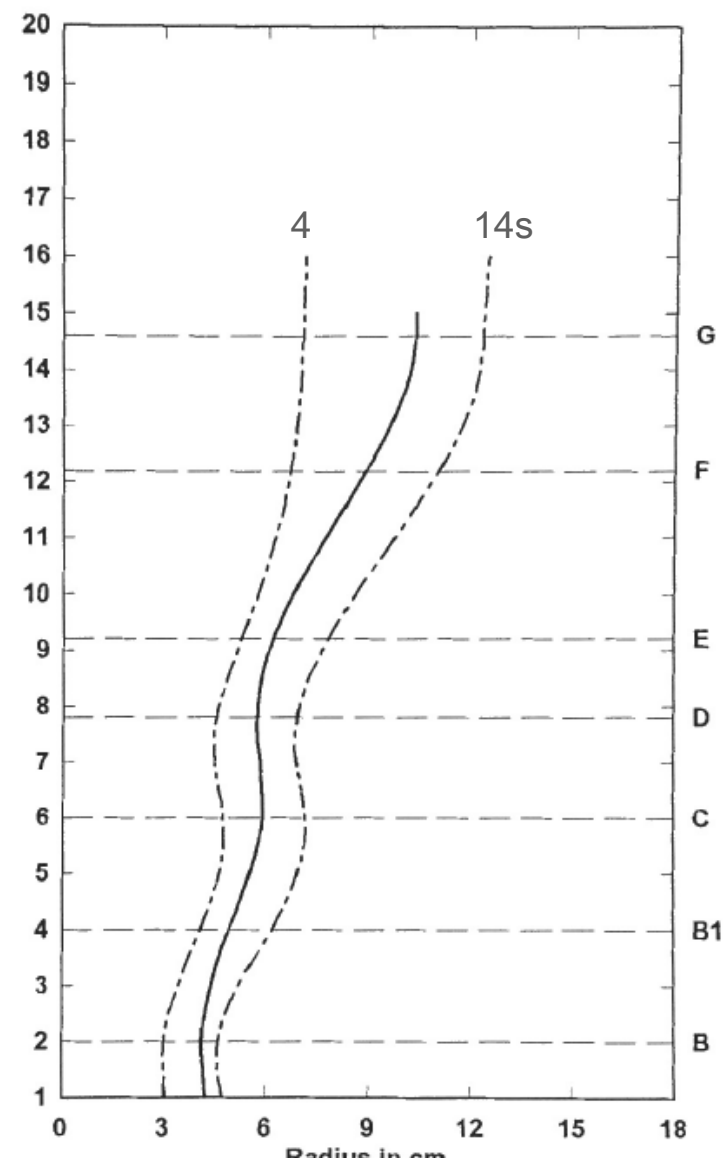
## Indicated values

Position	Height in cm	Clamp unit	Girth in cm
B	12.00	2.00	26.00
B1	22.00	4.00	31.00
C	32.00	6.00	37.00
D	41.00	7.80	36.00
E	48.00	9.20	39.00
F	63.00	12.20	56.00
G	75.00	14.60	65.00

## Calculated values

Clamp No.	Height in cm	Girth in cm
1	7.00	26.70
2	12.00	26.00
3	17.00	27.61
4	22.00	31.00
5	27.00	34.78
6	32.00	37.00
7	37.00	36.51
8	42.00	36.10
9	47.00	38.27
10	52.00	42.73
11	57.00	48.59
12	62.00	54.80
13	67.00	60.35
14	72.00	64.09
15	77.00	65.00

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## Marking I (standard)

### Marking board

- RAL-GZ 387/1:2008
- European standard (rejected)
- 2-dimensional
- irrespective on person
- reproducible from lab to lab
- no repetition/confirmation due to constant procedure



Marking II (just for special purposes!)

## Wooden model leg

- RAL-GZ 387/1:1987 (replaced 2000)
- 3-dimensional
- strongly depending on person
- greater variations from lab to lab
- at least 1 or 2 repetitions for confirmation needed



## Measurement

Start position ("unloaded")



Indicated / calculated girth



## Basic results

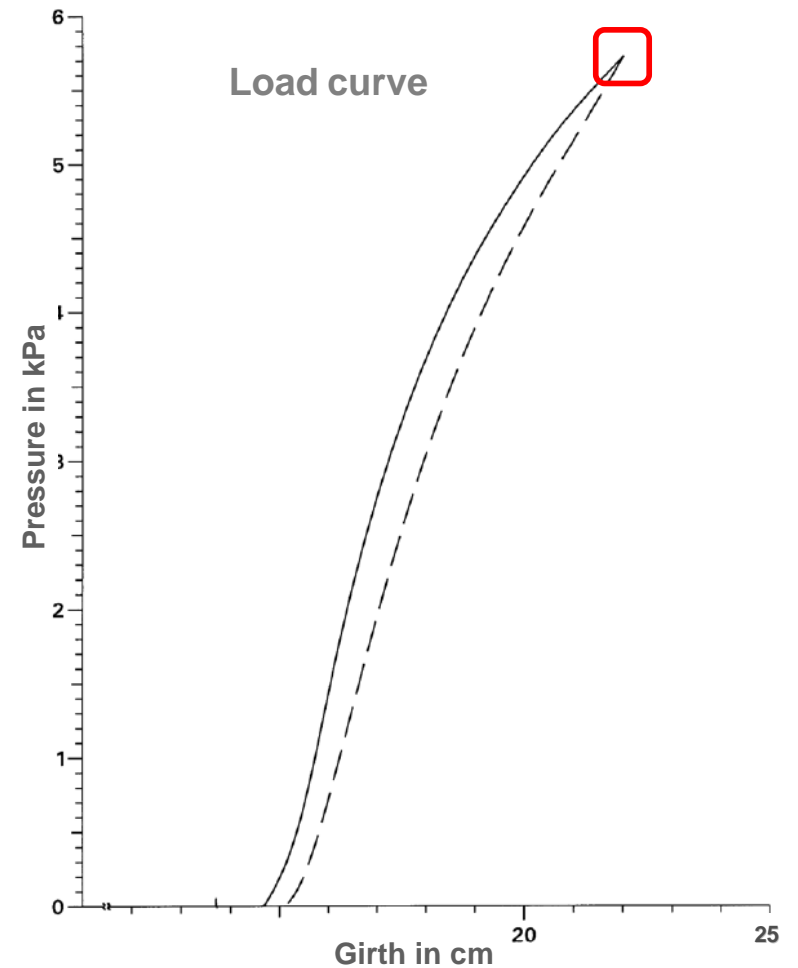
### KOMPRESSIONSMESSUNG SYSTEM HOHENSTEIN

Auftraggeber: HL  
 Artikel: Strumpf 1  
 Herst. Größe: AG 20-22  
 Prüfgröße: Nach Maß  
 Bemerkungen: max. Umfangsmaße

### Strumpf Nr. 1, Meßstelle B

Proz. der prakt. Dehng.	Deh- nung (%)	Umfang (cm)	Kraft (N/cm)			Druck (kPa)		
			Bel.	Entl.	Mw.	Bel.	Entl.	Mw.
0	0.0	14.63	0.00	0.00	0.00	0.00	0.00	0.00
5	2.5	15.00	.04	0.00	.02	.19	0.00	.09
10	5.0	15.36	.13	.03	.08	.51	.11	.31
15	7.6	15.73	.25	.11	.18	1.02	.42	.72
20	10.1	16.10	.41	.22	.31	1.60	.85	1.22
25	12.6	16.47	.56	.34	.45	2.12	1.31	1.71
30	15.1	16.84	.69	.47	.58	2.58	1.76	2.17
35	17.6	17.21	.82	.60	.71	2.98	2.20	2.59
40	20.2	17.58	.93	.73	.83	3.34	2.62	2.98
45	22.7	17.94	1.04	.86	.95	3.65	3.00	3.32
50	25.2	18.31	1.15	.97	1.06	3.93	3.34	3.64
55	27.7	18.68	1.24	1.09	1.17	4.18	3.66	3.92
60	30.2	19.05	1.34	1.20	1.27	4.41	3.94	4.18
65	32.8	19.42	1.43	1.30	1.36	4.62	4.21	4.42
70	35.3	19.79	1.52	1.40	1.46	4.82	4.45	4.64
75	37.8	20.16	1.60	1.50	1.55	5.00	4.69	4.84
80	40.3	20.53	1.69	1.60	1.65	5.17	4.90	5.04
85	42.8	20.89	1.77	1.70	1.74	5.33	5.11	5.22
90	45.4	21.26	1.85	1.80	1.82	5.47	5.31	5.39
95	47.9	21.63	1.93	1.90	1.91	5.60	5.50	5.56
100	50.4	22.00	2.01	2.01	2.01	5.73	5.73	5.73

Load curve



## Test results – check sheet

### Results for each clamp

- girth
- practical elongation (wear stretch)
- force
- pressure / residual pressure
- stiffness (informative)  
(values obtained as an extra („side effect“) by **calculation** at the maximum girth (spline formula, first derivation of load curve)

Auftrag Nr.: 2013  
 Auftraggeber: FI Hohenstein  
 Artikel: Stocking (Ccl.2)  
 Artikeltyp: AG  
 Kompressionsklasse: 2  
 Herst. Größe: AG 26-28 (57-63/68-76) # V  
 Prüfgröße: NACH MASS  
 Bemerkungen: with adhesive welt  
 Höhe Rand: 5.00  
 Höchste Klemme: 14  
 Federgröße: 2  
 Strumpfdicke (mm): .75/1.05  
 Letzte Klemme belegt zu (cm): 5.00  
 Maßdatei: hi5001

Schultz

15.01.2013  
 13:54:43

Zeitdauer der Dehnung (Sekunden): 20  
 Zeitdauer der Überdehnung (Sekunden): 0

BU	26.65	26.00	27.69	31.19	35.13	37.11	36.30	36.39
	39.00	42.63	46.68	50.82	54.52	56.80	0.00	0.00
	0.00	0.00	0.00	0.00				
PD	79.91	80.73	85.82	75.65	73.97	71.13	57.31	55.20
	59.35	59.89	61.78	54.99	42.25	34.05	0.00	0.00
	0.00	0.00	0.00	0.00				
ÜD	.01	.01	.01	.01	.01	.01	.01	.01
	.01	.01	.01	.01	.01	.01	0.00	0.00
	0.00	0.00	0.00	0.00				
KR	1.19	1.33	1.40	1.31	1.21	1.19	1.11	1.09
	1.08	1.03	1.00	.99	.96	1.18	0.00	0.00
	0.00	0.00	0.00	0.00				
DR	2.82	3.22	3.19	2.64	2.16	2.02	1.92	1.88
	1.74	1.51	1.35	1.22	1.10	1.30	0.00	0.00
	0.00	0.00	0.00	0.00				
RD	87.44	100.00	98.95	81.82	67.09	62.59	59.66	58.31
	53.96	46.98	41.80	37.91	34.28	40.42	0.00	0.00
	0.00	0.00	0.00	0.00				
SZ	.86	.87	.76	.65	.52	.47	.64	.71
	.60	.52	.44	.39	.45	.69	0.00	0.00
	0.00	0.00	0.00	0.00				
IG	0.00	3.04	6.29	9.22	11.60	13.67	15.63	17.53
	19.35	20.98	22.40	23.69	24.84	26.02	0.00	0.00
	0.00	0.00	0.00	0.00				

	B	B1	C	D	E	F	G
BU (cm)	26.00	32.01	36.97	36.06	39.00	50.00	54.52
PD (%)	80.73	74.36	72.78	54.44	59.35	57.14	42.25
KR (N/cm)	1.33	1.28	1.20	1.09	1.08	1.00	.96
DR (kPa)	3.22	2.52	2.03	1.90	1.74	1.25	1.10
DR (mm Hg)	24.16	18.88	15.25	14.23	13.03	9.38	8.28
RD (%)	100.00	78.15	63.14	58.92	53.96	38.81	34.28
SZ (hPa)	.87	.63	.47	.71	.60	.40	.45

## Test results – check sheet

### Measurement positions

BU = girth  
 PD = practical elongation  
 KR = force  
 DR = pressure  
 RD = residual pressure  
 SZ = stiffness (hPa)

	B	B1	C	D	E	F	G
BU (cm)	26.00	32.01	36.97	36.06	39.00	50.00	54.52
PD (%)	80.73	74.36	72.78	54.44	59.35	57.14	42.25
KR (N/cm)	1.33	1.28	1.20	1.09	1.08	1.00	.96
DR (kPa)	3.22	2.52	2.03	1.90	1.74	1.25	1.10
DR (mm Hg)	24.16	18.88	15.25	14.23	13.03	9.38	8.28
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BU	26.65	26.00	27.69	31.19	35.13	37.11	36.30	36.39
	39.00	42.63	46.68	50.82	54.52	56.80	0.00	0.00
	0.00	0.00	0.00	0.00				
PD	79.91	80.73	85.82	75.65	73.97	71.13	57.31	55.20
	59.35	59.89	61.78	54.99	42.25	34.05	0.00	0.00
	0.00	0.00	0.00	0.00				

DR (kPa)	3.22	2.52	2.03	1.90	1.74	1.25	1.10
DR (mm Hg)	24.16	18.88	15.25	14.23	13.03	9.38	8.28
RD (%)	100.00	78.15	63.14	58.92	53.96	38.81	34.28
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# Test Protocol

- Table
- girth
  - height / length
  - practical elongation (wear stretch)
  - force
  - pressure
  - residual pressure
- Graph
- pressure profile
  - upper / lower residual pressure funnel

Table No. 1  
to Test Report No. 10.2.9999

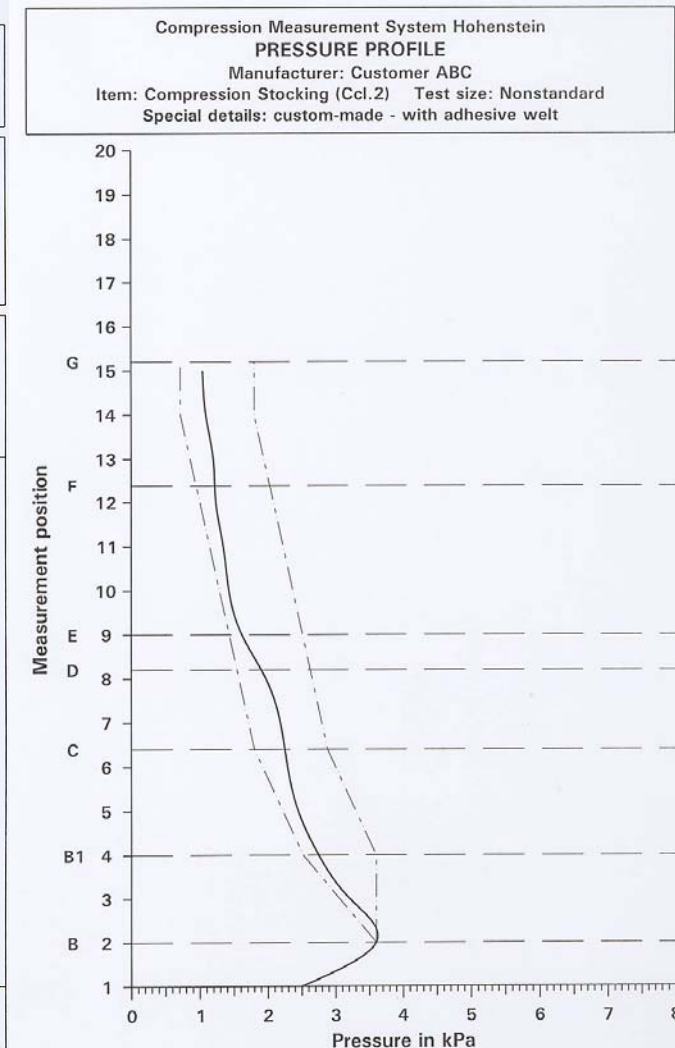
HOHENSTEIN●

Compression Measurement System Hohenstein								
TABLE OF RESULTS								
Manufacturer:		Customer ABC						
Item:		Compression Stocking (Ccl.2)						
Manuf. size:		custom-made						
Test size:		Nonstandard						
Special details:		with adhesive welt						
Measurement			Wear stretch	Tension	Pressure		Residual pressure	
Pos.	Circ.	Height			(kPa)	(mm Hg)		
	(cm)	(cm)	(%)	(N/cm)			(%)	
B	21.0	12.0	46.1	1.20	3.60	27.0	100.0	
B1	25.0	22.0	35.1	1.09	2.75	20.6	76.3	
C	33.0	34.0	53.8	1.18	2.25	16.9	62.4	
D	32.5	43.0	43.0	.98	1.90	14.3	52.8	
E	37.0	47.0	46.7	.95	1.62	12.1	44.9	
F	45.0	64.0	46.0	.88	1.22	9.2	33.9	
G	48.6	72.0	38.8	.84	1.09	8.2	30.3	
1	21.4	7.0	42.7	.85	2.50	18.8	69.6	
2	21.0	12.0	46.1	1.20	3.60	27.0	100.0	
3	22.1	17.0	38.4	1.13	3.21	24.1	89.2	
4	25.0	22.0	35.1	1.09	2.75	20.6	76.3	
5	29.3	27.0	48.9	1.14	2.45	18.4	67.9	
6	32.6	32.0	53.3	1.19	2.29	17.2	63.5	
7	32.4	37.0	52.3	1.12	2.18	16.4	60.6	
8	31.9	42.0	43.4	1.00	1.97	14.8	54.6	
9	37.0	47.0	46.7	.95	1.62	12.1	44.9	
10	41.2	52.0	50.5	.94	1.43	10.7	39.6	
11	43.2	57.0	48.2	.92	1.34	10.1	37.3	
12	44.4	62.0	46.5	.87	1.24	9.3	34.3	
13	46.2	67.0	44.2	.88	1.20	9.0	33.3	
14	48.6	72.0	38.8	.84	1.09	8.2	30.3	
15	50.3	77.0	38.4	.84	1.04	7.8	29.0	
The results show the average of 2 measurements.								

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Graph No. 1  
to Test Report No. 10.2.9999

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## Test protocol includes all relevant parameters acc. to RAL

### Table

- girth
- height / length
- practical elongation
- force
- pressure
- residual pressure

### Graph

- compression profile
- upper / lower residual pressure funnel

What about stiffness ?

Let's have a look at the German/RAL history



## Stiffness in standards - 1967 until today

Year	Title / Reference	Purpose / Definition	Comment / Conclusion	Nominal Value(s)
1967	Research assignment	Calculation of compression for measures beside the indicated sizes	applicable for linear areas	not specified
1967/1972	Technical Production Requirements	not specified	none	not specified
1967/1972	Test Requirements	not specified		not specified
1976	RAL-RG 387	not specified	none	not specified
1987	RAL-GZ 387	not specified	none	not specified
1990	Study „Examination and analysis of stiffness numbers with focus on European standardisation...”	Analysis and determination of status quo	Recommendation: Deleting of any slope requirements as the proposed ones are clearly higher than the average ones of RAL-stockings.	not specified
2000	RAL-GZ 387	not specified	none	not specified
2001	ENV 12718 (rejected)	Increase of compression per cm	Measurement at B only	not specified
2008	RAL-GZ 387/1	not specified	none	not specified
2000 - ....	HOSY-Measurements	not specified	none	not specified

## Study 1990

Study based on done quality assurance and application measurements acc. to RAL.

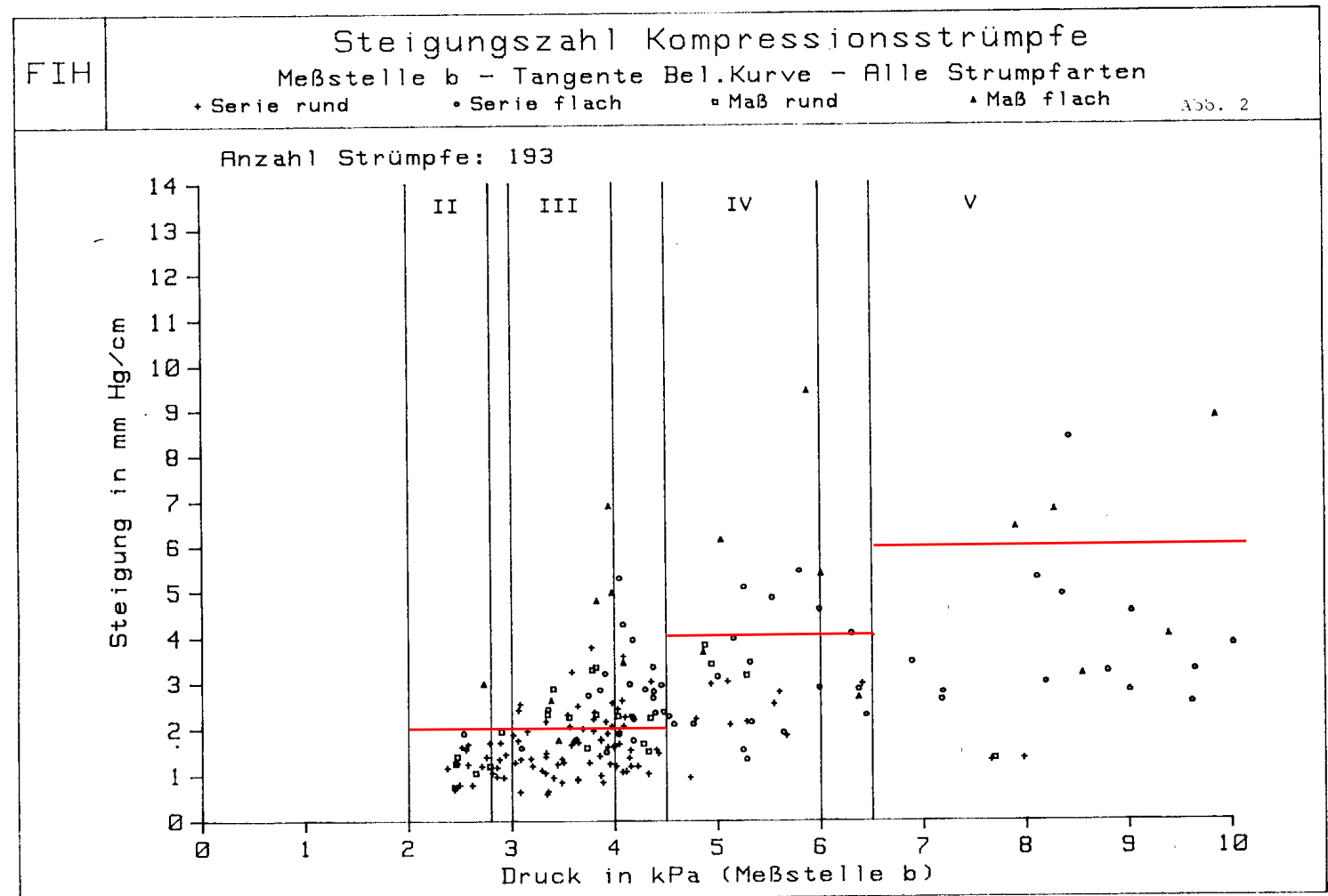
Market: D, NL, B, CH, I

Discussed nominal values

CCL III: 2,0 mmHg/cm

CCL IV: 4,0 mmHg/cm

CCL V: 6,0 mmHg/cm



## Stiffness – list of issues

- Status quo of today's stockings is unknown
- Measurement methods and their comparability
- Measurement positions – B (ankle) exclusively ?
- Nominal stiffness values – depending on  
measurement position – compression classes – knitting construction – sizes – adhesive welt ?
- Standard sizes covering size ranges
- Producibility with advanced requirements (see status quo)

**The end - thank you very much**

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