Counter surface parameters

The counter surface in the tribological system

R_a, R_z and M_r at C_{ref} = 0 %

and recommended counter surface parameters

Presented by

Merkel Freudenberg Fluidtechnic

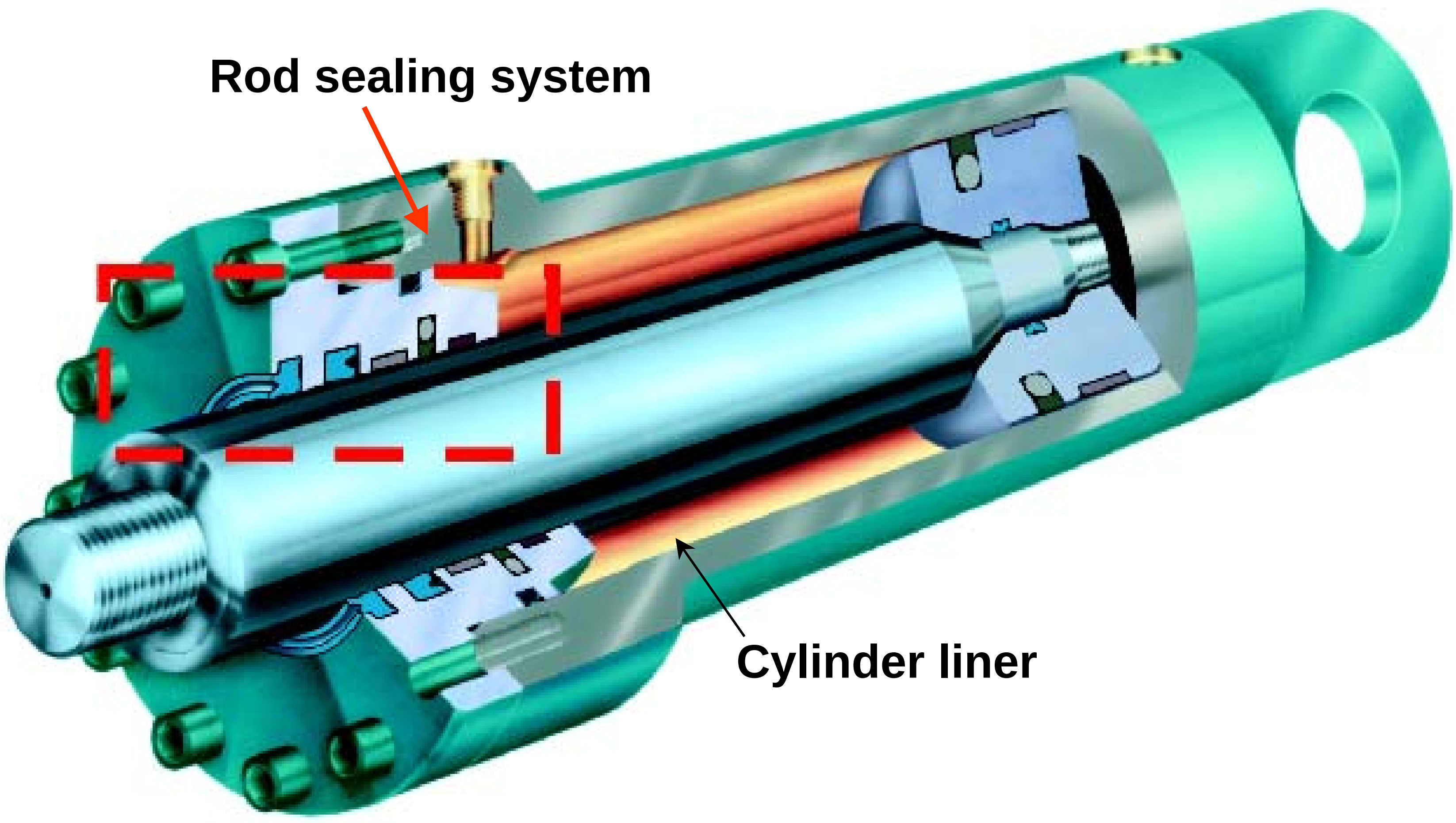
Hamburg

Agenda

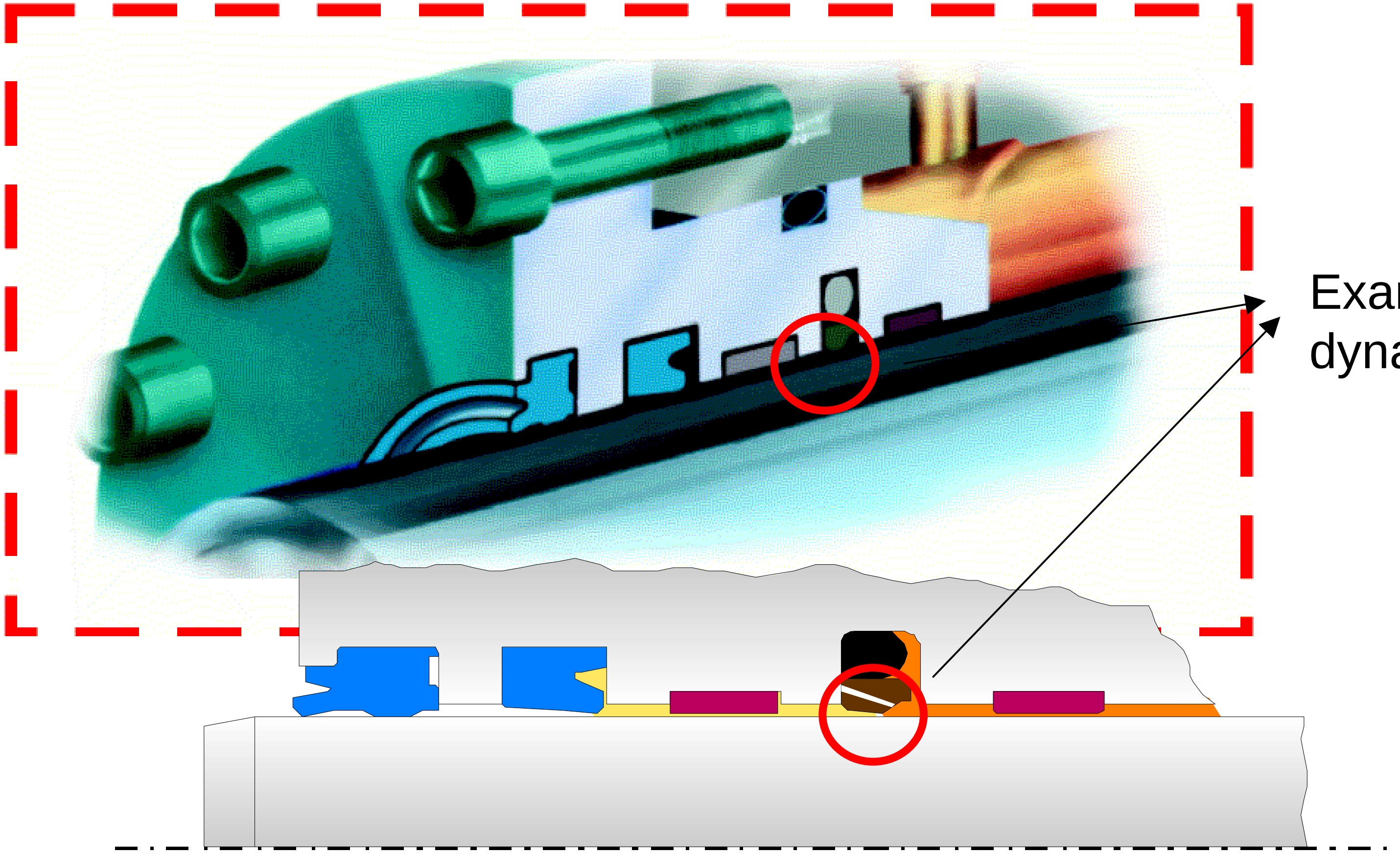
- Introduction
- Counter Surface parameters R_{max}, R_z and R_a
- The material proportion curve M_r at C_{ref} = 0%
- Additional counter surface parameters R_k group
- Recommended counter surface parameters
- Test results

Introduction

Introduction



Introduction

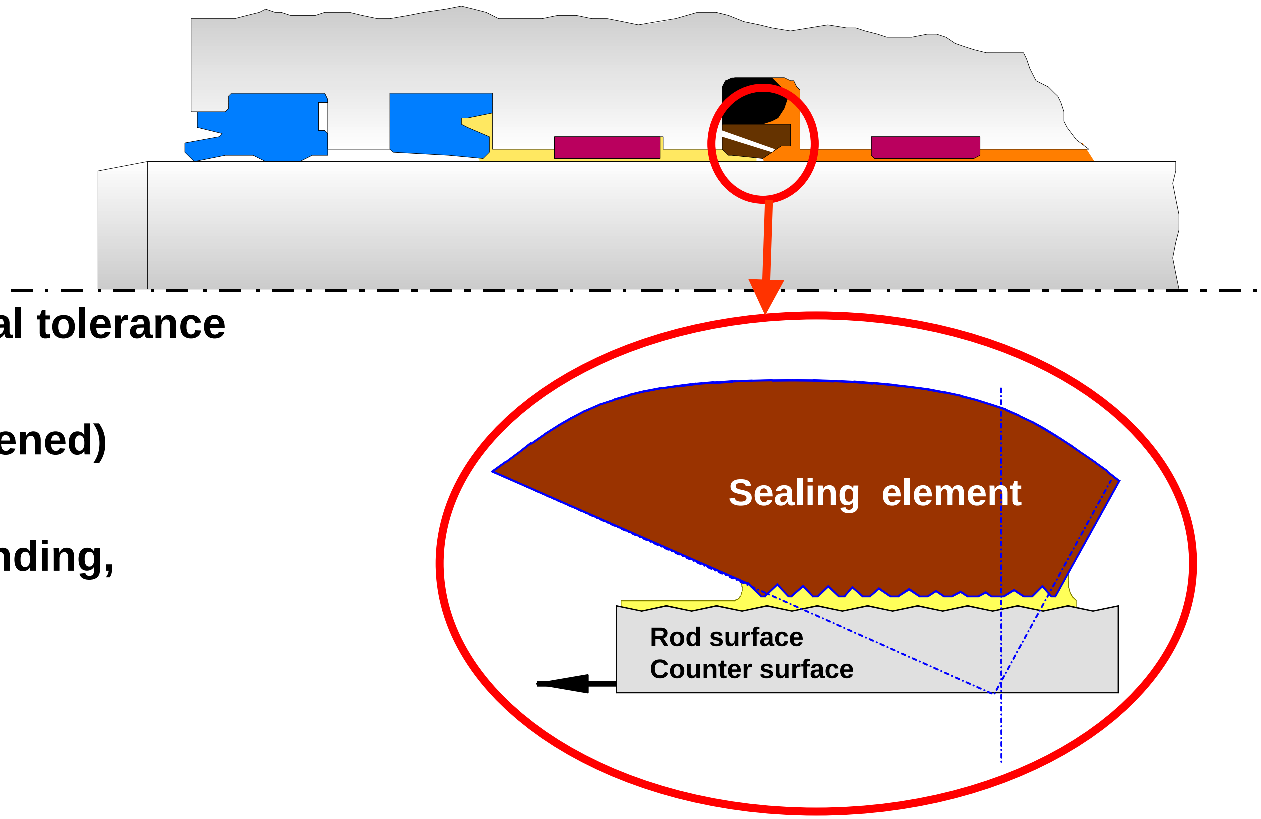


Example of a dynamic seal

Introduction

Rod surface = counter surface = Sealing function

- **Surface quality**
- **Dimensions**
- **Form and geometrical tolerance**
- **Wear-resistant (hardened)**
- **Made by turning, grinding, honing or polishing**



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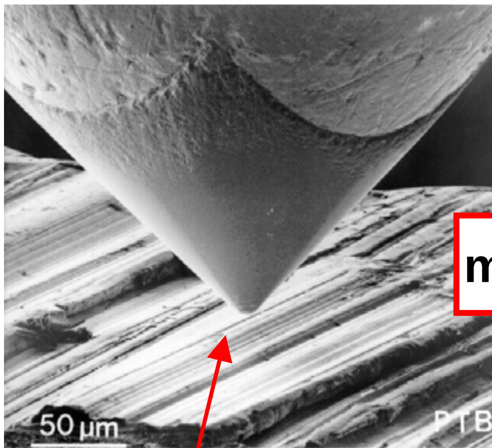
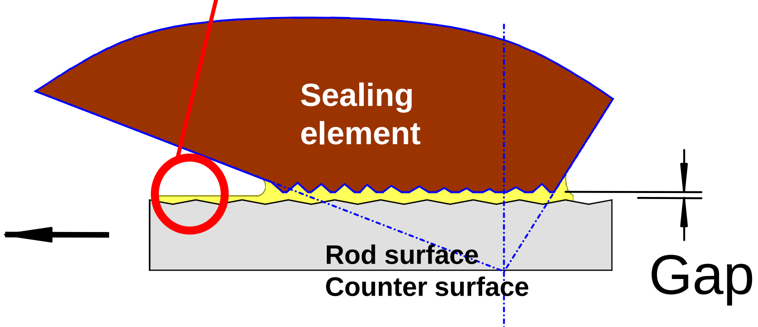
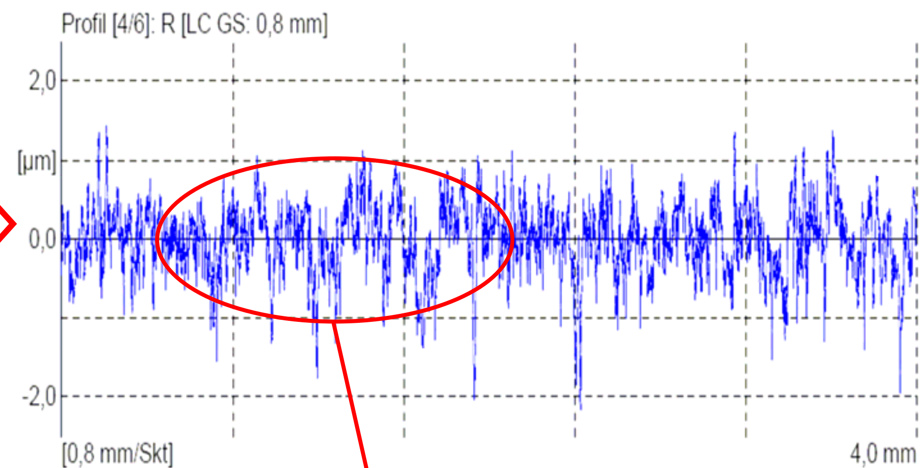


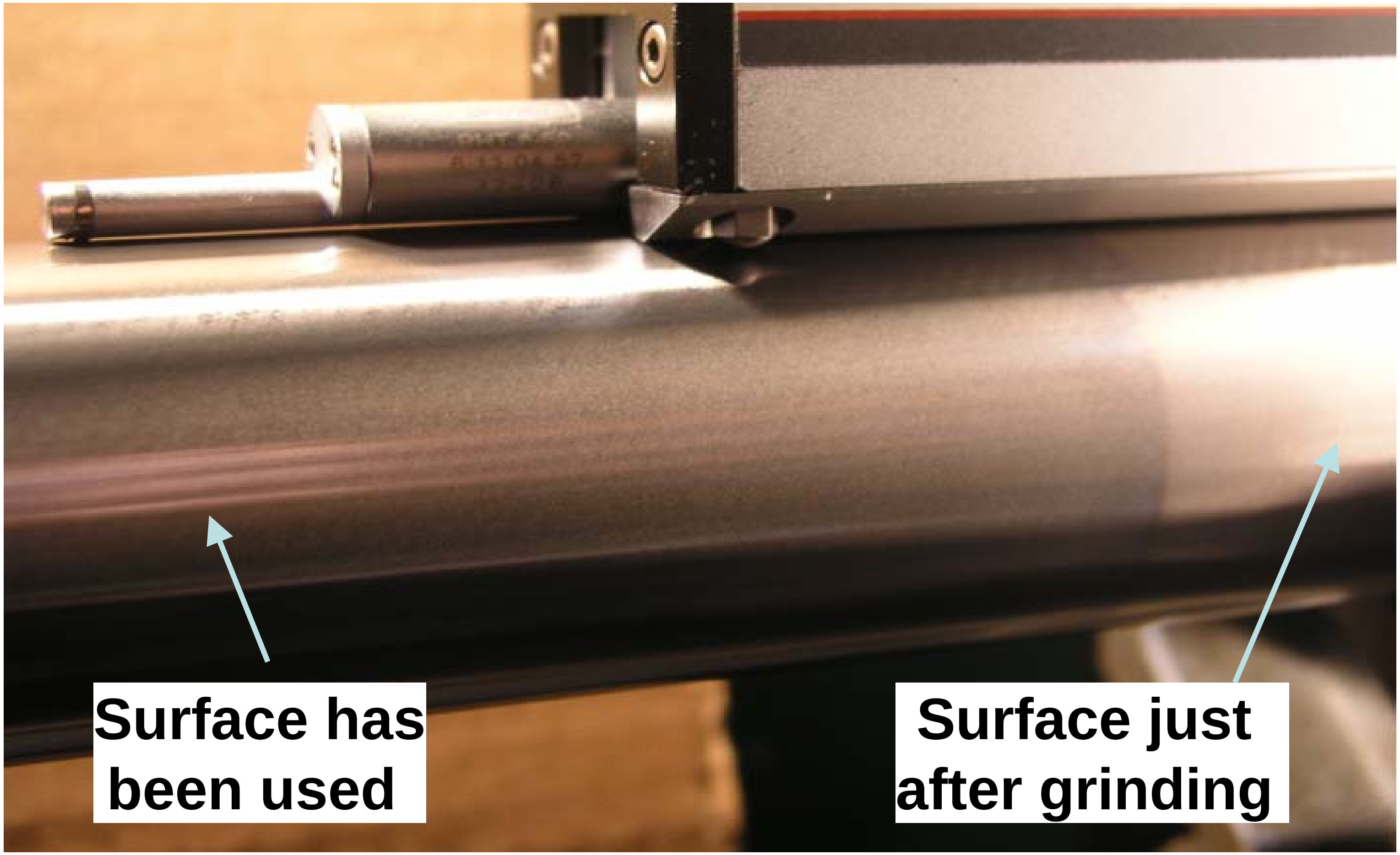




Challenge

Translate a surface measurement into sealing technology requirements

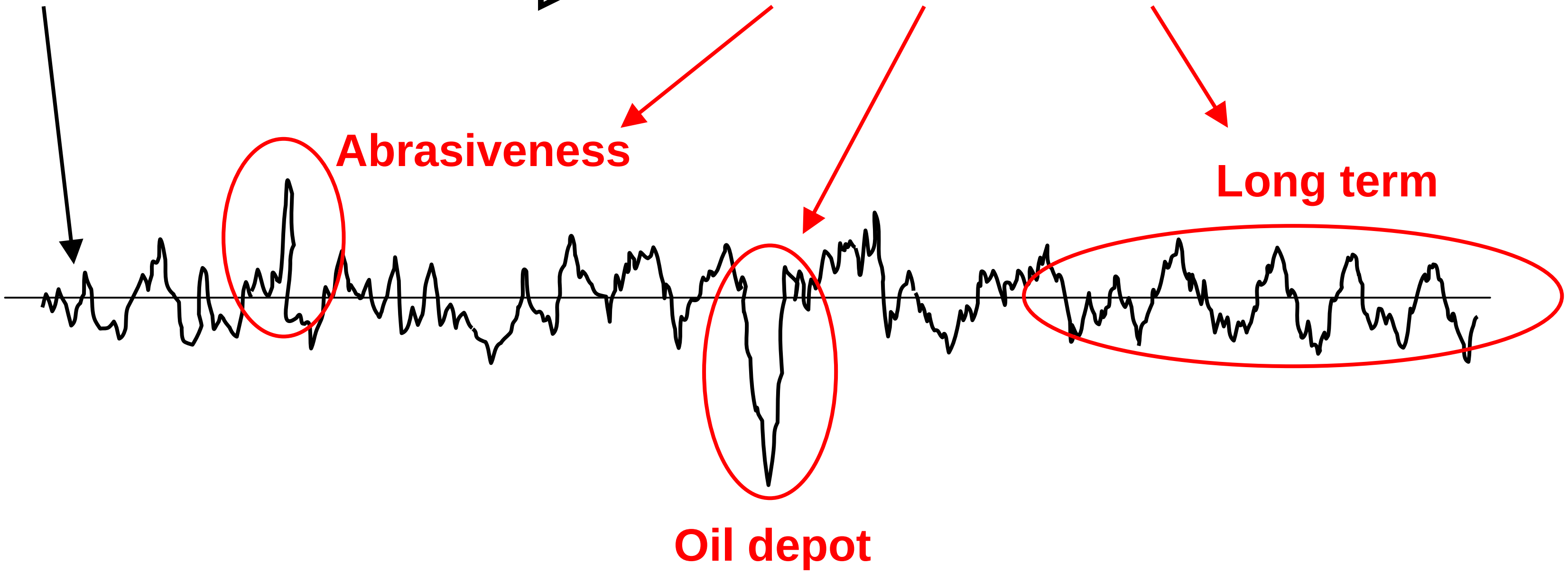
Introduction



Introduction

<u>Challenge</u>:

counter surface measurement → sealing technology requirements



Introduction

- Translate counter surface measurement into sealing technology requirements
- Parameters should identify abrasiveness, long-term behaviour and oil depots (lubricant / leakage)
- Parameters should be easy to handle
- Parameters should based on DIN or ISO standards
- Common parameters are R_z, R_{max} and R_a

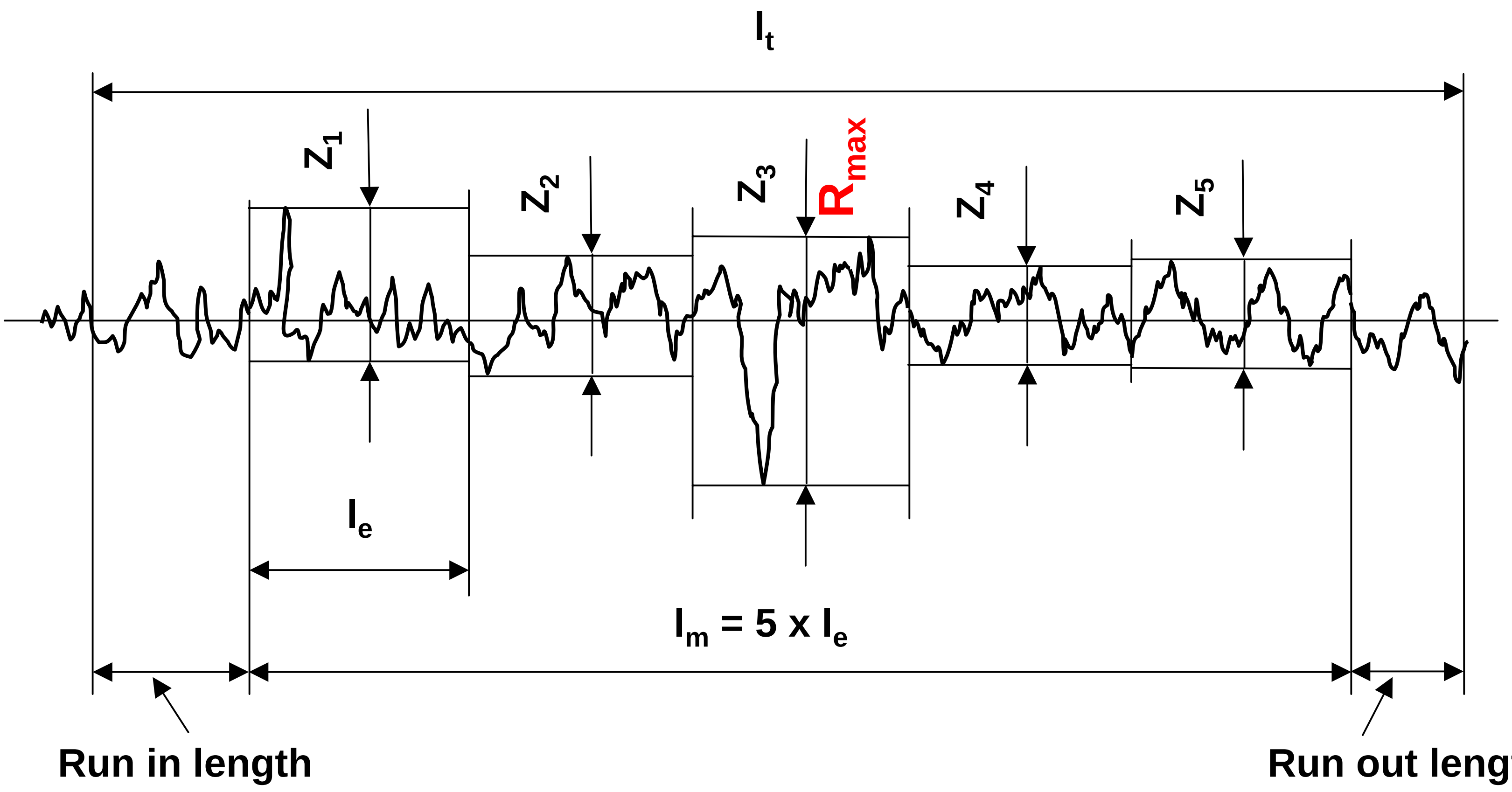
Counter Surface parameters

R_z, R_{max} and R_a

Average maximum height R_z

Maximum roughness depth R_{max}

R_z and R_{max}



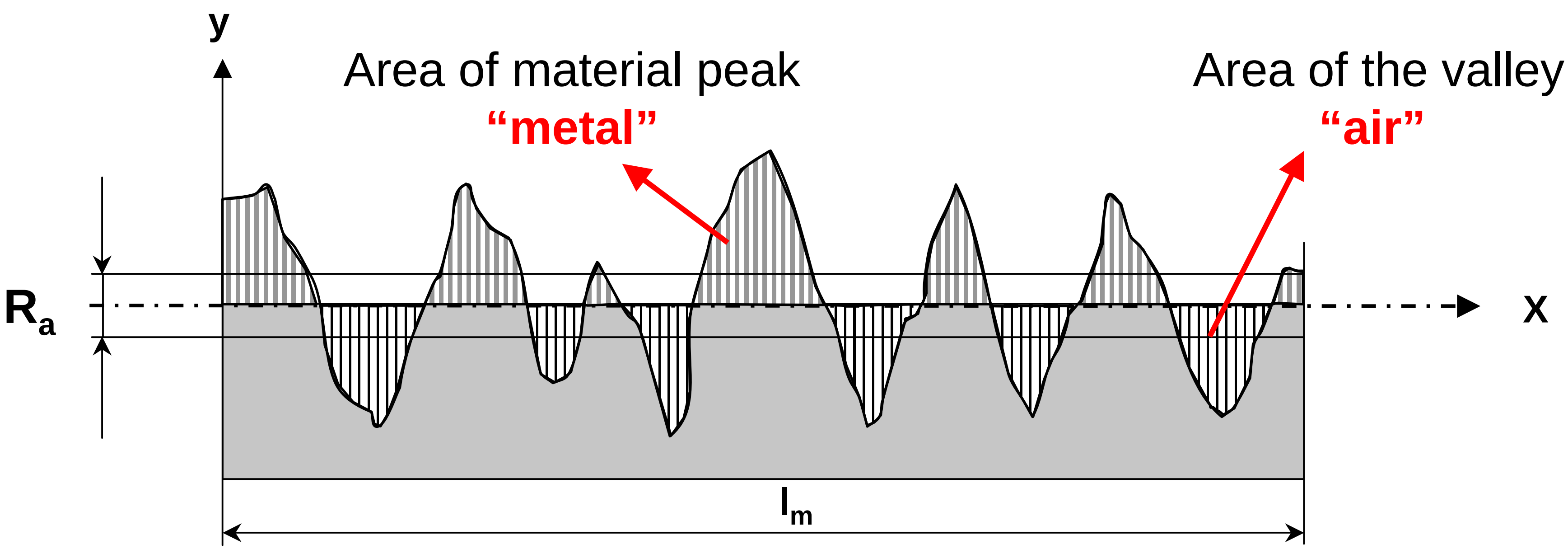
$$R_z = (1 / 5)(Z_1 + Z_2 + Z_3 + Z_4 + Z_5)$$

R_z and R_{max}

- R_z is the average maximum height of the profile
- R_{max} is the maximum value only of one out of 5 sections
- R_{max} is not the total profile depth
- R_{max} and R_z can be dominated by profile valleys
- No evaluation to abrasiveness, long term behaviour or capability to carry oil

Arithmetical mean roughness R_a

Arithmetical mean roughness R_a



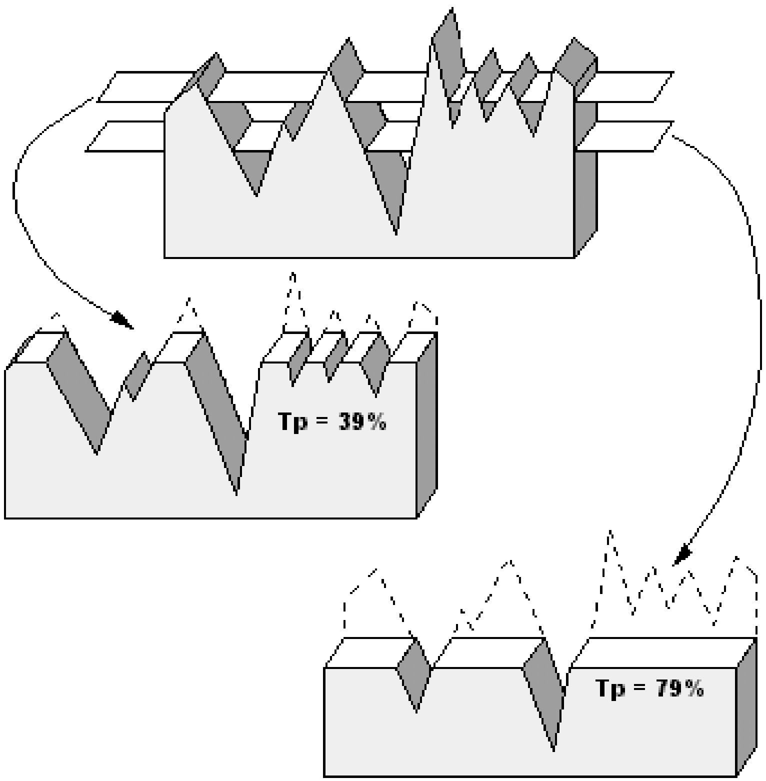
$$R_a = (1/lm)\int_0^{lm} |y(x)|\,dx$$

Arithmetical mean roughness R_a

- R_a is a mixture of “metal” and “air”
- Not good enough with respect to evaluate the surface quality within hard/soft contact or within the sealing technology
- But: Excellent indication of the surface quality with respect to a hard/hard or metal/metal contact

The material proportion curve M_r

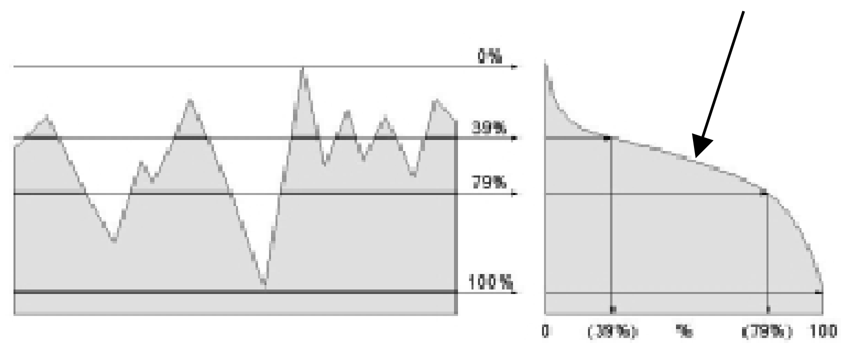
The material proportion curve M_r



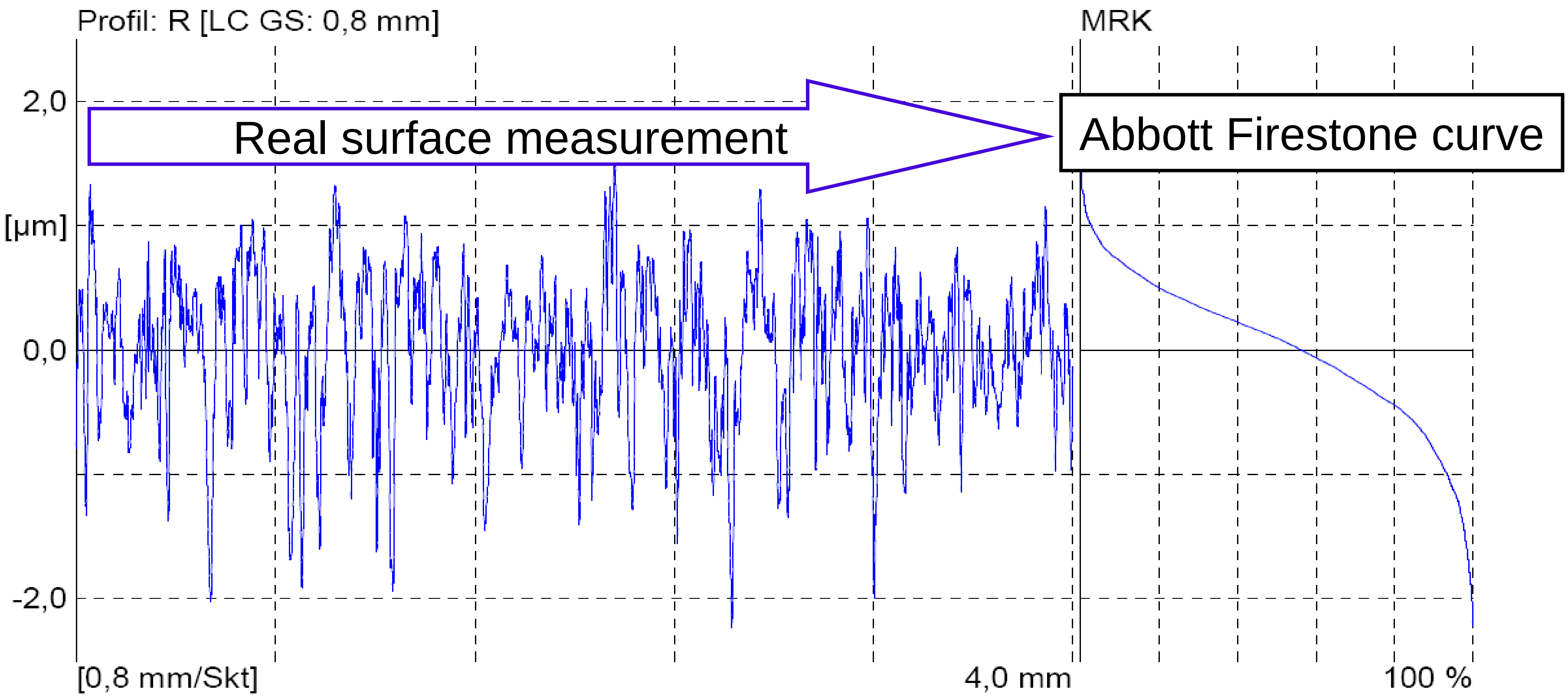
At a given depth, the profile is horizontally sliced and the material percentage is reported.

Tp has been replaced by Rmr (M_r)

Abbott Firestone curve

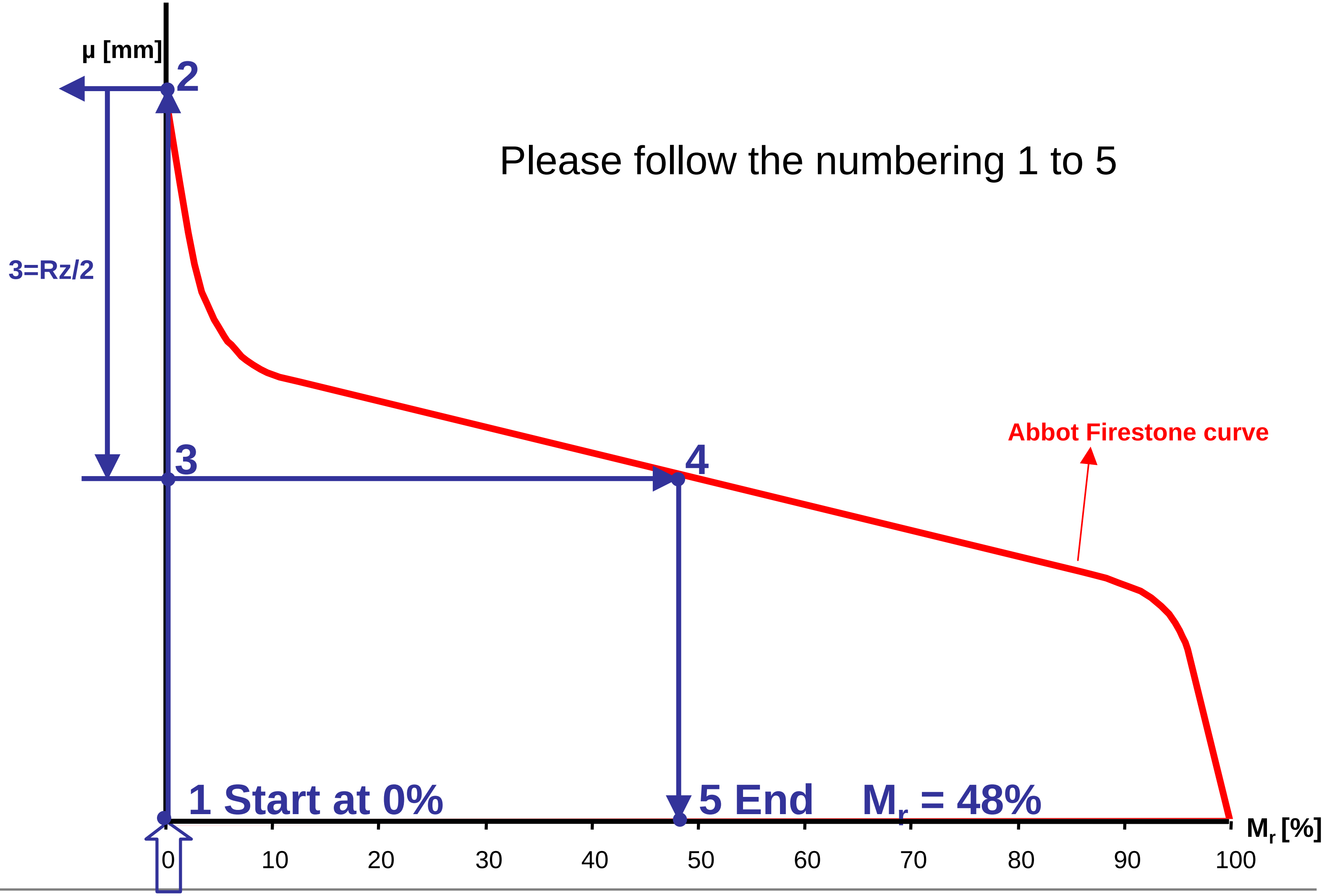


The material proportion curve M_r



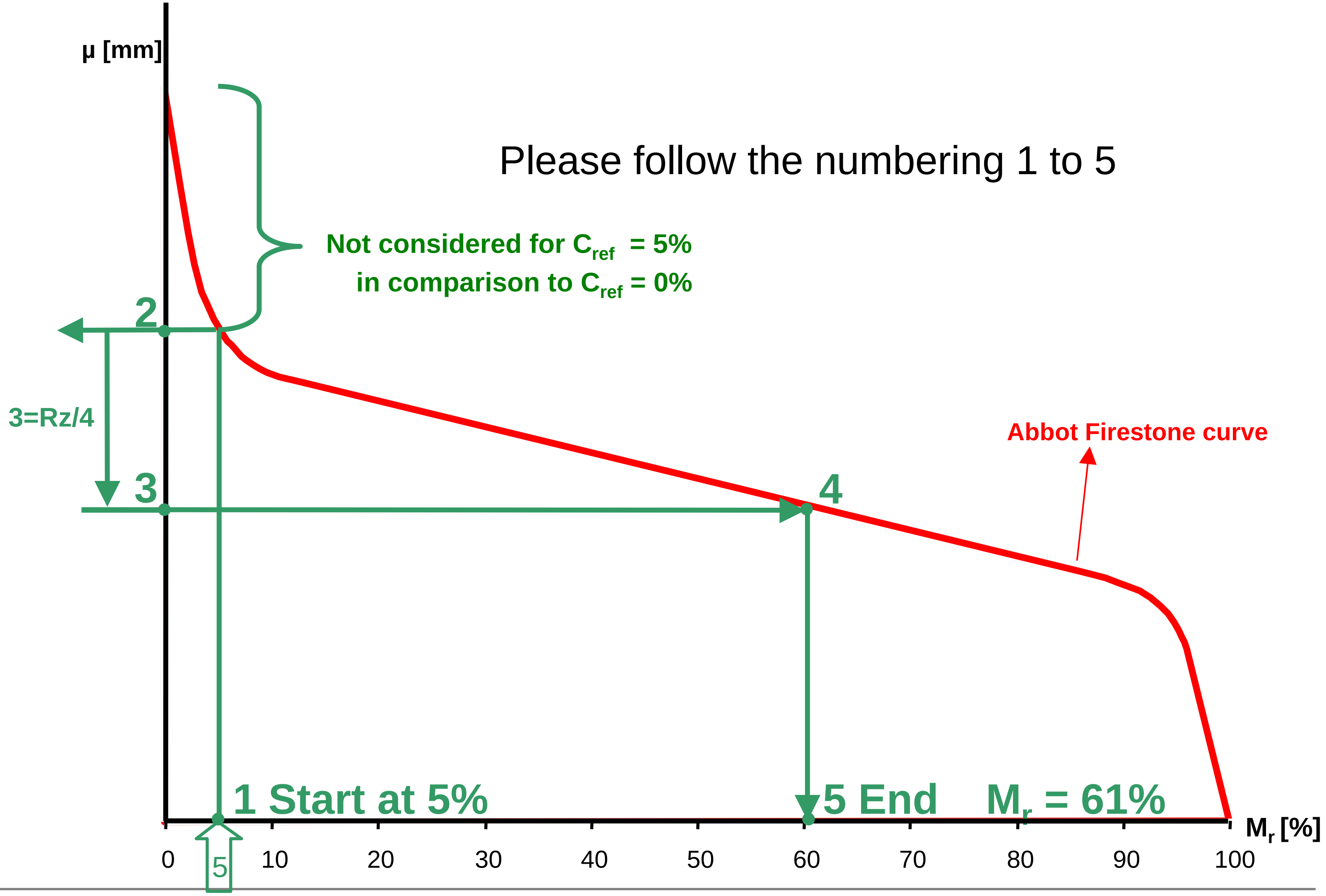
M_r at C_{ref} = 0% and cut off $R_z/2$

M_r at C_{ref} = 0% and cut off $R_z/2$



M_r at C_{ref} = 5% and cut off $R_z/4$

M_r at C_{ref} = 5% and cut off $R_z/4$



The material proportion curve M_r

- The material ratio curve is separating metal from air
- M_r at C_{ref} = 5% ignores surface peaks
- Difficult to handle and to evaluate with respect to the sealing technology
- The full potential of M_r is not used with respect to the sealing technology
- Leaves room for interpretation

Additional
counter surface parameters

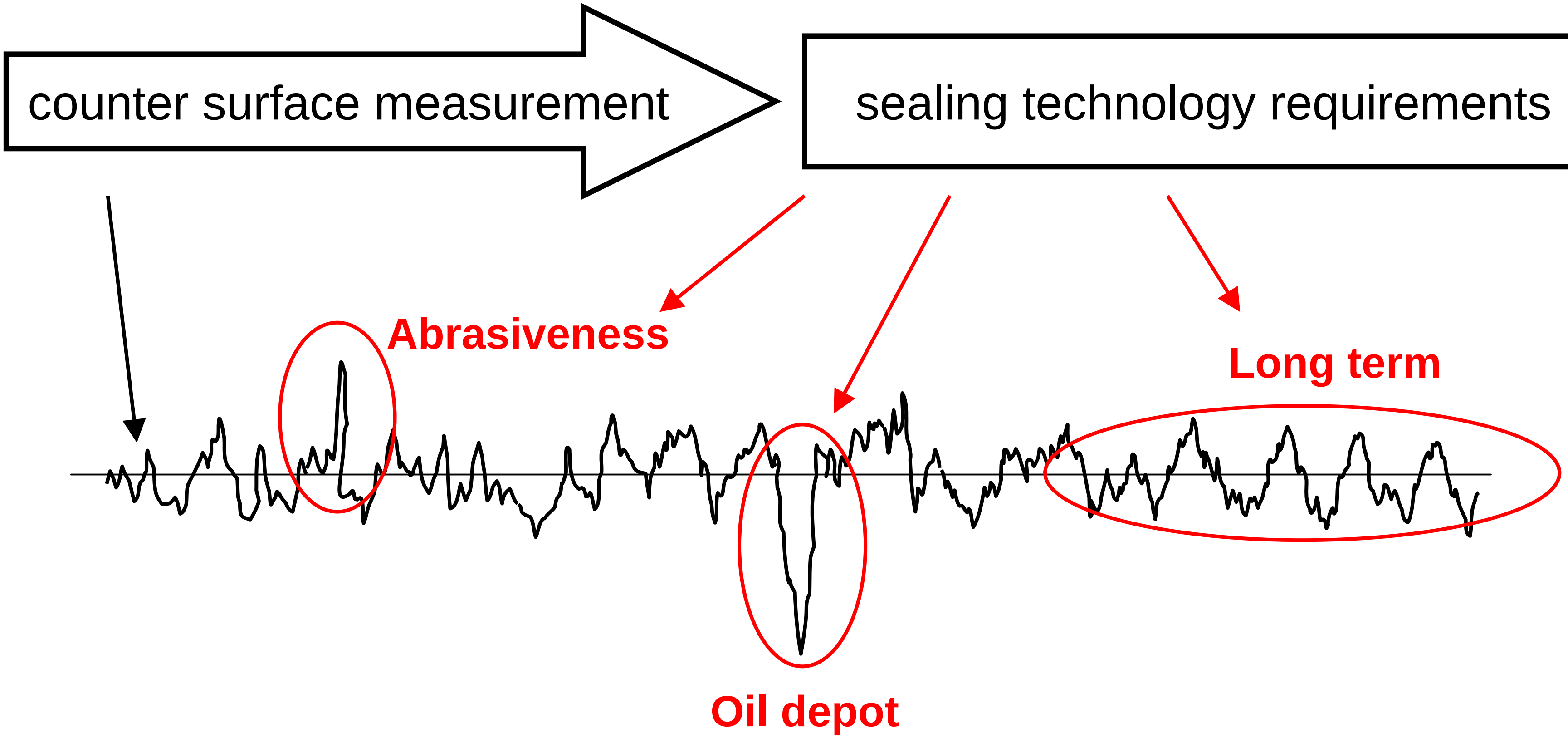
Counter surface Parameters based on the

Abbott Firestone curve

with respect to the sealing technology

Additional parameters

Challenge:



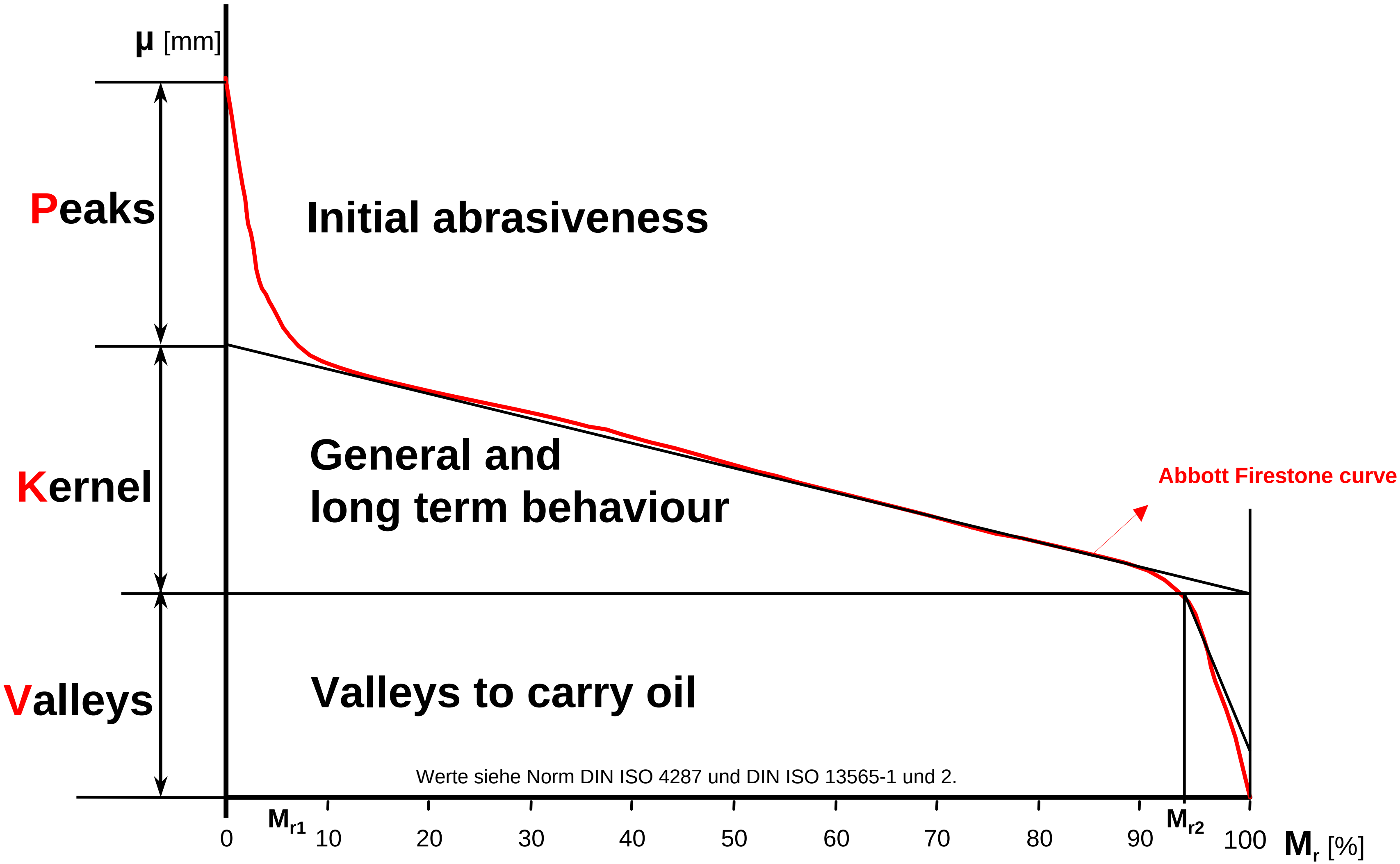
Additional parameters

- Translate counter surface measurement into sealing technology requirements
- Parameters should be easy to handle
- Parameters should based on DIN or ISO standards
- Common parameters like R_z, R_{max} and R_a not sufficient to identify abrasiveness, long-term behaviour and oil depots
- Additional parameters have been identified and qualified

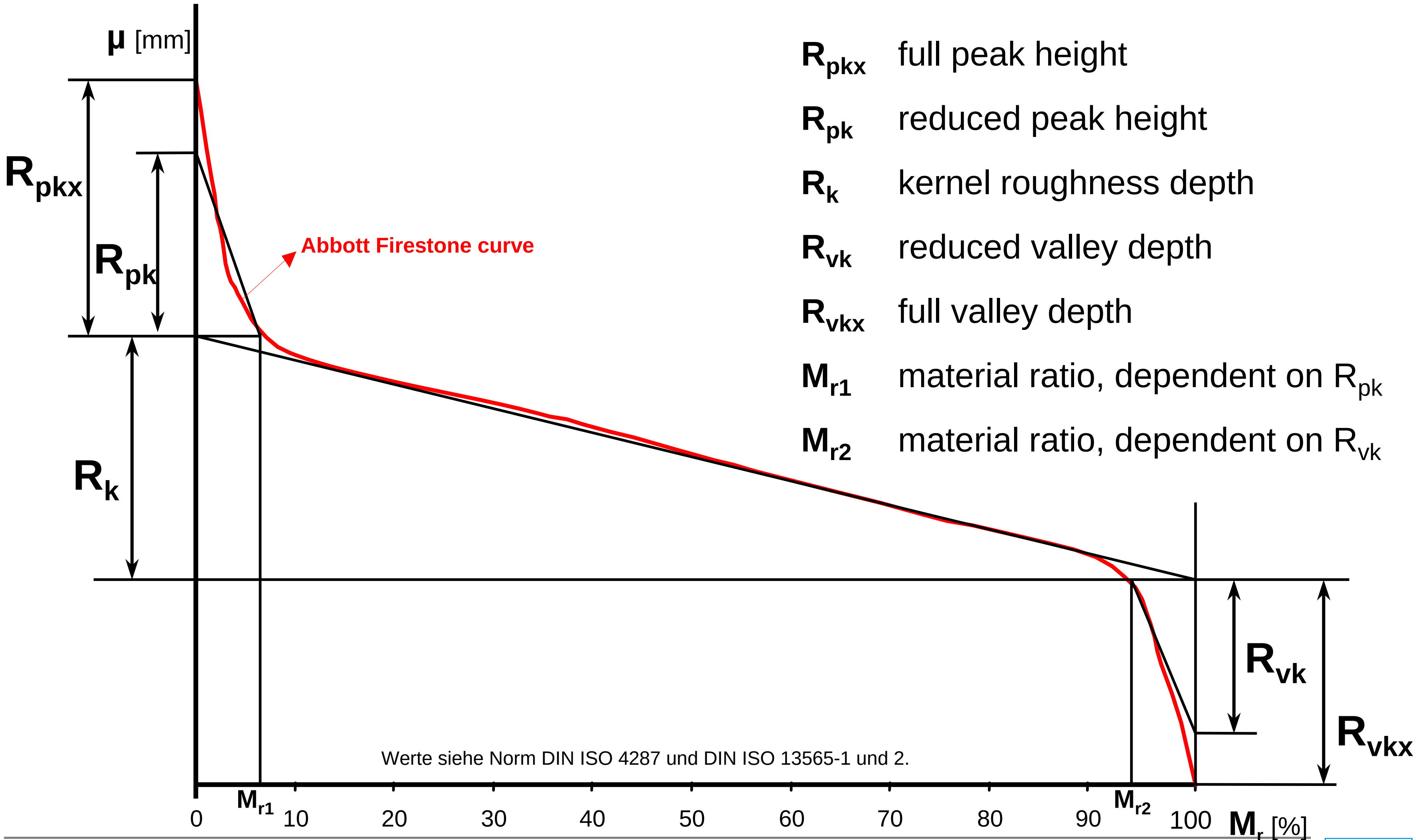
Additional parameters

- Surface Peaks to identify abrasiveness
- Surface Kernel to identify general and long-term behaviour
- Surface Valleys to identify abrasiveness and to carry oil

Additional parameters



Additional parameters

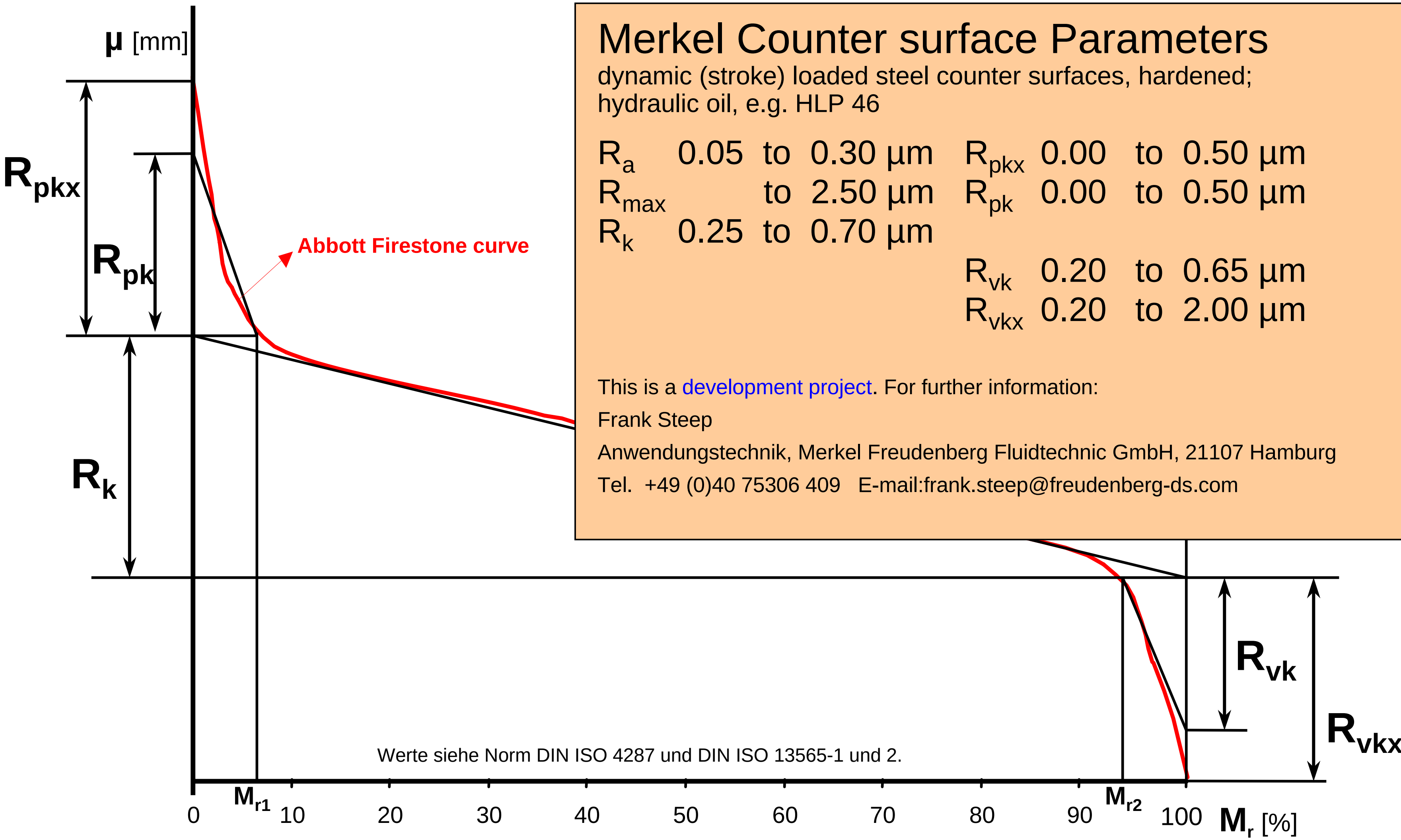


R_{pkx}	full peak height
R_{pk}	reduced peak height
R_k	kernel roughness depth
R_{vk}	reduced valley depth
R_{vkx}	full valley depth
M_{r1}	material ratio, dependent on R_{pk}
M_{r2}	material ratio, dependent on R_{vk}

Recommended counter surface parameters

Merkel **C**ounter surface **P**arameters

Merkel Counter surface Parameters



Merkel Counter surface Parameters

dynamic (stroke) loaded steel counter surfaces, hardened;
hydraulic oil, e.g. HLP 46

R_a	0.05	to	0.30 µm		R_{pkx}	0.00	to	0.50 µm
R_{max}		to	2.50 µm		R_{pk}	0.00	to	0.50 µm
R_k	0.25	to	0.70 µm					
					R_{vk}	0.20	to	0.65 µm
					R_{vkx}	0.20	to	2.00 µm

This is a development project. For further information:

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Merkel Counter surface Parameters

- MCP assign abrasiveness, long-term behaviour and oil depot to surface parameters
- Initial abrasiveness can be detected by R_{pkx} and R_{pk}
- Surface kernel to identify general and long-term behaviour R_k
- Surface valleys to identify abrasiveness and to carry oil R_{vk} and R_{vkx}
- No extra measurement - time required
- Any Counter surface can be judged by adjusted parameters

Merkel Counter surface Parameters

- Consequences to Merkel Freudenberg Fluidtechnic
  - MCP has been implemented
    - into all technical documentation
    - into simrit product catalogue
    - into simrit technical catalogue
  - MCP is part of all customised proposals
  - MCP has been introduced to Merkel customers, has replaced previous standards and has become actual standard.

Test results

R & D test lab

Merkel Freudenberg Fluidtechnic

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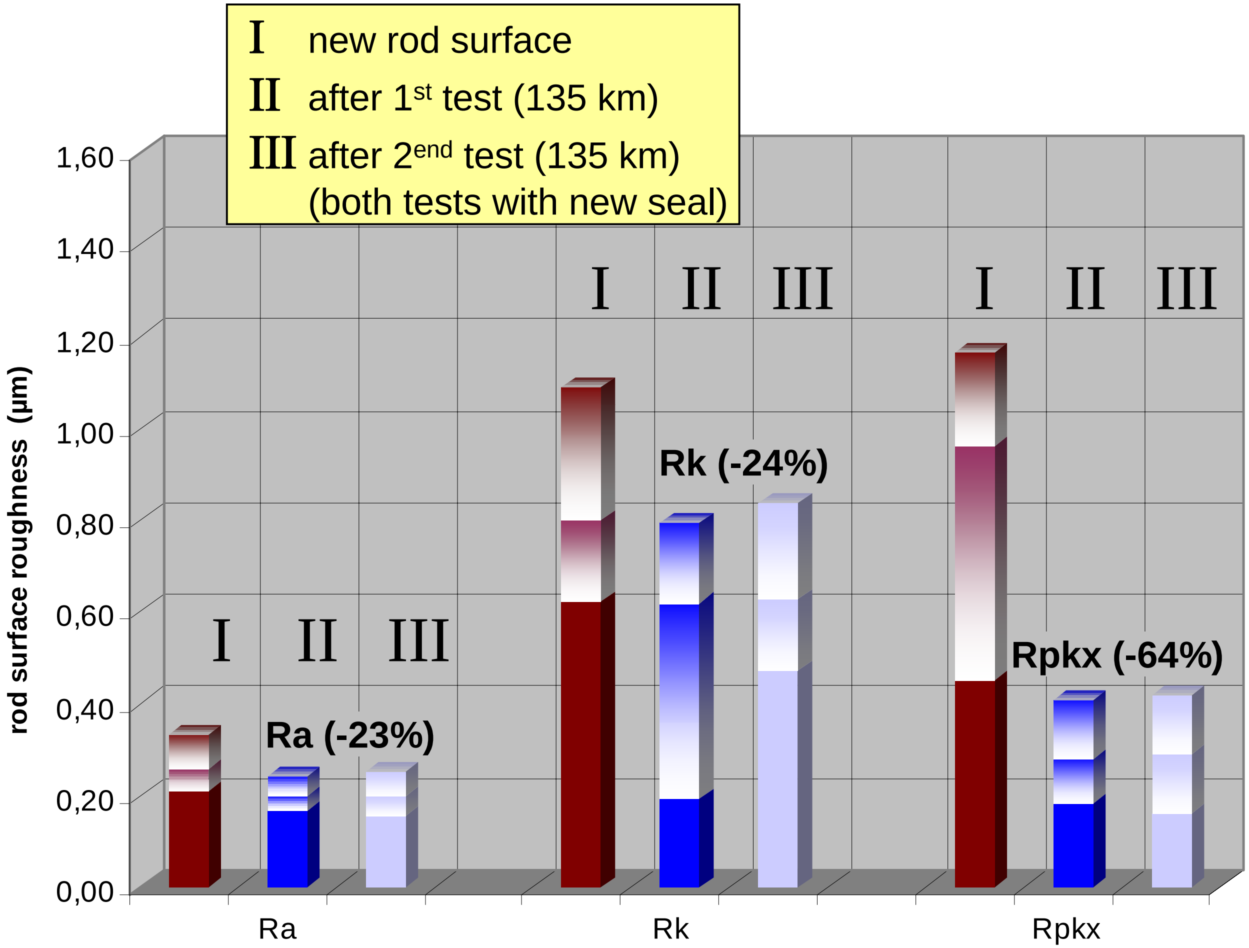
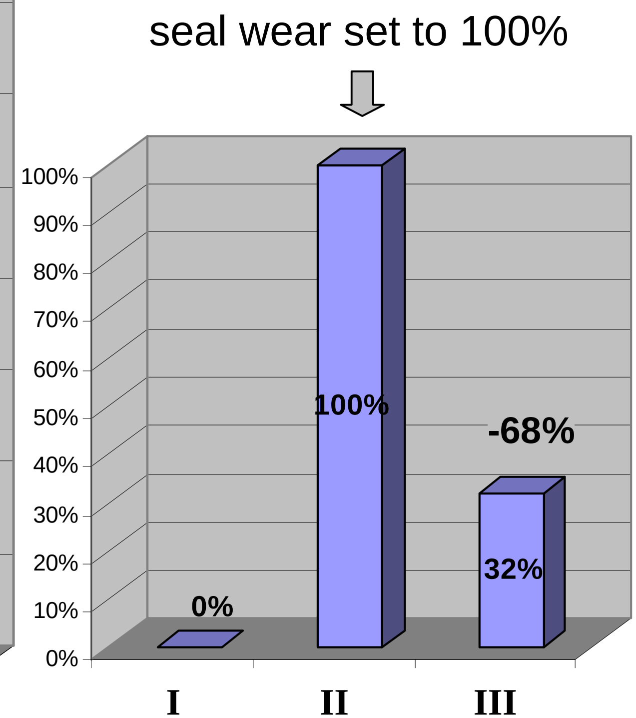
Abrasiveness related to R_a, R_k and R_{pkx}

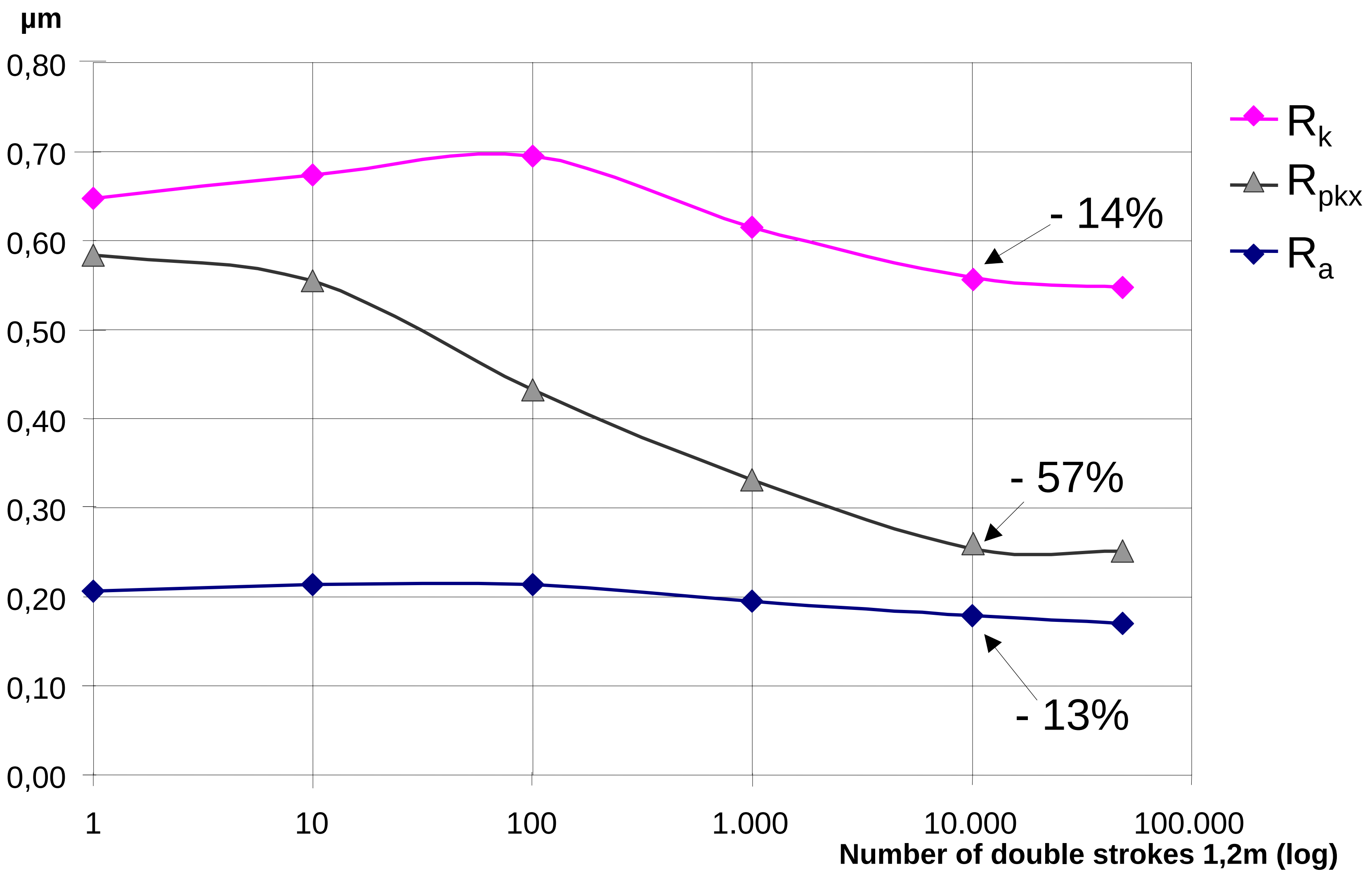
Abrasiveness related to R_a, R_k and R_{pkx}





Run-in effect related to R_{a}, R_{pkx} and R_{k}

Run-in effect related to $R_{a,}$ R_{pkx} and R_k



Spotlight on a days production

rod no		Ra	Rmax		Rk	Rpk	Rpkx	Rvk	Rvkx		present used limits	MFF-recomended limits
1		0,20	1,95		0,64	0,23	**0,51**	0,33	0,90		in	out
2		0,20	1,97		0,61	0,24	0,48	0,33	0,90		in	in
3		0,20	2,34		0,57	0,15	0,25	0,54	1,65		in	in
4		0,19	1,61		0,60	0,17	0,24	0,42	0,81		in	in
5		0,10	1,07		0,32	0,08	0,15	0,22	0,65		in	in
6		0,15	1,53		0,37	0,09	0,16	0,30	1,07		in	in
7		**0,36**	**3,06**		**1,14**	0,33	**0,59**	0,63	1,43		out	out
8		0,25	2,11		**0,75**	0,27	**0,55**	0,40	0,90		in	out
9		0,29	**3,72**		**0,94**	**0,53**	**2,05**	0,49	0,94		out	out
10		0,16	1,38		0,53	0,18	0,26	0,26	0,61		in	in
11		0,07	0,83		**0,17**	0,05	0,07	**0,15**	0,62		in	out
12		0,11	1,74		0,31	0,11	0,27	0,26	1,34		in	in
13		0,19	1,74		0,61	0,14	0,26	0,36	0,97		in	in
14		0,22	2,02		0,60	0,09	0,18	0,49	1,35		in	in
15		**0,35**	**2,98**		**0,96**	0,14	0,25	**0,72**	1,79		out	out
16		**0,35**	**5,50**		0,69	0,10	0,15	**1,42**	**4,69**		out	out
17		0,27	**4,70**		0,56	0,09	0,17	**0,88**	**4,09**		out	out
18		0,24	**5,53**		0,52	0,13	0,20	**0,82**	**4,91**		out	out
19		0,22	**4,91**		0,58	0,11	0,20	0,58	**4,17**		out	out
20		0,20	2,33		0,53	0,15	0,26	0,44	1,67		in	in
21		0,22	1,85		0,60	0,16	0,25	0,51	1,16		in	in
22		0,22	1,49		0,48	0,10	0,16	0,54	0,86		in	in

in	15	12
out	7	10

(Quality check of the rod surfaces)

Source verification

Merkel Freudenberg Fluidtechnic, Hamburg, seminar and training documents archive

Simrit catalogue, 2007

Mahr measurement systems

More training material. Fundamentals of surface technology, 9968032

Digital Metrology Solutions, Inc.. Cylinder Bore Surface Texture Analysis.
Mark C. Malburg, Ph.D.

Heinz Konrad Müller. Sealing of moving machine parts. ISBN 3-920484-00-2

DIN ISO 4287

DIN ISO 13565-1 and 2

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