



# MBRDS1c pre-collaring with stress sensitive Fuji film Methodology and analysis

TE-MS-C-LMF

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# Content

- Methodology of FUJI Prescale films
  - Method and spec. (MS HS HHS)
  - Analysis with office scanner and MATLAB **EDMS: 1885552**
- Analysis of the MBRDS1c short model mid-plane stress after pre-collaring
  - Installation in the mid-plane
  - Stress analysis: **EDMS 2303159**
  - Summary report of the collaring: **EDMS 2376012**

# Prescale film types

Product	Product Code	Pressure range [MPa] 1 MPa $\approx$ 10.2kgf/cm <sup>2</sup>		Product Size W(mm) $\times$ L(m)	Type					
		0.05 7.25	0.2 29			0.5, 0.8 73, 87	2.5 363	10 1,450	50 7,250	130 18,850
		Pressure range [psi] 1 psi $\approx$ 6895 pa								
Super High Pressure (HHS)	PRESCALE HHS R270 10M								270 $\times$ 10	Mono-sheet
High Pressure (HS)	PRESCALE HS R270 10M								270 $\times$ 10	Mono-sheet
Medium Pressure (MS)	PRESCALE MS R270 10M								270 $\times$ 10	Mono-sheet
Medium Pressure (MW)	PRESCALE MW R270 10M								270 $\times$ 10	Two-sheet
Low Pressure (LW)	PRESCALE LW R270 10M								270 $\times$ 10	Two-sheet
Super Low Pressure (LLW)	PRESCALE LLW R270 6M								270 $\times$ 6	Two-sheet
Ultra Super Low Pressure (LLLW)	PRESCALE LLLW R270 5M								270 $\times$ 5	Two-sheet
Extreme Low Pressure (4LW)	PRESCALE 4LW R310 3M								310 $\times$ 3	Two-sheet

Implemented in the Matlab evaluation script

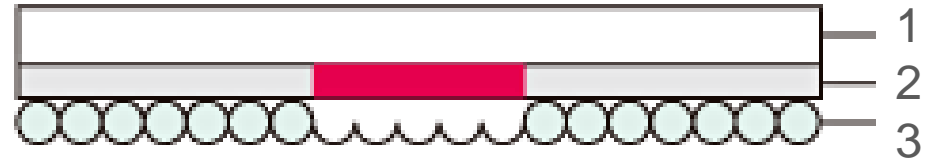
Overview of available Prescale film types

# Prescale film Types

## Specification

- Mono-sheet
  - MS 10 – 50 MPa
  - HS 50 – 130 MPa
  - HHS 130 – 300 MPa
- Thickness:  $100 \pm 5 \mu\text{m}$
- Spatial resolution: 0.1 mm
- Micro capsules 4 to 15  $\mu\text{m}$  with different wall thickness per film Type

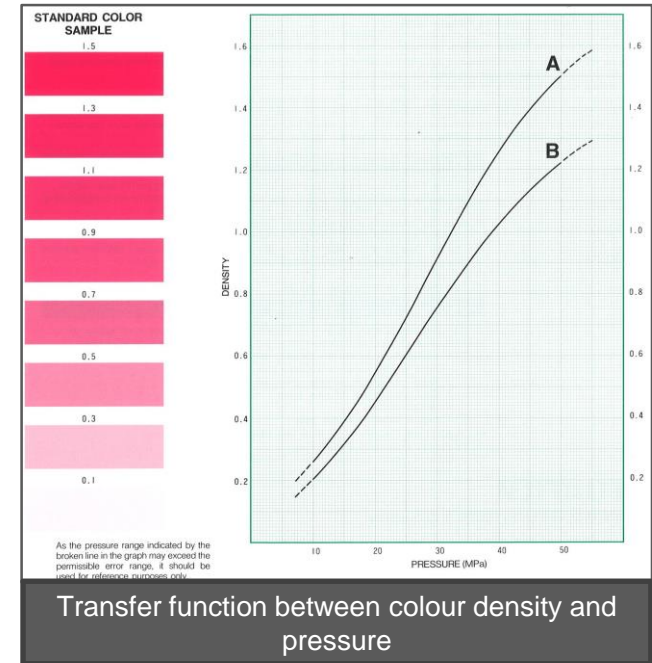
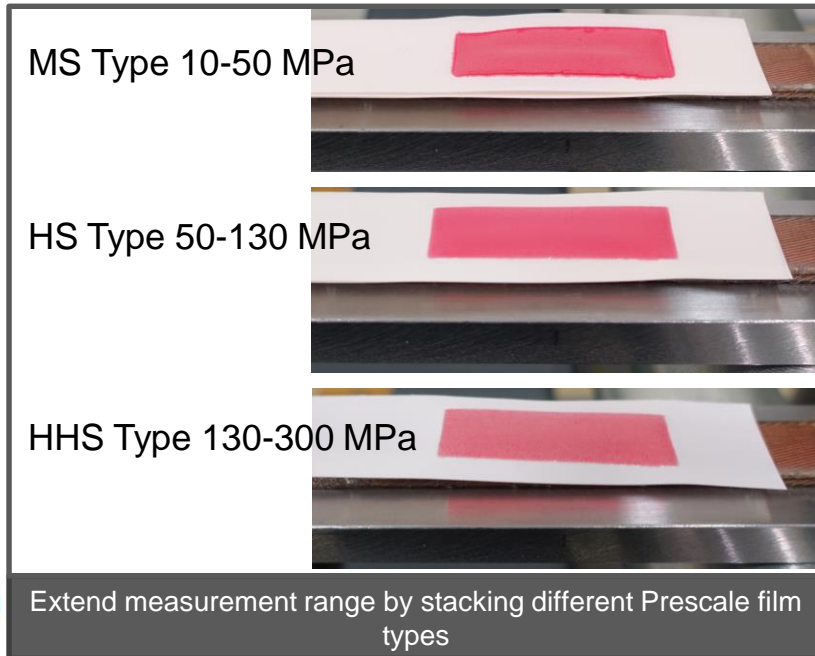
## Layout of a Mono-sheet Prescale Film



- 1 – Polyester base
- 2 – Colour-developing layer
- 3 – Micro-encapsulated colour-forming layer

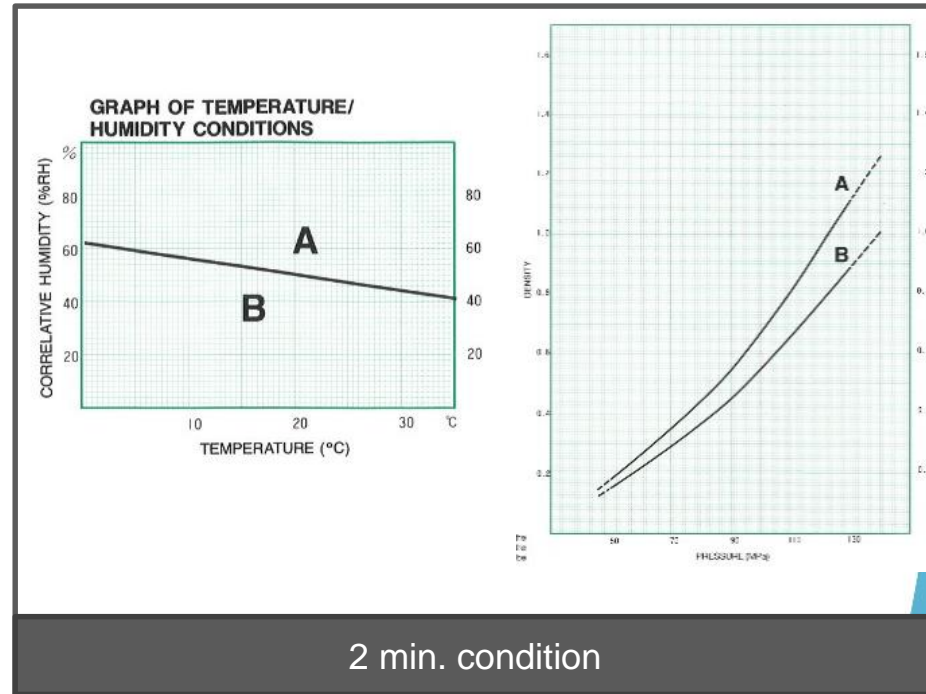
# Application of Prescale film

- Clean the surface of interest before applying the Prescale film.
- Do not write on the Prescale film in the region of interest.
- Extend the measurement range with a stack of different Prescale film types



# General information for Prescale film user

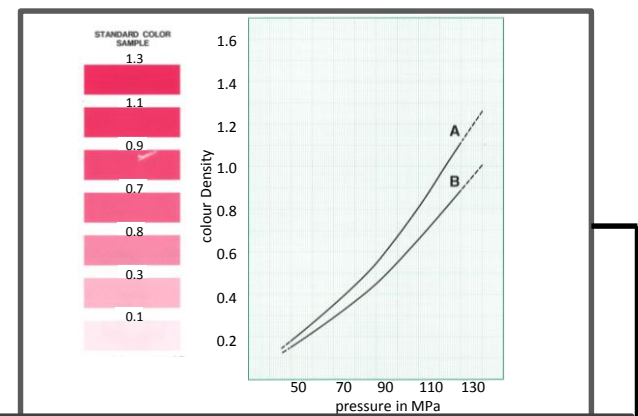
- Ambient condition dependency
  - Temperature
  - Humidity
  - **Record Temp. and Time!**
- Storage remark
  - Prescale film ages (keep it in the fridge and avoid sun light)
- Analysis
  - Analyse the shiny surface (as calibrated)



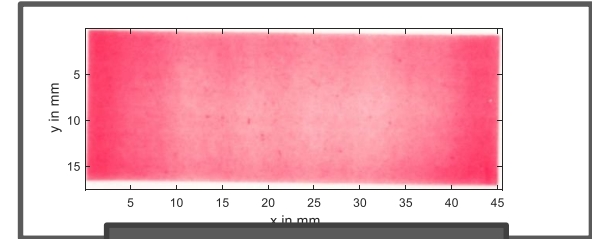
# Principle of analysis of the Prescale film with office scanners

Sequence to analyse the FUJI paper  
EDMS: 1885552

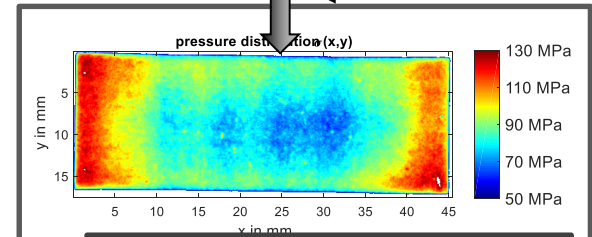
- Calibrate the MATLAB script (generate transfer function)
- Scan the FUJI Prescale film
- Convert colour data to grey-scale values
- Interpret grey-scale values as pressure values



Calibration of the scanner based on FUJI documentation

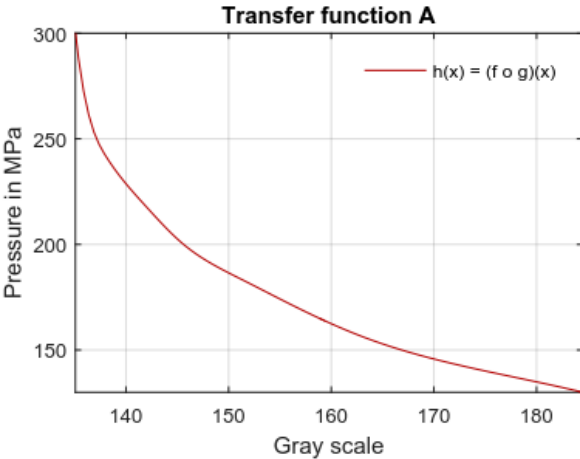


Colour scan of the Prescale film

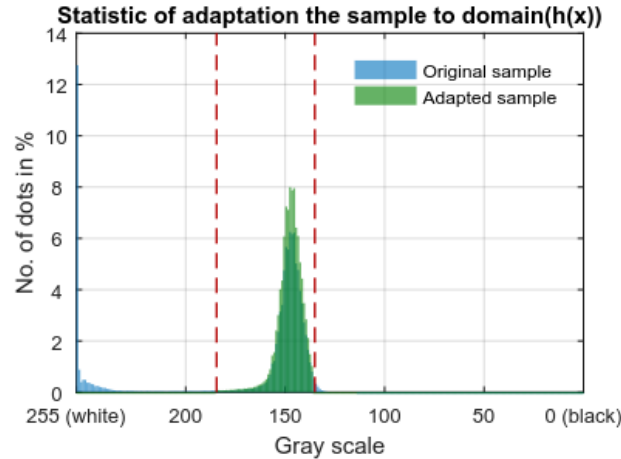


Analysed pressure distribution with  
MATLAB

# Result file as in EDMS 2303159

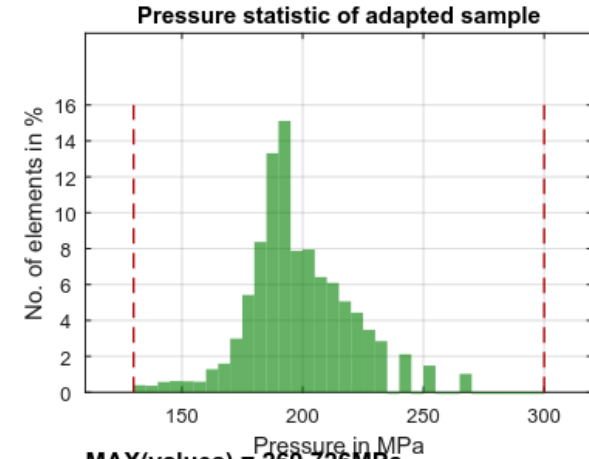


HHS pressure sensitive film  
 CODOMAIN( $h_{HHS}(x)$ ): [130.00MPa,300.00MPa]  
 DOMAIN( $h_{HHS}(x)$ ): [135.07,184.48]



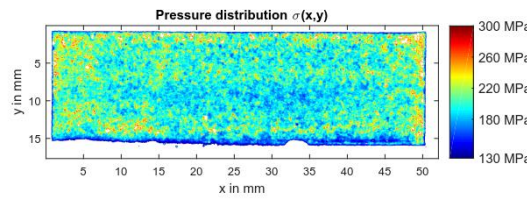
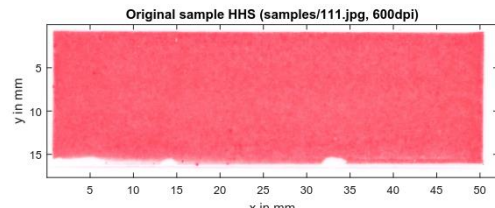
ORIGINAL grayscales: [114,255]  
 NO. ELEM. = 512910

ADAPTED grayscales: [136,184]  
 NO. used ELEM. = 401035 (78.19%)  
 too DARK = 7128 (1.39%)  
 too BRIGHT = 104747 (20.42%)  
 nearly WHITE = 52029 (10.14%)



MAX(values) = 269.726MPa  
 MIN(values) = 130.565MPa  
 MEAN(values) = 198.914MPa  
 STD(values) = 21.616MPa

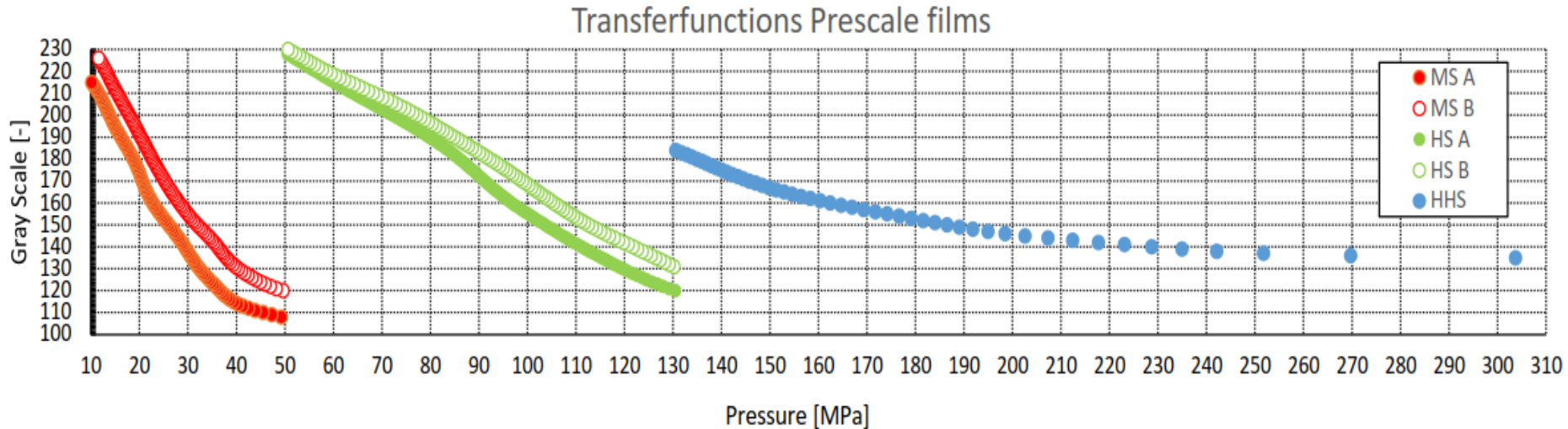
Total scanned area ...  $A_{SCAN} = 919.19171mm^2$   
 Resolution of the scanner ...  $A_{RESOLUTION} = 0.00179mm^2$   
 Area in stress domain ...  $A_{DOMAIN} = 718.69928mm^2$  (78.19%)  
 Area too high pressure ...  $A_{DARK} = 12.77417mm^2$   
 Area too low pressure ...  $A_{BRIGHT} = 187.71826mm^2$   
 Total integrated force ...  $F(A_{DOMAIN}) = 142.95922kN$





# General remark

- The pressure resolution is limited by grey scale values
  - Above 180MPa the resolution is less than 10 MPa



# Content

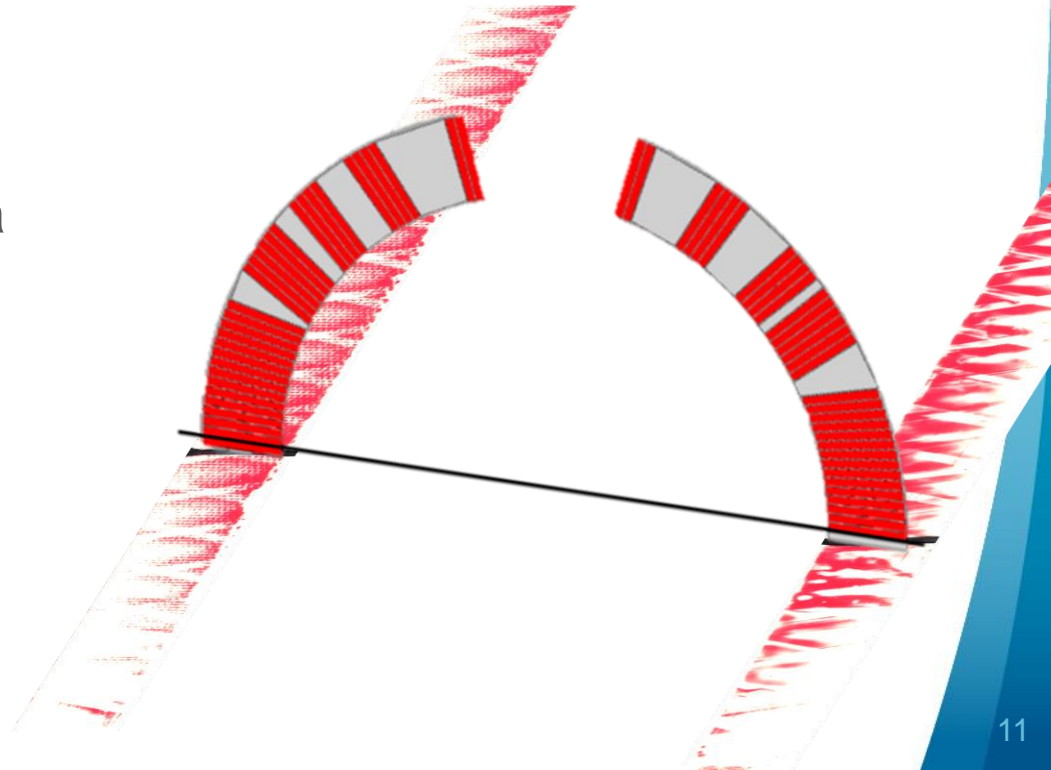
- Methodology of FUJI Prescale films
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# FUJI Prescal film Integration in the MBRDS1c mid-plane

## FUJI Prescal film HS

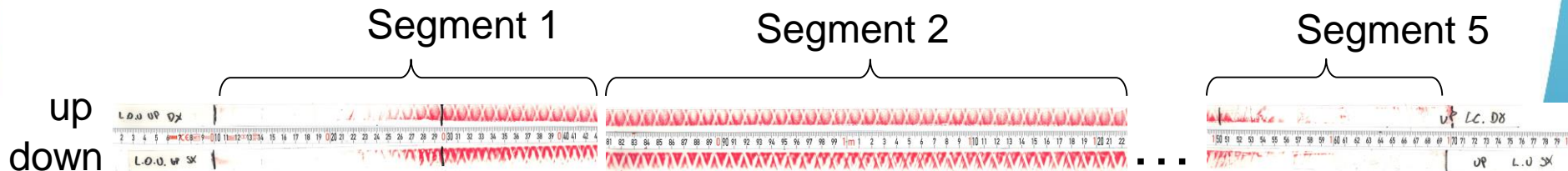
- Mono-sheet
  - Thickness:  $100 \pm 5 \mu\text{m}$
  - Stress range: 50-130 MPa
  - Total length: 1.6m

## Mid-plane instrumentation



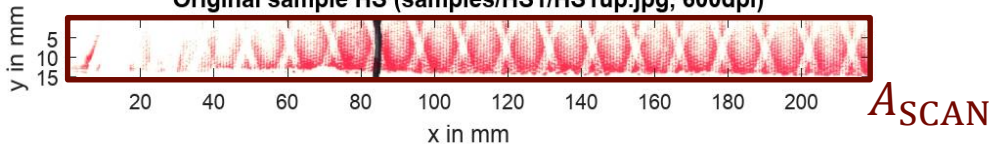
# Stress analysis of the Prescale film

- FUJI stripes has been divided into 5 segments
  - Coil halves are defined by up and down
- Stress range of the FUJI Prescale film is 50-130 MPa
  - Too dark areas have been set to 130MPa
  - Too bright areas have been set to 0 MPa
- Analysis available **EDMS: 2303159**
- Summary report of the collaring: EDMS 2376012

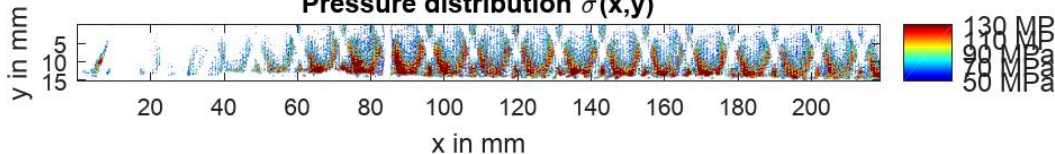


# Detail analysis of segment 1(S1 up)

Original sample HS (samples/HS1/HS1up.jpg, 600dpi)

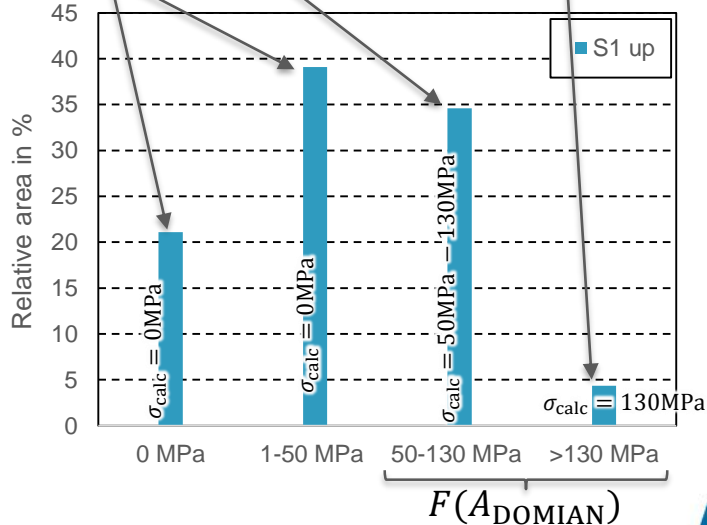
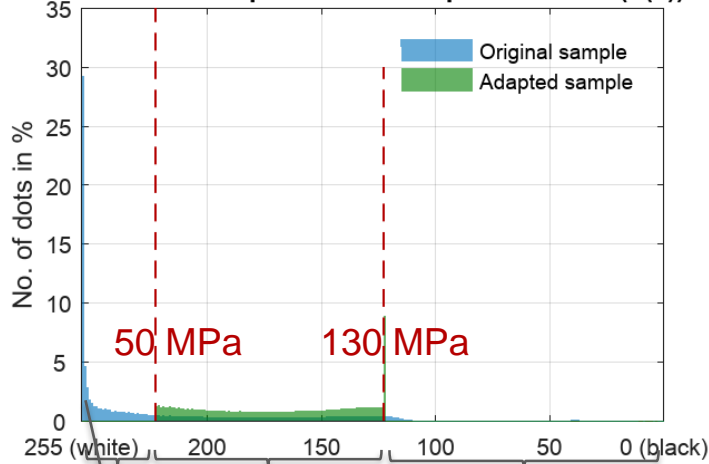


Pressure distribution  $\sigma(x,y)$



$$\text{Analyzed area S1 up } \sigma_{ave} = \frac{F(A_{DOMIAN})}{A_{SCAN}} = 35 \text{ MPa}$$

Statistic of adaptation the sample to domain(h(x))



# Analysis of all segments (up and down)

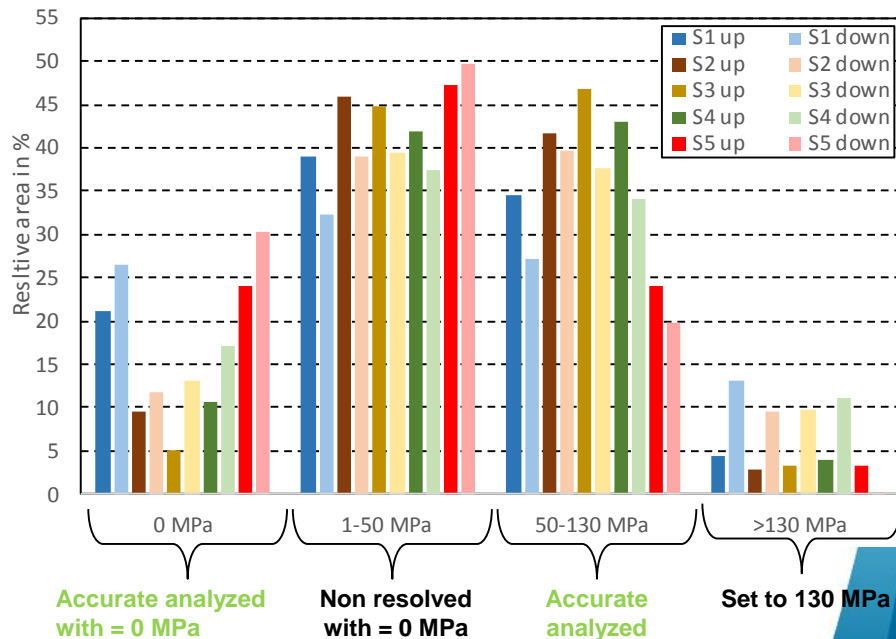
## Remarks on the stress reading

- Stress of 0 MPa (white) is accurate interpreted
- Stress range 1-50 MPa is non resolved (area 30-50%) as set to 0 MPa (very light red)
- Stress range 50-130 MPa is accurate interpreted (area 30-50%)
- Stress range above 130 MPa, dark red, is as set to 130 MPa (area 5-10%)

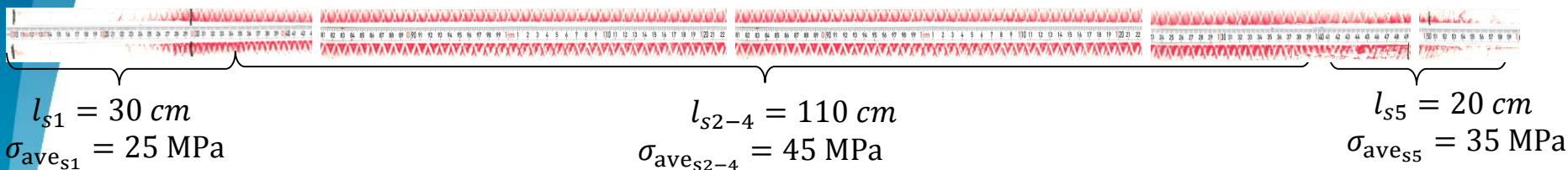
## What are we interested in?

- Peak stresses – Add an HHS paper to reduce the missing 5-10% (130-300MPa)
- Average stress – Add an MS paper to reduce the missing 30-50% (10-50 MPa)

## Stress characteristic of all segments



# Stress averaging



$$\sigma_{\text{average}} \cdot l_{\text{total}} = P_c \cdot \left( l_{s5} \frac{\sigma_{\text{ave}_{s5}}}{\sigma_{\text{ave}}} + l_{s4-2} \frac{\sigma_{\text{ave}_{s4}}}{\sigma_{\text{ave}}} + l_{s1} \frac{\sigma_{\text{ave}_{s1}}}{\sigma_{\text{ave}}} \right)$$

$$57 \text{ MPa} \cdot 160 \text{ cm} = P_c \cdot \left( 30 \text{ cm} \cdot \frac{25 \text{ MPa}}{45 \text{ MPa}} + 110 \text{ cm} \cdot \frac{45 \text{ MPa}}{45 \text{ MPa}} + 20 \text{ cm} \cdot \frac{35 \text{ MPa}}{45 \text{ MPa}} \right)$$

$$57 \text{ MPa} \cdot 160 \text{ cm} = P_c \cdot (30 \text{ cm} \cdot \mathbf{0.56} + 110 \text{ cm} \cdot \mathbf{1} + 20 \text{ cm} \cdot \mathbf{0.78})$$

$$P_c = 64 \text{ MPa}$$

- The stress range 1-50MPa is not measured by the Prescale film, the real average stress is higher
- The Prescale film allows to calculate stress ratios between lead end, return end and straight region
- The load equilibrium between the average applied stress (57MPa) of the press and the contact stress in the coil allows to calculate an corrected stress  $P_c$  at the center

# Conclusion on the MBRDS1c

- Uniform stress pattern with an Fuji film resolved average pressure of about 45 MPa and measured peak up to 130 MPa with non resolved higher stress domains representing maximum 5 to 10 %
- The pressure in coil ends is reduced at 25 MPa -35 MPa in average.
- Considering that the central straight region is the most representative of the applied collaring stress, the renormalization of the measured contact stress gives an average pressure  $P_c$  in straight region of 64 MPa
- The observed unbalance of Fuji film stress imprints between left and right coil branches does not exceed 10-20%.
- At nominal load, the values of pressure are expected to double to 128 MPa in the center and 71 MPa - 99 MPa at the respective coil ends



# Outlook for MBRDP collaring

- Precollaring of MBRDP shall be executed with Fuji Prescale film at the mid-plan
- Presclae film types MS(10-50MPa) and HS(50-130MPa) shall be used on top of each other to extend the stress-range
- The film thickness of 0.1mm per film has to be taken into account, whit respect to the overall shimming

**Thank you for your  
attention.**