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PROBABILISTIC ANALYSIS OF COMPOSITE GAS CYLINDERS

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COMPOSITE GAS CYLINDERS

Probabilistic Analysis of Minimum Load Cycle Requirements

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BAM – 3.2

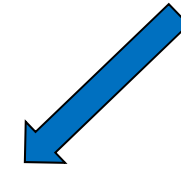
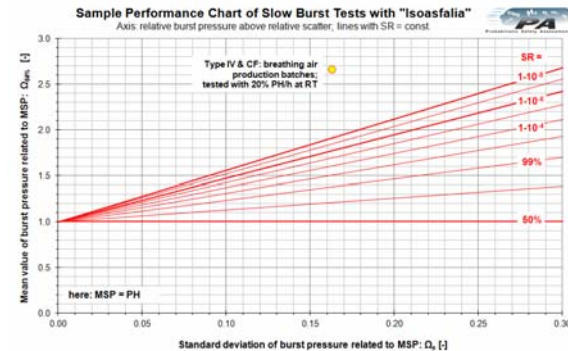
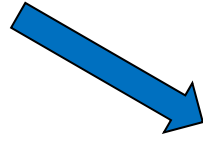
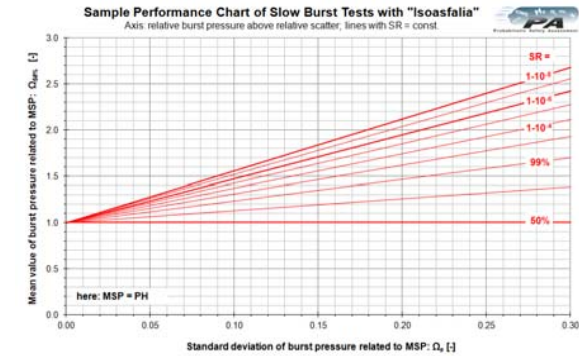
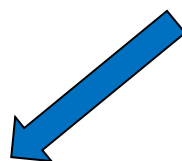
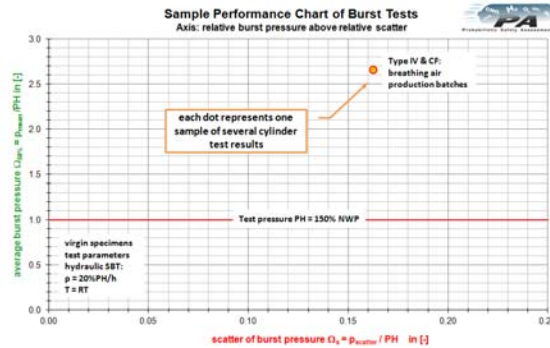
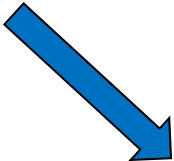
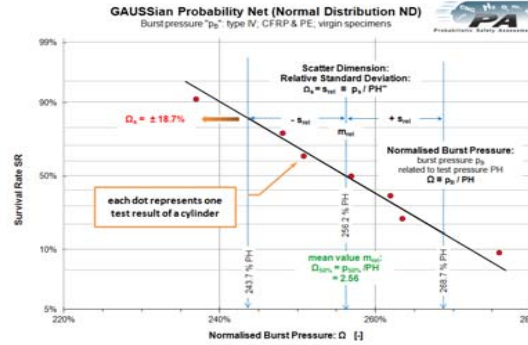
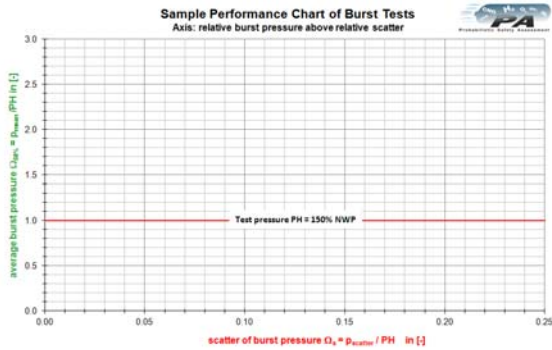
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Introduction

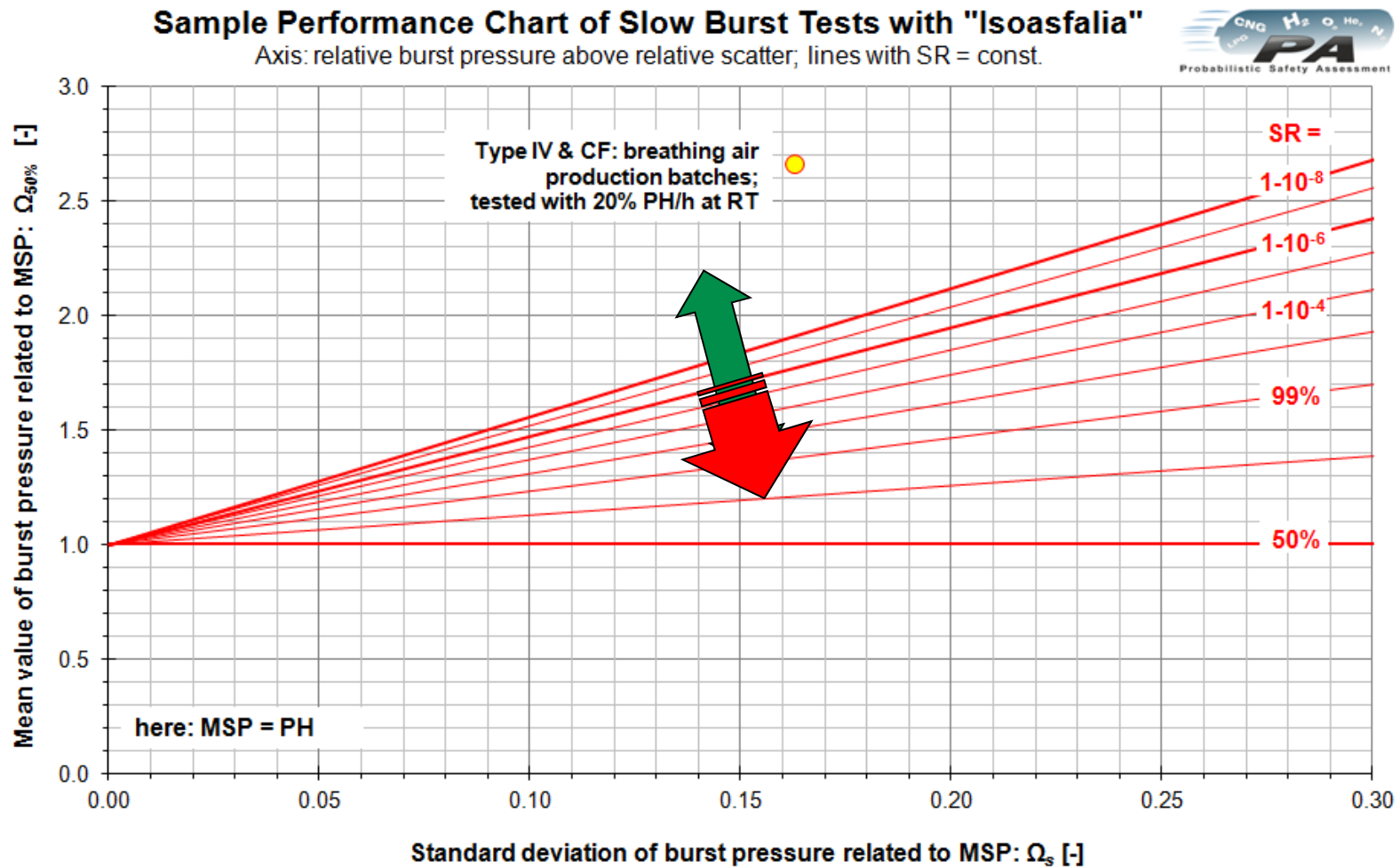
“Sample Performance Chart” SPC
enables the display of sample properties and
of lines of constant reliability values
“Iso-asfalia”

Please compare with ICHS 2013

The Sample Performance Chart (SPC)



The Sample Performance Chart (SPC)



Sample Performance Charts (SPC)

- ... enable to display sample strength properties as one dot per sample;
- ... allow to display changes in strength properties, due to production quality and due to in-service-degradation.

Isoasfalias (lines of constant survival rate)

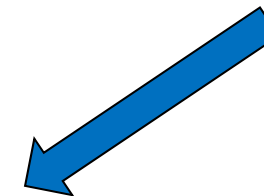
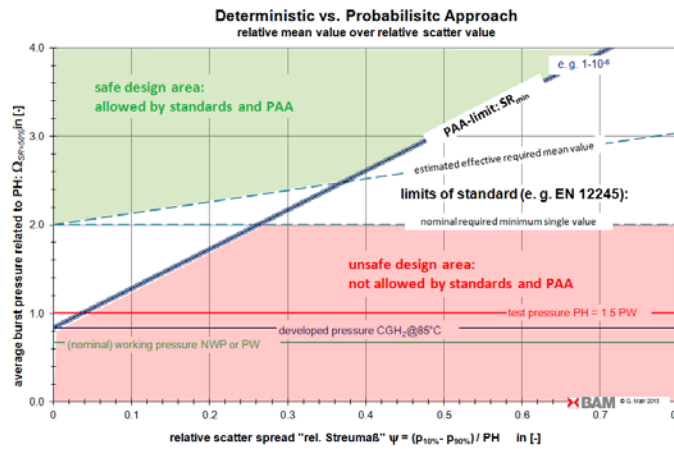
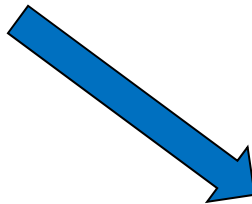
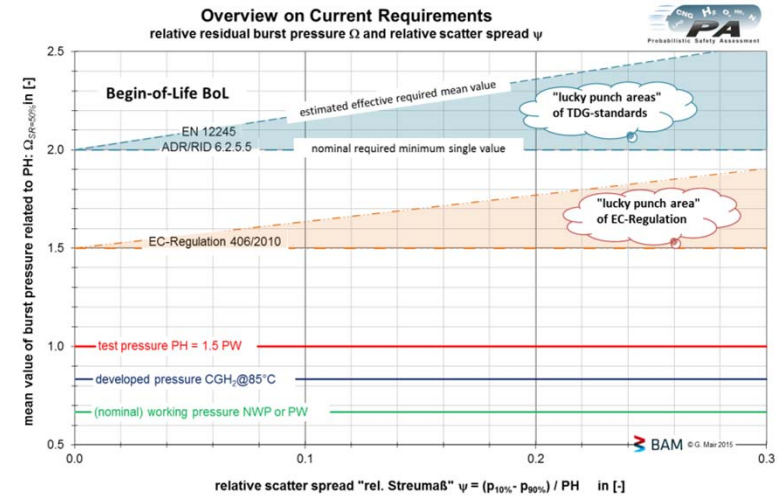
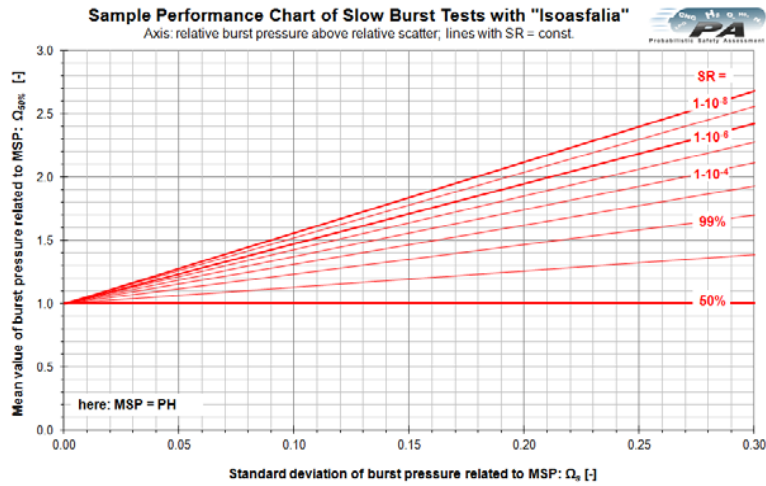
- ... allow to evaluate safety of a sample in the SPC;
- ... depend on distribution function and sample size

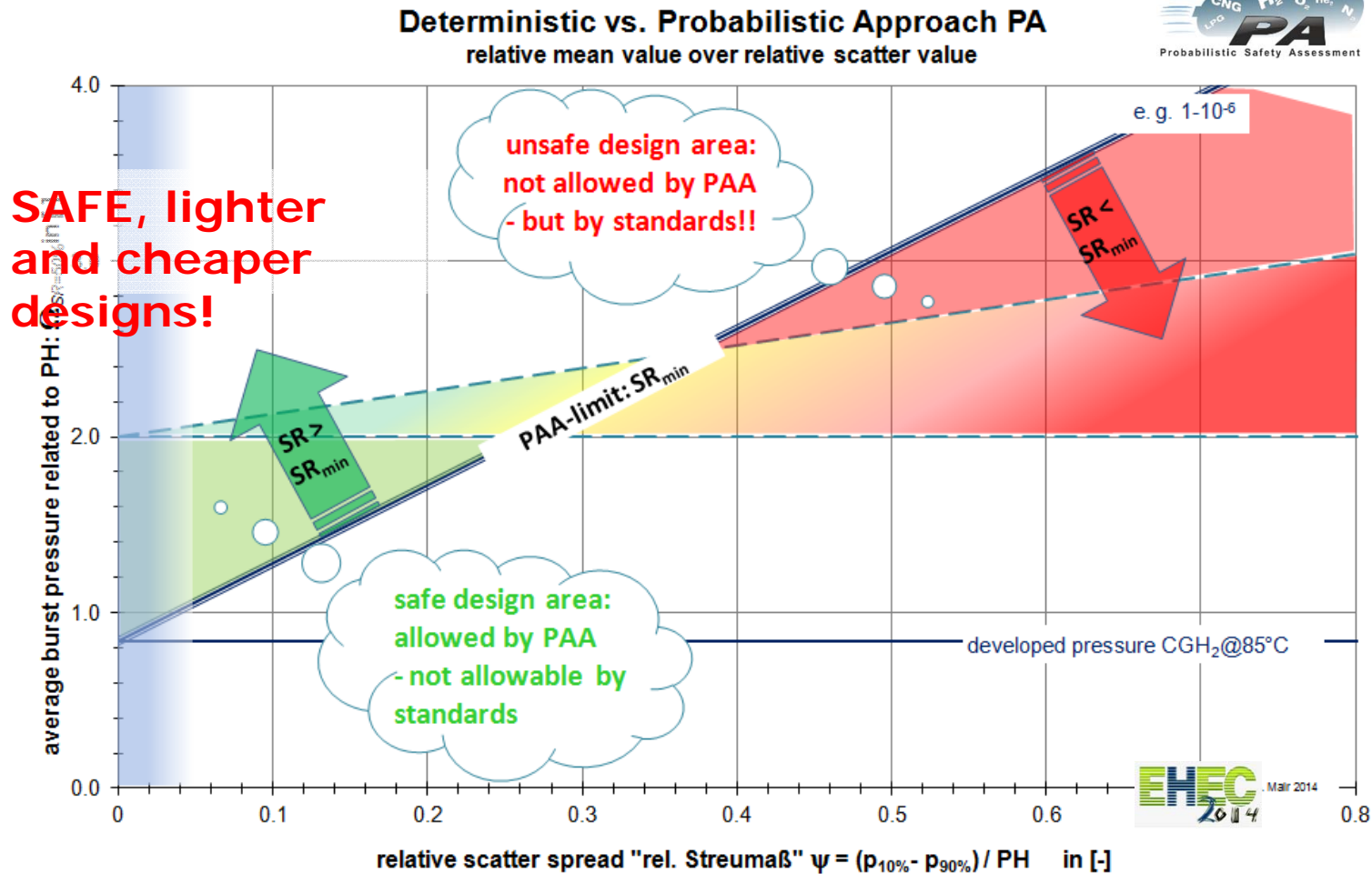
Comparison of Probabilistic Approach and Standards

The principle of this comparison is best to get explained by using the SPC for (slow) Burst Strength (SBT)

Please compare with EHEC 2014

SBT: Comparison of Standards and PA



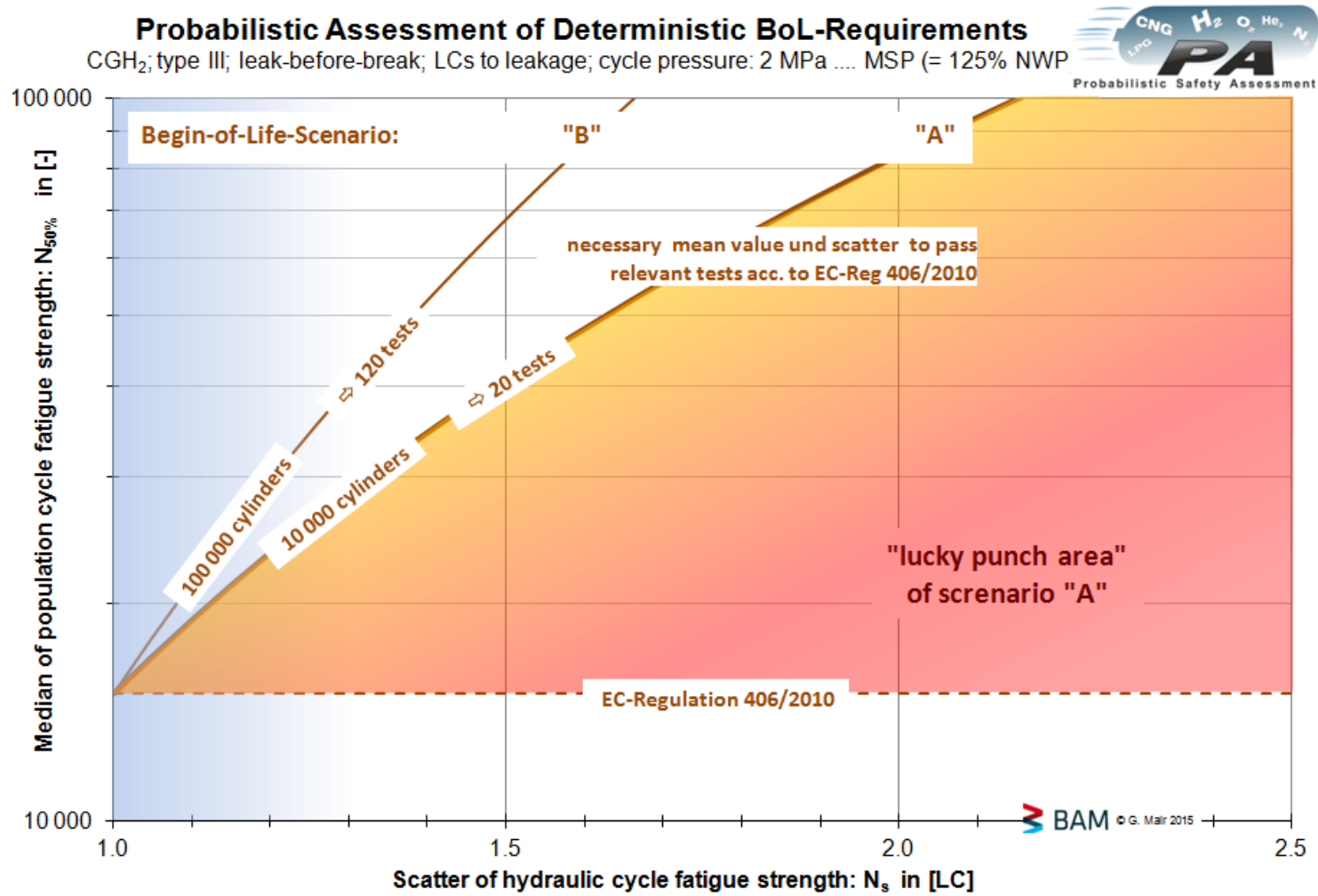


Comparison of Probabilistic Approach and Standards

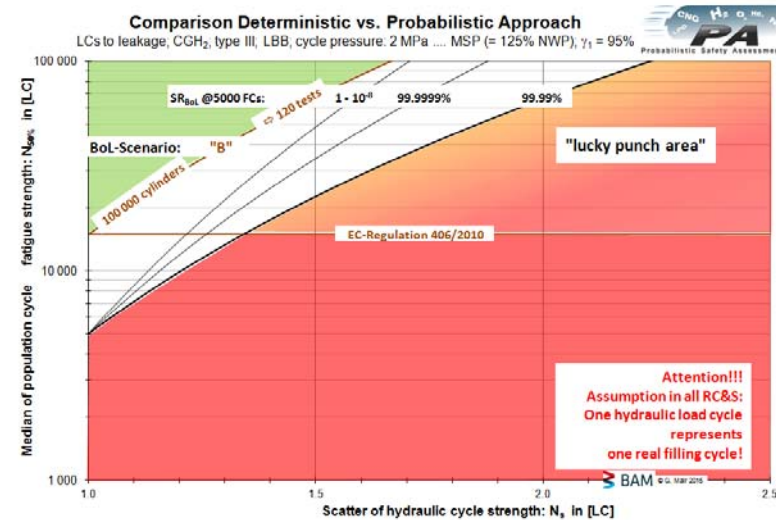
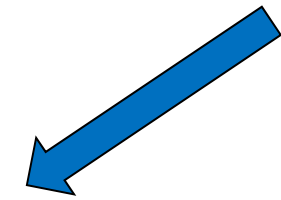
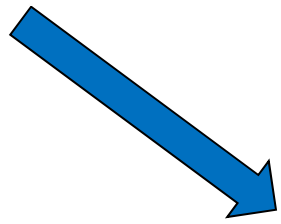
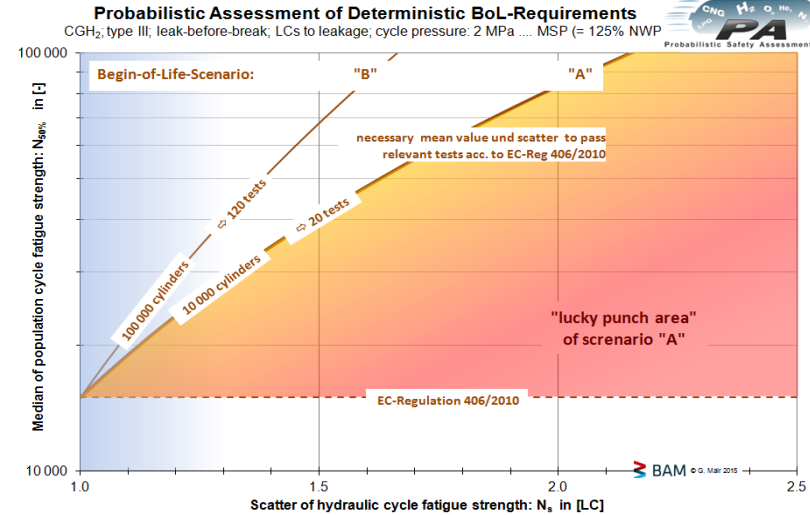
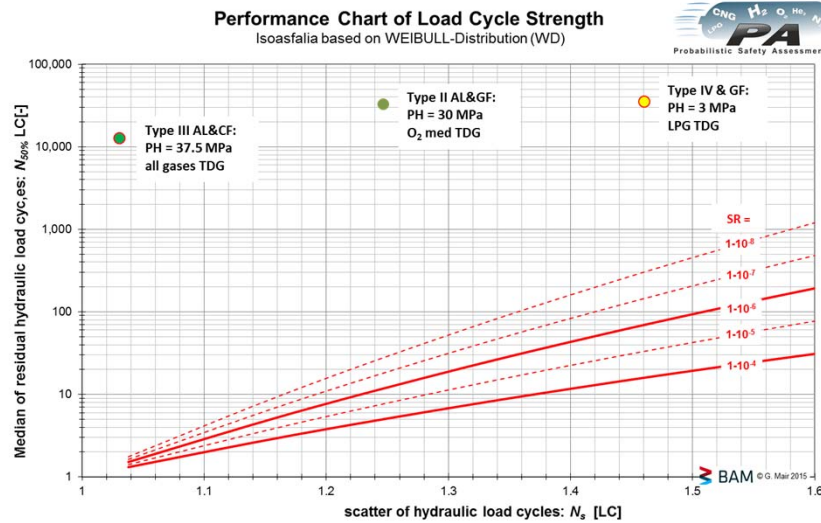
Evaluation of Load Cycle Strength (LC)
of CGH₂-Systems

- Properties of tested cylinders

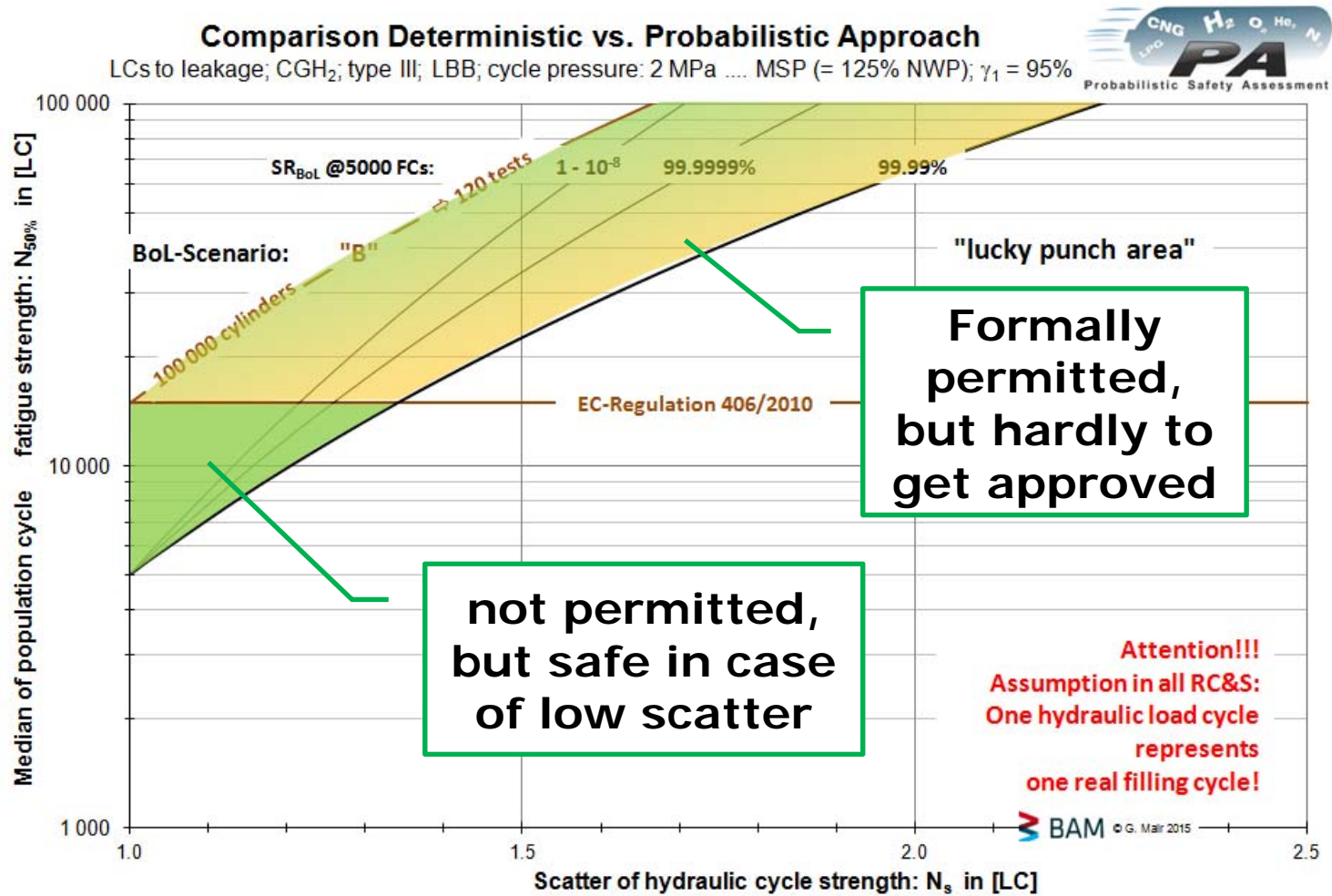
"Lucky Punch Area" of Load Cycles



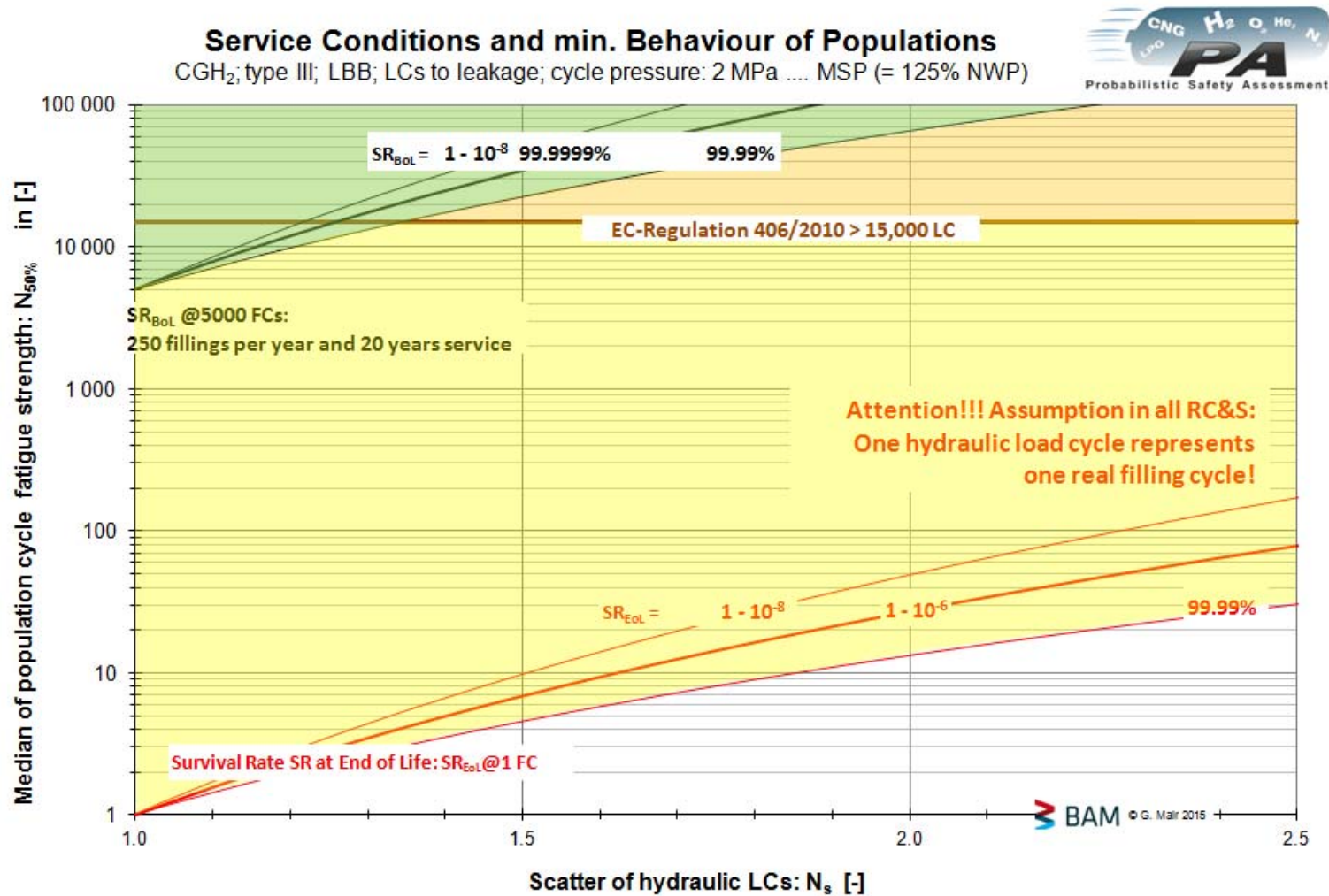
LC: Comparison of Standards and PA



LC: Discrepancy of Standards and PA



Comparison of BoL and EoL: Degradation in service



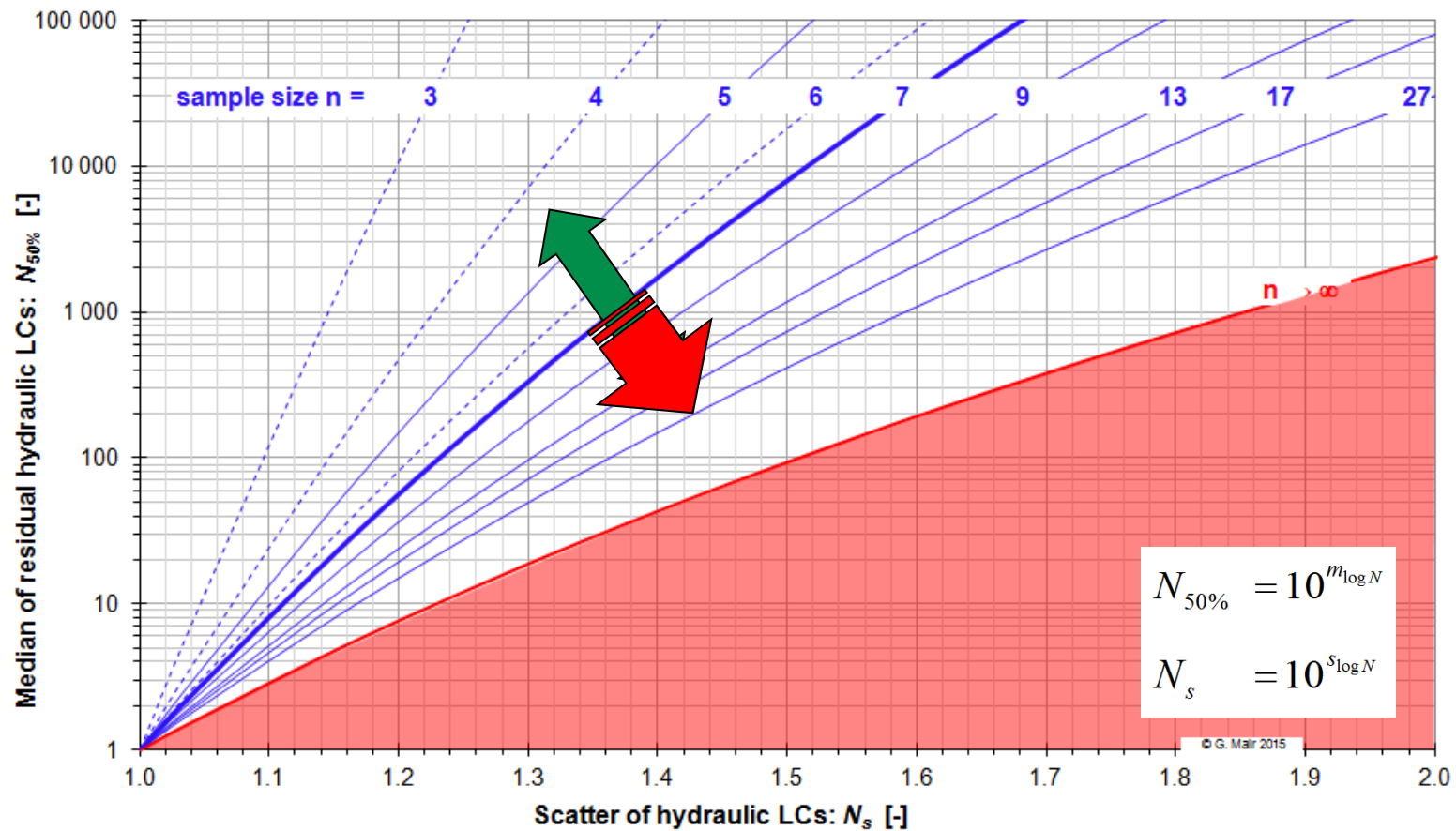
Comparison of Probabilistic Approach and Standards

Evaluation of Load Cycle Strength (LC)
of CGH₂-Systems,

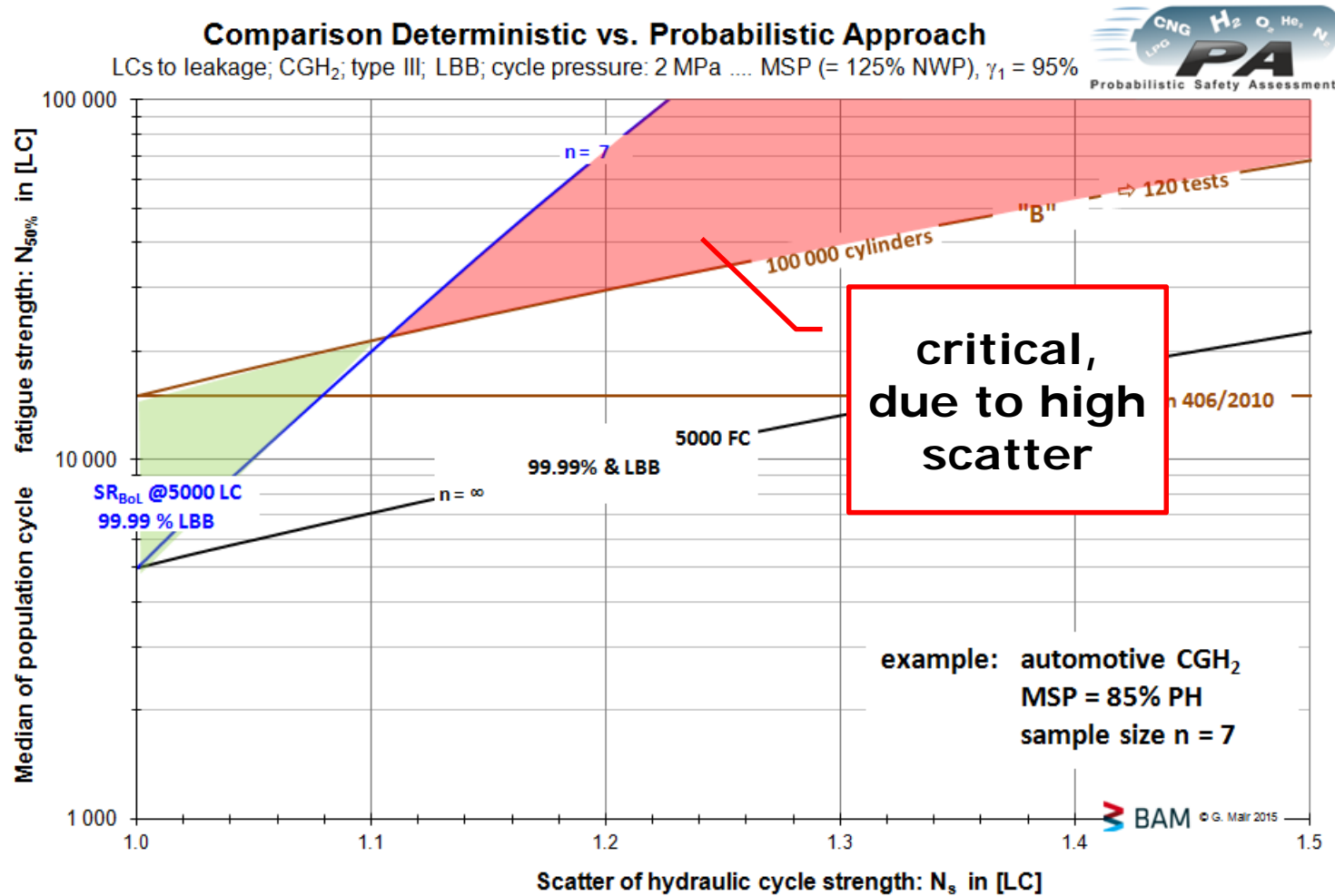
- Estimation on cylinder population,
considering influence of sample size
e. g. $n = 7$ cylinders

LC: Influence of Sample Size

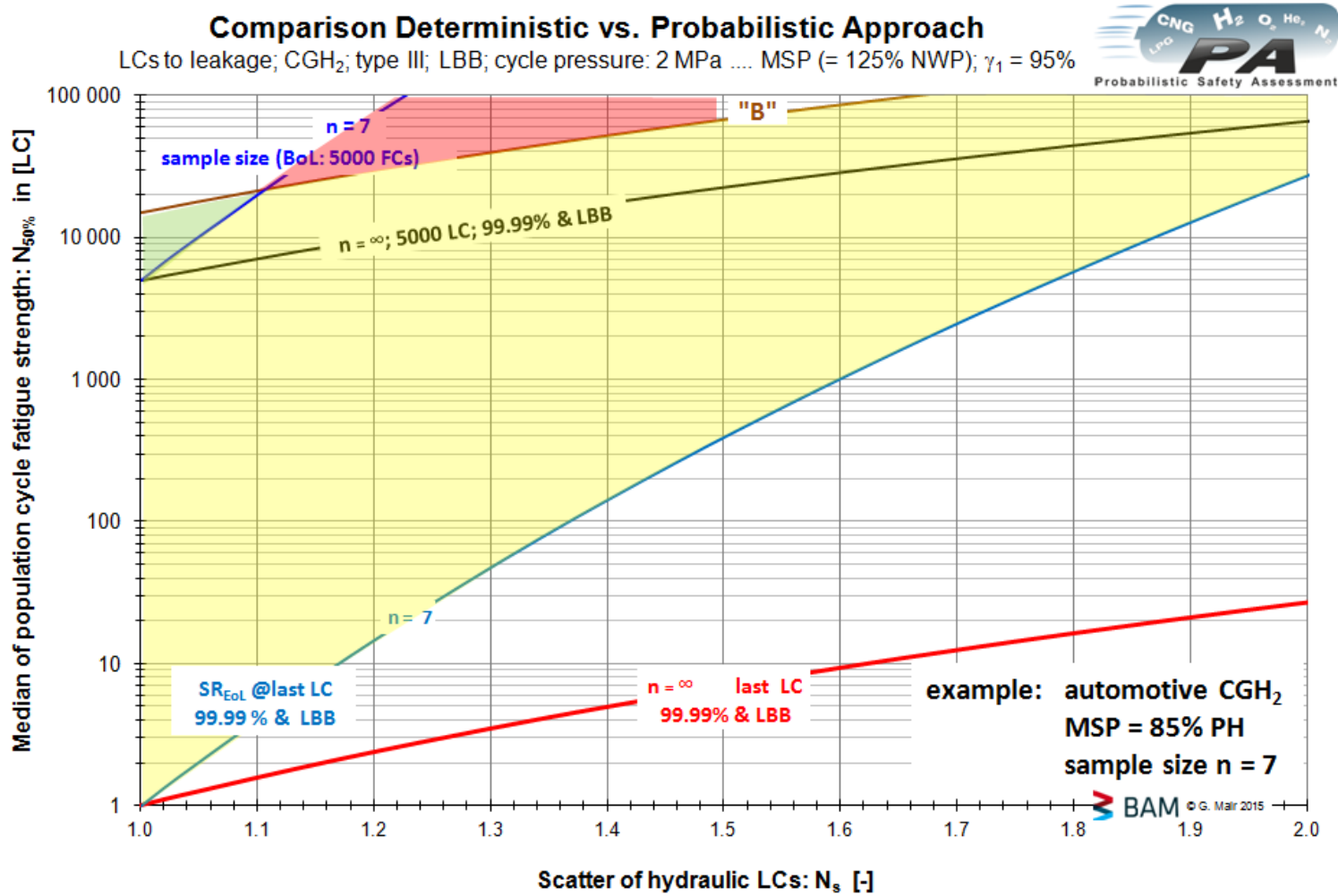
Influence of Sample Size n on "SR-Isoasfalia"
 WD; SR = $1-10^{-6} = 99.9999\%$; one sided confidence area $\gamma_1 = 95\%$



LC: Discrepancy of Standards and PA



LC: Discrepancy of Standards and PA - including degradation to EoL



Summary

Deterministic approach ...

- ... focuses mainly on BoL-properties
- In case of a low production scatter it requests a probably unnecessary high reliability level.
- In case of high production scatter individual requirements may be too low for insuring safety.

Probabilistic approach...

- ... opens the approval assessment to lower minimum requirements in case of low production scatter;
- ... focuses on EoL-properties - but needs checks of degradation;
- ... can be used for quantifying in-service-degradation
- ... can be used directly for determination of safe service life

This means...

... do not reduce current minimum safety margins

If you want to reduce minimum material effort...

... use the probabilistic approach for approval

**... and abstain from using
deterministic safety margins (EC-Reg/GTR)
for ensuring safety in approval,
not taking into account real strength scatter.**

Acknowledgement

Probabilistic Safety Assessment:



Several years of consequent research enabled by national and European research funding



... with a huge number of partners and experts!

Further Details and Explanations

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and probably

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Thank you for your attention!

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