BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

Oct, 18th 2017

OPEN ISSUES OF INSURING SAFETY OF CPVs BY STRENGTH TESTING

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UN GTR-Phase II Kick-off Meeting
EC DG Grow – Brussels

MIIs: Most important Issues

- **How to define safety?**
  - legal definitions
  - technical description

- **How to measure strength?**
  - cycle fatigue sensitive: load cycle testing
  - non-cycle fatigue sensitive: slow burst testing

- **How to ensure safe systems at end of life?**
  - artificial ageing vs. in-service degradation
  - acceptable degradation
  - influence of scatter on EoL-properties

- **How to care for production quality?**
  - surveillance of BoL-scatter by batch testing

Definition of Safety

Safety

The first view from the standpoint of a (German) justice:

Safety is achieved when an item is approved and has been produced, initially tested, operated, retested and maintained etc. properly, i.e. treated in line with the relevant regulations.

This shows how important appropriate approval requirements are!

Technical safety

From a technical point of view the status of safety means the absence of danger.

Danger means a status of having a risk being higher than acceptable. By knowing the consequence of (worst case) failure scenarios the frequency or probability of failures becomes the central aspect of safety. I.e. besides all other aspects…

….regulations have to ensure that the probability of a failure during the service life of a tank system is acceptable!

Measurement of strength

Common measurement of strength

- It is common to use the strength as benchmark for reliability and the fit for service property.
- (Hydraulic) burst strength testing is very common, relatively cheap and easy to construe, but may lead to wrong conclusions.
- (Hydraulic) load cycle testing is common to be used for measurement of service strength. CPVs with metal liners usually fail before 50,000 LCs but have high burst strength.

Advanced measurement of strength

- But, Type 4 CPVs made of CF usually show a service strength in laboratory tests that cannot be measured within 50,000 LCs.
- Static fatigue testing (creep rupture test to failure) does not work for design type testing or batch testing.
- A modification of the creep rupture test to failure into a kind of very slow and accurately controlled burst test is manageable, can be construed easily and shows degradation in a proper manner.

Safety at end of life

Artificial ageing

- CPVs in service experience some degradation of scatter (and of reliability)
- During design type testing we all try to simulate service loads and to check ageing effects.
- But, can we be confident in causing artificial ageing effects being comparable with the in-service degradation?....
- …..concerning effects on the type of degradation (failure mode) and amount (average loss of strength; increase of strength scatter of the population)?

Acceptable degradation

- Evaluation of degradation shall be done by comparing test results of aged CPVs with the same properties of new CPVs.
- Since safety is defined by statistical properties of tested groups of CPVs the testing of individual CPVs subsequent to ageing could lead to misinterpretations to both directions.
- Due to the combination of loss of strength with production scatter individual results without knowledge of the scatter (increase by ageing) cannot be construed reliably.

Production scatter

Scatter in production of CPVs

- The scatter properties of pre-series are usually higher than in the serial production.
- Comparisons of batch test results with properties measured during approval process cause unnecessary problems (ECE R 134).
- Nevertheless, the surveillance of production scatter is important for the transfer of degradation assumptions on the entire population of vehicles.

Summary

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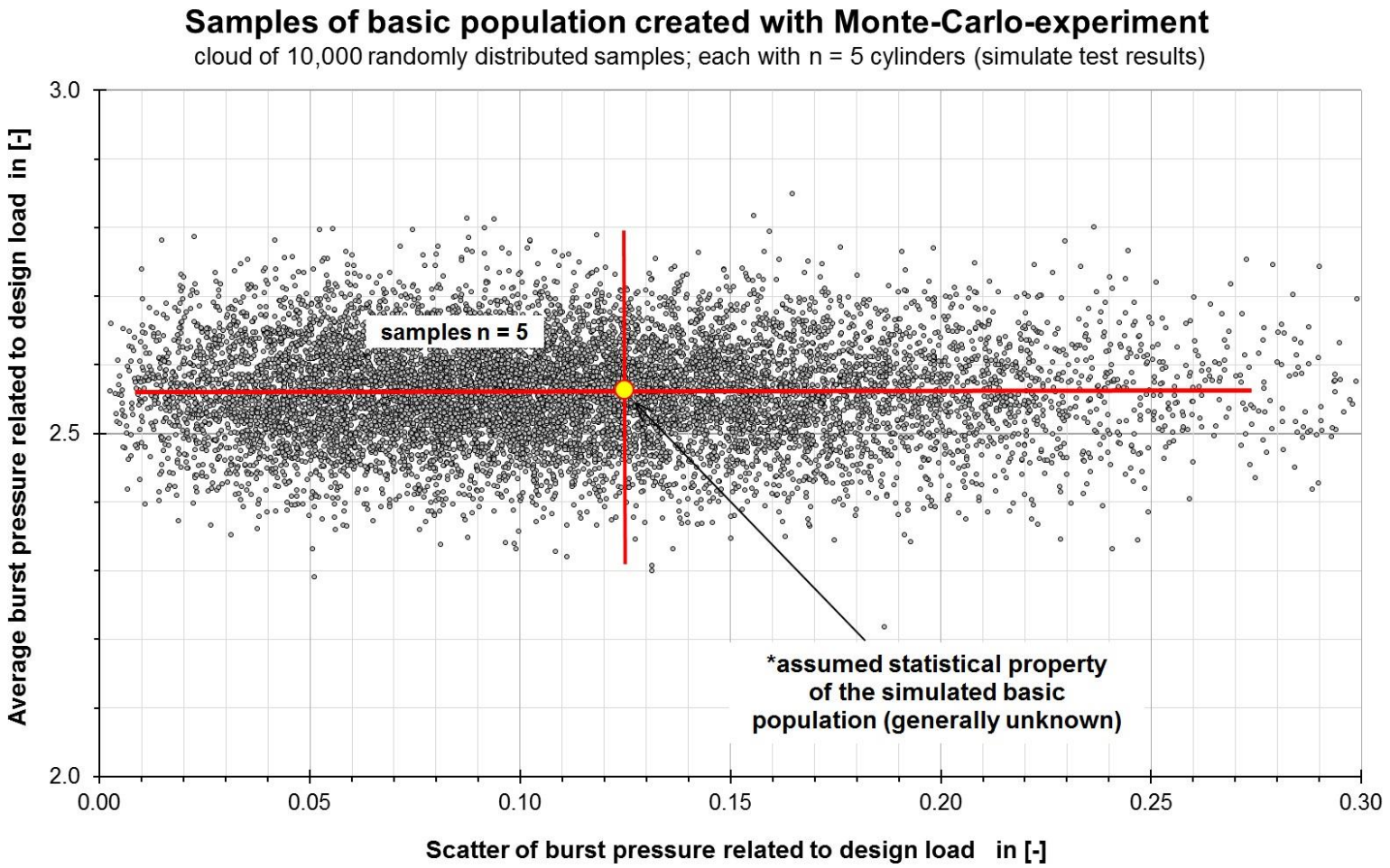
Several issues have been mentioned as weak items of the GTR 13 conc. strength measurement.

There is a lot of background knowledge available to each of these items and may be discussed in detail when issued on the agenda.

Summary


Samples of basic population created with Monte-Carlo-experiment
cloud of 10,000 randomly distributed samples; each with n = 5 cylinders (simulate test results)
Average burst pressure related to design load in [-]
3.0
2.5
2.0
samples n = 5
*assumed statistical property of the simulated basic population (generally unknown)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Scatter of burst pressure related to design load in [-]

Thank you for your attention!

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