Laser Damage Standard Development: Status Report

Telecon

19 June 2017

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&

M.D. Thomas (Spica Technologies)

Overview

- Communicate progress made on plan discussed and revised at TF7 meeting at DCC
  - Somehow the minutes of the DSS meeting are not in my files (so this status is from notes and memory)
  - Quick review of Anaheim (face to face)
- Progress on Next steps
  - Procedure drafting
  - Review
  - Papers
    - Boulder
    - NASA Meeting
  - ISO meeting

The technical gist of the US proposal is included as backup to this package for reference.

Main Outcomes of Anaheim Meeting

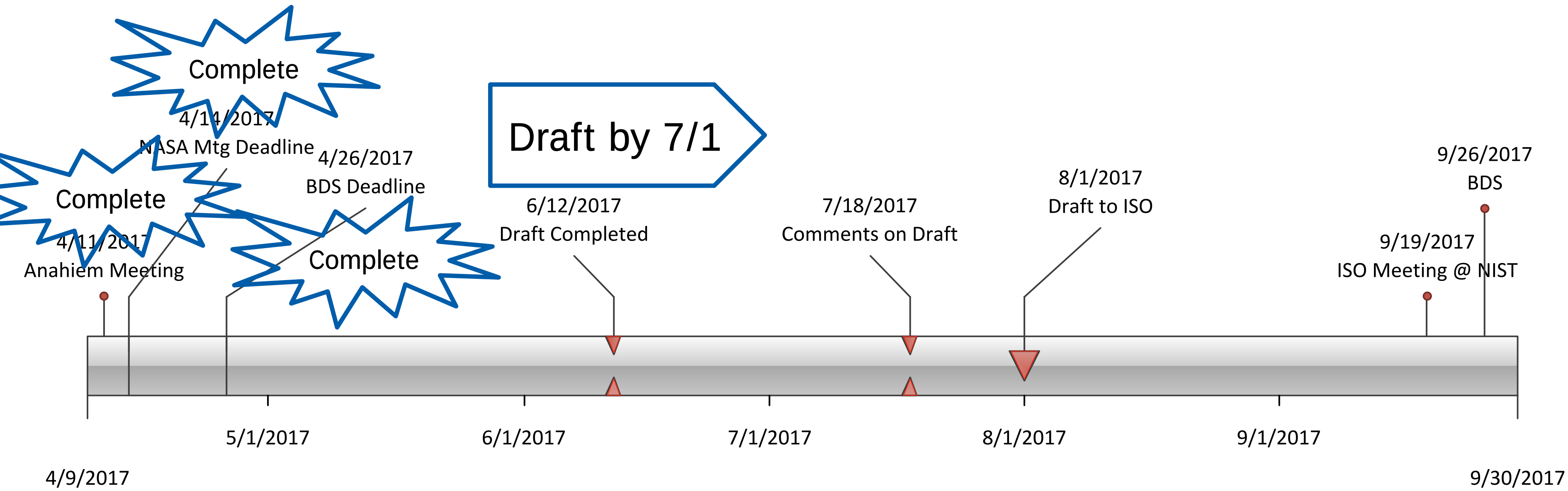
- Draft US Standard preparation
  - Identification of use cases (6) to be included in submission to TF7 and then ISO
    - In response to comments from T. Turner about the various kinds of test possible
  - US draft to be formulated for both defect count and area lost (functional threshold)
  - Draft to be prepared (in process) and circulated among US TF7 members for comments and then to wider US orbit
- Communications (papers) planned on TF7 draft
- Schedule through fall of 2017 presented

Six Use Cases Defined

- The six cases defined below encompass the majority of expected applications of the standard
  - Test costs (high/large area to low/small area) and no history to well known history
  - Plan is to write each of these cases as a small “white paper” and then figure out how to include the in the standard
    - Annex or technical report (JA’s preference is an informative annex)

Test size (cost)	No History (f totally unknown)	History (f approximately known)
Nearly all area	Excellent	Excellent
Large area	Good **Use Case**	Very good to excellent **Use Case**
Medium area	Can provide good results for moderate to high defect counts **Use Case**	Very good to excellent, and can adjust test levels **Use Case**
Small area	uncertain **Use Case**	Ok to good, can adjust test level to overtest **Use Case**

Schedule



- Abstracts submitted to both NASA Contamination Meeting (7/18) and BDS (9/18)
  - Slides will follow from use cases draft (~7/1/17)
    - NASA meeting slides only
    - BDS requires paper

- Draft procedure in process taking a little longer than planned but will be out for TF7 review NLT 7/1/17 (Happy 4th)

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Backup Material: Procedure Outline as Presented at San Francisco Meeting

Laser Damage Procedure Draft

Presented to OEOSC TF 7

Sunday, 29 January 2017

Donna Howland & Jon Arenberg

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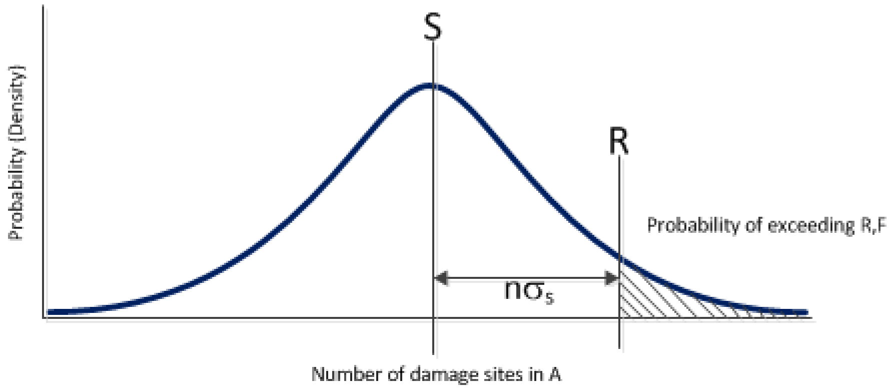
Background and Overview

- Desires for a damage test method
  - Test method that provides a clear unambiguous result, i.e. Doesn't require 3 PhDs, a rabbi and priest to interpret
  - Understandable in terms of risk in a system or application

- User should specify the maximum number of allowable damages. S, on the optic of area and the probability (tolerable risk), F, that the true value is larger than S



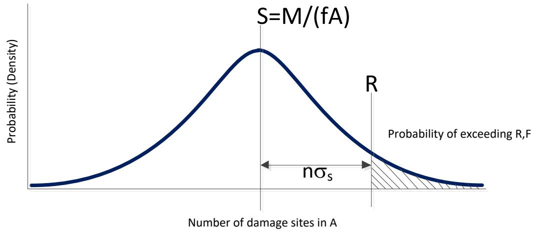
- Question for committee, should we write this procedure in terms of damage sites or in terms of damage area? Both?
  - Same logic applies, the area defined as a damage spot would be used to convert?

Laser Damage Procedure

- User to define number of allowed damage sites, R allowed over the full optic of area A and the allowable probability of exceeding R, F.

- Step 1 – Calculate the probability of not exceeding R damages in A, P
  - $P = 1 - F$ (1)

- Step 2 – Using Figure 1 determine, n the number of standard deviations of offset needed.

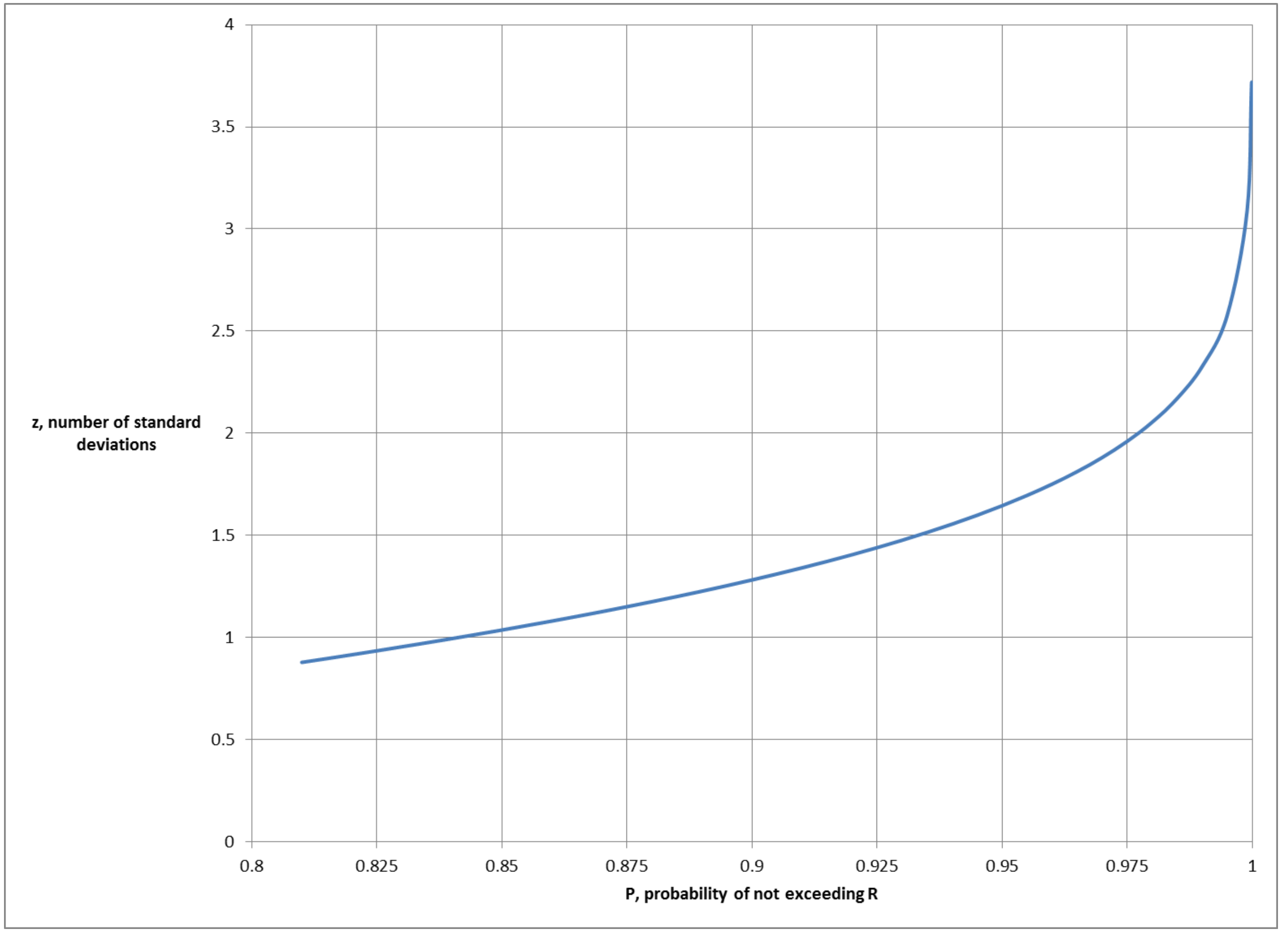


- Step 3 – Determine the upper limit of the number of observed damages, M that can be observed in fA (the area tested, f is the fraction of A exposed), to be at least P likely to have R damages or less in A.
  - $M = fR - \frac{1}{2}n^2 - \frac{1}{2}n\sqrt{(n^2 + 4fR)}$* (2)

Laser Damage Procedure Concept

* I (JWA) will happily provide the derivation of this equation. It should go in usage notes or a paper, not in the standard.

Figure 1

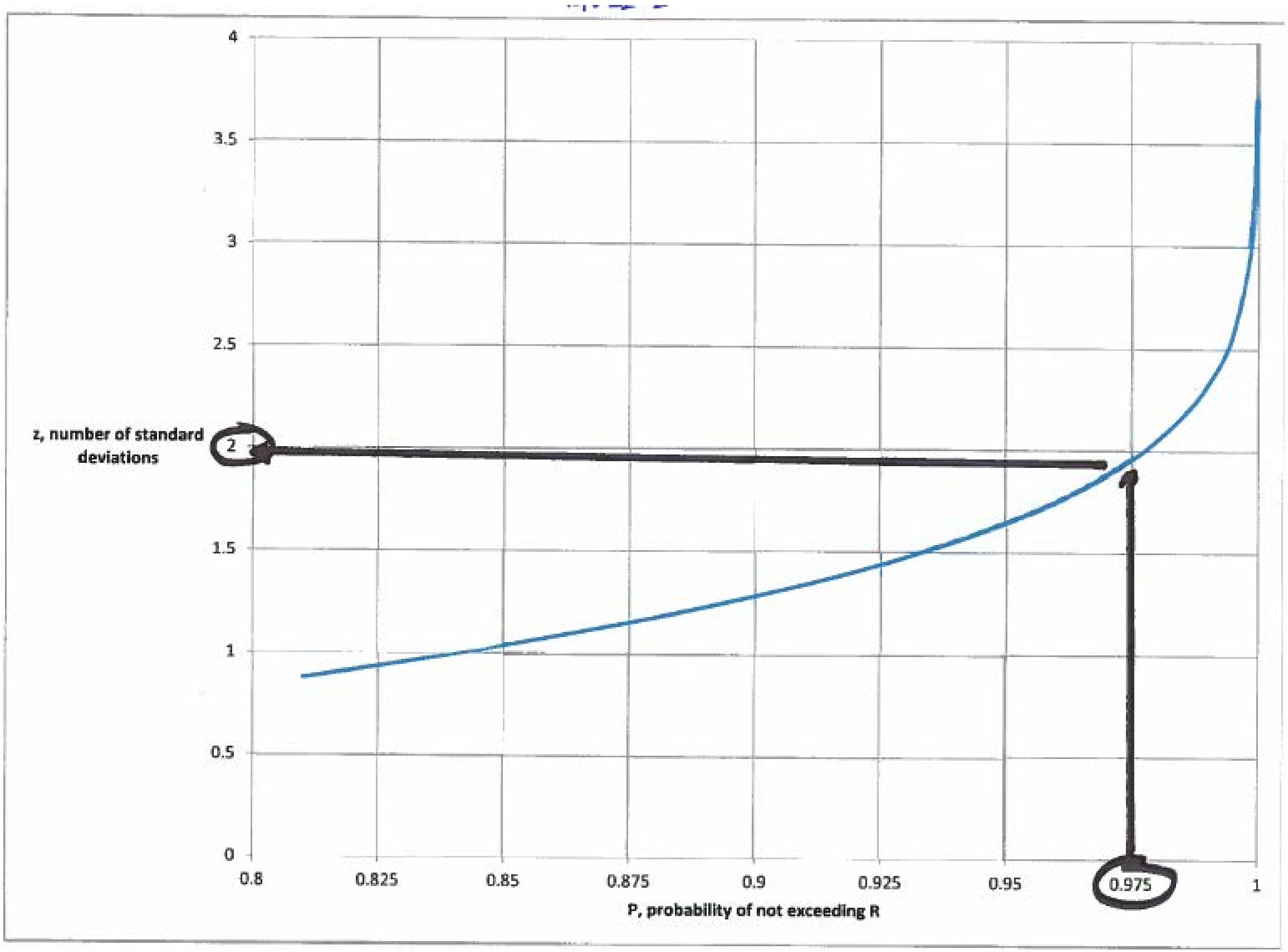


NB: This is possible since the Poisson curve can be well approximated by the Gaussian curve, making this calculation trivial in Excel, Matlab, Mathcad etc.

Laser Damage Procedure: Example

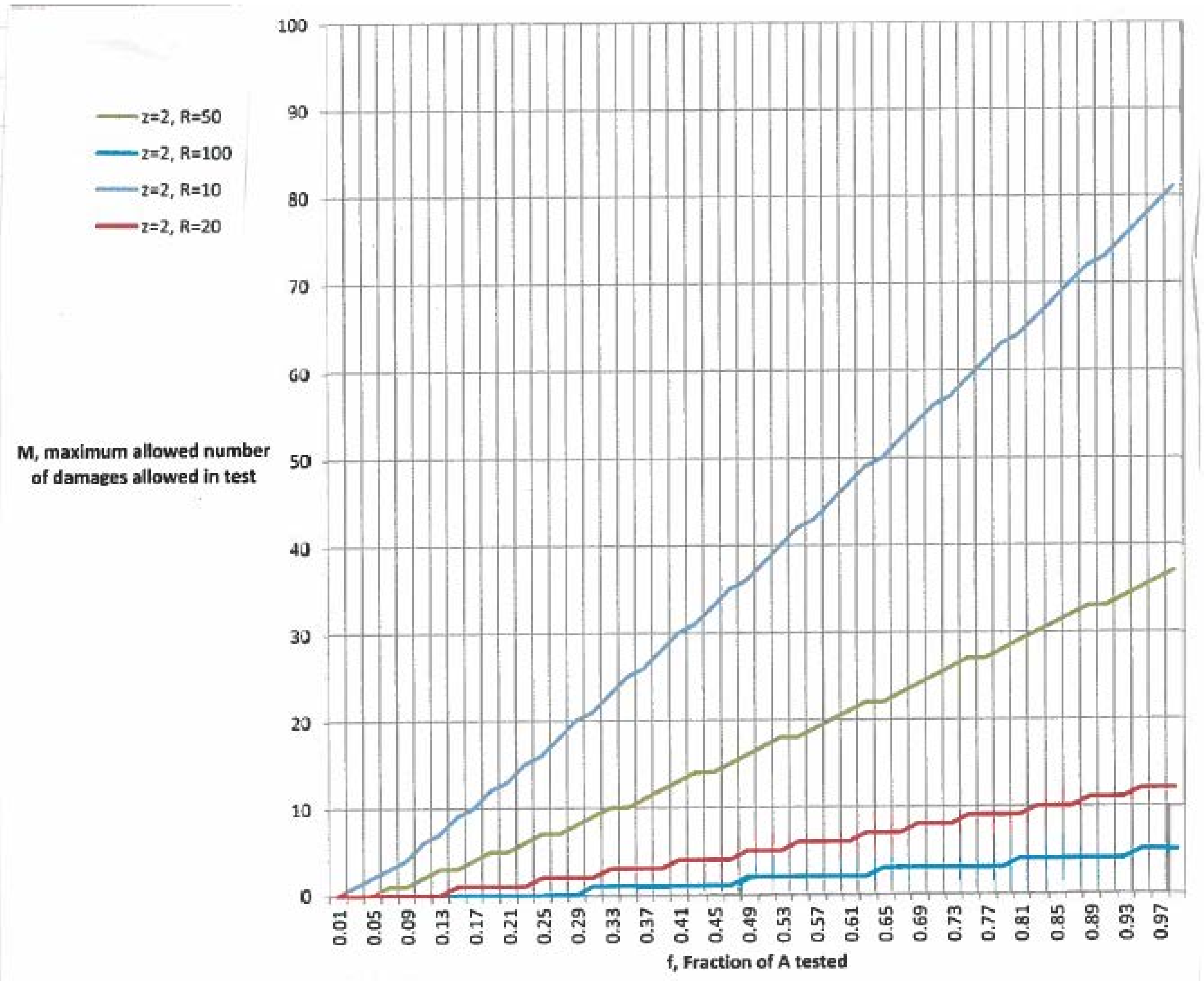
- The user wants to have less than 0.025 chance of having more than R damages on A. So F=0.025
  - P = 1 - 0.025 = 0.975 from (1)
- From Figure 2, we see that n~2. Equation (2) can then be evaluated for various values of R.
- The results are shown in Figure 3 for R = 10, 20, 50 and 100

Figure 2



4
3.5
3
2.5
z, number of standard deviations
2
1.5
1
0.5
0
0.8
0.825
0.85
0.875
0.9
0.925
0.95
0.975
1
P, probability of not exceeding R

Figure 3

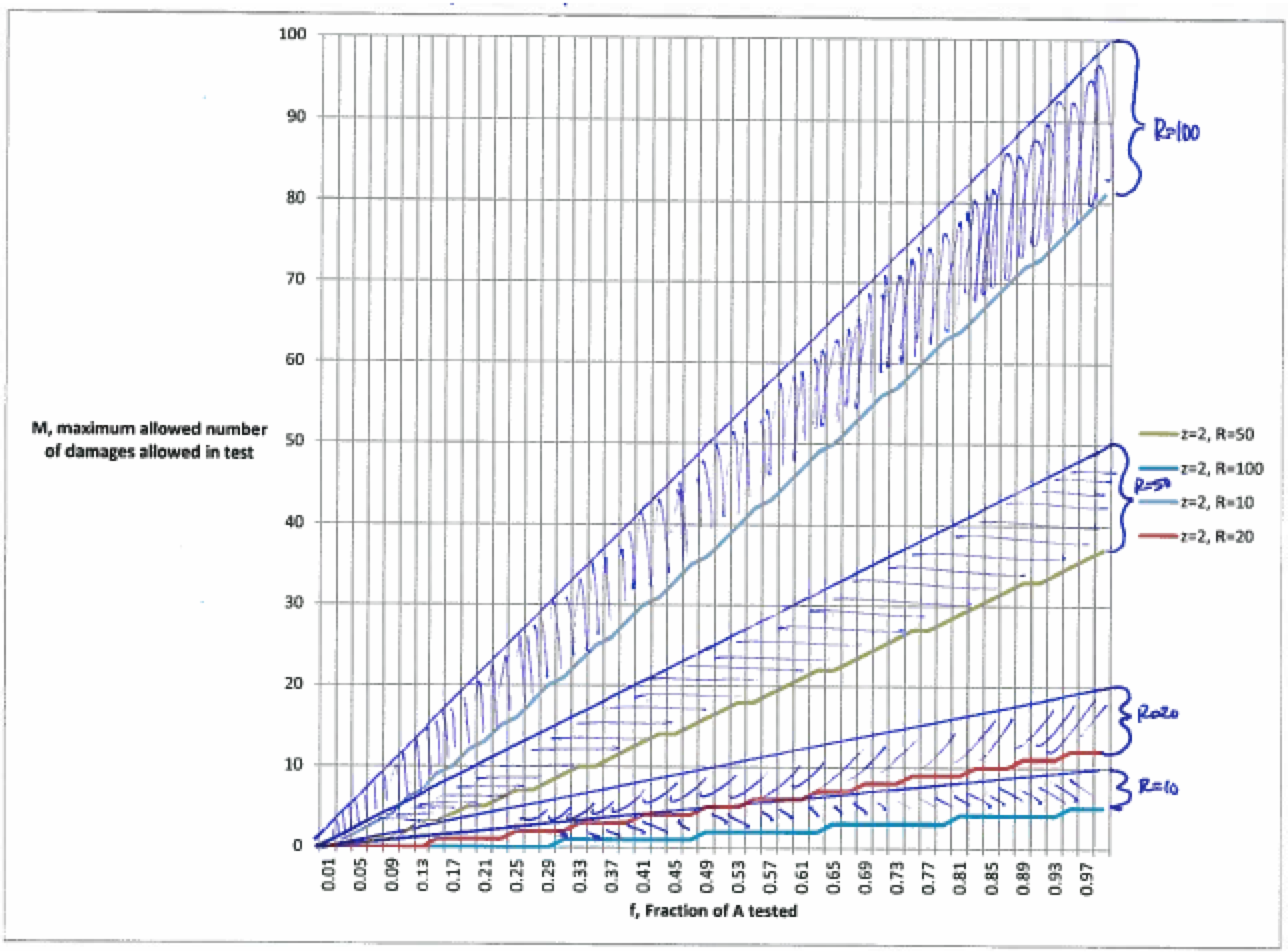


z=2, R=50
z=2, R=100
z=2, R=10
z=2, R=20
M, maximum allowed number of damages allowed in test
100
90
80
70
60
50
40
30
20
10
0
0.01
0.05
0.09
0.13
0.17
0.21
0.25
0.29
0.33
0.37
0.41
0.45
0.49
0.53
0.57
0.61
0.65
0.69
0.73
0.77
0.81
0.85
0.89
0.93
0.97
f, Fraction of A tested

Laser Damage Procedure (Cont.)

- Figure 4 shows the hand drown lines of fR for each R with computer plotted values of M. This distance is essentially the “price of confidence”

Figure 4



100
90
80
70
60
50
40
30
20
10
0
M, maximum allowed number of damages allowed in test
0.01
0.05
0.09
0.13
0.17
0.21
0.25
0.29
0.33
0.37
0.41
0.45
0.49
0.53
0.57
0.61
0.65
0.69
0.73
0.77
0.81
0.85
0.89
0.93
0.97
f, Fraction of A tested
z=2, R=50
z=2, R=100
z=2, R=10
z=2, R=20
R=100
R=50
R=20
R=10

Backup

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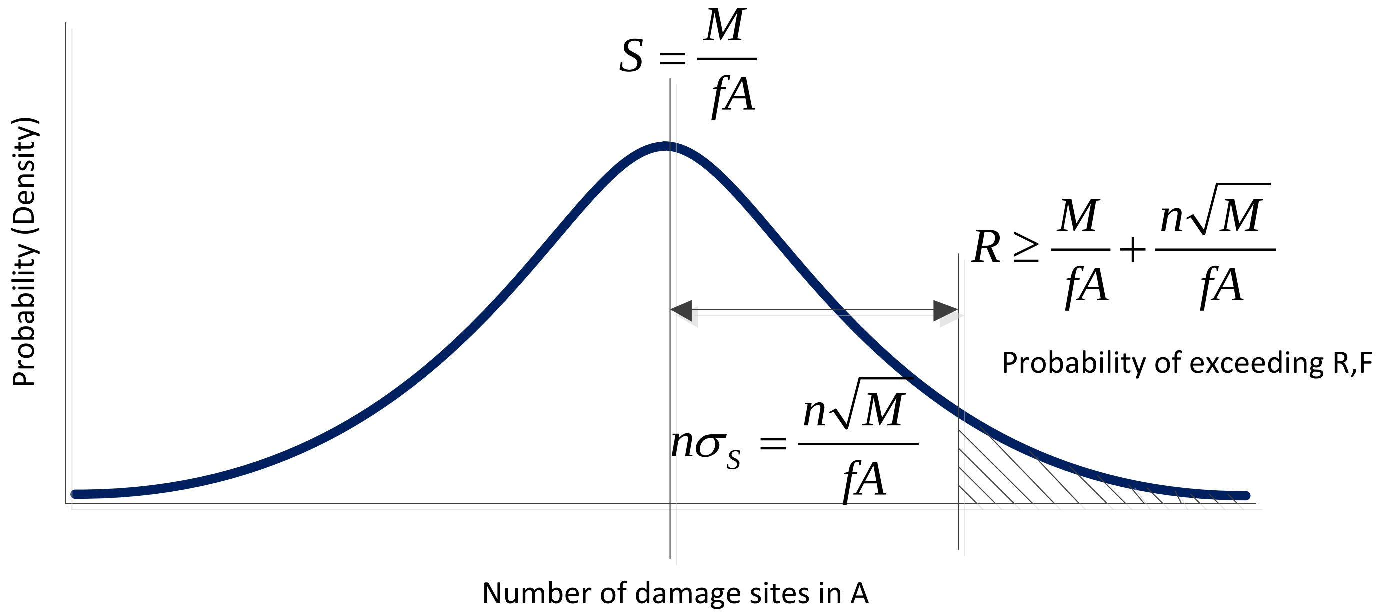
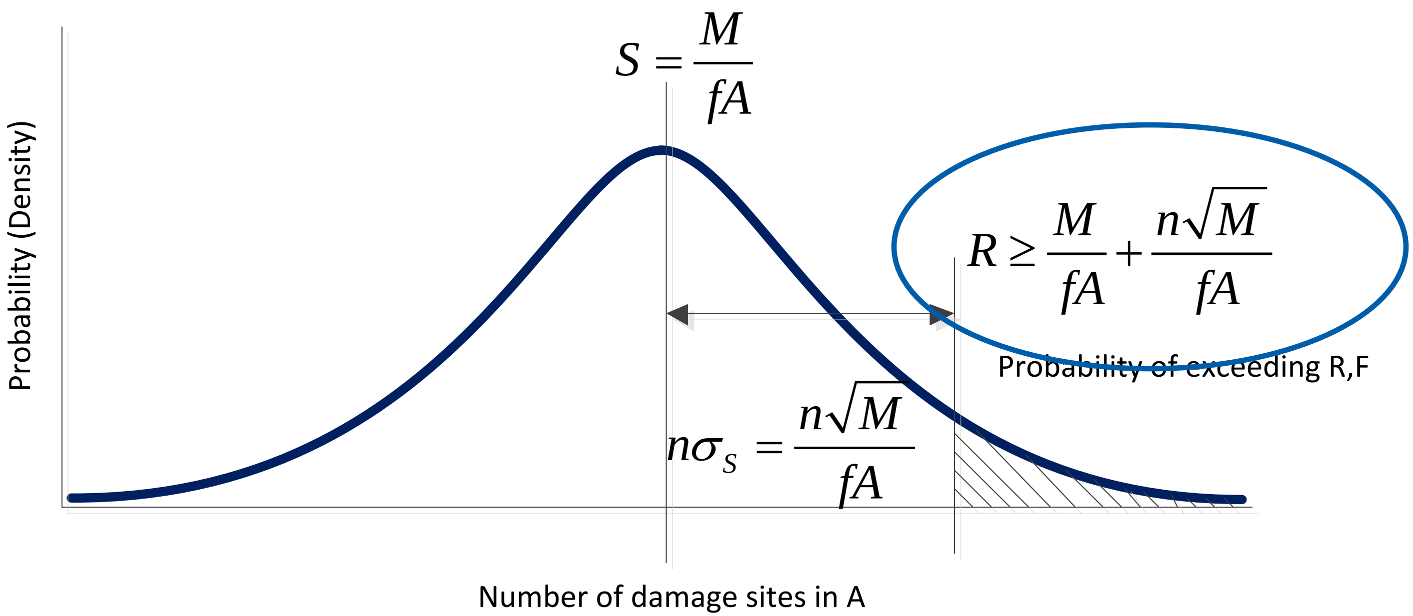
Explaining (2)



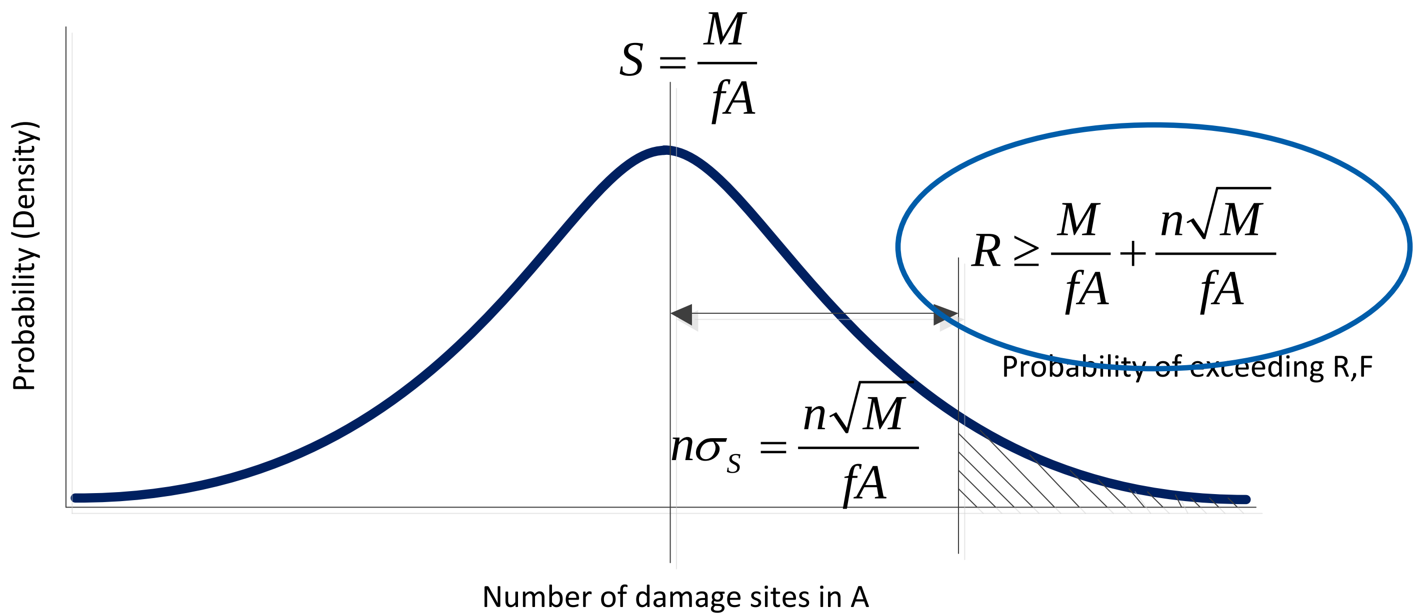
- M and therefore S are described by Poisson statistics

Explaining (2)



- M and therefore S are described by Poisson statistics
- In Poisson statistics, the mean and variance have the same value

Explaining (2)



- M and therefore S are described by Poisson statistics
- In Poisson statistics, the mean and variance have the same value
- The solution to n, is found by solving the quadratic in √M which is (2)

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