Laser Damage Standard Development: Status Report

Telecon
19 June 2017

Jonathan Arenberg, Donna Howland (NGAS) & 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)

<table>
<thead>
<tr>
<th>Test size (cost)</th>
<th>No History (if totally unknown)</th>
<th>History (if approximately known)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearly all area</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Large area</td>
<td>Good</td>
<td>Very good to excellent</td>
</tr>
<tr>
<td>Medium area</td>
<td>Can provide good results for moderate to high defect counts</td>
<td>Very good to excellent, and can adjust test levels</td>
</tr>
<tr>
<td>Small area</td>
<td>uncertain</td>
<td>Ok to good, can adjust test level to overtest</td>
</tr>
</tbody>
</table>
• 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)
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
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
  \[ P = 1 - F \]  

- 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.
  \[ M = fR - \frac{1}{2}n^2 - \frac{1}{2}n\sqrt{n^2 + 4fR} \]

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.
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 $n\sim 2$. 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
Figure 3
• 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
Backup
Explaining (2)

- $M$ and therefore $S$ are described by Poisson statistics.

$$S = \frac{M}{fA}$$

$$R \geq \frac{M}{fA} + \frac{n\sqrt{M}}{fA}$$

Probability of exceeding $R,F$

$\sigma_S = \frac{n\sqrt{M}}{fA}$

Number of damage sites in A

- $M$ and therefore $S$ are described by Poisson statistics.
• M and therefore S are described by Poisson statistics

• In Poisson statistics, the mean and variance have the same value

\[ S = \frac{M}{fA} \]

\[ n\sigma_S = \frac{n\sqrt{M}}{fA} \]

\[ R \geq \frac{M}{fA} + \frac{n\sqrt{M}}{fA} \]
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 $\sqrt{M}$ which is (2)

$$S = \frac{M}{fA}$$

$$R \geq \frac{M}{fA} + \frac{n\sqrt{M}}{fA}$$

Number of damage sites in A

Probability of exceeding $R, F$
THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN