Fracture Control
Composite, Bonded & Sandwich Structures

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⇓

Based on 2 type of defects:
- Manufacturing defects
- Mechanical damage

⇓

Conservatism is based on:
The use of ultimate load (instead of limit) + probability of defect existence for mechanical damage

But no general tool for growth prediction

Metallic Materials

⇓

Based on
Cracks like defect

⇓

Conservative approach based on:
(probability of defect existence / defect severity)

+ easy to predict the growth by using LEFM)

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- **Example of manufacturing defects:**

  - ✓ Delamination
  - ✓ High porosity ratio
  - ✓ Fibers misalignment
  - ✓ Debonding
  - ✓ Telegraphing
  - ✓ Cut or broken fibers
  - ✓ ……

  Maximum acceptable size consistent with :

  NDI & Process

- **Mechanical damage:**

  - ✓ Impact
  - ✓ Scratch
  - ✓ Abrasion
  - ✓ …….

  Damage threat Assessment § 8.4.3 → Upper level of mechanical damage

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- **Safe life:**
  Manufacturing defects at the max size + mechanical damage at the max expected level.

- **Fail safe:**
  Damage threat assessment but no mechanical damage need to be considered in the remaining parts.

- **Low risk:**
  Damage threat assessment but no mechanical damage larger than visual damage threshold.

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- **Damage Threat Assessment § 843:**

  - **Objectives:**

    To determine the upper level of mechanical damage for safe life and to avoid mechanical damage for low risk and fail safe (larger than VDT)

  - **Identification of potentially damage events:**

    Identification of possible events and credible magnitude for each event.

  - **Identification of resulting damage:**

    For credible magnitude of each event identification of mechanical damage resulting (type/size/level)

    Determination of max. level or size of mechanical damage possibly reduced by using protection / inspection / indicators

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- **Safe life assessment for manufacturing defects:**
  - ✓ Screening of possible type of manufacturing defects
  - ✓ Define max. size consistent with NDI (& process)
  - ✓ Demonstration of ultimate load capability + no growth after 1 life with load enhancement factor 1.15.

Possible to avoid the demonstration

Max. size included in qualification material properties ?
Proof test ?
Max. size enveloped by mechanical damage?

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- **Safe life assessment for mechanical damage:**
  - ✓ Perform Damage Threat Assessment
  - ✓ Define max. Mechanical Damage
  - ✓ Consider the most severe case: Max. mechanical damage or VDT
  - ✓ Demonstration of ultimate load capability + no growth after 1 life with load enhancement factor 1.15.
- **Safe life demonstration for manufacturing defects & mechanical damage:**
  - ✓ Demonstration by tests (full scale & subscale) or analyses supported by tests representative of structural details. (Tests shall be perform with induced defects)

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- **Fail Safe assessment:**

  - ✓ Demonstration same as metallic materials (4 service life replaced by 1 life with LEF 1.15)

    (Demonstration by test or analyze supported by tests)
  - ✓ Close visual inspection before flight covering 100% (in addition to NDI during manufacturing)
  - ✓ No mechanical damage expected
  - ✓ No mechanical damage need to be considered in the remaining path. (except detected defect)

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- **Low risk assessment:**
  - ✓ For limited item types
  - ✓ No mechanical damage expected (larger than VDT)
  - ✓ Close visual inspection before flight covering 100% (in addition to NDI during manufacturing)
  - ✓ Strain at the limit load below the damage tolerance threshold strain

    At the limit load: max.tensile stresses lower than 40% of the material ultimate capability / max. compressive stresses lower than 25% of the material ultimate capability

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- **Detected defects:**

  Size larger than acceptable manufacturing defects or 50% of max. size required for mechanical damage.

Safe life:	Fail safe:	Low risk:
Ultimate load + one life x LEF 1.15 *(unchanged)* + Tests on representatives defects	Defect in the remaining part Unfavorable choice of failed part + tests on representatives defects	Not permitted

\+ Possible improvement for detection