Maintaining Material Properties
F-22 Prospective

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Outline

- F-22 Structural Materials Mix
- Design Allowables Development
- Factors Affecting Material Properties
- Maintaining Allowables in Production
- Summary
- Questions
F-22 Structural Materials Mix
F-22 Materials Mix

Airframe Structural Weight

- Titanium: 39%
- Composite: 24%
- Aluminum: 15%
- Misc: 15%
- Fe: 7%

Representative of A/C 4028
Design Allowables Development
Design Allowables Development

- **Structural Development Test (SDT) Pgm**
  - Material Spec Development
    - Spec Min Values Estimated
  - Mechanical Property Development
    - ~3,600 Titanium Coupon Tests
      - Static
      - Durability & Damage Tolerance (DADT)
    - Statistically Reduced Allowables Developed
      - “B” Basis
      - Spec Values Verified
  - DADT Design Properties Established
Design vs Spec Values

Note: From Metallic Materials Properties Development and Standardization
Crack Growth Rate

Collect Crack Growth Data

Develop Mean & 2 x Rate Curves

Delta K

dA/dn

Mean Curve

2x Curve
Factors Affecting Material Properties
Factors Affecting Mechanical Properties

- **Raw Materials**
  - Source
  - Mfg Process
  - Quality
  - Morphology

- **Consolidation**
  - Electrode Fab
  - Melt Practice

- **Conversion**
  - Ingot to Product
  - TMP Route

- **Heat Treatment**
  - Solution Heat Treat Temp
  - Dwell Time
  - Cooling Rate
  - Age or SR Cycle
Maintaining Allowables in Production
Maintaining Allowables

- Existing Processes
  - Establish Fixed Practice Agreements (FPAs)
  - Monitor
    - SPC
- Qualify New Processes
  - Insure Design Allowables Supported
    - Static
    - DADT
SPC

Strength

Heat Lot

UCL

LCL

B-Basis

Spec Min
New or Changed Process

- Insure that new vendors &/or processes:
  - Warrant expenditure of program & vendor resources
  - Do not increase the program risks
  - Support existing design properties
  - Maintain consistent properties when transferred to production
Qualification Flow

Request for Qual → Business Case Eval

- Acceptable
  - Risk Eval
    - Unacceptable to Business Case
    - Unacceptable to Pgm Cost or Schedule
    - 1 or 2 Heat Lots
    - Test Matrices & Spec Locations
    - Qualification Approval of FPAs
  - Dev Qual Requirements
    - Funding, Schedule, Deliverables, & Responsibilities
    - Produce & Test Qual Materials

- Fail
  - Eval Qual Results to Criteria
    - Fixed Process for Production Materials
      - Periodic Review of SPC Data
      - Ship to Fabricators
        - Does't Support Design Prop
          - Adjust Process
        - Disposition Affected Hardware
          - MRB Disposition

- Acceptable
  - Produce & Test Qual Materials
    - Funding, Schedule, Deliverables, & Responsibilities

- Does't Support Design Prop
  - Adjust Process
  - Disposition Affected Hardware
  - MRB Disposition
## Acceptance Criteria

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Acceptance Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>Material Spec</td>
<td></td>
</tr>
<tr>
<td>Micro &amp; Macro Structure</td>
<td>Material Spec</td>
<td></td>
</tr>
<tr>
<td>Tensile</td>
<td>Support “B”</td>
<td>No Loss in properties</td>
</tr>
<tr>
<td>RT</td>
<td>Support “B”</td>
<td>Loss consistent with F/A-22 Database</td>
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<tr>
<td>RT Exposed</td>
<td>Consistent w SDT</td>
<td></td>
</tr>
<tr>
<td>700 F</td>
<td></td>
<td></td>
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<tr>
<td>Strain Life</td>
<td>No Results &lt; 25% D.L.</td>
<td>Replicates at three strain levels</td>
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<tr>
<td></td>
<td>Geom Avg &gt; 80% D.L.</td>
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<tr>
<td>FCGR</td>
<td>Smoothed Data does not exceed 2X Curve</td>
<td></td>
</tr>
<tr>
<td>Fracture Toughness</td>
<td>Material Spec</td>
<td></td>
</tr>
<tr>
<td>Stress Corrosion</td>
<td>Material Spec</td>
<td></td>
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</tbody>
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Summary

- F-22 structural integrity is based on production materials supporting the design properties
- Multiple factors can affect material properties
- Need to monitor existing processes
  - Detect detrimental trends & take corrective actions
- New process / vendor qualification
  - Support design values
    - Static
    - DADT
Questions