CKU-12/A
ROCKET CATAPULT
ASSEMBLY, AIRCRAFT
EJECTION SEAT

PROGRAM UPDATE

CAD/PAD TEW 2022
THANK YOU

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CKU-12/A PROJECT OVERVIEW

DESIGN & QUALIFICATION ACTIVITY

- The CKU-12/A RoCat (Rocket Catapult) Assembly is a derivative of the CKU-5C/A RoCat
  - Head Assembly and Retainer Assembly designs have been modified to support ACES (Advanced Concept Ejection Seat) integration into the low-profile cockpit geometries
- Qualification is based on an optimized set of tests and similarity
  - Delta-Qualification per MIL-P-83126A
  - Qualification by similarity to CKU-5C/A
- Structural/Environmental test levels based on enveloping legacy & new program requirements
  - CKU-5C/A (legacy)
  - USAF New Trainer
- Delta-Qualification Testing facilities:
  - Structural/Environmental – NTS (Santa Clarita, CA)
  - Drop – NSWC IHD (Indian Head, MD)
  - Ballistic – Collins Aerospace (Fairfield, CA)
- Dynamic Response Index (DRI) capability improvement
CKU-12/A DESIGN

OPTIMIZED TEST SET NEEDED TO ADDRESS HARDWARE CHANGES

• CKU-12/A fits in a more compact envelope
• CKU-12/A is a Derivative of the Previously Qualified CKU-5C/A
• 90% (35 of 39) of the Parts/Assemblies from CKU-5C/A specified
• CKU-12/A easy convertible from Collins Aerospace CKU-5C/A
• Same Manufacturing Process and Acceptance Tests as the CKU-5C/A (except Dynamic Response Index (DRI) upper limits optimized)
• No Changes to the Ballistic Performance
CKU-12/A DELTA-QUAL TEST SUMMARY

OPTIMIZED SET OF TESTS PER MIL-P-83126A

- Inspection
  - Visual
  - X-Ray
- Load Testing
  - - 65°F
- Vibration & Shock Testing
  - - 65°F
  - +165°F
- 3 ft Drop testing
  - - 65°F
  - +165°F
- 40 ft Drop Testing
  - Ambient Temperature
- Ballistic Testing
  - - 65°F
  - +70°F
  - +165°F
- MOS (Marginality of Success)
  - All Delta-Qual Units
## OPTIMIZED SET OF TESTS PER MIL-P-83126A

### Test Unit Numbers (23 Rocket Motors to be Tested **)

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Unit Number (23 Rocket Motors to be Tested **)</th>
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<tr>
<td>Item</td>
<td>Remints</td>
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<tr>
<td>1</td>
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<td>3.2.15</td>
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<td>12</td>
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### Notes:
1. a, b, c, etc. designates testing sequence.
2. * Part of baseline test firings.
3. Test Unit Numbers correspond to MIL-P-83126A.
4. Axis designation: (+z), (-z).
5. **Gaps exist within the Test Unit Number sequence due to the reduced number of environmental tests.

- Environmental Tests Focused on Structural Changes (Load, Vibration, Shock, and Drop Testing)
# CKU-12/A DELTA-QUALIFICATION TESTING

## RESULTS

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<td>Load</td>
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<td>Vibration</td>
<td>PASS</td>
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<td>Shock</td>
<td>PASS</td>
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<td>Drop (3 ft and 40 ft)</td>
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<tr>
<td>Ballistic</td>
<td>PASS</td>
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<tr>
<td>Marginality of Success</td>
<td>PASS</td>
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</table>
CKU-12/A DRI CAPABILITY IMPROVEMENT

DYNAMIC RESPONSE INDEX (DRI) CAPABILITY IMPROVEMENT

• DRI Upper Limits Optimized thru Statistical Analysis of Manufacturer Base Capability
• DRI Requirement Upper Limits Optimized to:
  • 16.0 Cold (CKU-5C/A is 18.0)
  • 20.0 Hot (CKU-5C/A is 22.0)
• Lower DRI Upper Limits Support Escape System MIL-HDBK-516C Airworthiness Requirements
• DRI Verified thru Ballistic Testing
CKU-12/A DRI CAPABILITY IMPROVEMENT

**Analysis**

**Work Scope:**
- Evaluate the feasibility of the following DRI limits for CKU-12/A based on historical CKU-5C/A LAT performance to align product specification requirements with MIL-HDBK-516C CN5 Escape System Airworthiness Requirements:
  - ✓ +165°F: 20 (as measured on LAT)
  - ✓ +77°F: 18 (calculated by interpolation)
  - ✓ -65°F: 16 (as measured on LAT)
- Provide recommendations for the achievable/repeatable DRI limits of performance for CKU-12/A.

**Data Process:**
- Data Source: CKU-5C/A historical LAT data at -65°F and 165°F.
- Data Segregating and Pooling:
  - ✓ Two data sets at -65°F and +165°F are segregated and modeled by different sub-populations respectively.
  - ✓ All the data points at -65°F are pooled for one sub-population; and all the data points at +165°F are pooled for another sub-population.
CKU-12/A DRI CAPABILITY IMPROVEMENT

DRI ANALYSIS RESULTS @ +165°F

• The feasibility of upper limit = 20 @ +165°F
  ✓ Statistical tolerance limit analysis result: P(F ≤ 20) = 0.998610 at 90% confidence
  ✓ Percentages from actual data:

<table>
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<tr>
<th>Data @ 165°F</th>
<th>DRI &gt; 19</th>
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<th>DRI &gt; 21</th>
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<td>Data Number</td>
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<tr>
<td>Percentage</td>
<td>0.8%</td>
<td>0.0%</td>
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</table>

✓ Conclusion: the upper limit = 20 @ +165°F is acceptable.

• The achievable upper limit = 20 @ +165°F
  ✓ Statistical tolerance limit analysis result: upper limit = 20.12 at P = 0.999 & 90% confidence
  ✓ Percentages from actual data: as shown above

✓ Conclusion: the achievable upper limit = 20 @ +165°F with P = 0.999 & 90% confidence
CKU-12/A ROCAT DRI CAPABILITY IMPROVEMENT

DRI ANALYSIS RESULTS @ -65°F

• The feasibility of upper limit = 16 @ -65°F
  ✓ Statistical tolerance limit analysis result: P(F ≤ 16) = 0.999980 at 90% confidence
  ✓ Percentages from actual data:

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<th>DRI @ -65°F</th>
<th>DRI&gt;14.75</th>
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<td>Data Number</td>
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<tr>
<td>Percentage</td>
<td>1.0%</td>
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✓ Conclusion: the upper limit = 16 @ -65°F is acceptable.

• The achievable upper limit = 16 @ -65°F
  ✓ Statistical tolerance limit analysis result: upper limit = 14.75 at P = 0.999 & 90% confidence
  ✓ Percentages from actual data: as shown above
  ✓ Conclusion: the achievable upper limit = 16 @ -65°F with P = 0.999 & 90% confidence. Notice that the lower percentages from actual data are likely caused by the deviation of actual data from the fitted distribution.
CKU-12/A PROJECT STATUS

- Completed Tasks (2020)
  - Baseline & Batch Check Units / Test Stand Firings
  - Test Fixture Design & Fabrication
  - Delta-Qualification Test Plan (Δ-QTP) Release
  - Detailed Qualification Test Procedure Release
  - Delta-Qualification Test Unit Builds
  - Qualification Unit Builds
  - Structural/Environmental Testing
    - Shock, Vibration, Loads
  - Drop Testing
    - 3 ft, 40 ft
  - Ballistic Testing - Subset
  - Marginality of Success (MOS) – Subset
  - CKU-12/A DRI Capability improvement Analysis

- Completed Tasks (2021)
  - Ballistic Testing – Remaining Test Units
  - Marginality of Success (MOS) – Remaining Test Units
  - Delta-Qualification Test Report

- Completed Tasks (2022)
  - Finalized Qualification Documentation
  - First fielding of flight test units
CONTINUED COLLABORATION

Collins Aerospace welcomes the opportunity to continue collaborating with the CAD/PAD JPO and industry partners toward enhancing energetics performance and capabilities in the interest of improved safety and sustainability for the next generation.
QUESTIONS?

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Brian.J.Webb20.civ@us.navy.mil
BACKUP INFO
## CKU-12/A PROJECT SCHEDULE

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CKU-12/A QUALIFICATION BY SIMILARITY

SUMMARY OF QUALIFICATION BY SIMILARITY TO CKU-5C/A

- 42-Day Storage
  - -65°F
  - +165°F
- 84-day Storage
  - -65°F
  - +165°F
- Temperature Cycling
  - -65°F
  - +165°F

- Rain, Salt, and Humidity
- Sand and Dust
- Fungus Resistance
- External Heat
- Bullet Impact
- Atmospheric
- Detailed Breakdown
- Propellant System Characterization