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

PROGRAM UPDATE

CAD/PAD TEW 2022

Collins Aerospace

THANK YOU

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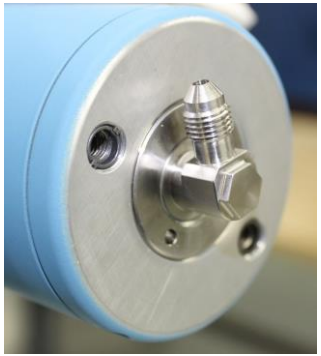
CKU-12/A PROJECT OVERVIEW

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-5C/A

CKU-12/A



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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

CKU-12/A DELTA-QUAL TEST MATRIX

OPTIMIZED SET OF TESTS PER MIL-P-83126A

Item	MIL-P-83126A Section		Test	Test Unit Number (23 Rocket Motors to be Tested **)																										
	Remints	Q.A. Provisions		1	2	6	7	11	12	20	21	22	23	32	33	34	35	36	37	38	39	40	41	42	43	52	57	65	66
1	n/a	n/a	Inspection	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
2	3.2.23.9	4.4.2.19	Loads at -65°F																								b		
3	3.2.17	4.4.2.24	Thrust Stand Firing	*	*	*	*	*	*																				
4	3.2.23.7	4.4.2.25	Vibration at -65°F							b	b			b	b														
			Vibration at +165°F									b	b			b	b												
5	3.2.23.6	4.4.2.15	Shock at -65°F (15.7G)											c	c														
			Shock at +165°F (15.7G)													c	c												
6	3.2.25.4	4.4.2.16	Three Ft Drop at -65°F															b (+z)	b (-z)	b (+z)									
			Three Ft Drop at +165°F																		b (+z)	b (-z)	b (+z)						
7	3.2.25.3	4.4.2.17	Forty Ft Drop																					b (+z)	b (-z)				
8	n/a	n/a	Inspection							c	c	c	c	d	d	d	d	c	c	c	c	c	c	c	c		c		
9	3.2.24.1	4.4.2.3.b	Ballistic -65°F	b	b					d		d		e		e		d	d	d									
			Ballistic +70°F			b	b																						
			Ballistic +165°F					b	b		d		d		e		e				d	d	d				d		
10	3.5.7	4.4.2.5	Marginality of Success (MOS)	c	c	c	c	c	c	e	e	e	e	f	f	f	f	e	e	e	e	e	e				e		
11	3.2.15	4.4.2.20	Compatibility (Inert)																									b	b
12	n/a	n/a	Contingency																							b			

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

Tests	Status
Load	PASS
Vibration	PASS
Shock	PASS
Drop (3 ft and 40 ft)	PASS
Ballistic	PASS
Marginality of Success	PASS

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:

DRI @ 165F	DRI>19	DRI>20	DRI>21
Data Number	3	0	0
Percentage	0.8%	0.0%	0.0%

DRI @ 165F	DRI≤19	DRI≤20	DRI≤21
Percentage	99.2%	100.0%	100.0%

  - ✓**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:

DRI @ -65F	DRI>14.75	DRI>15	DRI>16
Data Number	4	3	2
Percentage	1.0%	0.8%	0.5%

DRI @ -65F	DRI≤14.75	DRI≤15	DRI≤16
Percentage	99.0%	99.3%	99.5%

  - ✓ **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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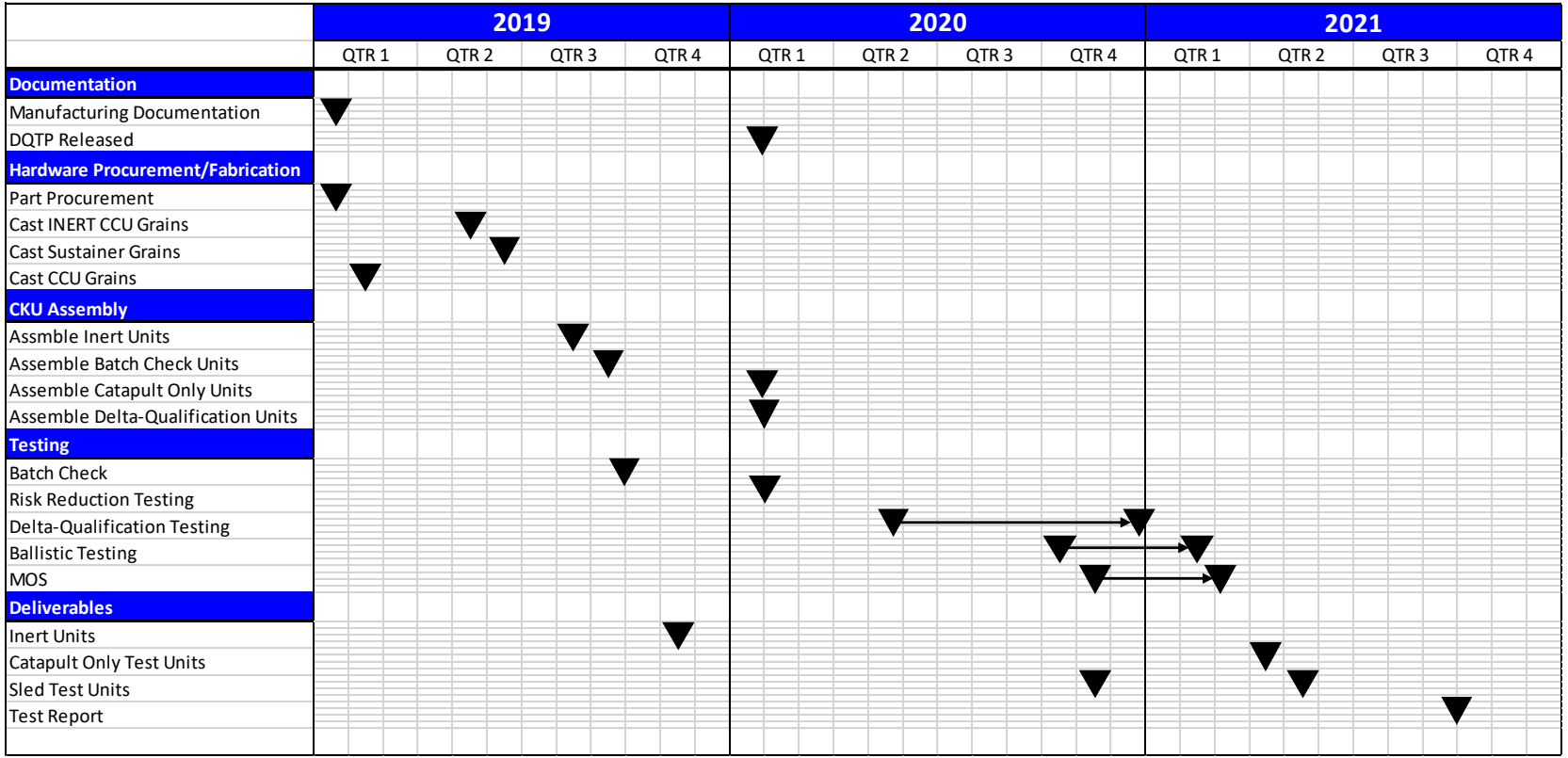
BACKUP INFO

CKU-12/A PROJECT SCHEDULE



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