Certification Authorities for Large Transport Aircraft (CATA)

CATA Worklist Item TCCA-003 – Engine Rotor Lock Testing

Date Raised:	Sept. 27/2016	Updated: N/A	Status:	**CLOSED**
Subject:	**Engine Rotor Lock Testing**			

Description of Issue(s):

(Give a brief background of issue(s)

The current validation policy for rotor lock testing is very prescriptive with some test points being unable to be met. The prescriptive policy has resulted in deviations from the process described in the current FAA policy statement for a number of applicants and has caused consternation for validating authorities.

Background:

The intent of the rotor lock test is to conduct a test under a set of prescribed critical conditions to maximize the conditions required to cause rotor lock. The authorities have different approaches to rotor lock testing. FAA In-Flight Engine Restart issue paper and FAA Policies (Part 25: PS-ANM-25-02, Part 33: PS-ANE-33.89-01) specify a rotor lock screening test procedure which is very prescriptive. EASA In-Flight Engine Restart CRI describes the rotor lock testing at a very high level. The TCCA Engine Rotor Lock issue paper attempts to cover both the FAA and EASA concerns on rotor lock screening tests.

The variations in the issue papers and preferred approaches has led to different interpretations of the rules. Certain key parameter should be used consistently across authorities (e.g. cruise at max altitude + MCT, drift down at Vmd - 10kts, restart at top of envelope…) to ensure harmonization in validation and certification approach.

Proposed Prioritization:

(Per CATA Technical Issues List Prioritization schema)

Question	Answer
1. Is there an active working group related to this issue?	No
2. In which documents are there deviations amongst the authorities?	Deviations are in the guidance documents, and published Issue Papers/Policies
3. Was this issue raised by or at the CMT?	No.
4. What is the level of impact on projects in the future (i.e. minor, major, critical)?	Major; historical issues with validations have taken up significant time and effort.
5. How many authorities does the issue impact?	Issue impacts all 4 authorities
6. What is the approximate technical complexity of the issue (i.e. low, medium, high)?	Medium complexity.

Recommendation:

Team of specialists from all authorities develop common guidance material as part of a technical task group. The means to document this guidance may vary depending on the authority (e.g., revised policy statement for the FAA, IP/CRI/FCAR for other authorities).

CATA Decision:

(Using CATA criteria for determination of technical issues)

CATA decision to action this issue. Authorities' SMEs consensus that topic deserved CATA attention.

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Final CATA Position:

(Explain agreement, dissent or conclusion)

This CWI is closed on the basis that there is agreed interim guidance attached herein, which will be incorporated at a later date into a proposed in-flight engine restart FAA Advisory Circular that will be developed through normal administrative processes, including public consultation. In the meantime, the ANAC, EASA, FAA and TCCA, as Certification Authority, will provide this agreed guidance to its applicants as acceptable clarifications to the baseline rotor lock policy found in FAA policy statements PS-ANM-25-02 and PS-ANE-33.89-01.

If the applicant and CA agree or propose to deviate from the guidance provided in the referenced FAA policy statements, including the clarifications provided in the attachment to this paper, then the CA must inform the other CMT authorities.

If the applicant accept the FAA policy Statement, with the clarifications provided in the attachment to this paper, then the other CMT authorities will do so as well.

Note: This CWI may be re-opened at a later date if necessary for additional discussions between authorities. If so, this may lead to further policy clarifications in the future.

Closure of CWI:

CATA Representative	Name	Signature	Date
ANAC	Marcelo Leite Daniel Pessoa	/s/ M. Leite for	29.11.2018 29.11.2018
EASA	Colin Hancock Mathilde Labatut	/s/ /s/	29.11.2018 29.11.2018
FAA	Tom Groves	/s/	29-11-2018
TCCA	Canh Nham	/s/	2018-11-29

Reference: FAA Policy Statement PS-ANM-25-02 - Guidance for Screening for Engine Rotor Lock in Transport Category Airplanes During Aircraft Certification, dated June 28, 2013.

Purpose: Clarify acceptable alternatives to the detailed rotor lock screening test in the policy statement and clarify areas where experience has shown applicants require more information from the authority.

Background of Topic 1: Section 3, Detailed Test, of the Policy section of this Policy Statement states the following:

"Applicants may propose an alternative to the screening test described below that includes the factors described above."

The airworthiness authorities have had difficulty determining which deviations to the detailed test procedures are acceptable based on the information provided in Section 2, Key Elements to Consider. Clarifications are needed, specifically with respect to step 2 and step 3 of the detailed test procedures. These include: the target airspeed to be used (as defined in step 2), how long to maintain the target airspeed for the descent defined in step 2, and at which altitude the airplane shall be levelled off to perform the restart procedure of step 4 (the top of the restart envelope in step 3)

Applicants have shown compelling evidence, due to specific aircraft design features, to reduce the time interval spent at the target airspeed (best glide airspeed minus 10 knots or a proposed higher alternative) to a significantly more rapid descent. This may appear to conflict with the Section 2 key element d, requiring "a time duration at the low airspeed determined by key element c, low airspeed, that allows the engine to cool significantly and the rotor to achieve the minimum windmill rotational speed and potentially come to a full stop."

Policy Clarification for Topic 1: The detailed parameters and procedures captured in Section 3, Detailed Test, remains the baseline for applicants who intend to follow the guidance of this policy to ensure the screening test is set up to most closely resemble conditions where rotor lock may occur.

Applicants may propose deviations from Section 3, Detailed Test, when justification is provided and found acceptable to the certificating authority. In general, the applicant may account for the following when proposing a deviation from step 2 and 3 of the detailed test procedures:

1. The airplane type design has specific flight deck warnings or indications, in addition to flightcrew memory (or recall) items and airplane flight manual (AFM) procedures, that alert the flightcrew about the loss of all engines and that mandate the flightcrew to maintain a specific minimum airspeed that is higher than the best glide airspeed;
2. The airplane type design has specific flight deck warnings or indications, through visual and aural means, that occur as a direct result of an all-engines-out condition (for example, a cabin depressurization) that alert the flightcrew of the additional failure condition requiring mandatory action to descend the airplane at a significantly higher airspeed than best glide airspeed. If the mandatory actions are based only on memory (or recall) items and AFM procedures, the applicant should justify why a more rapid airplane descent

resulting from the mandatory actions associated with the failure condition is representative of a reasonably expected pilot's response;

3. In any of the above cases, the applicant should apply safety margins to account for flightcrew recognition and reaction time and flightcrew ability to maintain target airspeed;
4. The applicant should provide a validated human factors analysis to substantiate flightcrew actions
5. In the case where the applicant proposes a change in descent airspeed as a result of a subsequent failure condition, the applicant should also apply safety margins, with sufficient justification, to account for any design factors that would increase the time at best glide airspeed (such as a conservatively long time before the cabin depressurizes on a tightly sealed airplane).

Background of Topic 2: Applicants have requested clarification on step 3 in Section 3, Detailed Test, specifically on the details of the transition from the descent speed to the restart speed in terms of target speed and altitudes (e.g., transition such that the restart speed is reached in time to restart at the defined maximum restart altitude envelope, or otherwise). Some applicants have stated it is difficult for their airplane to maintain the altitude at the top of the restart envelope with a single engine and have requested allowance to accelerate the airplane before the start of the restart envelope to compensate. The last sentence of step 3 states:

"At the top of the restart envelope, begin acceleration to the minimum windmill or starter assist restart envelope airspeed using the non-test engine thrust as required to maintain altitude."

Policy Clarification for Topic 2: The applicant is expected to begin the acceleration from the target airspeed defined in step 2 of the policy statement only after reaching the top of the restart envelope. This is based on the critical factor of maximizing the time during the drift down, as describe in paragraph 2.c. of the policy statement. An applicant may accelerate the airplane to achieve the minimum windmill restart airspeed at the top of the restart envelope if the applicant shows that it is more critical, with respect to rotor lock or rotor drag susceptibility, to accelerate the airplane earlier. The applicant should justify how it is more critical and substantiate any analysis. The flight test data should not show a pending rotor lock or rotor drag issue prior to accelerating the airplane (i.e., the data should not show that a rotor lock or rotor drag condition was likely to occur if the airplane continued descending slower at the target airspeed defined in step 2 of the policy statement).

Recall the rotor lock screening guidance is intended to evaluate the design's susceptibility to rotor lock or rotor drag conditions and is not intended to evaluate critical in-flight engine restart conditions. Applicants are required to evaluate the conditions critical for in-flight engine restart separately by issue paper or certification review item to address all-engines-out scenarios. The presence of rotor lock or rotor drag conditions will inherently challenge in-flight engine restart and it is not necessary to add further conservatism to the restart conditions. When a potential conflict exists in determining a critical point, then the priority should go towards critical conditions for rotor lock or rotor drag.

Step 3 requires the test airplane to maintain altitude and allows use of the non-test engine for this purpose. This aspect is intended to support a conservative assessment of rotor lock susceptibility by restarting the engine at the maximum altitude in the restart envelope. It is not intended to

demonstrate acceptable altitude loss in a rotor lock scenario. Allowable altitude loss during the restart is addressed separately from the rotor lock policy statement in the previously mentioned policy on in-flight engine restart following all-engines-out scenarios. For airplane designs that cannot maintain altitude at the top of the restart envelope, thrust on the non-test engine should be used to minimize altitude loss. Applicants may rely on descending the airplane with the non-test engine at idle to increase airspeed provided they justify that for factors influencing rotor lock or rotor drag it is more critical than minimizing altitude loss.

Background of Topic 3: Some applicants have experienced rotor lock conditions during the rotor lock screening flight test after already testing a different serial number engine with the same configuration without experiencing rotor lock conditions during that test. Some applicants have found it necessary to incorporate a production screening process during initial airplane production to ensure new design engines do not experience rotor lock conditions. This shows it may be difficult for an applicant to identify a single conservative engine configuration for the flight test demonstration.

The second paragraph of Section 1, Compliance Methods, states:

"Only one engine representative of the entry-into-service condition and conforming to the installed type design needs to be subjected to the rotor lock compliance screening test. The flight test conditions used to screen for rotor lock should be conducted prior to any abusive engine testing that may rub-in or increase clearances between the rotating and static structure of the test engine beyond that experienced during routine engine operation anticipated in-service. The condition of the components of the engine installation that may affect rotor lock or rotor drag should be representative of the critical case."

Policy Clarification for Topic 3: Applicants are only required to flight test one representative engine according to the policy statement. Applicants are also required to account for engine variations within the approved design that may influence rotor lock. They should be accounting for this variation and flight test the most conservative engine configuration, "critical case," to meet the intent of the policy statement.

If it is not straightforward to determine the most conservative configuration then an applicant should flight test more than one engine to account for the uncertainty in engine configuration. The applicant should also consider if a production test during the early production run should be used to screen for rotor lock if it is difficult to determine and test a conservative engine configuration.

Background of Topic 4: Some applicants have experienced rotor lock conditions on an engine that has successfully passed the rotor lock screening test. These occurred during separate flight tests evaluating different aspects where there was one-engine-inoperative. The in-flight engine restart of the inoperative engine demonstrated possible rotor lock susceptibility. Recent experience has also shown rotor lock conditions that prevent successful in-flight engine restart are not limited to the engine's core rotor. There has been at least one case where the low speed rotor experienced rotor lock conditions. Additional compliance demonstration activities, including additional rotor

lock screening tests at different conditions than in the policy statement, were necessary to clear the installed engine design of rotor lock susceptibility.

The first paragraph of Section 3, Detailed Test, includes the following statement:

"An applicant should perform a critical point analysis to ensure the factors applied to their engine installation are appropriate (e.g., an engine may need more than 10 minutes of operation to thermally stabilize)."

Policy Clarification for Topic 4: The critical point analysis described in the policy statement is intended for applicants to look at any critical condition or engine configuration within the engine's in-flight restart envelope. The example provided in the policy statement may mislead an applicant to only evaluate the scenario described in Section 3, Detailed Test for critical points. Applicants should have a critical point analysis that accounts for other flight conditions where an engine could be restarted. The applicant should also account for the potential for any rotor to experience rotor lock that could preclude a successful in-flight engine restart even though the policy statement focuses on the engine core rotor. The applicant should show that there are either no critical conditions that could lead to rotor lock for low speed engine rotors or show that the specific rotor lock conditions would not preclude a successful in-flight engine restart and ability to achieve maximum continuous engine thrust or power.

Conclusion: This document provides clarification for authorities to evaluate acceptable alternatives to the detailed rotor lock screening test within the scope of the FAA policy statement and clarify areas where experience has shown applicants require more information from the authority. If the certifying authority finds that an applicant's compliance proposal is within the deviation allowance established in the FAA policy when combined with this document, it should not be necessary to coordinate the deviation with a CMT partner authority validating the product.