Comment-Response Document (CRD) to CM-S-016 Issue 1 on Certification of Elastomeric Components on Rotorcraft

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1. Summary of the outcome of the consultation

This CRD includes comments across most chapters of CM-S-016. Due to the complexity of the topics comments ranged across most topics included in this CM.

81 comments were received and answered.

2. Individual comments and responses

In responding to comments, EASA states its position as follows:

(a) **Accepted** — EASA agrees with the comment and any proposed change is incorporated into the text.

(b) **Partially accepted** — EASA either partially agrees with the comment or agrees with it but the proposed change is partially incorporated into the text.

(c) **Noted** — EASA acknowledges the comment, but no change to the text is considered necessary.

(d) **Not accepted** — EASA does not agree with the comment or proposed change.

2.1. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*1* comment by: *DE-LBA* LBA has no comments.
response	Noted.

comment	*2* comment by: *FOCA (Switzerland)* Thank you for the opportunity to comment. We have no remarks on this document.
response	Noted.

comment	*46* comment by: *Federal Aviation Administration* FAA comment: In a dynamic system, the loads required to deflect a structural element are just as important as the speed that an element can return to a neutral position. Elastomers fulfill many roles in a dynamic system. There are more dynamic performance attributes than stiffness, such as spring-effect. The FAA recommends that any usage of “stiffness” be altered to “spring-effect and stiffness, including any other dynamic design performance requirements.”
response	Partially accepted. The text is adjusted to consider influences on the general performance and functionality of the elastomeric component, rather than specific properties.

comment	*48* comment by: *Bell* Elastomeric components as defined in the CM are composed of metallic and elastomeric elements. Failure of the two different elements within the component can have vastly different consequences. The CM does not recognize the difference between the hazards associated with degradation or failure of the elastomeric elements in the elastomeric component vs failure of the primary metallic elements. Hazards related to failure of the various subcomponents can be different from the hazards at the component level and need to be taken into consideration when determining the applicability of the considerations identified in the CM. There are many considerations that define different paths for certification of elastomeric components including; elastomer applications, service history, benign failure modes, inspection intervals, changes in ride quality, endurance testing, material qualification, resistance to environmental conditions, use only in applications with limited motion, etc.… Bell's field service experience has shown that the elastomer degrades slowly enough (elastomer crumbing, small cracks/delams in the elastomer) that it is discovered long before total separation through regular Chapter 5 inspections and inspections brought on by poor ride quality. Also, Bell design practice is that the elastomers are 'trapped' so that if they do fail, they can still react compressive loads. Bell recommends discussion with EASA on Bell's elastomeric component design practices and in-service experience.
response	Noted. As described in the document, different aspects should be considered in the assessment and compliance demonstration.

comment	*49* comment by: *Bell* The guidance provided within the CM is not aligned with the means of compliance that has been agreed with TCCA and the FAA on non-EU programs. For example, the FAA has identified two Categories of elastomeric components where non-PSEs are classified as Category 1 and PSEs are classified as Category 2 with different compliance methodologies. EASA are encouraged to ensure harmonization of the means of compliance for elastomeric components with TCCA and the FAA prior to imposing the guidance contained within the CM.
response	Noted: For the time being there is limited guidance publicly available from the FAA AC material and other FAA sources. While striving for continued harmonization, this CM complements the existing guidance. Our assessment did not show contradictions. Instead, this certification memorandum is intended to provide complementary guidance based on our project experience.

1.4. Definitions p. 4

comment	*39* comment by: *Parker Lord Corporation* A refinement on the definition of "Elastomeric Component." Parker Lord would reccomend changing, "These components are designed to P axial, shear and/or rotational forces," to "These components are designed to react load and accomodate motions."
response	Accepted. The definition is changed as proposed.

comment	*50* comment by: *Bell* Reference top of Page 5 "*" The definition of an elastomeric component is provided in the definitions. Adding ..."made including metallic elements" at the end of the first sentence at the top of Page 5 is redundant and confusing. Delete "made including metallic elements".
response	Not accepted. The additional mentioning of the CM covering components including metallic elements is seen as beneficial. Elastomeric components using another material instead of metal would need further investigation. The sentence is reworded for clarity.

3.1. Applicable Requirements for Elastomeric Components p. 6

comment	*18* comment by: *Transport Canada - Projects* The table that outlines potential requirements does not encompass all applicable ones. It is advisable to note that the list is not exhaustive, and requirements may vary depending on the application. For instance, the following sections could be taken into consideration: 27/29.629 Flutter and divergence (CM should assist in identifying those elastomeric elements that are important for demonstrating freedom from Flutter and Divergence) 27/29.861 Fire protection of structures, controls, and other components 27/29.907(a) Engine vibration Also, Figure 2 should include 27/29.629 Flutter and Divergence requirements.
response	Partially accepted. The chapter title is changed to “Requirement Considerations for Elastomeric Components” to increase the clarity that not all listed requirements are necessarily applicable. The applicable requirements differ depending to a certification project. 27/29.629, 27/29.861 and 27.907(a) are added. See also comment no. 51.

comment	*51* comment by: *Bell* The title of the section is "Applicable Requirements for Elastomeric Components", whereas the first sentence says that the table outlines the requirements to be considered which is more accurate. Whereas the Table lists those requirements to be considered, some of which may not be applicable; the title of Section 3.1 should be "Requirement Considerations for Elastomeric Components".
response	Accepted. See comment no. 18.

3.2. Approach for Certification p. 7

comment	*3* comment by: *AIRBUS HELICOPTERS* With regard to the Figure 2 - Left grey box with the title "Component Safety Assessment" : "*[...] the Elastomeric Material **and** Elastomer Laminate [...]"* Airbus Helicopters suggests modifying the sentence as follows : **Airbus Helicopters proposed text :** *"[...] the Elastomeric Material **OR** Elastomer Laminate [...]"* **Rationale for the comment :** It is suggested to change "*and*" by "*or*" as it is either a laminated package or a single elastomer layer .
response	Accepted. The wording is changed accordingly.

comment	*4* comment by: *AIRBUS HELICOPTERS* With regard to the Figure 2 - Left beige box "**<HAZ**" **Airbus Helicopters proposed text :** Airbus Helicopters suggests replacing "**<HAZ**" by "**MAJ**" **Rationale :** Airbus Helicopters considers that there is no added value to perform certification activities for all the mentionned requirements for parts having MIN and NSE failure severity
response	Not accepted. The need to establish compliance against the basic static strength requirements is independent from the hazard classification, while the means and extent of the compliance demonstration may differ depending on their (lower) criticality and the underlying applicant experience. i.e. static strength should be demonstrated to meet the installation requirements/needs. Therefore, the wording is not modified and this section is applicable also to parts having MIN and NSE failure severity.

comment	*5* comment by: *AIRBUS HELICOPTERS* With regard to the "*Figure 2: Substantiation principle based on criticality classification*" **Airbus Helicopters comment :** Airbus Helicopters suggests to clearly address, in the flow chart, requirements to be considered at elastomeric component level and the ones to be considered at element level. This is to take into account the fact that even if the elastomeric component classification should be based on the maximum failure severity level of all elements, each element must be substantiated in accordance with its severity.
response	Not accepted. Due to the strong interactions between the sub-components, EASA position is that the classification is based on the max criticality of any of the sub-components or the whole component. This is consistent with current practices also identified e.g. in AC 29-2C, AC 29.571B, where the component is classified based on the maximum criticality. However, the main focus is on the most critical areas/the locations of interest within that part that require particular attention.

comment	*6* comment by: *AIRBUS HELICOPTERS* With regard to the second bullet of the paragraph 3.2 : " - *to determine an operating limit based on reliability for non-catastrophic/hazardous elastomeric components with failure consequences < HAZ.*" Airbus Helicopters suggests modifying this 2nd bullet as follows : **Airbus Helicopters proposed text :** *"- to perform a static strength substantiation for an elastomeric component with major (MAJ) failure consequences"* **Rationale for the proposed change :** To ensure consistency between the Figure 2 (modified as per the Airbus Helicopters comment #4) and the paragraph right after, it is suggested to replace the sentence [- *to determine an operating limit based on reliability for non-catastrophic/hazardous elastomeric components with failure consequences < HAZ.*]
response	Partially accepted. Text adjusted to clarify the applicability for "<HAZ See also comments no. 4 and 5

comment	*7* comment by: *AIRBUS HELICOPTERS* With regard to the second bullet of the paragraph 3.2 : " - *to determine an operating limit based on reliability for non-catastrophic/hazardous elastomeric components with failure consequences < HAZ.*" Airbus Helicopters suggests modifying this 2nd bullet as follows :

Airbus Helicopters proposed text :
*"- to determine an operating limit**, to be recorded in MSM chapter 5,** based on reliability for non-catastrophic/hazardous elastomeric components with failure consequences < HAZ."*

Rationale for the proposed change :
If the wording of the 2nd bullet is kept, it is suggested to precise the location of the limit in the documentation.

response: Partially accepted.
See also comments no. 4, 5 and 25

comment *8* comment by: *AIRBUS HELICOPTERS*

With regard to the second bullet of the paragraph 3.2 : " - *to determine an operating limit based on reliability for non-catastrophic/hazardous elastomeric components with failure consequences < HAZ.*"

Airbus Helicopters comment :
If the wording of the 2nd bullet is kept, this wording can be misleading : Does "*non-catastrophic/hazardous*" mean "*non-catastrophic and non-hazardous*" ? If so, de facto, the failure consequence is > HAZ so it seems to be redundant.

response: Partially accepted.
The text is adjusted to improve its clarity.

comment *25* comment by: *Leonardo Helicopters*

It is unclear whether the result of Damage Tolerance analysis of such Hazardous components have to be included in Maintenance Manual in Chapter 4 or in Chapter 5.

Fatigue evaluations should be conducted on PSE in accordance with CS29.571/573 (and 27.571/573), avoiding damage tolerance evaluation on Hazardous components.

response: Accepted.
The results of the DT analysis should be included in the ALS.
The CM explains the reasoning for requesting DT evaluation for elastomeric components with HAZ failure consequences.
The wording is updated to clarify this aspect.

comment *40* comment by: *Parker Lord Corporation*

Parker Lord recommends evaluating the criticality of each element individually such that the appropriate analysis is performed on each element. The definition in Figure 2 appears to assign the max criticality of any one element to all elements. Elastomeric elements frequently have a different criticality classification when compared to metallic aramatures.

response: See comment no. 5

comment	*43* comment by: *Federal Aviation Administration* FAA comment: The FAA disagrees with selecting regulations for compliance based on hazard severity classification. The part must comply with all applicable regulations; however this section allows applicants to show compliance to a subset of required regulations based on hazard severity, which is inappropriate for structures. A Failure Modes and Effects Analysis (FMEA) may be used to determine if the part is a Principle Structural Element (PSE) and subject to Fatigue and Damage Tolerance requirements. The FAA proposes removing the hazard classification identified in Figure 2, and recommends using existing FAA guidance in Advisory Circular (AC) 27-1B and AC 29-2C to conduct an FMEA for fatigue and damage tolerance applicability.
response	Partially accepted. The document is updated accordingly to include a reference to the recognized FAA AC material.

comment	*52* comment by: *Bell* Figure 2 is missing the assessment of subcomponents of the elastomeric component. Based on the elastomeric component design features, failure of the elastomer within the component could have different hazards than metallic elements. If failure, detachment or degradation of the elastomer (and shims) is not HAZ or CAT, a fatigue and DT evaluation would not be necessary for the elastomer. Figure 2 needs to reflect assessment of not only the elastomeric component, but subcomponents within the elastomeric component to determine whether a fatigue and DT evaluation of the elastomer is necessary.
response	Please see comment no. 5

comment	*53* comment by: *Bell* The notes below Figure 2 should clarify that the DT requirements are applicable to the parts of the elastomeric component that could result in CAT or HAZ failure consequences and not necessarily to every part of the component.
response	Please see comment no. 5

comment	*54* comment by: *Bell* The applicability of fatigue and DT (referencing CS 29.571 and 27/29.573) for elastomeric components with HAZ consequences is not in accordance with the requirements of CS 29.571 and 27/29.573 which only apply to PSEs with CAT consequences. Adding applicability of CS 29.5and 27/29.573 through the CM is adding additional requirements which is not the purpose of Certification Memos (as explained on the cover page). CM to be aligned with the requirements of CS 29.571 and 27/29.573 where applicability of these requirements is only to PSEs. Elastomeric components with HAZ consequences do require special attention but compliance needs to be established based on other applicable requirements of CS-27 & 29.

response	Accepted. The CM is complemented to provide explanation regarding the fatigue and damage tolerance evaluation for HAZ components, referring to CS 27/29.601, CS 29.547(b) and CS 29.917(b)

3.2.1. Design Assessment p. 7

comment	*9* comment by: *AIRBUS HELICOPTERS* With regard to the first bullet of the paragraph 3.2.1 : " - *A hazard assessment performed at rotorcraft level,*" **Airbus Helicopters comment :** How will EASA ensure the consistency of the Functions Failure Conditions (e.g. within the FHA) between the different TC Holders?
response	Noted. EASA has a common interpretation of the topic and applies it consistently across all applicants.

comment	*10* comment by: *AIRBUS HELICOPTERS* With regard to the last sentence at the bottom of the page 7 : "*The elastomeric component classification should be based on the maximum failure severity level of all elements.*" Airbus Helicopters suggests modifying the sentence as follows : **Airbus Helicopters proposed text :** *"The elastomeric component classification should be based on the maximum failure severity level of all elements* ***but each element must be substantiated in accordance with its severity****."* **Rationale for the change :** The sentence may be completed as it does not address all subtantiation aspects.
response	Not accepted. Currently EASA does not agree to the substantiation for each sub-element on its own. See also comment no. 5.

comment	*11* comment by: *AIRBUS HELICOPTERS* With regard to the second sentence on top of the page 8 : "*This logic can also be adopted for CS 27 cat B rotorcraft, although design assessment is not a requirement for this category of rotorcraft.*" **Airbus Helicopters comment :** Applying the Certification Memo to CS-27 cat B designs cannot be understood as a *"complementary information and guidance for compliance demonstration with*

	current standards" (as stated in the introduction on the page 1) and should be covered by a RMT.
response	Accepted. The text is adjusted to reflect the approach.

comment	*44* comment by: *Federal Aviation Administration* FAA comment: There should not be an exception for CS27 Cat B rotorcraft, as stated in the last sentence of this section. For Part 27 rotorcraft, neither FAA nor EASA regulations distinguish between Cat A and Cat B rotorcraft operations when it comes to conducting a design assessment. The FAA proposes removing the exception to CS27 Cat B rotorcraft.
response	Not accepted. CS 27 Appendix C lists the applicable paragraphs of CS-29 that must be met in addition to the requirements for CS-27 for CS-27 Category A rotorcraft.

comment	*55* comment by: *Bell* The third paragraph correctly identifies that the failure analysis needs to be detailed to the sub-component level. This analysis should be used to determine the extent of qualification/testing/analysis required at the subcomponent level. In line with other comments, clarify that applicability of the guidance in the CM is based on the failure effects at the subcomponent level.
response	See answer to comments no. 5 and 10

comment	*56* comment by: *Bell* "TCH/STCHs should not consider compensating provisions when proceeding to the component classification." The design assessment is to be conducted based on 29.547(b) and 29.917(b). It is not clear why the note about compensating provisions is included. Please clarify in the CM.
response	Accepted. The text is adjusted to improve clarity. Compensating provisions are not intended to influence the original criticality classification.

3.2.4. Static Substantiation p. 8

comment	*19* comment by: *Transport Canada - Projects* CS 29.307 Mean of Compliance should be stated for static substantiation (test or analysis based on test) CS 27/29.603 The paragraph mentioned environmental conditions, but it did not consider the effects of temperature, chemical exposure, aging, creep, etc. CS 27/29.613 variability of the material should be considered.

response	Accepted. These requirements are now added to chapter 3.2.4. The environmental conditions are addressed in 3.2.8.2. For completeness, the effect of altitude and air density on loads must be accounted for has also been added to chapter 3.2.3.

comment	*27* comment by: *Leonardo Helicopters* Strains on elastomer are almost totally driven by motions and therefore, safety factor 1.5 is not applicable for strain/stress induces by pure motion as per CS29.303. The use of the maximum kinematic allowable motions can be considered to derive limit conditions. Factor should be applicable on external/internal load and not motions.
response	Accepted. The 1.5 factor should be applied to the external loads unless its application on internal stresses leads to more realistic loading conditions.

comment	*61* comment by: *Bell* CS 29.619 identifies requirements for casting, bearing and fitting factors. It is unclear how CS 29.619 is applicable to elastomeric components. The reference to CS 29.619 should be removed or applicability to elastomeric components clarified.
response	Partially accepted. 27/29.619, and the following special factors are design-specific and can be applicable to certain designs. Therefore, the statement is included "[…] as deemed applicable […]".

comment	*62* comment by: *Bell* The statement "For Ultimate Load Conditions it is currently accepted that the 1,5 factor is applied to the maximum internal stress or strain (corresponding to limit loads)" is not per current practices and not practical. Elastomer strains are primarily driven by displacements, so applying a 1.5 factor on strain would imply applying a 1.5 factor on displacements which is unrealistic as the control system on the aircraft cannot apply 1.5X limit motions. The UL factor is more appropriately applied to the loads that are applied to the part not the internal stresses or strains. Rephrase the paragraph to clarify the UL factor is applicable to the loads that are applied to the part not the internal stresses or strains.
response	See answer to comment no. 27

3.2.5. Damage Tolerance and Fatigue Evaluation p. 8

comment	*20* comment by: *Transport Canada - Projects* An example of certification using the building block method could be provided to mitigate the complexity of multiple materials and complex failure configurations.
response	Not accepted. The development of a test pyramid (building block method) is connected to the design and configuration of a part and therefore not included in this CM.

comment	*63* comment by: *Bell* The applicability of fatigue and DT (referencing CS 29.571 and 27/29.573) for elastomeric components with HAZ consequences is not in accordance with the requirements of CS 29.571 and 27/29.573 which only apply to PSEs with CAT consequences. Adding applicability of CS 29.571 and 27/29.573 through the CM is adding additional requirements which is not the purpose of Certification Memos (as explained on the cover page). CM to be aligned with the requirements of CS 29.571 and 27/29.573 where applicability of these requirements is only to PSEs. Elastomeric components with HAZ consequences do require special attention but compliance needs to be established based on the other applicable requirements of CS-27 & 29.
response	See answer to comments no. 25 and 54

comment	*64* comment by: *Bell* Applicability of DT and Fatigue Evaluation should be based on the hazards at the subcomponent level. In accordance with previous comment the section needs to be revised to reflect the applicability to the subcomponents.
response	See answer to comments no. 5 and 54.

comment	*65* comment by: *Bell* First sentence, second paragraph on page 9 should also include "failure consequences". Revise to read "Attention should be paid to designs where the use of multiple materials in complex configurations can result in many different failure consequences, damage modes, failure sequences, failure durations, etc."
response	Accepted. “Failure consequences” is added to the text.

3.2.2.2. Critical Part p. 8

comment	*26* comment by: *Leonardo Helicopters* Process critical parameters are known by Supplier only, since this is a proprietary technology protected by Intellectual Property (IP). The supplier provides a frozen Quality Plan (QP), however due to proprietary information, TCH is not allowed to completely control the process employed by the supplier in the fabrication of elastomeric components. Reporting the curing cycles parameters, the ramp of pressure during molding, etc. into the QP together with the frozen parameters values, is not feasible for the reasons above. The manufacturing process is controlled and frozen by supplier. The statement should be mofidied considering the boundary of the proprietary information disclosure.
response	Accepted. Reference added to chapter 3.2.8.1 on process qualification including intellectual property. See also answer to comment no. 41.

comment	*58* comment by: *Bell* The first sentence is incorrect. For CS 27/29.602 to be applicable you need both CAT failure and critical characteristic(s). Revise to read "For an elastomeric component with a critical characteristic, the failure of which could have a catastrophic effect upon the rotorcraft, compliance to CS 27/29.602 must be demonstrated."
response	Accepted. Sentence is adjusted to: “For an elastomeric component, the failure of which could have a catastrophic effect upon the rotorcraft, and for which critical characteristics have been identified, compliance to CS 27/29.602 must be demonstrated.”

comment	*59* comment by: *Bell* Although critical characteristics would be expected for elastomeric PSEs, they are not "automatic" as the paragraph suggests. The paragraph needs to be reworded to be clear that critical characteristics are those that need to be controlled to ensure the integrity of the part. Suggest the second sentence read "Elastomeric components may have critical characteristics…"
response	Accepted. “May” is added to the text.

3.2.2.1. PSE (Principal Structural Element) p. 8

comment	*45* comment by: *Federal Aviation Administration* FAA comment: In this Certification Memorandum, the definition of an elastomeric PSE (or PSE, which contains elastomers) should account for the dynamic performance characteristics, and the effect of a failure to respond as designed, where appropriate. The FAA has encountered applicants with an incomplete or incorrect understanding of elastomers. Applicants have claimed that an inability to react loads isn't a failure, or that the elastomeric material doesn't fatigue. The FAA proposes using the FMEA process to determine if the component meets the definition, i.e., "Elastomeric PSEs are structural elements that contribute significantly to the carrying of flight or ground loads; whose performance is critical to aircraft or system dynamics; and whose failure or reduction of critical performance attributes could result in catastrophic loss of the aircraft."
response	Noted. EASA is following the PSE definition defined in AC 29-2C Change 4.

comment	*57* comment by: *Bell* Reference to CS 29.571 and 27/29.573 could be added for clarity regarding classification of PSEs.
response	Noted. The reference to AC-29 and AC-27 MG8 and MG11 is given as guidance.

3.2.3. Loads p. 8

comment	*60* comment by: *Bell* "Elastomeric components may be subject to complex loading conditions, that dependent on frequencies…" Should read: "Elastomeric components may be subject to complex loading conditions, that depend on frequencies…"
response	Accepted. The text is corrected accordingly.

3.2.6. Inspection Interval substantiation principle p. 9

comment	*12* comment by: *AIRBUS HELICOPTERS* With regard to the 5th sentence of the paragraph 3.2.6 : "*However, the metallic shims should also be fatigue evaluated by analysis.*" **Airbus Helicopters comment :**

	The paragraph deals with PSE components and not with PSE elements. Thus, the above sentence is misleading as the distinction must be made between failure severity at component level and failure severity at element level. Metallic shims should be evaluated in fatigue only if their failure severity is CAT or HAZ.
response	Accepted. This sentence is removed.

comment	*21* comment by: *Transport Canada - Projects* It is suggested to remove words "So far" from the following sentence: "So far, certification by pure analysis is not accepted by Airworthiness Authorities."
response	Accepted. “So far” is removed and the sentence adjusted to clarify that pure analysis is currently not accepted on component level.

comment	*47* comment by: *Leonardo Helicopters* LHD agrees with this CM to evaluate by analysis fatigue of metallic shims. The position of LHD is to do not consider metallic shimc as PSE, therefore the fatigue anaylis is not performed to provide compliance to par 29.571. However this anaylis is done at design stage to size the shims in order to be achieve infinite life. If the statement "however, the metallic should..." is to be intended to comply par. CS29.571, the proposal is to remove this sentence from the CM.
response	Accepted. The sentence is deleted. See also comment no. 12 and 68

comment	*67* comment by: *Bell* It is stated that the shims should be evaluated by analysis yet the next statement states that pure analysis is not accepted which appears to be an impossible task. "However, the metallic shims should also be fatigue evaluated by analysis. So far, certification by pure analysis is not accepted by Airworthiness Authorities." These statements are contradictory. Recommend to delete or clarify intent. "However, the metallic shims should also be fatigue evaluated by analysis supported by test. So far, certification by pure analysis is not accepted by Airworthiness Authorities."
response	See comment no. 12, 47 and 68

comment	*68* comment by: *Bell* "However, the metallic shims should also be fatigue evaluated by analysis. So far, certification by pure analysis is not accepted by Airworthiness Authorities."

	Depending on the purpose and function of shims, there may or may not be a need to establish a service life for the shim. The requirement to establish a service life for shims needs to be determined based on the criticality of the parts based on the design assessment conducted IAW CS 29.547(b) and CS 29.917(b).
response	See comment no. 12 and 47

3.2.5.1. Fatigue Loads p. 9

comment	*28* comment by: *Leonardo Helicopters* Ground loads shold not be considered as per 29.471. On-ground conditions are typically Low Frequency cases.
response	Not accepted. This text is referring to the fatigue loading, which should cover the complete spectrum including landing loads and ground loads. This section does not intend to refer to the 29.471 ground loads.

3.2.5.2. Threat Assessment p. 9

comment	*29* comment by: *Leonardo Helicopters* It is propoesed to remove "elastomeric material/laminate" from the Threat Assessment analysis, since visible damages due to fatigue are much greater than the defects induced by installation, service or maintenance activities.
response	Not accepted. EASA acknowledges the primary threat is through degradation in service. However, a threat assessment is specific to the design, installation and application of a component and should be evaluated per project. The wording is kept general to avoid excluding a sub-component from this evaluation a priori. The threat assessment should be adapted to the design of a component and its elements, covering maintenance, installation and in-service as appropriate.

comment	*66* comment by: *Bell* The primary threat affecting elastomers is degradation in service. Threats (flaws) associated with manufacturing are generally not present due to the vulcanization processes used to manufacture elastomers. Emphasis should be placed on in-service threats.
response	See answer to comment no. 29.

3.2.6.1. Relevant testing phases p. 10

comment	*13* comment by: *AIRBUS HELICOPTERS* With regard to the title of the paragraph 3.2.6.1 : "*Relevant testing phases*" Airbus Helicopters suggests modifying the title as follows : **Airbus Helicopters proposed text :** *"3.2.6.1. Relevant testing phases* ***for an elastomeric component with hazardous (HAZ) / catastrophic (CAT) failure consequences****"* **Rationale for the change :** It is suggested to clearly mention that this paragraph 3.2.6.1 is applicable only to components CAT and HAZ components with CAT or HAZ failure severity.
response	Accepted. The header is adjusted accordingly.

comment	*14* comment by: *AIRBUS HELICOPTERS* With regard to the following paragraph : "*The inspection method proposed in service should be compatible with the damage occurring during the test. Particular care should be paid to the validation of the proposed inspection method, taking into account the level of accessibility to the component and the level of damage detectability. On ground, some elastomer damages (e.g. shim delamination) might be not visible without specific equipment or procedures.*" **Airbus Helicopters comment :** Does the shim delamination refer to elastomer layer crack ?
response	Noted. The example is clarified in the revised text.

comment	*22* comment by: *Transport Canada - Projects* CS 27/29.271(g) Creep deformation is not addressed in the damage tolerance evaluation, though it could be particularly critical at high temperatures. An example of how to measure creep deformation is provided by ASTM D390-76. CS 27/29.573(d)(1) Ageing can be assessed according to ASTM D 573-81. The duration between vulcanization (crosslinking) in the mold and testing is not specified, yet it influences the test results' variability. It is common practice to test after 16 hours of vulcanization, and sometimes longer periods are necessary. However, testing should generally be completed within 60 days of delivery to a purchaser.
response	Noted. The intention of this Certification Memorandum is to provide general guidance for compliance demonstration for elastomeric components. Specific details of the methods are not included. All degradation modes should be considered in the

	damage tolerance evaluation. This would include creep deformation when appropriate, a reference to temperature effects is stated.
comment	*30* comment by: *Leonardo Helicopters* Due to installation, the damage could be clearly detectable only with specific techniques/tests performed in laboratory, such as Detailed Inspection (DI) or Special Detailed Inspection (SDI). The proposal is to do not consider the GVI criteria as the unique technique to inspect parts in service.
response	Accepted. Specification of GVI was removed from the text and the text was adjusted to refer to inspections, typically visual.
comment	*31* comment by: *Leonardo Helicopters* The shims are not PSE's and their stress level are usually much lower than the metallic armatures that drive the Service Life of the elastomeric component. However, the metallic shims are tested with the rubber and their failure is not acceptable becoming an "end test criteria". The proposal is to modify the paragraph as follows: "The demonstrated time period until a detectable damage is identifiable as a rejection criterion is important for the TCH/STCH, to ensure acceptable reliability. ~~This time period may be used to derive a limitation for the elastomer laminate, which should not exceed the service life limits of the shims.~~"
response	Accepted. The sentence is removed.
comment	*32* comment by: *Leonardo Helicopters* The proposal is to modify the sentence as follows: "Test acceleration methodologies will have to take into account certain aspects, such as temperature, load frequency, etc. in order avoid unrealistic phenomena. Therefore, the methodology will mainly refer to the supplier's experience, in-service experience, test rig temperature surveys and the choices made should be justified and proposed for acceptance to EASA in the Qualification Test Plan".
response	Not accepted. The current phrasing tries to minimize restrictions and points towards acceptance by EASA for proposed methodologies.
comment	*33* comment by: *Leonardo Helicopters* Adhesion failure of the component is in general not allowed for an elastomeric package composed by several layers of rubber and metallic shims.

However, this criteria cannot be adopted for all types of elastomeric components, where this type of failure could be accepted especially when the kind of elastomer is stronger than the adhesive layer.

The proposal is to remove the sentence "under any design environment" and introducing the Adhesion Failure as general requirement or general design criteria.

response: Accepted.
The text is adjusted to highlight the issue to be considered, that adhesion failure should generally be considered.

comment: *34* comment by: *Leonardo Helicopters*

When test temperature is based on maximum or minimum operative conditions, plus overheating effect, the demonstration should be limited to one inspection interval only and not for the entire DP, which would result in a too conservative test.

response: Accepted.
The initiation is usually completed at room temperature and the propagation needs to consider environmental effects.

comment: *42* comment by: *Parker Lord Corporation*

The elastomeric fatigue test process described in section 3.2.6.1 is very lengthy as it typically can not be accelerated significantly without changing the degradation mode of the elastomer to one that isn't realistic on aircraft. To fully test one component can take 0.5-3 years. The long testing durations incur huge expense and time risk to both aircraft manufacturers and elastomeric component manufactures. The addition of multiple permutations of temperature application and contaminations multiplies the expense and time involved in these tests with minimal shown benefit of improved safety. A consideration on how to optimize the permutations required is typical. Temperature, contamination, and part configuration need to be considered for optimizing the number of tests specimens and conditions.

response: Accepted.
The text is adjusted to increase clarity. When acceleration methodologies are used, care should be taken to ensure the degradation mode has not been modified and remains representative.
The test conditions and configuration can be derived from the characteristics of each individual element (pyramid of test).
Other approaches can be proposed to the Agency.

comment: *69* comment by: *Bell*

Contaminant testing is normally completed by the elastomeric bearing manufacturer on a rubber sample specimen of same type that is used in the elastomeric bearing. The data for this testing is normally supplied as qualification by similarity. Contaminant testing is normally not completed on the actual elastomeric bearing. Doing this would cause unwarranted expense and schedule to qualify a bearing to become unrealistic. Also, natural rubber blend elastomeric bearings

	exhibit reasonable resistance to contaminants as long as they are not allowed to pool on surface of the elastomer. Characterization of elastomeric materials should be identified as an acceptable means to determine the susceptibility of materials to contamination as opposed to application of contaminants on the fatigue or endurance test article.
response	Partially accepted. Reference can be made to previous tests and validations. Typically EASA accepts testing on most critical component levels. The approach can be discussed with EASA. See answer to comment no. 75

comment	*70* comment by: *Bell* Propagation testing to be completed at high, standard and low temperatures. It is satisfactory to complete at standard (ambient) temperature propagation to identify inspection intervals. The high, standard and low temperature testing would be cost prohibitive and contribute to unrealistic qualification schedule for elastomeric bearing development. Propagation testing should be done at the critical temperature. Testing at multiple temperatures is cost prohibitive. High temperature is usually the most critical for elastomer fatigue. Cold temperatures typically result in stiffening of the elastomer and can increase loads on the surrounding structure during start-up until hysteretic heating causes the elastomer to warm up.
response	Partiallly accepted. The text is adjusted to include alternatives like lower level pyramid testing, in-service experience of similar elastomeric components or the use of other substantiation methodologies if justified to the authority.

comment	*71* comment by: *Bell* The following statement is inaccurate. "As highlighted in AMC 20-29, adhesion failures between elastomer and metallic shims are considered an unacceptable failure mode for elastomer components, under any design environment. Changes in the design and/or processes are required in case adhesion failures occur during the test." The section in AMC 20-29 is in reference to adhesion as it relates to composite components and does not discuss adhesion of shims and elastomers as stated in the CM. Failure of adhesion between elastomers may have benign effects. Failure effects are to be established through the applicable design assessments under CS 29.547(b) and CS 29.917(b). These failure effects will then influence the pass/fail criteria to be applied during the relevant testing.
response	Partially accepted.

	Adhesion failure is considered unacceptable. While it may have a benign effect, this would need to be demonstrated accordingly. The text was adjusted accordingly.

comment	*72* comment by: *Bell* "The demonstrated time period until a detectable damage is identifiable as a rejection criterion is important for the TCH/STCH, to ensure acceptable reliability. This time period may be used to derive a limitation for the elastomer laminate, which should not exceed the service life limits of the shims." Depending on the purpose and function of shims, there may or may not be a need to establish a service life for the shim. The requirement to establish a service life for shims needs to be determined based on the criticality of the parts based on the design assessment conducted IAW CS 29.547(b) and CS 29.917(b).
response	See answer to comment no. 31

comment	*73* comment by: *Bell* Metallic shims are an integral part of the elastomeric package and are substantiated in the endurance testing along with the elastomer itself. Analytical fatigue evaluation of the shims does not account for degradation of the elastomer impacting stresses on the metallic shims. Endurance testing of the complete elastomeric package (elastomer and shims) is more representative of the actual part usage.
response	Accepted. The testing is with the complete elastormeric component and the text has been clarified accordingly. The text regarding fatigue analysis of the metallic shims has been deleted. See also comment 47.

comment	*74* comment by: *Bell* Residual Strength Criteria: - UL should be demonstrated at the end of the damage initiation phase if the defined rejection criteria was obtained, considering environmental conditions (temperature / contaminants) CM-S-016 sec. 3.2.6.3 states that "the service life of the elastomeric component is generally driven by the metallic armature substantiation, whereas the inspection interval is generally driven by elastomer laminate." This implies on-condition replacement of the elastomer (i.e., elastomer is replaced when inspections indicate rejectable damage). With rejectable/detectable damage, the minimum residual strength requirement is limit load capability per CS29.573 (as part of inspection interval substantiation).

	The ability to withstand ultimate load is typically demonstrated by a stand-alone static specimen. Demonstrating residual strength up to limit load at the end of damage propagation testing is sufficient to ensure safety/integrity of the part.
response	Partially Accepted. UL load capability needs to be shown with min. quality and maximum damage.

comment	*75* comment by: *Bell* The CM requires damage propagation testing to be conducted with the worst case contaminant applied. Coupon testing of elastomeric material with contamination is more conservative due to the surface area where contaminants can be applied. CM to consider coupon testing to show the effects of contaminants on the elastomer. If no effect then contamination during the testing would not be necessary.
response	Accepted. If lower-level pyramid tests demonstrate no detrimental effect of contaminants on the elastomeric material, component level testing with contaminants is not necessary. See also comment no. 69

comment	*76* comment by: *Bell* The CM recommends residual testing at high, low and standard temperatures. Testing at the temperature (normally high temperature) deemed the most critical in terms of fatigue strength reduction of the elastomer is appropriate.
response	Partially accepted. The text is adjusted to include alternative justifications. See also answer to comment Nr. 70

3.2.6.2. Scatter Factor for inspection interval p. 11

comment	*35* comment by: *Leonardo Helicopters* The meaning of the term "scatter" in the title is not entirely clear, this considering also the references in paragraph to AMC 20-29 (composite parts). The scatter could to be intended as "Life Factor" (or "Reduction Factor") of the damage propagation phase. For metallic parts, the damage propagation reduction factor does not depend on material properties variation or on manufacturing process. In the same way, for the Elastomer Parts, it can be adopted the same reduction factors although Elastomeric Parts have a lower damage propagation rate than metals, as this approach is conservative.
response	Partially Accepted

	Text clarified that Life scatter factor is meant. Alternative approaches can be evaluated.

comment	*36* comment by: *Leonardo Helicopters* As additional option, it is proposed to use lower factors in case the worst test is used to give compliance.
response	Accepted This is intended to be covered by "Alternative approach can be evaluated by the Airworthiness authorities".

3.2.6.3. Maintenance concept p. 12

comment	*15* comment by: *AIRBUS HELICOPTERS* With regard to the first sentence of the paragraph 3.2.6.3 : "*The maintenance concept will be adapted to the substantiation approach selected. The definition of a rejection criteria will be associated to a safe inspection interval, generally recorded in the ALS.*" Airbus Helicopters suggests modifying this sentence as follows : **Airbus Helicopters proposed text :** "*The maintenance concept will be adapted to the substantiation approach selected. The definition of a rejection criteria will be associated to a safe inspection interval, generally recorded in the ALS* ***for elastomeric element with catastrophic (CAT) failure consequences****."* **Rationale for the change :** It is suggested that the sentence be completed to remind the link with CAT element.
response	Accepted. The text is updated accordingly.

comment	*16* comment by: *AIRBUS HELICOPTERS* With regard to the last sentence of the paragraph 3.2.6.3 : "*Maintenance linked to elastomer laminate substantiation is generally recorded in the normal maintenance program for HAZ components*" Airbus Helicopters suggests modifying this sentence as follows : **Airbus Helicopters proposed text :** "*Maintenance linked to elastomer laminate substantiation is generally recorded in the normal maintenance program for* ***< HAZ components***." **Rationale for the change :** The sentence may be completed to address components <HAZ.

response	Partially accepted. The sentence is adjusted to describe the limitations to be recorded in the maintenance manual. See also comment no. 15.

comment	*37* comment by: *Leonardo Helicopters* LHD manages elastomeric part as ON-CONDITION parts. Elastomeric parts have also a Shelf Life (when correctly stored). The proposal is to do not apply as mandatory requirement a calendar life, leaving the possibility to comply to this requirement with alternative approaches through, for example, dedicated visual inspections acted to identify ageing.
response	Accepted. The text is adjusted to open up substantiation possibilities next to a Calendar Life. Word “limit” changed to “life”

comment	*77* comment by: *Bell* “A calendar limit should be defined for each elastomeric material/laminate…”. The CM infers that a calendar limit applies to all components containing elastomeric materials. An economically viable calendar life takes years of service history or coupon testing to develop and is impractical to apply to all elastomeric components. Paragraph should be amended to clarify that calendar life may be applicable to elastomeric PSEs.
response	See comment no. 37 The word “limit” is changed to “life”.

comment	*78* comment by: *Bell* "Maintenance linked to elastomer laminate substantiation is generally recorded in the normal maintenance program for HAZ components." For products subject to M SG3, inspections and intervals are based on the analysis conducted under the MSG3 working groups and not as a result of the design compliance.
response	Partially accepted. Inspection interval should be listed in the maintenance manual. MSG 3 process may also be relevant.

3.2.8.2. Environmental conditions for material qualification p. 12

comment	*17* comment by: *AIRBUS HELICOPTERS* With regard to the first sentence of the paragraph 3.2.8.2 : "*An elastomeric material/laminate should encompass an environmental survey to investigate the*

effect of contamination (i.e. exposure to aggressive fluids), the effect of temperature on the mechanical properties (CS 27/29.609) and the impact of lightning (CS 27/29.610)."

Airbus Helicopters suggests modifying this sentence as follows :

Airbus Helicopters proposed text :
"*An elastomeric material/laminate should encompass an environmental survey to investigate the effect of contamination (i.e. exposure to aggressive fluids)**(CS 27/29.609)**, the effect of temperature on the mechanical properties and the impact of lightning (CS 27/29.610).*"

Rationale for the proposed change :
Location of "*(CS 27/29.609)*" does not seem appropriate in the sentence. Temperature effect on the mechanical properties is not adressed in the CS 27/29.609 when it is the case for effect of contamination.

response

Accepted.
2X.609 is moved and 2X.613 is added to the effect of temperature on mechanical properties.

comment *38* comment by: *Leonardo Helicopters*

LHD manages elastomeric part as ON-CONDITION parts.
Elastomeric parts have also a Shelf Life (when correctly stored).

The proposal is to do not apply as mandatory requirement a calendar life, leaving the possibility to comply to this requirement with alternative approaches through, for example, dedicated visual inspections acted to identify ageing.

response

See comment 37 under chapter 3.2.6.3

comment *80* comment by: *Bell*

The qualification of the elastomeric components and subcomponents would be commensurate with the identified hazards.

Clarify that the extent of the qualification is to be commensurate with the hazards identified in the design assessment.

response

Accepted.
The text is adjusted to clarify that a threat assessment should identify the relevant contaminants and that those should be assessed.

comment *81* comment by: *Bell*

Environmental effects on elastomeric materials need to be assessed based on the failure modes associated with the material.

	Service history of elastomeric components has shown that inspections and on-condition replacement of degraded components provides an acceptable level of safety.
response	Noted. The level of safety is ensured through the inspection interval and on-condition replacement which should take into account the relevant environmental conditions.

3.2.7. Dynamic Behaviour Characterisation p. 12

comment	*23* comment by: *Transport Canada - Projects* Due to nonlinear character of the elastomer material, Testing can yield the dynamic properties of the elastomer component, which can then serve as the basis for analysis.
response	Noted. MOC is not deliberately described in this section for dynamic behaviour characterisation. Applicants should propose and agree MOC during the certification process.

comment	*79* comment by: *Bell* The malfunction of an elastomeric component may cause increased vibration (which would also lead to detectability) but not result in a HAZ or CAT condition. Clarify the sentence to read "The malfunction or degradation of an elastomeric component should not create any ground resonance or excessive vibration that could lead to a CAT or HAZ condition." and add 29.547(b) and 29.917(b) to the list of requirements.
response	Partially accepted. The wording has been changed to be in line with the wording of the requirements and AC material added.

3.2.8.1. Process Qualification p. 12

comment	*41* comment by: *Parker Lord Corporation* Elastomeric formulations and processes are highly proprietary to all suppliers. The detail level for approval should be at the generic process control level.
response	Accepted. The text is adjusted to include considerations for intellectual property.

4. Remarks p. 13

comment	*24* comment by: *Jonas VOM WEG* Test
response	Test comment due to commentators mentioning issues with the commenting tool during the commenting phase.