



Notification of a Proposal to issue a Certification Memorandum

Certification, Type Design Definition, Material and Process Qualification for Composite Light Aircraft

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Regulatory requirement(s): Part 21.A.4, Part 21.A.20(b), Part 21.A.31, Part 21.A.33,
CS LSA.15,
CS VLA.572, CS 22/VLA.603, CS 22/VLA.605, CS 22/VLA.613,
CS 22/VLA.615, CS 22/VLA.619, CS 22/VLA.627

In accordance with the EASA Certification Memorandum procedural guideline, the European Aviation Safety Agency proposes to issue an EASA Certification Memorandum (CM) on the subject identified below. All interested persons may send their comments, referencing the EASA Proposed CM Number above, to the e-mail address specified in the “Remarks” section, prior to the indicated closing date for consultation.

EASA Certification Memoranda clarify the European Aviation Safety Agency’s general course of action on specific certification items. They are intended to provide guidance on a particular subject and, as non-binding material, may provide complementary information and guidance for compliance demonstration with current standards. Certification Memoranda are provided for information purposes only and must not be misconstrued as formally adopted Acceptable Means of Compliance (AMC) or as Guidance Material (GM). Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements and do not constitute any legal obligation.

EASA Certification Memoranda are living documents into which either additional criteria or additional issues can be incorporated as soon as a need is identified by EASA.



Log of issues

Issue	Issue date	Change description
01	20.01.2015	First issue.

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1. Introduction

1.1. Purpose and scope

This Certification Memorandum provides an interim EASA position regarding acceptance of compliance demonstration using composite materials and provides guidance on the relevant requirements for the following aircraft:

- Light Sport Aeroplanes CS-LSA,
- Very Light Aeroplanes CS-VLA,
- ELA1 aeroplanes where the certification basis references CS-VLA requirements for materials and fatigue,
- Sailplanes and Powered Sailplanes CS-22.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
Part 21.A.4	Coordination between design and production	Part 21	---	---
Part 21.A.20(b)	Certification Programme	Part 21	---	---
Part 21.A.31	Type Design Definition	Part 21	---	---
Part 21.A.33	Inspection and tests	Part 21	---	---
CS LSA.15 (F2245-10c 5.1.2 – 5.1.4)	Factor of safety Strength and deformation Proof of structure	CS-LSA	---	---
CS LSA.15 (F2245-10c 6.1, 6.2 & 6.3)	Materials, Fabrication Methods	CS-LSA	---	---
CS LSA.15 (F2245-10c 6.8)	Proof of Design	CS-LSA	---	---
CS VLA.572	Parts of structure critical to safety	CS-VLA	---	---
CS 22/VLA.603	Materials	CS-22/CS-VLA	---	---
CS 22/VLA.605	Fabrication Methods	CS-22/CS-VLA	---	---
CS 22/VLA.613	Material Strength Properties and Design Values	CS-22/CS-VLA	---	---



Reference	Title	Code	Issue	Date
CS 22/VLA.615	Design properties	CS-22/CS-VLA	---	---
CS 22/VLA.619	Special Factors	CS-22/CS-VLA	---	---
CS 22/VLA.627	Fatigue strength	CS-22/CS-VLA	---	---

1.3. Abbreviations

AGATE	Advanced General Aviation Transport Experiment
AFF	Arbeitskreis Faserverbund Flugzeuge
AMC	Acceptable Means of Compliance
ANF	Arbeitskreis Neue Fasern
CS	Certification Specification
CM	Certification Memorandum
CMH	Composite Material Handbook
DO	Design Organisation
HFF	Handbuch Faserverbund Flugzeuge
FAA	Federal Aviation Administration
LBA	Luftfahrt Bundesamt (CAA Germany)
LSA	Light Sport Aeroplane
MOC	Means of Compliance
NCAMP	National Centre for Advanced Materials Performance
NDT	Non Destructive Testing
PO	Production Organisation
tg	Glass Transition Temperature
VLA	Very Light Aeroplane



2. Background

The Agency has experienced in some certification projects of light composite aeroplanes that especially the standard referenced in CS-LSA about materials and fabrication methods is not very detailed and only limited guidance material is available.

Due to the inherent nature of composite structures that entails a strong relation between manufacturing process, material properties and mechanical performance, it is paramount to guarantee a proper identification of the design properties and conformity of manufactured parts with the defined design.

One approach to develop material properties in certified aviation is the building block approach (EASA AMC 20-29, CMH-17) which is not mandatory for small aircraft (CS-22, CS-LSA and CS-VLA). As similar information is not available for small aircraft, the intention of this Certification Memorandum is to provide guidance for the certification of small aircraft.

The development of detailed harmonised guidance and practices regarding the definition and use of composite materials remains relatively immature compared to the well-established metallic protocols.

On the other hand, composite materials in small aeroplanes and sailplanes, are used since 1950's and well established simple processes have been developed in several areas. Current examples are:

- Design allowables and qualification procedures (RHV [8]) have been developed by the LBA and sailplane manufactures together with research facilities and in the past approved by the authority for specific defined applications. Industry working groups (e.g., AFF - Working Group Composite Aircraft) have established guidance and procedures to certify materials and composite design solutions and have provided it to members (e.g., –HFF - Handbuch Faserverbund Flugzeuge)
- Shared databases (e.g. NCAMP) and procedures to establish material data on project level have been established mainly for prepreg materials in the framework of EASA AMC 20-29.

3. EASA Certification Policy

3.1. EASA Policy on Airworthiness Certification of Composite Aircraft Structures

3.1.1. Part 21.A.31 Type design

Essential for a successful certification project is the exact definition of the type design at an early phase of the project. The type design should include drawings and specifications but also information on materials and processes and on methods of manufacture and assembly of the product as detailed as necessary according paragraph 3.1.3.

The material has to be specified and identified on level of supplied material (e.g. resin, fabric, prepreg) as well on raw material level (e.g. fibres, seizing) by form, type, grade, class, standards, properties and applicable key process parameters, as far as necessary. Some materials are available in different qualities using the same marketing name (e.g., rovings in aviation and industry quality or fabrics using different fibre specifications).

3.1.2. Part 21.A.20(b) Certification programme and project familiarisation

The objective of the EASA Certification familiarization is to provide the Agency with sufficient information to agree with the certification basis and the certification programme and to establish the Agency's level of involvement.

The composite specific issues addressed in this Certification Memorandum with regard to material and process qualification should be presented. The basic structural design principles and the approach that will be followed for the certification of composite structural parts should be presented to EASA:



- Basic design principles for primary structure,
- Load introduction into composites (e.g., connections, secondary bonding),
- Critical structural elements,
- Company experience with chosen technologies in design and production,
- Procedures to ensure conformity of test specimen and test set-up,
- Specifications of the composite materials,
- Production of test articles and prototypes,
- Approach to composite as defined in this Certification Memorandum.

3.1.3. Part 21.A.4 Coordination between design and production

Stabilized and controlled processes for production of composite parts are essential to ensure conformity with applicable data and repeatability of composite material properties and behaviour. Therefore each design approval holder should collaborate with the production organisation to ensure satisfactory coordination between design and production.

In the absence of an already existing approved production organisation it is essential to establish the relevant procedures and initiate the production approval with the competent authority for production oversight at the beginning of the project. Only after ensuring that stabilized and controlled manufacturing processes are in place, the production of test specimen and prototypes can begin.

The Design Organisation applying for certification of a product should provide to the Production Organisation drawings and specifications as well as information on materials and processes as included in the type design definition. It is the full responsibility of the Production Organisation to ensure conformity with the type design but the DOA needs to identify the critical processes where quality of production has an effect on the airworthiness of the final product, considering items such as:

- (a) Work instructions (step-by-step process instructions),
- (b) Personnel competence,
- (c) Materials specification (consumable and structural, storage conditions, life limits),
- (d) Equipment specification (ovens, autoclaves, thermocouples,...including required accuracy),
- (e) Facility minimum requirements (humidity and temperature limits, positive pressure, clean room, ...),
- (f) Tooling (base plates, marks for ply orientation,...),
- (g) Process specification (lay-up, cure cycle, product identification).
- (h) Criteria for incoming material and supplier production acceptance,
- (i) Criteria for supplier qualification,
- (j) Criteria for process monitoring (personnel, what is inspected, test methods, including check thickness, ply lay-up, cure cycle, functional characteristics, NDT....),
- (k) Maintenance and calibration of tooling, facility and test equipment,
- (l) Identification, configuration control, maintenance and inspection of molds.

It is the final responsibility of the POA to implement procedures to ensure conformity with the defined type design.



3.1.4. Part 21.A.33 Inspection and tests

For any kind of testing during the certification process including testing to develop material properties, the DO should assure that materials and processes adequately conform to the specifications, and finally the test article adequately conforms to the proposed type design. Any intended or unintended deviation should be assessed by the DO and the result documented in the conformity statement.

Therefore the proper definition of the type design (as per 3.1.1) and established procedures under control of the DO to ensure conformity of test specimen and prototypes are essential. Production and release under POA procedures is the preferred solution.

3.2. EASA Policy on Certification Requirements Affecting Composite Materials

3.2.1. Material properties and design allowables

Material properties of a composite structure are the result of the component manufacturing process. Therefore, material and process specifications used to produce composite structure should contain sufficient information to ensure that critical parameters in the manufacturing process are identified and controlled during production are recorded for final inspection and verification.

3.2.1.1. Material qualification according EASA AMC 20-29 “Composite Aircraft Structure”

EASA AMC 20-29 describes the building block approach to develop a set of material properties and design allowables for composite materials and is applicable to CS-23, CS-25, CS-27 and CS-29 aircraft. The guidance of EASA AMC 20-29 might be helpful to develop a qualification programme for materials.

3.2.1.2. Use of existing material data and shared databases

EASA AMC 20-29 ‘Composite Aircraft Structure’ para 6.a.(7) ‘Material and Process Control’ states:

‘...the Agency does not certify materials and processes. However, materials and processes specifications are part of the type-design subject to type-certification. Appropriate certification credit may be given to products and organisations using the same materials and processes in similar applications subject to substantiation and applicability. In some cases, material and processing information may become part of accepted shared databases used throughout the industry. New users of shared qualification databases must control the associated materials and processes through proper use of the related specifications and demonstrate their understanding by performing equivalency sampling tests for key properties.’

1) NCAMP shared database

EASA Certification Memorandum CM-S-004 on ‘Composite Materials – Shared Databases - Acceptance of Composite Specifications and Design Values Developed using the NCAMP Process’ provides clarification regarding the acceptability of material specifications, material strength properties and material design values (allowables) developed by the National Centre for Advanced Materials Performance (NCAMP) for composite materials. NCAMP has published a document with standard operating procedures detailing the organisation, methods and processes that NCAMP uses with regard to material suppliers, manufacturers, and regulatory bodies to develop composite material specifications and limited associated material allowables. These procedures are based on experience gained from the Advanced General Aviation Transport Experiment (AGATE) and NCAMP.

2) HFF – Manual Composite Aircraft

The well-established German small airplane industry within the working group composite materials (AFF - Arbeitskreis Faserverbund Flugzeugbau) published its manual for composite aircraft called HFF (Handbuch Faserverbund Flugzeuge The HFF contains established guidance and procedures to certify materials and composite design solutions and was made available to members of the AFF.



3) LBA/ANF

Data established by the German ANF (Arbeitskreis Neue Fasern) a working group composed of glider manufactures, material suppliers, research institutions and authorities, is shared between participating companies. Some data has been approved by the German national aviation authority. This was done according a material qualification process defined by industries working group and supported by a high number of component fatigue tests.

4) reserved

Industry is invited to provide available information to amend this list.

In any cases it is essential to demonstrate that the chosen approach is fully understood and applicable on project level. All conditions (design principles, material qualifications, manufacturing processes,...) have to be regarded, keeping in mind that small deviations, e.g. fibre coating, might have significant effect on the static or fatigue behaviour!

3.2.2. Fatigue

Certification specifications require that the structure should be designed “as far as practicable” to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.

EASA AMC VLA 572 accepts that structural items have adequate safe lives, when in conjunction with good design practices to eliminate stress concentrations, certain stress levels are not exceeded. The applicant should show that the most critical points have been investigated. At least the wing main spar, the horizontal tail and their attachments have to be investigated for stress concentrations. The approach of EASA AMC VLA 572 (b)(1) is not acceptable for aircraft in the aerobatic category.

In the absence of a detailed structural analysis the measurement of stress levels during structural tests can be accepted. Points for measurement with expected critical stress levels should be identified before and the rationale behind should be clearly described.

In the field of CS-22 a common approach is to refer to representative fatigue tests. Information is e.g. provided in LBA document “ I 4 - FVK/91 Standards for Structural Substantiation of Sailplane and Powered Sailplane Components Consisting of Glass or Carbon Fibre Reinforced Plastics” - issued July 1991.

Wherever reference is made to similarity, established design practise, representative tests or established material properties it should be assured that all conditions are met, e.g. defined material qualifications or process specifications. The “referenced” structure or test should be assessed with regard to

- Operating stress levels (including all operational or life limits),
- Load spectrum,
- Construction, detailed design including effects of stress concentration,
- Materials, including variability, environmental effects and fabrication methods.

Suitable sources for the development of spectra for fatigue testing are

- KoSMOS load spectra
Kossira H. and Reinke W., “Determination of load spectra for the design of sailplanes”, OSTIV publication XVI
Kossira H., “Determination of load spectra and their application for keeping the operational life proof of sporting airplanes“, ICAS-Proc. 8/1982; ICAS-82-2.8.2; page 1330-1338
- Thielemann and Franzmeyer load spectra
Thielemann W., Franzmeyer F.K., „Statische und dynamische Festigkeits-untersuchungen an einem Tragflügel des Segelflugzeuges „Cirrus“, Institut für Flugzeugbau und Leichtbau, TU Braunschweig, 1969, IFL-Bericht-Nr.: 69-02



Constant amplitude testing is only accepted for relative testing to demonstrate that a new or replacement material is as suitable and durable as the old one and need to conservatively address damage accumulation. Even if some actual research shows that the approach used in early days of composite fatigue certification (e.g. 10000 limit load cycles) is conservative, this would need to be demonstrated for each individual application, ensuring that the load spectrum is conservative with regard to operation and damage accumulation and that it is reflecting conservatively damage behaviour on material level and bonding.

3.2.3. Structural testing

No test should be performed before the relevant test plan is accepted or EASA decided to not be involved and conformity of test specimen and test setup is ensured by accepted procedures. When test witnessing is requested by EASA the schedule should be provided to EASA well in advance.

3.2.3.1. Most critical loading conditions

The ultimate load test should show that the structure is able to withstand maximum loads in operation with an adequate safety factor. The critical loads should be applied in all critical sections for at least 3 seconds without structural failure.

The most critical loading conditions as well as the critical sections should be identified and assessed. The applied loads should be representative for the critical combination of loads in the tested component. When it is possible to demonstrate that one test setup is conservatively covering the operational envelope (e.g., positive and negative manoeuvre loads) a single test might be acceptable.

3.2.3.2. Limit load test

The absence of permanent detrimental deformations and the absence of interference of the deformation with safe operation should be demonstrated with maximum expected loads in operation (limit load) without need to apply additional safety factors.

3.2.3.3. Special factors for ultimate load testing

It is possible to certify small aircraft mainly based on static structural testing without detailed analyses of the complete structure and prediction of failure modes. EASA AMC 23.307 states 'Static testing to ultimate load may be considered an adequate substitute for formal stress analysis where static loads are critical in the design of the component'. Nevertheless it is of high importance to design the structure in a conservative way taking into account

- Most critical loading conditions,
- critical locations,
- environmental factors (e.g., temperature, humidity),
- material variability (raw material, process tolerances),
- bonding design, material and process,
- stress concentrations.

The development of the static test conditions should account for the above points.

For composite structures, a special test factor which takes into account material variability and the effects of temperature and absorption of moisture should be used. Uncertainties of material properties and variability including environmental influence should be compensated by higher test factors. In the absence of exact statistical determination of variations of material properties a super safety factor should be applied.



When statistical data is available and effects of temperature, moisture and production/material variability are known, the determined factor should be applied at the ultimate load test.

The following basic approaches (pedigrees) to consider material and production variability have been shown to be reliable in the past as listed in table 1:

Shared Database, 'A'-'B'-Values

When statistical data is available and effects of temperature, moisture and production/material variability are known, adequate factors should be established.

It should be assured that the factors are applicable to the actual material and production process and that all conditions are met, e.g., defined material qualifications or process specifications. An additional factor due to specific implementation of the production process by the company might be necessary.

LBA Approach

Material data has been approved in the past by the German national aviation authority. This was done by a material qualification process (known as RHV) defined by industries working group "ANF" and supported by a high number of component fatigue tests.

The material data that have been used by a high number of certification projects were partly incorporated into several other standards (CS-VLA fatigue limits, wind turbine bonding allowables).

Within this well-defined system of material qualification, design principles and manufacturing technologies, a standard for structural substantiation has been established. For the ultimate load testing under 54°C an additional safety factor of 1,15 was found sufficient to take environmental (temperature and humidity), material and production variability and stress concentrations into account when all conditions of the specific material and process have been met.

No statistical Data

An additional factor of 1,5 for specimen tested without specific allowance for moisture and temperature might be acceptable, or

an additional factor of 1,2 for moisture conditioned specimen tested at maximum service temperature, provided that a well-established manufacturing and quality control procedure is used. For structures cured at room temperature without any heat treatment it may be assumed that the completed structure is fully moisture conditioned.

A test factor following EASA AMC VLA 619, based on the coefficient of variation the manufacturer is able to show for the component, can be used.

Even when the compliance demonstration is purely based on structural testing the materials have to be properly specified and it has to be assured that the test specimen is representative for the type design.

Table 1: Minimum test factors for ultimate load testing:

Pedigree				Safety Factor	
	Stat. Basis	Env.	Prod.	Test cold	Test hot
1	A/B hot&wet Shared Database	EKDF	KDF	1,5 x EKDF x KDF	1,5 x KDF
2	"LBA"	No (1,25)	No (1,15)	1,5 x 1,25 x 1,15 (2,156)	1,5 x 1,15 (1,725)
3	no statistical data	No	No	1,5 x 1,5 (2,25)	1,5 x 1,2* (1,8) *Moistured specimen



3.2.3.4. Test repetition after failure

It is not acceptable to repeat a test without design change based on the test result unless it is possible to show that the failure is not related to the proposed type design (e.g. failure of test rig).

3.2.4. Bonded joints

Special attention should be given to bonded joints. The design should follow standard practise (e.g. LN 29 936, VDI 2014) to minimize peel loading on the bonding.

There is no explicit requirement to assure limit load capacity after failure of critical bonding or to include disbonding in any structural testing. Therefore it is even more important to choose conservative bonding allowables and design the bonding according established practices and ensure adequate process definition and control. Any variation of process or design parameters can significantly affect the bonding capability. For sailplanes and VLA bonding allowables have been established (9) based on extensive testing in combination with detailed limitations for design principles and material and process definition and show a good safety record.

As part of the type design and manufacturing process the following aspects should be addressed:

- Adhesives (mixing, application),
- Bondline thickness,
- Definition of processes, surface preparation, cure cycle and tolerances,
- Degradation in service.

Attention should also be given to consumables (e.g. peel ply, acetone, compressed air) as these are a common source for contamination (e.g. silicon, oil) during preparation of bonding surfaces.

Probable manufacturing defects (e.g. voids, adhesive problems) should be addressed by adequate process control and inspection methods and probably testing of production articles.

A simplified approach might be appropriate, based on availability and appropriateness of

- Alternative load path,
- Ultimate load testing with defects or additional safety factor,
- Conservative bonding allowables.

Mechanical fasteners might be seen as alternative load path or method to limit the failure size in case of adhesive failures. As mechanical fasteners could create additional problems and decrease the bonding strength they should only be used when the load path is fully understood and the bonded structure is capable of introducing adequate loads into the fasteners. Alternative design solutions like stringers to limit the “free” bond length should be considered.

Special attention should be given to metallic bonded joints and bonded joints of materials that due to the poor chemical reaction might be more sensitive to deficits in surface preparation and process variations as well as to environmental effects in operation.

3.2.5. Environmental effects

The continuing performance of composite structures is affected by environmental conditions, such as:

- Temperature,
- Humidity,
- Chemicals, fuel, etc.



Unless already covered by established factors and experience, the effect on material properties and degradation in operation should be considered.

To cover temperature effects, for white painted surface a test temperature of 54°C is accepted. For other bright colours or colours schemes a test temperature of 54°C is only acceptable when it can be demonstrated that the temperature of the main structure in operation is below 54°C or when the test temperature is determined according to EASA AMC VLA 613(c) or by representative test. If the test cannot be performed at this temperature an additional factor of 1,25 must be used unless a lower temperature factor (established on specimen level) is available and agreed upon with the Agency.

When the test is performed at room temperature the principle suitability of materials at least up to an operating temperature of 54°C without appreciable degradation of properties has to be shown; In practice a t_g value of the composite material of at least 27,8°C above the maximum operating temperature is considered acceptable.

3.2.6. Damages and production concessions

The concept of damage tolerance introduces redundant structures and increases the reliability after structural failures and is easy to apply in some cases without appreciable effect on aircraft complexity, weight and cost. Nevertheless, for aircraft which are part of the scope of this Certification Memorandum, damage tolerance has not to be demonstrated, as there is no equivalent requirement to CS 23.573 applicable to these aircraft.

When implemented properly, this Certification Memorandum should ensure materials and processes that are resistant against undetected damages and build-in defects during production.

3.2.7. Material and process changes

Any change of material specifications or processes during certification processes should be assessed as it could invalidate previous tests or compliance demonstration.

Subsequent to the certification any change of material specifications or processes needs to be assessed and might require a design change, this could include a change of POA or its suppliers.

In some fields test procedures (e.g. RHV) are established to ensure that a changed material (e.g. changed fibre coating) has no negative effect and the new composite meets the defined standard.

3.3. List of Documents regarding Composite Materials

Many other useful references exist on the subject of qualification and manufacturing of composite parts. The following is not an exhaustive list, but these documents are considered as acceptable to EASA:

- (1) FAA AC 21-26A "Quality System for the Manufacture of Composite Structure"
- (2) FAA AC 23-20 "Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems"
- (3) FAA AC 145-16 "Repair Stations for Composite and Bonded Aircraft Structure"
- (4) DOT/FAA/AR-02/109 "Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs"
- (5) DOT/FAA/AR-02/110 "Guidelines for the Development of Process Specifications, Instructions, and Controls for the Fabrication of Fiber-reinforced Polymer Composites"
- (6) PS-ACE100-2005-10038 "Bonded Joints and Structures - Technical Issues and Certification Considerations"
- (7) "I4-FVK/91 Standards for Structural Substantiation of Sailplane and Powered Sailplane Components Consisting of Glass or Carbon Fiber Reinforced Plastics" - LBA July 1991



- (8) "Richtlinien zur Führung des Nachweises für die Anerkennung von Harz-Faser-Verbundsystemen im Anwendungsbereich der Herstellung und Instandhaltung von Segelflugzeugen und Motorseglern (RHV)" Luftfahrt-Bundesamt Ausgabe Januar 1999
- (9) „Dimensionierungsrichtwerte für den Segel- und Motorsegelflugzeugbau“, idaflieg, March 1988
- (10) VDI 2014 "Design and construction of FRP Components"
- (11) "Handbuch Faserverbund Flugzeuge" – Arbeitskreis Faserverbund-Flugzeuge (AFF)
- (12) "Luftfahrttechnisches Handbuch (LTH)" - Arbeitskreis Faserverbund-Leichtbau

3.4. Who this Certification Memorandum Affects

This Certification Memorandum affects applicants who need to demonstrate compliance with structure and material requirements for composite structures of light aircraft.

4. Remarks

1. This EASA Proposed Certification Memorandum will be closed for public consultation on the **3rd of March 2015**. Comments received after the indicated closing date for consultation might not be taken into account.
2. Comments regarding this EASA Proposed Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu or fax +49 (0)221 89990 4459.
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