Light Aircraft Association

GUIDE TO CS-VLA

The full content of CS–VLA, the design requirements for certified very light aircraft, can be downloaded from the EASA website at http://www.easa.eu.int/home/certspecs_en.html

This Technical Leaflet has been written to help LAA members find out which paragraphs of CS-VLA relate directly to particular topics and aircraft components, to save a lot of leafing through the document, and we hope it will help members submitting modifications requests to come up with a more complete initial submission and so avoid at least one round of correspondence.

The information is provided in good faith but readers must bear in mind that it cannot be assumed that only the paragraphs listed need be considered when designing a modification. For example, fitting almost anything external to the aircraft could potentially affect the flight handling, and making almost any alteration to the flying controls involving changes in mass, stiffness, backlash or friction could affect the aeroplane's flutter characteristics. This guide cannot substitute for a sound understanding of aircraft design.

FLIGHT REQUIREMENTS

Topic	Paragraph	see note
General	21 (and AMC21), 23, 29	
Bouncing	231	
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Climb	65	
Control in landings	153, 231	
Controllability	143, 145	
Dynamic stability	181	
Directional stability	177	
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Engine RPM	33	
Flaps	697 (b)	
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Nose over when taxying	231	
Performance	45 (and AMC)	
Roll rate	157	
Spinning	221	
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Stalls	49, 201 (and AMC), 203, 207	
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DESIGN REQUIREMENTS

		Note
Ailerons	(A9, A11), 157, 455, 629, 651, 657, 659	3, 4
Airspeeds	1505, 1559	
ASI	1505, 1545	
Baggage compartment	787, 1557	
Battery	561, 1353, (A7, A9)	3,4
Brakes	231, 735, 863, 1436	3
Cables, control	689	
Cables, electrical	1365	3
Canopy	807, 773, 775, 783	
Carbon monoxide	831	
Carburettor	975, 1091, 1093, 1101, 1103, 1105	
Carpet, fireproof	853	
CHT	1519	
Circuit breakers	1357	
Cockpit	771, 773, 775, 783, 807, 831, 853,	
Compass	1547	
Controls (primary)	(A13) (397, 399) 457, 623, 629, 655, 671, 673, 675, 679, 681, 683, 685, 687, 689, 693, 697, 699, 701, 777, 771, 779, 865	3,4
Controls (secondary)	405 (and AMC), 677, 681, 683, 685, 687, 689, 693, 771, 777 (and AMC), 779, 781, 865, 1555	3
Control cables	681, 683, 685, 689	3
Cowl	901, 1193	
Doors	783, 807	
DV window	AMC 773	
Elevators	155, 629, 651, 655, 657, 659, (A11)	3,4
Electronic equipment	1301, 1309, 1431	
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Engine cooling	1041, 1047, 1061, 1063 (965),	Note
Engine cowl	901, 1193	
Engine induction system	1091, 1093, 1101, 1103, 1105 (and AMC)	
Engine installation	33, 865, 901, 903, 943, 993, 1041, 1047, 1061, 1063, 1182, 1183, 1191, 1305, 1321, 1337, 1551.	2,3
Engine instruments	1337	
Engine limitations	1519	
Engine mount	(A9) (361, 363) 561, 865	3,4
Exhaust	831, 1121, 1123, 1125	
Flaps	(A11) 345, 457, 629, 651, 657, 659, 697, 701	3,4
Flap position indicator	699	3
Flight manual	1581-1589	
Fin	(A11) 441(and AMC), 443 (and AMC), 445, 447, 629, 651 (b)	3,4
Fireproofing	853, 863, 865, 967, 1013, 1091, 1191, 1182, 1183, 1193, Appendix F	
Firewall	1182, 1191	
Fuel	863, 1521	
Fuel flowmeter	955	
Fuel selector valve	777, 779, 853, 951, 1555	
Fuel system	777, 779, 853, 943, 951, 955, 957, 959, 961,	

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Notes

1. Single and two-seat LAA aircraft not required to have type-certified propellers
2. Single and two-seat LAA aircraft with a stall speed less than 60 mph are not required to have type approved engines. Nor is a restart envelope normally defined.

3. Each of the additional requirements below also apply:

    - 303 Factor of safety
    - 305 Strength and deformation
    - 307 Proof of structure (and AMC)
    - 572 Parts of structure critical to safety (and AMC)
    - 601 General
    - 603 Materials and workmanship
    - 605 Fabrication methods
    - 607 Self locking nuts
    - 609 Protection of structure
    - 611 Accessibility
    - 613 Material strength properties and design values (and AMC)
    - 615 Design properties (and AMC)
    - 619 Special factors (and AMC)
    - 621 Casting factors
    - 623 Bearing factors
    - 625 Fitting factors
    - 627 Fatigue strength

4. If the aircraft is of conventional layout as defined in AMC 301(d), and Appendix A A11c, the flight envelope can be defined and the loads on the flying surfaces and control surfaces may be calculated using the simplified methods of CS-VLA Appendix A instead of the methods of CS-VLA 321 to 459, although note that the loads so calculated will usually be pessimistic. Note that the average surface loads shown in figures A4 and A5 assume that the manoeuvring speed, design cruise speed and flap limiting speed are the minimum permitted values. If the selected speeds are higher than the minimum values calculated per A7 then the surface loadings must be increased accordingly per the note at the base of table 2 of Appendix A. Note also that the average surface loads must be distributed chordwise per the diagrams of table 2 of Appendix A, and do not confuse the local load intensity W in table 2 with the average surface loading wbar.

5. See also CS-VLA Appendix 5 and AMC 479.

Note the separate requirements to demonstrate adequacy of

- energy absorption
- reserve energy absorption
- limit strength – basic conditions
- ultimate strength – basic conditions
- specific supplementary strength requirements – limit and ultimate

If drop tests are used to demonstrate compliance with undercarriage strength or energy absorption requirements, greased plates should be used to reduce the friction between the tires and the ground on impact if this is likely to result the critical condition for the test being undertaken.

6. Letter/number references in brackets relate to the Appendices, for example (A7) relates to paragraph 7 of Appendix A.

7. References to AMC relate to the corresponding paragraphs of 'Acceptable means of compliance' material found in section 2 at the back of CS-VLA.

8. Wing Torsion Due to Aileron Deflection

The requirements of CS-VLA 349 Rolling Conditions b) requires three aileron deflection and airspeed cases to be considered, simultaneously with two thirds of the positive manoeuvring wing loading. These cases are taken from CS-VLA 455 Ailerons and are as follows;

(i) Sudden maximum displacement of the aileron control at VA. Suitable allowance may be made for control system deflections.

(ii) Sufficient deflection at VC, Where VC is more than VA, to produce a rate of roll not less than obtained in subparagraph (a)(2)(i) of this paragraph.

(iii) Sufficient deflection at VD to produce a rate of roll not less than one third of that obtained in subparagraph (a)(2)(i) of this paragraph.

An acceptable methodology for calculating the aileron deflections required to achieve these roll rates is given in "Design of Light Aircraft" by Richard D. Hiscocks.

A third simplified requirement that LAA Engineering has accepted in the past that of ASTM F 2245 – 04. This is the design code associated with the FAA's Light Sport Aircraft category in the United States.

The airspeeds and deflections are defined in 5.7.1 of F 2245 – 04

5.7.1.1At speed V_A, the full deflection of the roll control.
5.7.1.2*At speed V_D, one-third of the full deflection of the roll control*.

(Note:- V_C is not considered.)

These cases are applied simultaneously with the wing loadings defined in X2.3.2 and X2.3.3

'Assume 75% of Point A or D on each wing'

We take this to mean the wing loads that would occur at load factors of 75% of those at point A and point D of the flight envelope, respectively.

9. Inconsistencies between CS-VLA and CFR Part 23

In the course of our work in assessing kit and homebuilt aircraft against the requirements of CS-VLA for the issue of Permits-to-Fly the Popular Flying Association has uncovered a couple of inconsistencies, between CS-VLA and CFR Part 23, in areas where we believe that equivalence was intended during the drafting of CS-VLA. The inconsistencies appear to be explainable as simple errors in conversion from the imperial units of CFR part 23, to the metric units of CS-VLA, and as such we believe them to be unintentional. In January of 2007 we are currently bringing these matters to the attention of EASA.

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The reference copy of CS-VLA, for the purposes of this following discussion, is Decision 2003/18/RM, Final 14/11/2003.
The issue status of the corresponding sections of CFR part 23, is identified as they are addressed.

1. Appendix A.

Figures A4 & A5.

Equations 1-5 in these Figures are labelled as kg/m^2 but whilst the input wing loading needs to be in kg/m^2, the output pressure is still in lb/ft^2, NOT kg/m^2. Whilst this will be evident to anyone who checks the output of the equations against the graphs, but there remains considerable potential for confusion.

2. Sub-part C – Structure

Vertical Tail Surfaces

CS-VLA 443. Gust Loads.

The equation for the lateral mass ratio is given as follows;

$$\mu_{gt} = \frac{2M}{\rho \bar{C}_t g a_{vt} S_{vt}} \left(\frac{K}{l_t} \right)^2 = \text{lateral mass ratio;}$$

The inputs are required in S.I. metric, with M being defined as the aircraft mass in kg. It should be noted that the mass is divided by g (acceleration due to gravity) giving this portion of the equation the dimensions Mass $Length^{-1}$ $Time^2$.

This is now compared with Part 23.443

$$\mu_{gt} = \frac{2W}{\rho c_t g a_{vt} S_{vt}} \frac{K^2}{l_{vt}} = lateral\, mass\, ratio;$$

The inputs here are in imperial units.

(note that the squared term is assumed to apply to both the numerator K and denominator l_{vt})

The principal difference here is that W is defined as the aircraft weight in lb (not mass as previously), and is still divided by g, giving Dimensions for W/g of Mass.

It appears to us that, assuming CFR Part 23 is correct, that the denominator g should be removed from the lateral mass ratio equation in CS-VLA 443.

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10. Aerobatics

Another oddity in CS-VLA is that tables 1 and 2 of Appendix A refer to aerobatic category requirements, even though VLA doesn't cover aerobatic aircraft and table 1 and 2 only give a partial picture of what would be required for aerobatic approval of the structure.

In order to clear a LAA aircraft designed to CS-VLA Appendix A for aerobatics, additional structural structural requirements that would need to be complied with are as follows:

- Aerobatic category flight envelope requirements as stated in tables 1 and 2 of Appendix A.
- The more severe asymmetric wing lift case applicable to aerobatic aircraft stated at A23.9 para c(2) of FAR 23
- The more severe asymmetric tail load case applicable to aerobatic aircraft, which is included in A23.11 para c(2)
- The more severe emergency landing cases for aerobatic aircraft included in FAR 23 .561
- The increased engine mount side load case for aerobatic aircraft of A23.9 d(3).

FAR 23 can be downloaded from:

http://www.flightsimaviation.com/data/FARS/part_23.html

11. CS-VLA Landing Loads Guidance

The applicant is required to demonstrate the landing gears capability to accommodate a full set of loads to CS-VLA. The relevant paragraphs are 479 to 499.

The load factor used to calculate these loads, must be validated, using 723, although under certain circumstances this may be done by analysis, rather than by the limit drop test of 725. (See 723 a. 3.). These circumstances are as follows;

(1) Increases in previously approved take-off and landing weights,

(2) Landing gears previously approved wheel type aeroplanes with similar weights and performances.

(3) Landing gears using a steel or composite material spring or any other energy absorption element where the shock absorption characteristics are not essentially affected by the rate of compression or tension,

(4) Landing gears for which adequate experience and substantiating data are available.

With LAA aircraft, number 3 is frequently applicable.

The energy absorption capacity of the gear must also be demonstrated, either by the drop test of 727, or once again (if meeting the above criteria) by analysis.

When calculating the energy absorption characteristics of sprung landing gear, it must be remembered to take into account any non-linearity of the gear spring rate, caused by changes in geometry with deflection.

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A good reference book for these analysis methods, which LAA Engineering recommend to our builders is;

Design of Light Aircraft
Richard D Hiscocks
ISBN 0-9699809-0-6 (Available from the LAA Bookshop)

If stress calculations or static stress tests are not submitted for the landing gear and mountings, for 479 to 483, compliance with the ultimate loads may still be shown using a single ultimate drop test under the terms of 726. It must be demonstrated that the landing condition being tested is the worst of the three. If this approach is taken, LAA Engineering will also require three limit drop tests to be carried out (using the drop height from 725 [a]) to establish that no permanent deformation occurred up to limit loads for each of the basic cases.

The limit drop height defined in CS-VLA 725 should be measured as the gap between the ground and the wheels in the drooped condition after lifting.

The reserve energy drop height in CS-VLA 727 should be at least 1.44 times that required by CS-VLA 725 and is measured in the same way.

The ultimate load drop height of CS-VLA 726, must be defined and measured in a different way for the objective of developing 1.5 times the limit load factor to be achieved;

i) Measure the static landing gear deflection at 1g for the test mass.
ii) Add this deflection to the limit drop height calculated in CS-VLA 725
iii) Multiply this total by 2.25 to obtain an ultimate drop height.
iv) The ultimate drop height is achieved by raising the airframe this amount, relative to its 1g static position. (i.e. not the wheel gap as for 725 and 727)

Please note that stress calculations or static tests will still be required to demonstrate compliance with 485 to 499 even if the drop test of 726 is performed.

It is in your interests NOT TO PERFORM any tests until LAA Engineering have agreed the proposed CS-VLA ground loads.

Composite Landing Gear Drop Tests

The ultimate strength of the landing gear may be demonstrated by the drop test of CS-VLA 726. However, this assumes a safety factor of 1.5.

Composite landing gear legs and supporting structure should be subject to an additional composite factor of 1.5 on top of the ordinary 1.5 limit to ultimate factor. The problem is, if we adjust the drop height to apply this extra 1.5 on the cg load factor, then we will be overloading all the other metallic components in the installation, which do not have to be subject to this extra factor.

LAA Engineering will accept the following method of clearing composite installations. The ultimate drop test is carried out using the weights and heights determined using 726, and ignoring the composite factor. During the ultimate drop test, the load factor or max landing gear deflection is to be measured. Then we need to see a stress calculation, showing that the reserve factor on the composite components when this load or deflection is applied, is greater than 1.5.

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The composite material allowable stress used in this calculation should be from an appropriate source, such as published data for your material, with a known statistical basis, or from a four point bend test carried out by yourselves on a piece of your actual leg material.

Engine Mounting Inertial Loads

CS-VLA 561 provides the engine max torque loads and engine lateral inertial loads to be considered when designing the engine mounting installation and the forward fuselage. These are frequently demonstrated by static test.

There are, however, other vertical inertial loads which should also be considered. Probably the two most significant ones are given below;

1. Gust load factor at aircraft minimum weight.
2. Landing Inertia Factor (at CG, not wheels).

If either of these are greater than the aircraft manoeuvre load factor, then they should be designed to and the structure cleared either by test or analysis.

Some engine torque will need to be applied simultaneously to provide a realistic load case. This is not defined in CS-VLA.

LAA Engineering will accept the mean torque associated with engine max continuous power, as a minimum acceptable figure. Note:- This torque does not have to be multiplied by the factor defined in CS-VLA 361 b.

Cable Safety Factors

In addition to an agreed certification code or set of requirements against which an applicant must demonstrate the compliance of their design, it lies within LAA Engineering's remit to impose further supplementary conditions addressing specific aspects of the design. These supplementary conditions can be generated specifically for the design in question, but may also be drawn from other design codes. A supplementary condition which LAA Engineering routinely invokes is BCAR Section S 626 (a) [See link on LAA website]

"S 626 **Cable[s and non-rigid members]**
a) An ultimate factor of safety of 2.0 on nominal cable strength must be applied to
cables used for structural applications and for all primary control systems. (See AMC S 626 a).)"

This is invoked to account for issues relating to manufacturing quality, ease of inspection or unusual structural design (particularly where the design incorporates design features more usually found on a microlight). Applicants should assume that BCAR Section S 626 a) is being invoked, unless otherwise agreed with LAA Engineering.

Seat belt Installations

In accordance with FAA AC21-34 (available off the web), to comply with the forward load case of VLA 561/785 for typical installation geometries an acceptable distribution of pilot restraint loads between the lap strap and shoulder harness is 60% on the lap strap and 40% on the shoulder harness. In addition, the lap strap alone should be able to carry 100% of the forward load. Note the additional 1.33 fitting factor also required to be included, from VLA 625.