Cabin Altitude Looks Like a Setting on the Passengers' Side, but One Proportionality Turns It Straight into Skin Thickness

— lowering the cabin altitude by **600** m, from **2400** to **1800** m, multiplies the differential pressure by **1.110646**, and holding the stress fixed takes **1.110646** times the thickness — the separator is whether cabin altitude is a setting on the passengers' side or a load on the structure's — [Paper 727]

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— From thinking to syncing. —

Abstract

Where to set the cabin pressure looks like a question of passenger comfort. In fact one proportionality turns it into the thickness of a sheet of metal.That comfort and weight are joined by a single number is shown.No new theorem or law is claimed. First, the outside pressure at 11000 m is under a quarter of the ground value——it is 22.632032 kPa (Section 2). **Second, choosing the cabin altitude fixes the differential——52.993624 kPa at 2400 m, 58.857174 kPa at 1800 m and 47.476488 kPa at 3000 m** (Section 2). **Third, and this is the core. Six hundred metres of comfort becomes a factor of 1.110646 in load——lowering the cabin altitude from 2400 m to 1800 m raises the load by that ratio** (Section 3). **Fourth, the stress is proportional to the differential, so the ratio carries straight over——from 79.490436 MPa to 88.285761 MPa, so holding the stress fixed takes 1.110646 times the thickness** (Section 3). **Fifth, one door makes it concrete——52.993624 kN on a square metre, equivalent to a mass of 5403.845776 kg** (Section 3). **Sixth, the separator is whether cabin altitude is a setting on the passengers' side or a load on the structure's——one and the same number is both** (Section 4). **Keywords**: pressurisation, cabin altitude, pressure differential, hoop stress, thin-walled cylinder, comfort against weight.

Scope of this paper (scope note): **No new theorem or law is claimed——the standard atmosphere, the hoop stress of a thin-walled cylinder and the notion of a pressurisation differential are all standard (Timoshenko 1930, Anderson 1999).Fatigue is not treated——that one flight is one load cycle is mentioned, but no life figure is derived.No real aircraft is claimed——cabin altitude, a thickness of 0.002 m and a radius of 3.0 m are all representative values.Stress concentration is not treated——only the thin-walled cylinder is used; the neighbourhoods of windows, doors and frames are not treated.Medicine is not discussed——air conditioning, oxygen partial pressure and effects on passengers are not treated.Abnormal conditions are not treated——behaviour during decompression and relief valves are not treated.Relation to earlier papers**: **Paper 392 showed the boiling point to be a property not of the substance but of the substance and the pressure together, and wrote that without pressurisation the water in the body boils at body temperature——there the subject was why pressurisation is needed. Here its price is counted. Why it is needed, and what it costs.**What is added is **tabulating the differential against cabin altitude**, **reducing 600 m of comfort to the single number 1.110646**, **showing the proportionality to carry the ratio straight into thickness**, **putting the force on one door at 5403.845776 kg equivalent**, and **placing the separator on the passengers' side against the structure's**.

1. Notation and the Question

Setting: **the difference between cabin and outside pressure presses the fuselage from within. The hoop stress of a thin-walled cylinder is the differential times the radius, divided by the thickness.**

$$\Delta p = p_{\text{cabin}} - p_{\text{outside}}, \qquad \sigma = \frac{\Delta p\, r}{t}, \qquad F = \Delta p\, A$$

Below, a cruise altitude of 11000 m, a fuselage radius of 3.0 m and a thickness of 0.002 m are assumed, with both pressures taken from the standard atmosphere.

Question: **whose quantity is the choice of cabin altitude?**

2. Choosing the Cabin Altitude Fixes the Differential

Computation 2.1: **the cabin pressure and the differential were derived for each cabin altitude.**

cabin altitude	cabin pressure	differential
1800 m	81.489206 kPa	58.857174 kPa
2400 m	75.625656 kPa	52.993624 kPa
3000 m	70.108520 kPa	47.476488 kPa

Observation 2.2

the outside pressure is only 22.632032 kPa.Under a quarter of the ground value——so most of the differential is made by the cabin pressure itself.

Observation 2.3

a cabin altitude of zero is possible.Holding the cabin at ground pressure is most comfortable for passengers ——and gives the largest differential, hence the largest load.

3. One Proportionality, and It Is Thickness

Computation 3.1: **the hoop stress and the force on one door of 1 m² were derived for each cabin altitude.**

cabin altitude	stress	force on the door	as a mass
1800 m	88.285761 MPa	58.857174 kN	6001.761455 kg
2400 m	79.490436 MPa	52.993624 kN	5403.845776 kg
3000 m	71.214733 MPa	47.476488 kN	4841.254493 kg

Observation 3.2

this is the core: 600 m of comfort is a factor of 1.110646 in load.Lowering the cabin altitude from 2400 m to 1800 m raises the differential by that ratio, and the stress by the same ratio from 79.490436 MPa to 88.285761 MPa——the two ratios agree to within 10^{-12}.

Observation 3.3

so holding the stress fixed takes the same factor in thickness.The stress is the differential times the radius over the thickness, so a factor of 1.110646 in differential is a factor of 1.110646 in thickness——the comfort setting becomes the weight of the fuselage.

Observation 3.4

one door makes it concrete.A square metre carries 52.993624 kN, equivalent to a mass of 5403.845776 kg——a cabin door does not stay shut in flight by its latches alone.

Observation 3.5

this load is applied once and removed once every flight.One flight is one cycle——no life figure is derived here, but it is worth writing that treating it as a static load alone drops that cycle.

Observation 3.6

cabin altitude is pulled from two sides.Lower it and the passengers are more comfortable; raise it and the fuselage is lighter——both are moving one and the same number.

4. The Separator

Observation 4.1

the separator is whether cabin altitude is a setting on the passengers' side or a load on the structure's.One and the same number is both——"it only makes things comfortable" cannot be said, because one proportionality runs all the way through.

Observation 4.2

beside Paper 392.Paper 392 showed the boiling point to be a property of the substance and the pressure together, and wrote that without pressurisation the water in the body boils——there the subject was why pressurisation is needed. Here its price is counted.

> **Observation 4.3**
>
> **what is not said.Fatigue life, stress concentration, medicine and abnormal conditions are not treated, and three dimensions are held fixed as representative——what is shown is that a comfort setting becomes a load through one proportionality.**

5. Roll Call and Closing

1. **outside pressure 22.632032 kPa** (Observation 2.2): **at 11000 m.**
2. **differential 52.993624 kPa at 2400 m** (Computation 2.1): **the reference.**
3. **58.857174 kPa at 1800 m** (Computation 2.1): **comfort raises it.**
4. **47.476488 kPa at 3000 m** (Computation 2.1): **and lowers it.**
5. **a factor of 1.110646** (Observation 3.2): **the core.**
6. **stress 79.490436 MPa** (Computation 3.1): **at 2400 m.**
7. **88.285761 MPa** (Computation 3.1): **up by the same ratio.**
8. **52.993624 kN on the door** (Computation 3.1): **a square metre.**
9. **5403.845776 kg equivalent** (Computation 3.1): **not the latches alone.**
10. **passengers' side or structure's** (Observation 4.1): **the separator; Paper 392.**

Closing: **Cabin altitude looks like a setting on the passengers' side, but one proportionality turns it straight into skin thickness.The outside pressure at 11000 m is only 22.632032 kPa, so most of the differential is made by the cabin pressure itself——a cabin altitude of 2400 m gives 52.993624 kPa, 1800 m gives 58.857174 kPa and 3000 m gives 47.476488 kPa.Buying 600 m of comfort therefore multiplies the differential by 1.110646 and the hoop stress by the same factor, from 79.490436 MPa to 88.285761 MPa, the two ratios agreeing to within 10^{-12}——so holding the stress fixed takes 1.110646 times the thickness, and the comfort setting becomes the weight of the fuselage.One door makes it concrete——a square metre carries 52.993624 kN, equivalent to a mass of 5403.845776 kg, so a cabin door does not stay shut in flight by its latches alone.And this load is applied once and removed once every flight, so one flight is one cycle——no life figure is derived here, but treating it as a static load alone drops that cycle.Cabin altitude is pulled from two sides: lower it and the passengers are more comfortable, raise it and the fuselage is lighter.The separator is whether cabin altitude is a setting on the passengers' side or a load on the structure's——one and the same number is both.Placed among the earlier papers——Paper 392 showed why pressurisation is needed; here its price is counted.To be honest——fatigue life, stress concentration and medicine are not treated, and three dimensions are held fixed as representative.**

References

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