ENV-1 — Fit-Check Report

Wall-mounted ESP32-C3 + SHT41 environmental sensor · enclosure for board PCB_Sensor rev A · AILA · 4 October 2026



33 / 33

checks passed — no unplanned contact between the board, its components and any enclosure part, in the assembled state and along every assembly path.

Every value below is **measured on the CAD solids** (OpenCASCADE B-rep booleans and exact minimum-distance queries), not estimated. The board outline, holes and every component position were read from `PCB_Sensor.kicad_pcb` (sha256 d3bba53d5e04f190…) and the board's KiCad 3D models.

0.400 mm min. 3D gap shell ↔ board	**1.74 mm** tallest part ↔ front wall	**0.000 mm** USB-C opening offset	**0.20 mm** key ↔ switch gap
0.30 mm light pipe ↔ LED gap	**1.8 %** snap-finger strain	**36.4 mm** SHT41 ↔ ESP32 module	**0 mm³** closing-sweep overlap

How the fit was checked

- **Static interference** — boolean intersection of every enclosure part with every board item (7 enclosure parts × 27 board items: the PCB + 26 component groups, including all 352 solids of the ESP32-C3 module) and of the enclosure parts with each other: 210 pairs.
- **Clearances** — exact 3D minimum distance from each enclosure part to every nearby board item, plus targeted gaps (front wall ↔ tallest part, keys ↔ switch actuators, light pipe ↔ LED, keyhole pockets ↔ board underside).
- **Assembly sweeps** — the board is lowered onto the rear housing (12 mm in 0.5 mm steps), the keys and light pipe are dropped into the shell (8 mm in 0.25 mm steps) and the front shell with keys and light pipe is closed along the wall normal (14 mm in 0.5 mm steps); at every step all solids are intersected again.
- **Engineering checks** — USB-C opening alignment and room for the plug overmold, snap-finger strain (cantilever $1.5 \cdot t \cdot y / L^2$), M2 thread engagement, distances from the sensor to the heat sources, vent areas vs. leak gaps, metal near the Wi-Fi antenna.

Board data taken from the KiCad project

KiCad coordinates are in mm with y pointing down. Product frame: X right, Y up as hung on the wall, Z out of the wall (Z = 0 is the wall). The product is centred on the status LED, so the light dot sits on the vertical axis; the sensor end of the board points down.

Item	KiCad (board)	Product frame	Used for
Board outline Edge.Cuts (15 segments, 1 closed loop)	x 100.0…158.0, y 100.0…124.0 → 58.0 × 24.0 mm, R1.5 corners	X -10.4…13.6, Y -29.0…29.0	shell size, wall gaps, support pads
Sensor isolation slot Edge.Cuts (inner segments)	along y = 110.0 (x 100.0…111.0), across x = 111.0 (y 104.0…110.0), 1.0 mm wide	X -0.4 and Y -18.0	sensor-chamber baffles + ribs sit exactly over it
Mounting hole H1 MountingHole_2.2mm_M2	(122.40, 102.60) Ø2.2	(-7.8, -6.6)	M2 boss Ø5 / pilot Ø1.7
Mounting hole H2 MountingHole_2.2mm_M2	(122.40, 121.40) Ø2.2	(11.0, -6.6)	M2 boss Ø5 / pilot Ø1.7
J1 — USB-C HRO TYPE-C-31-M-12 footprint USB_C_Receptacle_HRO_TYPE-C-31-M-12	(103.35, 116.00) rot -90°	(5.6, -25.7)	opening 12.4 × 6.4 centred on the receptacle mouth
SW1 — BOOT switch XKB TS-1187A footprint SW_XKB_TS-1187A	(129.20, 103.00) rot 0°	(-7.4, 0.2)	key BOOT, Ø2 hole
SW2 — RESET switch XKB TS-1187A footprint SW_XKB_TS-1187A	(137.20, 103.00) rot 0°	(-7.4, 8.2)	key RESET, Ø2 hole
D1 — status LED 0603 footprint LED_0603_1608Metric	(136.40, 110.40) rot 0°	(0.0, 7.4)	light pipe Ø2 — product centred on it
U4 — SHT41 sensor footprint Sensirion_DFN-4_1.5x1.5mm_P0.8mm_SHT4x_NoCentralPad	(104.60, 104.20) rot 0°	(-6.2, -24.4)	inside the walled chamber, inlet slots
U1 — ESP32-C3-MINI-1 module footprint ESP32-C3-MINI-1	(149.50, 112.00) rot -90°	(1.6, 20.5)	top end; antenna area kept metal-free
U3 — AP2112K LDO footprint SOT-23-5	(120.40, 112.60) rot 0°	(2.2, -8.6)	heat source, above the sensor chamber
Component heights KiCad 3D models (board STEP + .wrl)	tallest: J1 top at Z 10.06 (board top 6.90)	front wall inside Z 11.80	product depth 13.6 derived from it

All checks

	Check	Measured
Interference		
PASS	**Static interference, 210 part pairs (7 enclosure parts x 27 board items + enclosure pairs)** requirement: 0 mm3 unplanned overlap	unplanned overlap volume 0.0000 mm3; designed overlaps: rear_housing/screw_H1 3.8359 mm3; rear_housing/screw_H2 3.8359 mm3
Clearances		
PASS	**Front shell inner face -> tallest component (USB-C J1 top)** requirement: >= 1.0 mm	1.74 mm
PASS	**Front shell inner face -> ESP32-C3 module shield (U1)** requirement: >= 1.0 mm	2.45 mm

PASS	**Front shell -> any board part (3D minimum distance)** requirement: >= 0.2 mm	0.400 mm
PASS	**Board edge / surface -> front shell (incl. baffles over the slot)** requirement: >= 0.2 mm	0.400 mm
PASS	**Board seated on bosses + support pads (contact, no overlap)** requirement: contact = 0 mm	0.0000 mm gap
PASS	**Keyhole pocket roof -> board underside** requirement: >= 0.3 mm (THT tails of J1 are inside the board in the model)	0.40 mm
PASS	**Screw heads -> front shell** requirement: >= 1.0 mm	3.60 mm
USB-C		
PASS	**USB-C opening centred on the receptacle (X)**	offset 0.000 mm
PASS	**USB-C opening centred on the receptacle mouth (Z, from the KiCad 3D model)**	opening centre Z 8.48 mm = board top + 1.58 mm
PASS	**USB-C opening margin around the receptacle shell** requirement: plug overmold fits	side 1.58 mm, top/bottom 1.12 mm
PASS	**USB-C receptacle face set back from the outer surface** requirement: <= 2.5 mm	2.13 mm (plug overmold enters 2.13 mm; opening 12.4 x 6.4 mm accepts overmolds up to 12.0 x 6.0 mm)
PASS	**USB-C opening stays below the front edge round** requirement: >= 0.3 mm material	opening top Z 11.68 mm, round starts Z 12.10 mm
Keys and status light		
PASS	**Key BOOT on SW1: plunger -> switch actuator** requirement: gap 0.1-0.3 mm, centred	axial gap 0.20 mm, lateral offset 0.000 mm
PASS	**Key BOOT recessed below the front face** requirement: >= 0.4 mm, no accidental press	0.60 mm (hole 2.0 mm, press with a pen tip / paper clip)
PASS	**Key RESET on SW2: plunger -> switch actuator** requirement: gap 0.1-0.3 mm, centred	axial gap 0.20 mm, lateral offset 0.000 mm
PASS	**Key RESET recessed below the front face** requirement: >= 0.4 mm, no accidental press	0.60 mm (hole 2.0 mm, press with a pen tip / paper clip)
PASS	**Light pipe over LED D1**	gap 0.30 mm, lateral offset 0.000 mm, exit flush with front (Z 13.60 = 13.60)
PASS	**Status light on the product centre line**	X = 0.00 mm (product centred on the LED)
Fasteners		
PASS	**M2 screw thread engagement in boss** requirement: >= 2 x d	4.4 mm (= 2.2 x d), radial 0.15 mm in 1.7 mm pilot
Airflow and heat		
PASS	**SHT41 -> ESP32 module (courtyard edge)**	36.4 mm, and the sensor sits BELOW the module when hung (heat rises away)
PASS	**SHT41 -> LDO U3 (centres)**	17.9 mm

PASS	**SHT41 inside the walled sensor chamber**	sensor at X -6.2 / Y -24.4; chamber walls at X -0.4, Y -18.0 (on the board isolation slot)
PASS	**Sensor chamber vents (bottom + left side) vs. leak gap under the baffles** requirement: vents >= 3 x leak	40.2 mm2 open to the room vs 8.5 mm2 baffle gap (x4.7)
PASS	**Chimney: exhaust area at the top >= main inlet area**	55.2 mm2 top vs 15.1 mm2 lower right side
Wi-Fi antenna		
PASS	**Metal near the ESP32 antenna: wall-screw head -> antenna area**	6.6 mm (screw heads below the module GND area only); screws M2 at Y -6.6 are 30.0 mm away
PASS	**Antenna end of the board -> shell top wall (plastic only)**	2.8 mm air + 1.8 mm PC/ABS; no metal and no ribs over the antenna
Snap fits		
PASS	**Snap fingers: deflection while closing**	0.46 mm undercut, 4 fingers
PASS	**Snap fingers: bending strain (cantilever 1.5 t y / L^2)** requirement: <= 2.5 % for PC/ABS, repeated opening	1.8 % (t 1.0 mm, L 6.2 mm)
Assembly and opening		
PASS	**Assembly: board lowers straight onto the rear housing (12 mm travel, 0.5 mm steps)**	worst overlap 0.0000 mm3 (328 s)
PASS	**Assembly: keys + light pipe drop into the front shell from inside (8 mm)**	worst overlap 0.0000 mm3
PASS	**Assembly: front shell closes straight along the wall normal (14 mm, 0.5 mm steps)**	no contact except the 4 snap lips (6.18 mm3 of designed lip deflection near closing); (153 s)
PASS	**Opening: pull the front shell straight off; rear housing stays on the wall screws**	same path as c), 45 deg release face on every lip, fingernail notch at the top parting line

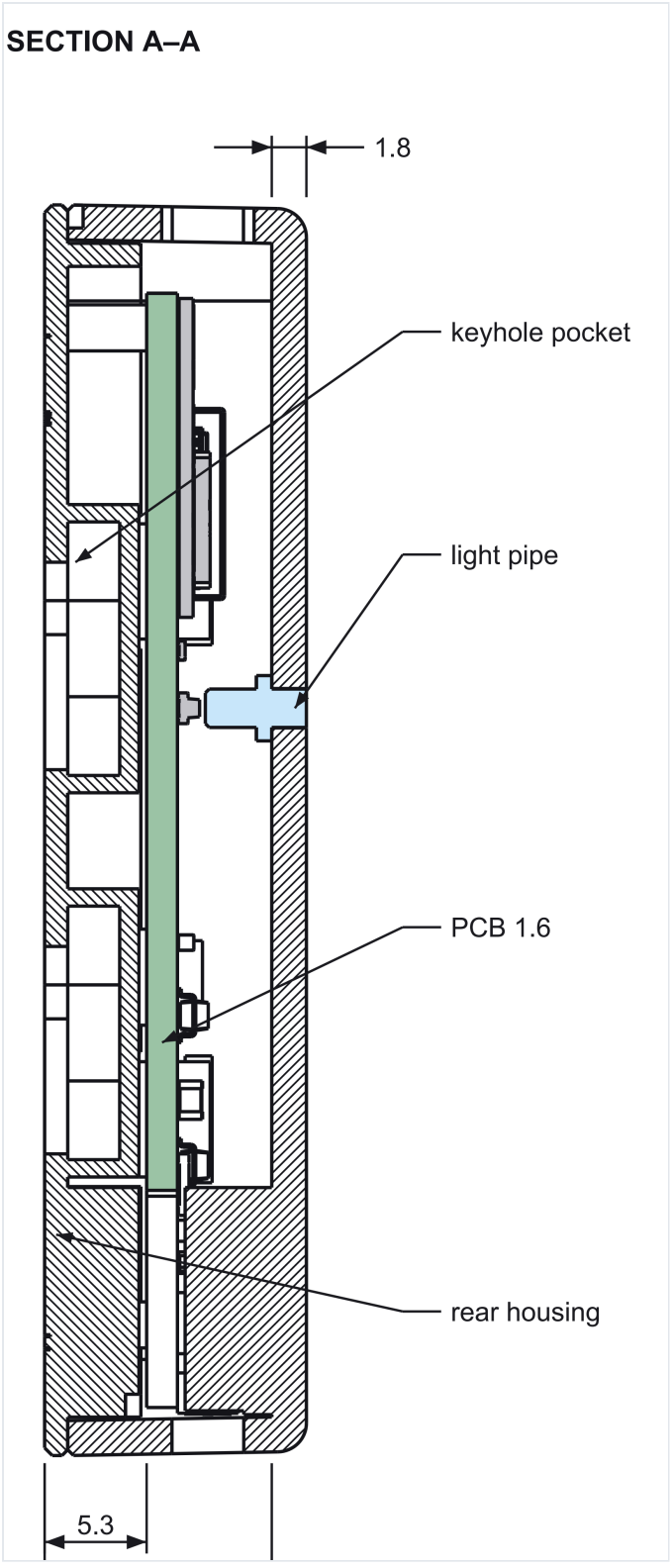
Closest approach of each enclosure part (mm)

Part	Nearest board items and their 3D gap
front_shell	PCB 0.40, F1 0.60, J1 0.93, C6 2.30, U1 2.45
rear_housing	PCB 0.00, J1 1.37, R10 1.65, SW2 2.00, SW1 2.03
light_pipe	D1 0.30, PCB 1.45, R9 1.97, R5 3.35
key_boot	SW1 0.20, PCB 1.70, SW2 4.20
key_reset	SW2 0.20, PCB 1.70, U1 3.62, SW1 4.20, C5 4.41
screw_H1	PCB 0.00, SW1 1.85
screw_H2	PCB 0.00

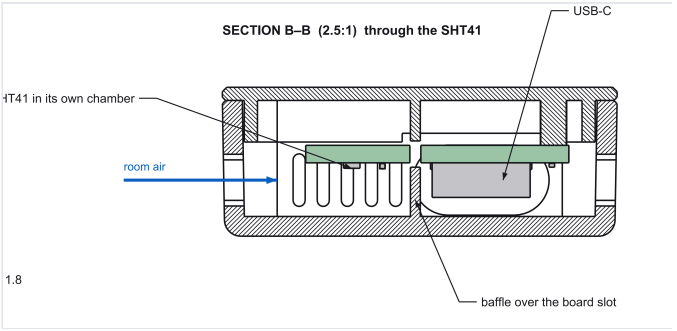
0.00 for the rear housing and the screws = designed contact (board seated on its bosses and pads, screw heads clamping the board).

Designed overlaps (the only non-zero intersections)

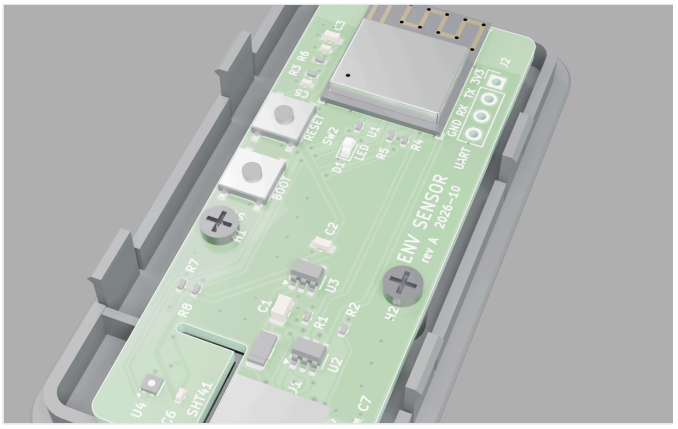
Pair	Volume	Why
rear_housing / screw_H1	3.84 mm^3	M2 thread-forming screw cutting its thread in the 1.7 mm boss hole (designed)
rear_housing / screw_H2	3.84 mm^3	M2 thread-forming screw cutting its thread in the 1.7 mm boss hole (designed)



Section A–A (X = 0, through the light pipe and both keyholes): wall plate 1.2 · board underside 5.3 · front wall inside 11.8 · depth 13.6 mm.



Section B–B (through the SHT41): the sensor sits in its own chamber; the baffle stands over the board's isolation slot; room air enters through the bottom and side slots.



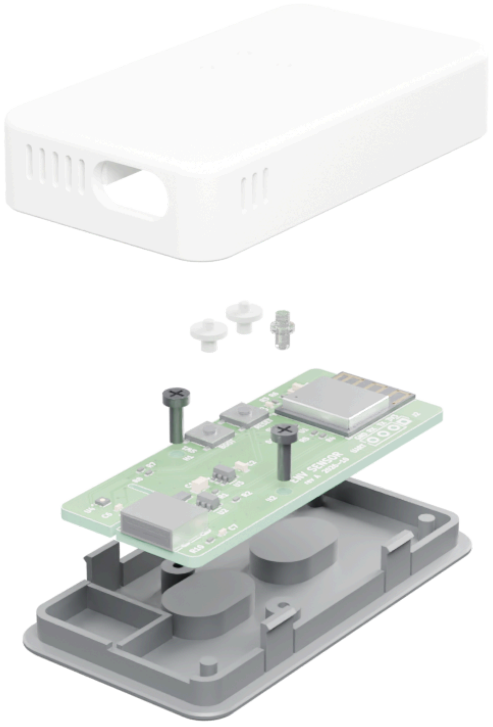
Board seated in the rear housing (front shell removed): 2 M2 screws, 3 support pads, snap fingers along the sides.

Airflow

Opening	Area
Sensor-chamber inlets (5 bottom + 3 left-side slots)	40.2 mm²
Leak path under the baffles (0.4 mm gap, conservative)	8.5 mm²
Main-compartment inlet (3 slots, lower right side)	15.1 mm²
Warm-air exhaust (11 slots on top)	55.2 mm²

Assumptions and limits

- **J2 (4-pin UART header) is not fitted** in the product build; USB-C is the programming port. With J2 fitted (8.5 mm tall) the parametric model grows the depth automatically (parameter `j2_fitted=True`).
- USB-C, SHT41 and the tact switches use the board project's simplified models (datasheet envelopes); the ESP32-C3 module uses Espressif's model. The THT tails of the USB-C shell are not modelled; 0.4 mm free space is kept under the board.
- Cable plugs with overmolds up to 12.0 × 6.0 mm fit the USB-C opening (0.2 mm clearance each side); the overmold enters 2.13 mm.
- Thermal behaviour is checked geometrically (separation, chamber walls, vent areas, chimney direction), not by CFD. A first-article test should log the SHT41 against a reference sensor with Wi-Fi active.
- Snap strain uses the standard cantilever formula; 1.8 % is within the usual 2–2.5 % limit for repeated opening of PC/ABS.
- Plastic mass (PC/ABS 1.15 g/cm³, PC 1.20 g/cm³): front shell 8.47 g, rear housing 4.82 g, light pipe + keys 0.09 g — total 13.4 g.
- Re-run: `01_CAD_source/build_all.py <KiCad project folder>` rebuilds the model, every export, this check and the drawing.



Assembly order (exploded spacing from ENV-1_positions.json): rear housing (on the wall) · board · 2 screws · light pipe and keys (into the shell) · front shell.