2025

The Proportional Compass

MARIAUD CONSULTING

Our PROGRAM

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The proportional compass

The proportional compass

01 Presentation

📌 The Proportional (or Reducing) Compass in Cooperage

The proportional compass, also called **the reducing compass**, is a tool used in cooperage to accurately determine **the progressive reduction of the staves** between the bilge and the head of the barrel.

It allows you **to transfer the dimensions** of the bilge to the head while respecting **the reducing coefficient** specific to each barrel volume. This ensures a uniform fit of the staves and a controlled curve.

📏 A Precise Calculation Tool

The proportional compass is used to:

✅ **Transfer the reduction** of the stave widths based on the barrel's diameter.
✅ **Ensure a perfect balance** between the curve of the bilge and the head.

🛠️ How the Proportional Compass Works

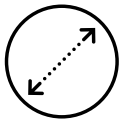
The compass is set to a specific reduction ratio, corresponding to the head diameter divided by the bilge diameter.

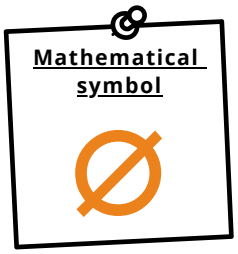
- **At its maximum opening**, it is aligned with the bilge diameter.
- **By progressively closing it**, it allows for the exact transfer of the reduced dimensions for the head diameter.

This tool is essential for ensuring that each stave fits perfectly into the barrel's structure, without excessive gaps or jointing constraints.

02 Necessary Calculations

1. Diameter of a Circle





Definition :

The diameter of a circle is the distance between two opposite points on the circle, passing through its center. It is twice the radius.

Formula : **D=2R Diameter = 2 x the radius**

Where :

D represents the diameter
R represents the radius

Example :

If a circle's radius is 10 cm, its diameter is:

D=2×10=20 cm

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2. Radius of a Circle

Definition :

The radius of a circle is the distance between its center and any point on its circumference. It's half of the diameter.

Formula : **R=D/2**

Example :

If a circle's diameter is 50 cm, its radius is:

R=50/2=25 cm

3. Circumference of a Circle

Definition :

The perimeter of a circle, also called the circumference, is the length of the circle's outline.

Formula : $P = \pi D$ ou $P = 2\pi R$

Where :

- P is the perimeter (circumference).
- D is the diameter.
- R is the radius.
- $\pi \approx 3.1416$ is the mathematical constant Pi.

Example :

If a circle has a radius of 7 cm, its perimeter is:

$$P = 2\pi \times 7 \approx 2 \times 3.1416 \times 7 \approx 43.98 \text{ cm}$$

Summary of formulas

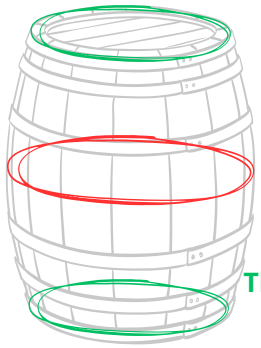
Concept	Formula	Variables
Diameter	$D=2R$	R : radius
Radius	$R=2D$	D : diameter
Perimeter (Circumference)	$P=\pi D$ or $P=2\pi R$	D : diameter R : radius π: 3.1416

4. Calculating the Reduction Coefficient

The reduction coefficient in cooperage is a key parameter that expresses the ratio between the barrel's maximum diameter, called **the bilge diameter,** and the diameter at its ends, called **the head diameter.**

This coefficient directly influences the barrel's shape, affecting its volume and interaction with the contents.

The reduction coefficient is calculated by dividing the head diameter by the bilge diameter:



$$\text{The reduction coefficient} = \frac{\text{The head diameter}}{\text{The bilge diameter}}$$

For example, consider a **225-liter** Bordeaux barrel with a head diameter of **57 cm** and a bilge diameter of **69 cm.**

The reduction coefficient would be: **57/69 = 0,826**
This means the head diameter represents approximately **82.6%** of the bilge diameter.

Importance of the Reduction Coefficient

This coefficient is crucial for several reasons:

- **Barrel Design**: It determines the curvature of the staves and the overall shape of the barrel, influencing its capacity and stability.
- **Manufacturing Process:** Coopers use this coefficient to adjust tools and techniques during stave assembly, ensuring a consistent shape and optimal sealing.
- **Interaction with Contents:** The barrel's shape, dictated by this coefficient, affects the contact surface area between the wood and the liquid, which influences the maturation process for wines and spirits.

Examples of Reduction Coefficients

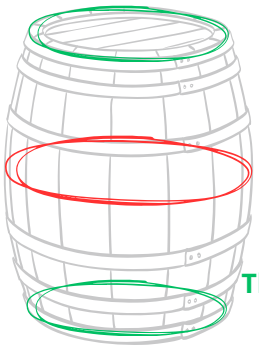
Different types of barrels have varied reduction coefficients depending on their design:

- **228-liter Burgundy barrel:** Has a head diameter of 60 cm and a bilge diameter of 72 cm, for a coefficient of approximately 0.833.
- **500-liter barrel**: Has a head diameter of 78 cm and a bilge diameter of 90 cm, for a coefficient of approximately 0.867.

These variations show how the reduction coefficient is adjusted based on the specific characteristics of each barrel to meet the needs of producers and the desired qualities of the final product.

The proportional compass

02 Necessary Calculations



The reduction coefficient= $\frac{\text{The head diameter}}{\text{The bilge diameter}}$

Capacity in liters	Ø HEAD	Ø BILGE	THE REDUCTION COEFFICIENT
1	11	15	0,73
5	18	22,2	0,81
10	21	26,1	0,80
15	23	29,6	0,78
20	27,5	34,3	0,80
25	29	36,6	0,79
28	30	37	0,81
30	30	38,2	0,79
35	31,5	38,5	0,82
40	31	40,1	0,77
50	34,5	44,2	0,78
57	39	47	0,83
60	35	45,5	0,77
70	36	46,1	0,78
75	37	47,7	0,78
105	43,5	55	0,79
114	49	58	0,84
140	46	59,2	0,78
150	47	60,8	0,77
200	54	68,1	0,79
210	57,5	68,1	0,84
225	56	69	0,81
228	60	73	0,82
250	61	74,8	0,82
265	60	73	0,82
300	62	73	0,85
350	66,5	81	0,82
400	70	86,5	0,81
500	76,5	94,7	0,81
600	86,5	102,5	0,84

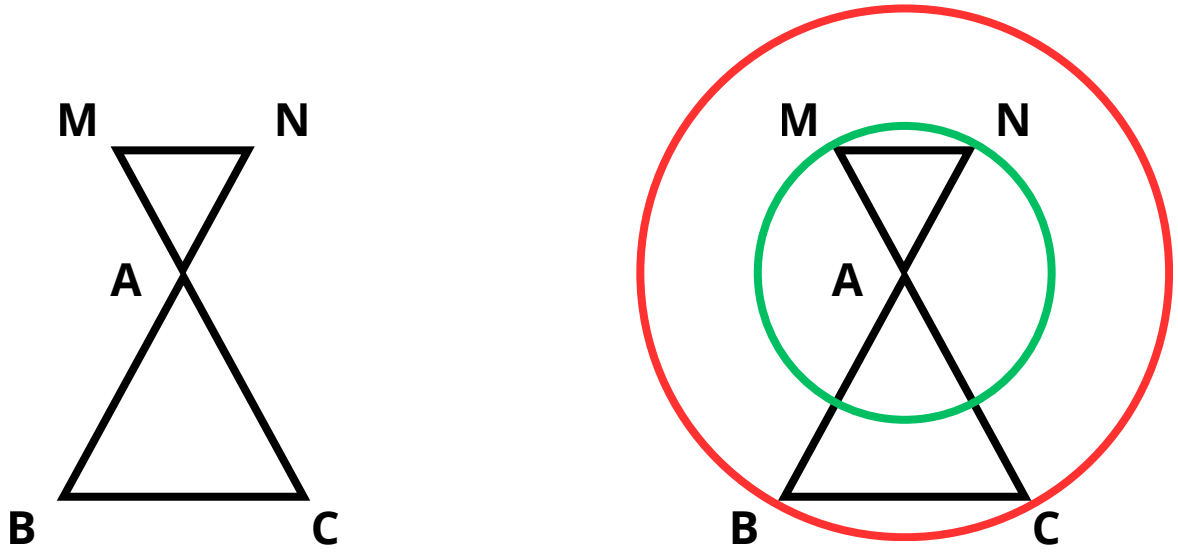
The proportional compass

02 Necessary Calculations

📌 **The Proportional Compass and Thales's Theorem**

To understand how **the proportional compass** works, a very well-known mathematical rule is used: **Thales's Theorem.** 📏

Mathematical Principle with Thales



In this arrangement:

- **The bilge diameter** represents the large base of the triangle **BC**.
- **The head diameter** is a smaller base located on the same axis **MN**
- **The apex A** is at the center of the bilge circl**e**.
- **B** and **C** are on the circle, so the distance between **A** and **B** (**AB**) and between **A** and **C** (**AC**) corresponds to **the bilge radius.**
- Thus, **AB = AC** , because they are the segments that connect the center of the circle to its circumference.

- Reduction coefficient = $\frac{MN}{BC}$

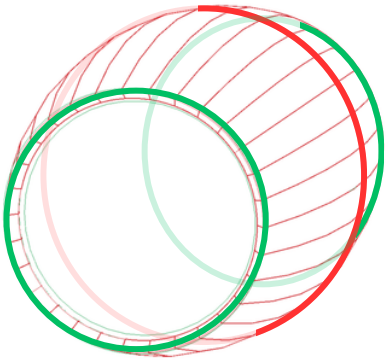
- It is necessary to consider **AB** and **AC** as being the **the bilge diameter.**
- It is necessary to consider **AM** and **AN** as being the **the head diameter**

The proportional compass

03 Construction of a compass

Example with a 225 L barrel

Diameter at the head (green): **57 cm**
Diameter at the bilge (red): **69 cm**



The necessary calculations:

Diameter at the head (green): **57 cm**
Radius at the head = 57 / 2 = 28.5 cm

Diameter at the bilge (red): **69 cm**
Radius at the bilge = 69 / 2 = 34.5 cm

The proportional compass must be **functional** and **easy to handle**, without being too cumbersome. If we directly use the barrel's actual radii (**34.5 cm at the bilge** and **28.5 cm at the head**), the compass legs would be too long and impractical to manipulate.

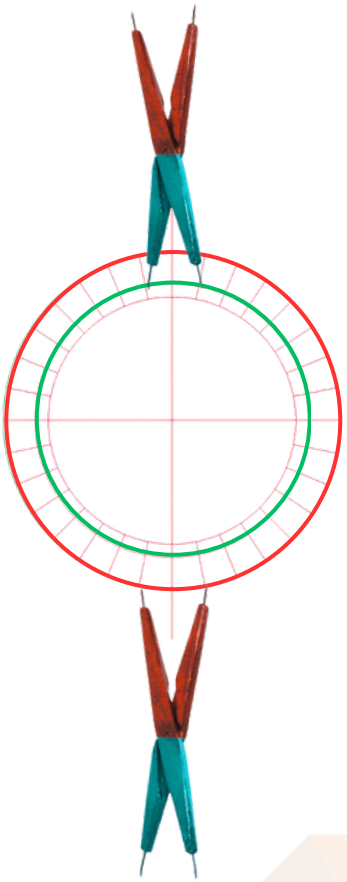
📌 **Solution: Proportional Reduction**
To get a more compact compass, the measurements are reduced by dividing **the radius by 5.**

Dividing the radius by **5** is a **practical method,** but it's **not a fixed rule.** This reduction makes **the compass easier to handle** while maintaining **the proportionality of the measurements.** However, the reduction factor can be **adjusted as needed,** depending on **the desired compass size and ease of use.** The essential **thing is to keep a constant ratio** between the bilge and head measurements to ensure optimal precision.

Proportion of the head diameter

Proportion of the bilge diameter

The green part of the compass allows for controlling the head dimension, while the red side ensures the proportionality between the head and the bilge, guaranteeing a uniform reduction in the widths of the staves.



Materials Required to Make a Proportional Compass

✅ **Main Materials**

🪵 **Hardwood** (oak, beech, maple, quality plywood) → Light, sturdy, and easy to work with.
🔩 **Metal** (aluminum, brass, stainless steel) → More resistant and durable, ideal for professional use.

🛠️ **Manufacturing Hardware**

📏 **Ruler and square** → To draw precise lines.
🖍️ **Pencil or marker** → To mark cutting and drilling points.
🛠️ **Coping saw or jigsaw** → To cut the compass legs.
🪚 **Wood rasp and sandpaper** → To smooth the cuts and avoid splinters.
🔧 **Drill with a fine bit** → To drill the pivot assembly hole.
🔗 **Pivot** (rivet, screw or wing bolt) → To articulate the two legs and allow for precise adjustment.
🔘 **Three washers** → One between the legs for a fluid articulation, and one on each side for optimal support.
🔩 **Locknut** (if screw or threaded rod) → To prevent the pivot from loosening over time.

📢 **Conclusion**

The choice of materials depends on the intended use:
✔️ **A wooden compass** will be lighter and easier to make.
✔️ **A metal compass** will offer better longevity and more precision.

👉 **With these tools and materials, you can create an effective and durable proportional compass!** 🔧📏



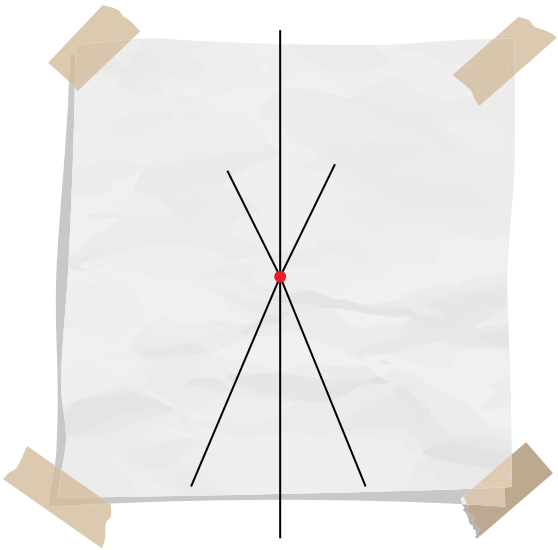




The proportional compass

03 Construction of a compass

1 Defining the Compass Dimensions and Verifying the Proportions



Before cutting the materials, it's essential to precisely define the compass dimensions to ensure an exact layout.

Trace a central axis on the sheet → It will serve as a reference for aligning the compass legs.

Determine the length of the legs → By dividing the radius by an appropriate reduction factor **(ex: ÷5 for better maneuverability).**

- **Reduced bilge radius:** $\frac{34.5}{5} = 6.9$ cm
- **Reduced head radius:** $\frac{28.5}{5} = 5.7$ cm

Trace the two compass legs by respecting these lengths and connecting them to a central point.

Position the pivot point → At the intersection of the legs, leave space for **a rivet, bolt, or articulated screw**.

✅ **Verification before moving to the next step**
✓ The lengths are correctly reduced for a manageable compass.
✓ **The legs are symmetrical** and aligned with the central axis.
✓ **The ratio between the reduced radius** respects the reduction coefficient (0.826).
✓ The pivot point is marked for a fluid articulation.

👉 This step allows for a precise guide before cutting and helps avoid any alignment errors.

📌 **Correct Calculation of a Leg's Length**

Since **BAN** and **CAM** are aligned, **the total length of one leg** is simply the sum of the two reduced radius:

Total length of a leg = BA + AC
Total length = 6.9 + 5.7
Total length = **12.6 cm**

📌 **Pivot Position**

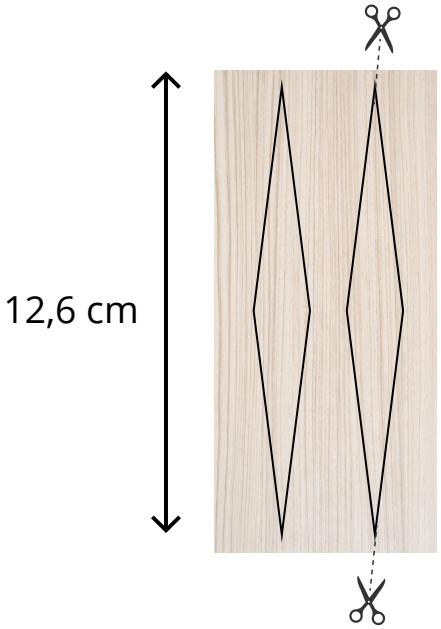
The compass's pivot is located at the intersection of the BAN and CAM segments, that is, at the junction between the two parts of the leg, thus allowing for articulation and proportion adjustment. 📏🔧

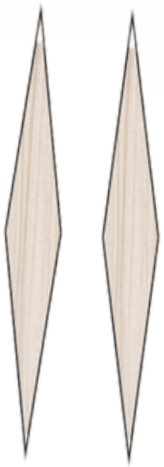
The proportional compass

03 Construction of a compass

2

Cutting the Compass Legs





Take the chosen material (wood or metal) and transfer the **12.6 cm** measurement onto two identical pieces.

Trace the outlines of the legs with a ruler to ensure a clean, straight cut.

Carefully cut the two legs by following the lines, using a coping saw, jigsaw, or hand saw depending on the material used.

Smooth the edges with sandpaper or a rasp to avoid splinters and ensure comfortable handling.

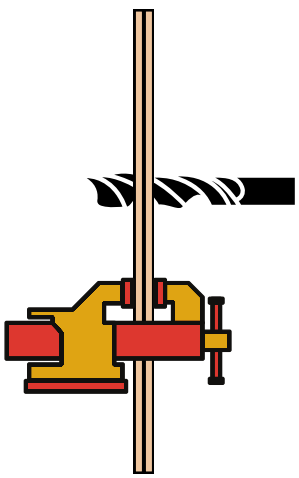
✅ **Verification before moving to the next step**

✓ **Both legs measure 12.6 cm** and are perfectly identical.
✓ **The edges are clean and smooth** for a good assembly.
✓ **The legs are ready to be drilled for the pivot.**

👉 This step ensures a symmetrical and easy-to-articulate compass. 🔧📏

3

Drilling the Pivot Location



Mark the pivot location:

- Trace a median axis on each leg.
- Measure **6.9 cm** from the large end and **5.7 cm** from the small end to determine the center of the hole.

Superimpose the two legs and clamp them together for a perfectly aligned hole.

Choose a drill bit that matches the pivot's diameter (between 3 and 5 mm depending on the axle used).

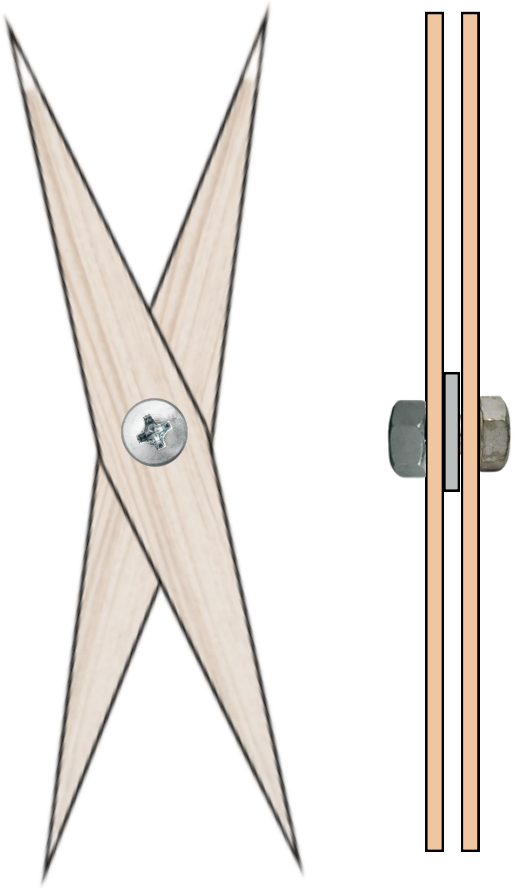
Drill slowly, keeping the bit perpendicular for a clean, splinter-free hole.

✅ **Verification before moving to the next step**

✓ The hole is centered and goes through both legs.
✓ The alignment is correct, with no offset.
✓ The pivot fits freely but without excessive play.

👉 This step ensures a fluid and sturdy articulation for a precise compass. 🔧📏

4 Pivot Installation



Choose the pivot:

- Use **a screw, rivet, or metal rod suited to** the hole's diameter **(between 3 and 5 mm).**
- The length must allow for a solid attachment while leaving a little play for articulation.

Insert the pivot into the drilled holes of the two legs, adding **a washer between** them to facilitate rotation and prevent direct friction of the wood or metal.

Fix without overtightening:

- If it's a screw: add **a washer on each side,** then tighten moderately with a locknut.
- If it's a rivet: carefully peen it to avoid blocking the articulation.
- If it's a metal rod: use **locknuts** or a stopping system (pin, crimping).

Test the rotation:

- The legs should pivot **without excessive resistance and without too much play.**
- Adjust the tightening if necessary.

✅ **Verification before moving to the next step**

✓ The pivot is securely in place.

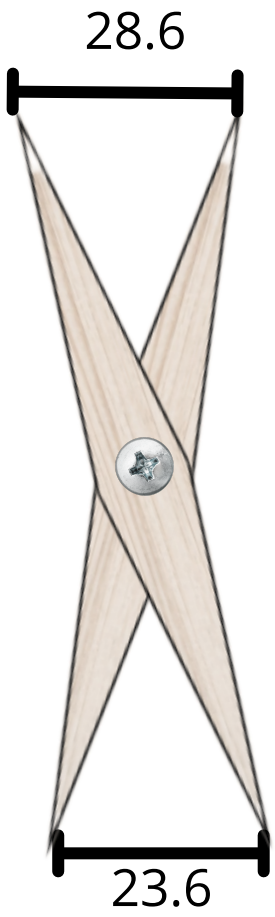
✓ **The central washer allows for fluid, regular rotation.**

✓ The compass can open and close without constraint.

👉 **This step ensures a functional and precise compass.** 🔧📏

The proportional compass

04 Compass Verification



Test Opening and Closing

- Open and close the compass several times.
- Check that the movement is fluid, **with no hard spots or excessive play.**

Check Proportions

- Open the compass to different values and measure the distances between the legs.
- Verify that the ratio between the two sides **remains constant** (e.g., if one side measures 10 cm, the other must respect the expected proportional ratio).

Verify the Accuracy of Ratios

- Test with known measurements (e.g., divide a segment into sections of a precise ratio).
- Compare the results with a ruler to ensure the proportions are accurate.

Ensure the Pivot is Solid

- The pivot must be securely held in place **without being too tight.**
- The central washer must allow for fluid rotation without changing the ratio.

Test in a Real-World Scenario

- Use the compass on a drawing or a project that requires precise proportions.
- Verify that it facilitates the reproduction of correct ratios between dimensions.

✅ **Final Validation**

✓ The compass opens and closes without excessive resistance.
✓ **The measurements follow the intended proportional ratio.**
✓ The pivot is stable and the rotation is fluid.
✓ The compass is ready to be used for precise layouts.

👉 **This step guarantees a functional and accurate compass for proportional layouts.** ✏️📏

The proportional compass

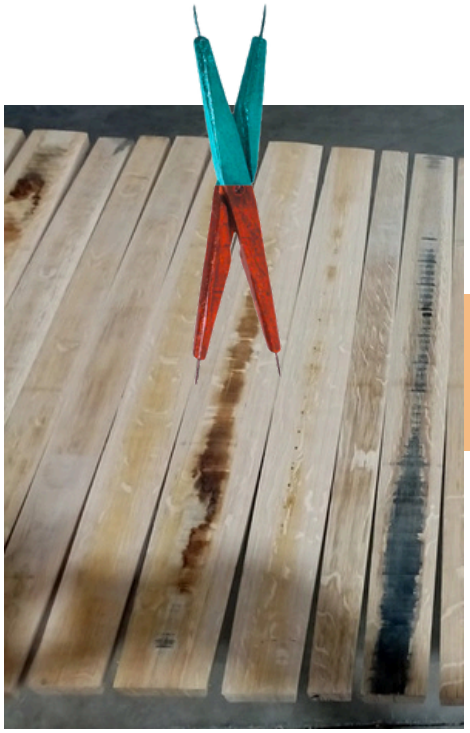
05 Using the Compass

📌 **Verifying the Use of the Proportional Compass**

In the example opposite, the proportional compass is used to check that the dimensions at the ends of a stave are equal.

✅ We observe that the width at both **heads** of the stave corresponds exactly to the values defined by **the green side** of the compass.
✅ We observe that the widths at both heads of the stave are identical.

The angle of the piece is well-positioned in the compass's axis, thus ensuring **correct alignment** and **controlled symmetry** in the final assembly.



📌 **Verifying the Use of the Proportional Compass**

After validating that the dimensions at **the heads** of the piece are equal, the second step is to use **the other side of the compass** to check the bilge width.

✅ The compass is placed with the bilge side (red) gap, and the correspondence with the stave's width in the middle is checked.

✅ The bilge width must correspond to the gap defined by the head measurements.

If the gap is correct, it confirms that the piece respects the correct proportions and can be integrated into the assembly.
If not, an adjustment will be necessary before the final placement.

Now it's up to you to put your knowledge into practice and perfect your skills!