

2025

# The double key

MARIAUD CONSULTING



# Our PROGRAM

01

Presentation

02

Necessary Calculations

03

Making a Double Jointing Key

04

Verification of the Gauge

05

Use of the Jointing Gauge

06

Advantages and Disadvantages



The jointing gauge (or key) is a wooden or metal template used in cooperage.

It helps to determine the exact proportions of the staves to achieve the desired barrel shape and ensure a precise joint between them.

This template contains several essential pieces of information:

- The curve of the stave at the bilge and/or head.
- The jointing angle at the bilge and/or head.
- The reduction proportion between the bilge and the head.

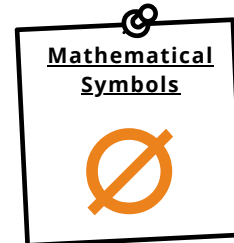
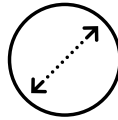
There are two main types of jointing keys:

- The single key, which allows for the control of:
  - The stave's curvature at the head.
  - The jointing angle at the head.
  - The proportions between the head and the bilge.
- The double key, which offers a more comprehensive check by allowing you to verify:
  - The stave's curvature at both the head and the bilge.
  - The jointing angle at both the head and the bilge.
  - The proportions between the head and the bilge.



Each gauge is unique and must be specifically designed for each type of barrel to ensure the staves fit optimally, guaranteeing the final shape and watertightness of the barrel.

### 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 :  **$D=2R$  Diamètre = 2 x le rayons**

Where : **D est le diamètre du cercle  
R est le rayon du cercle**

#### Example :

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

$$D=2 \times 10=20 \text{ cm}$$

---

### 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:

$$R=50/2=25 \text{ cm}$$

### 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 or formulas

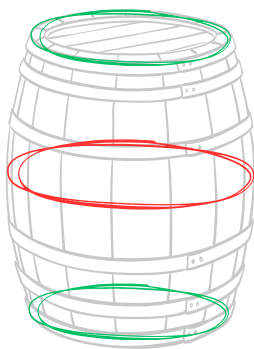
Concept	Formula	Variables
Diameter	$D=2R$	R : radius
Radius	$R=D/2$	D : diameter
Perimeter (Circumference)	$P=\pi D$ or $P=2\pi R$	D : diameter R : radius $\pi$ : 3.1416

### 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:



The head diameter

The bilge diameter

The head diameter

The reduction coefficient

The head diameter

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:

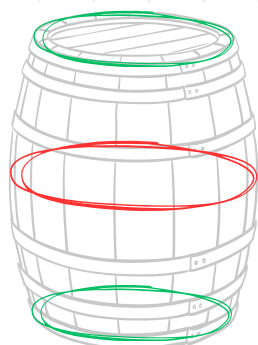
- **228-liter Burgundy barrel:** Has a head diameter of 60 cm and a bilge diameter of 72 cm, for a coefficient of approximately 0.833.
- **500-liter barrel:** Has a head diameter of 78 cm and a bilge diameter of 90 cm, for a coefficient of approximately 0.867.

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 double key

02

## Necessary Calculations



The head diameter

The bilge diameter

The head diameter

The reduction coefficient

The head diameter

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 double key

03

## Making a Double Jointing Key

### 1. Preparing the Plank

Materials and Dimensions

- Take a rectangular plank of approximately 25 cm x 10 cm with a thickness of between 5 and 7 mm.
- Plane both faces to obtain a smooth and even surface.
- Plywood or another smooth, solid, and easy-to-work material can be used.

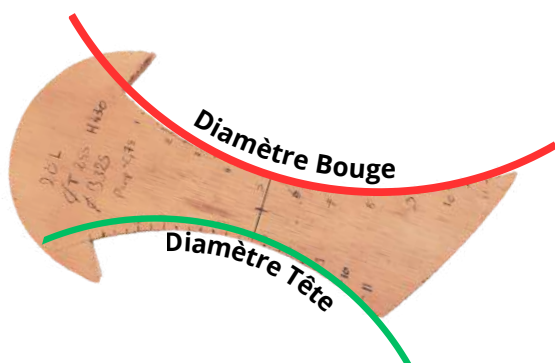
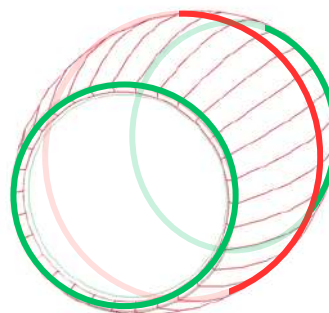
#### Example with a 225 L barrel

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

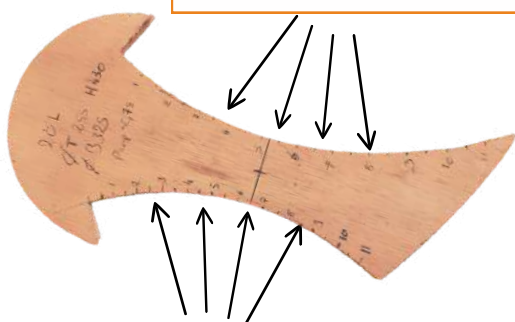
#### The necessary calculations:

Diameter at the head (green): **57 cm**  
Radius at the head =  $57 / 2 = 28.5 \text{ cm}$

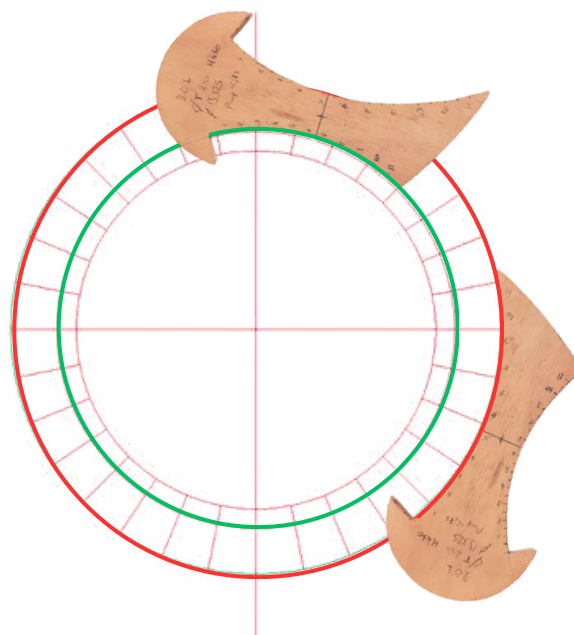
Diameter at the bilge (red): **69 cm**  
Radius at the bilge =  $69 / 2 = 34.5 \text{ cm}$



These marks correspond to the proportions at the bilge.



These marks correspond to the proportions at the head.



The double key adjusts the jointing by taking into account both the angle and diameter at the head, and the angle and diameter at the bilge.

### Materials and Tools for Making a Jointing Key

#### 1. Core Materials (For the Body of the Key)

- ✓ Hardwood (oak, beech, ash, maple) - Resistant to wear and stable over time.
- ✓ Quality plywood - An easier option to work with for a first template.
- ✓ Metal (steel or aluminum) - For a more durable and rigid key.

#### 2. Tracing and Measuring Tools

- ✏ Graduated ruler - To draw precise lines.
- ⊗ Compass - To draw the arcs corresponding to the head and bilge diameters.
- ✍ Grease pencil or fine-point marker - For visible lines on the wood.

#### 3. Cutting and Finishing Tools

- 🪚 Coping saw or jigsaw - To cut the general shape.
- 🔧 File and sandpaper (fine grit) - For a clean and smooth finish.

#### 4. Fastening and Adjustment Elements

- 🔩 Screws or nails - To fasten the key to the workbench.



# The double key

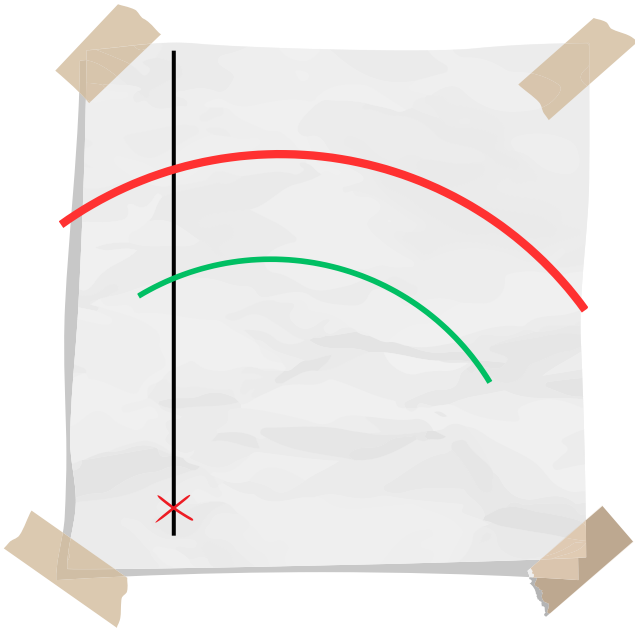
03

## Making a Double Jointing Key

1

### Preparatory Tracing on a Sheet

This step involves creating a template on a separate sheet of paper, allowing you to get a clean and precise tracing of the proportions before applying them to the jointing key



### Drawing the Axis and Diameters

Draw a single axis at the center of the sheet.

Define a central point and, from there:

- Draw a first circle corresponding to **the bilge diameter (69 cm → radius 34.5 cm)**.
  - Draw a second circle corresponding to **the head diameter (57 cm → radius 28.5 cm)**.
- Ensure that the two circles are concentric (share the same center).

2

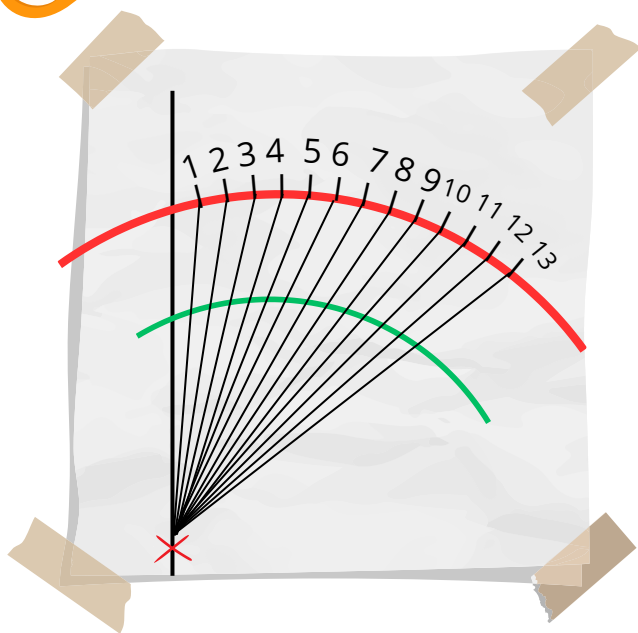


### Reporting a Regular Spacing on the Bilge Arc

With a compass, transfer a 1 cm spacing along the entire bilge arc.

Mark these points regularly along the entire curve to create a precise division.

3



### Drawing the Numbered Lines

**Connect the center point** to the marks you made on the bilge arc using radiating straight lines.

**Number each line from 1 to 13**, following an ordered progression.

**Extend these lines to pass through the head arc**, which will provide a precise reference for the next steps of the drawing.

### Verification Before Proceeding to the Next Step

- ✓ The main axis is correctly drawn.
- ✓ The two circles are correctly centered on the same reference point.
- ✓ The 1 cm spacing is correctly marked on the bilge arc.
- ✓ Lines 0.1 to 13 are neatly drawn and allow for a clear reading of the marks.

The points drawn on the sheet are used to accurately transfer the proportions of the staves onto the double jointing key, respecting the progressive reduction between the bilge and the head.

4



**Place the plank on a stable surface** (a workbench or table).

**Position 4 tacks at the corners of the plank**, making sure they don't get in the way of the future tracing area.

**Lightly tap the tacks in with a hammer**, just enough to hold the plank still without damaging it.

**Check that the plank doesn't move by applying a little pressure on the edges.**

♦ **Tip:** If the plank is too thin, use double-sided tape to hold it in place without damaging it.

### Verification Before Proceeding to the Next Step

- ✓ The plank is securely fastened and does not move.
- ✓ The tacks do not interfere with tracing the arcs and jointing angles.
- ✓ The work surface is flat and stable to avoid measurement errors.

# The double key

03

## Making a Double Jointing Key

5



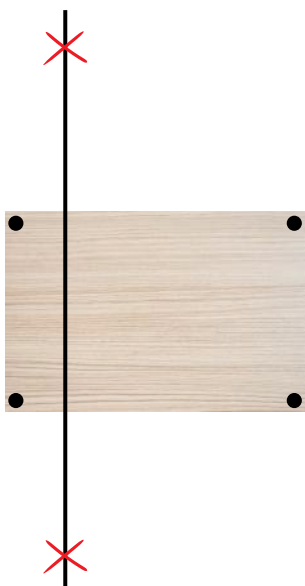
**Position the ruler** on the plank to draw a clean, continuous straight line.

**Draw a straight line** that extends on both sides of the plank, making sure it is longer than the bilge radius on one side (**34.5 cm here**) and longer than the head radius on the other side (**28.5 cm here**).

### Verification Before Proceeding to the Next Step

- ✓ The line is clearly visible and continuous.
- ✓ It extends past the plank with a length suitable for both the head (**28.5 cm**) and bilge (**34.5 cm**) radii.
- ✓ It is perfectly straight, with no deviation.

6



**Define a point on the line** on one side of the plank for the head radius.

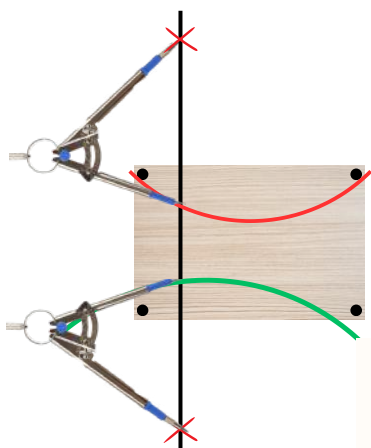
**Define a second point** on the other side of the plank for the bilge radius.

**Veiller à ce que les deux points soient espacés de 3 à 5 cm** sur l'axe, afin que les rayons ne se croisent pas au centre de la planche.

### Verification Before Proceeding to the Next Step

- ✓ Each point is correctly positioned on each side of the plank.
- ✓ The space between the two points is between 3 and 5 cm, thus preventing the radii from crossing in the center.
- ✓ The plank is ready for tracing the key's radii.

7



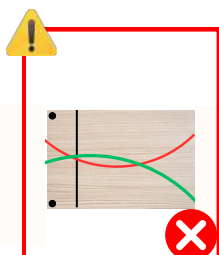
**From the point you defined for the bilge**, draw an arc that corresponds to the bilge radius (**34.5 cm**).

**From the point you defined for the head**, draw an arc that corresponds to the head radius (**28.5 cm**).

**Be careful not to cross the two arcs in the center of the plank** to avoid any confusion in the tracing.

### Verification Before Proceeding to the Next Step

- ✓ Each arc is properly traced from its respective reference point.
- ✓ The arcs remain distinct and do not cross in the center of the plank.
- ✓ The curves correspond correctly to the bilge (**34.5 cm**) and head (**28.5 cm**) radii.



# The double key

03

## Making a Double Jointing Key

8

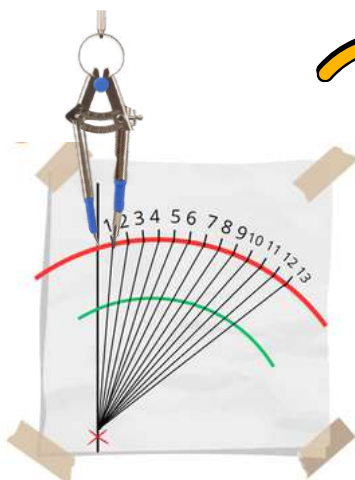
Take the tracing sheet and transfer each point onto the corresponding arc on the key. Use a compass to measure the distance between the axis and each point on **the bilge** arc. Transfer these measurements onto the plank, starting from the intersection point of the axis and **the bilge** diameter, then mark each corresponding point. Repeat the process for each graduation to get a tracing that is faithful to the proportions defined on the sheet.

### Verification Before Proceeding to the Next Step

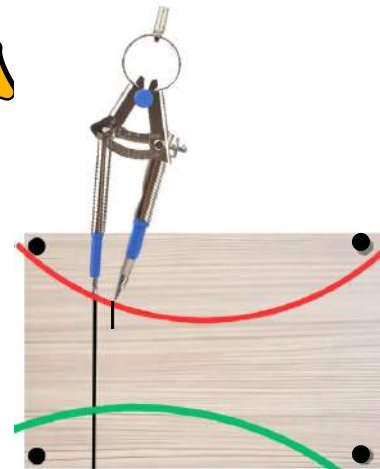
- ✓ Each point is correctly transferred onto the plank.
- ✓ The distances respect the measurements taken from the sheet.

For greater accuracy, always use the intersection of the **bilge** arc and the **head** arc with the central axis as your reference, rather than transferring the points successively. This method helps to avoid the accumulation of errors.

Point N°1



Sheet with the data

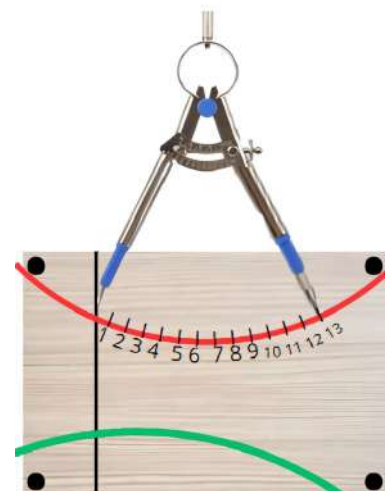


The double key

Point N°13



Sheet with the data



The double key

# The double key

03

## Making a Double Jointing Key

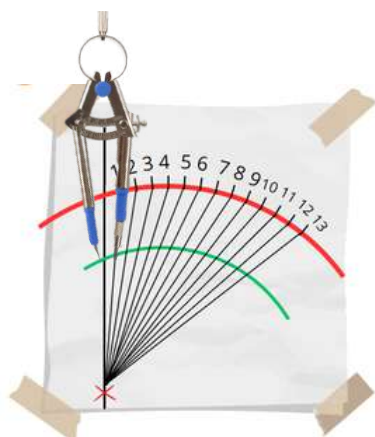
9

Take the **tracing sheet** and transfer each point onto the corresponding arc on the key. Use a **compass to measure** the distance between the axis and each point on **the bilge** arc. **Transfer these measurements onto the plank**, starting from the intersection point of the axis and **the bilge** diameter, then mark each corresponding point. **Repeat the process for each graduation** to get a tracing that is faithful to the proportions defined on the sheet.

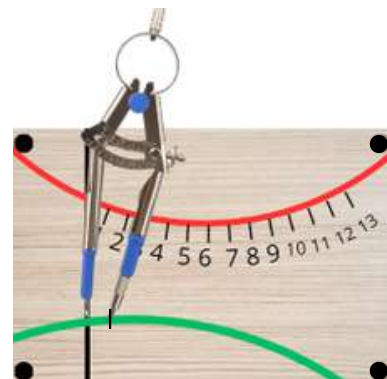
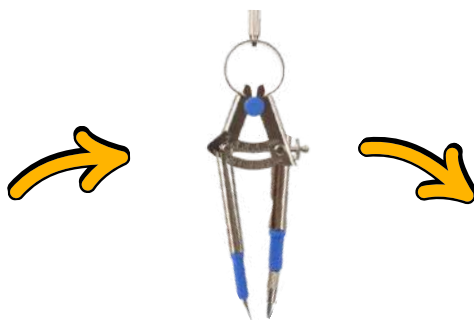
### Verification Before Proceeding to the Next Step

- ✓ Each point is correctly transferred onto the plank.
- ✓ The distances respect the measurements taken from the sheet.

Point N°1

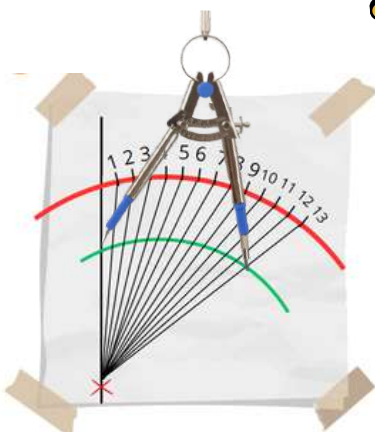


Sheet with the data

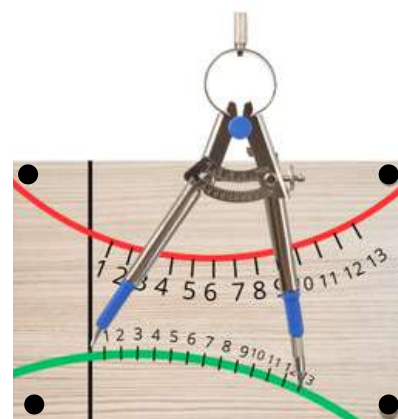


The double key

Point N°13



Sheet with the data



The double key

# The double key

03

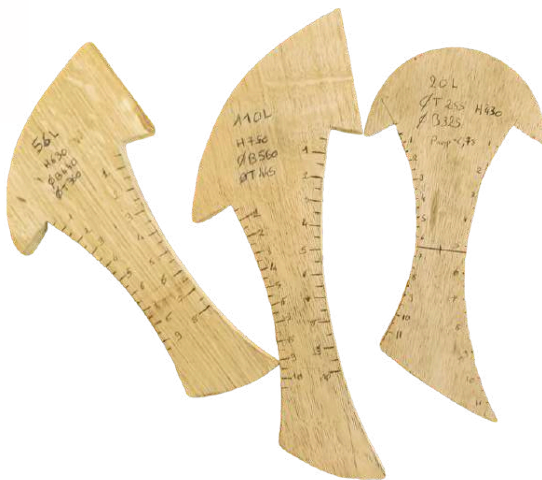
## Making a Double Jointing Key

### Information to Inscribe on the Jointing Key

- ◆ Barrel Volume → Example: 225L, 500L, etc.
- ◆ Head Diameter → Example: H = 57 cm
- ◆ Bilge Diameter → Example: B = 69 cm
- ◆ Head Radius → Example: HR = 28.5 cm
- ◆ Bilge Radius → Example: BR = 34.5 cm
- ◆ Bilge Development → Example: Bdv ≈ 216.7 cm for a 225L barrel.

### Expected Outcome

- ✓ A clear and well-identified key.
- ✓ Time-saving during use.
- ✓ Assurance that the dimensions are respected before assembly.

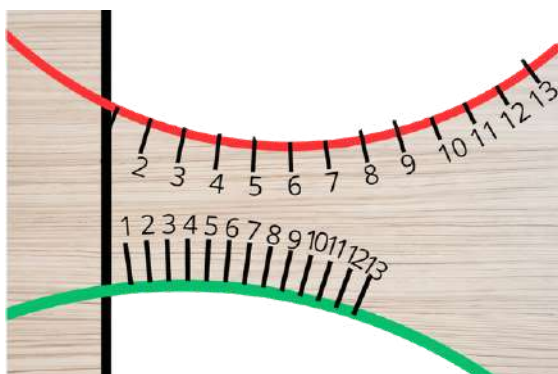


Inscribe "**Bilge Diameter (ØB)**" with its markings on one side and "**Head Diameter (ØT)**" with its markings on the other.

To avoid any confusion, specify **the respective radii:**

- **RB = 34.5 cm**
- **RT = 28.5 cm**

### Expected Outcome



### Verifications Before Proceeding to the Next Step

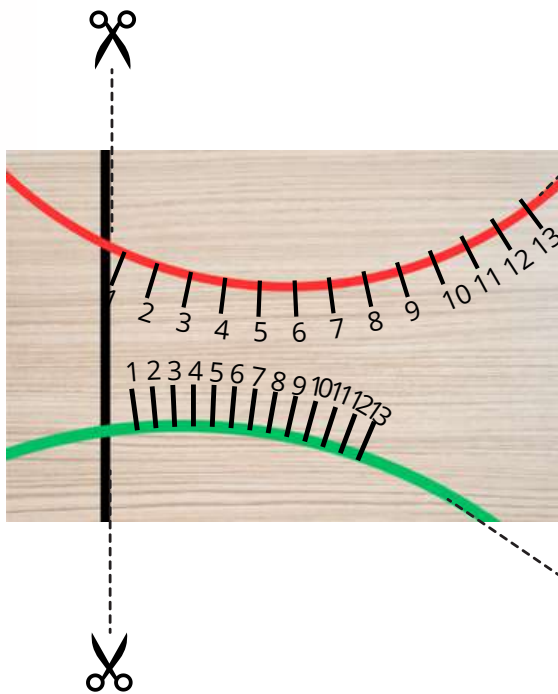
- ✓ The dimensions and angles are precise.
- ✓ The cuts are clean, precise, and conform to the tracings.
- ✓ The curves of the bilge and head are well respected.

# The double key

03

## Making a Double Jointing Key

Cutting **the Bilge Diameter** Axis  
Cut from the center to the intersection with **the bilge** diameter arc.

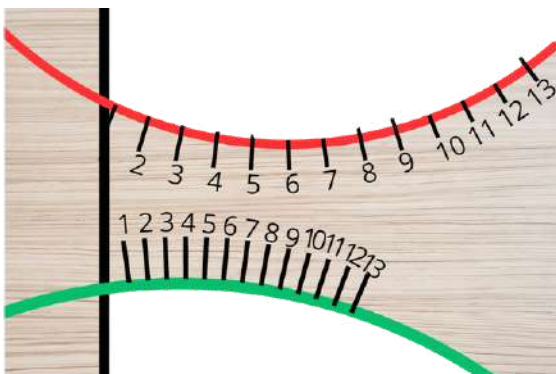


Cutting **the Bilge** Diameter Arc  
Follow the arc to its intersection with **the bilge** diameter axis.

Cutting **the Head** Diameter Arc  
Follow the arc to its intersection with **the head** diameter axis.

Cutting **the Head** Diameter Axis  
Cut from the center to the intersection with **the head** diameter arc.

### Expected Outcome



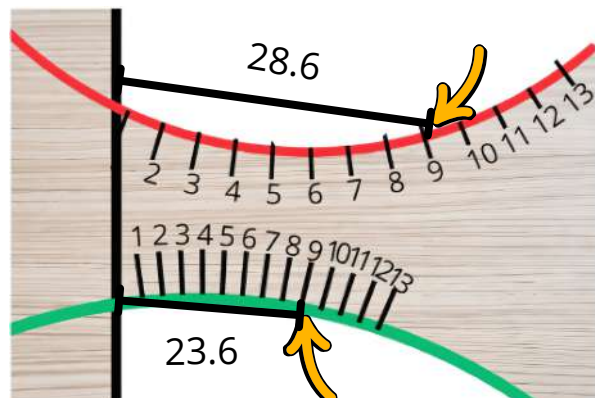
### Verifications Before Proceeding to the Next Step

- ✓ The dimensions and angles are precise.
- ✓ The cuts are clean, precise, and conform to the tracings.
- ✓ The curves of the bilge and head are well respected.

# The double key

04

## Verification of the Gauge



### Choose Two Numbers

- Select a **number** on the head arc.
- Select **the same number** on the bilge arc .

### Measure the Corresponding

- Measure the distance between the central axis and the chosen number on the head arc.
- Measure the distance between the central axis and the number directly following it on the bilge arc.

### Calculate the Reduction Coefficient

$$K = \frac{\text{Distance measured on the head arc}}{\text{Distance measured on the bilge arc}}$$

### Verify the Consistency of the Values

#### Simplified Summary:

- If  $K_{\text{measured}} \approx K_{\text{initial}}$  → The trace is correct, the key is valid.
- If  $K_{\text{measured}} \neq K_{\text{initial}}$  → Error in trace, requires correction.

### Exemple Concret de Vérification de la Clef de Jointage pour une Barrique de 225L

#### Contexte :

Nous avons une barrique de 225L avec :

- Diamètre en tête : 57 cm
- Diamètre en bouge : 69 cm
- Coefficient réducteur théorique :  $K = \frac{R_t}{R_b} = \frac{28,5}{34,5} \approx 0,826$

L'objectif est de vérifier la précision de la clef de jointage avant son utilisation.

### 1 Étape 1 : Mesurer la Distance Réelle sur la Clef

- 1 Placer la clef sur une surface plane et bien stabilisée.
- 2 Avec une règle graduée ou un pied à coulisse, mesurer la distance entre :
  - L'axe central et un numéro sur l'arc de tête → ex. 23.6 cm
  - L'axe central et un numéro correspondant sur l'arc de bouge → ex. 28.6 cm

### 2 Étape 2 : Calcul du Coefficient Réducteur Mesuré

Formule :

$$K_{\text{mesuré}} = \frac{\text{Distance mesurée sur l'arc de tête}}{\text{Distance mesurée sur l'arc de bouge}}$$
$$K_{\text{mesuré}} = \frac{23,6}{28,6} = 0,825$$

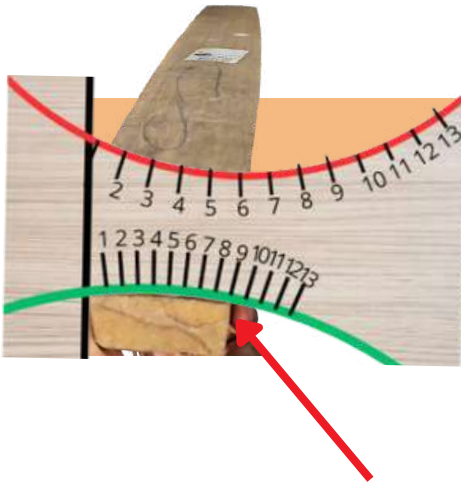
### 3 Étape 3 : Comparaison avec le Coefficient Théorique

- Si  $K_{\text{mesuré}} \approx K_{\text{théorique}}$  (ex. :  $0,825 \approx 0,826$ )
- Le tracé est correct, la clef est validée.
- Si  $K_{\text{mesuré}} \neq K_{\text{théorique}}$  (écart supérieur à 0.01)
- Erreur détectée, nécessite une correction (ponçage léger, ajustement du tracé).

# The double key

05

## Use of the Jointing Gauge

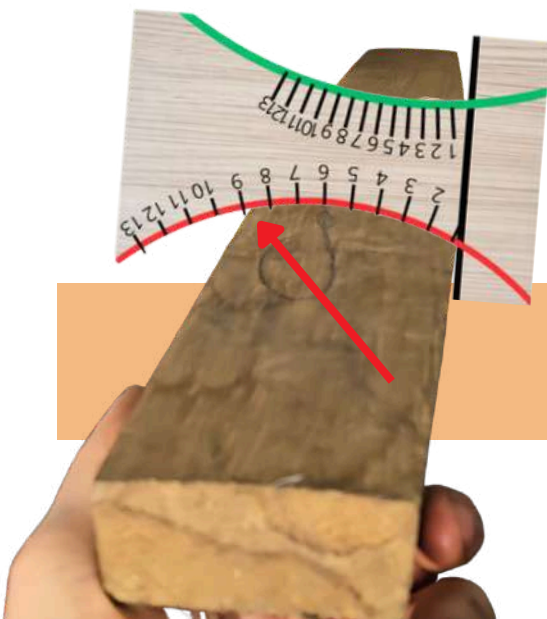


### Verification of the Jointing Key's Use

In the accompanying example, the jointing key is placed on a stave to check its proportions and verify the jointing angle at the head.

- ✓ It is observed that the stave corresponds to number 9 on the key.
- ✓ The jointing angle associated with this mark is respected, ensuring a precise fit.

The stave's angle is pressed firmly against the central axis of the key, thus ensuring good positioning and a uniform distribution of the staves when assembling the barrel.



### Verification of the Jointing Key's Use

In the accompanying example, the jointing key is placed on a stave to check its proportion and verify the jointing angle at the bilge.

- ✓ By using the bilge side of the key, it is found that the stave also corresponds to number 9.
- ✓ The jointing angle associated with this mark is respected, ensuring a precise fit.

The stave's angle is pressed firmly against the central axis of the key, thus ensuring good positioning and a uniform distribution of the staves when assembling the barrel.

### ✦ Advantages and Disadvantages of the Double Jointing Key

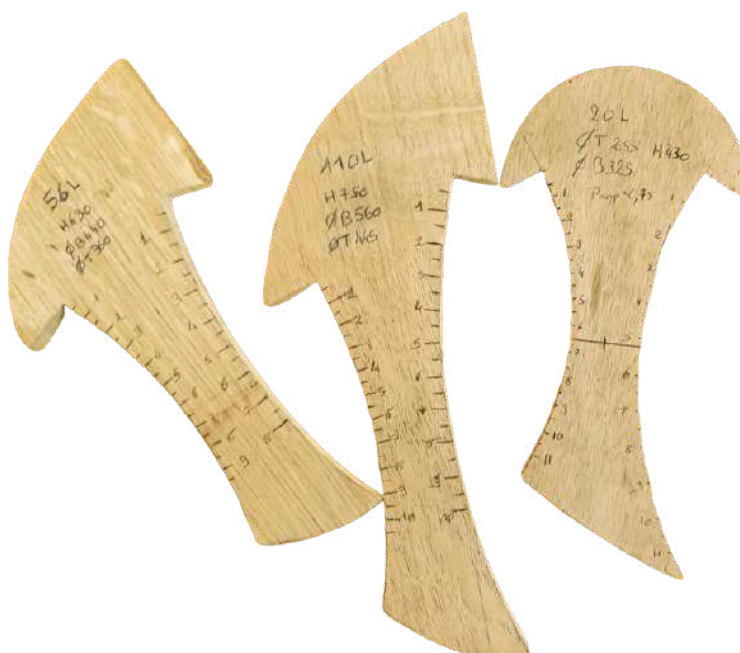
The use of **the double jointing key** has both **advantages and disadvantages** that are important to know in order to optimize its use when tracing staves.

#### ✓ Advantages of the Double Key

- ✓ **More precise** → Allows for optimal stave adjustment thanks to a more detailed tracing.
- ✓ **Control of the curvature and angle at the bilge** → Ensures a better distribution and a uniform alignment of the barrel.
- ✓ **Easy to use** → Once traced, the key facilitates the rapid and precise positioning of the staves.

#### ✗ Disadvantages of the Double Key

- ⚠ **Longer tracing process** → The creation requires more steps and precision than a single key.
- ⚠ **Complexity of use** → Requires a good understanding of the ratio between the head and bilge for correct application.
- ⚠ **Reliance on accurate measurements** → Any tracing or proportion error can impact the entire jointing process.





*It's up to you to put  
your knowledge into  
practice and perfect  
your expertise!*