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The four important factors for a ship’s windage area calculations

by Team TheNavalArch | Sep 8, 2020 | Marine Operations, Marine Transportation | 2 comments

Introduction

The windage area of a vessel or offshore structure is the area that is exposed directly to

- Part of the hull/offshore structure above the waterline
- Superstructure/Living Quarters
- Any deck cargo

Calculating the windage area is required when we need to know the wind forces acting on the vessel. The formula for wind force calculation on any structure is:

Wind Force = Pressure x Area exposed to the wind direction

Pressure is given as Pressure = ½ ρV^2, where ρ is the density of wind, which is generally taken as 1.23 kg/m^3, and V is the wind speed in m/s. The area exposed to the wind direction is also called 'Windage area'

This article explores the intricacies involved in both the calculation of wind speed and the calculation of the windage area. We take a look at four important factors – Wind Speed & Direction, Height Factor, Shape Factor, and Shielding effects.

Windage Area

The windage area of a structure is the area exposed to the wind projected at a section that is perpendicular to the wind direction. The windage area from different directions will also be different, depending on the geometry of the structure. This is illustrated in the figure below. We can see that when the wind is from the transverse direction (beam wind), the exposed area of the cargo to the wind is Length x Depth, while for the wind from longitudinal direction (head wind), the exposed area is Breadth x Depth, which is lesser.

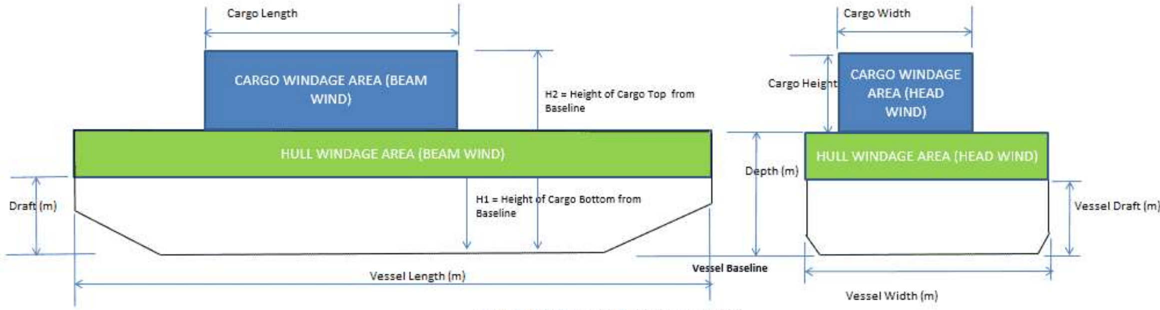
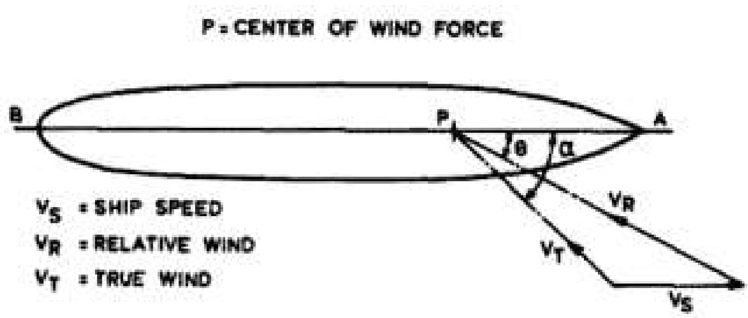


Figure 1 - Windage Areas for Head and Beam Seas

What if the wind is not in the transverse or longitudinal direction? What if it is at an angle to the longitudinal axis of the structure? How do we calculate the windage area?

For such cases, there's a simpler way of estimating the wind force if the transverse and longitudinal windage areas are known. Referring to **PNA Vol 2, Sec 5.2, Eq 26 [Ref 2],** we can see from the figure below



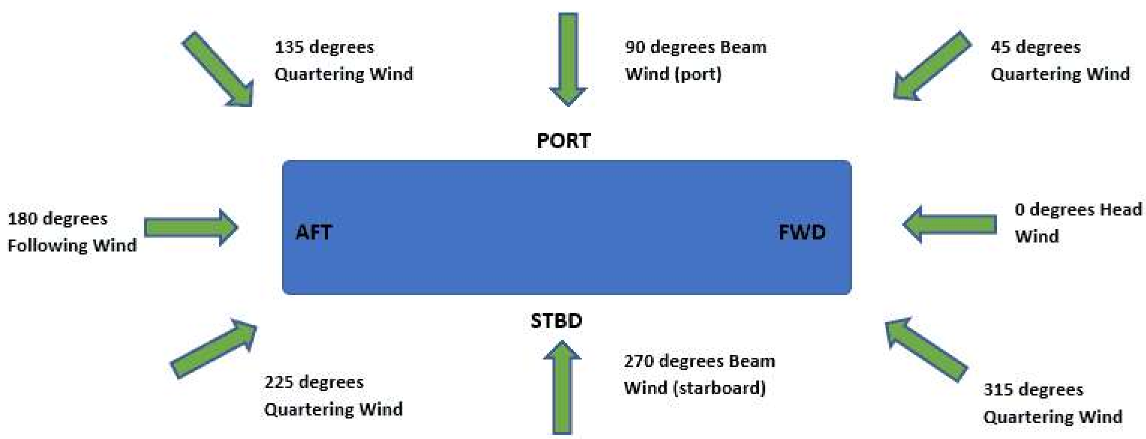
Wind angle calculations (Ref [2])

$$F_W = K * \rho_{air}*V_R^2*(A_L \sin^2\theta + A_T \cos^2\theta)/\cos(\alpha - \theta) \text{ .... (Formula A)}$$

Here the vessel is moving forward with a speed V_S, while the true wind is V_T at an angle α to the longitudinal axis of the vessel. A_L and A_T are the projected windage areas for head and beam wind. The value of K varies between 0.5 and 0.65 and is generally taken as 0.6. The above equation can be used even for head and beam wind directions.

Wind Speed and direction

Wind speed is simply the speed at which the wind is blowing. However, it is the direction and height at which the wind is blowing that assume significance when calculating the wind load on a structure. The wind speed can be different in different directions, resulting in varying wind loads. The dominant wind direction and speed have to be taken into consideration for design purposes.



Wind directions shown in Vessel's plan view

Height Factor

At the same time, the speed of wind also varies with the height of the structure above the water surface. Generally, the wind speed is higher at higher levels of a structure. The effect of height is taken into account by adding a factor called 'height factor' in the calculation of the windage area. A structure is divided into different 'height zones' depending on its

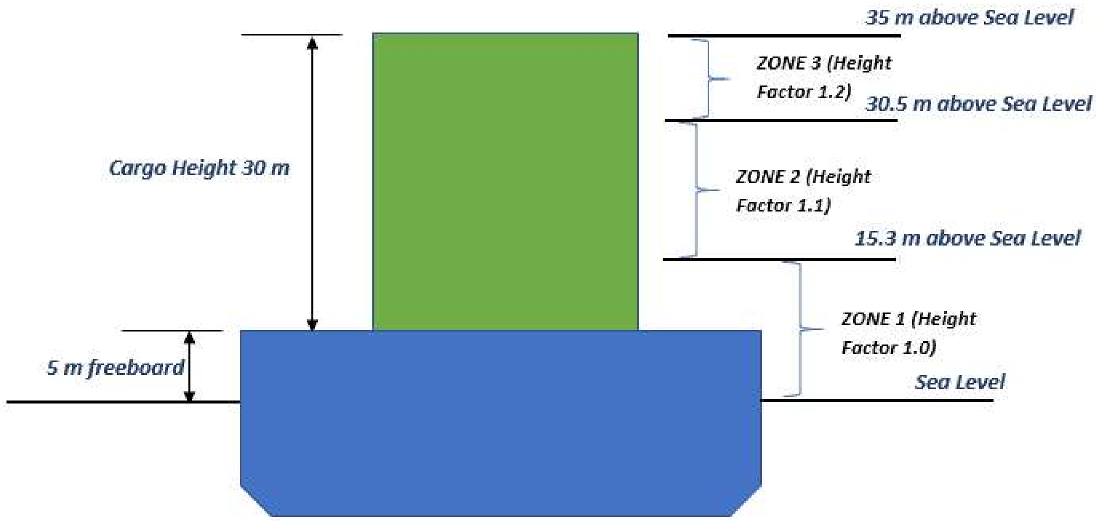


TABLE 2
Values of C_h

The height, h, in m (ft), is the vertical distance from the design water surface to the center of area, A, defined in 3-1-3/1.3.3.

Height (Meters)	*Height (Feet)*	C_h
0.0–15.3	0–50	1.00
15.3–30.5	50–100	1.10
30.5–46.0	100–150	1.20
46.0–61.0	150–200	1.30
61.0–76.0	200–250	1.37
76.0–91.5	250–300	1.43
91.5–106.5	300–350	1.48
106.5–122.0	350–400	1.52
122.0–137.0	400–450	1.56

Height factor for different zones (Ref [1])

Shape factor

The shape of a structure exposed to wind also influences the wind force that it experiences. For example, a cylinder when exposed to wind will experience lesser force windage area. Shape factor can be obtained from standard references like ABS Rules [Ref 1]

Values of C_s (2012)

Shapes or combinations of shapes which do not readily fall into the specified categories will be subject to special consideration.

Spherical	0.4
Cylindrical shapes (all sizes)	0.5
Flat surfaces	1.0
Hull	1.0
Upper structure (column-stabilized unit)	1.0
Superstructure or deck house	1.0
Isolated Structural shapes (large cranes)	1.5
Under deck areas (smooth surfaces)	1.0
Under deck areas (exposed beams and girders)	1.3
Open truss rig derrick (each face)	1.25
Wires (total surface exposed in transit)	1.2

Shielding effects

When one structure is blocked by another structure in front of it (the windward frame), then the wind force on the first structure (leeward frame) is expected to be less, and it is called ‘shielded’ by the second structure. This ‘shielding effect’ can be taken into account by factoring the windage area of the shielded structure by a factor called ‘shielding factor’. The shielding factor for a particular structure depends on how solid is the windward frame, and what is the shape of the members comprising the windward frame. DNV-RP-C205 Sec 5.3.3 [Ref 3] provides detailed tables for calculating shielding effects. For a conservative calculation, shielding effects can be ignored.

vessel, its superstructure and cargo, and calculates the factored windage areas for each of them.

The calculation steps are lined out below:

- Take the vessel's geometry details from the user. The vessel's wind area is the part of the vessel above water, i.e., the freeboard of the vessel. The freeboard is divided into different 'height' zones depending on how high the freeboard is. From *ABS Rules for Building and Classing Mobile Offshore Drilling Units, 2019, C 3-1-2/1.3.2,* we can see that the height coefficient is 1.0 for a freeboard of up to 15.3 m. If the vessel's freeboard is more than 15.3 m (which is generally rare), then the zone of the hull that is at a height more than 15.3 m from the waterline will have to be assigned a height coefficient of 1.1.
    - If A1 is the area in Zone 1 (below 15.3 m from waterline), and A2 is the area in Zone 2(more than 15.3 m from the waterline, but less than 30.5 m from waterline), then the total windage area factored for height will be A = 1.0 x A1 + 1.1 x A2. This applies to both longitudinal or transverse areas
    - The shape coefficient for the hull is generally taken as 1.0, as the part of the hull above the freeboard is generally flat with near rectangular section.

- Apply a similar method as for the hull to Superstructure and cargo
    - For each item, calculate the effective windage area by factoring the different zones with different height coefficients
    - Shape coefficients will have to be assigned depending on the shape of the item facing the wind
    - The shape coefficient may be different in transverse and longitudinal directions,

- If the wind force is required in a direction other than transverse or longitudinal, then use Formula A to get the results

Following the steps above, a fair assessment of the wind forces on a structure can be done.

That brings us to the end of this article. We hope this was useful to you. Please do check TheNavalArch's own product for windage area calculations that helps you perform this calculation effectively and with a simple user interface.

References

1. *ABS Rules for Building and Classing Mobile Offshore Drilling Units, 2019, C 3-1-2/1.3.2*

2. Principles of Naval Architecture, Vol 2, Sec 5.2, Eq 26

3. DNV-RP-C205, Sec 5.3.3

Wind Load Calculator for Ships

$99.00

What does this Excel App do? This Excel app helps the user calculate the complete wind load for a vessel with cargo/topsides Windload is given by: FW = K * ρair*VR^2*(AL sin^2θ + AT cos^2θ)/cos(α – θ)** ρair = Density of Air, VR = Wind Speed relative to vessel , AT = Cargo + Hull … Continue reading

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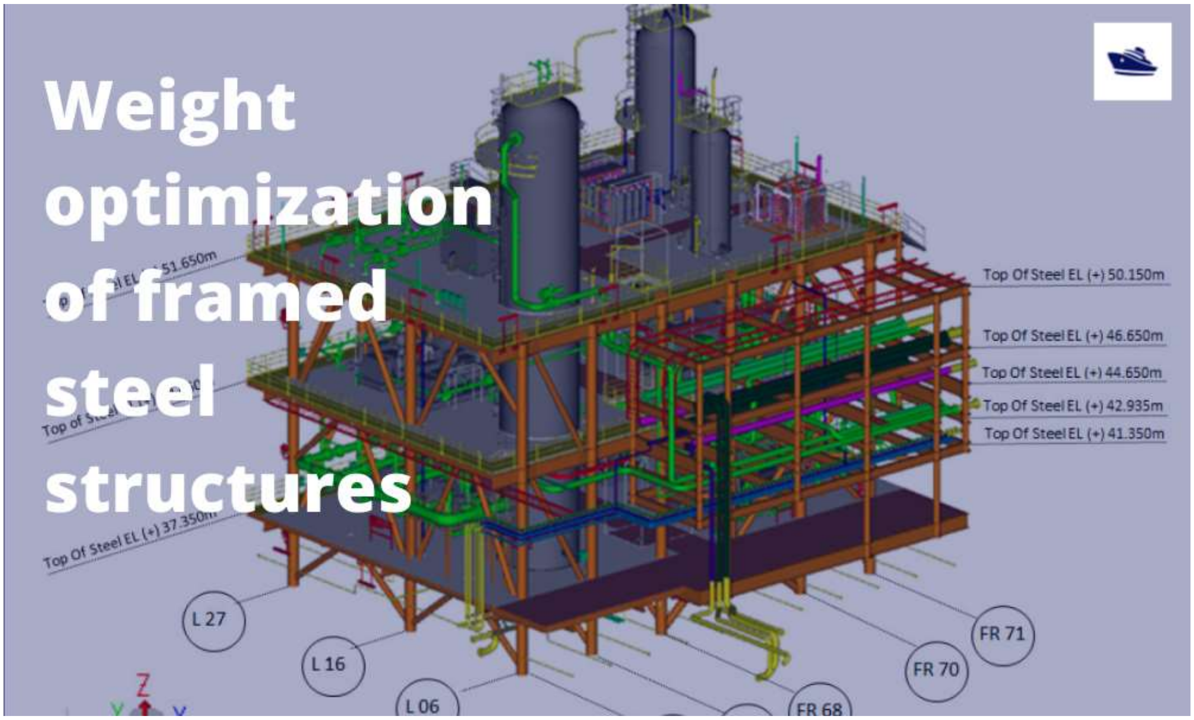

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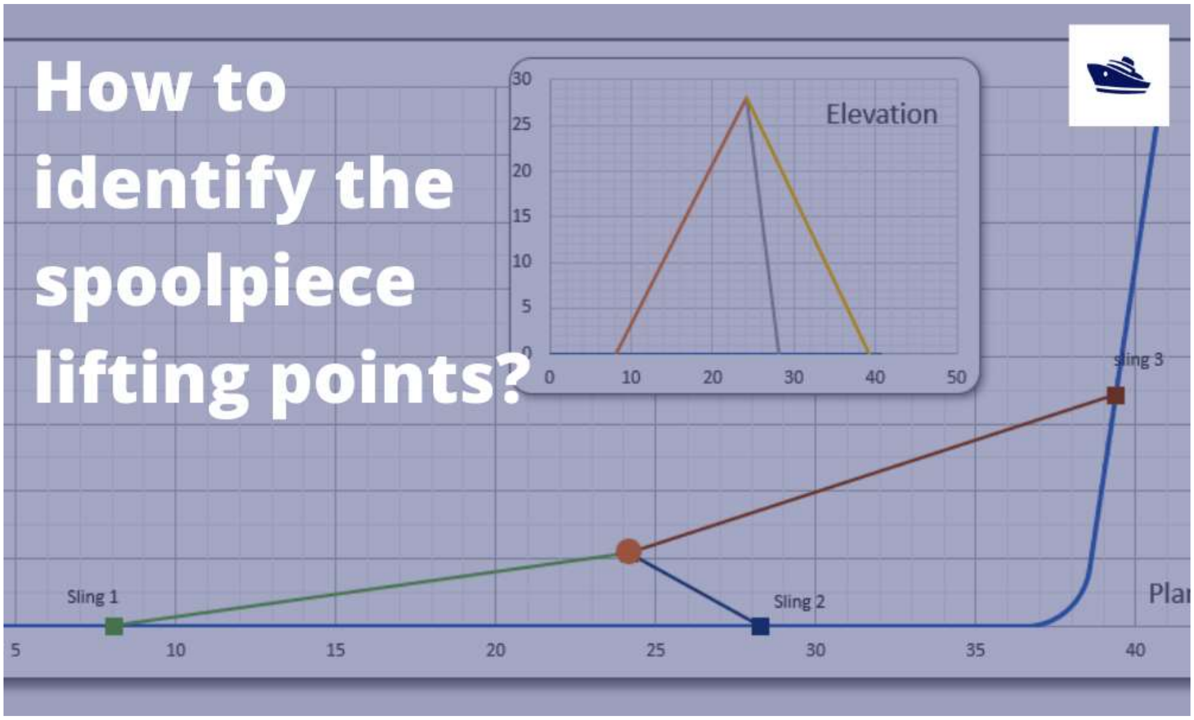

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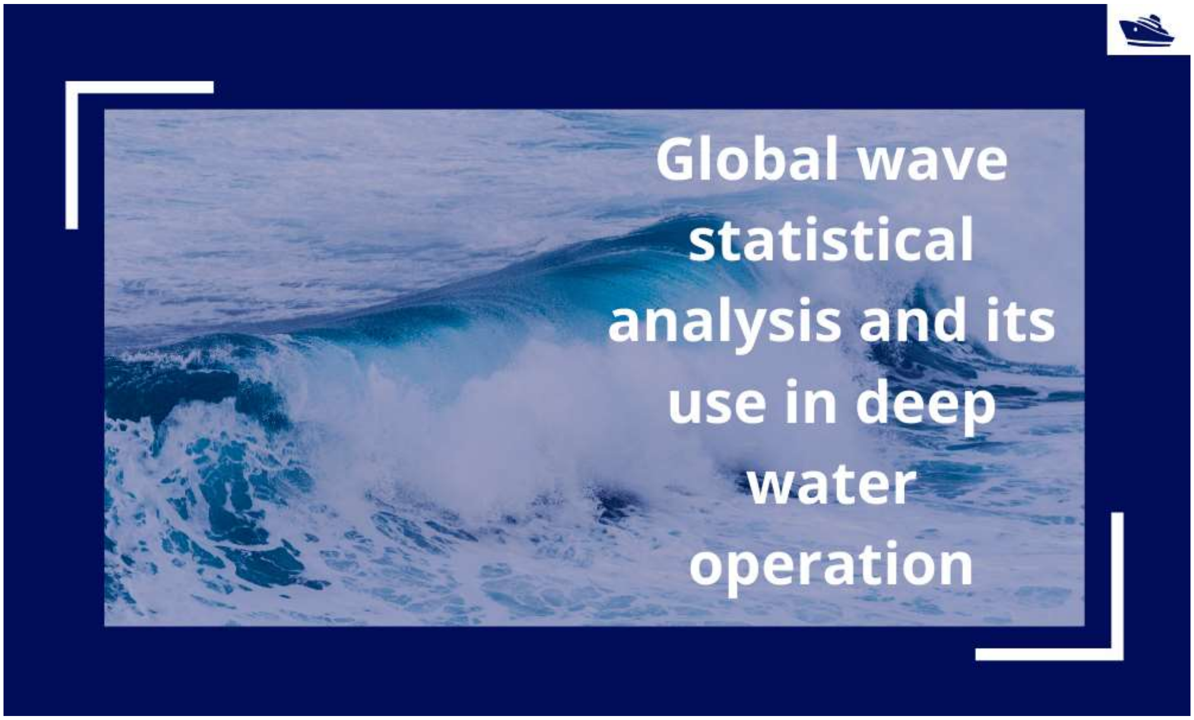

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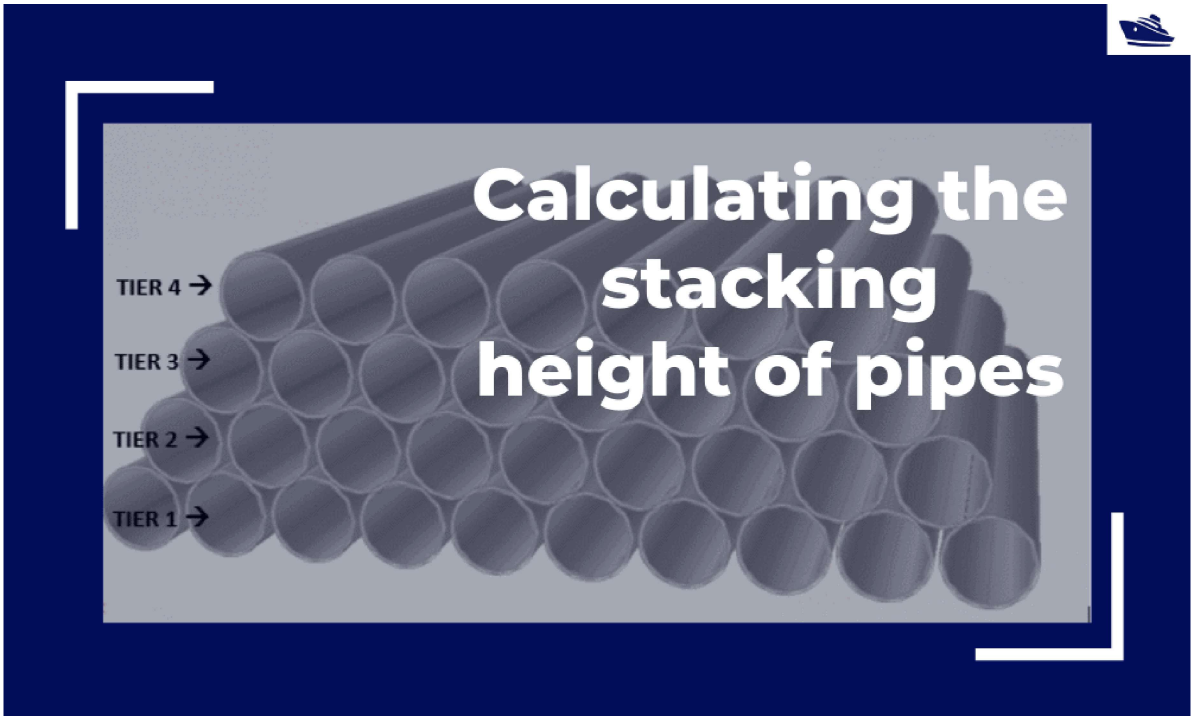

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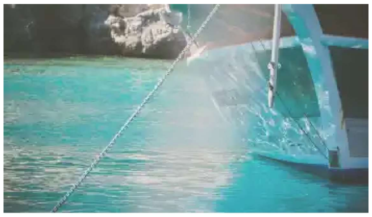

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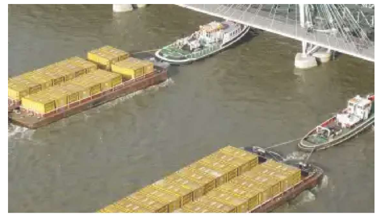

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Pietro on October 4, 2022 at 3:54 am

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Team TheNavalArch on October 5, 2022 at 5:03 pm

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