Condensation mitigation of forward cabin bed in an Outbound 46

Executive Summary (the Why, What and How):

Why is this even a subject to discuss? Well the **"WHY",** is to stay healthy.

Many see condensation under mattresses as a lack of ventilation. Ventilation can help solve the problem. But "Lack of ventilation" is not the true problem statement.

The true problem statement is something like this: There is unwanted water on the board under the forward cabin mattress (during the cold-water season), which causes mold and potential health problems. We want it to be dry.

The high level **"WHAT" we try to achieve,** is to have it dry.

Looking at this from a physics standpoint. There are only three things involved in making condensation happen (or not) at the bed-board under the mattress. Air temperature and Relative humidity [RH] in the mattress (air), and surface temperature at the bed-board. If the dew point is above the temperature of the board surface, water vapor will condense onto it. If the dew point is below the board surface temperature, moisture will not condense.

The detailed level "WHAT" is: Ensure that the dew point is below the surface temperature at the bed-board at all seasons.

Going straight to the HOW, we've chosen to:

1. Put a leak-proof mattress cover on the mattress, to decrease the RH in the mattress.
2. Put insulation under the bed-board, to decrease the dew-point at the bed-board surface.

Result: *At this point, we have no result since we have passed the cold season in the Med. The true test will be next winter. Results will be posted then.*

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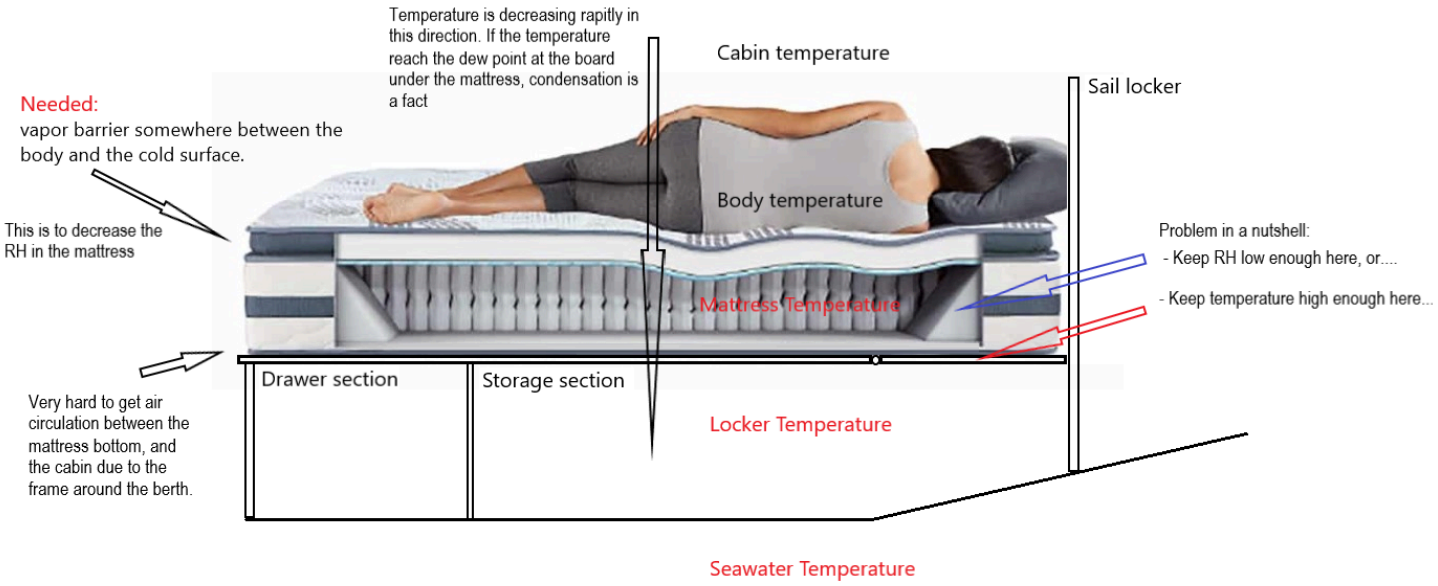
Detailed Analysis:

So **"HOW"** can this be solved?

We need to manipulate the Air temperature, RH and/or the surface temperature at the bed-board under the mattress to ensure the dew point is below the surface temperature at the board. (Note that the aft mattress never get condensation, since the water heater is in the compartment underneath, so the dew point is never reached)

Let's assume that the air temperature in the mattress under a warm body is fixed. This leads to only two ways to avoid condensation at the board. Influence one of them or a combination of the two, can solve the problem:

1. Decreasing the RH in the mattress.
2. Increasing the temperature of the board.



Solution Thoughts:

Froli or Hypervent:

Looking at the popular solution of having plastic springs Froli system or hypervent mats under the mattress. I believe this affects both #1 and #2 above. There is air movement under the mattress that removes any condensation on the board that formed during the night. It also mitigates the mattress material to absorb the condensation, making the RH even higher inside the mattress. It is possible that the board surface temperature is increased due to the ventilation.

Pros:

- Proven solution recommended by many cruisers.

Cons:

- Cost
- Installation (Froli).
- Adds height to the bed.
- Adds weight to the bed, which makes it harder to open.

How to decrease the mattress RH:

Idea 1:
Put a leak-proof mattress cover on the mattress. (We have done that).

Idea 2:
Increase ventilation with Froli or Hypervent (see above)

How to increase the surface temperature of the bed-board:

Idea 1:
Add insulation under the bed-board.
This is the solution we will undertake. See details here.

Idea 2:
Add insulation under the mattress on the lid.

Idea 3:
Add a 12 volt electrical blanket under the mattress.

Idea 3:
Increasing the temperature in the “Storage section”.

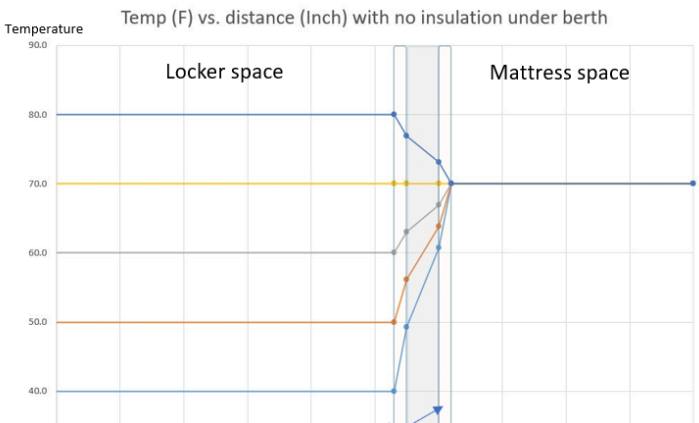
Ways to do that:

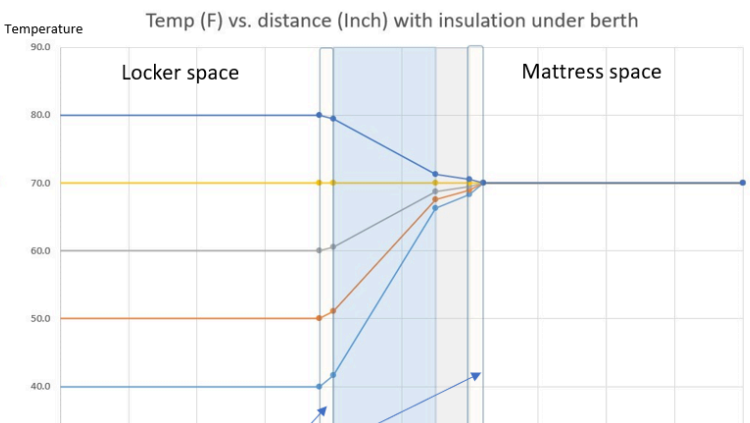
- With a fan, force cabin air to exchange the locker air. By that, increase the temperature in the locker space. – A 12V fan is probably silent enough and low power enough to work without shore power.
- Install an electrical heater in the locker space. Thermostat operated. – Probably needs to be line voltage, so it only works with shore power.

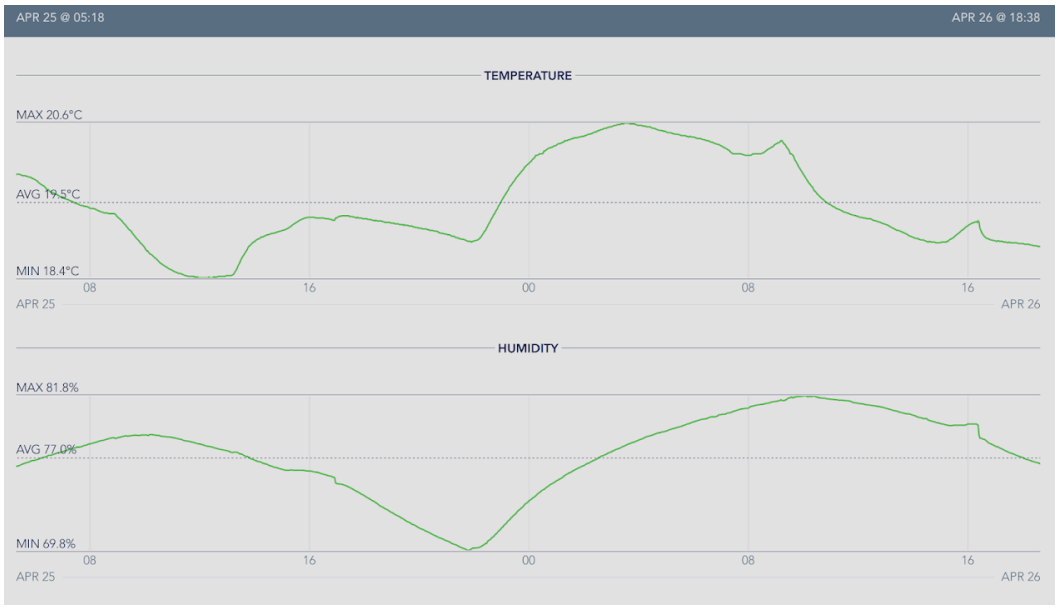
Insulation under the bed-board:

After calculations , it seems like this is a viable option to get rid of the condensation. Looking at possible temperature differences, R-Values for the wood bed-board and Polystyrene sheets. Then calculate the heat transfer and the dew-point, show that the bed-board should stay dry if adding 1.5” Polystyrene under the board. This is easily done and most of it will be invisible, and not in the way at all.

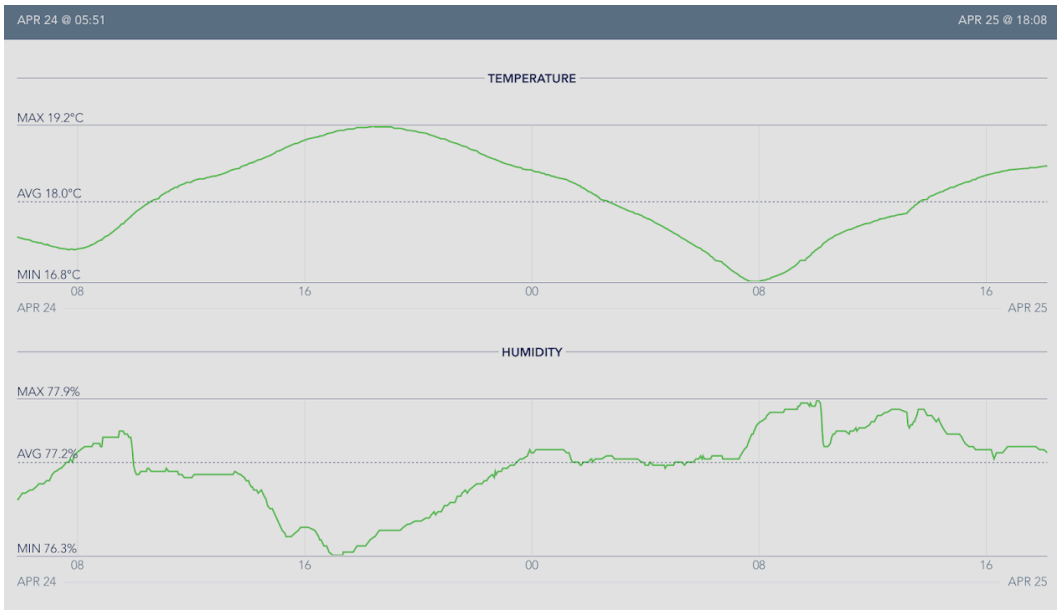
- 2 nights measurement shows that the RH at the wood board level increases from 70% to over 80% over night, and then returns to 70% during the next day.
- Calculations show that at 80% RH, a temperature difference larger than 7F will cause condensation.
- Without insulation under the bed-board, the delta-T is >7F as soon as the locker temperature is <50F
- With insulation, delta-T is <7F all the way down to freezing temperatures.
- Even at 90%RH, where only 3F difference is needed for condensation, the insulation should do the job.







Under the mattress.



In the locker.

After insulation was added, the board temperature was significantly increased, which is an indication that the insulation is doing its job.

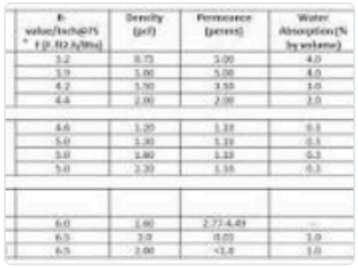
Insulation under the middle part of the bed. The part “foot-end” of the bed is above a ventilated better insulated part of the bed. And the body heat and moisture is less at your legs and feet. So insulation isn’t as necessary there.

Detail of the insulation under the head-part of the bed.

The world’s best insulation team :-)

In action under the bed…. with the insulation attached above.

Information source: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf



View all

3.6 to 4.2 per inch

Expanded **Polystyrene**. Also called **Styrofoam insulation**, this is the least expensive material. It provides **R-values** that range from 3.6 to 4.2 per inch.

1.25

In general, one **inch** of solid wood is considered to have an **R value** of 1. The general **plywood R value per inch** is 1.25. The general **R-value** of particle board underlayment is 1.31 **per inch**. Dec 21, 2018

The physics behind condensation under a bed:

Condensation Happens — Keep Track of the Dew Point!!

Air contains water vapor. Wherever air goes, water vapor goes. When humid air contacts a surface that is cold enough, the water vapor in the air will condense onto that cold surface. The concept of the air dew-point temperature is very useful in understanding when, why and how much condensation will occur—and how to avoid it.

Dew Point vs. Relative Humidity

Relative humidity is just that, a relative measurement and not one that expresses the absolute amount of water vapor in the air. In simple terms, RH is the amount of water vapor in the air compared to the maximum amount the air can hold at its current temperature. Knowing only the RH of the air is not much help in predicting condensation.

Unlike RH, the dew point does not change with air temperature. In that sense it is an “absolute” measurement of the amount of water vapor in the air. When you know the dew point of the air and the temperature of a surface, you can predict condensation. If the dew point is *above* the temperature of the surface, water vapor

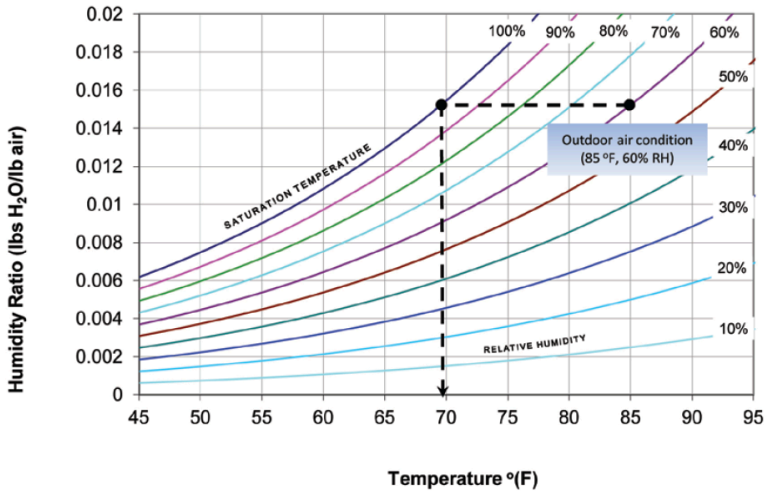
will condense onto that cold surface. If the dew point is *below* the surface temperature, moisture will not condense. It is simple to predict condensation, as long as you know the dew point of the air surrounding the surface.

With a psychrometric chart you can find the dew point based on the temperature and RH of the air. With this chart and measuring air temperature and RH, you can determine the value of the dew point.

(A simplified psychrometric chart is shown in Figure 1-18)

Example below Figure 1-18: Air temperature of 85°F and RH 60%. The dew point is 70°F. In other words, air at those conditions will begin to condense moisture when it contacts any surface that has a temperature of 70°F or below. Interestingly, at RH = 90%, a surface only has to be 3°F cooler than the air for condensation to occur.

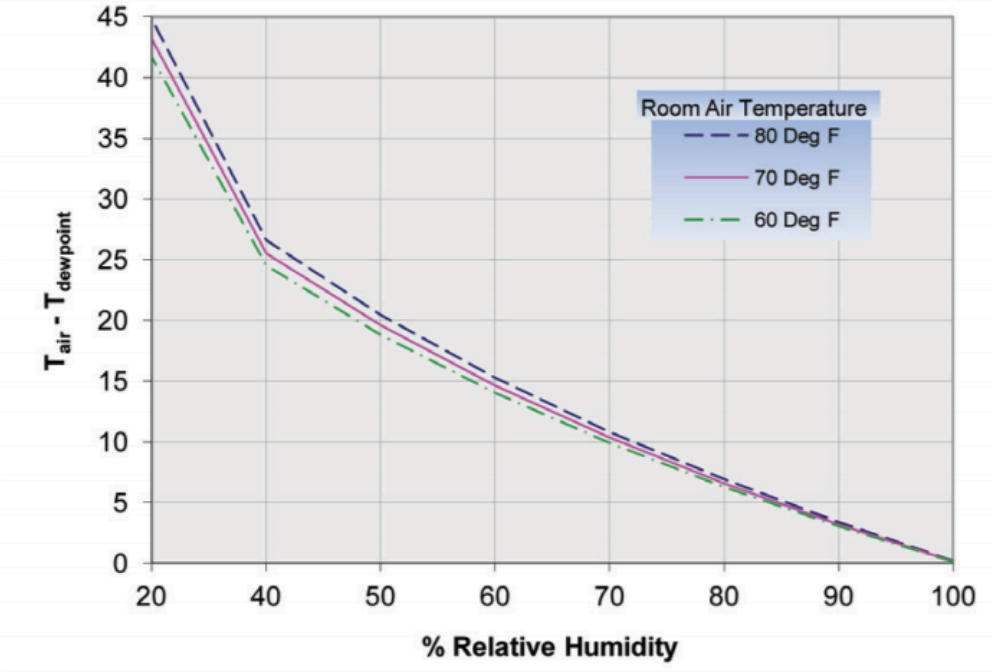
Figure 1-18 A Simplified Psychrometric Chart Relates Air Temperature, RH and Dew Point.



[11] The technically more accurate definition of relative humidity is the ratio of vapor pressure in the air sample compared to the vapor pressure of that air if it were completely saturated at the same temperature, expressed as a percentage. But the definition provided above is sufficiently accurate, easier to understand and useful for managing moisture in buildings.

[12] The psychrometric chart is a powerful tool for understanding the water vapor characteristics of air and the effects of heating and cooling moist air. Its history and use are fully explained in the ASHRAE publication *Understanding Psychrometrics* by Donald Gatley.

Figure 1-19 The Difference Between Room Air Temperature and the Dew Point as a Function of RH



Causes of Condensation:
Condensation is the result of excessively high dew point, unusually cold surfaces, and/or a combination of the two.

The dew point is a balance between the addition and subtraction of water vapor from the air. A bed has both indoor and human sources that add water vapor, and the bed's mechanical systems must have adequate dehumidification capacity to remove it (ventilation), or add heating under the bed, in order to keep the dew point within reasonable limits.

During the warm water season, this is not a problem since the temperature difference between a body, mattress and the temperature of the bottom plate is neglectable. So, no condensation is happening.

However, during the cool water season, the temperature difference between the top and bottom of the mattress is huge. The largest source of humidity and heat are the warm body at the top of the mattress. And since the bottom is cool, condensation happens.

Water vapor may be removed from indoor air by dehumidification (e.g., air conditioners or dehumidifiers) or by ventilation (only when the outside air is dry).

Solution: Control Condensation
Effective condensation control requires keeping the dew point below the temperature of surfaces where it can cause problems. The dew point can be lowered by designing, installing and maintaining a system to control temperature and humidity in the bed environment. Bed enclosures can be designed and constructed so surface temperatures within the assemblies are above the dew point regardless of season.

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