

Anticipating Condensation Risk in Shipping Containers Before Departure

Moisture can quietly damage cargo during weeks at sea, but which containers are actually at risk? This thesis shows the answer can be anticipated before a container leaves the port.

Before a shipping container even departs, it is possible to identify which shipments are more likely to experience condensation risk. In this study, the 40 % of shipments ranked as highest risk accounted for 71 % of those that later experienced elevated exposure.

That matters because once the container doors are closed, there is no opportunity to change how its cargo is protected. The doors often remain sealed for weeks while the container crosses oceans, seasons and climate zones. Any decision about moisture protection must therefore be made before the conditions that create the problem have even developed. The importance becomes even more apparent when looking at the bigger picture. Around 80 % of the volume of internationally traded goods travel by sea. At this scale, moisture-related damage to packaging, cargo and materials can become substantially costly, both for the company and the environment. Protecting the cargo against moisture is therefore important, but protection also comes at a cost.

So, what makes one shipment riskier than another?

The answer, it turns out, is not chance. Instead, four pieces of information available before the container departs stood out: which route the container is set to travel, when it is set to depart, whether it is moving from a warmer to a colder climate, and how humid the air already inside is when the doors are sealed shut.

One particularly interesting discovery concerned the direction of travel, i.e. moving

from warm to cold and vice versa. Imagine a container loaded in a warm, humid climate and transported towards a much cooler destination. As the container cools, the air inside becomes less able to hold moisture. Under sufficiently humid conditions, condensation can form. This means that two containers travelling between the same places can face different conditions simply because they are moving in opposite directions.

These discoveries were made by analyzing temperature and humidity measurements from 322 real shipments together with global climate data. The measurements were used to determine how much of each container journey was spent under conditions associated with condensation risk. The four risk-drivers were then combined into a statistical model that estimated the likelihood of a shipment experiencing elevated risk exposure.

The model cannot predict exactly what will happen inside each container. However, it enables ranking shipments from lower to higher risk before departure. Much like a weather forecast cannot tell where every raindrop will fall but can still tell us when to bring an umbrella, a ranked risk estimate can help signal where preventive measures may be most valuable. Instead of treating every shipment as equally exposed, companies could use information from past journeys to prioritize moisture protection towards shipments with greater expected risk. In this way, data from yesterday's containers can help protect the cargo of tomorrow.

