D. Copper Tubing Design

The copper tube heat exchanger should extra 395.45 W. For effective heat transfer between the refrigerant and the copper ambient air, the refrigerant is set to evaporate at -3ºC inside the tube. This gives a saturation pressure of 178 kPa and hence a latent heat of vaporization of 160.2 kJ/kg. The mass flow rate of the refrigerant is then 0.00257 kg/s. For the selected unit, the copper tube has an internal diameter of 0.011 m. Therefore the velocity of flow is 0.05 m/s giving a Reynolds number of 2527.07 which is in the turbulent flow regime. The Nussult number is then 18.2. For this the internal convective heat transfer coefficient (h_i) is 121.64 W/m^2-K. For external heat transfer coefficient (h_o) the Prandtl number is 0.71 and the Grashof-Prandtl number is obtained as 2022.24. This leads to h_o = 16.3 W/m^2-K for an outside tube diameter of 0.0127 m. The overall heat transfer coefficient for is then h = 12.6 W/m^2-K.

The heat transfer energy balance (eqn. 1) gives the heat transfer area as 1.08 m^2 and a corresponding tube length of 27 m. This is then arranged on the testing chamber ceiling as shown in the model in Fig. 4. A full set of manufacturing drawings was produced.

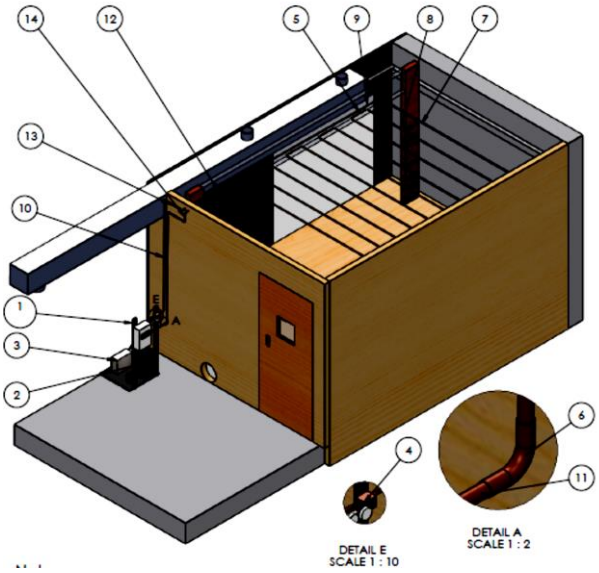

Fig. 4: Configuration of the chilled ceiling copper tubing evaporator

IV. Conclusions and Recommendations

An independent chilled ceiling system for a standalone office with direct expansion displacement ventilated HVAC system was analyzed and design. Key performance parameter were identified and quantified. The design process led to a splitting of the cooling load between the DV system (65%) and the chilled ceiling (35%). Copper tubing of 27 m length was determined to effect the required ceiling cooling.

The system was constructed, installed and commissioned. The next step in the work is to conduct performance testing of the chilled ceiling system and its effectiveness on improving indoor air quality. It is therefore recommended that full tests be conducted to fully understand the system.

Acknowledgments

We would like to thank the following people for some of the development work on the design construction and commissioning of the testing chamber: Ranwedzi Mukhonobwane, Tlou William Kgaabi and Omphile Masilo.

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