Modelling the e-stack F-1000 in Dynamic Thermal Modelling Software

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Introduction

This document is to allow our clients to model the e-stack ventilation system in commercial dynamic thermal modelling software such as IES or TAS.

The main advantage of the e-stack system over other natural ventilation systems is that in the winter, we do not bring in air via opening windows, as this requires a large amount of preheating energy. Instead we operate in 'mixing mode' where we bring in air at high level and mix it with warm room air to create a tempered air stream which is comfortable for occupants.

To accurately model conventional natural ventilation systems, a preheat at the low level windows would have to be incorporated which is almost never done by modellers, thereby giving results which are too optimistic. By contrast, the results for modelling an e-stack using the method below will be far more accurate, as in the winter the incoming air is treated as part of the energy balance, accurately representing our mixing strategy.

Summary of the Strategy

External Temperature	Internal Temperature	Strategy
< 16 degC	-	Winter Mixing Mode Minimum ventilation on CO_2
> 16 degC	<24 degC	Upwards Displacement Mode No Fans
> 16 degC	>24 degC	Upwards Displacement Mode Fan Assistance
>25degC	-	Nightcooling operates that night

Modelling the Winter Mixing Mode

The e-stack system is not a heat exchanger, and therefore cannot be modelled as a mechanical system with heat recovery. The system saves energy by bringing air into the space and mixing it with room air to reduce cold draughts, by using low powered fans. The casual gains produced inside the space by the occupants lighting and equipment, keep it warm on all but the coldest days (<5-10degC).

As the system is controlled on CO2 in winter the supply should be set to provide minimum fresh air. This means that if the space is unoccupied (eg. during lunchtime) the ventilation should stop. This is in contrast to uncontrolled systems that provide fresh air at a constant rate.

The simplest way to define the flow rate is to specify an air exchange to provide an equivalent of 5l/s/person of outside air and create a variation profile which operates in the same way for each occupied day of the year, when **External Temperature<16**, during all occupied hours.

Modelling the Upwards Displacement Mode

This mode relies on natural buoyancy and wind to drive air through the space and the fans are not required. In this mode, the unit consumes minimal power. The F-1000 unit can be simply modelled as a high level opening door on the facade. The size of the door and the aerodynamic free area should be achieved as specified below. In actual fact the free area of the system will depend entirely on the size of the louvre and damper system on the wall above the F-Series unit. The free areas shown in the table below assumes there is a 1000mm x 1000mm damper on the façade above the F-1000 unit.

Unit	Door Dimension *(mm)*	Aerodynamic Free Area *(m^2)*	Equivalent Orifice Area assuming C_d of 0.62 *(m^2)*
F-1000	1000 x 1000	0.22	0.354

The e-stack F-1000 will be working in conjunction with the additional high level openings in summer and winter so the system should have at least another **0.3m^2** of **high level aerodynamic free area** on top of the F-1000 door. This can be in the form of louvres or high level opening windows.

It is also important that all the windows and other openings are positioned correctly in the space as this will affect the natural ventilation flow. The e-stack door, additional high level openings and all of the low level openings should open based on a modulating profile that varies linearly between the following values:

Int T	Opening (%)
19degC	0
24degC	100

Two profiles should be created separately for the low level openings and the e-stack 'door'. The low level openings should operate in the same way all year round for each occupied day, and should open when **External Temperature>16**, **Internal Temperature>21.5** and **Internal Temperature>External Temperature**, during all occupied hours.

The daily profile for the F-1000 door and high level openings will be more complicated but should begin with the same formula as above put in for all occupied hours.

Modelling the Upwards Displacement Mode with Fan Assistance

The system is still driven predominantly by buoyancy and wind, but assistance is given to the flow by the fans that are also used in winter. To model this, an additional mechanical extract should be specified from the room to the exterior. The maximum extract rate for each unit is as follows:

Unit	Fan Assistance (l/s)
F-Series	100

In this mode only one fan is used so specific fan power should be set to 0.15W/l/s

The simplest was to define the flow rate is to specify an air exchange with the correct flow rate from each room to the atrium, which operates in the same way for each occupied day of the year, whenever **Internal Temperature>24** and **Internal Temperature>External Temperature** during all occupied hours.

Modelling the Nightcool Mode

If the day before has been particularly hot, a night cooling strategy is used that night. This is operated between the hours of 21.00 and 06.00. During this time the F-1000 unit and the additional high level openings are fully open.

It is often difficult, in software, to control the nightcool based on temperatures the previous day, so a simplified profile can be applied when **Internal Temperature>18** and **Internal Temperature >External Temperature** from 21.00 to 06.00 during the summer months (1st May-30th August), to the atrium opening profile which was partially created earlier. For the other months of the year the simple low level opening profile can be applied. *Where necessary hours of nightcool operation can be extended to be exclusive of occupied hours.*

If the room temperature has not dropped below 18degC by 03.00, the fans are switched on and provide assisted ventilation at the rate described in the last table until 6am.

The simplest way to define the flow rate is to specify an air exchange with the correct flow rate, when **Internal Temperature>18** and **Internal Temperature>External Temperature**, **from** 03.00 to 6.00 during the summer months (1st May-30th August).