Modelling e-stacks F-500s in Dynamic Thermal Modelling Software

Author: Fiona Dickinson
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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. In this system, F-500 e-stack units are used to provide mixing at the façade and an atrium or passive exhaust stack is used to provide an air outflow pathway.

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	-	Upwards Displacement Mode No Fans
>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).

In the winter, when outside temperature is below 16degC, the e-stack F-500 units should be the only façade opening which is open. Breathing Buildings should recommend the number of unit required in each space to meet minimum ventilation requirements. The unit comprises an external weather louvre, a modulating damper and the mixing box. Each unit has a combined free area given in the table below and typically the louvre would be represented by a door measuring 1000mm by 500mm.

Unit	Door Dimension *(mm)*	Aerodynamic Free Area *(m^2)*	Equivalent Orifice Area assuming C_d of 0.62 *(m^2)*
F-500 with external weather louvre	1000(W) x 500(H)	0.11	0.177

The outflow air pathway is typically via acoustic attenuators into an atrium then through actuated openings in the atrium or by a passive stack in the room. *A typical Breathing Buildings passive attenuator has an aerodynamic free area of 0.17m^2 and could be represented by drawing a hole of 0.55m x 0.5m between the room and the atrium.*

In winter the modulation of opening will be predominantly based on CO_2 with the following modulating profiles.

Opening Type	0% Open	100% Open
e-stack F-500	1000ppm	1300ppm
Passive Stack in Room	1000ppm	1300ppm
Atrium High Level Openings	800ppm	1200ppm

The fan in the e-stack F-500 is running in this mode to draw warm room air into the mixing box, and uses a maximum of 45W.

Modelling the Summertime Upwards Displacement Mode

This mode relies on natural buoyancy and wind to drive air through the space and the fans are not required. The direction of flow is the same as in the winter mode, however typically e-stack F-500 will be working in conjunction with additional low level openings in the summer. Breathing Buildings can advise on the sizing of these openings on a project-by-project basis.

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 F-500 door and additional low level openings in each room 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 F-500 door and the other façade openings. The façade 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-500 door will be more complicated but should begin with the same formula as above put in for all occupied hours.

During the summer, when external temperature is greater than 16degC during the occupied day, the passive stack or atrium high level openings should also open based on the same modulating profile.

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-500 units are fully open, as is the passive stack or atrium high level openings.

It is often difficult, in software, to control the nightcool based on temperatures the previous day, so a simplified control inequality, such as **Internal Temperature>18** and **Internal Temperature >External Temperature** can be applied from 21.00 to 6.00 during the summer months (1st May-30th August), to the F-500 door opening profile which was partially created earlier. For the other months of the year the simple low level opening profile can be applied.