A.2 Design and Management of Engineered openings

This addendum provides guidance for clauses 3.6 and 3.8 of NVF/DG001 Issue 1:

3.6 VELOCITY TO LIMIT BACK-FLOW

This clause is concerned with the minimum air velocity at openings to limit back-flow of contaminated particles

Adventitious openings are gaps and cracks resulting from the construction and design of the containment enclosure. Construction gaps and cracks are too small to measure velocities and should be sealed as effectively as possible. The 0.5 ms^{-1} minimum velocity quoted is for small gaps and slots that may be measurable, such as around closed doors.

Engineered openings allow access for people, equipment, process materials, or services (including ventilation).

Airflow into a gap forms a 'vena contracta' due to its momentum. This creates vortices ('eddies') close to the wall, giving the potential to trap contamination and transport it against the direction of bulk flow. Eventually the flow re-attaches to the wall and the inward flow direction is established across the whole gap.

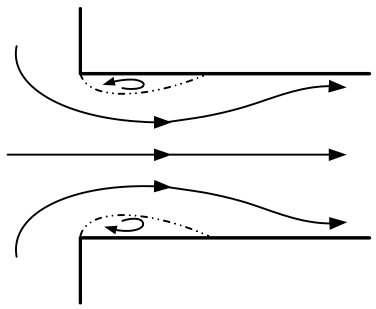

Figure 1 flow into a gap

The strength of the vortices, and their stability, is dependant on the velocity of the air and the geometry of the opening. Thin openings, fig 2(a), and high velocities are more likely to allow back-flow, than long openings with slower velocities. Flanged, flared or extended entry geometry can improve performance.

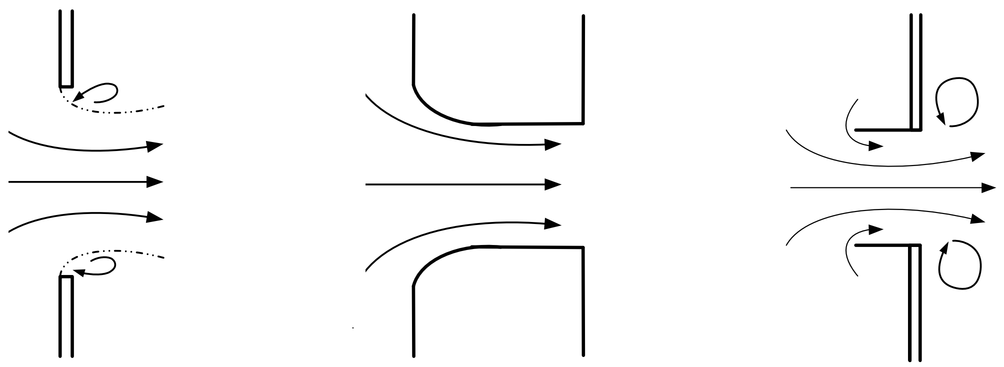

Figure 2 (a) Thin opening (b) flared long gap (c) re-entrant stub

The re-entrant stub, fig 2(c), is similar to a glove port. The additional 'length' of the gap improves performance of the thin wall.

The 0.5 ms^{-1} minimum velocity comes from past experience in the nuclear industry and elsewhere (such as for fume cupboards). Experience with higher levels of challenge, such as glove boxes containing powder, has led to an accepted minimum 1.0 ms^{-1} required through an open glove port. Higher velocities give stronger vortex effects and the effect of disturbances may be more acute due to the additional energy [momentum] within the system.

3.8 VELOCITIES BETWEEN AREAS

The intent of this clause is to ensure engineered openings are designed to maintain the **containment integrity** between areas.

The containment performance of an engineered opening should match the required containment integrity of the barrier it is part of. Careful design of an opening can improve its containment performance (e.g. seals on a tight fitting door). However, openings are provided for access – once they are open, any disturbance can cause a change in airflow patterns, resulting in the unpredictable movement and potential escape of airborne contamination.

The clause implies that a given velocity across a single opening is suitable, for example 1.0ms^{-1} through an open door into a RED area. Given that **air flow is an unreliable method of containment**, this is not recommended. Entry systems must allow for failure of a single barrier, usually by providing additional permanent or temporary barriers (depending on the operational philosophy for the entry point). The use of a single door as an entry system (subject to risk assessment) is not disallowed, however, a system for monitoring performance, and additional barriers whenever the 'door' is opened, must be provided.

Good practice is to have two 'doors' in series so that only one is opened at any given time. The area between the doors should be managed, to get early warning of contamination at the innermost door (closest to the hazard), and cleaned to prevent an eventual challenge to the outermost door.

The **containment performance** should match the potential hazard. For example: a fully sealed double door posting system on a RED area enclosure; an airlock on a secondary containment; and two doors in series for a building tertiary containment. The designer and operators of an **engineered entry system** need to understand the potential airflow patterns (including induced airflows) resulting from the layout and geometry, and operate the system accordingly.

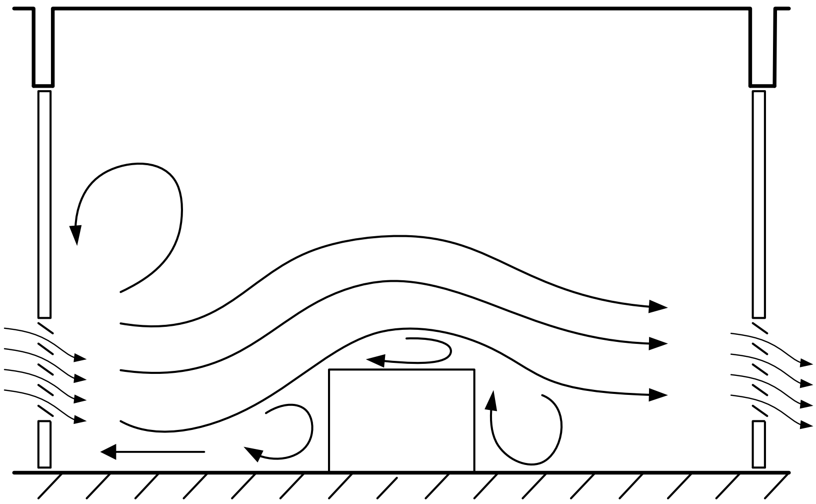

Figure 3 simplistic view of a change room air flow patterns

Some service openings, such as a ventilation duct, are obviously not 'closed'. The requirement for back-flow protection (clause 3.8.2) relates to these.

For temporary containments and frog tunnels refer to other specific guidance.

Further reading

- "Containment and velocities", R Doig, IMechE seminar, March 2002
- "Ventilation applications for Alpha plants", M Crouch, IMechE seminar, March 2002
- "CFD: contribution to the design of containment and ventilation systems" C Roach and V Edelman, IMechE seminar October 2010
- Controlling airborne contaminants at work [a guide to local exhaust ventilation], HSE books