#3394

Low energy factory buildings

Derek Hughes describes how annual building energy savings of 38% were achieved in a project within the Energy Efficiency Office's energy efficiency demonstration scheme.

In 1981 the Joint Technical Committee (JTC) of the Welsh Development Agency (WDA), the Scottish Development Agency, English Industrial Estates and the Northern Ireland Department of Commerce recognised the need for increased energy efficiency for factory space heating. They proposed a set of low energy standards for their advance factory building programme. A range of low energy factories was then designed and constructed by the WDA on behalf of the JTC, incorporating higher levels of insulation and reduced rates of air infiltration.

A detailed monitoring programme was set up to assess fabric and ventilation losses in these buildings. The work was funded by the Energy Efficiency Demonstration Scheme and monitored by the Welsh School of Architecture at UWIST in Cardiff over a three year period in a total of eight factories (ranging in area from 175 m^2 to 2250 m^2). These included six of the new design and two control factories built to contemporary *Building Regulation* standards.

Two methods of construction were used: the smaller factories were of brick diaphragm wall construction with a metal cladding roof, and the larger factories were of metal cladding wall and roof construction.

Both methods of construction used higher levels of insulation than required by *Building Regulations:* 80 mm of insulation were installed rather than 60 mm. This resulted in cladding construction design U-values of 0·45W/m^2/K and diaphragm construction design U-values of 0·35W/m^2/K. *Building Regulations* require minimum U-values of 0·7W/m^2/K.

These factories were also fitted with insulated loading doors. These had a U-value of 0·45W/m^2/K, compared with values as high as 5 or 6 W/m^2/K for some conventional loading doors. In one factory the insulated door was motorised to speed opening and closing, and was backed up by a heavy duty transparent plastic curtain to reduce further heat loss during door-open periods. The doors were installed carefully to minimise air infiltration through cracks around the units. The heating systems installed in the factories represented best current practice.

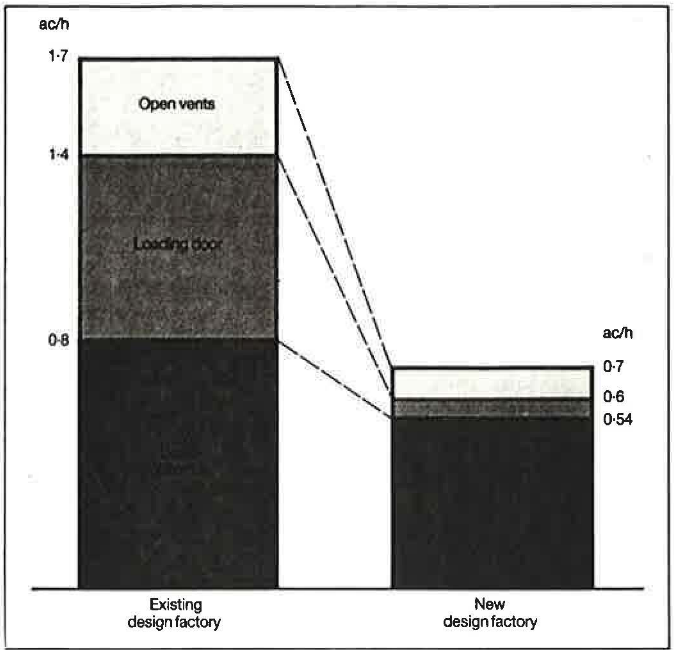

Figure 1: Reduction in air infiltration and ventilation for a 176 m^2 low energy factory compared with a standard factory.

The thermal performance of all the factories was measured in various ways including the continuous monitoring on a computerised data-logger of internal and external temperatures and heating system switching, computer controlled constant concentration tracer gas analysis, pressurisation testing and infra-red thermographic techniques.

A significant impact on total energy consumption was achieved. In a medium/large advance factory (1670 m^2 floor area) the higher levels of fabric insulation resulted in a reduction of 21% in fabric losses, or annual savings of £344 (thermographic techniques were used to ascertain that the thermal insulation was correctly fitted.) The reduced air infiltration rates resulted in a 52% reduction in ventilation losses equivalent to annual savings of £601.

The total building heat loss was reduced by about 32% which is equivalent to annual savings of £945 (all 1987 prices).

Similar results were achieved for the other low energy factories in this project. Annual energy savings calculations were based on the measurements performed on all the factories, as shown in table 1.

One of the most important factors in these energy savings was the impact of the loading doors on air infiltration rate, as illustrated in figure 1. This was reduced from 49% of the total for the conventional doors to 9% for the insulated doors or from 0·6 to 0·06 ac/h.

Table 1: Energy savings for all factory sizes

Floor area (m^2)	Energy use (GJ/m^2/pa)	Energy saving	% saving (£/pa)	Cost saving
175/230	0·33	0·27	45	244
840	0·23	0·19	45	847
1670	0·23	0·11	32	945
2250	0·21	0·08	28	929
Mean		0·17	38	741

Using thermographic techniques it was possible to determine that, in the 200 m^2 factories, the conventional doors represented about 25% of the total fabric losses, compared with 3% for the insulated doors. These savings were obtained with the doors closed. The motorised door/plastic curtain option was found to halve losses incurred during door-open periods. The penalty of having the door open for 1 h per day in a 200 m^2 factory was reduced from 10% of daily energy use to 5%. The annual energy savings due to the insulated loading doors were found to be in the order of £220 (at 1987 prices). With an overcost of about £500 for the insulated door, this yields a payback of two years - within the range originally envisaged by the WDA.

The typical payback period given by all the energy efficient measures is about two years. In the future, more careful attention to sizing of heating plant should achieve closer matching between factory design and heating systems and result in the specification of smaller, lower cost heating systems. This should reduce the overall payback period to less than two years.

The monitoring exercise has proven that energy efficient building design is compatible with the objectives of producing energy efficient, quality industrial buildings which have low maintenance costs and commercial viability in terms of rental value in the open market. As a result of this work the WDA have decided that, as a matter of policy, all their advance factories will be built to the new low energy design. The WDA now also requires that all new low energy advance factories are subject to a thermographic survey to check that their performance meets design requirements.

BRE publications are available singly or on annual subscription. For details write to: Publication sales, Building Research Establishment, Garston, Watford, WD2 7JR.