Innergy tech inc.

Hoval series Plate Heat Exchangers for Heat Recovery in Ventilation Systems.

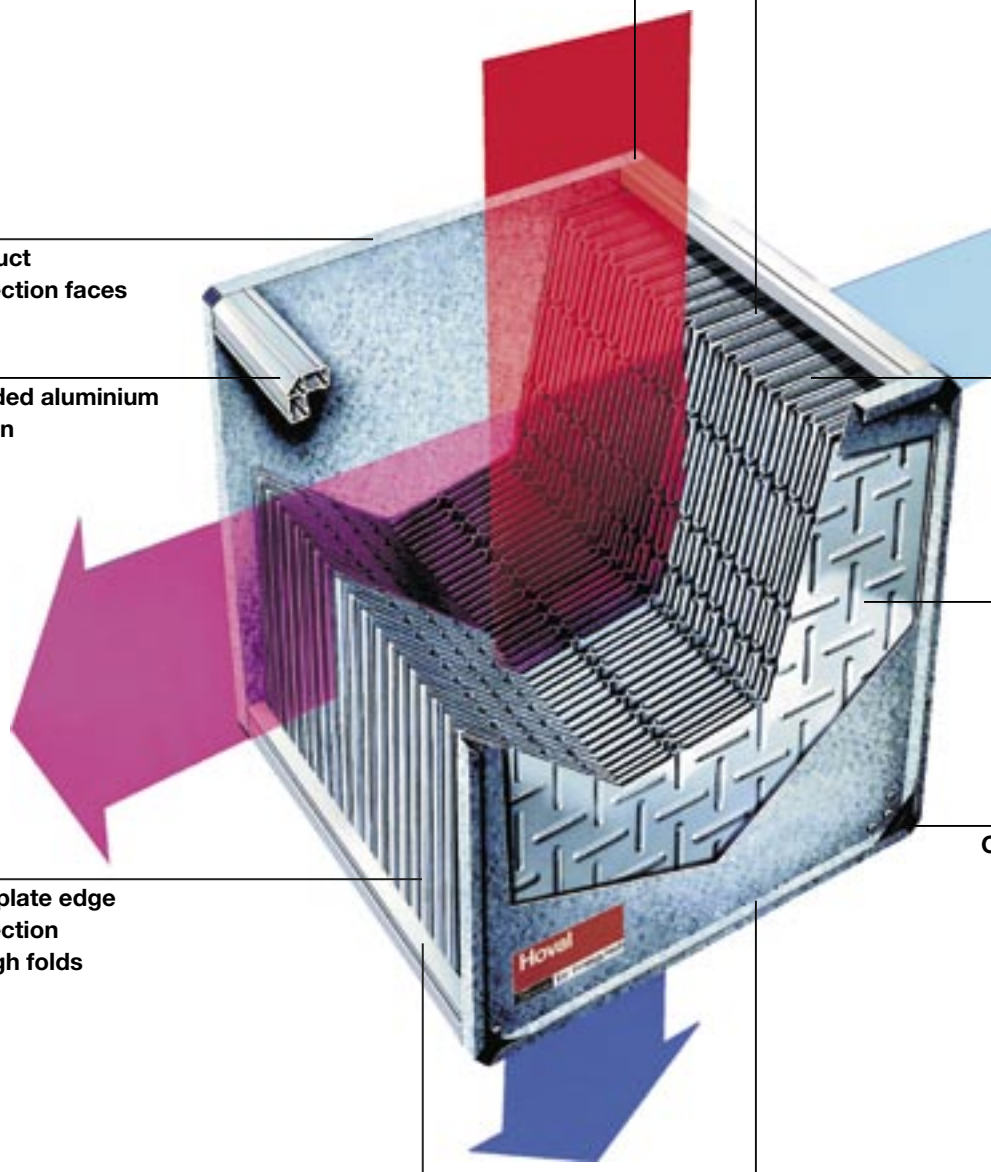
Intelligent **Fresh Air** Systems

air2energy

Hoval

Series by Innergy tech

Cut-Away View of Design N



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Hoval Plate series Heat Exchangers
Handbook for Design, Installation and Operation

Subject to technical alterations.
01/2007

At a Glance

Heat recovery reduces costs and protects the environment

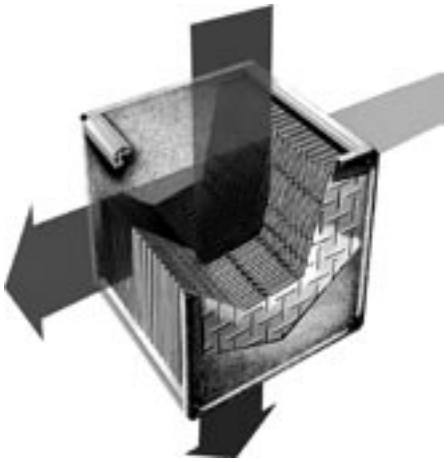
Hoval series plate heat exchangers are important elements in saving energy in industry, commerce, hotels, hospitals, sports halls, office buildings, seminar rooms, swimming pools, drying processes, paint spray booths, extraction plants etc. They are used in air handling units, ductwork systems and in process technology. This investment pays off in several ways:

- Lower energy consumption
- Lower investment for heat generation and distribution
- Less damage to the environment

No cross-contamination of the air streams

In the Hoval series plate heat exchanger the warm extract air and the cool fresh air, separated by thin plates, pass each other in cross-flow. No mixing of the two air streams takes place. Therefore, the transmission of dirt, odours, moisture, bacteria, etc. is impossible. Heat is transmitted from extract air to fresh air purely by conduction as a result of the temperature difference between the two air streams. The warm extract air is cooled down, the cool fresh air is heated.

Design N
Mostly used for ventilation of occupied area ex: office, school, mall center,hospital...



Wide variety of sizes available

Hoval series plate heat exchangers are available in a wide range of sizes to suit every application:

- Exchanger lengths from 23.6 to 66.9 inches (0.6 to 1.7 metres)
- Individual core from 3.9 to 118.1 inches (0.1 to 3 metres) height

The individual plate exchanger can be supplied with different plate spacings and heat recovery efficiencies.

At a Glance

Materials which suit the applications

Three series are available to suit a wide variety of applications:

- Standard series V: with the exchanger package of aluminium, the casing of aluminium extrusions and Galvanized sheet steel
- Corrosion-protected series G: where the exchanger package and the casing are coated
- High-temperature series T: with a special sealing agent resistant to temperatures up to 200 °C

Reliable in operation

Hoval series plate heat exchangers have no moving parts. Their function requires no electrical connection. There are therefore no extra running costs and operation is always guaranteed: 100 % reliability.
Many years of operation in numerous applications have proved that Hoval series plate heat exchangers are extraordinarily resistant to dirt build-up. Therefore no special maintenance is required.

Reliable data

Hoval series plate heat exchangers are independently tested time and again. The technical data are based on these test results. The Innergytech computer calculation program Winnergy allows easy and quick selection of the optimum plate heat exchanger for every application.

Energy recovery component certified to the ARI air-to-air Energy Recovery Ventilation Equipment Certification Program in accordance with ARI standard 1060-2005. Actual performance in packaged equipment may vary.

Hoval series plate heat exchangers offer many advantages

- High heat recovery effectiveness → low investment costs
- No moving parts → no wear, always ready for operation
- Separate air streams → no cross-contamination
- No electrical connections → no extra running costs
- Three series, a wide variety of sizes and plate spacings, any desired width → the optimum solution for every application
- Lightweight, compact design → easy to install
- Automated production → constant high quality

1 Principle and Operation

Hoval series plate heat exchangers operate within the guidelines for heat recovery as recuperators with joint faces. The heat releasing and heat absorbing air streams pass along the joint face, through which the heat is directly transmitted. Supply and extract air must therefore be brought together and flow through the heat exchanger.

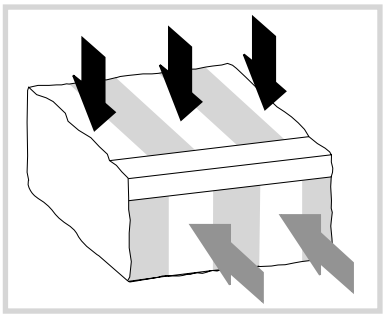


Fig. 1-1: Separated by the plates, the air streams pass each other.

1.1 Heat transmission

Hoval series plate heat exchangers operate on the cross-flow principle. Heat is transmitted via the plates from the warm to the cold air stream. A much simplified performance calculation is:

$$Q = k \cdot A \cdot \Delta t$$

When temperatures are given, the transmitted heat performance is assumed by design characteristics.

■ Heat transfer rate: The k-value is calculated from the thickness and heat conductivity of the plates, as well as heat transfer on both sides:

$$\frac{1}{k} = \frac{1}{\alpha_1} + \frac{d}{\lambda} + \frac{1}{\alpha_2}$$

As thin plates are used, for cost reasons, the influence of the material can be neglected. This is shown in table 1–1:

Material	Thickness [mm]	λ [W/mK]	$\alpha_1 = \alpha_2$ [W/m²K]	k [W/m²K]
Aluminium	0.125	200	40	19.9998
Aluminium	0.500	200	40	19.9990
Plastic	0.500	0.20	40	19.0476

Table 1-1: Plate thickness and material have only a slight effect on the effectiveness.

For good heat transmission, the heat transfer α must be high on both sides of the plates. For this reason Hoval optimised the plate profiles by extensive tests. The results are high effectiveness, relatively independent of the flow velocity.

■ Exchanger surface area: The amount of heat transmitted is directly dependent on the exchanger surface area. With the number of plates, i.e. their spacing, the effectiveness is easily changed, optimised or selected to meet a particular specification. Therefore different plate spacings are available for most types of Hoval series plate heat exchangers. The optimum exchanger can only be selected with an economic calculation directly concerning a specific project.

1.2 Leakage

Components of air handling units, such as e.g. dampers, ducts or casings, are not normally 100 % leakproof. This is mainly because it is not necessary to ensure the correct function and it would be very expensive. In practical use, however, leakage must not exceed technically justifiable limits. For heat recovery units, there is no such data at the moment. Nevertheless, actual values are known from tests.

A difference has to be made between the following:

- Leakage to outside (external)
- Leakage between supply and extract air (internal)

While sealing to outside normally does not cause any problems (it is above all a question of assembly quality), the internal leakage mainly depends on the system and exchanger construction. The Hoval series plate heat exchanger is particularly tight. Tests have shown the following leakage rates (relating to the nominal air flowrate and a pressure drop of 0.8" w.g. (200 Pa)):

- External leakage: 0.0014 %
  (at a pressure difference of 1.6" w.g. (400 Pa))
- Internal leakage: 0.0158 %
  (at a pressure difference of 1.0" w.g. (250 Pa))

These are excellent results and far better than other manufacturers' data. Nevertheless, it must be noted that exchangers are not 100 % leakproof unless special measures are taken.

Principle and Operation

1.3 Moisture transmission

The two air streams are separated in the Hoval series plate heat exchanger; transmission of moisture is therefore not possible. This is a special advantage when moisture is removed with the warm air, e.g. in swimming pools, drying processes, etc.

1.4 Condensation

Hoval series plate heat exchangers do not transmit moisture but still can use part of the latent heat of moist extract air. At low outside temperatures, when there is a high heat demand, the extract air is cooled down to such a degree that the saturation temperature is reached and condensation is formed. Thus the latent heat of evaporation is released. This reduces further cooling of the extract air, i.e. the temperature difference between the air streams in the plate heat exchanger is greater than when there is no condensation. Also the heat transfer is better; consequently the effectiveness is raised significantly. This can be seen clearly in the hx diagram. The cold air stream is heated more than the warm air is cooled. Nonetheless the enthalpy difference is the same, assuming equal water content. Condensation in the extract air reduces the free area of the airway and is responsible for an increase in pressure drop. Therefore it is important that the condensation can drain away. This depends mainly on the fitting position of the heat exchangers and on the form of the plates. Hoval series plate heat exchangers offer advantages because of their special profiles.

If condensation occurs the internal and external leakage of the exchanger is of particular importance. Even with a leakage rate of only maximum 0.1 % of the nominal air flowrate – as with the Hoval plate heat exchanger – up to 0.26 gallon (3 litres) condensate an hour can leak out, even more in extreme cases. The absolute value depends on the size of the exchanger, the number of plates, the amount of condensate and the pressure difference.

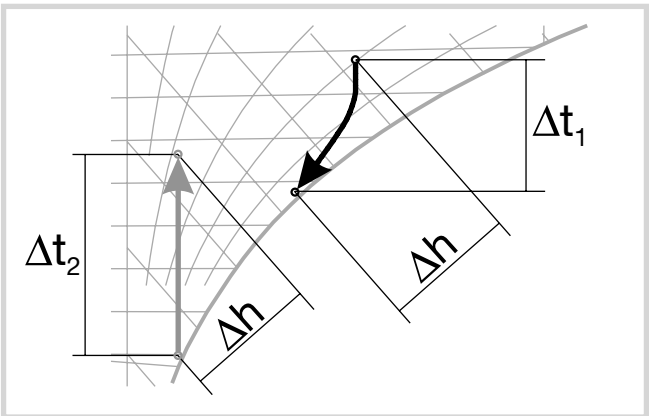


Fig 1-2: Changes of condition in the hx diagram

1.5 Temperature profile

With the cross-flow heat exchanger, the air streams are not heated and cooled evenly. This means that the temperatures vary along the cross section of the air stream. The computer graphic, calculated by the finite element method, shows this.

Because of the temperature variation the verification of the effectiveness under operating conditions is practically impossible. For this reason, the performance of representative Hoval series plate heat exchangers has been empirically tested, measured and agreed by independent test institutes – to safeguard the consultant, installer and operator. The technical data of Hoval series plate heat exchangers are certified by ARI.

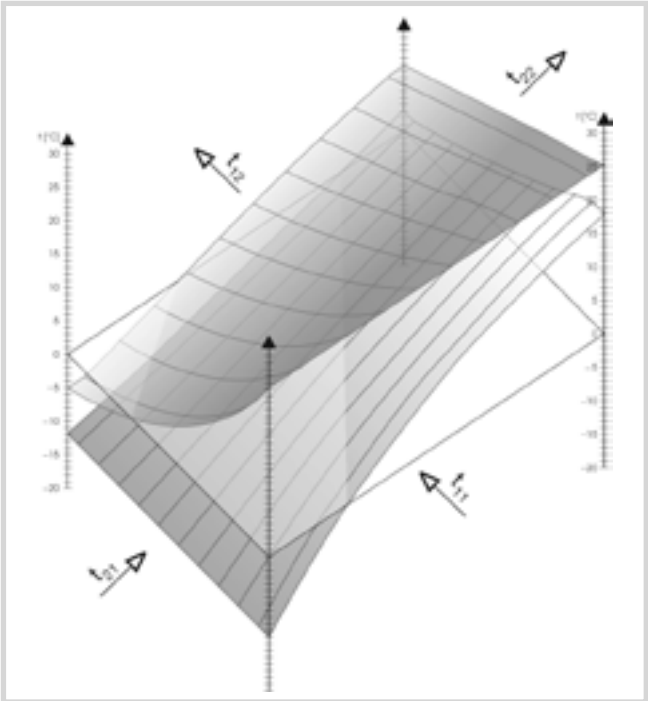
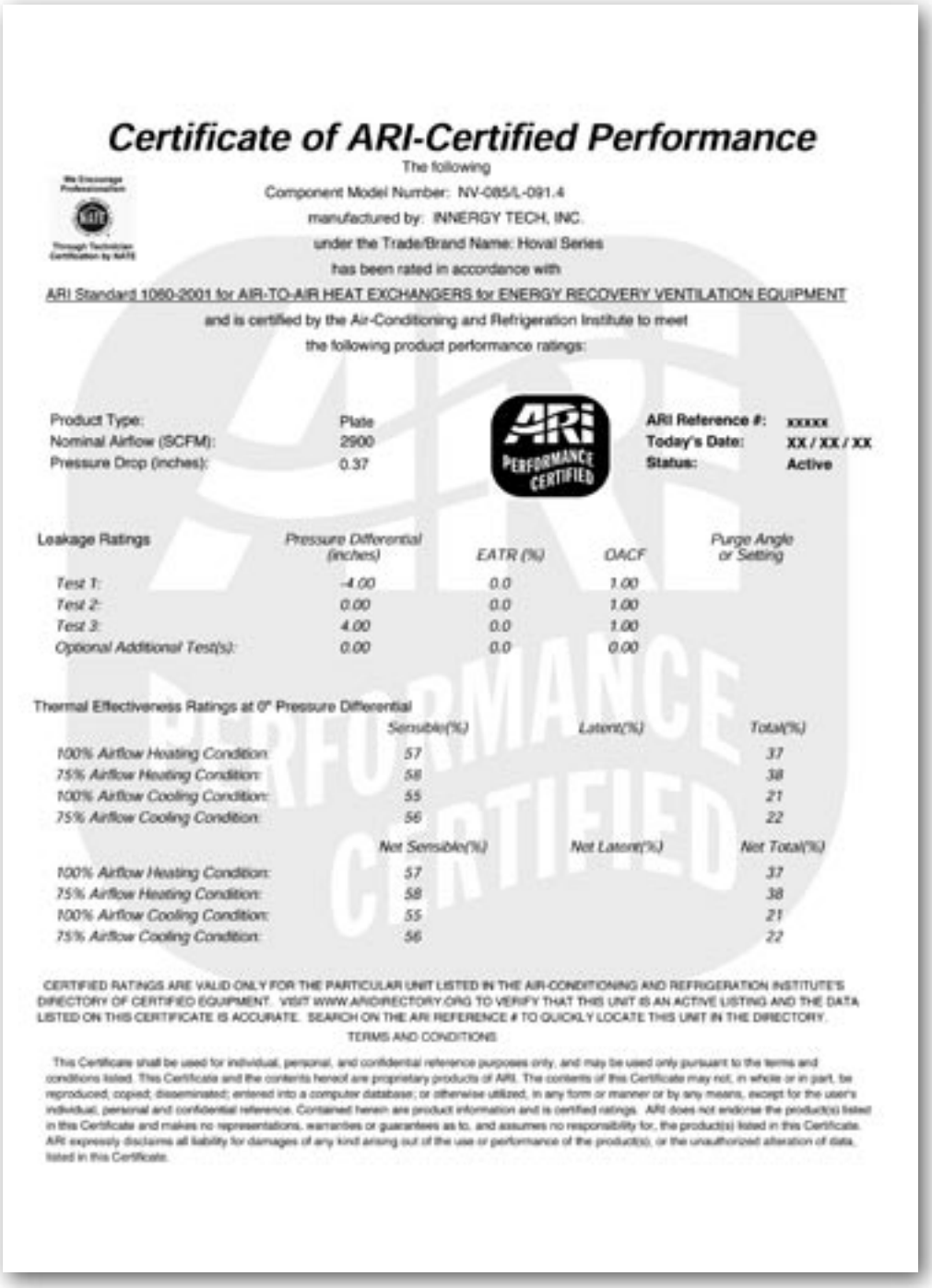


Fig. 1-3: Temperature profile of the air streams (computer graphic)

Principle and Operation



Certificate of ARI-Certified Performance

The following

Component Model Number: NV-085/L-091.4

manufactured by: INNERGY TECH, INC.

under the Trade/Brand Name: Hoval Series

has been rated in accordance with

ARI Standard 1060-2001 for AIR-TO-AIR HEAT EXCHANGERS for ENERGY RECOVERY VENTILATION EQUIPMENT

and is certified by the Air-Conditioning and Refrigeration Institute to meet

the following product performance ratings:

Product Type:	Plate
Nominal Airflow (SCFM):	2900
Pressure Drop (inches):	0.37

ARI Reference #: xxxxx
Today's Date: XX / XX / XX
Status: Active

Leakage Ratings	Pressure Differential (inches)	EATR (%)	OACF	Purge Angle or Setting
Test 1:	-4.00	0.0	1.00	
Test 2:	0.00	0.0	1.00	
Test 3:	4.00	0.0	1.00	
Optional Additional Test(s):	0.00	0.0	0.00	

Thermal Effectiveness Ratings at 0" Pressure Differential

	Sensible(%)	Latent(%)	Total(%)
100% Airflow Heating Condition:	57		37
75% Airflow Heating Condition:	58		38
100% Airflow Cooling Condition:	55		21
75% Airflow Cooling Condition:	56		22
	Net Sensible(%)	**Net Latent(%)**	**Net Total(%)**
100% Airflow Heating Condition:	57		37
75% Airflow Heating Condition:	58		38
100% Airflow Cooling Condition:	55		21
75% Airflow Cooling Condition:	56		22

CERTIFIED RATINGS ARE VALID ONLY FOR THE PARTICULAR UNIT LISTED IN THE AIR-CONDITIONING AND REFRIGERATION INSTITUTE'S DIRECTORY OF CERTIFIED EQUIPMENT. VISIT WWW.ARIDIRECTORY.ORG TO VERIFY THAT THIS UNIT IS AN ACTIVE LISTING AND THE DATA LISTED ON THIS CERTIFICATE IS ACCURATE. SEARCH ON THE ARI REFERENCE # TO QUICKLY LOCATE THIS UNIT IN THE DIRECTORY.

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Fig. 1-4: Example of ARI certificate (www.ari.org)

Principle and Operation

1.6 Frost limit

If the warm air stream is severely cooled down, it is not only possible for condensation to form, but also to freeze. The cold air temperature at which freezing starts, is called the 'frost limit'. In practice this is rare as several factors must coincide:

- Very low temperature of the cold air stream
- Cold air volume is greater than warm air volume.
- High effectiveness of the exchanger
- Relatively little condensation
- The condensation cannot drain away easily.

If several of these circumstances coincide the plate heat exchanger can ice up, starting at the cold corner. The Hoval series plate heat exchanger is not damaged, but the pressure drop is increased and the air flowrate is reduced. In extreme cases the whole exchanger can slowly ice up. Long experience shows that this is very rarely the case. When designing under the following conditions, the frost limit need not be considered:

- Mass flow ratio cold air to warm air $m_2/m_1 < 1$
- Lowest cold air temperature > 5 F (-15 °C) (mostly the case when no night operation)
- Normal installation of the heat exchanger, i.e. the plates are vertical.
- Exhaust air flowrate can be reduced for short periods.

If these conditions are not met, it is recommended to calculate the frost limit for each project with the computer program and to take necessary precautions (de-icing exhaust fan switch, preheating, bypass).

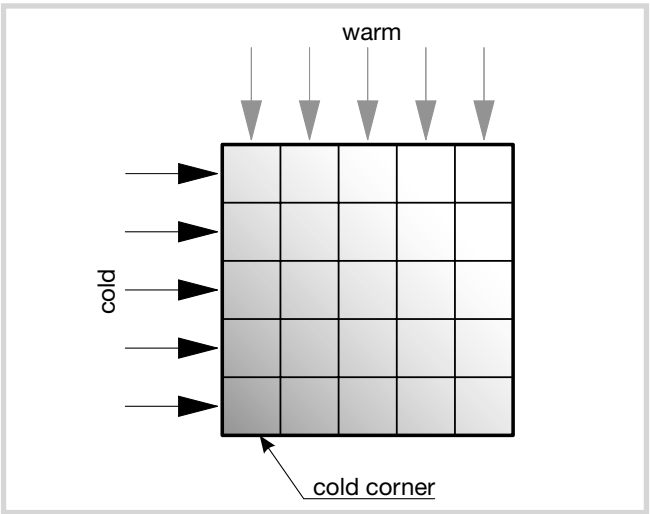


Fig. 1-5: Under extreme conditions the exchanger can ice up, starting at the 'cold corner'.

1.7 Heat recovery effectiveness

In principle, nearly any effectiveness can be achieved if sized and designed to suit. For instance, the effectiveness can be substantially raised by installing two exchangers in series. However, this increase in effectiveness

- either is at the expense of a high pressure drop,
- or at the expense of a large space requirement,
- but in any case at the expense of costs.

The 'correct' effectiveness is a subjective decision and depends on the economic calculation, i.e. on operating data such as energy prices, useful life, running times, temperatures, maintenance costs, interest rates, etc. It is important that the calculated optimum values for heat recovery effectiveness and pressure drop are then put into practice. Even small deviations (a few percent less effectiveness, a few pascals more pressure drop) can cause substantially worse values for the present value and payback period. With regard to profitability and environmental protection the heat recovery effectiveness should be at least 50 %.

1.8 Pressure drop

Heat recovery units cause additional pressure drop on the extract and fresh air sides; incurring higher running costs. Under present conditions the economical values range between 0.6" w.g. (150 Pa) and 1.0" w.g. (250 Pa). However, to cut down costs, heat recovery units whose pressure drop exceeds these values are often installed. The profitability of heat recovery is thereby jeopardised. But there is also an economic limit: The effectiveness for generation of electrical current ranging between only 35 % to 40 %, the expenditure for the additional pressure drop must not exceed this value in relation to the energy savings in total.

Principle and Operation

1.9 Pressure difference

A distinction is made between

- the internal pressure difference (between fresh air and extract air) and
- the external pressure difference (between inside and outside of the exchanger).

■ External pressure difference: This pressure difference has a major effect on the external leakage of the plate heat exchanger. Yet when the exchanger is properly and carefully installed in a ductwork system, its effect can be neglected. More important is the influence on mechanical resistance. Particularly the side walls are heavily stressed at big pressure differences. Hoval therefore strengthens the side walls of large plate heat exchangers with a special reinforcing section.

■ Internal pressure difference: Likewise, the internal pressure difference has a crucial influence on internal leakage between the two air streams. Although Hoval series plate heat exchangers are very tight in comparison with other constructions, the following should be considered when designing:

- The pressure difference in the heat exchanger should be kept to a minimum.
- The pressure gradient and thus leakage should be from the supply air to the extract air side.

The internal pressure difference also may cause a deformation of the plates. The plate spacing is then narrowed and/or widened, resulting in corresponding variations of pressure drop (up to 20 %).

Extensive tests have shown that the influence of deformation depends on the plate spacing. An internal overpressure exceeding the permissible value of 10” w.g. (2500 Pa) show that the pressure drop strongly increases with small plate spacings whereas it hardly changes with big plate spacings.

The pressure difference depends on the position of fans. Overpressure on one side and underpressure on the other side add up.

The permitted pressure difference between the two air streams is limited to 10” w.g. (2500 Pa).

2 Performance Control

The Hoval series plate heat exchanger operates as a temperature moderator between the two air streams. The direction of the heat transmission is of no consequence, i.e. depending on the temperature difference between extract and fresh air, either heat recovery or cool recovery takes place. Therefore performance control of the Hoval series plate heat exchanger is not necessary when the extract air temperature is identical to the desired room temperature. In this case, the outside temperature is always either heated or cooled through the plate heat exchanger in the direction of the set tempera-ture.
In many cases, however, heat gains are present in the ventilated space (people, machinery, lighting, solar, process plants), which increase the room temperature, so that the extract air temperature is higher than the set temperature. In this case, at full performance of the heat exchanger, check at which outside temperature heat-up begins, and if this cannot be tolerated, the performance of the heat exchanger must be regulated.

Example

In an industrial building the room air is heated from 18 °C to 24 °C through lighting and machinery. The heat recovery figure Φ_2 is 66 %. At which outside temperature t_{21} is the space heated only by heat recovery without additional heating?

$$t_{21} = \frac{t_{22} - (\Phi_2 \cdot t_{11})}{(1 - \Phi_2)}$$

$$t_{21} = \frac{18 - (0.66 \cdot 24)}{(1 - 0.66)} = 6\ °C$$

At an outside temperature of +6 °C the supply air temperature after the heat exchanger is 18 °C = set temperature. At higher outside temperatures the hall is heated above the desired room temperature, this means the performance of heat recovery should be controlled.

With the Hoval series plate heat exchanger the performance control through change of the mass flow ratio is simply and economically accomplished with the bypass. Whether a bypass is fitted on the side or in the middle depends on local conditions and on the width of the exchanger. The arrangement of further ventilation components after the bypass, e.g. air heater, moisture eliminator, etc., must take into consideration the fact that the velocity profile can be uneven.

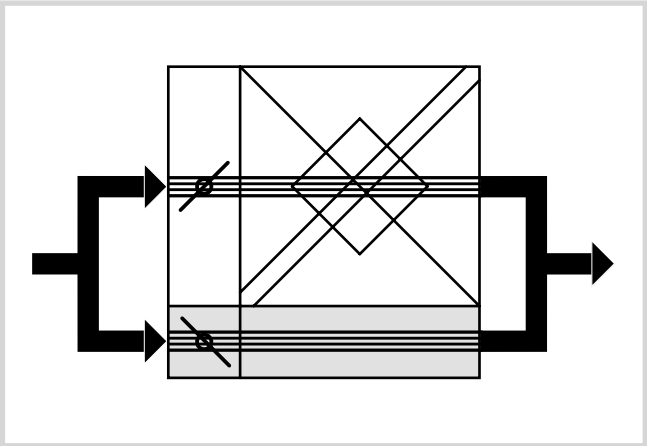


Fig. 2-1: The bypass is most effective for the control of performance.

There are two options for the fitting of the bypass:

- **Bypass in the fresh air:**
Depending on damper position, between 0 % and 100 % of the fresh air passes through the bypass. The extract air always flows through the heat exchanger and is cooled according to the fresh air flowrate. With this arrangement the cooling of the extract air and thus freezing can be avoided.

- **Bypass in the extract air:**
Between 0 % and 100 % of the extract air passes through the bypass. The fresh air always passes through the plate heat exchanger. This arrangement is recommended when the extract air is very dirty, as during summer operation the extract air does not pass through the plate heat exchanger.

3 Construction

Hoval series plate heat exchangers consist of the exchanger package and the casing. Sizing of the exchanger package (plate size and plate spacing) depends mainly on the air flowrate. To achieve an optimum result with regard to heat recovery effectiveness, pressure drop and costs Innergytech proposes different sizes and spacings:

- design N
  with plate spacings from around 0.118 to 0.248 inches (3 mm to 6.3 mm)

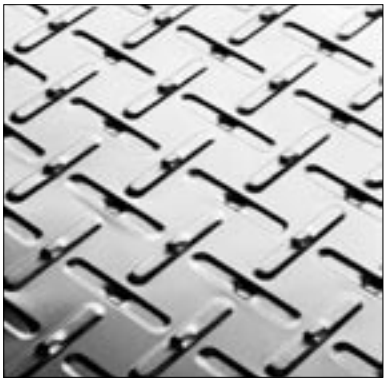


Fig. 3-1:
The special profiles of Hoval series plates are the result of extensive tests and measurements (design N shown here).

3.1 Exchanger package in design N

The exchanger package consist of specially formed aluminium plates. The profile has been optimised by extensive tests for heat recovery effectiveness, pressure drop and stability. The important advantages are:

- Little dependency of the heat recovery effectiveness on the air velocity
- Exact spacing between the plates through positive/ negative stamping
- High rigidity of the thin aluminium plates through the special arrangement of the vertical and horizontal ribs
- The profiles are arranged in such a way that the condensation can drain in every direction.
- Uneven flow patterns can even out inside the heat exchanger.

There are three different plate sizes, which are formed with different profile depths, i.e. for different plate spacings. Thus a great variety of different exchanger packages can be made, independent of width.

Fig. 3-2:
Folded connections give the exchanger package severalfold material thickness for the leading and trailing edges (design N shown here).

Construction

3.2 Plate connection

In both designs the connection of the plates is made by a fold. This gives a severalfold material thickness for the leading and trailing edges, which gives good rigidity to the exchanger package. Also a streamlined flow profile is given, which reduces not only pressure drop but also the possibility of dirt deposits.
With casting of the corner sealants, the plate fold is additionally sealed with casting resin. Thus the exchanger package is extremely leakproof.

3.3 Casing

The exchanger package is fitted into a casing of aluminium corner sections with side walls of Galvanized sheet steel. The specially developed sections are particularly important:

- The edges of the exchanger package are cast into the sections with a resin. This technique, which is patented by Hoval, ensures optimum integration of the package into the casing.
- Other components can be bolted or riveted directly to the hollow sections without affecting the rigidity of the exchanger or damaging the exchanger package.
- At the corners the sections are flattened by 45°, which facilitates installation of the plate heat exchanger and reduces the diagonal dimension.

The side walls are bolted to the corner sections (each with three screws). This creates flat surfaces for connecting ducts or other components. A punched seal between corner section and side wall ensures highest tightness. Attractively shaped plastic elbow pieces finish off the side walls. In addition, they allow installation of a side sealing all round together with the returned edge. This facilitates installation into a casing.
With very wide exchangers, stability of the casing is additionally improved by the installation of intermediate walls at regular intervals.
The side walls of all compound plate heat exchangers have a special profile for a sealing bead. This together with the sealing bead in the corner section ensures tight connection of the individual exchanger blocks.

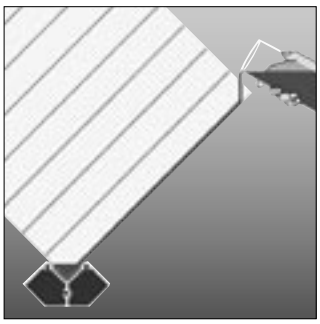


Fig. 3-3: When casting the corner section the plate connection is sealed again.

Fig. 3-4: The specially developed aluminium corner sections offer many advantages.

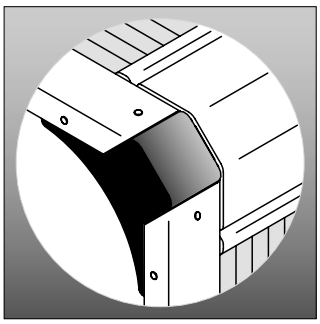


Fig. 3-5: The side walls are finished off with plastic elbow pieces.

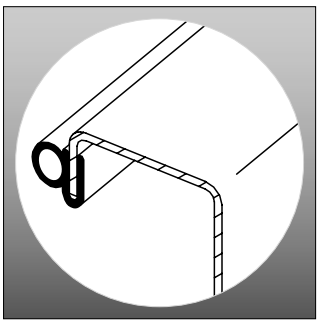


Fig. 3-6: A side sealing can be fastened to the returned edge of the side wall.

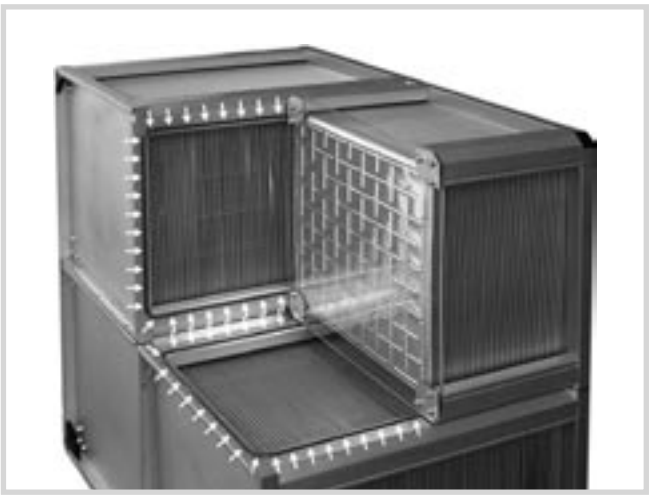


Fig. 3-7: The circumferential sealing bead in the frame of each exchanger block ensures tight connection of compound exchangers (here a cut-away model).

4 Model Range

To achieve the optimum solution for all applications, the Hoval series plate heat exchanger is offered in different series and sizes.

4.1 Designs

Depending on usage and air flowrate different design possibilities of Hoval plate heat exchangers are available.

4.2 Series

Three different material types are available:

Series V (standard)	The exchanger package consist of aluminium plates. This provides highest possible resistance against corrosion. The corner sections are made of aluminium extrusions. They are fastened to the rigid side walls of Galvanized sheet steel. The plate package is cast into the corner sections with permanent elastic resin; the exchangers are silicone-free. The maximum permissible temperature is 212 F (100 °C).
Series T (high temperature)	The construction is identical to series V, except: • Instead of the permanent elastic casting resin a high-temperature silicone is used for sealing of the corner sections. • Instead of the plastic elbow piece a metal cover is used. Thus the exchangers are resistant to temperatures up to 392 F (200 °C).
Series G (corrosion-protected)	The basic materials correspond to those of series V, however, the complete casing and the plates are coated. The exchangers are silicone-free. The maximum permissible temperature is 212 F (100 °C). This series is used when large amounts of condensate occur, in wet rooms, swimming pools, etc., and for mild corrosion (industry, process technology, etc.).

Model Range

4.3 Exchanger sizes

The exchanger package is responsible for the air performance (heat recovery effectiveness, pressure drop, air flowrate). Depending on the design, different sizes are available.

■ Exchangers in design N: Innergytech manufactures six different sizes. The size designation indicates the exchanger lengths in centimetres.

060	070	085	120	140	170

Sizes 060 to 085 consist of one exchanger package, sizes 120 to 170 are compound exchangers, made up of four exchanger packages.

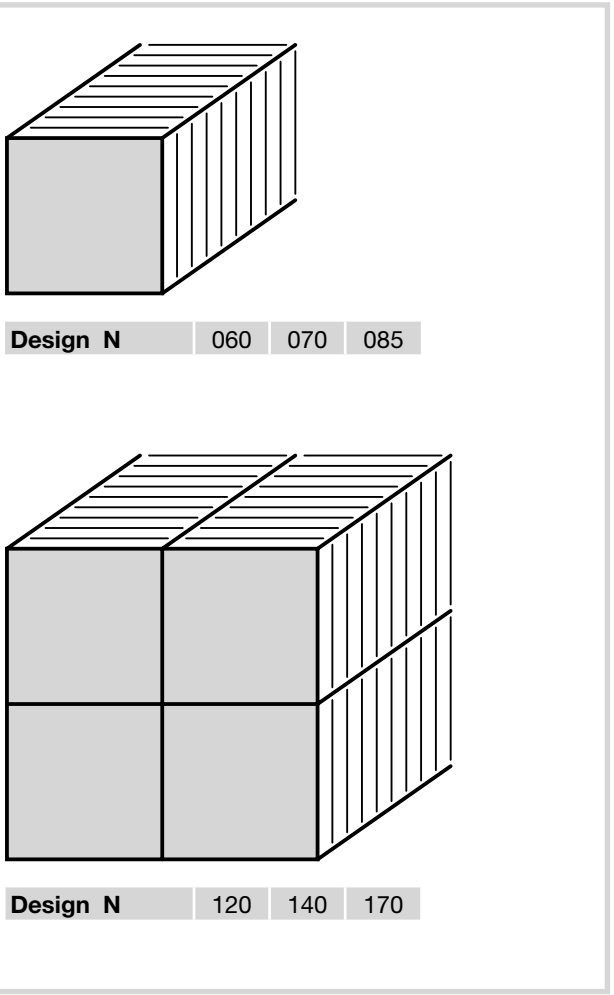


Fig. 4-2: Individual plate heat exchangers are constructed from different exchanger packages.

4.4 Plate spacing

The plate spacing effects the surface area and thus the heat recovery effectiveness, the pressure drop and the price. Hoval offers several spacings for most sizes so that an optimum solution can be achieved for each project.

R	= Small spacing	= Very high heat recovery effectiveness
X	= Middle spacing	= High heat recovery effectiveness
L	= Large spacing	= Middle heat recovery effectiveness
W	= Very large spacing	= Low heat recovery effectiveness

The approximate plate spacing is calculated from the width of the exchanger package b divided by the number of plates. Depending on the width, minor deviations from the nominal value are possible in practice.

Plate spacing	Design N					
	060	**070**	**085**	**120**	**140**	**170**
R	3.0	3.3	3.9	5.0	5.3	6.3
X	4.0	4.3	5.1	6.3	6.3	
L	5.0	5.3	6.3			
W	6.3	6.3				

Table 4-1: Nominal values of clear plate spacings (in mm) design N

4.5 Exchanger width

The width of the Hoval series plate heat exchanger can be as desired. It can be selected according to local conditions and design criteria (e.g. pressure drop). For stability reasons, but also to simplify transport and installation, the maximum exchanger width is limited to 118.1 inches (3000 mm).

5 Option

Horizontal installation L

Normally the Hoval series plate heat exchanger is installed in such a way that the plates are vertical. Horizontal installation is also possible, considering the following:

- There is a higher icing-up hazard because condensate can remain on the plates.
- Due to uncontrolled condensate drain a condensate drip try should be installed below the exchanger.
- Condensate drops can be carried along with the air flow;
- Install plate heat exchangers of design N in such a way that the fold is bent downwards:

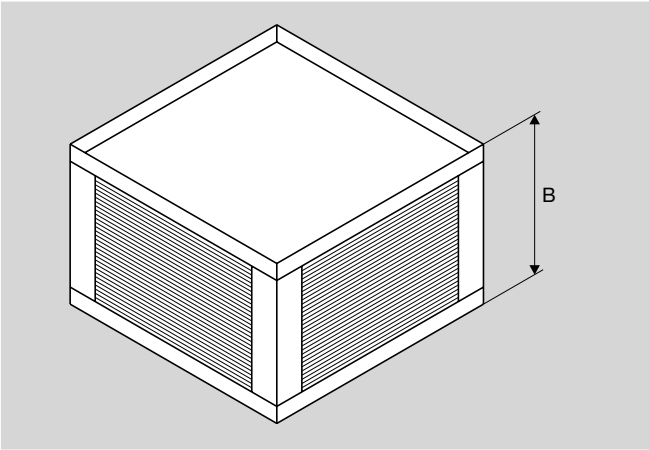


Fig. 5-1: Schematic view of a plate heat exchanger installed in horizontal position

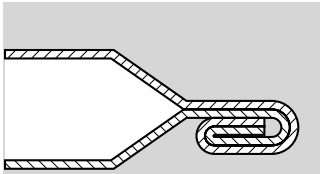


Fig. 5-2

- To increase stability, supports are fitted in the exchanger package.

For horizontally installed exchangers the width B in the unit type reference becomes the exchanger height.

During transport, the plates must be vertical.

Application limits

6 Unit Type Reference, Application Limits, Specification of Material

Hoval series plate heat exchangers are clearly defined with the unit type reference. This shows all possibilities for design and options.
Table 6-1 shows which limits are to be respected when planning, designing and operating.

7 Exchanger Dimensions

The following drawings show various designs and exchanger sizes. The dimensions given are those relevant for connection of the plate heat exchanger. For clarity, details of type sizes made up of four exchanger packages have been omitted.

	Temperature	Width	Pressure differential	Pressure diff. to outside	Pressure drop
Design V and G	-40...212 F (-40 ... 100 °C)	2.75...118.1 in (70 ... 3000 mm)	max. 10" w.g. max. (2500 Pa)	max. 10" w.g. max. (2500 Pa)	Pressure drop should not exceed 1.2" w.g. (300 Pa) for economical reasons. Recommended: 0.6...0.8"w.g. (150 ... 200 Pa)
Design T	-40...392 F (-40 ... 200 °C)	2.75...118.1 in (70 ... 3000 mm)	max. 4" w.g. max. (1000 Pa)	max. 4" w.g. max. (1000 Pa)	

Table 6-1: Application limits for Hoval plate heat exchangers

	Series V	Series G	Series T
Plate exchanger			
Plates	Aluminium	Aluminium epoxy-coated	Aluminium
Casing	Galvanized sheet steel Aluminium sections	Galvanized sheet steel wet-painted red (RAL 3000) Aluminium sections wet-painted orange (RAL 2008)	Galvanized sheet steel Aluminium sections
Sealing	Casting resin	Casting resin	HT silicone

Table 6-2: Specification of material for Hoval series plate heat exchangers

Unit Type Reference

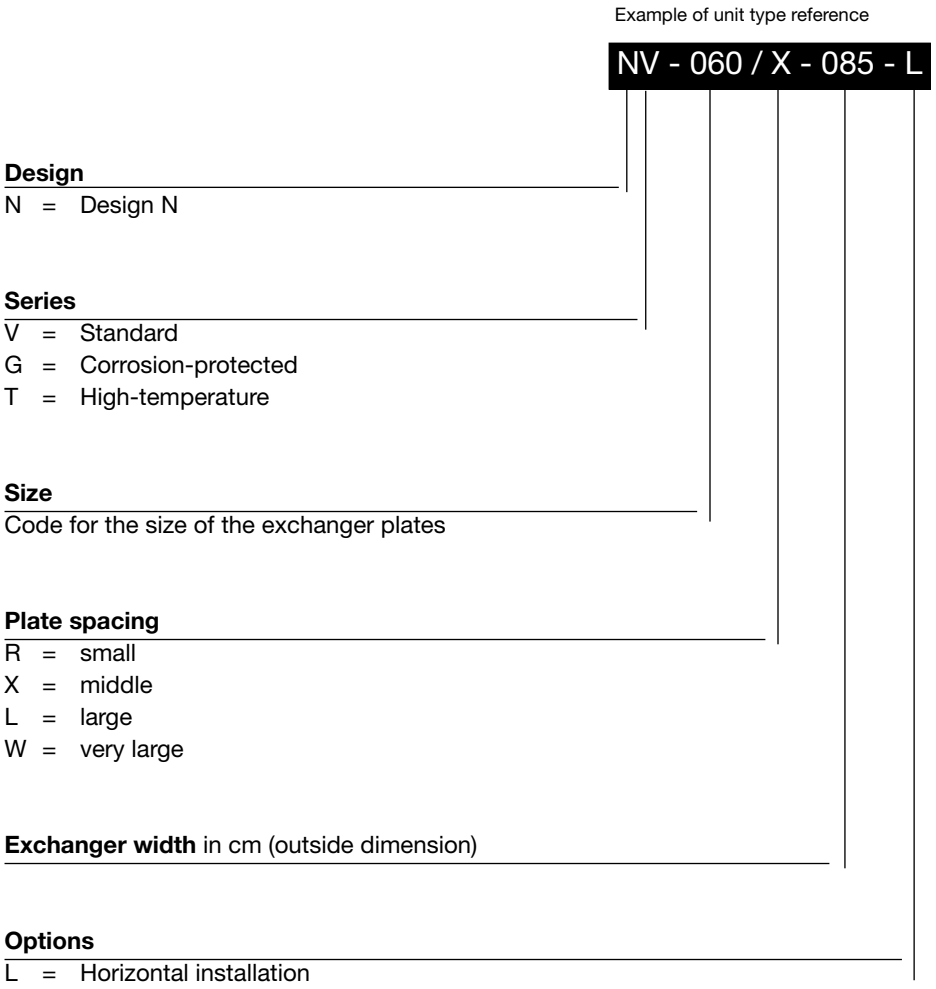
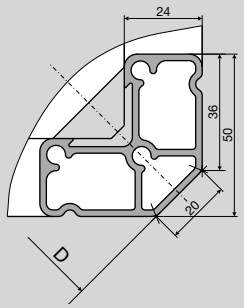


Table 6-3: Unit type reference for Hoval series plate heat exchangers

Exchanger Dimensions

		Design N (in mm)					
Exchanger size		**060**	**070**	**085**	**120**	**140**	**170**
Height, length	**H = L**	600	700	850	1200	1400	1700
Diagonal	**D**	829	970	1182	1677	1960	2384

Detail A



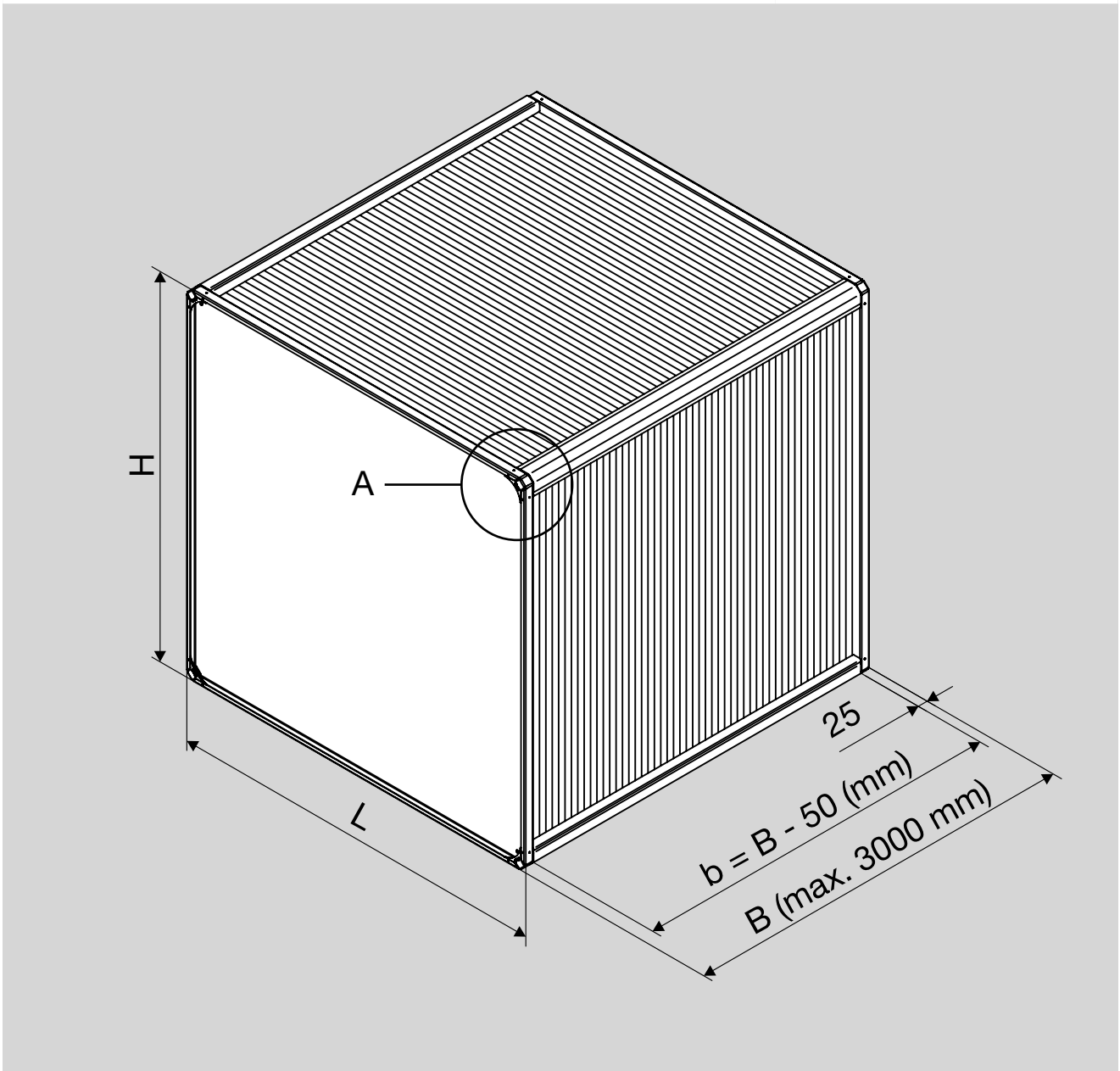


Table 7-1: Dimensions of exchangers without bypass (in mm)

8 Design Guidelines

8.1 Selection program Winnergy

The design of Hoval series plate heat exchangers is easy and quick with the selection program Winnergy. It runs under Microsoft® Windows and offers the following:

- Reliable design data thanks to ARI-certified data
- Exact calculation of a specific Hoval series plate heat exchanger
- Calculation of all appropriate plate heat exchangers for a specific project
- Price calculation

The selection program Winnergy is available for download on our homepage (www.innergytech.com).

Table 8-1: The design of Hoval series plate heat exchangers is easy and quick with the selection program Winnergy.

8.2 Design data

When designing, correct data is essential to achieve the desired values. This is often particularly difficult in air handling installations because the specific density and specific heat are dependent on temperature. Also the water vapour contained in the air is very important for the design. For an exact calculation of a plate heat exchanger the air conditions at entry to the exchanger are required.

Extract air	Air flowrate at exchanger entry
	Rel. humidity at exchanger entry
	Temperature at exchanger entry
Fresh air	Air flowrate at exchanger entry
	Temperature at exchanger entry
	Rel. humidity at exchanger entry

Table 8-1: Design data for plate heat exchangers.

The following errors should be avoided when collecting the data:

- For winter operation the moisture in the air is often estimated too high. (Where does the moisture come from?)
- Are the temperatures (fresh air, extract air) really as stated in practice (or are they wishful thinking)?

8.3 Rules and guidelines

Ascertain before designing which rules and guidelines apply. For instance, for some applications (e.g. hospitals) some heat recovery systems are not suitable or can only be allowed after appropriate proving.

8.4 Positioning of unit and system layout

- Where should the heat recovery unit be positioned?
- Which is the optimum air path?
- Which dimensions are allowed?

These questions are important when selecting a plate heat exchanger and should be thoroughly examined in advance. Little general recommendation can be given for positioning

and air path. Only take care that condensate, if present, can drain freely and does not remain inside the exchanger, thus causing a higher pressure drop. This is always guaranteed with a downward extract air flow. Yet, in practice all possible airflows and positions are used without any problems. Section 5.6 gives special tips for horizontal installation.

8.5 Cost-effective design

If the calculation is not carried out with the Innergytech selection program Winnergy, select the most economical type, regarding effectiveness and/or plate spacing. The following rules apply:

- Long periods of operation (e.g. 3 operating shifts)
  → high effectiveness
- Long life span of unit
  → high effectiveness
- High extract air humidity and thus improved effectiveness through condensation
  → medium, large or very large plate spacing
- High dirt hazard
  → large or very large plate spacing

When using plate heat exchangers in process technology, ascertain whether the heat recovery figure is limited due to supply air temperature.
The optimum plate heat exchanger selection can only be based on an economic calculation.

8.6 Twin exchangers

If a particularly high effectiveness is required it is possible to connect two or even more plate heat exchangers in series.

Various arrangements are possible; the important thing is that the two air streams pass each other in cross flow.

8.7 Performance control

Check which internal heat sources are available in the hall. If the extract air temperature is expected to be clearly higher than the desired temperature, a performance control of the plate heat exchanger should be considered (see section 2).

8.8 Recirculation bypass

If the air handling installation allows for recirculation operation as well (e.g. during the night) this can also be achieved with a recirculation bypass in the plate heat exchanger.
If recirculation is also possible during fresh air operation, reasonable control priorities (recirculation/heat recovery) must be defined.

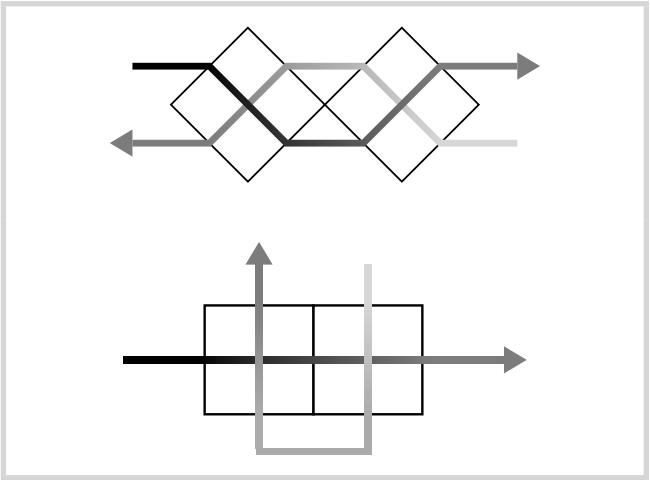


Fig. 8-2: Twin exchangers offer interesting connection possibilities and highest heat recovery values.

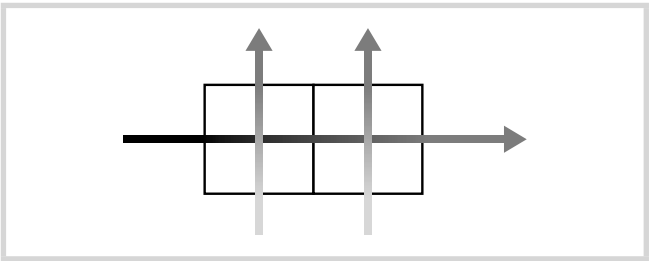


Fig. 8-3: For unequal mass flow rates check parallel flow or counter flow arrangements.

8.9 Sound attenuation

Plate heat exchangers have a sound-dampening effect. The performance depends on the plate size and spacing. More details based on various tests and theoretical considerations are available upon request.

8.10 Corrosion

Series V of Hoval plate heat exchangers has proved satisfactory for installation into air handling equipment. If corrosion is expected – e.g. in swimming pools, kitchens, and certain industrial applications – series G (corrosion-protected) is used. The Innergytech technical department will advise which series is suitable for specific applications.

8.11 Application limits

Prior to selecting a plate heat exchanger, check if any application limits have been exceeded (temperature, pressure difference).

Design Guidelines

8.12 Dirt build-up

In 'normal' air handling equipment the air streams are cleaned mostly by coarse dust filters. Therefore there is no dirt hazard for the plate heat exchanger, but if this is expected, in specific applications, consider the following:

- Position the exchanger in such a way that it can be cleaned easily or
- install in such a way that it can easily be removed for cleaning.
- Fit inspection ports before and after the plate heat exchanger.
- If possible, filter the air streams so that dirt built-up is minimised or cleaning intervals are longer.

It was found in practice that dirt built-up is far less than expected. The Innergytech technical department will advise.

8.13 Condensation in the warm air stream

Plate heat exchangers are not 100 % leakproof unless special measures are taken (see section 1.2 and 1.4). Therefore, if condensation is expected:

- Install condensate drip trays on the supply and extract air side.
- Position the fans in such a way that the pressure gradient and thus leakage is from the supply to the extract air.

When large amounts of condensate are present in the extract air and the air velocity is higher than 8.2 ft/s (2.5 m/s), condensate drops can be carried along with the airflow and enter ducts or other ventilation components downstream of the heat exchanger. To avoid this and thus uncontrolled condensate escape, we recommend that a drop eliminator is installed after the plate heat exchanger. In addition, check the following and arrange for appropriate measures:

- How is the condensate drained away?
- Is icing-up hazard expected (see section 1.6)?

8.14 Solvent resistance

Plate heat exchangers may sometimes be used in applications where solvents (e.g. acetone, methanol, toluol, xylol, propanol and MEK) are contained in the extract air stream. These attack the casting resin used for sealing the corner sections. On request, we therefore supply a special design as follows:

- Solvent-resistant casting resin
- Solvent-resistant adhesive tape
- Metal cover instead of plastic elbow piece

For such applications please also consider:

- Control dampers must be installed in the (clean) fresh air stream.
- A pressure gradient from the supply air to the extract air side should be provided, avoiding the transmission of solvents to the supply air. (In addition, a leakage test is recommended.)
- Check if the other materials (aluminium, Galvanized, etc.) are resistant to the solvent.

8.15 Operation and function reliability

Hoval series plate heat exchangers do not require power drive, have no moving parts and thus are 100 % reliable in operation.

Therefore it is possible, at the planning stage, to take recovered heat into consideration. The heat generation and distribution required (boilers, heaters, flues) can therefore be dimensioned and selected on a smaller scale. Thus cost savings are already in evidence at the installation stage.

9 Transport and Installation

Hoval series plate heat exchangers have no moving parts. Therefore they are easy to install and totally reliable in operation. The following should be checked before installation:

- Has the plate heat exchanger been damaged during transport (visual check of casing and plate package)?
- Has the correct type been delivered (design, series, size, plate spacing, options)?
- How is the plate heat exchanger to be positioned (installation position?)

9.1 Transport

- The plates must always be vertical during transport.
- The exchangers may be lifted at the side walls, yet to avoid damage the tensile direction must be vertical (parallel to the side wall). Also lifting facilities (hooks, loops, etc.) may be bolted to the returned edge of the side wall for transportation.
- Do not lift the exchanger at the aluminium corner section because this might cause damage to the corner sealing (leakage).
- Do not lift the exchanger at the reinforcing bar spacers of the bypass.
- In general: Do not suspend the exchanger in one point but always over a crane beam (Fig. 9-1).

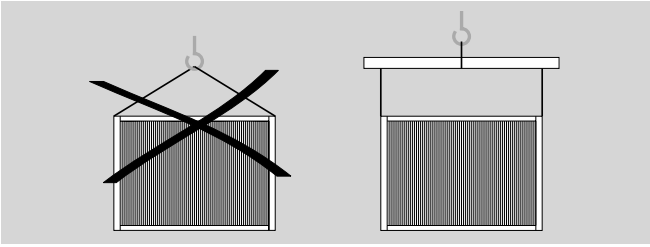


Fig. 9-1: Do not suspend the exchanger in one point!

9.2 Mechanical installation

The Hoval series construction offers particular advantageous for installation into air handling units or connection to ducts or other ventilation equipment:

- The corner sections of aluminium are hollow. They can be bolted or riveted without damaging the exchanger.
- Also the flange of the side walls can be used for bolting and riveting.
- The returned edge of the side wall allows easy installation of a sealing all round. It can also be used for side fastening (bolting, riveting).

The examples below show some possibilities for the installation of Hoval Series plate heat exchangers into air handling units:

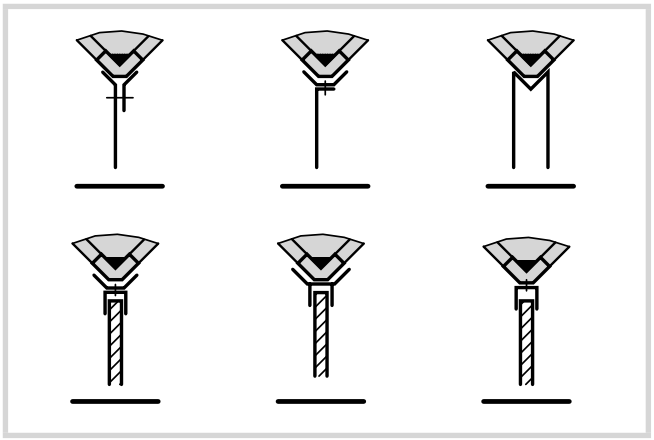


Fig. 9-2: Installation possibilities

9.3 Condensate drain connection
If condensation is expected make sure that this can drain away freely. We recommend condensate drip trays on both sides, i.e. for both air streams. The expected amount of condensate is calculated with the Hoval computer program. Correspondingly sized condensate drains should be installed.

9.4 Fitting of sensors and other detectors
If e.g. temperature sensors are required in the plate heat exchanger make sure that the exchanger package is not damaged by their installation.

9.5 Assembly on site
Depending on local conditions (particularly for retro-fitting) it may be necessary to deliver the plate heat exchanger in several parts. These must then be assembled on site by bolting and riveting. There are various possibilities for break-down of the exchanger:
- In the width, sections can be manufactured as desired.
- In the height and length, only compound exchangers can be divided. In this case the individual exchanger blocks can be supplied.

10 Commissioning and Maintenance

10.1 Commissioning
Before commissioning, ensure that the air streams can flow freely through the plate heat exchanger. Furthermore, check if installation has been carried out correctly and make sure that the application limits (temperature, pressure difference, material, etc.) cannot be exceeded.

10.2 Maintenance
Only periodic visual checks are necessary. After initial 3-monthly inspection intervals, checks can be carried out every 12 months.
Based on long experience, dirt build-up inside the plate heat exchangers installed in air handling equipment is not expected. Yet should dirt enter the plate heat exchanger when used for special applications, e.g. welding shops, paint shops, kitchen extracts, etc., the exchanger package can be cleaned as follows:
- Remove dust and fibres with a soft brush or with a vacuum cleaner. Take care when cleaning with compressed air that the exchanger package is not damaged. Keep at a distance!
- Oils, solvents, etc. can be removed with hot water or grease solvents, by washing or immersing. Cleaning with high-pressure devices is possible if:
  – a flat nozzle 40° is used (type WEG40/04)
  – the max. water pressure is 1450 PSI (100 bar)

When cleaning take care that the exchanger is not damaged, neither mechanically nor chemically:
→ Choose harmless cleansing agents.
→ Clean carefully.

Specification Text

11 Specification Text

Hoval series cross-flow plate heat exchanger for heat recovery, consisting of exchanger package and casing:
The exchanger package consists of aluminium plates with pressed-in spacers; condensate drainage is possible in every direction.
The plates are connected by a fold. This gives a severalfold material thickness at air entry and exit. In addition, the fold is sealed with casting resin.
The corners of the exchanger package are cast and sealed into especially rigid aluminium extrusions in the casing with permanent elastic resin using a patented method. The side walls of Galvanized sheet steel are bolted tightly to these extrusions.
All performance data is ARI-certified.

Series V (standard):
Aluminium plates, extruded aluminium sections and Galvanized sheet steel; silicone-free; resistant to temperatures up to 212 F (100 °C).

Series G (corrosion-protected):
All components (Aluminium plates, extruded aluminium sections and Galvanized sheet steel) coated; silicone-free; resistant to temperatures up to 212 F (100 °C).

Series T (high-temperature):
Aluminium plates, extruded aluminium sections and Galvanized sheet steel; special sealing agent, resistant to temperatures up to 392 F (200 °C).

Options
- Horizontal installation position must be considered in fabrication.

Technical data
Type
Weight
Height
Width
Length
Warm air
Air flowrate at exchanger entry
Temperature at exchanger entry
Rel. humidity at exchanger entry
Temperature at exchanger exit
Pressure drop (with condensation)
Cold air
Air flowrate at exchanger entry
Temperature at exchanger entry
Rel. humidity at exchanger entry
Temperature at exchanger exit
Pressure drop
Mass flow ratio

Explanation of Symbols

Symbol	Unit	Term
A	m^2	Exchanger surface area
b	mm or m	Width of the exchanger package
d	mm	Plate thickness
h	kJ/kg	Enthalpy
k	W/m^2K	Heat transmission
m	kg/h	Mass flow= $V \cdot \rho$
Δp	Pa	Pressure drop
Q	kW	Heat performance
t	K or °C	Temperature
V	m^3/h	Volume flow
α	W/m^2K	Heat transfer rate
Φ	%	Heat recovery effectiveness
RH	%	Relative humidity
ρ	kg/m^3	Specific density
μ	–	Mass flow ratio $\mu = \frac{m_2}{m_1}$
λ	W/mK	Heat conductivity
First index		1 ... Heat releasing medium 2 ... Heat absorbing medium
Second index		1 ... Plate heat exchanger entry 2 ... Plate heat exchanger exit

Note: Refer to calculation formulas inside this brochure.

Experience Over Many Years Guarantees Sound Advice

Hoval – a leading manufacturer of heat recovery systems. Hoval, a group with several production plants and sales offices in Europe, is a pioneer of heating technology. Today the product range includes not only boilers but also air heaters, radiators and steam boilers.
Since 1976 Hoval has manufactured in Liechtenstein plate heat exchangers for heat recovery. And since 2002, in addition to this recuperative system, the production program also includes regenerative rotary heat exchangers, such exchangers having been sold in Switzerland for more than twenty years already. The resultant experience forms the basis for Hoval application and technical advisory service.

Vaduz factory (Liechtenstein)

Striving for Excellence

Innergytech –a market leader in energy recovery components. Innergytech, a company based in Canada, has 11 years of experience in research, development and production of energy recovery components. Our units are highly efficient air-to-air energy recovery devices reducing energy losses in HVAC and industrial process applications. Our product line includes plastic and aluminum plate exchangers, heat pipes and energy recovery wheel. Our products offer innovative and cost effective solutions that can be easily integrated to any energy recovery ventilation system.

Guaranteed effectiveness with ARI Certification Seal. Innergytech components are tested independently and proven to be one of the most efficient energy recovery devices on the market. Our units are ARI certified under the Air-to-Air Energy Recovery Ventilation Equipment Certification Program and bear the ARI 1060 Performance Certification seal.

Innergytech factory (Drummondville, Canada)

Certified quality with ISO 9001. The Innergytech quality system is tested and certified under ISO 9001. This means that optimized procedures are adhered to in development, fabrication and distribution – to guarantee the Innergytech quality.

Automatic production to customer specification. Innergytech components are manufactured to customer specification. State-of-the-art machinery ensures constant high quality products.

Innergy tech inc.

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