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TNO report

TNO 2017 R10535

Performance of 2 Recair Heat exchangers
Test report in accordance with EN 308:1997

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Contents

1 Introduction

TNO was commissioned by Recair to determine the dry temperature efficiency and leak tightness of two heat exchangers build in a test box in accordance with:

- EN 308 - Heat exchangers - Test procedures for establishing performance of air to air and flue gases heat recovery devices (reference [1]).

Results for the airtightness and the dry temperature efficiency measurements are given in this test report. The testing is for the heat exchanger in a test box, thus there are no integral fans or filters.

Some activities are performed under ISO/IEC 17025 accreditation (RvA registration no. L115). See table below.

Test	ISO/IEC 17025
Airtightness	Yes
Efficiency of heat recovery	Yes

2 Identification of the appliance

Manufacturer	Recair Spuiweg 28 5145 NE Waalwijk The Netherlands.
Start date of testing	March 2017.

Type plate of the tested heat exchanger 1 (HX1).

Type plate of the tested heat exchanger 2 (HX2).

3 Airtightness

The airtightness of the device is determined on the basis of the internal and external leakage at various over and under pressures.

The leakage is quantified according to EN308 with a particular pressure difference between the appliance fresh air / exhaust air compartments or across the appliance external casing, according to clauses 5.2 and 5.3.

The 2 units were tested with +/- 400Pa on both air sides for external leakage testing and 250Pa difference between the two streams for internal leakage (with the flow measurement stream at 0Pa).

The leakages were very low and below the level where they could be reliably measured, up to and including the pressures given above. It can be stated that all external leakages at +/- 400Pa and internal leakages at 250Pa were less than 2.6m^3/hr.

The nominal flow for these heat exchangers is not known (other than it is greater than 100m^3/hr), but even for the minimum flow of 100m^3/hr, the leakages are less than the maximum allowed (3%) to comply with the requirements of the standard. It is therefore permitted to continue with the temperature efficiency measurements.

4 Efficiency of heat recovery

4.1 Principles used for the determination of the efficiency

EN 308, specifies the method for carrying out the efficiency measurements.

The temperature efficiency was determined under the test conditions as shown in table 1.

Table 1 Test conditions for the determination of the efficiency in accordance with NBN EN 308

	Outdoor air		Extract air		
Measurement no.	temperature	Absolute humidity	temperature	Absolute humidity	Relative humidity
	[°C]	[g/kg]	[°C]	[g/kg]	[%]
1, 2, 3, 4, 5	5 ± 0.5	-	25 ± 0.5	5.5 ± 0.5	~ 28

The tests were carried out at an ambient room temperature of 24°C ± 3 K in which the unit is situated.

The efficiency is determined for various air flow rates according to the manufacturer's specification. See table 2.

Table 2 Determination of the air flows

Measurement no.	Air flow m^3/h
1	100
2	150
3	200
4	300
5	400

When setting the operating condition the pressure differences were evenly distributed over the inlet and the outlet side of the appliance.
The over / under pressures set during the measurements were (table 3 and 4):

Table 3 Setting values for static pressure around the energy recovery appliance HX1

Measurement no.	Supply air (Pa)		Exhaust air (Pa)	
	intake	discharge	intake	discharge
1	13	-13	13	-13
2	22	-22	22	-22
3	30	-30	32	-32
4	52	-52	59	-59
5	74	-74	88	-88

Table 4 Setting values for static pressure around the energy recovery appliance HX2

Measurement no.	Supply air (Pa)		Exhaust air (Pa)	
	intake	discharge	intake	discharge
1	5	-5	6	-6
2	9	-9	10	-10
3	13	-13	14	-14
4	22	-22	25	-25
5	33	-33	38	-38

4.2 Carrying out the measurements

4.2.1 Test setup

The test setup for the determination of the temperature efficiency is shown in figure 1.

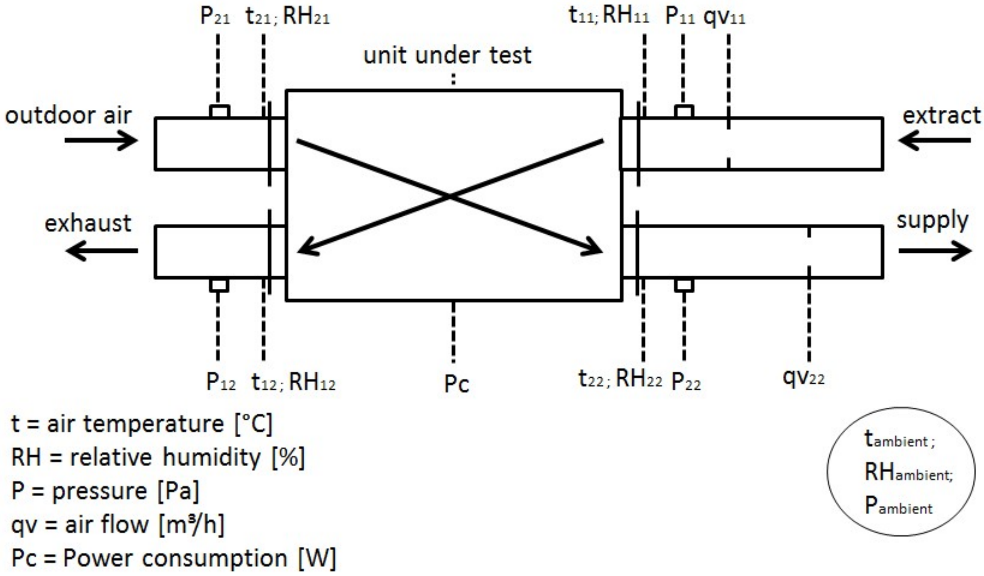

Figure 1 Test setup for determination the temperature efficiency.

4.2.2 General

The measured values are recorded using a data acquisition system that reads the values at fixed intervals (reading and saving all data simultaneously). If the measured values of the incoming air flows show a too great variation in time, these variations will be visible at the discharge side of the appliance with a time delay (= the through-put time in the appliance). Too great a variation in temperature, humidity and/or air flow in time results in a wide spread in the performances of the appliance. The measured values for the incoming air flows are checked for a maximum allowed variation in time in order to restrict this spread to a minimum. The check on exceeding the maximum variation is in principle carried out on-line for every measurement interval by comparison with the previously measurement interval. When the measurement interval is 15 seconds a measurement period of 10 minutes (= 40 measurement intervals) gives a good picture of the stability achieved.

The average values of the measured values are calculated for each measurement period and compared with the result of the preceding measurement period. The variation may not exceed a pre-determined value. In addition, the difference between the minimum and maximum value of the efficiency is checked for the maximum allowed difference over four successive stable measurement periods. In order to declare a measurement valid, at least four consecutive measurement periods must comply with the stability criteria as given in 4.2.3.
The total duration of the measurements depends on the stability of the measurement process.

4.2.3 Criteria for the stability of the measurement process

Incoming air flows:

- maximum variation of temperature reading: ± 0.5 K;
- maximum variation of the absolute humidity: ± 0.5 g/kg;
- maximum variation of air flow: ± 3 %.

Results efficiency:

- maximum difference between two successive measurement periods: 0.003
- maximum difference between minimum and maximum value during 4 consecutive measurement periods: 0.005.

Duration of measurements:

- the minimum duration of measurements during which the stability criteria are complied with 4 consecutive measurement periods of 10 minutes.

4.3 Results

The results of the efficiency measurements are shown in tables 7 to 16.
The efficiency at different airflows is summarised in tables 5 and 6, both uncorrected and corrected for the mass flow ratio (although EN308 does not specify the need for a mass flow correction due to mass flow imbalances, it is included for completeness. Therefore the “uncorrected” value is the one used as per the standard).

Temperature efficiency uncorrected for the mass flow ratio: $\eta_{t=}\frac{t_{22}-t_{21}}{t_{11}-t_{21}}.$

Temperature efficiency corrected for the mass flow ratio: $\eta_{t=}\frac{t_{22}-t_{21}}{t_{11}-t_{21}}\times\frac{qm_{22}}{qm_{11}}.$

Table 5 Results of the efficiency performance tests EN 308 HX1

Measurement no.	Air flow	Uncorrected η_{temp}	Corrected η_{temp}
	m^3/h	%	%
1	100	91.5	92.1
2	150	90.2	90.5
3	200	88.9	89.4
4	300	87.1	88.1
5	400	85.0	86.0

Table 6 Results of the efficiency performance tests EN 308 HX2

Measurement no.	Air flow	Uncorrected η_{temp}	Corrected η_{temp}
	m^3/h	%	%
1	100	88.6	89.6
2	150	87.3	87.3
3	200	85.0	85.4
4	300	81.3	82.0
5	400	78.1	79.3

Table 7 Results of efficiency measurement at 100 m³/h HX1

EN308	nominal airflow		100 m³/h		
Unit	Recair HX1		date	25-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	5.09	T drybulb	°C	23.40
RH	%	50.93	RH	%	14.41
Pressure duct	Pa	13	Pressure duct	Pa	-13
			Air flow	m³/h	102.3
			Air flow	kg/h	123.2
Spec. heat (h)	kJ/kg	11.94	Spec. heat (h)	kJ/kg	29.95
Moisture (x)	g/kg	2.72	Moisture (x)	g/kg	2.52
Spec. mass	kg/m³	1.284	Spec. mass	kg/m³	1.205
P vapour max	kPa	0.878	P vapour max	kPa	2.873
P vapour	kPa	0.447	P vapour	kPa	0.414
T wetbulb	°C	1.4	T wetbulb	°C	10.3
			Heatflow	kJ/h	3690.8
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.11	T drybulb	°C	6.83
RH	%	25.2	RH	%	79.46
Pressure duct	Pa	13	Pressure duct	Pa	-13
Air flow	m³/h	102.3			
Air flow	kg/h	122.4			
Spec. heat (h)	kJ/kg	37.74	Spec. heat (h)	kJ/kg	18.94
Moisture (x)	g/kg	4.90	Moisture (x)	g/kg	4.80
Spec. mass	kg/m³	1.196	Spec. mass	kg/m³	1.274
P vapour max	kPa	3.183	P vapour max	kPa	0.990
P vapour	kPa	0.802	P vapour	kPa	0.786
T wetbulb	°C	13.4	T wetbulb	°C	5.2
Heatflow	kJ/h	4619.7			
Ambient					
Air pressure	kPa	102.71			
T amb	°C	24.64			
RH amb	%	25.56			
P vapour amb	kPa	0.791			
X amb	g/kg	4.83			
Spec. heat (h)	kJ/kg	37.09			
Spec. mass	kg/m³	1.198			
T wetbulb	°C	13.20			
			Results		
			Massflowratio	-	1.007
			T efficiency	%	91.5
			T efficiency cor.	%	92.1
			h rend	%	91.6

Table 8 Results of efficiency measurement at 150 m^3/h HX1

EN308	nominal airflow	150 m^3/h			
Unit	Recair HX1		date	27-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	4.88	T drybulb	°C	23.10
RH	%	51.95	RH	%	14.52
Pressure duct	Pa	22	Pressure duct	Pa	-22
			Air flow	m^3/h	153.8
			Air flow	kg/h	184.6
Spec. heat (h)	kJ/kg	11.80	Spec. heat (h)	kJ/kg	29.61
Moisture (x)	g/kg	2.74	Moisture (x)	g/kg	2.50
Spec. mass	kg/m^3	1.279	Spec. mass	kg/m^3	1.200
P vapour max	kPa	0.865	P vapour max	kPa	2.822
P vapour	kPa	0.449	P vapour	kPa	0.410
T wetbulb	°C	1.3	T wetbulb	°C	10.1
			Heatflow	kJ/h	5464.7
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.08	T drybulb	°C	6.83
RH	%	24.89	RH	%	79.98
Pressure duct	Pa	22	Pressure duct	Pa	-22
Air flow	m^3/h	154.4			
Air flow	kg/h	183.9			
Spec. heat (h)	kJ/kg	37.58	Spec. heat (h)	kJ/kg	19.07
Moisture (x)	g/kg	4.85	Moisture (x)	g/kg	4.85
Spec. mass	kg/m^3	1.191	Spec. mass	kg/m^3	1.268
P vapour max	kPa	3.177	P vapour max	kPa	0.990
P vapour	kPa	0.791	P vapour	kPa	0.792
T wetbulb	°C	13.4	T wetbulb	°C	5.2
Heatflow	kJ/h	6911.9			

Ambient		
Air pressure	kPa	102.255
T amb	°C	24.28
RH amb	%	26.09
P vapour amb	kPa	0.790
X amb	g/kg	4.84
Spec. heat (h)	kJ/kg	36.76
Spec. mass	kg/m^3	1.194
T wetbulb	°C	13.07

Results		
Massflowratio	-	1.004
T efficiency	%	90.2
T efficiency cor.	%	90.5
h rend	%	90.3

Table 9 Results of efficiency measurement at 200 m^3/h HX1

EN308	nominal airflow	200 m^3/h			
Unit	Recair HX1		date	27-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	4.98	T drybulb	°C	22.83
RH	%	52.44	RH	%	14.98
Pressure duct	Pa	30	Pressure duct	Pa	-30
			Air flow	m^3/h	202.0
			Air flow	kg/h	242.7
Spec. heat (h)	kJ/kg	12.01	Spec. heat (h)	kJ/kg	29.43
Moisture (x)	g/kg	2.79	Moisture (x)	g/kg	2.54
Spec. mass	kg/m^3	1.279	Spec. mass	kg/m^3	1.202
P vapour max	kPa	0.871	P vapour max	kPa	2.776
P vapour	kPa	0.457	P vapour	kPa	0.416
T wetbulb	°C	1.5	T wetbulb	°C	10.1
			Heatflow	kJ/h	7142.7
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.07	T drybulb	°C	7.14
RH	%	24.53	RH	%	78.34
Pressure duct	Pa	32	Pressure duct	Pa	-32
Air flow	m^3/h	202.5			
Air flow	kg/h	241.3			
Spec. heat (h)	kJ/kg	37.38	Spec. heat (h)	kJ/kg	19.39
Moisture (x)	g/kg	4.77	Moisture (x)	g/kg	4.85
Spec. mass	kg/m^3	1.192	Spec. mass	kg/m^3	1.267
P vapour max	kPa	3.175	P vapour max	kPa	1.011
P vapour	kPa	0.779	P vapour	kPa	0.792
T wetbulb	°C	13.3	T wetbulb	°C	5.4
Heatflow	kJ/h	9020.2			
Ambient					
Air pressure	kPa	102.292			
T amb	°C	24.09			
RH amb	%	25.96			
P vapour amb	kPa	0.777			
X amb	g/kg	4.76			
Spec. heat (h)	kJ/kg	36.37			
Spec. mass	kg/m^3	1.195			
T wetbulb	°C	12.92			
			Results		
			Massflowratio	-	1.006
			T efficiency	%	88.9
			T efficiency cor.	%	89.4
			h rend	%	88.9

Table 10 Results of efficiency measurement at 300 m³/h HX1

EN308	nominal airflow	300 m³/h			
Unit	Recair HX1		date	24-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	5.11	T drybulb	°C	22.55
RH	%	52.45	RH	%	15.51
Pressure duct	Pa	52	Pressure duct	Pa	-52
			Air flow	m³/h	303.7
			Air flow	kg/h	367.5
Spec. heat (h)	kJ/kg	12.16	Spec. heat (h)	kJ/kg	29.23
Moisture (x)	g/kg	2.80	Moisture (x)	g/kg	2.57
Spec. mass	kg/m³	1.287	Spec. mass	kg/m³	1.210
P vapour max	kPa	0.879	P vapour max	kPa	2.729
P vapour	kPa	0.461	P vapour	kPa	0.423
T wetbulb	°C	1.6	T wetbulb	°C	10.0
			Heatflow	kJ/h	10739.6
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.13	T drybulb	°C	7.95
RH	%	26.3	RH	%	78.94
Pressure duct	Pa	59	Pressure duct	Pa	-59
Air flow	m³/h	303.3			
Air flow	kg/h	363.6			
Spec. heat (h)	kJ/kg	38.29	Spec. heat (h)	kJ/kg	20.93
Moisture (x)	g/kg	5.10	Moisture (x)	g/kg	5.14
Spec. mass	kg/m³	1.199	Spec. mass	kg/m³	1.271
P vapour max	kPa	3.187	P vapour max	kPa	1.068
P vapour	kPa	0.838	P vapour	kPa	0.843
T wetbulb	°C	13.7	T wetbulb	°C	6.1
Heatflow	kJ/h	13920.5			
Ambient					
Air pressure	kPa	102.912			
T amb	°C	24.01			
RH amb	%	28.05			
P vapour amb	kPa	0.836			
X amb	g/kg	5.09			
Spec. heat (h)	kJ/kg	37.13			
Spec. mass	kg/m³	1.203			
T wetbulb	°C	13.21			
			Results		
			Massflowratio	-	1.011
			T efficiency	%	87.1
			T efficiency cor.	%	88.1
			h rend	%	87.1

Table 11 Results of efficiency measurement at 400 m^3/h HX1

EN308	**nominal airflow**		**400** m^3/h		
Unit	Recair HX1		date	24-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	5.11	T drybulb	°C	22.08
RH	%	53.01	RH	%	16.21
Pressure duct	Pa	74	Pressure duct	Pa	-74
			Air flow	m^3/h	400.4
			Air flow	kg/h	484.7
Spec. heat (h)	kJ/kg	12.24	Spec. heat (h)	kJ/kg	28.86
Moisture (x)	g/kg	2.83	Moisture (x)	g/kg	2.61
Spec. mass	kg/m^3	1.286	Spec. mass	kg/m^3	1.211
P vapour max	kPa	0.879	P vapour max	kPa	2.652
P vapour	kPa	0.466	P vapour	kPa	0.430
T wetbulb	°C	1.6	T wetbulb	°C	9.8
			Heatflow	kJ/h	13988.3
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.07	T drybulb	°C	8.39
RH	%	27.39	RH	%	79.2
Pressure duct	Pa	88	Pressure duct	Pa	-88
Air flow	m^3/h	399.8			
Air flow	kg/h	479.2			
Spec. heat (h)	kJ/kg	38.73	Spec. heat (h)	kJ/kg	21.83
Moisture (x)	g/kg	5.30	Moisture (x)	g/kg	5.32
Spec. mass	kg/m^3	1.199	Spec. mass	kg/m^3	1.267
P vapour max	kPa	3.175	P vapour max	kPa	1.101
P vapour	kPa	0.870	P vapour	kPa	0.872
T wetbulb	°C	13.8	T wetbulb	°C	6.6
Heatflow	kJ/h	18557.7			
Ambient					
Air pressure	kPa	102.847			
T amb	°C	23.67			
RH amb	%	29.72			
P vapour amb	kPa	0.868			
X amb	g/kg	5.29			
Spec. heat (h)	kJ/kg	37.29			
Spec. mass	kg/m^3	1.203			
T wetbulb	°C	13.27			
			Results		
			Massflowratio	-	1.012
			T efficiency	%	85.0
			T efficiency cor.	%	86.0
			h rend	%	85.0

Table 12 Results of efficiency measurement at 100 m^3/h HX2

EN308	nominal airflow		100 m^3/h		
Unit	Recair HX2		date	28-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	5.06	T drybulb	°C	22.84
RH	%	50.98	RH	%	14.58
Pressure duct	Pa	5	Pressure duct	Pa	-5
			Air flow	m^3/h	100.5
			Air flow	kg/h	120.4
Spec. heat (h)	kJ/kg	11.96	Spec. heat (h)	kJ/kg	29.29
Moisture (x)	g/kg	2.74	Moisture (x)	g/kg	2.48
Spec. mass	kg/m^3	1.274	Spec. mass	kg/m^3	1.198
P vapour max	kPa	0.876	P vapour max	kPa	2.778
P vapour	kPa	0.446	P vapour	kPa	0.405
T wetbulb	°C	1.4	T wetbulb	°C	10.0
			Heatflow	kJ/h	3527.1
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	25.13	T drybulb	°C	7.41
RH	%	25.31	RH	%	79.02
Pressure duct	Pa	6	Pressure duct	Pa	-6
Air flow	m^3/h	100.3			
Air flow	kg/h	119.1			
Spec. heat (h)	kJ/kg	37.93	Spec. heat (h)	kJ/kg	20.04
Moisture (x)	g/kg	4.96	Moisture (x)	g/kg	5.01
Spec. mass	kg/m^3	1.187	Spec. mass	kg/m^3	1.262
P vapour max	kPa	3.187	P vapour max	kPa	1.030
P vapour	kPa	0.807	P vapour	kPa	0.814
T wetbulb	°C	13.5	T wetbulb	°C	5.7
Heatflow	kJ/h	4516.5			

Ambient		
Air pressure	kPa	101.92
T amb	°C	24.42
RH amb	%	26.37
P vapour amb	kPa	0.805
X amb	g/kg	4.95
Spec. heat (h)	kJ/kg	37.19
Spec. mass	kg/m^3	1.190
T wetbulb	°C	13.23

Results		
Massflowratio	-	1.011
T efficiency	%	88.6
T efficiency cor.	%	89.6
h rend	%	88.6

Table 13 Results of efficiency measurement at 150 m³/h HX2

EN308	nominal airflow	150	m³/h		
Unit	Recair HX2		date	28-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	4.95	T drybulb	°C	22.43
RH	%	51.78	RH	%	14.99
Pressure duct	Pa	9	Pressure duct	Pa	-9
			Air flow	m³/h	151.1
			Air flow	kg/h	181.3
Spec. heat (h)	kJ/kg	11.90	Spec. heat (h)	kJ/kg	28.89
Moisture (x)	g/kg	2.76	Moisture (x)	g/kg	2.49
Spec. mass	kg/m³	1.275	Spec. mass	kg/m³	1.200
P vapour max	kPa	0.869	P vapour max	kPa	2.709
P vapour	kPa	0.450	P vapour	kPa	0.406
T wetbulb	°C	1.4	T wetbulb	°C	9.8
			Heatflow	kJ/h	5238.2
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	24.97	T drybulb	°C	7.45
RH	%	25.59	RH	%	77.99
Pressure duct	Pa	10	Pressure duct	Pa	-10
Air flow	m³/h	152.6			
Air flow	kg/h	181.2			
Spec. heat (h)	kJ/kg	37.78	Spec. heat (h)	kJ/kg	19.95
Moisture (x)	g/kg	4.97	Moisture (x)	g/kg	4.95
Spec. mass	kg/m³	1.188	Spec. mass	kg/m³	1.262
P vapour max	kPa	3.156	P vapour max	kPa	1.033
P vapour	kPa	0.808	P vapour	kPa	0.805
T wetbulb	°C	13.5	T wetbulb	°C	5.7
Heatflow	kJ/h	6846.6			
Ambient					
Air pressure	kPa	101.959			
T amb	°C	24.52			
RH amb	%	26.37			
P vapour amb	kPa	0.810			
X amb	g/kg	4.98			
Spec. heat (h)	kJ/kg	37.36			
Spec. mass	kg/m³	1.190			
T wetbulb	°C	13.30			
			Results		
			Massflowratio	-	1.000
			T efficiency	%	87.3
			T efficiency cor.	%	87.3
			h rend	%	87.2

Table 14 Results of efficiency measurement at 200 m^3/h HX2

EN308	nominal airflow	200	m^3/h		
Unit	Recair HX2		date	28-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	4.98	T drybulb	°C	21.97
RH	%	52.11	RH	%	15.62
Pressure duct	Pa	13	Pressure duct	Pa	-13
			Air flow	m^3/h	200.5
			Air flow	kg/h	240.9
Spec. heat (h)	kJ/kg	11.99	Spec. heat (h)	kJ/kg	28.51
Moisture (x)	g/kg	2.78	Moisture (x)	g/kg	2.52
Spec. mass	kg/m^3	1.275	Spec. mass	kg/m^3	1.202
P vapour max	kPa	0.871	P vapour max	kPa	2.635
P vapour	kPa	0.454	P vapour	kPa	0.412
T wetbulb	°C	1.5	T wetbulb	°C	9.7
			Heatflow	kJ/h	6867.7
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	24.98	T drybulb	°C	7.80
RH	%	24.61	RH	%	75.56
Pressure duct	Pa	14	Pressure duct	Pa	-14
Air flow	m^3/h	201.8			
Air flow	kg/h	239.7			
Spec. heat (h)	kJ/kg	37.30	Spec. heat (h)	kJ/kg	20.21
Moisture (x)	g/kg	4.78	Moisture (x)	g/kg	4.91
Spec. mass	kg/m^3	1.188	Spec. mass	kg/m^3	1.260
P vapour max	kPa	3.158	P vapour max	kPa	1.058
P vapour	kPa	0.777	P vapour	kPa	0.799
T wetbulb	°C	13.3	T wetbulb	°C	5.8
Heatflow	kJ/h	8942.7			
Ambient					
Air pressure	kPa	101.96			
T amb	°C	24.15			
RH amb	%	25.84			
P vapour amb	kPa	0.777			
X amb	g/kg	4.77			
Spec. heat (h)	kJ/kg	36.45			
Spec. mass	kg/m^3	1.191			
T wetbulb	°C	12.95			
			Results		
			Massflowratio	-	1.005
			T efficiency	%	85.0
			T efficiency cor.	%	85.4
			h rend	%	84.8

Table 15 Results of efficiency measurement at 300 m³/h HX2

EN308	nominal airflow		300 m³/h		
Unit	Recair HX2		date	28-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	4.94	T drybulb	°C	21.13
RH	%	52.79	RH	%	16.76
Pressure duct	Pa	22	Pressure duct	Pa	-22
			Air flow	m³/h	301.7
			Air flow	kg/h	363.5
Spec. heat (h)	kJ/kg	12.02	Spec. heat (h)	kJ/kg	27.79
Moisture (x)	g/kg	2.81	Moisture (x)	g/kg	2.57
Spec. mass	kg/m³	1.275	Spec. mass	kg/m³	1.205
P vapour max	kPa	0.868	P vapour max	kPa	2.503
P vapour	kPa	0.458	P vapour	kPa	0.419
T wetbulb	°C	1.5	T wetbulb	°C	9.3
			Heatflow	kJ/h	10100.4
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	24.85	T drybulb	°C	8.57
RH	%	26.07	RH	%	75.06
Pressure duct	Pa	25	Pressure duct	Pa	-25
Air flow	m³/h	303.3			
Air flow	kg/h	360.4			
Spec. heat (h)	kJ/kg	37.80	Spec. heat (h)	kJ/kg	21.57
Moisture (x)	g/kg	5.02	Moisture (x)	g/kg	5.15
Spec. mass	kg/m³	1.188	Spec. mass	kg/m³	1.256
P vapour max	kPa	3.134	P vapour max	kPa	1.114
P vapour	kPa	0.817	P vapour	kPa	0.836
T wetbulb	°C	13.5	T wetbulb	°C	6.5
Heatflow	kJ/h	13625.0			
Ambient					
Air pressure	kPa	101.945			
T amb	°C	23.58			
RH amb	%	28.07			
P vapour amb	kPa	0.815			
X amb	g/kg	5.01			
Spec. heat (h)	kJ/kg	36.49			
Spec. mass	kg/m³	1.193			
T wetbulb	°C	12.96			
			Results		
			Massflowratio	-	1.008
			T efficiency	%	81.3
			T efficiency cor.	%	82.0
			h rend	%	81.1

Table 16 Results of efficiency measurement at 400 m³/h HX2

EN308	nominal airflow	400	m³/h		
Unit	Recair HX2		date	29-3-2017	
Supply air inlet			supply air outlet		
T drybulb	°C	5.05	T drybulb	°C	20.61
RH	%	53.09	RH	%	17.6
Pressure duct	Pa	33	Pressure duct	Pa	-33
			Air flow	m³/h	401.0
			Air flow	kg/h	485.0
Spec. heat (h)	kJ/kg	12.21	Spec. heat (h)	kJ/kg	27.36
Moisture (x)	g/kg	2.84	Moisture (x)	g/kg	2.61
Spec. mass	kg/m³	1.278	Spec. mass	kg/m³	1.210
P vapour max	kPa	0.875	P vapour max	kPa	2.424
P vapour	kPa	0.465	P vapour	kPa	0.427
T wetbulb	°C	1.6	T wetbulb	°C	9.2
			Heatflow	kJ/h	13270.1
Exhaust air inlet			Exhaust air outlet		
T drybulb	°C	24.98	T drybulb	°C	9.37
RH	%	26.36	RH	%	72.22
Pressure duct	Pa	38	Pressure duct	Pa	-38
Air flow	m³/h	401.2			
Air flow	kg/h	477.8			
Spec. heat (h)	kJ/kg	38.14	Spec. heat (h)	kJ/kg	22.56
Moisture (x)	g/kg	5.11	Moisture (x)	g/kg	5.21
Spec. mass	kg/m³	1.191	Spec. mass	kg/m³	1.256
P vapour max	kPa	3.158	P vapour max	kPa	1.176
P vapour	kPa	0.833	P vapour	kPa	0.849
T wetbulb	°C	13.6	T wetbulb	°C	6.9
Heatflow	kJ/h	18222.9			
Ambient					
Air pressure	kPa	102.203			
T amb	°C	23.93			
RH amb	%	28.04			
P vapour amb	kPa	0.832			
X amb	g/kg	5.10			
Spec. heat (h)	kJ/kg	37.07			
Spec. mass	kg/m³	1.195			
T wetbulb	°C	13.19			
			Results		
			Massflowratio	-	1.015
			T efficiency	%	78.1
			T efficiency cor.	%	79.3
			h rend	%	77.7

5 Summary of the test results

Leak tightness
After the measurement it can be concluded that the 2 heat exchangers have no measurable internal or external leakage (thus <2.6m^3/hr).

Efficiency of heat recovery
The heat recovery efficiencies are shown in Table 17 and 18.

Table 17 Results of the efficiency performance tests EN 308 HX1

Measurement no.	Air flow	Uncorrected η_{temp}	Corrected η_{temp}
	m^3/h	%	%
1	100	91.5	92.1
2	150	90.2	90.5
3	200	88.9	89.4
4	300	87.1	88.1
5	400	85.0	86.0

Table 18 Results of the efficiency performance tests EN 308 HX2

Measurement no.	Air flow	Uncorrected η_{temp}	Corrected η_{temp}
	m^3/h	%	%
1	100	88.6	89.6
2	150	87.3	87.3
3	200	85.0	85.4
4	300	81.3	82.0
5	400	78.1	79.3

6 Measuring sensors

The applied measuring sensors are listed in Table 19.

Table 19 Measuring sensors

Measuring Channel	TUI Number	Identification	Calibration period
1003	41111733	Ta_mp11	Jul-2014
1007	Ktw67	Ta_mp6	Dec-2015
1008	41111735	Ta_mp12	Jul-2014
1011	41111734	Ta_mp13	Aug-2014
1012	60140908	Ta_mp14	Sept-2015
1012	D66	Ta_mp14	Dec-2015
1013	D61	Ta_mp15	Dec-2015
1016	41111736	Ta_mp16	Aug-2014
1018	D69	Ta_mp18	Dec-2015
1020	STDKP	Ta_amb	Aug-2014
1022	11850236	Pa_mp44	May-2014
1023	11860275	Pa_mp47	May-2014
1025	11860017	Dpa_mp42	July-2014
1026	11870083	Dpa_mp45	May-2014
1030	11930571	P_air	May-2014
1031	34088004	Rv_mp52	Feb-2016
1032	34088006	Rv_mp53	Feb-2016
1033	34088003	Rv_mp55	Feb-2016
1034	34088002	Rv_mp56	May-2014
1022	11950298	MR160	July-2014
1023	11950299	MR160	July-2014
1022	MR125SI	MR125	July-2014
1023	MR125PU	MR125	July-2014
2001	41130001P	Power consumption	Dec-2015
2002	41130001I	Current	Dec-2015
2003	41130001Q	Power factor	Dec-2015
2004	41130001U	Main voltage	Dec-2015
Manual	34071400	Betz-manometer	Oct-2015
Manual	34071401	Betz-manometer	Oct-2015

7 Photos

Test box

Outside air connection 21

Open test box

Inside testbox

8 Signature

Delft, 20 April 2017

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