PROPRIETARY

OYSTER PROJECT

Calculation Sheet for HVAC, Plumbing, Fire Fighting of CNS Utility Bldg

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Quality Class	□QC1	□QC2	□QC3	■Non-QC	□N/A

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RID will release this document with purpose AFC (Approved for Construction) after the detailed engineering in Phase 2 is finalised and approved.

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Revision History

Document Title: Calculation Sheet for HVAC, Plumbing, Fire Fighting of CNS Utility Bldg

Document No.: OYSTER-EM-CBU-CA-001

Rev. No.	Date	Description of Revision (Including the chapters and provisions of the revision)	Prepared by	Approved by
P0	2015. 04. 13	Issued for review	J.H. Lee	H.S. Chang
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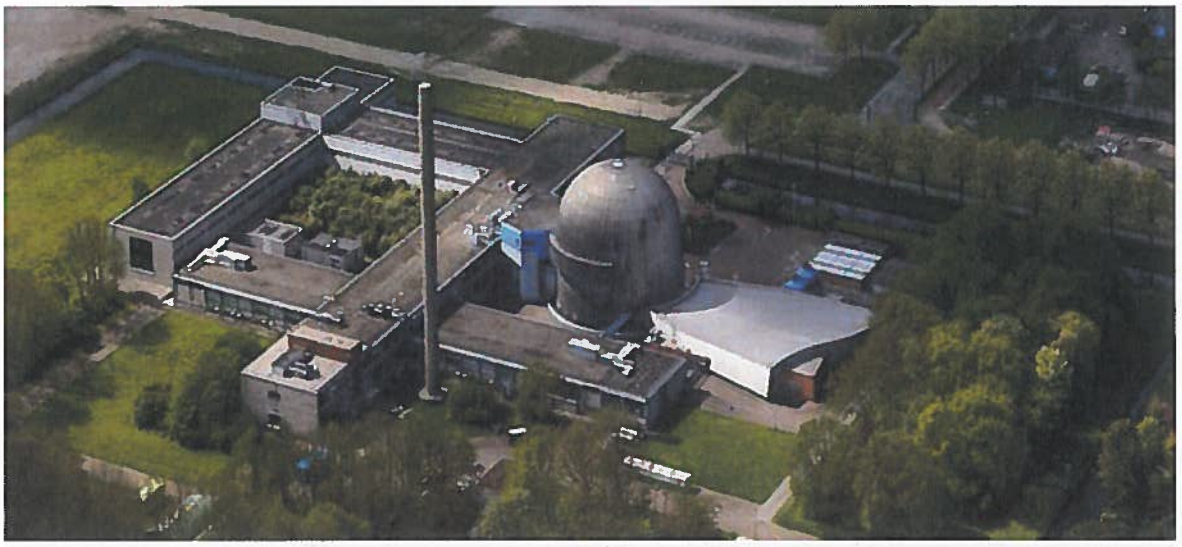
Notes				



Oyster Project Delft

OYSTER-EM-CBU-CA-001
Calculation HVAC

Hyundai Engineering Co Ltd

8 April 2015
Basic Design Final Report
BD4376

Royal HaskoningDHV
Enhancing Society Together

Client:	Reactor Institute Delft
Project:	BD4376 Oyster
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File:	Calculation HVAC
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Description

This report summarizes the calculations which are performed on the HVAC system of the CNS Utility building in the Oyster project. The building houses process equipment for the cooling of the neutron beam in the reactor building, and is occupied by one or two persons for one hour a day on average. The building is therefore characterized as a technical room with a large heating load. Calculations are based on the requirements set in the Basis Of Design (date: 08.04.2015)

Design conditions

Property	Symbol	Value	Unit
Summer outdoor temperature (DB)	$T_{o,s}$	32	[C]
Summer outdoor relative humidity	rh_s	55	[%]
Winter outdoor temperature (DB)	$T_{o,w}$	-12	[C]
Winter outdoor relative humidity	rh_w	75	[%]
Average specific mass of air	ρ_{air}	1,2	[kg / m³]
Specific heat of air	$c_{p,air}$	1000	[J / kg K]
Latent heat load summer	Q_{latent}	16500	[J/kg]
Air infiltration factor	q_v	0,00019	[m³ / m² s]
Correction factor on infiltration	Z_i	0,5	[-]
Minimum indoor temperature	$T_{i,min}$	15	[C]
Maximum indoor temperature	$T_{i,max}$	28	[C]
Insulation of building	R_c	3,5	[m²K /W]

Building geometry

Room name	Floor	Width [m]	Length [m]	Height [m]	Floor area [m²]	Volume [m³]
101 Vaccum box room	1st	3,6	14,4	2,8	51,8	146,4
202 CNS Control & electrical room	2nd	4,1	5,0	4,7	20,3	96,0
201 CNS Refrigerator room	2nd	8,1	14,4	4,7	96,3	455,7

HVAC Calculations

This page shows the results of heat loss, heat load and ventilation calculations. These are used as input values for the design of the HVAC system. Calculations are based on ISSO publications on heat loss / heat load calculations.

Heat losses

Room name	Transmission [W]	Ventilation [W]	Infiltration [W]	Total [W]
101 Vaccum box room	1.184	1.071	313	2.568
202 CNS Control & electrical room	338	2.808	73	3.218
201 CNS Refrigerator room	2.547	3.332	583	6.462
Total				12.249
Total per square meter				73
Total per cubic meter				18

Heat load

Room name	Transmission + radiation walls [W]	Transmission + radiation windows [W]	Ventilation [W]	Infiltration [W]	Internal heat load [W]	Total [W]
101 Vaccum box room	398	-	754	46	2.133	3.331
202 CNS Control & electrical room	81	-	1.976	11	11.907	13.974
201 CNS Refrigerator room	1.245	-	2.345	86	34.726	38.403
Total						55.708
Average per square meter [W/m²]						331
Average per cubic meter [W/m³]						80

Ventilation

Room name	Fresh air [m³/h]	Recirculation for heating [m³/h]	Recirculation for cooling [m³/h]	Maximum air flow [m³/h]
101 Vaccum box room	73	264	644	718
202 CNS Control & electrical room	192	72	3.000	3.192
201 CNS Refrigerator room	228	552	9.014	9.242
Total	493	889	12.658	13.151

Equations heat loss calculation [ISSO publications on heat loss calculations]

Property	Symbol	Unit	Equation
Transmission losses	Q_{tr}	[W]	$Q_{tr} = \frac{1}{R_c} A(T_i - T_o)$
Ventilation losses (sensible heat)	$Q_{vent,sens}$	[W]	$Q_{vent,sens} = V_{vent} \rho_{air} c_{p,air} (T_i - T_o)$
Infiltration losses	Q_{inf}	[W]	$Q_{inf} = \rho_{air} c_{p,air} q_v A Z (T_i - T_o)$
With	Rc	[m²K/W]	Insulation factor
	A	[m²]	Area of (part of) facade
	T_i	[C]	Indoor temperature
	T_o	[C]	Outdoor temperature
	V_{vent}	[m³/s]	Volumeflow of fresh air
	ρ_{air}	[kg/m³]	Specific mass of air
	$C_{p,air}$	[J/kgK]	Specific heat of air
	q_v	[m³/m² s]	Air infiltration factor
	Z	[-]	Correction factor on infiltration

Equations heat load calculation [ISSO publications on heat load calculations]

Property	Symbol	Unit	Equation
Transmission losses windows	$Q_{tr,window}$	[W]	$Q_{tr,window} = \frac{1}{R_c} A(T_i - T_o)$
Radiation through windows	$Q_{rad,window}$	[W]	$Q_{rad,window} = zA_g ZTA q_{zg}$
Transmission + radiation walls	$Q_{tr+rad,walls}$	[W]	$Q_{tr+rad,walls} = aAq_{zt}$
Ventilation losses (sensible heat)	$Q_{vent,sens}$	[W]	$Q_{vent,sens} = V_{vent} \rho_{air} c_{p,air} (T_i - T_o)$
Ventilation losses (latent heat)	$Q_{vent,latent}$	[W]	$Q_{vent,latent} = V_{vent} \rho_{air} Q_{latent}$
Infiltration losses	Q_{inf}	[W]	$Q_{inf} = \rho_{air} c_{p,air} q_v A Z (T_i - T_o)$
Internal heat load	Q_{int}	[W]	$Q_{int} = Q_p + Q_l + Q_e$
With	z	[-]	Sun protection factor due to shading
	ZTA	[-]	Transmittance of glass
	q_{zq}	[W/m²]	Heat flow through windows (orietation dependent)
	q_{zt}	[W/m²]	Heat flow through walls (orientation dependent)
	α	[-]	Absorption factor
	Q_{latent}	[J/kg]	Latent heat load (cooling from 35°C/55% to 15°C)
	Q_p	[W]	Internal heat load due to persons
	Q_l	[W]	Internal heat load due to lighting
	Q_e	[W]	Internal heat load due to equipment

Plumbing + fire fighting calculations

This page shows the results of the plumbing and fire fighting calculations. These are used in the design of water supply piping. Calculations are based on 'NEN 1006' (water supply) and NTR 3216 (storm water drainage + sewage)

Water supply (NEN 1006)

Fire hose	
Number of fire hoses	2 [-]
Water supply fire hose	0,36 [l/s]
Total water supply	0,72 [l/s]

Sink basin	
Number of sink basins	2 [-]
Tap units per sink basin	5 [-]
Flow per tap unit	0,083 [l/s]

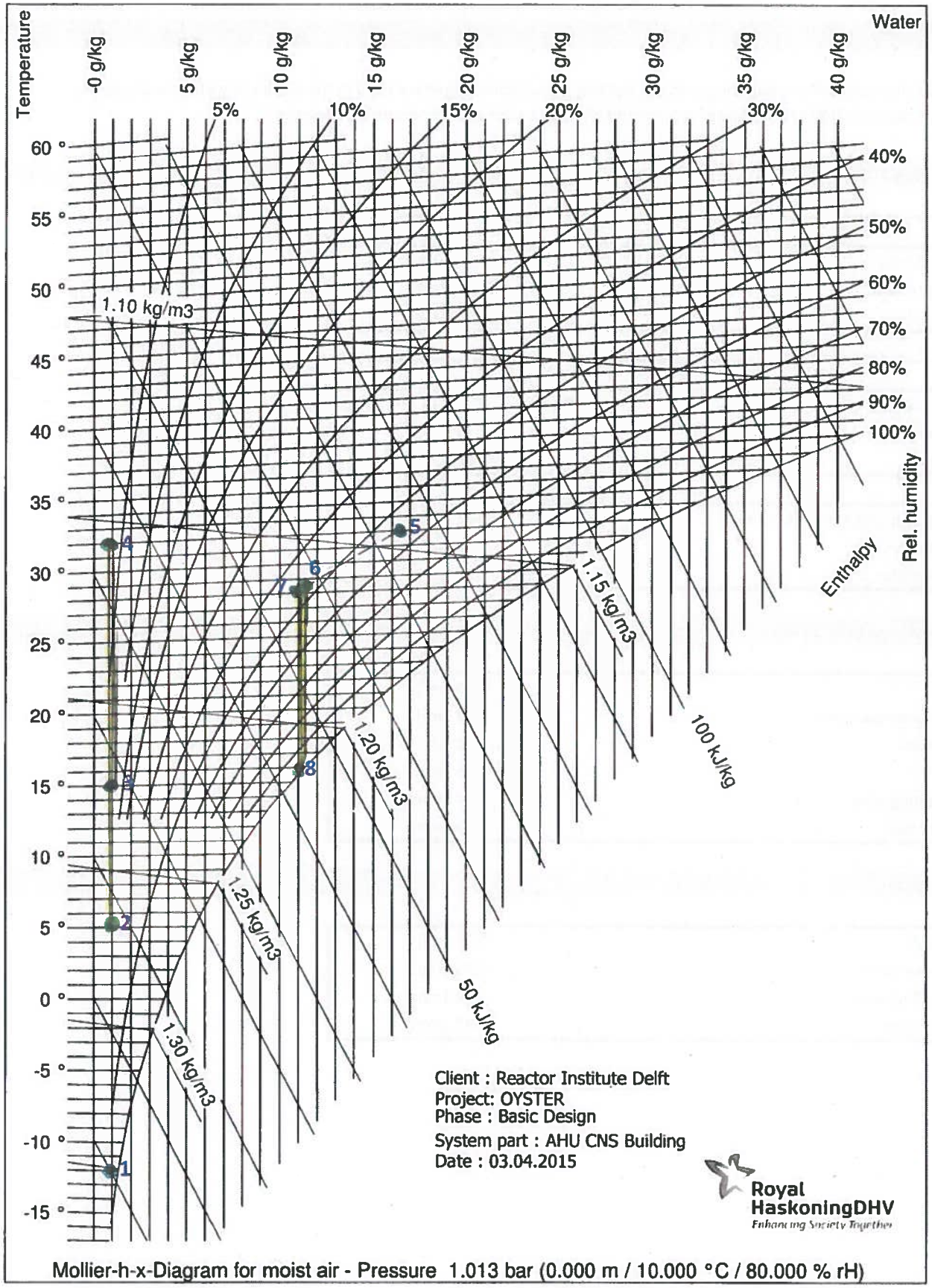
Capacity of suppy piping towards building	0,72 [l/s]
Maximum water velocity	2 [m/s]
Main piping diameter	21 [mm]

Storm water drainage (NTR 3216)

Roof area	96,3 [m²]
Maximum roof area per gully	100 [m²]
Number of gullies	2 [-]
Rainfall	2,25 [l/s]
Diameter collecting pipe	84 [mm]
Diameter stand pipe	69 [mm]

Sewage (NTR 3216)

Capacity per sink	0,75 [l/s]
Capacity per floor drain	0,75 [l/s]
Diameter collecting pipe	69 [mm]
Diameter stand pipe	57 [mm]



Mollier-h-x-Diagram for moist air - Pressure 1.013 bar (0.000 m / 10.000 °C / 80.000 % rH)

Winter conditions:		Summer conditions:	
1	Outdoor temperature	5	Outdoor temperature
2	Mixing temperature	6	Mixing temperature
3	Indoor temperature	7	Indoor temperature
4	Temperature after heating	8	Temperature after cooling