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TRABAJO FIN DE MÁSTER

HVAC SYSTEM OF AN OFFICE BUILDING IN MADRID

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Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título

HVAC systcm of an office building in Madrid

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SISTEMA HVAC DE UN EDIFICO DE OFICINAS EN MADRID.

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RESUMEN DEL PROYECTO

INTRODUCCIÓN

El objetivo del trabajo es dimensionar un sistema HVAC que se encargue de la climatización (calefacción, refrigeración y ventilación) de un edifico de oficinas situado en la comunidad de Madrid, España. Se consigue satisfacer las necesidades de climatización del edificio, garantizando los requisitos técnicos y legales de España [BOE_98], utilizando el mercado existente en la nación para la selección de equipos y componentes del sistema. El proyecto ha sido orientado siguiendo los objetivos de desarrollo sostenible: “producción y consumo responsable” y “ciudades y comunidades sostenibles”.

Hoy en día se recurren a la instalación de sistemas HVAC para garantizar el confort y salud de los empleados que trabajan en edificios de oficinas. De forma general se puede decir que el HVAC se encarga de solucionar los problemas de la renovación del aire y de su tratamiento para conferirle unas condiciones de salubridad (es decir condiciones de pureza, acondicionamiento para conseguir un aire apto para la respiración), temperatura y humedad confortables para las personas. Concretamente en Madrid, el mayor reto está en los meses más calurosos donde se alcanzan temperaturas muy elevadas, disminuyendo el rendimiento de los empleados y poniendo en riesgo su bienestar.

El edificio con el que trabaja el proyecto está ubicado en el parque empresarial Avenida Prado del Espino, 28660, Madrid. Consta de 8 pisos habilitados como oficinas y un último piso en la azotea que contiene la mayoría de los equipos de la instalación (calderas, grupo de refrigeradores, UTAs, bombas, etc.). Tiene un área de 1,496 m^2 y una altura de 27 metros, estando la fachada orientada en dirección este.

METODOLOGÍA

Los objetivos y metodología seguidos para la realización de este trabajo desde la asignación por parte de la directora son los siguientes:

- Diseño y propuesta a la directora de la metodología y objetivos a seguir.
- Estudio de los Objetivos de Desarrollo Sostenible [ONU_15] para decidir la orientación del trabajo en función de los objetivos más apropiados.
- Cálculo de las cargas térmicas en el mes más desfavorable.

- Cálculo del sistema de tuberías agua. Selección de material, diámetros de las tuberías, y pérdidas.
- Cálculo del sistema de conductores de aire. Selección de diámetros y cálculo de pérdidas.
- Selección de los equipos y elementos del sistema HVAC (calderas, grupo refrigerador, unidades de tratamiento de aire, bombas, inductores, difusores y rejillas).
- Presupuesto del proyecto.

Para los cálculos realizados se ha a partido del mes más desfavorable. En el caso de Madrid son los meses de enero y julio en los que se alcanzan las temperaturas más extremas del año de frio y de calor, respectivamente. De esta forma se sobredimensiona la instalación para garantizar un correcto funcionamiento durante todos los meses del año.

RESULTADOS

Los Objetivos de Desarrollo Sostenible que se han tenido en cuenta para el dimensionamiento de la instalación son “producción y consumo responsable” como principal, y “ciudades y comunidades sostenibles” como secundario.

Para aclimatar el aire del interior del edificio a los valores deseados de temperatura y humedad, se utilizarán dos sistemas HVAC. Se utilizará un sistema de aire-agua con AHU para lograr los niveles de humedad deseados y una temperatura base (20% de las cargas térmicas totales) en todo el edificio, ya que las AHU están en el techo y alimentan de manera homogénea la humedad y la temperatura a todos los difusores en el edificio. El segundo sistema HVAC es agua-agua que genera/evacua energía calorífica desde la azotea (grupo de calderas y refrigeradores) para suministrar energía a los inductores en todo el edificio, cubriendo el 80% de las cargas térmicas en cada habitación. De esta forma la temperatura de cada habitación es independiente partiendo de las condiciones base establecidas por el sistema AHU. Estos dos sistemas funcionan simultáneamente en todo el edificio. Se ha elegido esta estructura, ya que es más económica y respetuosa con el medio ambiente el uso de UTA para lidiar con la mayor diferencia de temperatura entre el aire exterior e interior del edificio. Sin embargo, el uso del sistema inductor permite un margen de regulación de temperatura independiente para cada habitación.

Resultados (caudales, diámetros, longitudes y perdidas) y selección de las tuberías de agua. Altura que debe satisfacer la bomba.

Siguiendo los criterios del RITE de la sección 12 IT 1.2.4.2, que establece una pérdida máxima permitida de 30 mm c. a./m y una velocidad de agua máxima de 2 m / s, los diámetros de tubería más adecuados se han seleccionado utilizando el gráfico de *Diameter ratio, losses, flow and speed water pipes at 60ºC* del *Annexed 4. Calculation of water pipes*. El material de las tuberías es de acero no aleado adecuado para soldar y roscar, de acuerdo con la norma UNE 10255, con un aislamiento de espuma elastomérica (de la tabla *Minimum thickness of pipe insulation according to RITE* in *Annexed 4. Calculation of water pipes*).

A continuación, se muestra un ejemplo de los resultados de perdidas por tramo de las plantas baja, 1 y 3 de los dos circuitos CI-1 y CI-2:

		SECTION	Q (l / h)	DN (mm)	DN (")	Losses. mm.c.a. /m	L (m)	V(m/s)	Tot acces.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
CI-1	FLOOR 0	1	195	15	0,5906	12	2,09	0,28	0	25,08	25,08
		2	390	20	0,7874	10	2,86	0,31	0	28,60	53,68
		3	586	20	0,7874	7	0,47	0,3	0	3,29	56,97
		4	781	25	0,9843	11	0,86	0,39	1,5	25,96	82,93
		5	976	25	0,9843	16	0,53	0,47	1,5	32,48	115,41
		6	1171	25	0,9843	22	0,93	0,56	1,5	53,46	168,87
		7	2192	32	1,2598	18	7,15	0,61	1,8	161,10	329,97
		8	3946	40	1,5748	25	5,84	0,81	2,4	206,00	535,97
		9	5279	50	1,9685	13	5,51	0,67	3	110,63	646,60
		10	7387	50	1,9685	25	8,12	0,95	3,9	300,50	947,10
	FLOOR 1	11	192	15	0,5906	12	1,13	0,28	0	13,56	960,66
		12	383	20	0,7874	9	2,99	0,29	0	26,91	987,57
		13	766	25	0,9843	10	1,23	0,37	0	12,30	999,87
		14	1149	25	0,9843	21	1,21	0,56	1,5	56,91	1.056,78
		15	1735	32	1,2598	12	6,65	0,49	1,8	101,40	1.158,18
		16	3464	40	1,5748	20	6,53	0,72	2,4	178,60	1.336,78
		17	4815	50	1,9685	11	5,95	0,62	3,9	108,35	1.445,13
		18	8647	65	2,5591	9	8,24	0,66	5,4	122,76	1.567,89
		19	16034	65	2,5591	28	2,5	1,21	3,6	170,80	1.738,69
	FLOOR 3	29	207	15	0,5906	13	1,11	0,29	0	14,43	2.544,71
		30	364	20	0,7874	9	3,13	0,29	0	28,17	2.572,88
		31	778	25	0,9843	11	1,33	0,3	0	14,63	2.587,51
		32	1101	25	0,9843	20	1,26	0,54	1,5	55,20	2.642,71
		33	1742	32	1,2598	12	6,65	0,49	1,8	101,40	2.744,11
		34	3523	40	1,5748	20	6,5	0,72	2,4	178,00	2.922,11
		35	4932	50	1,9685	12	5,9	0,64	3,9	117,60	3.039,71
		36	9271	65	2,5591	10	8,34	0,6	5,4	137,40	3.177,11
		37	33952	100	3,937	14	2,5	1,1	3,6	85,40	3.262,51
CI-2	FLOOR 0	74	155	15	0,5906	8	2,76	0,22	0	22,08	6.566,71
		75	309	20	0,7874	6	1,63	0,23	0	9,78	6.576,49
		76	464	20	0,7874	13	1,48	0,36	0	19,24	6.595,73
		77	773	25	0,9843	10	2,64	0,37	1,5	41,40	6.637,13
		78	1217	32	1,2598	6	7,11	0,34	1,8	53,46	6.690,59
		79	2482	40	1,5748	11	7,4	0,52	2,4	107,80	6.798,39
		80	4037	50	1,9685	8	5,05	0,52	4,5	76,40	6.874,79
		81	5075	50	1,9685	12	6,14	0,64	3	109,68	6.984,47
	FLOOR 1	82	192	15	0,5906	12	1,13	0,28	0	13,56	6.998,03
		83	383	20	0,7874	9	3,23	0,29	0	29,07	7.027,10
		84	766	25	0,9843	10	1,23	0,37	0	12,30	7.039,40
		85	1149	25	0,9843	21	1,08	0,56	1,5	54,18	7.093,58
		86	1729	32	1,2598	7	6,5	0,37	1,8	58,10	7.151,68
		87	3266	40	1,5748	18	7,46	0,68	2,4	177,48	7.329,16
		88	4839	50	1,9685	11	5,91	0,62	4,5	114,51	7.443,67
		89	8353	65	2,5591	9	5,74	0,66	5,4	100,26	7.543,93
		90	13427	65	2,5591	21	2,5	1,02	3,6	128,10	7.672,03
	FLOOR 3	100	207	15	0,5906	13	1,1	0,29	0	14,30	8.379,99
		101	414	20	0,7874	11	3,21	0,33	0	35,31	8.415,30
		102	828	25	0,9843	12	1,23	0,41	0	14,76	8.430,06
		103	1243	25	0,9843	25	1,21	0,5	1,5	67,75	8.497,81
		104	1900	32	1,2598	14	6,41	0,54	1,8	114,94	8.612,75
		105	3932	40	1,5748	24	7,46	0,8	2,4	236,64	8.849,39
		106	5515	50	1,9685	14	6,15	0,7	4,5	149,10	8.998,49
		107	9541	65	2,5591	11	6,05	0,73	5,4	125,95	9.124,44
		108	31321	100	3,937	12	2,5	1,02	3,6	73,20	9.197,64

Tabla 1-a. Ejemplo de resultados de las pérdidas en cada sección de tubería de la ruta más desfavorable de los dos circuitos CI-1 y CI-2, planta baja, planta 1 y planta 3.

Finalmente se muestra los resultados totales de las pérdidas de la ruta más desfavorable desde la mezcla de agua fría y caliente en el techo hasta los elementos terminales más remotos de cada planta, de los dos circuitos que suministran todos los inductores. en las habitaciones interiores y convergen en el techo (circuito CI-1 y CI-2), incluyendo las pérdidas por válvulas y filtros; y la altura efectiva que la bomba del circuito debe superar:

	SECTION	Q (l / h)	DN (mm)	DN (")	Losses. mm.c.a. /m	L (m)	V(m/s)	Tot valv.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
UNDER COVEF	145	136896	200	7,874	7	22,7	1,19	0	232,40	12.591,76
	DRIVE + RETURN							0	12.591,76	25.183,52
	VALV. and FILTERS		200	7,874	7	34,5		2778	19.688,90	44.872,42

		Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
Subtotal			44.872,42
valv control			2.000,00
		total	46.872,42
		% secur.	10,00%
ALTEFFECTIVE PUMP HEIGHT (M.C.A.)			51,56

Tabla 1-b. Resultados totales de las pérdidas de la ruta más desfavorable y la altura efectiva que las bombas de circuito deben superar.

<u>Resultados (caudales, diámetros, velocidades, longitudes equivalentes y pérdidas) y selección de los conductos de aire de impulsión y retorno.</u>

Se han seleccionado los diámetros apropiados para los conductos circulares, respetando el criterio de que todas las secciones no tienen pérdidas mayores de 0.4 mm.c.a./m ni una velocidad mayor de 12 m / s. Estos parámetros se han obtenido del grafico *Loss diagram in circular air ducts* in *Annexed 5. Calculation of duct*s.

El tipo de conducto circular seleccionado para el sistema aire-aire es la compañía ALDER. Son conductos circulares en chapa de acero galvanizado cosidos en la hélice. Acero galvanizado según la norma EN 10 142. Conducto reforzado con nervadura externa para diámetros superiores a 630 mm. Puede ver la ficha técnica del fabricante de estos conductos en *Technical sheet of the manufacturer of the air-air ducts* in *Annexed 5. Calculation of ducts*.

Los resultados de las pérdidas en el circuito más crítico de los conductos de suministro de aire que van a la primera AHU (AHU-AP1) se muestran a continuación como ejemplo:

	GROUND FLOOR DISCHARGE DUCTS							
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Acces Type**	**V (m/s)**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	64	100	Elbow	2,271	4,82	0,09	0,43
	2	128	125	Der+Red	2,907	6,35	0,1	0,64
	3	257	125	Derivation	5,814	22,22	0,38	8,44
	4	321	125	Derivation	7,268	27,05	0,4	10,82
	5	385	150	Der+Red	6,056	22,13	0,3	6,64
	6	450	150	Derivation	7,066	27	0,39	10,53
	7	514	175	Der+Red	5,933	21,18	0,35	7,413
	8	1091	250	Der+Red	6,174	26,74	0,15	4,011
	9	1990	300	Der+Red	7,822	40,42	0,2	8,084
	10	4376	350	Der+Red	11,82	85,04	0,35	29,764
	11	4701	400	Der+Red	10,39	55,48	0,27	14,9796
vertical course	12	9401	550	Der+Red+Elb	10,99	84,83	0,22	18,6626
	13	14102	700	Der+Red	10,18	57,76	0,14	8,0864
	14	18802	900	Der+Red	8,21	38,49	0,06	2,3094
	15	23503	1000	Der+Red	8,312	42,9	0,05	2,145
	16	28203	1100	Der+Red	8,244	40,17	0,04	1,6068
	17	32904	1100	Derivation	9,618	52,54	0,06	3,1524
	18	37604	1100	Derivation	10,99	64,71	0,1	6,471
	Diffusers							408,640
						Subtotal		552,83
						Loss in diffusion		2,5
						Safety coef. %		10%
						TOTAL		610,86

Tabla 2. Resultados de las pérdidas en el circuito más crítico de los conductos de suministro de aire que van a la primera AHU (AHU-AP1).

A continuación, se muestran los resultados de las pérdidas en el circuito del conducto de retorno del caso más crítico discutido anteriormente:

	GROUND FLOOR DISCHARGE DUCTS							
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Acces Type**	**V (m/s)**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	46	150	-	0,73	2,59	0	0,00
	2	92	200	Der+Red	0,82	5,21	0	0,00
	3	139	200	Derivation	1,22	5,55	0,012	0,07
	4	185	250	Der+Red	1,05	9,58	0	0,00
	5	272	250	Derivation	1,54	12,86	0,014	0,18
	6	724	300	Elb+Der+Red	2,85	68,45	0,02	1,37
	7	1416	300	Derivation	5,56	13,73	0,12	1,65
vertical course	8	2832	500	Elb+Der+Red	4,01	72,67	0,034	2,47
	9	4247	600	Der+Red	4,17	109,12	0,027	2,95
	10	5663	650	Der+Red	4,74	109,12	0,035	3,82
	11	7079	750	Der+Red	4,45	101,75	0,05	5,09
	12	8495	800	Der+Red	4,69	42,9	0,025	1,07
	13	9911	850	Der+Red	4,85	23,52	0,021	0,49
	14	11327	850	Derivation	5,54	9,55	0,028	0,27
	15	22653	1100	Elb+Der+Red	6,62	65,86	0,03	1,98
	Grids							209,34
						Subtotal		230,73
						Loss in diffusion		2,5
						Safety coef. %		10%
						TOTAL		256,56

Tabla 3. Resultados de las pérdidas en el circuito del conducto de retorno del caso más crítico discutido anteriormente.

<u>Resultados de las cargas térmicas en verano e invierno y selección de las calderas y grupo refrigerador.</u>

Para conseguir los niveles de temperatura que garanticen el confort de los trabajadores, se puede observar en los resultados del proyecto que se necesitan una máxima de 1132 kW de potencia frigorífica en verano y de 751 kW de potencia calorífica en invierno (estos dos resultados de potencia se han calculado estimando la potencia para alimentar a todos los inductores del edificio, llegando a ellos a través de cuatro circuitos de tuberías de agua y estimando la potencia necesaria para alimentar las baterías de frio y calor de las UTAs, como se muestra en las tablas de resultados a continuación). Para cubrir esta demanda, se han seleccionado dos calderas de 380kW de potencia nominal, modelo ADINOX 339 de la marca ADISA trabajando en paralelo y un grupo frigorífico de 1.226 kW de potencia nominal, modelo BG / WRAT R407C 4828 de la marca CLIMAVENETA. Se muestran estos resultados comentados en las siguientes tablas:

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	SUMMER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	COLD BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	885	247
REFRIGERATION HEAT (kW)		1132

Tabla 4. Resumen de todas las cargas térmicas que debe cubrir el grupo de refrigeración.

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	WINTER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	HEAT BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	578	173
TOTAL HEATING HEAT (kW)		**751**

Tabla 5. Resumen de todas las cargas térmicas que deben cubrir las calderas.

Resultados (caudales de impulsión y retorno y potencias de las baterías de frio y calor) y selección de las unidades de tratamiento de aire.

Con el objetivo de hacerse cargo del 20% de la carga térmica del edificio se ha recurrido a dos unidades de tratamiento de aire, que constan de un recuperador entálpico para mejorar la eficiencia de la maquina (con su correspondiente beneficio medioambiental) al recuperar parte de la energía del aire de retorno que se expulsa al exterior, a la vez que garantiza el nivel de calidad del aire para oficinas que establece RITE (IDA 3). Estas UTAs deben satisfacer la demanda expuesta en el proyecto de 37604 m^3/h y 36596 m^3/h de caudal de impulsión, 22653 m^3/h y 22046 m3/h de caudal de retorno, respectivamente cada una de las dos UTA que utilizan sistemas de conductos distintos. Al haberse diseñado los circuitos de conductos que son alimentadas por las dos UTA con una demanda muy parecida, las dos UTA serán iguales con un flujo máximo de 38,500 m^3/h del modelo CLA-2030/4 de la marca TERMOVEN. A continuación, se muestra un esquema del tipo de UTA utilizado para aclimatar el edificio, que consta de un recuperador entálpico para mejorar la eficiencia de la maquina y reducir su impacto al medioambiente:

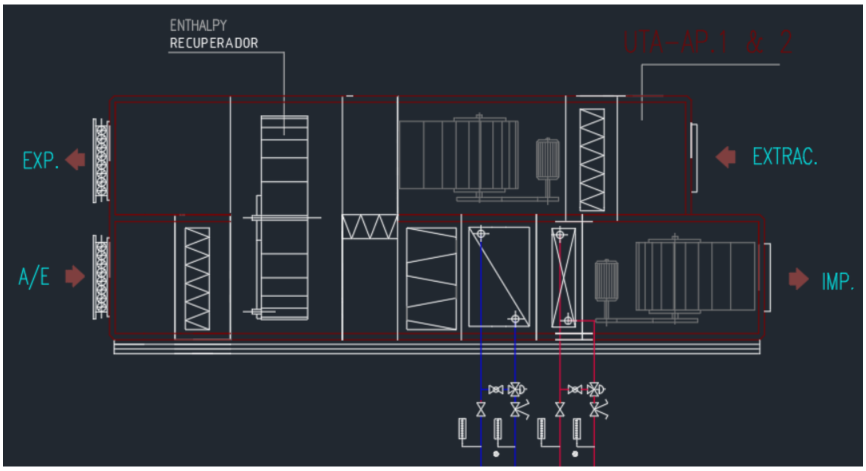

Figura 1. Diagrama de este tipo de equipo utilizado para AHU-AP1 y AHU-AP2.

A continuación, se muestran los resultados de los caudales de impulsión y retorno, junto con las potencias de las baterías de calor y frio, que deberán cubrir las dos UTAs:

	IMPULSION FLOW (m3/h)	RETURN FLOW (m3/h)	HEAT BATTERY (W)	COLD BATTERY (W)
AHU AP1	37604	22653	124658	87104
AHU AP2	36596	22046	121316	84769

Tabla 6. Los parámetros requeridos por el sistema de suministro de agua (baterías de calor y frío) y el sistema aire-aire (flujos de aire de suministro y retorno).

Resultados (número de unidades, caudales y altura) y selección de las bombas para los circuitos de tuberías de agua.

El sistema de tuberías de agua a requerido el uso de seis sets de bombas (13 bombas contando con 4 de repuesto y 3 de ellas trabajando en paralelo) para cada uno de los circuitos: bombas de circuito primario frío, bombas de circuito primario de calor, bombas de acondicionadores de aire frío secundarios, inductores de circuito secundario, bombas de zona interior, inductores de circuito secundario, bombas de zona de fachada y circuito de calor secundario para climatizar bombas. Estos circuitos se pueden ver esquemáticamente en el *Plano 1. Principle scheme*. A continuación, se muestran los resultados de los caudales y alturas que necesitan satisfacer cada una de las bombas:

PUMP SET	SECTION	QUANTITY (REPLACEMENT)	UNIT FLOW (m3/h)	HEIGHT (m)
B3	AHUs cold secondary circuit	1 (1)	128	12
B6	AHUs cold secondary circuit	1 (1)	46	12
B4	Secondary circuit inductors inner zone (CI1 + 2)	1 (1)	147	78
B5	Facade zone inductors secondary circuit (CF1 + 2)	1 (1)	56	73
B1	Primary cold circuit	2 (0)	220	10
B2	Primary heat circuit	3 (0)	57	8

Tabla 7. Parámetros necesarios para seleccionar los tipos de bombas necesarios para cada circuito.

Seleccionando los siguientes modelos de la compañía ELIAS, en función de sus necesidades técnicas:

PUMP SET	SECTION	COMPANY	SERIE	R.P.M.
B3	AHUs cold secondary circuit	ELIAS	IAC-100-312	1450
B6	AHUs cold secondary circuit	ELIAS	IAC-80-202	1450
B4	Secondary circuit inductors inner zone (CI1 + 2)	ELIAS	BQP 150/50	1450
B5	Facade zone inductors secondary circuit (CF1 + 2)	ELIAS	BQP 150/50	1450
B1	Primary cold circuit	ELIAS	BQP 150/26	1450
B2	Primary heat circuit	ELIAS	IAC-80-203	1450

Tabla 8. Se han seleccionado bombas apropiadas para satisfacer el sistema de tuberías de agua.

<u>Resultados (número de unidades y cargas térmicas a cubrir en verano e invierno) y selección de los inductores.</u>

A continuación, se muestran los resultados que recogen la potencia de refrigeración y calefacción que debe cubrirse en cada una de las salas, junto con el número de inductores necesarios para esta tarea por sala:

LOCATION				SUMMER		WINTER	
TIPE OF ROOM	FLOOR	ROOM	INDUCTORS QUANTITY	TOTAL HEAT COVERED BY INDUCTORS (kW)	HEAT/ INDUCTOR (kW)	TOTAL HEAT COVERED BY INDUCTORS	HEAT/ INDUCTORS (kW)
room	0	2	5	5,81	1,16	4,93	0,99
room	0	3	11	7,62	0,69	6,17	0,56
room	0	4	8	6,81	0,85	5,72	0,72
room	0	5	8	5,40	0,67	0,00	0,00
room	0	8	1	3,46	3,46	2,90	2,90
room	0	10	2	3,35	1,68	2,78	1,39
hall	0	12	30	38,74	1,29	32,93	1,10
room	1	23	80	89,12	1,11	74,86	0,94
hall	1	25	2	1,18	0,59	1,55	0,78
hall	1	26	8	4,56	0,57	6,12	0,76
hall	1	27	3	2,46	0,82	3,00	1,00
hall	1	28	2	1,50	0,75	1,76	0,88
room	2	32	80	89,12	1,11	74,86	0,94
hall	2	34	2	1,18	0,59	1,55	0,78
hall	2	35	8	4,56	0,57	6,12	0,76
hall	2	36	3	2,46	0,82	3,00	1,00
hall	2	37	2	1,50	0,75	1,76	0,88

room	3	41	2	3,90	1,95	3,27	1,64
room	3	42	2	1,72	0,86	1,44	0,72
room	3	43	2	2,41	1,20	1,92	0,96
room	3	44	2	2,42	1,21	3,20	1,60
room	3	45	3	3,28	1,09	2,79	0,93
room	3	46	2	2,50	1,25	2,07	1,04
room	3	47	3	2,73	0,91	2,29	0,76
room	3	48	4	2,70	0,67	3,56	0,89
room	3	49	2	3,23	1,61	2,71	1,36
room	3	50	2	2,49	1,24	2,09	1,04
room	3	51	1	1,89	1,89	1,59	1,59
room	3	52	2	2,21	1,11	2,92	1,46
room	3	53	2	5,06	2,53	4,25	2,13
hall	3	54	19	21,72	1,14	18,25	0,96
hall	3	55	5	3,53	0,71	2,96	0,59
hall	3	56	19	18,07	0,95	15,18	0,80
hall	3	57	5	3,68	0,74	2,98	0,60
hall	3	58	17	19,55	1,15	16,42	0,97
hall	3	59	2	1,51	0,76	1,27	0,64
room	4	64	2	3,90	1,95	3,27	1,64
room	4	65	2	1,72	0,86	1,44	0,72
room	4	66	2	2,41	1,20	1,92	0,96
room	4	67	2	2,42	1,21	3,20	1,60
room	4	68	3	3,28	1,09	2,79	0,93
room	4	69	2	2,50	1,25	2,07	1,04
room	4	70	3	2,73	0,91	2,29	0,76
room	4	71	4	2,70	0,67	3,56	0,89
room	4	72	2	3,23	1,61	2,71	1,36
room	4	73	2	2,49	1,24	2,09	1,04
room	4	74	1	1,89	1,89	1,59	1,59
room	4	75	2	2,21	1,11	2,92	1,46
room	4	76	2	5,06	2,53	4,25	2,13
hall	4	77	19	21,72	1,14	18,25	0,96
hall	4	78	5	3,53	0,71	2,96	0,59
hall	4	79	19	18,07	0,95	15,18	0,80
hall	4	80	5	3,68	0,74	2,98	0,60
hall	4	81	17	19,55	1,15	16,42	0,97
hall	4	82	2	1,51	0,76	1,27	0,64

room	5	32	80	89,12	1,11	74,86	0,94
hall	5	34	2	1,18	0,59	1,55	0,78
hall	5	35	8	4,56	0,57	6,12	0,76
hall	5	36	3	2,46	0,82	3,00	1,00
hall	5	37	2	1,50	0,75	1,76	0,88
room	6	32	80	89,12	1,11	74,86	0,94
hall	6	34	2	1,18	0,59	1,55	0,78
hall	6	35	8	4,56	0,57	6,12	0,76
hall	6	36	3	2,46	0,82	3,00	1,00
hall	6	37	2	1,50	0,75	1,76	0,88
room	7	64	2	3,90	1,95	3,27	1,64
room	7	65	2	1,72	0,86	1,44	0,72
room	7	66	2	2,41	1,20	1,92	0,96
room	7	67	2	2,42	1,21	3,20	1,60
room	7	68	3	3,28	1,09	2,79	0,93
room	7	69	2	2,50	1,25	2,07	1,04
room	7	70	3	2,73	0,91	2,29	0,76
room	7	71	4	2,70	0,67	3,56	0,89
room	7	72	2	3,23	1,61	2,71	1,36
room	7	73	2	2,49	1,24	2,09	1,04
room	7	74	1	1,89	1,89	1,59	1,59
room	7	75	2	2,21	1,11	2,92	1,46
room	7	76	2	5,06	2,53	4,25	2,13
hall	7	77	19	21,72	1,14	18,25	0,96
hall	7	78	5	3,53	0,71	2,96	0,59
hall	7	79	19	18,07	0,95	15,18	0,80
hall	7	80	5	3,68	0,74	2,98	0,60
hall	7	81	17	19,55	1,15	16,42	0,97
hall	7	82	2	1,51	0,76	1,27	0,64

Tabla 9. Resumen de las cargas térmicas que deben cubrir los inductores distribuidos en cada habitación, el número de inductores en cada habitación y el inductor seleccionado para cada habitación.

Se ha dimensionado este proyecto para conseguir cubrir todas las cargas térmicas de cada habitación, recurriendo solo a una única serie de inductores IHK-F (2-PIPE SYSTEM), de la compañía KOOLAIR de tres tamaños distintos en función de la demanda, 900, 1200 y 1500.

Selección de las unidades terminales de los circuitos de conductos de aire (difusores y rejillas), de las válvulas y elementos del sistema de tuberías de agua.

Como elementos terminales del sistema de conductos de aire, se han utilizado difusores para distribuir el caudal de impulsión proveniente de las UTA, y rejillas para el caudal de retorno. Se ha respetado la condición que garantiza que los difusores producen un nivel de ruido no superior a 40 dB, asegurando un ambiente agradable para el trabajo de oficina. Se ha elegido el modelo VDN para los difusores y el modelo AT de la marca TROX.

Los distintos tipos de válvulas y elementos del sistema de tuberías se han seleccionado de la marca ANDERSOON.

Resultados y medidas tomadas para cumplir con los Objetivos de Desarrollo Sostenible.

Al cambiar las calderas estudiadas inicialmente (ADI CD 100) por las calderas definitivas (ADINOX 339 BT) que son más caras, pero con mayor eficiencia y menores emisiones de CO_2, se ha conseguido evitar un 12,34% de emisiones adicionales de CO_2 a la atmosfera (331.602 kg CO_2 frente 295.162 kg CO_2 al año).

Se ha optado por utilizar dos sistemas de climatización que trabajen simultáneamente cubriendo las cargas térmicas de cada una de las salas. Cubriendo el 20% de la carga térmica con un sistema aire-agua usando UTAs y el 80% restante con un sistema agua-agua utilizando inductores como elementos terminales.

Las dos UTAs principales que se han seleccionado son de modelo CLA-2030/4 de la marca TERMOVEN que constan de un recuperador entálpico que mejore la eficiencia de la máquina aun suponiendo un mayor coste.

Emplazamiento del edificio de oficinas alejado de la ciudad de Madrid, en el Parque Empresarial de la Avenida del Prado del Espino 28660.

Presupuesto general

BUDGET MECHANICAL FACILITIES MADRID OFFICES		
CODE	DESCRIPTION	AMOUNT
Chapter 1	COLD PRODUCTION	226.665,02 €
Chapter 2	HEAT PRODUCTION	55.110,91 €
Chapter 3	AIR HANDLING UNIT	223.666,84 €
Chapter 4	PUMP SET	13.022,81 €
Chapter 5	INDUCTORS. TERMINAL ELEMENT	570.791,20 €
Chapter 6	DIFFUSERS / GRIDS. TERMINAL ELEMENT	15.127,31 €
Chapter 7	PIPELINES WITH INSULATION	678.717,93 €
Chapter 8	AIR DUCTS AND INSULATION	365.039,13 €
Chapter 9	MECHANICAL CONTROL AND MEASURING EQUIPMENT	58.147,26 €
	TOTAL	2.206.288,41 €

Tabla 10. Presupuesto general.

CONCLUSIONES

En este proyecto se ha conseguido dimensionar un sistema HVAC para un edifico de oficinas, garantizando el confort de los trabajadores y cumpliendo con la normativa vigente. Se ha conseguido enfocar el proyecto cumpliendo dos de los Objetivos de Desarrollo Sostenible, “Producción y consumo responsable” como objetivo principal y “Ciudades y comunidades sostenibles” como secundario.

Como era de esperar, se denota en los resultados que el escenario en el que se necesitará más energía para cubrir las cargas térmicas es en el mes de julio, el más desfavorable de verano (potencia para refrigerar), ya que el edifico se encuentra emplazado en la comunidad de Madrid.

Se ha complido con los objetivos “Producción y consumo responsable” y “Ciudades y comunidades sostenibles” tomando las medidas recogidas en el capítulo *Part III. Alignment with the United Nations Sustainable Development Goals (SDGs)* observándose las siguientes conclusiones:

- La cantidad muy notable de kg de CO2 que se evita generar al año por utilizar un tipo de calderas las eficientes y con menores emisiones, frente a las calderas más económicas que se estudiaron en primer lugar para este proyecto.

- Cubrir las cargas térmicas con un sistema aire-agua usando UTAs y agua-agua usando inductores en un 20% y 80% respectivamente, consigue un equilibrio entre los objetivos de mejorar la eficiencia del edificio reduciendo el impacto medioambiental, a la vez que consigue una regulación independiente de la temperatura de cada sala. Esta conclusión se deduce comparando este escenario frente al de haber cubierto el 100% de la demanda térmica con un sistema agua-agua con inductores como elementos terminales, que perjudicaría en mayor medida al medio ambiente y al escenario de haber cubierto el 100% de la demanda térmica con un sistema aire-agua usando UTAs, renunciando al beneficio de poder gestionar la temperatura de cada sala de forma independiente.

- Las UTAs principales seleccionadas tiene un precio de compra más alto, pero garantiza una mejor eficiencia del sistema al necesitar menos aporte de energía de las calderas y la unidad de enfriamiento para alcanzar la humedad y temperatura deseadas gracias a tener recuperadores de entalpía, reduciendo la huella de carbono de estos equipos.

- El terreno donde se construirá el edificio de oficinas se encuentre en las afueras de la ciudad de Madrid, evitando que las emisiones de CO2 generadas por los dispositivos del sistema HVAC se liberen cerca de áreas densamente pobladas, no perjudicando la calidad de vida de los ciudadanos.

REFERENCIAS

[BOE_98] “Reglamento de Instalaciones Térmicas en los Edificios (RITE)”. Editado por la Agencia Estatal Boletín Oficial del Estado. Aprobado por Real Decreto 1751/1998, de 31 de julio.

[ONU_15] “Objetivos de Desarrollo Sostenible”. Aprobación de la Agenda 2030 por la ONU. 2015

HVAC SYSTEM OF AN OFFICE BUILDING IN MADRID.

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Director: Green-Miller, Angela.

Collaborating entity:

University of Illinois Urbana-Champaign

PROJECT SUMMARY

INTRODUCTION

The objective of the work is to size an HVAC system that oversees the air conditioning (heating, cooling and ventilation) of an office building located in the community of Madrid, Spain. It is possible to satisfy the building's air conditioning needs, guaranteeing the technical and legal requirements of Spain [BOE_98], using the existing market in the nation for the selection of equipment and system components. The project has been oriented following the objectives of sustainable development: "responsible production and consumption" and "sustainable cities and communities".

Today, HVAC systems are used to ensure the comfort and health of employees who work in office buildings. In general, it can be said that the HVAC oversees solving the problems of air renewal and its treatment to confer health conditions (that is, purity conditions, conditioning to achieve air suitable for breathing), temperature and comfortable humidity for people. Specifically, in Madrid, the biggest challenge is in the hottest months where very high temperatures are reached, decreasing employee performance and putting their well-being at risk.

The building with which the project works is in the Avenida Prado del Espino business park, 28660, Madrid. It consists of 8 floors enabled as offices and a last floor on the roof that contains most of the installation's equipment (boilers, group of refrigerators, UTAs, pumps, etc.). It has an area of 1,496 m2 and a height of 27 meters, with the facade facing east.

METHODOLOGY

The objectives and methodology followed to carry out this work from the assignment by the director are as follows:

- Design and proposal to the director of the methodology and objectives to follow.
- Study of the Sustainable Development Goals [UN__15] to decide the orientation of the work based on the most appropriate objectives.
- Calculation of thermal loads in the worst month.
- Calculation of the water piping system. Selection of material, pipe diameters, and losses.

- Calculation of the air conductors system. Selection of diameters and calculation of losses.
- Selection of equipment and elements of the HVAC system (boilers, cooler group, air handling units, pumps, inductors, diffusers and grids).
- The project budgets.

For the calculations made, the worst month was used. In the case of Madrid, it is the months of January and July that reach the most extreme temperatures of the year of cold and heat, respectively. In this way, the installation is oversized to guarantee correct operation during all months of the year.

RESULTS

The Sustainable Development Objectives that have been considered for the dimensioning of the facility are "responsible production and consumption" as the main, and "sustainable cities and communities" as secondary.

To acclimatize the air inside the building to the desired values of temperature and humidity, two HVAC systems will be used. An air-water system with AHU will be used to achieve the desired humidity levels and a base temperature (20% of the total thermal loads) throughout the building, since the AHU are on the roof and homogeneously feed the humidity and the temperature. to all the diffusers in the building. The second HVAC system is water-water that generates heat from the rooftop (group of boilers and refrigerators) to supply power to the inductors throughout the building, which cover 80% of the thermal loads in each room. In this way, the temperature of each room is independent based on the base conditions established by the AHU system. These two systems operate simultaneously throughout the building. This structure has been chosen, since it is more economical and environmentally friendly to use UTA to deal with the greatest temperature difference between the exterior and interior air of the building. However, the use of the inductor system allows an independent temperature regulation margin for each room.

<u>Results (flows, diameters, lengths and losses) and selection of water pipes. Height to be satisfied by the pump.</u>

Following the RITE criteria of section 12 IT 1.2.4.2, which establishes a maximum allowable loss of 30 mm c. a./m and a maximum water velocity of 2 m / s, the most suitable pipe diameters have been selected using the *Diameter ratio, losses, flow and speed water pipes at 60ºC graph in Annexed 4. Calculation of water pipes*. The material of the pipes is non-alloy steel suitable for welding and threading, according to UNE 10255, with an elastomeric foam insulation (from the table *Minimum thickness of pipe insulation according to RITE in Annexed 4. Calculation of water pipes*).

The following is an example of the loss results per section of the ground floors, 1 and 3 of the two circuits CI-1 and CI-2:

		SECTION	Q (l / h)	DN (mm)	DN (")	Losses. mm.c.a. /m	L (m)	V(m/s)	Tot acces.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
CI-1	FLOOR 0	1	195	15	0,5906	12	2,09	0,28	0	25,08	25,08
		2	390	20	0,7874	10	2,86	0,31	0	28,60	53,68
		3	586	20	0,7874	7	0,47	0,3	0	3,29	56,97
		4	781	25	0,9843	11	0,86	0,39	1,5	25,96	82,93
		5	976	25	0,9843	16	0,53	0,47	1,5	32,48	115,41
		6	1171	25	0,9843	22	0,93	0,56	1,5	53,46	168,87
		7	2192	32	1,2598	18	7,15	0,61	1,8	161,10	329,97
		8	3946	40	1,5748	25	5,84	0,81	2,4	206,00	535,97
		9	5279	50	1,9685	13	5,51	0,67	3	110,63	646,60
		10	7387	50	1,9685	25	8,12	0,95	3,9	300,50	947,10
	FLOOR 1	11	192	15	0,5906	12	1,13	0,28	0	13,56	960,66
		12	383	20	0,7874	9	2,99	0,29	0	26,91	987,57
		13	766	25	0,9843	10	1,23	0,37	0	12,30	999,87
		14	1149	25	0,9843	21	1,21	0,56	1,5	56,91	1.056,78
		15	1735	32	1,2598	12	6,65	0,49	1,8	101,40	1.158,18
		16	3464	40	1,5748	20	6,53	0,72	2,4	178,60	1.336,78
		17	4815	50	1,9685	11	5,95	0,62	3,9	108,35	1.445,13
		18	8647	65	2,5591	9	8,24	0,66	5,4	122,76	1.567,89
		19	16034	65	2,5591	28	2,5	1,21	3,6	170,80	1.738,69
	FLOOR 3	29	207	15	0,5906	13	1,11	0,29	0	14,43	2.544,71
		30	364	20	0,7874	9	3,13	0,29	0	28,17	2.572,88
		31	778	25	0,9843	11	1,33	0,3	0	14,63	2.587,51
		32	1101	25	0,9843	20	1,26	0,54	1,5	55,20	2.642,71
		33	1742	32	1,2598	12	6,65	0,49	1,8	101,40	2.744,11
		34	3523	40	1,5748	20	6,5	0,72	2,4	178,00	2.922,11
		35	4932	50	1,9685	12	5,9	0,64	3,9	117,60	3.039,71
		36	9271	65	2,5591	10	8,34	0,6	5,4	137,40	3.177,11
		37	33952	100	3,937	14	2,5	1,1	3,6	85,40	3.262,51
CI-2	FLOOR 0	74	155	15	0,5906	8	2,76	0,22	0	22,08	6.566,71
		75	309	20	0,7874	6	1,63	0,23	0	9,78	6.576,49
		76	464	20	0,7874	13	1,48	0,36	0	19,24	6.595,73
		77	773	25	0,9843	10	2,64	0,37	1,5	41,40	6.637,13
		78	1217	32	1,2598	6	7,11	0,34	1,8	53,46	6.690,59
		79	2482	40	1,5748	11	7,4	0,52	2,4	107,80	6.798,39
		80	4037	50	1,9685	8	5,05	0,52	4,5	76,40	6.874,79
		81	5075	50	1,9685	12	6,14	0,64	3	109,68	6.984,47
	FLOOR 1	82	192	15	0,5906	12	1,13	0,28	0	13,56	6.998,03
		83	383	20	0,7874	9	3,23	0,29	0	29,07	7.027,10
		84	766	25	0,9843	10	1,23	0,37	0	12,30	7.039,40
		85	1149	25	0,9843	21	1,08	0,56	1,5	54,18	7.093,58
		86	1729	32	1,2598	7	6,5	0,37	1,8	58,10	7.151,68
		87	3266	40	1,5748	18	7,46	0,68	2,4	177,48	7.329,16
		88	4839	50	1,9685	11	5,91	0,62	4,5	114,51	7.443,67
		89	8353	65	2,5591	9	5,74	0,66	5,4	100,26	7.543,93
		90	13427	65	2,5591	21	2,5	1,02	3,6	128,10	7.672,03
	FLOOR 3	100	207	15	0,5906	13	1,1	0,29	0	14,30	8.379,99
		101	414	20	0,7874	11	3,21	0,33	0	35,31	8.415,30
		102	828	25	0,9843	12	1,23	0,41	0	14,76	8.430,06
		103	1243	25	0,9843	25	1,21	0,5	1,5	67,75	8.497,81
		104	1900	32	1,2598	14	6,41	0,54	1,8	114,94	8.612,75
		105	3932	40	1,5748	24	7,46	0,8	2,4	236,64	8.849,39
		106	5515	50	1,9685	14	6,15	0,7	4,5	149,10	8.998,49
		107	9541	65	2,5591	11	6,05	0,73	5,4	125,95	9.124,44
		108	31321	100	3,937	12	2,5	1,02	3,6	73,20	9.197,64

Table 1-a. Example of the results of the losses in each section of pipeline of the most unfavorable route of the two circuits CI-1 and CI-2, ground floor, floor 1 and floor 3.

Finally, the total results of the losses of the most unfavorable route from the mixture of hot and cold water on the roof to the most remote terminal elements of each plant, of the two circuits that supply all inductors are shown. in interior rooms and converge on the ceiling (circuit CI-1 and CI-2), including losses from valves and filters; and the effective height that the circuit pump must exceed:

	SECTION	Q (l / h)	DN (mm)	DN (")	Losses. mm.c.a. /m	L (m)	V(m/s)	Tot valv.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
UNDER COVER	145	136896	200	7,874	7	22,7	1,19	0	232,40	12.591,76
	DRIVE + RETURN							0	12.591,76	25.183,52
	VALV. and FILTERS		200	7,874	7	34,5		2778	19.688,90	44.872,42

		Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
Subtotal			44.872,42
valv control			2.000,00
		total	46.872,42
		% secur.	10,00%
ALTEFFECTIVE PUMP HEIGHT (M.C.A.)			51,56

Table 1-b. Total loss results from worst-case route and effective height that circuit pumps must exceed.

<u>Results (flow rates, diameters, speeds, equivalent lengths and losses) and selection of the supply and return air ducts.</u>

Appropriate diameters have been selected for the circular ducts, respecting the criterion that all the sections do not have losses greater than 0.4 mm.c.a./m nor a speed greater than 12 m / s. These parameters have been obtained from the graph *Loss diagram in circular air ducts in Annexed 5. Calculation of ducts*.

The type of circular duct selected for the air-air system is the ALDER company. They are circular ducts in galvanized steel sheet sewn into the propeller. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters greater than 630 mm. You can see the technical sheet of the manufacturer of these ducts in *Technical sheet of the manufacturer of the air-air ducts in Annexed 5. Calculation of ducts*.

The results of the losses in the most critical circuit of the air supply ducts going to the first AHU (AHU-AP1) are shown below as an example:

	GROUND FLOOR DISCHARGE DUCTS							
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Acces Type**	**V (m/s)**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	64	100	Elbow	2,271	4,82	0,09	0,43
	2	128	125	Der+Red	2,907	6,35	0,1	0,64
	3	257	125	Derivation	5,814	22,22	0,38	8,44
	4	321	125	Derivation	7,268	27,05	0,4	10,82
	5	385	150	Der+Red	6,056	22,13	0,3	6,64
	6	450	150	Derivation	7,066	27	0,39	10,53
	7	514	175	Der+Red	5,933	21,18	0,35	7,413
	8	1091	250	Der+Red	6,174	26,74	0,15	4,011
	9	1990	300	Der+Red	7,822	40,42	0,2	8,084
	10	4376	350	Der+Red	11,82	85,04	0,35	29,764
	11	4701	400	Der+Red	10,39	55,48	0,27	14,9796
vertical course	12	9401	550	Der+Red+Elb	10,99	84,83	0,22	18,6626
	13	14102	700	Der+Red	10,18	57,76	0,14	8,0864
	14	18802	900	Der+Red	8,21	38,49	0,06	2,3094
	15	23503	1000	Der+Red	8,312	42,9	0,05	2,145
	16	28203	1100	Der+Red	8,244	40,17	0,04	1,6068
	17	32904	1100	Derivation	9,618	52,54	0,06	3,1524
	18	37604	1100	Derivation	10,99	64,71	0,1	6,471
	Diffusers							408,640
						Subtotal		552,83
						Loss in diffusion		2,5
						Safety coef. %		10%
						TOTAL		610,86

Table 2. Results of the losses in the most critical circuit of the air supply ducts going to the first AHU (AHU-AP1).

The results of the losses in the return duct circuit of the most critical case discussed above are shown below:

	GROUND FLOOR DISCHARGE DUCTS							
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Acces Type**	**V (m/s)**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	46	150	-	0,73	2,59	0	0,00
	2	92	200	Der+Red	0,82	5,21	0	0,00
	3	139	200	Derivation	1,22	5,55	0,012	0,07
	4	185	250	Der+Red	1,05	9,58	0	0,00
	5	272	250	Derivation	1,54	12,86	0,014	0,18
	6	724	300	Elb+Der+Red	2,85	68,45	0,02	1,37
	7	1416	300	Derivation	5,56	13,73	0,12	1,65
vertical course	8	2832	500	Elb+Der+Red	4,01	72,67	0,034	2,47
	9	4247	600	Der+Red	4,17	109,12	0,027	2,95
	10	5663	650	Der+Red	4,74	109,12	0,035	3,82
	11	7079	750	Der+Red	4,45	101,75	0,05	5,09
	12	8495	800	Der+Red	4,69	42,9	0,025	1,07
	13	9911	850	Der+Red	4,85	23,52	0,021	0,49
	14	11327	850	Derivation	5,54	9,55	0,028	0,27
	15	22653	1100	Elb+Der+Red	6,62	65,86	0,03	1,98
	Grids							209,34
						Subtotal		230,73
						Loss in diffusion		2,5
						Safety coef. %		10%
						TOTAL		256,56

Table 3. Results of the losses in the return duct circuit of the most critical case discussed above.

<u>Results of thermal loads in summer and winter and selection of boilers and cooler group.</u>

In order to achieve the temperature levels that guarantee the comfort of the workers, it can be seen in the project results that a maximum of 1132 kW of cooling power is required in summer and 751 kW of heating power in winter (these two power results They have been calculated by estimating the power to supply all the inductors in the building, reaching them through four circuits of water pipes, and estimating the power necessary to supply the cold and heat batteries of the UTAs, as shown in the tables. of results below). To meet this demand, two 380kW boilers of nominal power have been selected, model ADINOX 339 of the ADISA brand working in parallel and a 1,226 kW refrigerator unit of nominal power, model BG / WRAT R407C 4828 of the CLIMAVENETA brand. These commented results are shown in the following tables:

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	SUMMER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	COLD BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	885	247
REFRIGERATION HEAT (kW)		1132

Table 4. Summary of all thermal loads to be covered by the cooling group.

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	WINTER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	HEAT BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	578	173
TOTAL HEATING HEAT (kW)		**751**

Table 5. Summary of all the thermal loads that the boilers must cover.

Results (flow and return flow rates and power of the cold and heat batteries) and selection of the air treatment units.

In order to take over 20% of the thermal load of the building, two air treatment units have been used, which consist of an enthalpic recuperator to improve the efficiency of the machine (with its corresponding environmental benefit) by recovering part of the return air energy that is expelled to the outside, while guaranteeing the level of air quality for offices established by RITE (IDA 3). These UTAs must satisfy the demand set forth in the project of 37604 m3 / h and 36596 m3 / h of delivery flow, 22653 m3 / h and 22046 m3 / h of return flow, respectively each of the two UTAs that use different duct systems. As the duct circuits that are supplied by the two UTAs have been designed with a very similar demand, the two UTAs will be the same with a maximum flow of 38,500 m3 / h of the model CLA-2030/4 of the TERMOVEN brand. Below is a diagram of the type of UTA used to acclimatize the building, which consists of an enthalpic recuperator to improve the efficiency of the machine and reduce its impact on the environment:

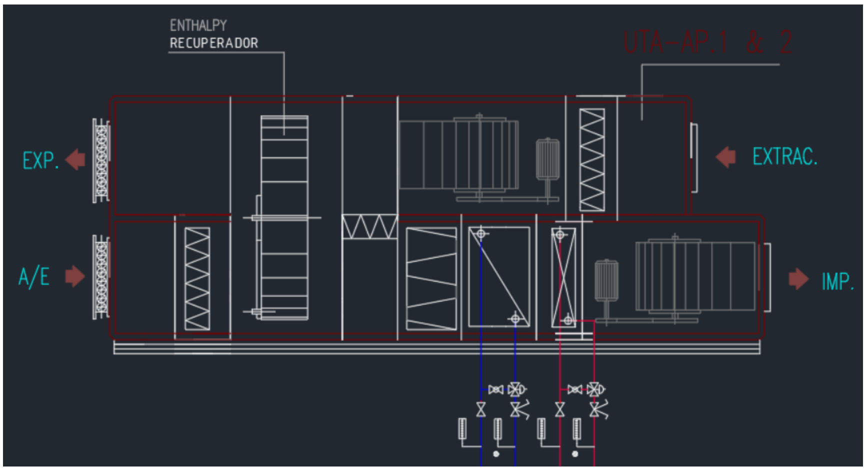

Figure 1. Diagram of this type of equipment used for AHU-AP1 and AHU-AP2.

The results of the discharge and return flow rates are shown below, together with the powers of the heat and cold batteries, which the two UTAs must cover:

	IMPULSION FLOW (m3/h)	RETURN FLOW (m3/h)	HEAT BATTERY (W)	COLD BATTERY (W)
AHU AP1	37604	22653	124658	87104
AHU AP2	36596	22046	121316	84769

Table 6. The parameters required by the water supply system (hot and cold batteries) and the air-air system (supply and return air flows).

<u>Results (number of units, flow rates and height) and selection of pumps for water piping circuits.</u>

The water piping system has required the use of six sets of pumps (13 pumps with 4 spare and 3 of them working in parallel) for each of the circuits: cold primary circuit pumps, primary heat circuit pumps , secondary cold air conditioner pumps, secondary circuit inductors, indoor zone pumps, secondary circuit inductors, facade zone pumps, and secondary heat circuit for air conditioning pumps. These circuits can be seen schematically in Plan 1. Principle scheme. Below are the results of the flow rates and heights that each pump needs to satisfy:

PUMP SET	SECTION	QUANTITY (REPLACEMENT)	UNIT FLOW (m3/h)	HEIGHT (m)
B3	AHUs cold secondary circuit	1 (1)	128	12
B6	AHUs cold secondary circuit	1 (1)	46	12
B4	Secondary circuit inductors inner zone (CI1 + 2)	1 (1)	147	78
B5	Facade zone inductors secondary circuit (CF1 + 2)	1 (1)	56	73
B1	Primary cold circuit	2 (0)	220	10
B2	Primary heat circuit	3 (0)	57	8

Table 7. Parameters required to select the types of pumps required for each circuit.

Selecting the following ELIAS company models, depending on your technical needs:

PUMP SET	SECTION	COMPANY	SERIE	R.P.M.
B3	AHUs cold secondary circuit	ELIAS	IAC-100-312	1450
B6	AHUs cold secondary circuit	ELIAS	IAC-80-202	1450
B4	Secondary circuit inductors inner zone (CI1 + 2)	ELIAS	BQP 150/50	1450
B5	Facade zone inductors secondary circuit (CF1 + 2)	ELIAS	BQP 150/50	1450
B1	Primary cold circuit	ELIAS	BQP 150/26	1450
B2	Primary heat circuit	ELIAS	IAC-80-203	1450

Table 8. Appropriate pumps have been selected to satisfy the water piping system.

Results (number of units and thermal loads to cover in summer and winter) and selection of inductors.

The results of the cooling and heating power to be covered in each room are shown below, along with the number of inductors required for this task per room:

LOCATION				SUMMER		WINTER	
TIPE OF ROOM	FLOOR	ROOM	INDUCTORS QUANTITY	TOTAL HEAT COVERED BY INDUCTORS (kW)	HEAT/ INDUCTOR (kW)	TOTAL HEAT COVERED BY INDUCTORS	HEAT/ INDUCTORS (kW)
room	0	2	5	5,81	1,16	4,93	0,99
room	0	3	11	7,62	0,69	6,17	0,56
room	0	4	8	6,81	0,85	5,72	0,72
room	0	5	8	5,40	0,67	0,00	0,00
room	0	8	1	3,46	3,46	2,90	2,90
room	0	10	2	3,35	1,68	2,78	1,39
hall	0	12	30	38,74	1,29	32,93	1,10
room	1	23	80	89,12	1,11	74,86	0,94
hall	1	25	2	1,18	0,59	1,55	0,78
hall	1	26	8	4,56	0,57	6,12	0,76
hall	1	27	3	2,46	0,82	3,00	1,00
hall	1	28	2	1,50	0,75	1,76	0,88
room	2	32	80	89,12	1,11	74,86	0,94
hall	2	34	2	1,18	0,59	1,55	0,78
hall	2	35	8	4,56	0,57	6,12	0,76
hall	2	36	3	2,46	0,82	3,00	1,00
hall	2	37	2	1,50	0,75	1,76	0,88

room	3	41	2	3,90	1,95	3,27	1,64
room	3	42	2	1,72	0,86	1,44	0,72
room	3	43	2	2,41	1,20	1,92	0,96
room	3	44	2	2,42	1,21	3,20	1,60
room	3	45	3	3,28	1,09	2,79	0,93
room	3	46	2	2,50	1,25	2,07	1,04
room	3	47	3	2,73	0,91	2,29	0,76
room	3	48	4	2,70	0,67	3,56	0,89
room	3	49	2	3,23	1,61	2,71	1,36
room	3	50	2	2,49	1,24	2,09	1,04
room	3	51	1	1,89	1,89	1,59	1,59
room	3	52	2	2,21	1,11	2,92	1,46
room	3	53	2	5,06	2,53	4,25	2,13
hall	3	54	19	21,72	1,14	18,25	0,96
hall	3	55	5	3,53	0,71	2,96	0,59
hall	3	56	19	18,07	0,95	15,18	0,80
hall	3	57	5	3,68	0,74	2,98	0,60
hall	3	58	17	19,55	1,15	16,42	0,97
hall	3	59	2	1,51	0,76	1,27	0,64
room	4	64	2	3,90	1,95	3,27	1,64
room	4	65	2	1,72	0,86	1,44	0,72
room	4	66	2	2,41	1,20	1,92	0,96
room	4	67	2	2,42	1,21	3,20	1,60
room	4	68	3	3,28	1,09	2,79	0,93
room	4	69	2	2,50	1,25	2,07	1,04
room	4	70	3	2,73	0,91	2,29	0,76
room	4	71	4	2,70	0,67	3,56	0,89
room	4	72	2	3,23	1,61	2,71	1,36
room	4	73	2	2,49	1,24	2,09	1,04
room	4	74	1	1,89	1,89	1,59	1,59
room	4	75	2	2,21	1,11	2,92	1,46
room	4	76	2	5,06	2,53	4,25	2,13
hall	4	77	19	21,72	1,14	18,25	0,96
hall	4	78	5	3,53	0,71	2,96	0,59
hall	4	79	19	18,07	0,95	15,18	0,80
hall	4	80	5	3,68	0,74	2,98	0,60
hall	4	81	17	19,55	1,15	16,42	0,97
hall	4	82	2	1,51	0,76	1,27	0,64

room	5	32	80	89,12	1,11	74,86	0,94
hall	5	34	2	1,18	0,59	1,55	0,78
hall	5	35	8	4,56	0,57	6,12	0,76
hall	5	36	3	2,46	0,82	3,00	1,00
hall	5	37	2	1,50	0,75	1,76	0,88
room	6	32	80	89,12	1,11	74,86	0,94
hall	6	34	2	1,18	0,59	1,55	0,78
hall	6	35	8	4,56	0,57	6,12	0,76
hall	6	36	3	2,46	0,82	3,00	1,00
hall	6	37	2	1,50	0,75	1,76	0,88
room	7	64	2	3,90	1,95	3,27	1,64
room	7	65	2	1,72	0,86	1,44	0,72
room	7	66	2	2,41	1,20	1,92	0,96
room	7	67	2	2,42	1,21	3,20	1,60
room	7	68	3	3,28	1,09	2,79	0,93
room	7	69	2	2,50	1,25	2,07	1,04
room	7	70	3	2,73	0,91	2,29	0,76
room	7	71	4	2,70	0,67	3,56	0,89
room	7	72	2	3,23	1,61	2,71	1,36
room	7	73	2	2,49	1,24	2,09	1,04
room	7	74	1	1,89	1,89	1,59	1,59
room	7	75	2	2,21	1,11	2,92	1,46
room	7	76	2	5,06	2,53	4,25	2,13
hall	7	77	19	21,72	1,14	18,25	0,96
hall	7	78	5	3,53	0,71	2,96	0,59
hall	7	79	19	18,07	0,95	15,18	0,80
hall	7	80	5	3,68	0,74	2,98	0,60
hall	7	81	17	19,55	1,15	16,42	0,97
hall	7	82	2	1,51	0,76	1,27	0,64

Table 9. Summary of the thermal loads to be covered by the inductors distributed in each room, the number of inductors in each room and the selected inductor for each room.

This project has been sized to cover all the thermal loads in each room, using only a single series of IHK-F inductors (2-PIPE SYSTEM), from the KOOLAIR company of three different sizes depending on demand, 900, 1200 and 1500.

<u>Selection of terminal units of air duct circuits (diffusers and grilles), valves and elements of the water piping system.</u>

As terminal elements of the air duct system, diffusers have been used to distribute the discharge flow from the UTAs, and grids for the return flow. The condition that guarantees that the diffusers produce a noise level not exceeding 40 dB has been respected, ensuring a pleasant environment for office work. The VDN model has been chosen for the diffusers and the AT model of the TROX brand.

The different types of valves and elements of the piping system have been selected from the ANDERSOON brand.

Results and measures taken to meet the Sustainable Development Goals.

By changing the initially studied boilers (ADI CD 100) for the definitive boilers (ADINOX 339 BT) which are more expensive, but with greater efficiency and lower CO2 emissions, it has been possible to avoid 12.34% of additional CO2 emissions at the atmosphere (331.602 kg CO2 vs. 295.162 kg CO2 per year).

It has been chosen to use two air conditioning systems that work simultaneously covering the thermal loads of each of the rooms. Covering 20% of the thermal load with an air-water system using UTAs and the remaining 80% with a water-water system using inductors as terminal elements.

The two main UTAs that have been selected are model CLA-2030/4 of the TERMOVEN brand that consist of an enthalpic recuperator that improves the efficiency of the machine even assuming a higher cost.

Location of the office building away from the city of Madrid, in the Business Park of Avenida del Prado del Espino 28660.

General budget

BUDGET MECHANICAL FACILITIES MADRID OFFICES		
CODE	DESCRIPTION	AMOUNT
Chapter 1	**COLD PRODUCTION**	226.665,02 €
Chapter 2	**HEAT PRODUCTION**	55.110,91 €
Chapter 3	**AIR HANDLING UNIT**	223.666,84 €
Chapter 4	**PUMP SET**	13.022,81 €
Chapter 5	**INDUCTORS. TERMINAL ELEMENT**	570.791,20 €
Chapter 6	**DIFFUSERS / GRIDS. TERMINAL ELEMENT**	15.127,31 €
Chapter 7	**PIPELINES WITH INSULATION**	678.717,93 €
Chapter 8	**AIR DUCTS AND INSULATION**	365.039,13 €
Chapter 9	**MECHANICAL CONTROL AND MEASURING EQUIPMENT**	58.147,26 €
	TOTAL	2.206.288,41 €

Table 10. General budget.

CONCLUSIONS

In this project it has been possible to size an HVAC system for an office building, guaranteeing the comfort of the workers and complying with current regulations. The project has been successfully focused on meeting two of the Sustainable Development Goals, "Responsible Production and Consumption" as the main objective and "Sustainable Cities and Communities" as secondary.

As expected, it is denoted in the results that the scenario in which more energy will be needed to cover the thermal loads is in the month of July, the most unfavorable in summer (power to cool), since the building is located in the community of Madrid.

The objectives "Responsible production and consumption" and "Sustainable cities and communities" have been met, taking the measures included in Chapter Part III. Alignment with the United Nations Sustainable Development Goals (SDGs) observing the following conclusions:

- The very notable amount of kg of CO2 that is avoided to generate per year by using an efficient type of boiler with lower emissions, compared to the most economical boilers that were studied in the first place for this project.

- Covering thermal loads with an air-water system using UTAs and water-water using inductors by 20% and 80% respectively, achieves a balance between the objectives of improving the efficiency of the building while reducing the environmental impact, while achieving an independent regulation of the temperature of each room. This conclusion is deduced by comparing this scenario against that of having covered 100% of the thermal demand with a water-water system with inductors as terminal elements, which would harm the environment to a greater extent and the scenario of having covered 100% of the Thermal demand with an air-water system using UTAs, giving up the benefit of being able to manage the temperature of each room independently.

- The selected main UTAs have a higher purchase price but guarantee better system efficiency by requiring less energy input from the boilers and the cooling unit to achieve the desired humidity and temperature thanks to having enthalpy recuperators, reducing the footprint carbon of these teams.

- The land where the office building will be built is on the outskirts of the city of Madrid, preventing the CO2 emissions generated by the HVAC system devices from being released near densely populated areas, not harming the quality of life of citizens.

REFERENCES

[BOE_98] “Reglamento de Instalaciones Térmicas en los Edificios (RITE)”. Edited by the State Agency Official State Gazette. Approved by Royal Decree 1751/1998, of July 31.

[UN__15] "Sustainable Development Goals" Approval of the 2030 Agenda by the UN. 2015

MÁSTER UNIVERSITARIO EN

INGENIERÍA INDUSTRIAL

TRABAJO FIN DE MÁSTER

HVAC SYSTEM OF AN OFFICE BUILDING IN MADRID

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Madrid

Junio de 2

DOCUMENT I.

MEMORY

General memory index

Part I. Memory

Memory index

CONTENT

TABLES

1. Context

Through this project, the HVAC system (Heating, ventilation, and air conditioning) of an office building in the province of Madrid will be designed, considering the needs and characteristics of the building and the area, according to current legislation (Regulation of Thermal Installations of Buildings "RITE", [BOE_98]).

The techniques and methodology used will be those learned in the "Environ Control & HVAC Systems" and "Indoor Environmental Control" classes that I have taken in my year of exchange at the University of Illinois Champaign. But this HVAC system will be conditioned for an office building located in Madrid (according to the needs and characteristics of the area, according to current legislation).

2. Status of the issue

Nowadays, HVAC systems are used to guarantee the comfort and health of employees working in office buildings. In general, it can be said that the HVAC is responsible for solving the problems of air renewal and its treatment to confer health conditions (purity conditions, conditioning to achieve an air suitable for breathing), temperature and Comfortable humidity for people. Specifically, in Madrid, the biggest challenge is in the hottest months where very high temperatures are reached, reducing employee performance and putting their well-being at risk.

3. Motivation

The main motivation is to meet the design needs of this HVAC system for the office building, complying with the instructions imposed in the specifications, with Spanish regulations and using HVAC machinery and equipment marketed in Spain.

As an additional motivation and cause for what makes this project interesting, is to be able to design an HVAC system for a building located in Spain using the knowledge and methodology learned in the two classes I have studied on HVAC systems at the University of Illinois during my year of exchange. To adapt knowledge focused on HVAC systems for the United States, to differences in weather, weather conditions, legislature and marking of sections for an HVAC system, for a building in Spain.

4. Methodology and objectives of the project

Design an HVAC system for an office building in Madrid, to ensure the effectiveness of employees by ensuring their working conditions in the building (temperature and humidity that establishes comfort and healthy air levels), considering making the least impact to the environment as possible.

To carry out this project there will be several minor objectives:

- Sizing and calculations of the HVAC installation.
  - Thermal loads of the building (summer / winter).
  - Pipes and ducts selection.
  - Loss of load in pipes and ducts
- Choice of equipment.
  - Air Handling Units.
  - Boilers.
  - Refrigeration group
  - Inductors
  - Pumps.
  - Valves
  - Terminal elements (diffusers and grids)
- United Nations Sustainable Development Goals (SDGs).
- Budget (materials, supply, installation assembly, etc.).

5. Tools used

The following programs will be used for sizing, installation calculations and plans:

- AutoCAD.
- Excel.

To consult the techniques and knowledge of HVAC systems, consult:

- HVAC Simplified by Stephen P. Kavanaugh. 2006

- HEATING, VENTILATION, AND AIR CONDITIONING. Analysis and Design. McQuiston/Parker/Spitler.
- Material of the "Environ Control & HVAC Systems" class.
- Material of the "Indoor Environmental Control" class.

6. Building Description

The HVAC system of an office building located in the Avenida Prado del Espino business park, 28660, Madrid will be designed.

The building consists of 8 floors enabled as offices and a last floor on the roof that contains all the equipment of the installation (boilers, refrigerator group, AHUs, pumps ...). The orientation of the building's facade is east. Each floor of the building has an area of 1,496 m2 and a height between floors of 3 m (the effective height of the offices discounting the false ceiling is 2.5 m), the building having a total height of 27 m.

The data of the building elements necessary for the sizing of the installation are shown below:

CALCULATION PARAMETERS	
DOUBLE GLASS SOLAR FACTOR	0,76
PVC FRAMES (W / m2K)	3
FRACTION FRAMEWORK OCCUPATION	0,1
ACTIVE FRACTION WINDOW	1
FRACTION SHADOW OTHER BUILDINGS	0
EXTERIOR WALLS (W / m2K)	0,76
FLOORS (W / m2K)	1,3
CEILINGS (W / m2K)	2,02

Table 1.1. Parameters of the building description

The parameters in the following tables have been taken from the tables in *Annex 3 Thermal load calculation parameters.*

You can see figures of the plant of each of the levels of the building in *Annex 1. Floor plans*. To see the different equipment on the top floor on the roof, see *Plan 1. Principle scheme*.

7. Exterior design conditions

The building is in Madrid, below are the necessary data from the region to carry out the installation calculations in the two most critical months of summer and winter (July and January):

CALCULATION PARAMETERS	
CITY	Madrid
CLIMATE ZONE	D3
OUTDOOR AIR QUALITY	IDA 2
ESTIMATED TOTAL PRESSURE (Pa)	93317
HEIGHT ABOVE SEA LEVEL (m)	689
SUMMER	
OUTDOOR DRY Tª (ºC)	33,6
TUM HUMEDA (ºC)	21,1
TEMPERATURE CHANGE (ºC)	13,9
AVERAGE TEMPERATURE IN THE MONTH (ºC)	25,4
MONTH CONSIDERED	JULY
CONSIDERED TIME	15
OUTDOOR AIR QUALITY	IDA 2
ESTIMATED TOTAL PRESSURE (Pa)	93317
HEIGHT ABOVE SEA LEVEL (m)	689
WINTER	
OUTDOOR DRY Tª (ºC)	0,3
EXTERIOR RELATIVE HUMIDITY (%)	0,69
TEMPERATURE CHANGE	3,5
AVERAGE TEMPERATURE IN THE MONTH	6
MONTH CONSIDERED	JANUARY
CONSIDERED TIME	9

Table 1.2. Parameters of the external design conditions

The parameters in the following tables have been taken from the tables in *Annex 3 Thermal load calculation parameters* and from [AEME13].

8. Interior design conditions

The conditions to be considered inside the building are all those that affect the thermal load of the interior (occupants, lighting and equipment). The data to be considered inside the building are shown below:

CALCULATION PARAMETERS	
APPLICATION	Offices_12h
OFFICE AIR QUALITY	IDA 3
LIGHTS (W / m2K)	20
RADIATING FRACTION LIGHTS	0,5
EQUIPMENT (W / m2)	5
RADIANT FRACTION EQUIPMENT	0,05
SUMMER	
INTERIOR DRY Tª (ºC)	25
RELATIVE INDOOR HUMIDITY (%)	50
WINTER	
INTERIOR DRY Tª (ºC)	22
RELATIVE INDOOR HUMIDITY (%)	40

Table 1.3. Parameters of the interior design conditions

The parameters in the following tables have been taken from the tables in *Annex 3 Thermal load calculation parameters*.

To acclimatize the air inside the building to the desired temperature and humidity values, two HVAC systems will be used. An air-water system with AHUs will be used to achieve the desired humidity levels and a base temperature (20% of the total thermal loads) throughout the building since the AHUs are on the roof and homogeneously feed the humidity and temperature. to all the diffusers in the building. The second HVAC system is water-water generating heat from the roof (boilers and refrigerator group) to supply the inductors throughout the building, which cover 80% of the thermal loads in each room, thus achieving power regulation The temperature of each room is independent depending on the base conditions established by the AHU system. These two systems work simultaneously oughout the building. This structure has been chosen, since it is more economical and more environmentally friendly to use AHUs to achieve the greatest difference in temperature between the outside and inside air of the building. However, the use of the inductor system allows an independent temperature regulation margin for each room.

Part II. Calculations

Calculations index

CONTENT

TABLES

FIGURES

1. Calculation of thermal loads (cooling and heating loads)

This section explains the procedure followed to calculate the summer and winter loads in the most critical months of highest and lowest temperatures (July and January). A public Excel spreadsheet designed by the professors of the Polytechnic University of Valencia (UPV) has been used. All the data used in this Excel have been searched and chosen from the attached tables in the *Annex 3. Thermal load calculation parameters*. The loads contributed by the formulas of values with units in kcal/h that the Excel transforms to W when it presents the results that are observed in the example *from Annex 2. Excels example used to calculate loads* [PINA19]. This spreadsheet considers the following factors to estimate thermal loads:

1. CALCULATION OF SENSIBLE THERMAL LOAD

The following expression is used to calculate the sensible thermal load (Qs):

$$Q_s = Q_{sr} + Q_{str} + Q_{st} + Q_{si} + Q_{sai}$$

where:

Qsr is the value of the sensible load due to solar radiation through the glazed surfaces (W)

Qstr is the sensible load by transmission and radiation through exterior walls and ceilings (W)

Qst is the sensible load by transmission through interior walls, ceilings, floors and doors (W)

Qsi is the sensitive load transmitted by outside air infiltrations (W)

Qsai is the sensible load due to internal contributions (W)

1.1 Sensible gains from radiation

It corresponds to the heat provided through the windows from the sun. For this calculation, the most unfavorable months and hours have been considered. It is calculated with the following formula:

$$Q_{sr} = S \cdot R \cdot F$$

where:

Q_{sr} is the thermal load by solar radiation through glass [W]
R Unit value of solar radiation as a function of orientation and date and time (direct and diffuse radiation) [W / m2]. Value from *Annexed 3*.

S = Window area [m2]
F = It is the radiation correction factor depending on the type of glass used in the window, any shadow effects that may exist… Value from *Annexed 3*.

1.2 Sensible heat transmission throught building exterior materials

The transmission and radiation load that is transmitted through the opaque walls and ceilings that border the exterior (Qstr) is calculated as follows:

$$Q_{str} = K \cdot S \cdot (T_{ec} - T_i)$$

where:

Qstr is the transmission load through exterior walls and ceilings, in W.
K is the global coefficient of thermal transmission of the enclosure, also called thermal transmittance, expressed in W / m2ºC. Value from *Annexed 3*.
S is the wall surface exposed to the temperature difference, in m2.
Ti is the interior design temperature of the premises (ºC). From PART I. Memory, *Table 1.2.*
Tec is the calculation outside temperature on the other side of the premises (ºC). From PART I. Memory, *Table 1.2.*

1.3 Sensible heat transmission throught building interior materials

The transmission load through the interior enclosures of the premises that limit it with other rooms in the building (Qst) is calculated by applying the following expression:

$$Q_{st} = K \cdot S \cdot (T_e - T_i)$$

Where:

Qst is the transmission load through the inner enclosures, in W. Value from *Annexed 3*.
K is the global coefficient of thermal transmission of the enclosure, also called thermal transmittance, expressed in W / m2ºC.
S is the area of the inner enclosure, in m2.
Te is the design temperature on the other side of the enclosure (ºC). From PART I. Memory, *Table 1.3.*
Ti is the interior design temperature of the premises (ºC). From PART I. Memory, *Table 1.3.*

1.4 Air infiltrations

Infiltration occurs when outside air is drawn into the building due to a pressure difference (it has been assumed that building pressurization is greater than the wind and stack pressures at all levels and sides of the building). In this project, infiltrations will not occur since it has been dimensioned in a system of air supply and return ducts through the UHA so that slightly less air is extracted from the interior of the building than it is introduced, thus achieving a slight overpressure inside.

The aim is to guarantee an overpressure condition in the building (to avoid infiltrations from the outside that dirties the clean air of the AHUs), so the return flow must be that of impulsion, minus that of extraction of the toilets (UE-A1 ducts, UE-A2 and UE-A3) and minus 5% to guarantee overpressure. The extraction flow of the baths has been equaled to the proportional part of the total discharge flow, depending on the area occupied by the baths with respect to the total area (5.13% of the total air discharge flow).

1.5 Sensible load due to internal contributions

Sensitive load due to internal contributions the sensible load gain due to internal contributions from the premises (Qsai) is in turn determined as the sum of the following types of loads generated within it:

$$Q_{sai} = Q_{sil} + Q_{sp} + Q_{se}$$

where:

Qsil is the value of the internal gain of sensible load due to the interior lighting of the room (W).

Qsp is the internal gain of sensible load due to the occupants of the premises (W).

Qse is the internal gain of sensible load due to the various devices in the room, such as electrical appliances, computers, etc. (W).

a) Sensitive lighting load (Qsil):

$$Q_{sil} = A \cdot k_1$$

where:

A is the area of the room in m2.

K_1 is lighting power fraction per unit area, depending on the type of lamp and the lux required per m2. It is in W per m2. This value is derived from the reference [LTWC__] and [CAST18].

b) Sensitive load by occupants (Qsp):

$$Q_{sp} = A \cdot (1/n) \cdot C_{sensible,persona}$$

where:

A is the area of the room in m2.
n is the ratio of area per occupant in offices in m2 per occupant. Value by reference [LANS19].
Csensible,persona is the sensible heat per person and activity that you carry out in W. Value from *Annexed 3*.

c) Sensitive load by electrical devices (Qse):

$$Q_{se} = A \cdot k_2$$

where:

A is the area of the room in m2
K_2 it is the fraction of power per unit area, depending on the type of equipment used in the office. It is in W per m2. A value of 5 W / m2 has been used, recommended in the Excel that has been used from the Universidad Politécnica de Valencia.

2. CALCULATION OF SENSIBLE THERMAL LOAD

For the calculation of the latent thermal load (Ql) the following expression is used:

$$Q_l = Q_{li} + Q_{lp}$$

where:

Qli is the latent load transmitted by outside air infiltrations (W);
Qlp is the latent load due to the occupation of the premises (W).

2.1 Latent load transmitted by outside air infiltration

There will be no infiltrations. The justification can be read in section *1.4* of this same chapter.

2.2 Latent load by occupation

$$Q_{sp} = A \cdot (1/n) \cdot C_{latente,\ persona}$$

where:

A is the area of the room in m2.
n is the ratio of area per occupant in offices in m2 per occupant. Value by reference [LANS19].

Clatente, persona is the latent heat per person and activity that you carry out in W. Value from *Annexed 3*.

3. TOTAL THERMAL LOAD

The total thermal load is the sum of the sensible and latent loads previously calculated:

$$Q = Q_s + Q_l$$

where:

Q is the total load (W).

Qs is the sensible load (W).

Ql is the latent load (W).

The final thermal loads that have been estimated in each room, collect all the different types of loads previously exposed, and increase by 10% (value of major) to guarantee a factor of safety.

Some representative graphs of the values that affect the value of the calculated loads are shown according to the hours of the most critical day (21) of the most critical month (July) of the year:

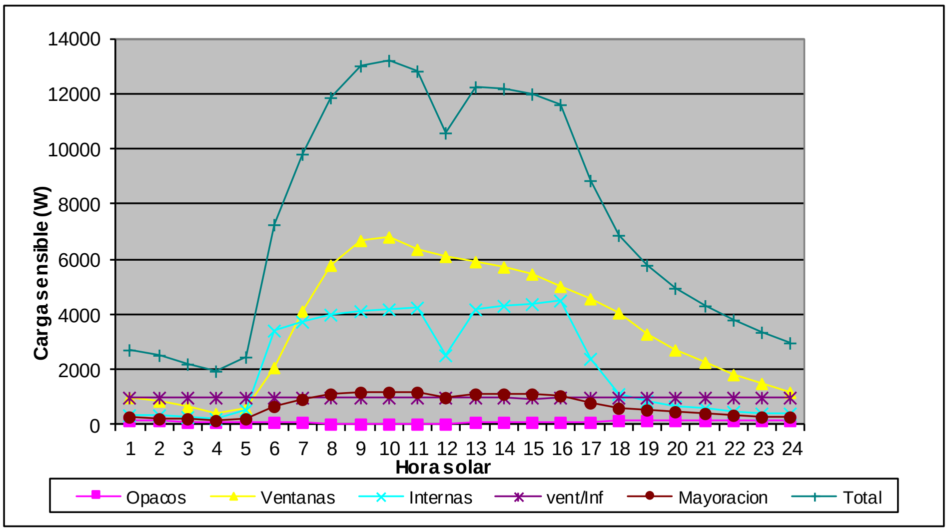


Figure 2.1. Sensitive load of building structures on the most critical daylight in July

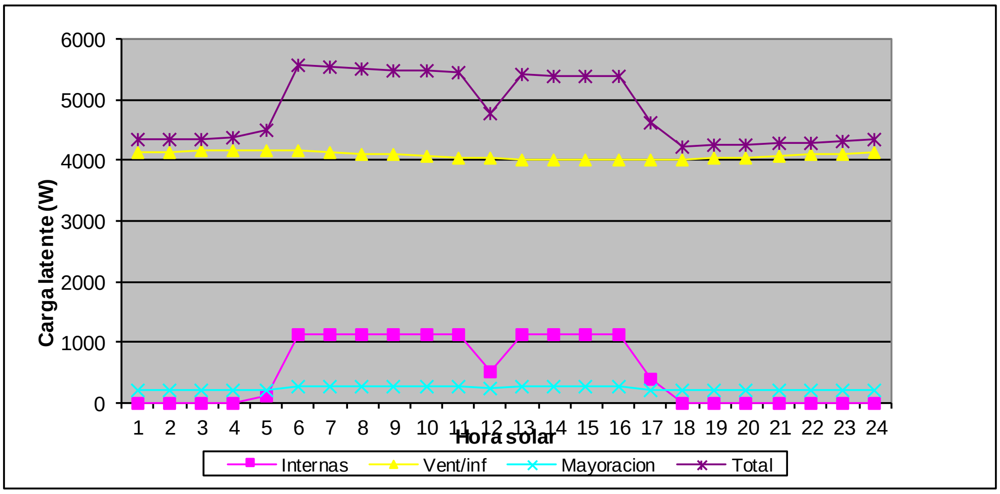


Figure 2.2. Latent load of building structures on the most critical daylight in July

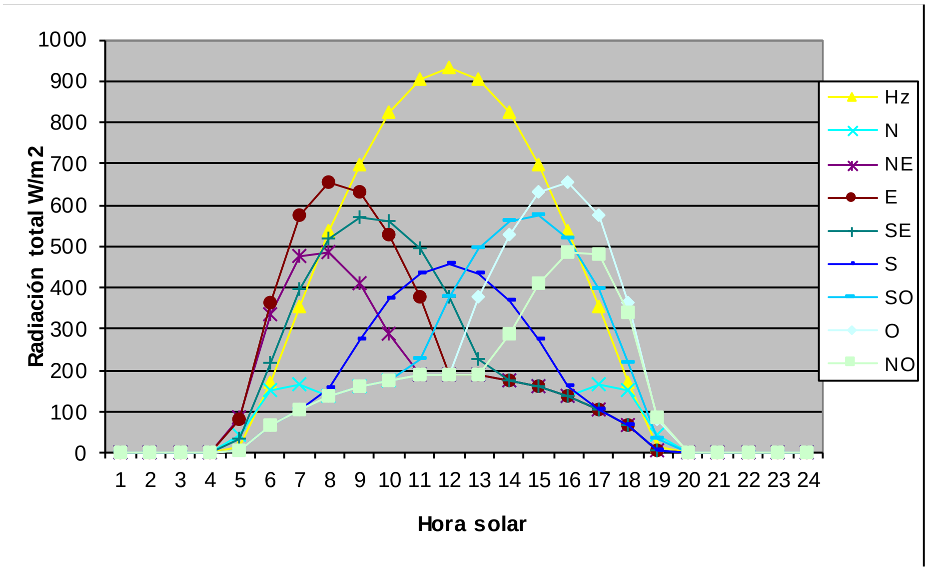


Figure 2.3. Solar radiation on the most critical daylight in July

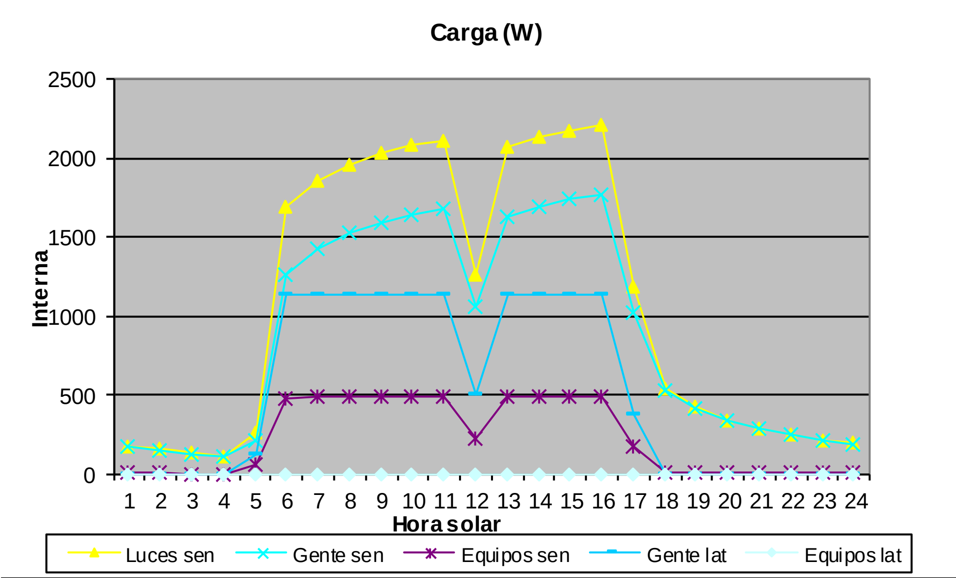


Figure 2.4. Internal loads on the most critical daylight in July

CALCULATION PARAMETERS

The following table shows a summary of the parameters used to calculate the thermal loads, which have been taken from the tables presented in the annex section.

CALCULATION PARAMETERS	
CITY	Madrid
CLIMATE ZONE	D3
APPLICATION	Offices_12h
OUTDOOR AIR QUALITY	IDA 2
ESTIMATED TOTAL PRESSURE (Pa)	93317
HEIGHT ABOVE SEA LEVEL (m)	689
OFFICE AIR QUALITY	IDA 3
DOUBLE GLASS SOLAR FACTOR	0,76
PVC FRAMES (W / m2K)	3
FRACTION FRAMEWORK OCCUPATION	0,1
ACTIVE FRACTION WINDOW	1
FRACTION SHADOW OTHER BUILDINGS	0
EXTERIOR WALLS (W / m2K)	0,76
FLOORS (W / m2K)	1,3
CEILINGS (W / m2K)	2,02
LIGHTS (W / m2K)	20
RADIATING FRACTION LIGHTS	0,5
EQUIPMENT (W / m2)	5
RADIANT FRACTION EQUIPMENT	0,05
SAFETY FACTOR (MAJORITY) (%)	10

SUMMER	
OUTDOOR DRY Tª (ºC)	33,6
TUM HUMEDA (ºC)	21,1
TEMPERATURE CHANGE (ºC)	13,9
AVERAGE TEMPERATURE IN THE MONTH (ºC)	25,4
INTERIOR DRY Tª (ºC)	25
RELATIVE INDOOR HUMIDITY (%)	50
MONTH CONSIDERED	JULY
CONSIDERED TIME	15
OUTDOOR AIR QUALITY	IDA 2
ESTIMATED TOTAL PRESSURE (Pa)	93317
HEIGHT ABOVE SEA LEVEL (m)	689

WINTER	
OUTDOOR DRY Tª (ºC)	0,3
EXTERIOR RELATIVE HUMIDITY (%)	0,69
TEMPERATURE CHANGE	3,5
AVERAGE TEMPERATURE IN THE MONTH	6
INTERIOR DRY Tª (ºC)	22
RELATIVE INDOOR HUMIDITY (%)	40
MONTH CONSIDERED	JANUARY
CONSIDERED TIME	9

Table 2.1. Calculation parameters for thermal loads in Summer and winter

FINAL SUMMATY OF THERMAL LOADS IN CRITICAL MONTHS

The first step in dimensioning an HVAC system is to know the thermal demand that will exist in the office building. In order to achieve optimal conditions for the operation of the installation, and to guarantee the temperature and humidity levels previously exposed to the interior conditions of the building, the installation must be sized for the worst case (maximum thermal load).

As the office building is in Madrid (specifically on Prado del Espino Avenue), the days that will suppose the highest thermal load of the year correspond to the summer months. This conclusion can be seen in the results of the thermal loads presented below, where the thermal loads of the hottest month in Madrid (July) and the coldest month (January) have been calculated. The system needs more power to be able to cover the thermal loads in the hottest than in the coldest, so the data obtained from July will be used to size the installation for the worst case.

The HVAC system will cover the thermal demand through two different systems. 20% of the thermal load will be covered by an air-water system with Air Handler Units (AHU) through a circuit of air ducts through all the plants. 80% of the thermal load will be covered by a water-water system using a circuit of pipes that distribute hot and cold water from the boilers and the refrigeration unit to the terminal elements (inductors). AHUs provide a homogeneous temperature and humidity level for all floors of the building, while inductors distributed throughout the different areas are capable of being regulated independently. In this way, average values are achieved with the AHU system throughout the building, and then by means of inductors each room can be adjusted to the desired temperature independently of the system. This decision has been made since the use of AHU is cheaper and more respectful with the environment than that of inductors, in this way the primary variation of temperature and humidity that is needed to achieve the desired values inside the building is achieved without resorting to inductors.

The thermal loads calculated for each room in the building in June and the losses in January are shown below:

LOCATION				SUMMER				WINTER		
TIPE OF ROOM	FLOOR	ROOM	SURFACE (m2)	TOTAL EFFECTIVE HEAT (W)	TOTAL HEAT COVERED BY AHU (W)	TOTAL HEAT COVERED BY INDUCTORS (W)	TOTAL HEAT (W)	TOTAL HEAT COVERED BY AHU (W)	TOTAL HEAT COVERED BY INDUCTORS (W)	TOTAL HEAT (W)
room	0	1	110	8014	2596	10383	12979	2132	8527	10659
room	0	2	43	5317	1451	5806	7257	1234	4934	6168
room	0	3	93	5329	1905	7622	9527	1543	6173	7716
room	0	4	85	4678	1703	6812	8515	1431	5723	7154
room	0	5	64	3856	1349	5396	6745	1	5	6
room	0	6	72	2975	1245	4980	6225	1060	4238	5298
room	0	7	37	4739	1282	5127	6409	1756	7024	8780
room	0	8	31	2921	864	3456	4320	724	2897	3621
room	0	9	22	909	380	1522	1902	510	2039	2549
room	0	10	27	2971	838	3351	4189	694	2777	3471
room	0	11	41	3131	996	3985	4981	837	3348	4185
hall	0	12	486	26486	9685	38738	48423	8233	32930	41163
harehouse	0	13	7	672	198	790	988	168	674	842
harehouse	0	14	5	207	86	346	432	117	467	584
harehouse	0	15	10	413	173	692	865	228	912	1140
harehouse	0	16	11	455	190	761	951	251	1003	1254
harehouse	0	17	20	826	346	1383	1729	462	1848	2310
harehouse	0	18	8	331	138	553	692	179	715	894
restroom	0	19	33	2697	837	3349	4186	703	2811	3514
restroom	0	20	4	165	69	277	346	58	232	290
restroom	0	21	13	537	225	899	1124	301	1206	1507
restroom	0	22	16	661	277	1107	1383	365	1461	1826
room	1	23	1098	61846	22281	89125	111406	18716	74865	93581
room	1	24	39	4601	1272	5089	6361	1056	4224	5280
hall	1	25	17	702	294	1176	1470	388	1552	1940
hall	1	26	66	2727	1141	4565	5706	1529	6117	7646
hall	1	27	29	1767	615	2461	3076	750	3001	3751
hall	1	28	16	1147	374	1495	1869	440	1759	2199
restroom	1	29	37	3514	1037	4147	5184	1280	5120	6400
restroom	1	30	16	661	277	1107	1383	373	1494	1867
restroom	1	31	13	797	277	1107	1383	371	1483	1854
room	2	32	1098	61846	22281	89125	111406	18716	74865	93581
room	2	33	39	4601	1272	5089	6361	1056	4224	5280
hall	2	34	17	702	294	1176	1470	388	1552	1940
hall	2	35	66	2727	1141	4565	5706	1529	6117	7646
hall	2	36	29	1767	615	2461	3076	504	2018	2522
hall	2	37	16	1147	374	1495	1869	318	1271	1589
restroom	2	38	37	3514	1037	4147	5184	840	3359	4199
restroom	2	39	16	661	277	1107	1383	373	1494	1867
restroom	2	40	13	797	277	1107	1383	371	1483	1854
room	3	41	32	3426	974	3896	4870	818	3273	4091
room	3	42	20	1243	429	1717	2146	361	1442	1803
room	3	43	28	1744	602	2406	3008	481	1925	2406
room	3	44	35	1446	605	2421	3026	799	3195	3994
room	3	45	38	2386	820	3281	4101	697	2789	3486
room	3	46	26	1947	624	2496	3120	518	2072	2590
room	3	47	29	2103	682	2729	3412	573	2293	2866
room	3	48	39	1611	674	2697	3372	890	3561	4451
room	3	49	37	2366	807	3229	4036	678	2712	3390
room	3	50	27	1891	622	2488	3110	522	2090	2612
room	3	51	21	1414	472	1889	2362	397	1587	1984
room	3	52	32	1322	553	2213	2767	730	2922	3652
room	3	53	38	4609	1265	5060	6325	1063	4250	5313
hall	3	54	278	14606	5431	21723	27154	4562	18248	22809
hall	3	55	51	2107	882	3527	4409	741	2963	3704
hall	3	56	231	12157	4517	18067	22583	3794	15176	18970
hall	3	57	46	2523	920	3680	4600	745	2981	3726
hall	3	58	270	12247	4887	19547	24434	4105	16420	20525
hall	3	59	16	1169	378	1513	1891	318	1271	1589
harehouse	3	60	13	537	225	899	1124	189	755	944
restroom	3	61	35	3397	995	3982	4977	826	3305	4131
restroom	3	62	17	702	294	1176	1470	391	1564	1955
restroom	3	63	21	868	363	1452	1816	479	1917	2397

room	4	64	32	3426	974	3896	4870	818	3273	4091
room	4	65	20	1243	429	1717	2146	361	1442	1803
room	4	66	28	1744	602	2406	3008	481	1925	2406
room	4	67	35	1446	605	2421	3026	799	3195	3994
room	4	68	38	2386	820	3281	4101	697	2789	3486
room	4	69	26	1947	624	2496	3120	518	2072	2590
room	4	70	29	2103	682	2729	3412	573	2293	2866
room	4	71	39	1611	674	2697	3372	890	3561	4451
room	4	72	37	2366	807	3229	4036	678	2712	3390
room	4	73	27	1891	622	2488	3110	522	2090	2612
room	4	74	21	1414	472	1889	2362	397	1587	1984
room	4	75	32	1322	553	2213	2767	730	2922	3652
room	4	76	38	4609	1265	5060	6325	1063	4250	5313
hall	4	77	278	14606	5431	21723	27154	4562	18248	22809
hall	4	78	51	2107	882	3527	4409	741	2963	3704
hall	4	79	231	12157	4517	18067	22583	3794	15176	18970
hall	4	80	46	2523	920	3680	4600	745	2981	3726
hall	4	81	270	12247	4887	19547	24434	4105	16420	20525
hall	4	82	16	1169	378	1513	1891	318	1271	1589
harehouse	4	83	13	537	225	899	1124	189	755	944
restroom	4	84	35	3397	995	3982	4977	826	3305	4131
restroom	4	85	17	702	294	1176	1470	391	1564	1955
restroom	4	86	21	868	363	1452	1816	479	1917	2397
room	5	32	1098	61846	22281	89125	111406	18716	74865	93581
room	5	33	39	4601	1272	5089	6361	1056	4224	5280
hall	5	34	17	702	294	1176	1470	388	1552	1940
hall	5	35	66	2727	1141	4565	5706	1529	6117	7646
hall	5	36	29	1767	615	2461	3076	504	2018	2522
hall	5	37	16	1147	374	1495	1869	318	1271	1589
restroom	5	38	37	3514	1037	4147	5184	840	3359	4199
restroom	5	39	16	661	277	1107	1383	373	1494	1867
restroom	5	40	13	797	277	1107	1383	371	1483	1854
room	6	32	1098	61846	22281	89125	111406	18716	74865	93581
room	6	33	39	4601	1272	5089	6361	1056	4224	5280
hall	6	34	17	702	294	1176	1470	388	1552	1940
hall	6	35	66	2727	1141	4565	5706	1529	6117	7646
hall	6	36	29	1767	615	2461	3076	504	2018	2522
hall	6	37	16	1147	374	1495	1869	318	1271	1589
restroom	6	38	37	3514	1037	4147	5184	840	3359	4199
restroom	6	39	16	661	277	1107	1383	373	1494	1867
restroom	6	40	13	797	277	1107	1383	371	1483	1854
room	7	64	32	3426	974	3896	4870	818	3273	4091
room	7	65	20	1243	429	1717	2146	361	1442	1803
room	7	66	28	1744	602	2406	3008	481	1925	2406
room	7	67	35	1446	605	2421	3026	799	3195	3994
room	7	68	38	2386	820	3281	4101	697	2789	3486
room	7	69	26	1947	624	2496	3120	518	2072	2590
room	7	70	29	2103	682	2729	3412	573	2293	2866
room	7	71	39	1611	674	2697	3372	890	3561	4451
room	7	72	37	2366	807	3229	4036	678	2712	3390
room	7	73	27	1891	622	2488	3110	522	2090	2612
room	7	74	21	1414	472	1889	2362	397	1587	1984
room	7	75	32	1322	553	2213	2767	730	2922	3652
room	7	76	38	4609	1265	5060	6325	1063	4250	5313
hall	7	77	278	14606	5431	21723	27154	4562	18248	22809
hall	7	78	51	2107	882	3527	4409	741	2963	3704
hall	7	79	231	12157	4517	18067	22583	3794	15176	18970
hall	7	80	46	2523	920	3680	4600	745	2981	3726
hall	7	81	270	12247	4887	19547	24434	4105	16420	20525
hall	7	82	16	1169	378	1513	1891	318	1271	1589
harehouse	7	83	13	537	225	899	1124	189	755	944
restroom	7	84	35	3397	995	3982	4977	826	3305	4131
restroom	7	85	17	702	294	1176	1470	391	1564	1955
restroom	7	86	21	868	363	1452	1816	479	1917	2397

Table 2.2. Thermal loads calculated for each room in the building in June and the losses in January

2.Calculation of water supply and return pipes

80% of the thermal loads are covered with the use of Inductors as terminal elements of a water piping system that transfers heat from the boilers and the cooling group to these terminal elements. The refrigerant used to transport energy is water. This system will achieve the necessary water flow to meet the thermal demands of each room using pumps.

Unlike other typical smaller facilities, this building uses a single network of pipes to transport water to the terminal points. In other words, from the rooftop, an electronic control system is used to mix hot and cold water to reach the desired temperature (no separate pipes are used for cold water and hot water for distribution between floors). The circuit is a closed system that drives the inductors and returns the heat sources.

These offices have two independent piping circuits, one to supply the inductors distributed between the rooms (IC circuit) and the other to supply the inductors that are located around the façade (CF circuit); These circuits cover 80% of the loads on all floors of the building. An independent inductor circuit has been arranged around the façade to create a thermal barrier that guarantees a homogeneous distribution of temperature in all areas and reduces losses due to heat exchange with the outside. In addition to these two circuits of pipes (CI and CF) for mixing hot and cold water, there are other exclusively cold or hot water pipes on the top floor (roof) where the initial devices for generating the circuit's heat are located. The two boilers and the refrigeration unit supply (through the hot and cold water pipes on the roof) to the heat and cold batteries, respectively, of the three AHUs of the air-water air conditioning system and the CI and CF piping circuits that they feed the Inductors to the water-water system to achieve the desired levels of indoor air. This distribution of the water pipes can be seen graphically on map number 1 “Principle scheme”.

The water flow necessary to supply each terminal element (Inductors) depending on the thermal load they need to cover is given by the formula:

$$Q(m^3/h) = \frac{P}{\Delta T \cdot Ce}$$

Where:

Q: flow supplied to each fan coil (effective total heat) or air conditioning (total heat)

P: required heat output in each room (kcal / h)

ΔT: increase in water temperature. 5oC for cold water and 10oC for hot water

Ce: specific heat of water (1cal / g)

The pipes material is non-alloy steel suitable for welding and threading, according to UNE 10255 standard, with an elastomeric foam insulation (from table *Minimum thickness of pipe insulation according to RITE* in *Annexed 4. Calculation of water pipes*).

For the calculation of the losses of the water pipes circuit, the most unfavorable case (the route with the highest pressure losses) from the initial element (mixing hot and cold water on the roof) to the terminal element furthest from each one of the floors (room furthest from each floor to the ground floor).

Following the RITE criteria of section 12 IT 1.2.4.2, which establishes a maximum allowable loss of 30 mm c. a./m and a maximum water speed of 2 m / s, the most suitable pipe diameters have been selected using the attached graphic *Diameter ratio, losses, flow and speed water pipes at 60ºC* in *Annexed 4. Calculation of water pipes*.

Below is an example of the results of the losses in each pipe section of the most unfavorable route from the mix of hot and cold water on the roof to the most remote terminal elements of each plant, of the two circuits that it supply all the inductors in the interior rooms and converge on the roof (circuit CI-1 and CI-2) and the effective height that the circuit pumps must exceed:

NOTES: the sections have been defined every time there was a flow variation. These losses include those due to pipe length, to elbows, to connections between pipes and includes losses due to the different valves and filters depending on the diameters (these values have been taken from the table *Head loss calculation for pipe fittings* in *Annexed 4. Calculation of water pipes*). An extra 10% has been established as a safety margin.

	SECTION	Q (l / h)	DN (mm)	DN (")	Losses. mm.c.a. /m	L (cm)	L (m)	V(m/s)	elbows 90º		tes		Tot acces.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
									uds	perd (ml)	uds	perd (ml)			
FLOOR 0	1	195	15	0,5906	12	209	2,09	0,28	1	0			0	25,08	25,08
	2	390	20	0,7874	10	286	2,86	0,31			1	0	0	28,60	53,68
	3	586	20	0,7874	7	47	0,47	0,3			1	0	0	3,29	56,97
	4	781	25	0,9843	11	86	0,86	0,39			1	1,5	1,5	25,96	82,93
	5	976	25	0,9843	16	53	0,53	0,47			1	1,5	1,5	32,48	115,41
	6	1171	25	0,9843	22	93	0,93	0,56			1	1,5	1,5	53,46	168,87
	7	2192	32	1,2598	18	715	7,15	0,61			1	1,8	1,8	161,10	329,97
	8	3946	40	1,5748	25	584	5,84	0,81			1	2,4	2,4	206,00	535,97
	9	5279	50	1,9685	13	551	5,51	0,67	1	0,6	1	2,4	3	110,63	646,60
	10	7387	50	1,9685	25	812	8,12	0,95	1	0,9	1	3	3,9	300,50	947,10
FLOOR 1	11	192	15	0,5906	12	113	1,13	0,28					0	13,56	960,66
	12	383	20	0,7874	9	299	2,99	0,29			1	0	0	26,91	987,57
	13	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	999,87
	14	1149	25	0,9843	21	121	1,21	0,56			1	1,5	1,5	56,91	1.056,78
	15	1735	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	1.158,18
	16	3464	40	1,5748	20	653	6,53	0,72			1	2,4	2,4	178,60	1.336,78
	17	4815	50	1,9685	11	595	5,95	0,62	1	0,9	1	3	3,9	108,35	1.445,13
	18	8647	65	2,5591	9	824	8,24	0,66	1	1,8	1	3,6	5,4	122,76	1.567,89
	19	16034	65	2,5591	28	250	2,5	1,21			1	3,6	3,6	170,80	1.738,69
FLOOR 2	20	192	15	0,5906	12	113	1,13	0,28					0	13,56	1.752,25
	21	383	20	0,7874	9	299	2,99	0,29			1	0	0	26,91	1.779,16
	22	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	1.791,46
	23	1149	25	0,9843	21	121	1,21	0,56			1	1,5	1,5	56,91	1.848,37
	24	1735	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	1.949,77
	25	3464	40	1,5748	20	653	6,53	0,72			1	2,4	2,4	178,60	2.128,37
	26	4815	50	1,9685	11	595	5,95	0,62	1	0,9	1	3	3,9	108,35	2.236,72
	27	8647	65	2,5591	9	824	8,24	0,66	1	1,8	1	3,6	5,4	122,76	2.359,48
	28	24681	65	2,5591	28	250	2,5	1,21			1	3,6	3,6	170,80	2.530,28

CI-1	FLOOR 3	29	207	15	0,5906	13	111	1,11	0,29					0	14,43	2.544,71
		30	364	20	0,7874	9	313	3,13	0,29			1	0	0	28,17	2.572,88
		31	778	25	0,9843	11	133	1,33	0,3			1	0	0	14,63	2.587,51
		32	1101	25	0,9843	20	126	1,26	0,54			1	1,5	1,5	55,20	2.642,71
		33	1742	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	2.744,11
		34	3523	40	1,5748	20	650	6,5	0,72			1	2,4	2,4	178,00	2.922,11
		35	4932	50	1,9685	12	590	5,9	0,64	1	0,9	1	3	3,9	117,60	3.039,71
		36	9271	65	2,5591	10	834	8,34	0,6	1	1,8	1	3,6	5,4	137,40	3.177,11
		37	33952	100	3,937	14	250	2,5	1,1			1	3,6	3,6	85,40	3.262,51
	FLOOR 4	38	207	15	0,5906	13	111	1,11	0,29					0	14,43	3.276,94
		39	364	20	0,7874	9	313	3,13	0,29			1	0	0	28,17	3.305,11
		40	778	25	0,9843	11	133	1,33	0,3			1	0	0	14,63	3.319,74
		41	1101	25	0,9843	20	126	1,26	0,54			1	1,5	1,5	55,20	3.374,94
		42	1742	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	3.476,34
		43	3523	40	1,5748	20	650	6,5	0,72			1	2,4	2,4	178,00	3.654,34
		44	4932	50	1,9685	12	590	5,9	0,64	1	0,9	1	3	3,9	117,60	3.771,94
		45	9271	65	2,5591	10	834	8,34	0,6	1	1,8	1	3,6	5,4	137,40	3.909,34
		46	43223	100	3,937	22	250	2,5	1,41			1	3,6	3,6	134,20	4.043,54
	FLOOR 5	47	192	15	0,5906	12	113	1,13	0,28					0	13,56	4.057,10
		48	383	20	0,7874	9	299	2,99	0,29			1	0	0	26,91	4.084,01
		49	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	4.096,31
		50	1149	25	0,9843	21	121	1,21	0,56			1	1,5	1,5	56,91	4.153,22
		51	1735	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	4.254,62
		52	3464	40	1,5748	20	653	6,53	0,72			1	2,4	2,4	178,60	4.433,22
		53	4815	50	1,9685	11	595	5,95	0,62	1	0,9	1	3	3,9	108,35	4.541,57
		54	8647	65	2,5591	9	824	8,24	0,66	1	1,8	1	3,6	5,4	122,76	4.664,33
		55	51870	125	4,9213	11	250	2,5	1,1			1	3,6	3,6	67,10	4.731,43

	FLOOR 6	56	192	15	0,5906	12	113	1,13	0,28					0	13,56	4.744,99
		57	383	20	0,7874	9	299	2,99	0,29			1	0	0	26,91	4.771,90
		58	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	4.784,20
		59	1149	25	0,9843	21	121	1,21	0,56			1	1,5	1,5	56,91	4.841,11
		60	1735	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	4.942,51
		61	3464	40	1,5748	20	653	6,53	0,72			1	2,4	2,4	178,60	5.121,11
		62	4815	50	1,9685	11	595	5,95	0,62	1	0,9	1	3	3,9	108,35	5.229,46
		63	8647	65	2,5591	9	824	8,24	0,66	1	1,8	1	3,6	5,4	122,76	5.352,22
		64	60517	125	4,9213	14	250	2,5	1,27			1	3,6	3,6	85,40	5.437,62
	FLOOR 7	65	207	15	0,5906	13	111	1,11	0,29					0	14,43	5.452,05
		66	364	20	0,7874	9	313	3,13	0,29			1	0	0	28,17	5.480,22
		67	778	25	0,9843	11	133	1,33	0,3			1	0	0	14,63	5.494,85
		68	1101	25	0,9843	20	126	1,26	0,54			1	1,5	1,5	55,20	5.550,05
		69	1742	32	1,2598	12	665	6,65	0,49			1	1,8	1,8	101,40	5.651,45
		70	3523	40	1,5748	20	650	6,5	0,72			1	2,4	2,4	178,00	5.829,45
		71	4932	50	1,9685	12	590	5,9	0,64	1	0,9	1	3	3,9	117,60	5.947,05
		72	9271	65	2,5591	10	834	8,34	0,6	1	1,8	1	3,6	5,4	137,40	6.084,45
		73	69788	125	4,9213	19	2062	20,6	1,48			1	3,6	3,6	460,18	6.544,63

	FLOOR 0	74	155	15	0,5906	8	276	2,76	0,22	1	0			0	22,08	6.566,71
		75	309	20	0,7874	6	163	1,63	0,23			1	0	0	9,78	6.576,49
		76	464	20	0,7874	13	148	1,48	0,36			1	0	0	19,24	6.595,73
		77	773	25	0,9843	10	264	2,64	0,37			1	1,5	1,5	41,40	6.637,13
		78	1217	32	1,2598	6	711	7,11	0,34			1	1,8	1,8	53,46	6.690,59
		79	2482	40	1,5748	11	740	7,4	0,52			1	2,4	2,4	107,80	6.798,39
		80	4037	50	1,9685	8	505	5,05	0,52	1	1,5	1	3	4,5	76,40	6.874,79
		81	5075	50	1,9685	12	614	6,14	0,64	2	1,5			3	109,68	6.984,47
	FLOOR 1	82	192	15	0,5906	12	113	1,13	0,28					0	13,56	6.998,03
		83	383	20	0,7874	9	323	3,23	0,29			1	0	0	29,07	7.027,10
		84	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	7.039,40
		85	1149	25	0,9843	21	108	1,08	0,56			1	1,5	1,5	54,18	7.093,58
		86	1729	32	1,2598	7	650	6,5	0,37			1	1,8	1,8	58,10	7.151,68
		87	3266	40	1,5748	18	746	7,46	0,68			1	2,4	2,4	177,48	7.329,16
		88	4839	50	1,9685	11	591	5,91	0,62	1	1,5	1	3	4,5	114,51	7.443,67
		89	8353	65	2,5591	9	574	5,74	0,66	1	1,8	1	3,6	5,4	100,26	7.543,93
		90	13427	65	2,5591	21	250	2,5	1,02			1	3,6	3,6	128,10	7.672,03
	FLOOR 2	91	192	15	0,5906	12	113	1,13	0,28					0	13,56	7.685,59
		92	383	20	0,7874	9	323	3,23	0,29			1	0	0	29,07	7.714,66
		93	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	7.726,96
		94	1149	25	0,9843	21	108	1,08	0,56			1	1,5	1,5	54,18	7.781,14
		95	1729	32	1,2598	7	650	6,5	0,37			1	1,8	1,8	58,10	7.839,24
		96	3266	40	1,5748	18	746	7,46	0,68			1	2,4	2,4	177,48	8.016,72
		97	4839	50	1,9685	11	591	5,91	0,62	1	1,5	1	3	4,5	114,51	8.131,23
		98	8353	65	2,5591	9	574	5,74	0,66	1	1,8	1	3,6	5,4	100,26	8.231,49
		99	21780	80	3,1496	22	250	2,5	1,18			1	3,6	3,6	134,20	8.365,69

		100	207	15	0,5906	13	110	1,1	0,29					0	14,30	8.379,99
		101	414	20	0,7874	11	321	3,21	0,33			1	0	0	35,31	8.415,30
		102	828	25	0,9843	12	123	1,23	0,41			1	0	0	14,76	8.430,06
		103	1243	25	0,9843	25	121	1,21	0,5			1	1,5	1,5	67,75	8.497,81
CI-2	FLOOR 3	104	1900	32	1,2598	14	641	6,41	0,54			1	1,8	1,8	114,94	8.612,75
		105	3932	40	1,5748	24	746	7,46	0,8			1	2,4	2,4	236,64	8.849,39
		106	5515	50	1,9685	14	615	6,15	0,7	1	1,5	1	3	4,5	149,10	8.998,49
		107	9541	65	2,5591	11	605	6,05	0,73	1	1,8	1	3,6	5,4	125,95	9.124,44
		108	31321	100	3,937	12	250	2,5	1,02			1	3,6	3,6	73,20	9.197,64
		109	207	15	0,5906	13	110	1,1	0,29					0	14,30	9.211,94
		110	414	20	0,7874	11	321	3,21	0,33			1	0	0	35,31	9.247,25
		111	828	25	0,9843	12	123	1,23	0,41			1	0	0	14,76	9.262,01
		112	1243	25	0,9843	25	121	1,21	0,5			1	1,5	1,5	67,75	9.329,76
	FLOOR 4	113	1900	32	1,2598	14	641	6,41	0,54			1	1,8	1,8	114,94	9.444,70
		114	3932	40	1,5748	24	746	7,46	0,8			1	2,4	2,4	236,64	9.681,34
		115	5515	50	1,9685	14	615	6,15	0,7	1	1,5	1	3	4,5	149,10	9.830,44
		116	9541	65	2,5591	11	605	6,05	0,73	1	1,8	1	3,6	5,4	125,95	9.956,39
		117	40862	100	3,937	19	250	2,5	1,31			1	3,6	3,6	115,90	10.072,29
		118	192	15	0,5906	12	113	1,13	0,28					0	13,56	10.085,85
		119	383	20	0,7874	9	323	3,23	0,29			1	0	0	29,07	10.114,92
		120	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	10.127,22
		121	1149	25	0,9843	21	108	1,08	0,56			1	1,5	1,5	54,18	10.181,40
	FLOOR 5	122	1729	32	1,2598	7	650	6,5	0,37			1	1,8	1,8	58,10	10.239,50
		123	3266	40	1,5748	18	746	7,46	0,68			1	2,4	2,4	177,48	10.416,98
		124	4839	50	1,9685	11	591	5,91	0,62	1	1,5	1	3	4,5	114,51	10.531,49
		125	8353	65	2,5591	9	574	5,74	0,66	1	1,8	1	3,6	5,4	100,26	10.631,75
		126	49214	100	3,937	28	250	2,5	1,5			1	3,6	3,6	170,80	10.802,55

		127	192	15	0,5906	12	113	1,13	0,28					0	13,56	10.816,11
		128	383	20	0,7874	9	323	3,23	0,29			1	0	0	29,07	10.845,18
		129	766	25	0,9843	10	123	1,23	0,37			1	0	0	12,30	10.857,48
		130	1149	25	0,9843	21	108	1,08	0,56			1	1,5	1,5	54,18	10.911,66
	FLOOR 6	131	1729	32	1,2598	7	650	6,5	0,37			1	1,8	1,8	58,10	10.969,76
		132	3266	40	1,5748	18	746	7,46	0,68			1	2,4	2,4	177,48	11.147,24
		133	4839	50	1,9685	11	591	5,91	0,62	1	1,5	1	3	4,5	114,51	11.261,75
		134	8353	65	2,5591	9	574	5,74	0,66	1	1,8	1	3,6	5,4	100,26	11.362,01
		135	57567	125	4,9213	13	250	2,5	1,23			1	3,6	3,6	79,30	11.441,31
		136	207	15	0,5906	13	110	1,1	0,29					0	14,30	11.455,61
		137	414	20	0,7874	11	321	3,21	0,33			1	0	0	35,31	11.490,92
		138	828	25	0,9843	12	123	1,23	0,41			1	0	0	14,76	11.505,68
		139	1243	25	0,9843	25	121	1,21	0,5			1	1,5	1,5	67,75	11.573,43
	FLOOR 7	140	1900	32	1,2598	14	641	6,41	0,54			1	1,8	1,8	114,94	11.688,37
		141	3932	40	1,5748	24	746	7,46	0,8			1	2,4	2,4	236,64	11.925,01
		142	5515	50	1,9685	14	615	6,15	0,7	1	1,5	1	3	4,5	149,10	12.074,11
		143	9541	65	2,5591	11	605	6,05	0,73	1	1,8	1	3,6	5,4	125,95	12.200,06
		144	67108	125	4,9213	18	525	5,25	1,44			1	3,6	3,6	159,30	12.359,36

	SECTION	DN (mm)	DN (")	Losses. mm.c.a. /m	L (cm)	L (m)	BUTTER		FILTER		SEAT		RET		Tot valv.	Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
							uds	perd (ml)	uds	perd (ml)	uds	perd (ml)	uds	perd (ml)			
UNDER COVER	145	200	7,874	7	2270	22,7									0	232,40	12.591,76
	DRIVE + RETURN														0	12.591,76	25.183,52
	VALV. and FILTERS	200	7,874	7		34,5	50	3,6	20	36	34	47,3	20	13,5	2778	19.688,90	44.872,42

		Losses by section (mm.c.a.)	Accumulated losses (mm.c.a.)
Subtotal			44.872,42
valv control			2.000,00
	total		46.872,42
	% secur.		10,00%
ALTEFFECTIVE PUMP HEIGHT (M.C.A.)			51,56

Table 2.3. Results of the losses in each pipe section of the most unfavorable route and the effective height that the circuit pumps must exceed

3. Duct calculation

The air conditioning system through the AHUs (AHU-AP1, AHU-AP2 and AHU-SA) is carried out by transporting the outside air collected and adapted by the AHUs to all the terminal elements (diffusers and grilles) through a duct circuit. These ducts are distributed from the roof where the AHU is located to the terminal elements of all the floors of the building. There is one air duct circuit to the diffusers and two air return circuits to the AHUs through the louvers.

For the calculation of the necessary air flow rates in each room to cover 20% of the thermal loads (the remaining 80% are carried out by the Water-Water System Inductors) for each room, another Excel program has been used. The calculation of the necessary flow for room 1 is shown below as an example, detailing the formula used:

HORA SOLAR: 15	ROOM 1				MADRID	
MES: JULIO	FLOOR 0					
CONDICIONES						
Tª SECA INTERIOR (ºC)	25,0					
Carga termica habitación (W)	12979,0					
A.D.P. (minima temp. de rocio en la bateria)						
	ADP =	12	°C			
CANTIDAD DE AIRE SUMINISTRADO						
	25,0	-	12	ADP=	11,05	
CAUDAL DE AIRE M3/H		12.979		=	3.915	
	3 X	11,05				

Table 2.4. Example of air flow calculation

Once the air flow rates have been calculated, the appropriate diameters for the circular ducts have been selected, respecting the criteria that all the sections do not have losses greater than 0.4 mm.c.a./m nor a speed greater than 12 m / s. All these parameters are listed in graphic *Loss diagram in circular air ducts* in *Annexed 5. Calculation of duct*s, which has been used to select the diameters of the circular ducts.

To calculate the losses of the air ducts, they have been divided into sections and the losses have been calculated for the most critical case (from the AHU on the roof to the diffuser furthest from the ground floor). These sections are defined each time there is a flow variation, each time there is a new branch.

Losses in elbows, branches and duct reductions have also been considered in the calculations of losses in the supply and return ducts, along with the losses due to diffusers and grids respectively. These values have been taken from tables *Losses due to diffusers in circular air ducts, Grid losses in circular ducts, Equivalent length of circular air ducts per elbow* and *Equivalent length of circular air ducts for deviations and reductions* in *Annexed 5. Calculation of ducts*. Below is an example of the loss calculations for the diffusers and grilles selected for the installation in the ground floor (the information on the models can be seen in chapter 4 *Selection of equipment and elements of HVAC system*):

TIPE OF ROOM	FLOOR	ROOM	Flow rate (m3/ h)	Unit flow rate per diffuser (m3/h)	Size	Sound power (dB)	Unit losses (mmc.a.)	Lost per room (mmc.a.)
room	0	2	438	87,57	300x24	25	1,122	5,61
room	0	3	575	57,48	300x24	25	1,122	8,976
room	0	4	514	64,21	300x24	25	1,122	8,976
hall	0	12	2921	83,47	300x24	25	1,122	19,074
TOTAL PB								44,88

Table 2.5. Losses from the ground floor diffusers

TIPE OF ROOM	FLOOR	ROOM	Flow rate (m3/ h)	Unit flow rate per diffuser (m3 /h)	Size	Sound power (dB)	Unit losses (mmc.a.)	Lost per room (mmc.a.)
room	0	2	438	218,93	325x125	27	0,920	4,6
room	0	3	575	95,80	225x125	12	0,200	1,6
room	0	4	514	51,37	225x125	12	0,200	1,6
hall	0	12	2921	224,72	325x125	27	0,920	15,64
TOTAL PB								23,44

Table 2.6. Losses through the grids on the ground floor

The type of circular duct selected for the air-air system is the ALDER company. They are circular ducts in galvanized steel sheet sewn into the propeller following the manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses per diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters greater than 630 mm. You can see the technical sheet of the manufacturer of these ducts in *Technical sheet of the manufacturer of the air-air ducts* in *Annexed 5. Calculation of ducts*. The length of the ducts required for the air-air system of the building of the two circuits of the AHU (AHU-AP1 and AHU-AP2) is shown below according to their diameter:

LOGITUDES TOTALES DE CONDUCTOS EN FUNCION DEL DIAMETRO																						
		mm	100	125	150	175	200	250	300	350	400	500	550	600	650	750	800	850	900	1000	1100
AP1	IMPULSION	m	5	56	49	21	0	27	40	85	55	0	85	0	0	0	0	0	38	43	157
	whole plant	m	10	111	98	42	0	53	81	170	111	0	170	0	0	0	0	0	77	86	315
	nºplants	m	77	890	786	339	0	428	647	1361	888	0	848	0	0	0	0	0	308	86	315
	RETURN	m	0	0	3	0	11	22	82	0	0	73	0	109	109	102	43	33	0	0	66
	whole plant	m	0	0	5	0	22	45	164	0	0	145	0	218	218	204	86	66	0	0	132
	nºplants	m	0	0	41	0	172	359	1315	0	0	1163	0	1091	873	611	172	66	0	0	132
	TOTAL	m	77	890	828	339	172	787	1962	1361	888	1163	848	1091	873	611	172	66	308	86	447
AP1 + AP2	TOTAL	m	154	1780	1655	678	344	1574	3923	2721	1775	2325	1697	2182	1746	1221	343	132	616	172	893

Table 2.7. Ducts length required for the air-air system of the building of the two circuits of the AHU (AHU-AP1 and AHU-AP2)

The results of the losses in the most critical circuit of the air supply ducts that go to the first AHU (AHU-AP1) are shown below as an example:

	GROUND FLOOR DISCHARGE DUCTS										
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Leng. (m)**	**Acces Type**	**V (m/s)**	**L. eq. (m)**	**nº acces,**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	64	100	1,47	Elbow	2,271	3,35	1	4,82	0,09	0,43
	2	128	125	1,54	Der+Red	2,907	4,81	1	6,35	0,1	0,64
	3	257	125	2,95	Derivation	5,814	19,27	1	22,22	0,38	8,44
	4	321	125	0,84	Derivation	7,268	26,21	1	27,05	0,4	10,82
	5	385	150	2,86	Der+Red	6,056	19,27	1	22,13	0,3	6,64
	6	450	150	0,79	Derivation	7,066	26,21	1	27	0,39	10,53
	7	514	175	1,91	Der+Red	5,933	19,27	1	21,18	0,35	7,413
	8	1091	250	7,47	Der+Red	6,174	19,27	1	26,74	0,15	4,011
	9	1990	300	6,18	Der+Red	7,822	34,24	1	40,42	0,2	8,084
	10	4376	350	1,44	Der+Red	11,82	83,6	1	85,04	0,35	29,764
	11	4701	400	7,5	Der+Red	10,39	47,98	1	55,48	0,27	14,9796
vertical course	12	9401	550	4,25	Der+Red+Elb	10,99	80,58	1	84,83	0,22	18,6626
	13	14102	700	4,25	Der+Red	10,18	53,51	1	57,76	0,14	8,0864
	14	18802	900	4,25	Der+Red	8,21	34,24	1	38,49	0,06	2,3094
	15	23503	1000	4,25	Der+Red	8,312	38,65	1	42,9	0,05	2,145
	16	28203	1100	4,25	Der+Red	8,244	35,92	1	40,17	0,04	1,6068
	17	32904	1100	4,25	Derivation	9,618	48,29	1	52,54	0,06	3,1524
	18	37604	1100	4,25	Derivation	10,99	60,46	1	64,71	0,1	6,471
	Diffusers										408,640
									Subtotal		552,83
									Loss in diffusion		2,5
									Safety coef. %		10%
									TOTAL		610,86

Table 2.8. Results of the losses in the most critical circuit of the air supply ducts that go to the first AHU (AHU-AP1)

The aim is to guarantee an overpressure condition in the building (to avoid infiltrations from the outside that dirties the clean air of the AHUs), so the return flow must be that of impulsion, minus that of extraction of the toilets (UE-A1 ducts, UE-A2 and UE-A3) and minus 5% to guarantee overpressure. The extraction flow of the baths has been equaled to the proportional part of the total discharge flow, depending on the area occupied by the baths with respect to the total area (5.13% of the total air discharge flow).

The most critical air return duct circuit that has been used to size the air-air conditioning system is from the grid furthest from the ground floor, to AHU-AP1 (the return ducts to each of the AHUs). They consist of two circuits that must be considered in these calculations). The distribution of the pipes according to the plants and AHU can be seen graphically in plan 2 "Ventilation scheme".

The results of the losses in the return duct circuit of the most critical case discussed above are shown below:

	GROUND FLOOR DISCHARGE DUCTS										
	Section	**Q (m3/h)**	**Ø eq. (mm)**	**Leng. (m)**	**Acces Type**	**V (m/s)**	**L. eq. (m)**	**nº acces,**	**L. Total (m)**	**(mm.c.a/m)**	**(mm.c.a)**
horizontal course	1	46	150	2,59	-	0,73	-	-	2,59	0	0,00
	2	92	200	3,06	Der+Red	0,82	2,15	1	5,21	0	0,00
	3	139	200	3,48	Derivation	1,22	2,07	1	5,55	0,012	0,07
	4	185	250	3,02	Der+Red	1,05	6,56	1	9,58	0	0,00
	5	272	250	8,8	Derivation	1,54	4,06	1	12,86	0,014	0,18
	6	724	300	7,02	Elb+Der+Red	2,85	61,43	1	68,45	0,02	1,37
	7	1416	300	4,88	Derivation	5,56	6,71	1	13,73	0,12	1,65
vertical course	8	2832	500	4,25	Elb+Der+Red	4,01	67,79	1	72,67	0,034	2,47
	9	4247	600	4,25	Der+Red	4,17	104,87	1	109,12	0,027	2,95
	10	5663	650	4,25	Der+Red	4,74	104,87	1	109,12	0,035	3,82
	11	7079	750	4,25	Der+Red	4,45	97,5	1	101,75	0,05	5,09
	12	8495	800	4,25	Der+Red	4,69	38,65	1	42,9	0,025	1,07
	13	9911	850	4,25	Der+Red	4,85	19,27	1	23,52	0,021	0,49
	14	11327	850	4,25	Derivation	5,54	5,3	1	9,55	0,028	0,27
	15	22653	1100	4,25	Elb+Der+Red	6,62	61,61	1	65,86	0,03	1,98
	Grids										209,34
									Subtotal		230,73
									Loss in diffusion		2,5
									Safety coef. %		10%
									TOTAL		256,56

Table 2.9. Results of the losses in the return duct circuit of the most critical case discussed above

Once the return air flow has been calculated, the required ventilation flow has been calculated to guarantee adequate air renewal in a building that will be used as offices established by RITE and must have an IDA2 air quality (45 m3 / h per person), you can be seen in *table Interpretation of the regulation: Air flow rates for premises ventilation* in *Annexed 5. Calculation of ducts.*

To demonstrate that the return air flow of each room is always greater than or equal to the mandatory ventilation flow established by RITE, an example of the first two floors is shown:

			SUMMER		
TIPE OF ROOM	FLOOR	ROOM	REQUIRED VENTILATION FLOW (m3/h)	RETURN FLOW (m3/h)	RITE VENTILATION COMPLIANCE CHECK (≥0)
room	0	1	569	704	214
room	0	2	222	393	215
room	0	3	481	517	94
room	0	4	440	462	74
room	0	5	331	366	76
room	0	6	372	338	3
room	0	7	191	347	195
room	0	8	160	234	100
room	0	9	114	103	1
room	0	10	140	227	113
room	0	11	212	270	88
hall	0	12	2514	2625	408
harehouse	0	13	36	54	23
harehouse	0	14	26	23	0
harehouse	0	15	52	47	0
harehouse	0	16	57	52	0
harehouse	0	17	103	94	1
harehouse	0	18	41	38	0
restroom	0	19	171	227	82
restroom	0	20	21	19	0
restroom	0	21	67	61	1
restroom	0	22	83	75	1
room	1	23	5679	6040	1042
room	1	24	202	345	182
hall	1	25	88	80	1
hall	1	26	341	309	3
hall	1	27	150	167	36
hall	1	28	83	101	30
restroom	1	29	191	281	121
restroom	1	30	83	75	1
restroom	1	31	67	75	16

Table 2.10. Example to demonstrate of air flow being greater than the mandatory ventilation flow of first and second floors

4. Selection of equipment and elements of the HVAC system

This chapter gathers all the equipment and elements necessary to size an HVAC system, showing how they have been selected to meet the demands of the system for this building. These elements belonging to the offer that exists in the Spanish market have been chosen. A brief compilation of the technical sheets of these selected elements is included in the annex chapter, focusing on the most relevant supplier data for the project.

BOILERS

The boilers must cover the thermal demand of all the inductors in the building (all the inductors of the water pipe network that feed the interior and the façade inductors: CI-1, CI-2, CF-1 and CF-2). In addition, they must also cover the demand for the heat batteries of the three AHUs (AHU-AP1, AH-AP2 and AH-SA). All equipment is located on the top floor (on the roof) and the terminal elements are spread over all floors. The boilers are fed by a gas supply that comes from the sidewalk up to the roof.

Below is a summary of all the thermal loads the boilers must cover:

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	WINTER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	HEAT BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	578	173
TOTAL HEATING HEAT (kW)		**751**

Table 2.11. Summary of all the thermal loads the boilers must cover

After calculating these data, it has been determined to install two boilers of 380 kW of nominal power each (760 kW in total), of the ADISA brand, model ADINOX 339 BT. The technical data sheet is in *Annexed 6. Technical data of the boilers.*

REFRIGERATION GROUP

The cooling group must cover the thermal demand of all the inductors in the building (all the inductors of the water pipe networks that feed the interior inductors and those of the façade: CI-1, CI-2, CF-1 and CF- 2). In addition, they must also cover the demand for the cold batteries of the three AHUs (AHU-AP1, AH-AP2 and AH-SA). Below is a summary of all the thermal loads the cooler group must cover:

	BUILDING CONSUMPTION	AHUs CONSUMPTION
	SUMMER	
	TOTAL HEAT COVERED BY INDUCTORS BY CI1 + CI2 + CF1 + CF2	COLD BATTERY OF AHU-AP1 + AHU-AP2 + AHU-SA
SUMMARY (kW)	885	247
REFRIGERATION HEAT (kW)		1132

Table 2.12. Summary of all the thermal loads the refrigeration group must cover

After calculating these data, it has been determined to install a 1,226 kW nominal power refrigerator group, CLIMAVENETA brand, model BG / WRAT R407C 4828. The technical data sheet is in *Annexed 7. Technical data of the refrigerator group.*

AIR HANDLER UNITS (AHU)

These devices are responsible for introducing and extracting air in the building from the outside, acclimatizing it beforehand to the desired temperature by means of the cold and heat batteries, and achieving the desired humidity level. The two main AHUs consist of an of enthalpy recuperator that improves equipment efficiency (with its corresponding reduction in impact on the environment) by reusing part of the heat from the waste air inside the building, without transfer of flow between the flow and return (only heat is transferred, the flow rates are isolated from each other). These devices achieve constant ventilation in the offices, guaranteeing the level of air quality imposed by RITE for offices (IDA 3). The following is a diagram of this type of equipment used for AHU-AP1 and AHU-AP2:

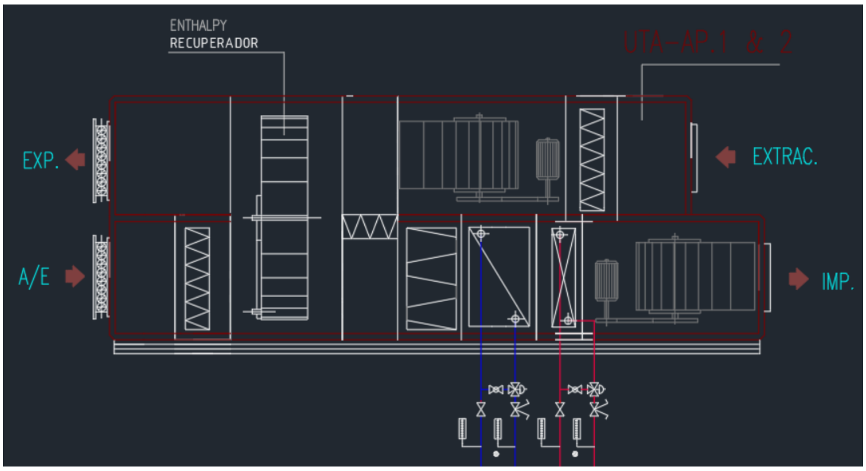


Figure 2.5. Diagram of this type of equipment used for AHU-AP1 and AHU-AP2

The third AHU is a more basic and less powerful unit that is used only to acclimatize a ground floor meeting room independently of the rest of the building. This AHU, unlike the previous ones, does not have a recloser of enthalpy, since there is a partial transfer of flow between the return and delivery ducts inside the AHU. In this way, the efficiency of the appliance is increased by recovering part of the heat from the return waste air. The reason this method is used to improve its efficiency is because it has the advantage that it is cheaper than the use of recuperators of enthalpy, although it has the disadvantage that the supply air that it introduces into the building is not 100% from the outside (rich in oxygen and devoid of contamination produced inside the building). Below is a diagram of this type of equipment used for AHU-SA:

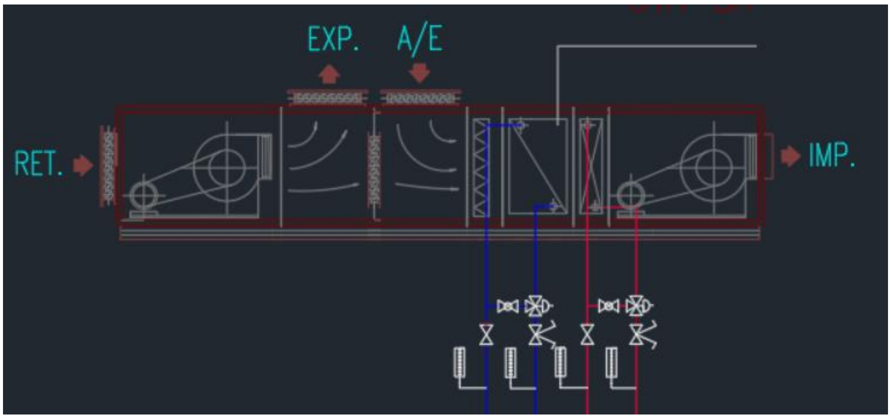


Figure 2.6. Diagram of this type of equipment used for AHU-SA

To select the main AHUs with a recuperator of enthalpy, the parameters required by the water supply system (heat and cold batteries) and the air-air system (supply and return air flows) have been calculated, which are shown at continuation:

	IMPULSION FLOW (m3/h)	RETURN FLOW (m3/h)	HEAT BATTERY (W)	COLD BATTERY (W)
AHU AP1	37604	22653	124658	87104
AHU AP2	36596	22046	121316	84769

Table 2.13. The parameters required by the water supply system (heat and cold batteries) and the air-air system (supply and return air flows)

After calculating these data, the two equal AHUs have been selected, from the TERMOVEN brand, model CLA-2030/4, with a maximum flow rate of 38.5000 m3 / h. The technical data sheet is in *Annexed 8. Air Handler Unit (AHU) datasheet.*

INDUCTORS

As end elements of the air-water system, it has been chosen to use Inductors fed by two pipes (one for the supply and the other for the return of mixed water on the hot / cold roof). Inductors have been chosen instead of Fan coils because although it has the disadvantage of taking longer to acclimatize the rooms since it does not have a fan, it has the advantage of not producing noise since it does not have mechanical fans running (in an office building no variations are needed temperature frequently and very quickly, it is valued more than they do not produce noise that bothers the workers). These elements must be able to cover the maximum thermal load of the most critical months (cold in July and hot in January). Below is a summary of the thermal loads that must be covered by the inductors distributed in each room, the number of inductors in each room, and the inductor selected for each room:

LOCATION				SUMMER		WINTER		INDUCTORS		
TIPE OF ROOM	FLOOR	ROOM	INDUCTORS QUANTITY	TOTAL HEAT COVERED BY INDUCTORS (kW)	HEAT/ INDUCTOR (kW)	TOTAL HEAT COVERED BY INDUCTORS	HEAT/ INDUCTORS (kW)	COMPANY	SERIE	SIZE
room	0	2	5	5,81	1,16	4,93	0,99	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	0	3	11	7,62	0,69	6,17	0,56	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	0	4	8	6,81	0,85	5,72	0,72	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	0	5	8	5,40	0,67	0,00	0,00	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	0	8	1	3,46	3,46	2,90	2,90	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	0	10	2	3,35	1,68	2,78	1,39	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	0	12	30	38,74	1,29	32,93	1,10	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	1	23	80	89,12	1,11	74,86	0,94	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	1	25	2	1,18	0,59	1,55	0,78	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	1	26	8	4,56	0,57	6,12	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	1	27	3	2,46	0,82	3,00	1,00	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	1	28	2	1,50	0,75	1,76	0,88	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	2	32	80	89,12	1,11	74,86	0,94	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	2	34	2	1,18	0,59	1,55	0,78	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	2	35	8	4,56	0,57	6,12	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	2	36	3	2,46	0,82	3,00	1,00	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	2	37	2	1,50	0,75	1,76	0,88	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900

room	3	41	2	3,90	1,95	3,27	1,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	42	2	1,72	0,86	1,44	0,72	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	3	43	2	2,41	1,20	1,92	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	44	2	2,42	1,21	3,20	1,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	45	3	3,28	1,09	2,79	0,93	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	46	2	2,50	1,25	2,07	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	47	3	2,73	0,91	2,29	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	3	48	4	2,70	0,67	3,56	0,89	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	3	49	2	3,23	1,61	2,71	1,36	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	50	2	2,49	1,24	2,09	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	51	1	1,89	1,89	1,59	1,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	52	2	2,21	1,11	2,92	1,46	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	3	53	2	5,06	2,53	4,25	2,13	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	3	54	19	21,72	1,14	18,25	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	3	55	5	3,53	0,71	2,96	0,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	3	56	19	18,07	0,95	15,18	0,80	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	3	57	5	3,68	0,74	2,98	0,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	3	58	17	19,55	1,15	16,42	0,97	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	3	59	2	1,51	0,76	1,27	0,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900

room	4	64	2	3,90	1,95	3,27	1,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	65	2	1,72	0,86	1,44	0,72	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	4	66	2	2,41	1,20	1,92	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	67	2	2,42	1,21	3,20	1,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	68	3	3,28	1,09	2,79	0,93	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	69	2	2,50	1,25	2,07	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	70	3	2,73	0,91	2,29	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	4	71	4	2,70	0,67	3,56	0,89	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	4	72	2	3,23	1,61	2,71	1,36	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	73	2	2,49	1,24	2,09	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	74	1	1,89	1,89	1,59	1,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	75	2	2,21	1,11	2,92	1,46	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	4	76	2	5,06	2,53	4,25	2,13	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	4	77	19	21,72	1,14	18,25	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	4	78	5	3,53	0,71	2,96	0,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	4	79	19	18,07	0,95	15,18	0,80	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	4	80	5	3,68	0,74	2,98	0,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	4	81	17	19,55	1,15	16,42	0,97	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	4	82	2	1,51	0,76	1,27	0,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900

room	5	32	80	89,12	1,11	74,86	0,94	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	5	34	2	1,18	0,59	1,55	0,78	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	5	35	8	4,56	0,57	6,12	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	5	36	3	2,46	0,82	3,00	1,00	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	5	37	2	1,50	0,75	1,76	0,88	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	6	32	80	89,12	1,11	74,86	0,94	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	6	34	2	1,18	0,59	1,55	0,78	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	6	35	8	4,56	0,57	6,12	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	6	36	3	2,46	0,82	3,00	1,00	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	6	37	2	1,50	0,75	1,76	0,88	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900

room	7	64	2	3,90	1,95	3,27	1,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	65	2	1,72	0,86	1,44	0,72	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	7	66	2	2,41	1,20	1,92	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	67	2	2,42	1,21	3,20	1,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	68	3	3,28	1,09	2,79	0,93	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	69	2	2,50	1,25	2,07	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	70	3	2,73	0,91	2,29	0,76	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
room	7	71	4	2,70	0,67	3,56	0,89	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
room	7	72	2	3,23	1,61	2,71	1,36	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	73	2	2,49	1,24	2,09	1,04	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	74	1	1,89	1,89	1,59	1,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	75	2	2,21	1,11	2,92	1,46	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
room	7	76	2	5,06	2,53	4,25	2,13	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	7	77	19	21,72	1,14	18,25	0,96	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	7	78	5	3,53	0,71	2,96	0,59	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	7	79	19	18,07	0,95	15,18	0,80	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1200
hall	7	80	5	3,68	0,74	2,98	0,60	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900
hall	7	81	17	19,55	1,15	16,42	0,97	KOOLAIR	IHK-F (2-PIPE SYSTEM)	1500
hall	7	82	2	1,51	0,76	1,27	0,64	KOOLAIR	IHK-F (2-PIPE SYSTEM)	900

Table 2.14. Summary of the thermal loads that must be covered by the inductors distributed in each room, the number of inductors in each room, and the inductor selected for each room

After calculating these data, it has been possible to satisfy all the thermal load of the building in the most extreme case using three sizes of inductors of the KOOLAIR brand of the IHK-F model (2-PIPE SYSTEM) of sizes 900, 1200 and 1500. The file technique is in *Annexed 9. Inductors datasheet*.

DIFFUSERS AND GRIDS

The diffusers/grilles have been chosen based on the air flow that must supply/return to cover all the thermal loads in each room. Another condition that has been considered is that they should not produce a noise level higher than 40 dB so as not to disturb the workers as it is an office building.

In compliance with these conditions, diffusers and grilles of the TROX brand of the VDN and AT model, respectively, have been selected. The manufacturer's technical data sheets can be found in *Losses due to diffusers in circular air ducts* and *Grid losses in circular ducts* in *Annexed 5. Calculation of ducts*.

PUMPS

The pumps oversee propelling the water through the circuits of pipes from the ground floor to the roof. Six sets of pumps are used for the following six piping circuits: cold primary circuit pumps, heat primary circuit pumps, secondary cold air conditioners pumps, secondary circuit inductors interior zone pumps, secondary circuit inductors facade zone pumps and secondary heat circuit climatizes pumps. The primary cold circuit consists of 2 pumps and the heat circuit has 3. The secondary circuits only need one pump, but another is installed in parallel to each one for safety reasons.

The parameters necessary to select the types of pumps required for each circuit are the water flow (m3 / h) and the height (m) that they must satisfy. These parameters are shown below:

PUMP SET	SECTION	QUANTITY (REPLACEMENT)	UNIT FLOW (m3/h)	HEIGHT (m)
B3	AHUs cold secondary circuit	1 (1)	128	12
B6	AHUs cold secondary circuit	1 (1)	46	12
B4	Secondary circuit inductors inner zone (CI1 + 2)	1 (1)	147	78
B5	Facade zone inductors secondary circuit (CF1 + 2)	1 (1)	56	73
B1	Primary cold circuit	2 (0)	220	10
B2	Primary heat circuit	3 (0)	57	8

Table 2.15. Parameters necessary to select the types of pumps required for each circuit

After calculating these data, the appropriate pumps have been selected to satisfy the water piping system shown below:

PUMP SET	SECTION	COMPANY	SERIE	R.P.M.
B3	AHUs cold secondary circuit	ELIAS	IAC-100-312	1450
B6	AHUs cold secondary circuit	ELIAS	IAC-80-202	1450
B4	Secondary circuit inductors inner zone (CI1 + 2)	ELIAS	BQP 150/50	1450
B5	Facade zone inductors secondary circuit (CF1 + 2)	ELIAS	BQP 150/50	1450
B1	Primary cold circuit	ELIAS	BQP 150/26	1450
B2	Primary heat circuit	ELIAS	IAC-80-203	1450

Table 2.16. Appropriate pumps have been selected to satisfy the water piping system

The technical sheet is in *Annexed 10. Technical specifications pumps*.

VALVES AND COMPONENTS OF THE WATER PIPING SYSTEM

These components used in the installation will be from the manufacturer TOUR-ANDERSSON. The following types will be used:

Figure 2.7. Components used in the installation from TOUR-ANDERSSON

Part III. Alignment with the United Nations Sustainable Development Goals (SDGs).

The objective of this project is to size an HVAC installation for an office building, so that it is efficient and economically viable. But these are not the only criteria that have been considered when the installation has been dimensioned, rather the project has been oriented with sustainable development goals. In recent years, the need to guide projects not only for the benefit of the client has become evident, but they must also respect and favor the rest of society (workers in the building, inhabitants of the region, etc.), to the environment and the sustainability of the planet.

One of the current problems that most concern society is the damage caused by human interaction to the environment of our planet. Currently this problem is focused on the energy consumption of our society. This problem is to be solved in two different ways: the responsible generation of energy (either through the use of renewable generation methods or those with less impact on the environment), and the reduction of energy generation (reducing high levels of consumption either by raising awareness of society or by improving efficiency in the generation and consumption of energy). Regarding the main objective that has been followed in this project "Responsible Consumption and Production", specifically it has been designed to achieve an efficient HVAC system that requires less energy consumption to meet the thermal demands of the office building, guaranteeing that consumption energy is reasonable and efficient, covering levels of comfort and health of employees. In other words, achieving an efficient HVAC installation achieves less energy use (natural gas that feeds the thermal boilers, electricity that feeds the cooler group, the fans, the control system, etc.) achieving the same results, impacting in a milder way to the environment due to the prejudices of the generation of these energies (mainly the generation of CO_2). In Spain, electric power generation companies are making greater use of renewable generation and of less harmful methods for the environment, but due to such high demand for energy, they must continue to resort mainly to combined cycle power plants, with great efficiency in the generation of energy but with its corresponding damage due to the expulsion of CO_2 into the atmosphere.

The main objective that has been considered in this project is **“Responsible Consumption and Production”** [UN__15]. As a secondary objective, the project has been directed to satisfy **"Sustainable Cities and Communities"** [UN__15].

<u>Main objective:</u>

Responsible Consumption and Production

Three measures have been taken following this objective:

First Measure

One of the measure that has been studied and implemented to reduce CO2 emissions into the atmosphere, covering the thermal demand of the building, is the choice of the two boilers used to supply the AHUs batteries and the inductors distributed throughout the rooms of the building, calculating its carbon footprint. Two ADISA brand boilers have been chosen, model ADINOX 339 BT with 380kW nominal power, high efficiency and low level of CO2 emissions into the atmosphere, being 8.1% CO2 for natural gas (technical data from the Manual Installation, use and maintenance of the boiler of *Annexed 6. Technical data of the boilers*). For the calculation of the carbon footprint from the boilers, an average value of heating consumption in offices of 135 kWh / m^2 per year has been assumed [ENEC15]. The office building has an area to be air-conditioned equivalent to 10,770 m^2, so the two boilers will need 1,454 MWh per year to cover the heating demand. The 0.203 kg CO2 /kWh emission factor of Natural Gas published on the website of the Carbon Footprint Registry, compensation and carbon dioxide absorption projects for the year 2017 are used [REAL14]. Therefore, the boilers generate 295,162 kg CO2 per year.

To illustrate the benefit to the environment of the use of efficient boilers with a low level of CO2 emissions, the calculation of the carbon footprint of another cheaper model that was ruled out is shown, since this project prioritizes the least environmental impact over the lower economic cost of the installation, following the objective of sustainable development "Responsible Consumption and Production": The hip studied first and subsequently discarded is the ADI CD 100 model with a value of 9.1% CO2 for natural gas (technical data taken out of the Boiler Installation, Use and Maintenance Manual, *Annexed 6. Technical data of the boilers*). Considering the same energy needed for heating the building of 1,454 MWh per year and considering the percentages of CO2 emissions of each boiler, there would be 331,602 kg CO2 of emissions per year from the operation of the boilers. Assuming an increase of 12.34% in annual CO2 emissions to the atmosphere if this cheaper model of boilers were used, compared to the finally selected ADINOX 339 BT model.

Second Measure

A second decision for the dimensioning of this installation taken directly to follow the objective "Responsible Consumption and Production" and which has differentiated this project from typical building air conditioning projects; is to achieve a more efficient and environmentally friendly HVAC system opted for the use of two air conditioning systems (air-water with AHU and water-water with boilers and a cooling group) to simultaneously cover a percentage of the thermal demand of each room. This project differs from the classic projects that only use one type of air conditioning system (air-water with AHU, water-water with boilers and cooling groups, etc.) and only one type of terminal elements (Diffusers, Fancoils, Inductors, etc.) to cover 100% of the thermal demand within the same room.

In this project, 20% of the thermal load will be covered by an air-water system with Air Treatment Units (AHU) through a circuit of air ducts through all the plants. The remaining 80% of thermal load will be covered by a water-water system using a circuit of pipes that distribute hot and cold water from the boilers and the refrigeration unit to the terminal elements (Inductors). AHUs provide a homogeneous temperature and humidity level for all floors of the building, while inductors distributed throughout the different areas are capable of being independently regulated. In this way, average values are achieved with the AHU system throughout the building, and then by means of the inductors each room can be adjusted to the desired temperature independently of the system. This decision has been made since the use of AHU is cheaper and more respectful of the environment than that of inductors, in this way the primary variation of temperature and humidity that is needed to achieve the desired values inside the building is achieved without resorting to inductors.

Third measurement

A third decision made in the project following the objective "Responsible Consumption and Production", has been the selection of the three AHUs of the building. The two largest AHUs that cover the majority of the thermal demand designated for the air-water system, have chosen to use the CLA-2030/4 model from the TERMOVEN brand, which has a higher purchase price, but guarantees a better system efficiency; needing less energy input from the boilers and the cooling unit to reach the desired humidity and temperature thanks to having recuperators of enthalpy. These recuperators of enthalpy improve the efficiency of the apparatus by reusing part of the heat from the waste air inside the building, without transfer of flow between the flow and return (only heat is transferred, the flow rates are isolated from each other). By improving the efficiency of the AHUs, less energy will be needed from the boilers and the cooler group, reducing the carbon footprint of these equipment.

<u>Secondary objective:</u>

Sustainable Cities and Communities

To fulfill the secondary objective "Sustainable Cities and Communities", it has been chosen that the land where the office building is going to be built is on the outskirts of the city of Madrid. The Business Park of Avenida del Prado del Espino 28660 has been chosen. In this way it is avoided that the $CO2$ emissions generated by the HVAC system devices are released near densely populated areas, improving the quality of life of the citizens of Madrid. The choice of this location also benefits the project in that it is simpler and cheaper to build this building of 1,496 m^2 in area and with a height of 27 m spread over 8 floors on land on the outskirts of the city.

Part IV. Annexes

Annexes index

Annexed 1. Floor plans

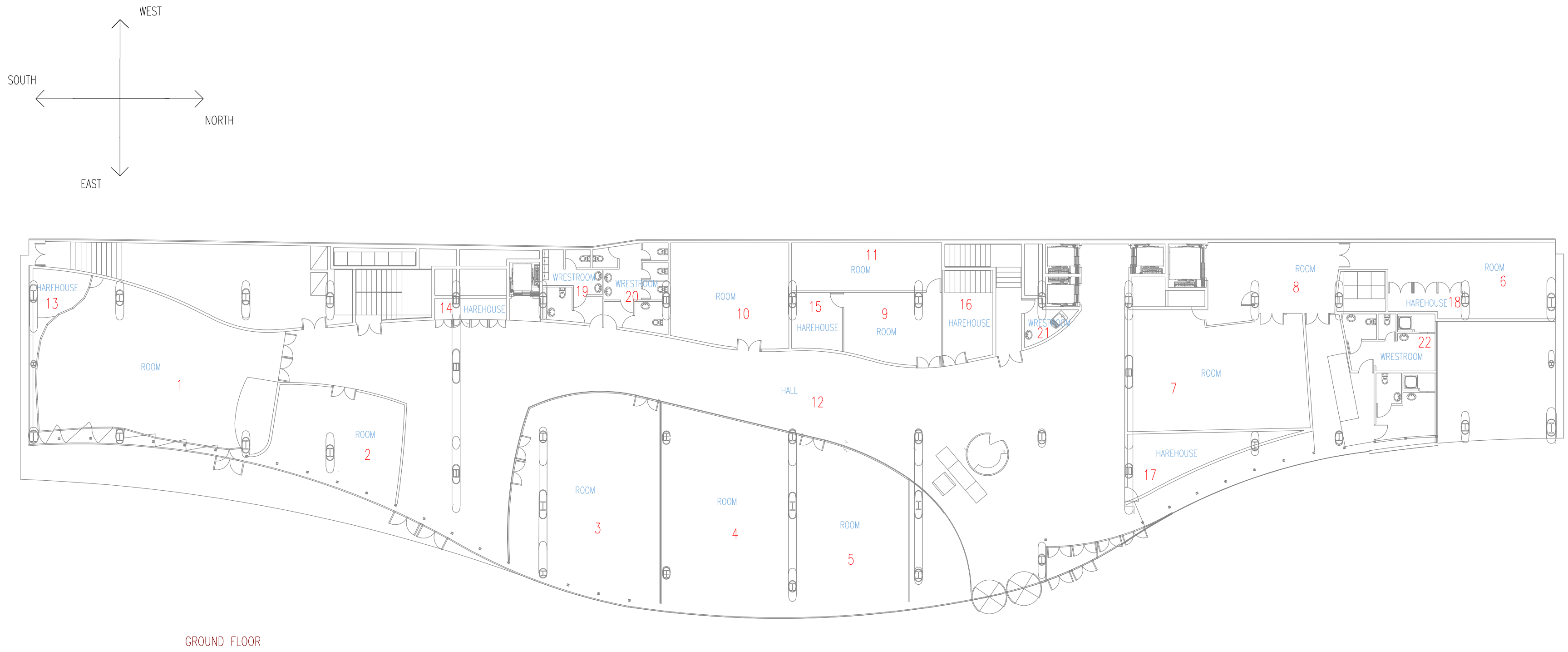


Figure 4.1. Ground floor**.**

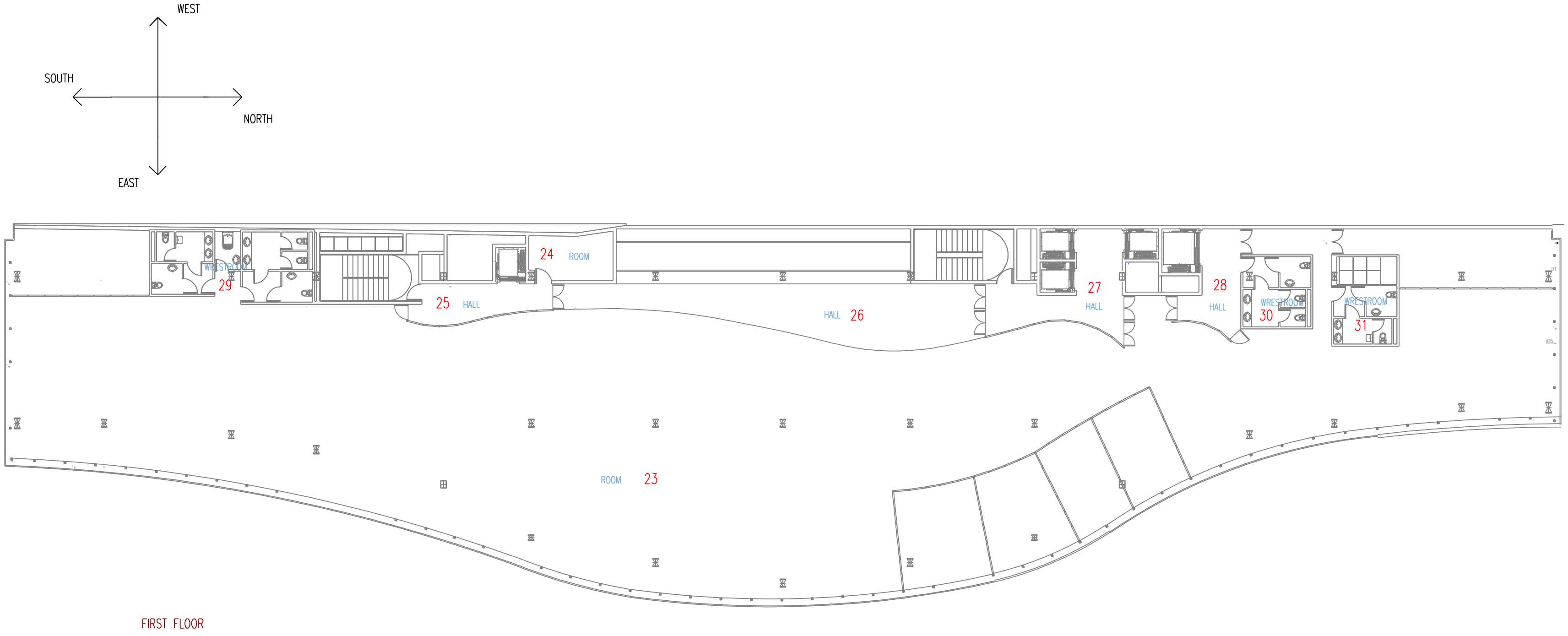


Figure 4.2. First floor**.**

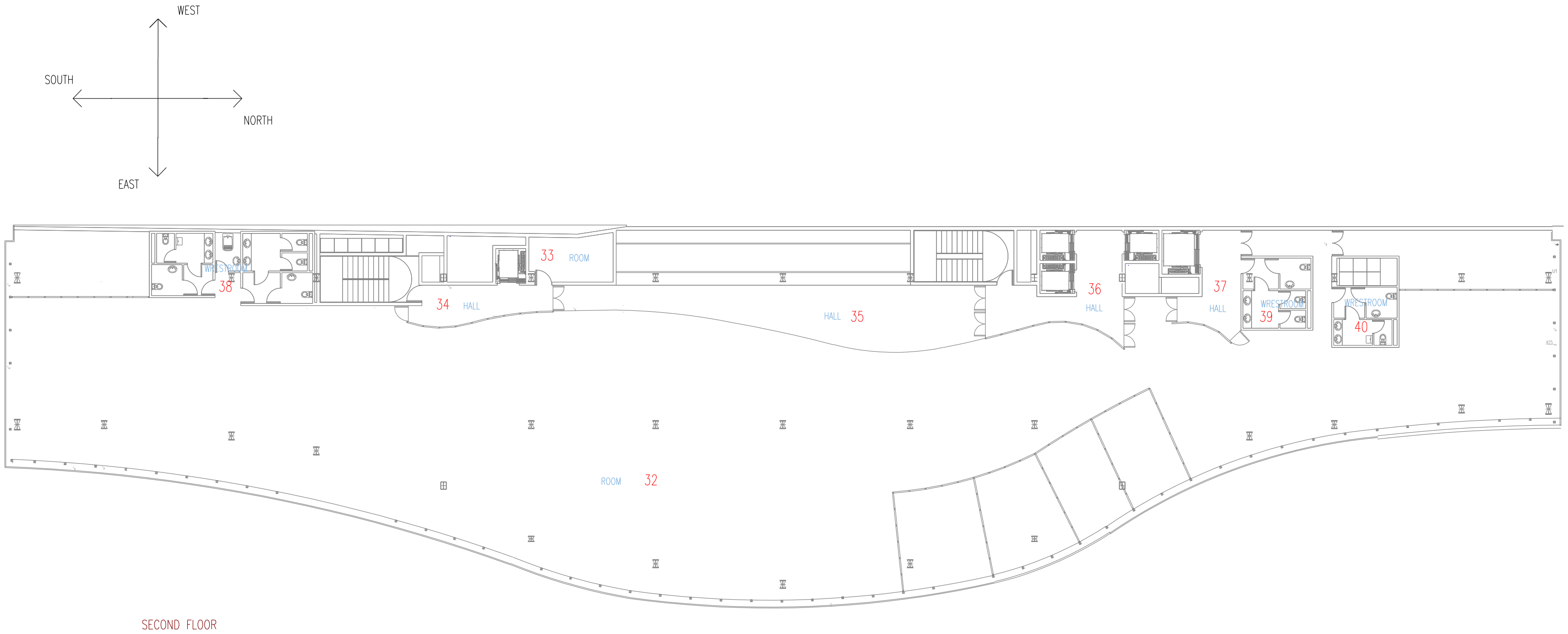


Figure 4.3. Second floor**.**

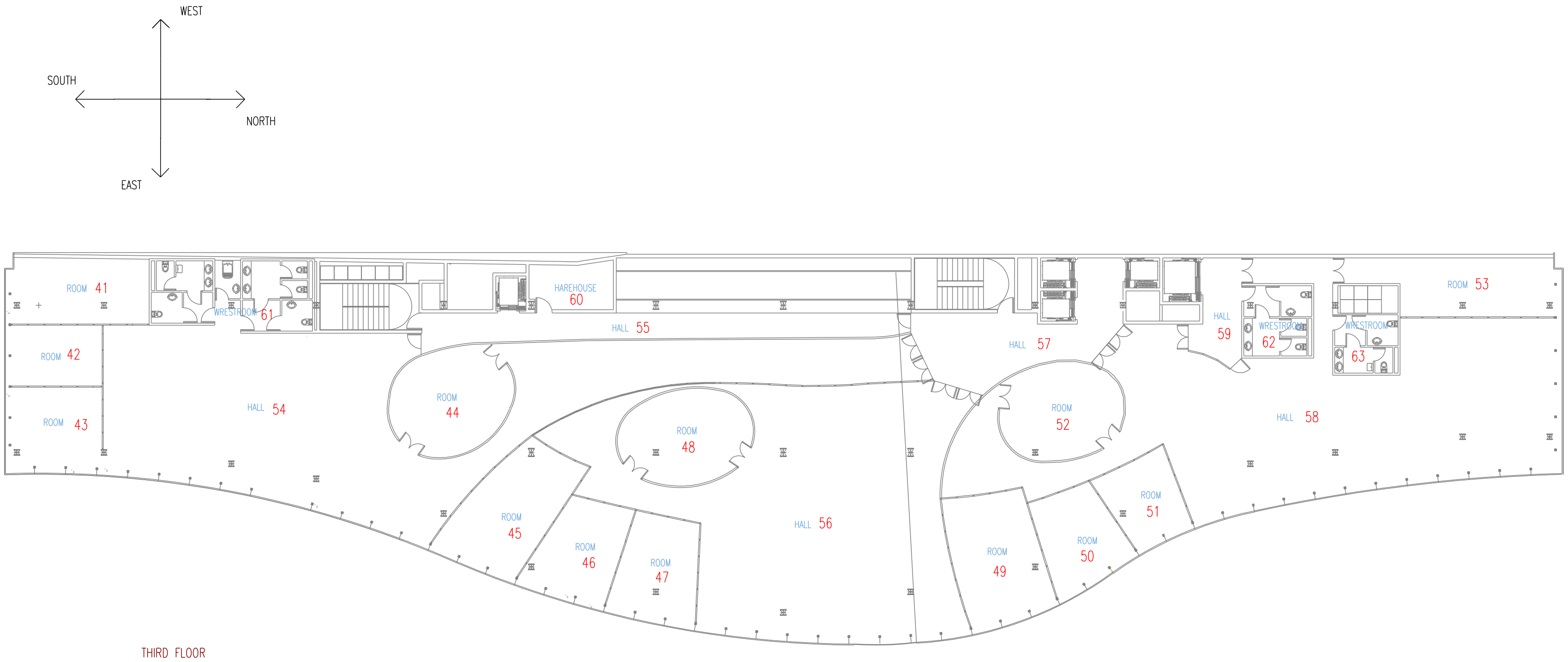


Figure 4.4. Third floor**.**

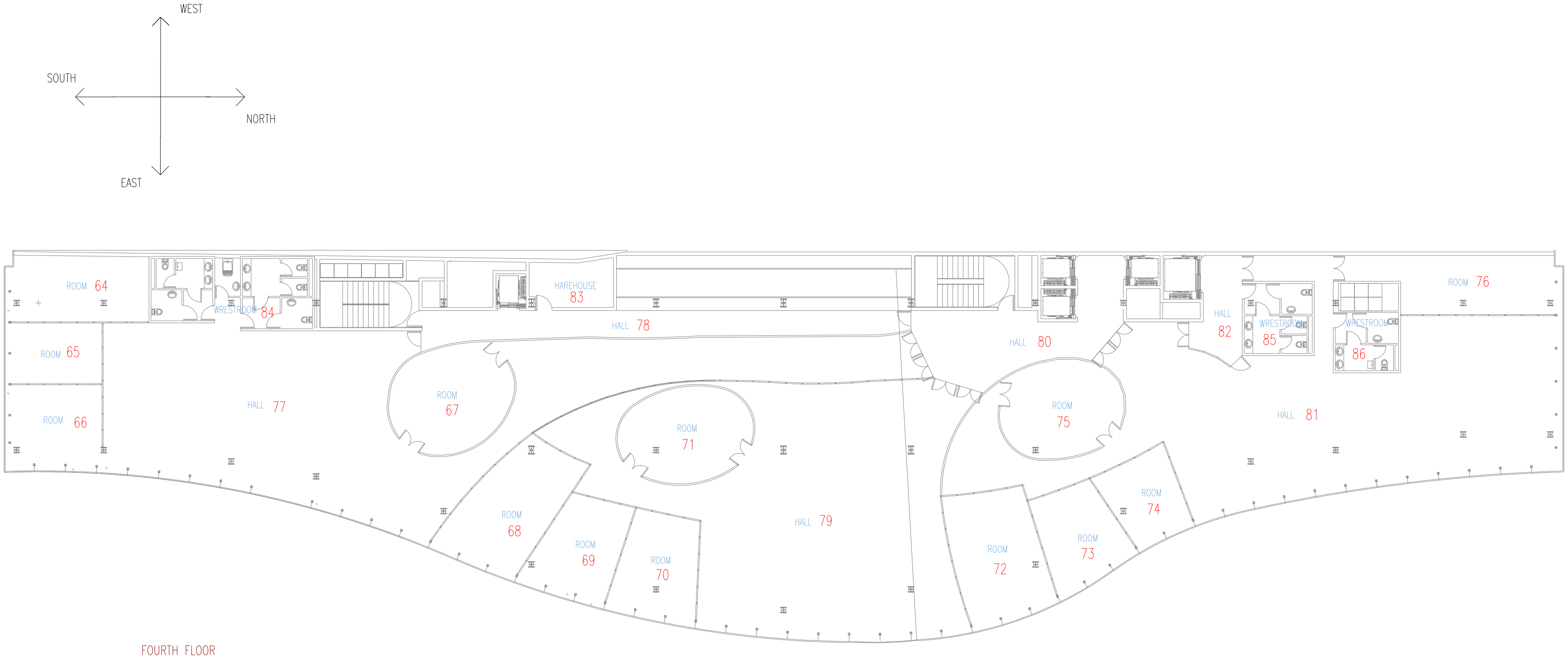


Figure 4.5. Fourth floor**.**

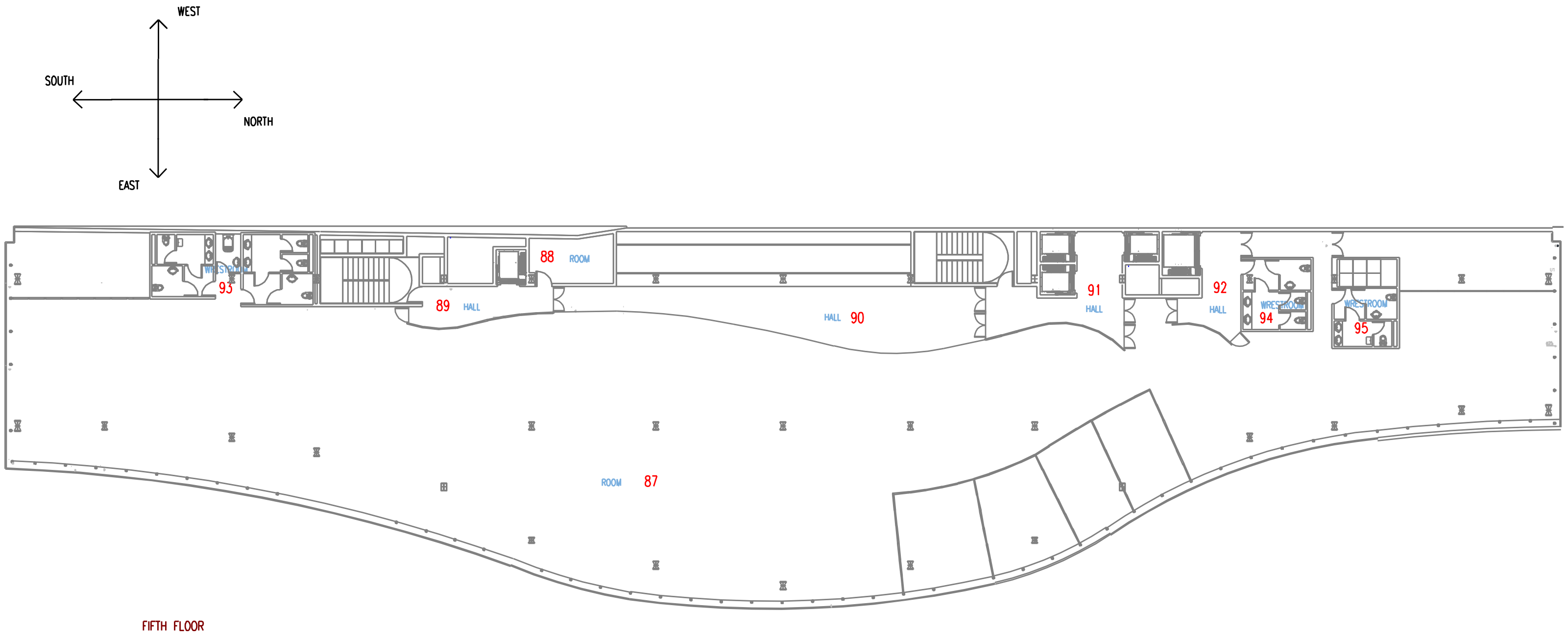


Figure 4.6. Fifth floor**.**

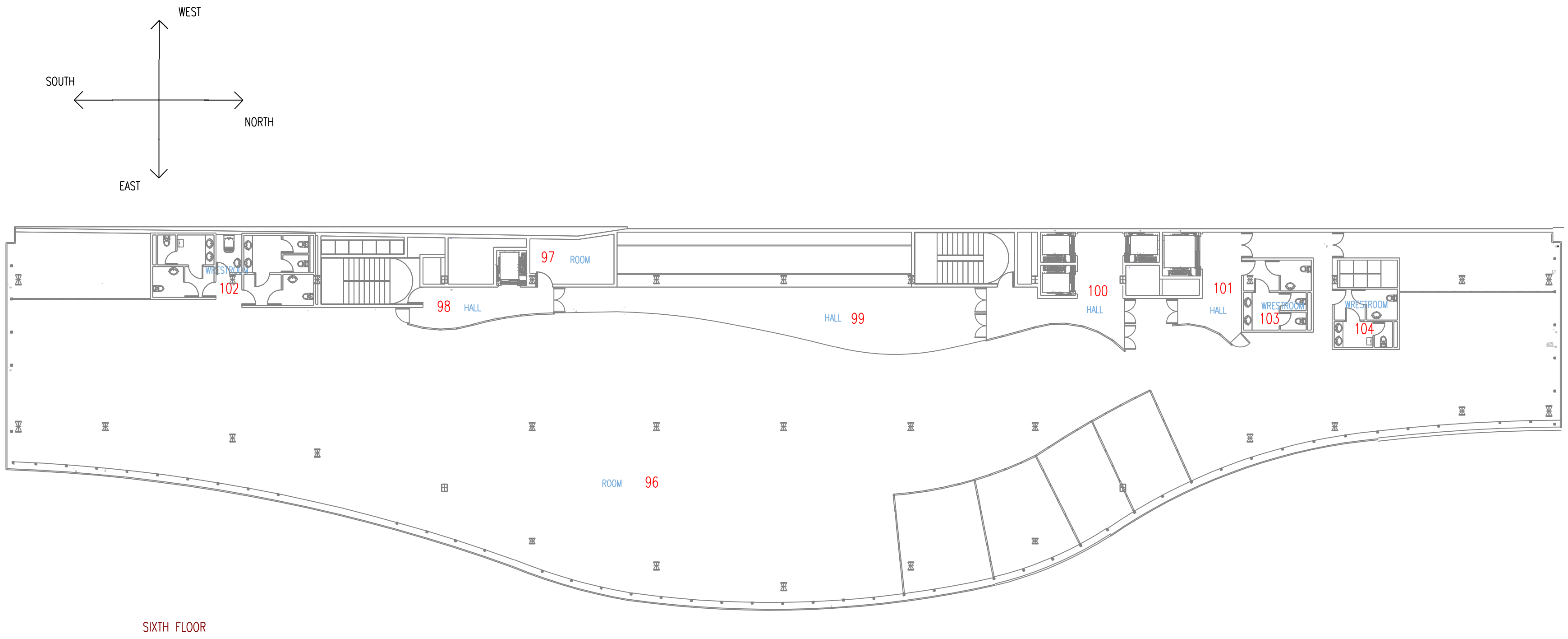


Figure 4.7. Sixth floor**.**

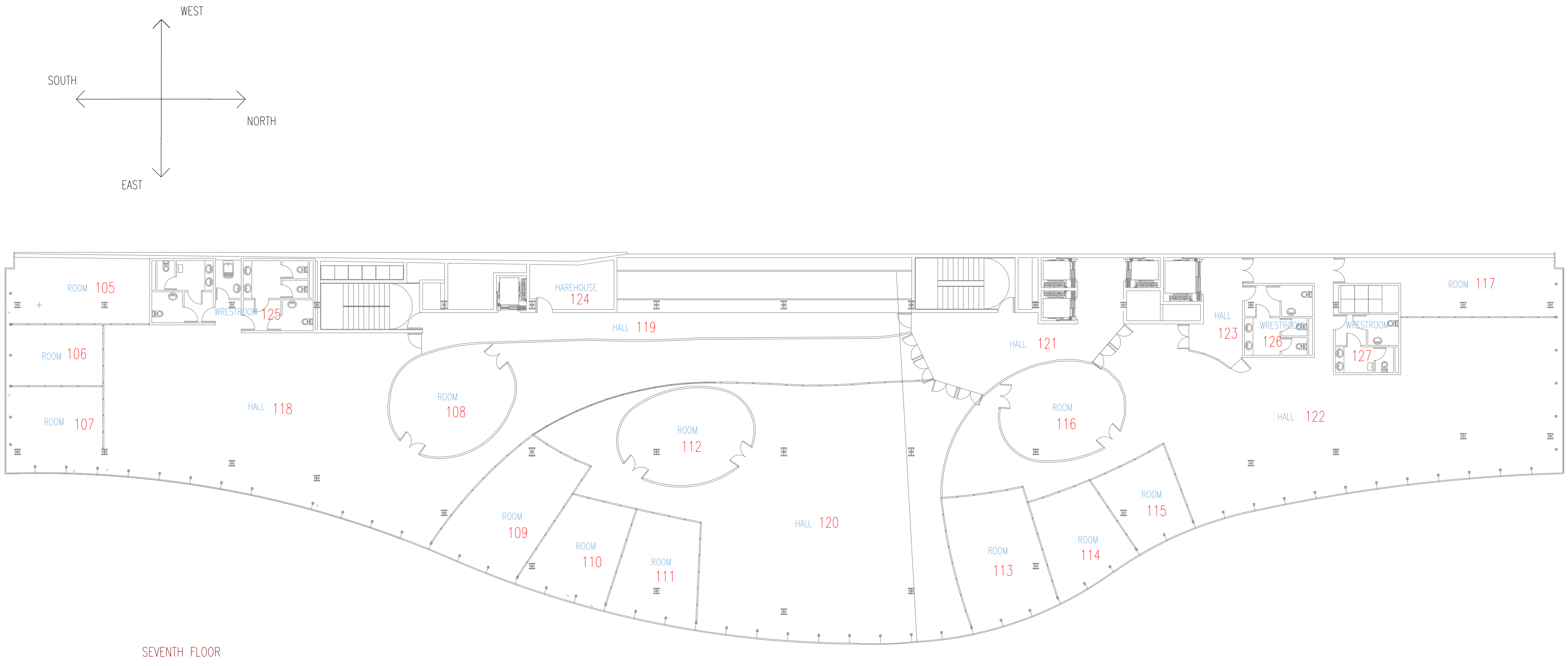


Figure 4.8. Seventh floor

Annexed 2. Excels example used to calculate loads

REFRIGERACION		nicipic		Madrid		asnm	689	Pt(Pa)	93317			ZC.HE1	D3
Mes calefac.	**Enero**	Ts.ext. d	**0,3**	Hr(%)	**69**	OMD ºC	**3,5**	Tm.mes	6	DTCiu	0	difusa%	75
Est.referencia	54 Madrid (Retiro)			Latitud º	40,4	Long.Oe	3,7	Tm.anu	14,9	NPerc	1/99	asnm	667
Mes refriger.	**Julio**	Ts.ext. d	**33,6**	Th ºC	**21,1**	OMD ºC	**13,9**	Tm.mes	25,4	DTCiu	0		
Mes cálculo	7	Dia	21	hora.sol	15		Tipo atmósfera		Estánda	Reflexión alrededores			Estánda
Exteriores		Temp. ºC	33,45	Hr(%)	34,0	W(kg/kg	0,0119						
Interiores		Temp. ºC	25,00	Hr(%)	50,0	W(kg/kg	#####			**Hora max.sen**			**10**
DATOS ZONA			Super.(m2	Vol.(m3)	Zona	Tipo	Alfombr	% Acris	Aplicación		IDA	Control	
Nombre	Room 1, Floor 0		110	275	Exterior	Medio	SA	60	Oficinas_12h		IDA2	Cte_dia	
OPACOS ext	A.Neta(	Bruta(m2	U(W/m2K	color	coef.abs							Qsen (W	Qlat (W
Techo	0,0	0,0	2,02	Medio	0,8							0	0
N-Muro	0,0	0,0	0,76	Medio	0,8							0	0
NE-Muro	0,0	0,0	0,76	Medio	0,8							0	0
E-Muro	9,4	35,4	0,76	Medio	0,8							46	0
SE-Muro	0,0	0,0	0,76	Medio	0,8							0	0
S-Muro	15,3	26,4	0,76	Medio	0,8							38	0
SO-Muro	0,0	0,0	0,76	Medio	0,8							0	0
O-Muro	0,0	0,0	0,76	Medio	0,8							0	0
NO-Muro	0,0	0,0	0,76	Medio	0,8							0	0
Suelo	0,0	0,0	1,3									0	0
OPACOS otros				Cont.ext	Totro(ºC	z(m)	b	**Ais.pe**	D(m)	k(W/m	e(m)		
Otro Local 1	0,0	0,0	1,5	Medio	29,2		0,5					0	0
Otro Local 2	0,0	0,0	1,5	Medio	29,2		0,5					0	0
Muro Terreno	0,0	0,0	1			1						0	0
Suelo Terreno	0,0	0,0	1			0		C.ais.H	1	0,03	0,10	0	0
S.Vacio sanit	0,0	0,0	1,0			L(m)	L(estimada_m)					0	0
Puentes térmicos otros			0,2			0	14					0	0
Puentes térmicos ventanas			0,2			0	104					0	0
												84	0
VENTANAS	ancho(r	alto(m)	c(m)	d(m)	e(m)	f(m)	g(m)	m(m)	n(m)			Qsen (W	Qlat (W
Tipo	2,50	1,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	Sin accesorios			
Somb.1			Ucristal	Umarco		f	f	Pos.	%	Fsombra (0 sol, 1 sombra)			
	Area (m2	g	(W/m2K)	(W/m2K)	FM	Uacce	Facce	Acce	Activo	aleros	Otros edif.		
Techo	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0	0	0	0
N-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
NE-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
E-Muro	26,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	3941	0
SE-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
S-Muro	11,1	0,76	2,6	3	0,1	1,00	1	Ext	100	0,55	0	1507	0
SO-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0,15	0	0	0
O-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0,12	0	0	0
NO-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0,26	0	0	0
Somb.2	2,50	1,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	Sin accesorios			
Techo	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0	0	0	0
N-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
NE-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
E-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
SE-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
S-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,55	0	0	0
SO-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,15	0	0	0
O-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,12	0	0	0
NO-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,26	0	0	0
												5448	0
INTERNAS	Frac.rad	Calef.(%	W/m2	% sen	Reac/Transf.		Pot. Maxima (W		Sen(W)	Lat(W)		Qsen (W	Qlat (W
LUCES	0,5	10	20		Si				2200			2178	0
EQUIPOS	0,05	10	5	100					550	0		491	0
	sexo	Calef.(%	m2/ocup	Actividad			qs/per	ql/per			n.per.		
OCUPANTES	Media	1	4	Sentado muy ligero (oficin			78	46	2145	1265	27,5	1737	1139
VENTILACIO	1238	UTA Primario						Ts(ºC)	27,60	W(kg/	0,0151	962	4004
INFILTRACIO	0							Ts(ºC)	33,45	W(kg/	0,0119	0	0
MAYORAC.%	Sensible	10	Latente	5	W/m2	158,08	Total (W)		**17389**	**FCS**	**0,69**	**11990**	**5399**
Hora max.sen.	**10**				W/m2	170,2	Total (W)		**18722**	FCS	**0,707**	**13244**	**5478**

Excel example used to calculate loads in July (summer)

CALEFACCION		nicipic		Madrid		asnm	689	Pt(Pa)	93317			ZC.HE1	D3
Mes calefac.	**Enero**	Ts.ext. d	0,3	Hr(%)	69	OMD ºC	3,5	Tm.mes	6	DTCiu	0	difusa%	75
Est.referencia	54 Madrid (Retiro)			Latitud º	40,4	Long.Oe	3,7	Tm.anu	14,9	NPerc	1/99	asnm	667
Mes refriger.	**Julio**	Ts.ext. d	33,6	Th ºC	21,1	OMD ºC	13,9	Tm.mes	25,4	DTCiu	0		
Mes cálculo	1	Dia	21	hora.sol	9		Tipo atmósfera		Estánda	Reflexión alrededores			Estánda
Exteriores		Temp. ºC	0,71	Hr(%)	67,0	W(kg/kg	0,0029						
Interiores		Temp. ºC	20,00	Hr(%)	40,0	W(kg/kg	#####				**Hora max.sen**		5
DATOS ZONA			Super.(m2	Vol.(m3)	Zona	Tipo	Alfombr	% Acris	Aplicación		IDA	Control	
Nombre	Room 1, Floor 0		110	275	Exterior	Medio	SA	60	Oficinas_12h		IDA2	Cte_dia	
OPACOS ext	A.Neta(	Bruta(m2	U(W/m2K	color	coef.abs							Qsen (W	Qlat (W
Techo	0,0	0,0	2,02	Medio	0,8							0	0
N-Muro	0,0	0,0	0,76	Medio	0,8							0	0
NE-Muro	0,0	0,0	0,76	Medio	0,8							0	0
E-Muro	9,4	35,4	0,76	Medio	0,8							-131	0
SE-Muro	0,0	0,0	0,76	Medio	0,8							0	0
S-Muro	15,3	26,4	0,76	Medio	0,8							-214	0
SO-Muro	0,0	0,0	0,76	Medio	0,8							0	0
O-Muro	0,0	0,0	0,76	Medio	0,8							0	0
NO-Muro	0,0	0,0	0,76	Medio	0,8							0	0
Suelo	0,0	0,0	1,3									0	0
OPACOS otros				Cont.ext	Totro(ºC	z(m)	b	**Ais.pe**	D(m)	k(W/m	e(m)		
Otro Local 1	0,0	0,0	1,5	Medio	10,4		0,5					0	0
Otro Local 2	0,0	0,0	1,5	Medio	10,4		0,5					0	0
Muro Terreno	0,0	0,0	1			1						0	0
Suelo Terreno	0,0	0,0	1			0		C.ais.H	1	0,03	0,10	0	0
S.Vacio sanit	0,0	0,0	1,0			L(m)	L(estimada_m)					0	0
Puentes térmicos otros			0,2			0	14					0	0
Puentes térmicos ventanas			0,2			0	104					0	0
												-345	0
VENTANAS	ancho(m	alto(m)	c(m)	d(m)	e(m)	f(m)	g(m)	m(m)	n(m)			Qsen (W	Qlat (W
Tipo	2,50	1,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	Sin accesorios			
Somb.1			Ucristal	Umarco		f	f	Pos.	%	Fsombra (0 sol, 1 sombra)			
	Area (m2	g	(W/m2K)	(W/m2K	FM	Uacce	Facce	Acce	Activo	aleros	Otros edif.		
Techo	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0	0	0	0
N-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
NE-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
E-Muro	26,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0,08	0	-969	0
SE-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	0,03	0	0	0
S-Muro	11,1	0,76	2,6	3	0,1	1,00	1	Ext	100	0,08	0	-413	0
SO-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
O-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
NO-Muro	0,0	0,76	2,6	3	0,1	1,00	1	Ext	100	1	0	0	0
Somb.2	2,50	1,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	Sin accesorios			
Techo	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0	0	0	0
N-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
NE-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
E-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,08	0	0	0
SE-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,03	0	0	0
S-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	0,08	0	0	0
SO-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
O-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
NO-Muro	0,0	0,76	3	3	0,1	1,00	1,00	Ext	100	1	0	0	0
												-1382	0
INTERNAS	Frac.rad	Calef.(%	W/m2	% sen	Reac/Transf.		Pot. Maxima (W		Sen(W)	Lat(W)		Qsen (W	Qlat (W
LUCES	0,5	10	20		Si				2200			203	0
EQUIPOS	0,05	10	5	100					550	0		49	0
	sexo	Calef.(%	m2/ocup	Actividad			qs/per	ql/per			n.per.		
OCUPANTES	Media	1	4	Sentado muy ligero (oficin			94	30	26	8	0,275	19	7
VENTILACIO	1238	UTA Primario						Ts(ºC)	27,60	W(kg/	0,0151	3192	9150
INFILTRACIO	0							Ts(ºC)	0,71	W(kg/	0,0029	0	0
MAYORAC.%	Sensible	10	Latente	5	W/m2	104,78	Total (W)		11526	FCS	0,166	1910	9615
Hora max.sen	5				W/m2	98,57	Total (W)		10842	FCS	0,112	1219	9623

Excel example used to calculate loads in January (winter)

Annexed 3. Thermal load calculation parameters

Elemento	Zonas climáticas de invierno					
	α	A	B	C	D	E
Muros y suelos en contacto con el aire exterior (U_S, U_M) **Muros, suelos y cubiertas en contacto con espacios no habitables (U_{NH}) o con el terreno (U_T)** **Medianerías (U_{MD})**	1,35	1,25	1,00	0,75	0,60	0,55
Cubiertas en contacto con el aire exterior (U_C)	1,20	0,80	0,65	0,50	0,40	0,35
Huecos (conjunto de marco y vidrio) (U_H)	4,00	4,00	3,20	2,70	2,30	1,80

Wall heat transfer coefficients (W / m2K)

U (W/m2K) para Vidrios	Vertical	Horizontal
Dobles bajo emisivos 0,1-0,2	2,7	2,9
Dobles bajo emisivos 0,03-0,1	2,6	2,8
Dobles bajo emisivos <0,03	2,5	2,6

Glass heat transfer coefficients (W / m2K)

MARCOS		***Transmitancia térmica ($U_{H,m}$) W/m²K***	
TIPO	***DESCRIPCION***	***VERTICAL***	***HORIZONTAL***
METALICOS	METALICO sin rotura de puente térmico entre 4 y 12 mm	5,7	7,2
	METALICO con rotura de puente térmico entre 4 y 12 mm	4	4,5
	METALICO con rotura de puente térmico mayor de 12 mm	3,2	3,5
MADERA	MADERA densidad media alta.	2,2	2,4
	MADERA densidad media baja.	2	2,1
PVC	DOS cámaras	2,2	2,4
	TRES cámaras	1,8	1,9

Frames heat transfer coefficients (W / m2K)

Uso del local y categoría de calidad de aire interior exigible		Con fumadores	Sin fumadores
Hospitales y clínicas Laboratorios Guarderías	IDA 1 (calidad óptima)	0,04 m^3 / s.per 40 dm^3 / s.per 144 m^3 / h.per	0,02 m^3 / s.per 20 dm^3 / s.per 72 m^3 / h.per
Oficinas Locales comunes de hoteles y similares Residencias de ancianos Residencias de estudiantes Salas de lectura Museos Salas de tribunales Aulas de enseñanza y asimilares Piscinas (*)	IDA 2 (buena calidad)	0,025 m^3 / s.per 25 dm^3 / s.per 90 m^3 / h.per	0,0125 m^3 / s.per 12,5 dm^3 / s.per 45 m^3 / h.per
Edificios comerciales Cines y teatros Salones de actos Habitaciones de hoteles y similares Restaurantes, cafeterías y bares Salas de fiestas Gimnasios y locales para el deporte (excepto piscinas) Salas de ordenadores	IDA 3 (calidad media)	0,016 m^3 / s.per 16 dm^3 / s.per 57,6 m^3 / h.per	0,008 m^3 / s.per 8 dm^3 / s.per 28,8 m^3 / h.per
	IDA 4 (calidad baja)	0,01 m^3 / s.per 10 dm^3 / s.per 36 m^3 / h.per	0,005 m^3 / s.per 5 dm^3 / s.per 18 m^3 / h.+per
(*) En piscinas climatizadas se utiliza el método de dilución.			

Air quality offices according to RITE

C	Radiación	Convección
Lámparas incandescentes ó LED	80%	20%
Fluorescentes	50%	50%
Halógenas	50%	50%

Radiant fraction depending on the type of lights

Fracción sombra Ventana sombra tipo 1

Hora solar	N	NE	E	SE	S	SO	O	NO
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0,094459464	0,019010775	0,023595997	0,122659166	1	1	1	1
6	0,212706484	0,048400447	0,035600639	0,117077755	1	1	1	1
7	0,57484263	0,086932506	0,05038003	0,121146005	1	1	1	1
8	1	0,145573996	0,073748868	0,130939242	1	1	1	1
9	1	0,258682938	0,119300135	0,147278985	0,546007522	1	1	1
10	1	0,626187073	0,198710174	0,174722139	0,378071075	1	1	1
11	1	1	0,411100886	0,23579557	0,310494185	1	1	1
12	1	1	1	0,417859934	0,27832012	0,417859934	1	1
13	1	1	1	1	0,310494185	0,23579557	0,411100886	1
14	1	1	1	1	0,378071075	0,174722139	0,198710174	0,626187073
15	1	1	1	1	0,546007522	0,147278985	0,119300135	0,258682938
16	1	1	1	1	1	0,130939242	0,073748868	0,145573996
17	0,574843271	1	1	1	1	0,121146005	0,05038003	0,086932506
18	0,212706611	1	1	1	1	0,117077755	0,035600639	0,048400447
19	0,094459505	1	1	1	1	0,122659166	0,023595997	0,019010775
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0

Shaded fraction depending on the type of window, solar time and orientation

Radiacion total W/m2									
Hora Solar	Hz	N	NE	E	SE	S	SO	O	NO
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	14	41	84	81	34	6	6	6	6
6	168	150	335	362	215	65	65	65	65
7	354	163	478	575	396	105	105	105	105
8	537	135	486	653	517	158	135	135	135
9	698	159	411	629	572	273	159	159	159
10	825	176	289	529	563	370	176	176	176
11	904	186	186	375	494	433	228	186	186
12	931	190	190	190	377	455	377	190	190
13	904	186	186	186	228	433	494	374	186
14	824	176	176	176	176	369	562	529	288
15	699	159	159	159	159	273	573	630	411
16	537	135	135	135	135	158	518	654	486
17	355	164	105	105	105	105	398	577	480
18	169	151	65	65	65	65	216	365	338
19	14	42	6	6	6	6	34	81	84
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0

Total radiation values (W/m2)

Radiacion directa W/m2									
Hora Solar	Hz	N	NE	E	SE	S	SO	O	NO
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	4	35	77	74	28	0	0	0	0
6	73	85	271	298	150	0	0	0	0
7	214	58	373	470	291	0	0	0	0
8	374	0	350	518	382	22	0	0	0
9	521	0	252	471	413	114	0	0	0
10	638	0	113	353	387	194	0	0	0
11	712	0	0	188	307	247	41	0	0
12	737	0	0	0	187	265	187	0	0
13	712	0	0	0	41	247	307	188	0
14	637	0	0	0	0	194	386	353	112
15	521	0	0	0	0	114	414	471	252
16	374	0	0	0	0	22	382	519	351
17	215	58	0	0	0	0	292	471	374
18	73	86	0	0	0	0	151	300	273
19	4	35	0	0	0	0	28	75	78
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0

Direct radiation values (W/m2)

Radiacion difusa W/m2									
Hora Solar	Hz	N	NE	E	SE	S	SO	O	NO
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	10	6	6	6	6	6	6	6	6
6	96	65	65	65	65	65	65	65	65
7	139	105	105	105	105	105	105	105	105
8	163	135	135	135	135	135	135	135	135
9	178	159	159	159	159	159	159	159	159
10	187	176	176	176	176	176	176	176	176
11	192	186	186	186	186	186	186	186	186
12	194	190	190	190	190	190	190	190	190
13	192	186	186	186	186	186	186	186	186
14	187	176	176	176	176	176	176	176	176
15	178	159	159	159	159	159	159	159	159
16	163	135	135	135	135	135	135	135	135
17	140	105	105	105	105	105	105	105	105
18	96	65	65	65	65	65	65	65	65
19	10	6	6	6	6	6	6	6	6
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0

Diffuse radiation values (W/m2)

ACTIVIDAD REALIZADA	28 ºC		27 ºC		26 ºC		24 ºC	
	Sensible	Latente	Sensible	Latente	Sensible	Latente	Sensible	Latente
Sentado en reposo. Escuela.	45	45	50	40	55	35	60	30
Sentado trabajo ligero. Instituto.	45	55	50	50	55	45	60	40
Oficinista, actividad ligera.	45	70	50	65	55	60	60	50
Persona de pie. Tienda.	45	70	50	75	55	70	65	60
Persona que pasea. Banco.	45	80	50	75	55	70	65	60
Trabajo sedentario.	50	90	55	85	60	80	70	70
Trabajo ligero taller.	50	140	55	135	60	130	75	115
Persona que camina.	55	160	60	155	70	145	85	130
Persona que baila.	70	185	75	175	85	170	95	155
Persona en trabajo penoso.	115	250	120	250	125	245	130	230

Latent and sensible heat given off by person (W)

Annexed 4. Calculation of water pipes

Accesorios/Válvulas		Longitud equivalente (m)														
ø	pulgadas	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"	8"	10"	12"
	mm	10	15	20	25	32	40	50	65	80	100	125	150	200	250	300
Codo a 45°					0,3	0,3	0,6	0,6	0,9	0,9	1,2	1,5	2,1	2,7	3,3	3,9
Codo a 90°					0,6	0,9	1,2	1,5	1,8	2,1	3	3,6	4,2	5,4	6,6	8,1
Codo a 90° Radio largo					0,6	0,6	0,6	0,9	1,2	1,5	1,8	2,4	2,7	3,9	4,8	5,4
Té o Cruz					1,5	1,8	2,4	3	3,6	4,5	6	7,5	9	10,5	15	18
Valv MARIPOSA								1,8	2,1	3	3,6	3,6	3	3,6	5,7	6,4
Valv COMPUERTA			0,18	0,21	0,27	0,3	0,46	0,7	0,85	0,98	1,2	1,8	2,1	2,7	3,6	3,9
Valv RETENCION de clapeta oscilante					1,5	2,1	2,7	3,3	4,2	4,8	6,6	8,3	10,4	13,5	16,5	19,5
Valv RETENCION de asiento								12,1	18,9	19,7	25,4	30,5	35,9	47,3	61,9	
Valv BOLA			0,18	0,21	0,27	0,3	0,46	0,7	0,85	0,98	1,2	1,8	2,1			
Filtros de agua			1,5	1,7	1,8	2,6	2,6	3,2	9	10	15	15,4	19	36	50	64

Head loss calculation for pipe fittings

	DIN 2440											
Ø nominal pulgadas	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
mm	10	15	20	25	32	40	50	65	80	100	125	150
Ø interior mm	12,5	16	21,6	27,2	35,9	41,8	53	68,8	80,8	105,3	130	155,4
Perdida de carga en mm.c.a. / ml	CAUDAL EN L/H / VELOCIDAD EN M/S											
3	49	130	210	394	848	1.273	2.441	4.915	7.472	15.299	26.967	43.037
	0,11	0,18	0,16	0,19	0,23	0,26	0,31	0,37	0,40	0,49	0,56	0,63
4	65	136	248	466	992	1.491	2.818	5.675	8.780	17.666	31.139	49.695
	0,15	0,19	0,19	0,22	0,27	0,30	0,36	0,42	0,48	0,58	0,65	0,73
5	81	136	280	527	1.124	1.690	3.200	6.453	9.997	20.142	34.814	56.810
	0,18	0,19	0,21	0,25	0,31	0,34	0,40	0,48	0,54	0,64	0,73	0,83
6	97	136	310	584	1.231	1.851	3.505	7.069	10.951	22.065	38.957	62.232
	0,22	0,19	0,23	0,28	0,34	0,37	0,44	0,53	0,59	0,70	0,82	0,91
7	101	149	339	631	1.348	2.029	3.847	7.771	11.828	23.833	42.079	67.218
	0,24	0,21	0,26	0,30	0,37	0,41	0,48	0,58	0,64	0,76	0,88	0,98
8	101	159	362	683	1.441	2.169	4.112	8.307	12.645	26.003	44.984	71.859
	0,24	0,22	0,27	0,33	0,40	0,44	0,52	0,62	0,69	0,83	0,94	1,05
9	101	170	388	724	1.550	2.335	4.362	8.811	13.667	27.581	47.713	76.218
	0,24	0,24	0,29	0,35	0,43	0,47	0,55	0,66	0,74	0,88	1,00	1,12
10	101	181	409	773	1.634	2.462	4.674	9.288	14.407	29.073	50.294	80.341
	0,21	0,25	0,31	0,37	0,45	0,50	0,59	0,69	0,78	0,93	1,05	1,18
11	101	190	434	811	1.714	2.582	4.902	9.741	15.110	30.492	52.749	86.245
	0,22	0,26	0,33	0,39	0,47	0,52	0,62	0,73	0,82	0,97	1,10	1,26
12	101	201	453	847	1.790	2.696	5.120	10.361	15.782	31.848	56.332	90.080
	0,23	0,28	0,34	0,41	0,49	0,55	0,64	0,77	0,85	1,02	1,18	1,32
13	106	209	472	882	1.890	2.850	5.329	10.784	16.426	33.148	58.633	93.758
	0,24	0,29	0,36	0,42	0,52	0,58	0,67	0,81	0,89	1,06	1,23	1,37
14	110	219	496	927	1.961	2.958	5.530	11.191	17.046	34.399	60.846	97.298
	0,25	0,30	0,38	0,44	0,54	0,60	0,70	0,84	0,92	1,10	1,27	1,42
15	115	227	513	960	2.030	3.061	5.724	11.584	17.644	35.607	62.982	100.713
	0,26	0,31	0,39	0,46	0,56	0,62	0,72	0,87	0,96	1,14	1,32	1,47
16	119	234	530	991	2.097	3.162	6.013	11.964	18.223	36.774	65.047	104.016
	0,27	0,32	0,40	0,47	0,58	0,64	0,76	0,89	0,99	1,17	1,36	1,52
17	123	241	546	1.022	2.161	3.259	6.198	12.332	18.784	37.906	67.049	107.217
	0,28	0,33	0,41	0,49	0,59	0,66	0,78	0,92	1,02	1,21	1,40	1,57
18	127	251	569	1.051	2.224	3.354	6.377	12.690	19.329	39.005	68.993	110.325
	0,29	0,35	0,43	0,50	0,61	0,68	0,80	0,95	1,05	1,24	1,44	1,62
19	131	258	584	1.095	2.319	3.446	6.552	13.037	20.251	40.936	70.883	113.348
	0,30	0,36	0,44	0,52	0,64	0,70	0,82	0,97	1,10	1,31	1,48	1,66
20	134	264	599	1.123	2.380	3.535	6.722	13.376	20.778	41.999	72.725	116.293
	0,30	0,37	0,45	0,54	0,65	0,72	0,86	1,00	1,13	1,34	1,52	1,70
21	139	271	614	1.151	2.438	3.680	6.888	13.706	21.291	43.037	74.521	119.165
	0,31	0,37	0,47	0,55	0,67	0,74	0,87	1,02	1,15	1,37	1,56	1,75
22	142	280	629	1.178	2.496	3.767	7.051	14.029	21.792	44.049	76.274	121.969
	0,32	0,39	0,48	0,56	0,68	0,76	0,89	1,05	1,18	1,41	1,60	1,79
23	145	287	643	1.204	2.552	3.852	7.209	14.344	22.281	45.039	77.989	124.710
	0,33	0,40	0,49	0,58	0,70	0,78	0,91	1,07	1,21	1,44	1,63	1,83
24	149	293	665	1.230	2.607	3.934	7.364	14.932	22.761	46.008	79.666	127.393
	0,34	0,40	0,50	0,59	0,72	0,80	0,93	1,12	1,23	1,47	1,67	1,87
25	153	299	679	1.255	2.661	4.016	7.516	15.240	23.230	46.957	81.309	130.019
	0,35	0,41	0,51	0,60	0,73	0,81	0,95	1,14	1,26	1,50	1,70	1,90
26	156	305	692	1.280	2.713	4.095	7.665	15.541	23.690	47.887	82.919	132.594
	0,35	0,42	0,52	0,61	0,74	0,83	0,97	1,16	1,28	1,53	1,74	1,94
27	159	311	705	1.323	2.765	4.173	7.811	15.838	24.141	48.799	84.499	135.120
	0,36	0,43	0,53	0,63	0,76	0,84	0,98	1,18	1,31	1,56	1,77	1,98
28	162	320	718	1.347	2.816	4.250	7.954	16.128	24.584	49.694	86.049	137.600
	0,37	0,44	0,54	0,64	0,77	0,86	1,00	1,21	1,33	1,59	1,80	2,02
29	165	325	731	1.371	2.865	4.325	8.095	16.414	25.019	50.574	87.572	140.035
	0,37	0,45	0,55	0,66	0,79	0,88	1,02	1,23	1,36	1,61	1,83	2,05
30	168	331	743	1.394	2.914	4.399	8.379	16.694	25.447	51.438	89.069	142.429
	0,38	0,46	0,56	0,67	0,80	0,89	1,05	1,25	1,38	1,64	1,86	2,09
31	172	336	756	1.417	3.009	4.472	8.517	16.970	25.868	52.289	90.542	144.784
	0,39	0,46	0,57	0,68	0,83	0,91	1,07	1,27	1,40	1,67	1,89	2,12

	DIN 2448						
Ø nominal pulgadas	8"	10"	12"	14"	16"	18"	20"
mm	200	250	300	350	400	450	500
Ø interior mm	207,3	260,4	309,7	339,6	388,8	437,2	486
Perdida de carga en mm.c.a. / ml	CAUDAL EN L/H / VELOCIDAD EN M/S						
3	92.570	167.752	265.496	343.450	481.682	664.595	892.507
	0,76	0,87	0,98	1,05	1,13	1,29	1,34
4	106.890	198.736	314.969	396.582	572.324	767.408	1.030.579
	0,88	1,04	1,16	1,22	1,34	1,42	1,54
5	122.458	222.193	352.146	443.393	639.877	857.988	1.152.222
	1,01	1,16	1,30	1,36	1,50	1,59	1,73
6	134.146	243.401	385.756	485.712	700.950	939.879	1.262.196
	1,10	1,27	1,42	1,49	1,64	1,74	1,89
7	144.895	262.903	416.664	524.629	757.113	1.046.429	1.363.327
	1,19	1,37	1,54	1,61	1,77	1,94	2,04
8	154.899	281.055	445.433	577.112	809.388	1.118.680	1.457.458
	1,27	1,47	1,64	1,77	1,89	2,07	2,18
9	164.295	298.104	472.453	612.120	858.485	1.186.539	1.545.868
	1,35	1,55	1,74	1,88	2,01	2,20	2,31
10	173.182	314.229	498.009	645.231	904.923	1.250.722	1.629.488
	1,43	1,64	1,84	1,98	2,12	2,31	2,44
11	181.635	329.566	522.316	676.724	949.091	1.311.768	1.709.021
	1,49	1,72	1,93	2,08	2,22	2,43	2,56
12	189.712	344.220	545.542	706.815	991.293	1.370.097	1.785.014
	1,56	1,80	2,01	2,17	2,32	2,54	2,67
13	197.458	368.094	567.818	735.676	1.031.771	1.426.043	1.857.902
	1,63	1,92	2,09	2,26	2,41	2,64	2,78
14	204.912	381.989	589.252	763.448	1.070.719	1.479.874	1.928.036
	1,69	1,99	2,17	2,34	2,51	2,74	2,89
15	212.104	395.396	609.934	790.243	1.108.300	1.531.815	1.995.707
	1,75	2,06	2,25	2,42	2,59	2,83	2,99
16	219.060	408.363	629.937	816.160	1.144.647	1.582.052	2.061.157
	1,80	2,13	2,32	2,50	2,68	2,93	3,09
17	231.668	420.931	668.149	841.278	1.179.875	1.630.742	2.124.592
	1,91	2,20	2,46	2,58	2,76	3,02	3,18
18	238.385	433.135	687.520	865.668	1.214.082	1.678.020	2.186.187
	1,96	2,26	2,54	2,65	2,84	3,10	3,27
19	244.917	445.003	706.359	889.389	1.285.739	1.724.001	2.246.094
	2,02	2,32	2,60	2,73	3,01	3,19	3,36
20	251.279	456.564	724.710	912.494	1.319.141	1.768.788	2.304.444
	2,07	2,38	2,67	2,80	3,09	3,27	3,45
21	257.485	467.839	742.606	935.028	1.351.717	1.812.468	2.361.352
	2,12	2,44	2,74	2,87	3,16	3,35	3,54
22	263.544	478.848	760.082	957.032	1.383.526	1.855.121	2.416.921
	2,17	2,50	2,80	2,93	3,24	3,43	3,62
23	269.467	489.610	777.164	978.541	1.414.621	1.896.814	2.471.241
	2,22	2,55	2,87	3,00	3,31	3,51	3,70
24	275.263	500.141	793.880	999.587	1.445.046	1.937.610	2.524.392
	2,27	2,61	2,93	3,07	3,38	3,59	3,78
25	280.939	510.454	810.250	1.020.200	1.474.844	1.977.565	2.576.446
	2,31	2,66	2,99	3,13	3,45	3,66	3,86
26	286.503	520.563	826.296	1.040.404	1.504.052	2.016.729	2.627.470
	2,36	2,72	3,05	3,19	3,52	3,73	3,93
27	291.960	530.479	842.036	1.060.223	1.532.703	2.055.146	2.677.522
	2,40	2,77	3,10	3,25	3,59	3,80	4,01
28	297.318	540.214	857.488	1.079.678	1.560.828	2.092.858	2.726.655
	2,45	2,82	3,16	3,31	3,65	3,87	4,08
29	302.580	549.776	872.666	1.098.789	1.588.456	2.129.903	2.774.918
	2,49	2,87	3,22	3,37	3,72	3,94	4,16
30	307.753	559.174	887.584	1.117.573	1.615.611	2.166.314	2.822.356
	2,53	2,92	3,27	3,43	3,78	4,01	4,23
31	312.840	568.418	902.256	1.136.046	1.642.317	2.202.123	2.869.009
	2,57	2,96	3,33	3,48	3,84	4,07	4,30

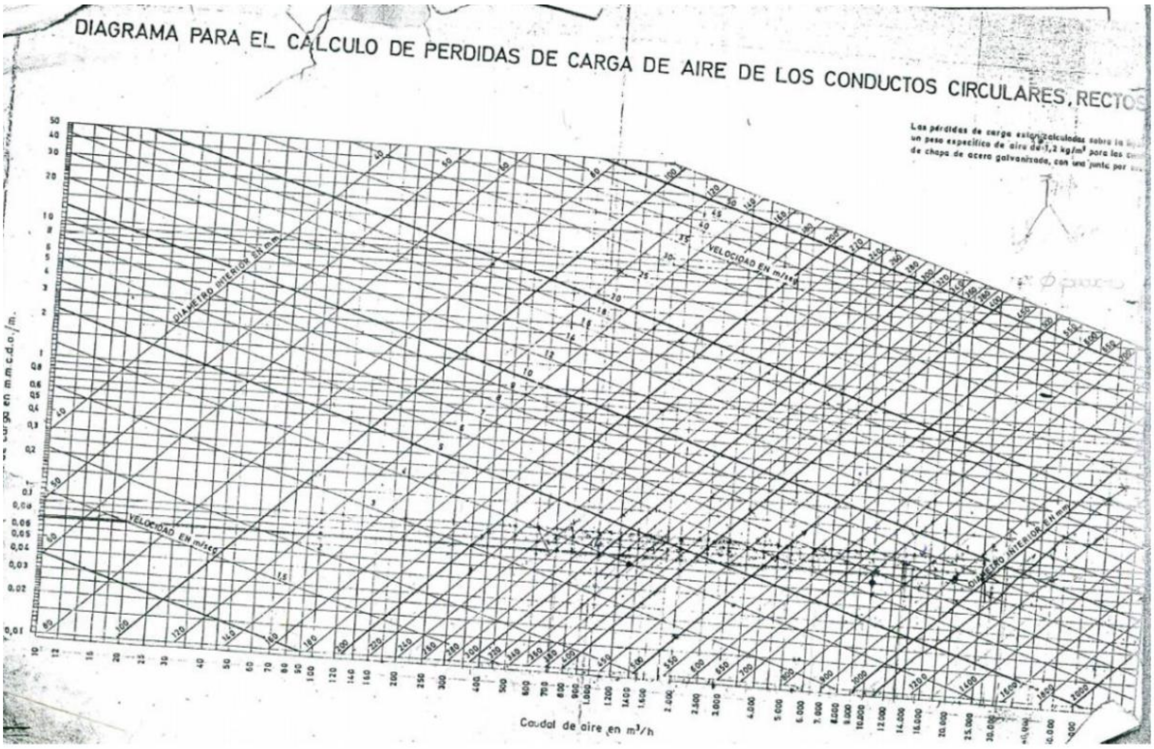
	DIN 2458						
	22"	24"	26"	28"	30"	32"	Ø nominal pulgadas
	550	600	650	700	750	800	mm
	546,4	597,4	645,8	696,8	746	797	Ø interior mm
	CAUDAL EN L/H / VELOCIDAD EN M/S						Perdida de carga en mm.c.a. / ml
	1.196.183	1.495.148	1.816.629	2.268.850	2.690.807	3.174.543	3
	1,42	1,48	1,54	1,65	1,71	1,77	
	1.381.234	1.763.068	2.166.456	2.619.842	3.107.076	3.794.305	4
	1,64	1,77	1,84	1,91	1,97	2,11	
	1.544.266	1.993.530	2.422.172	2.929.073	3.473.816	4.242.162	5
	1,83	1,98	2,05	2,13	2,21	2,36	
	1.691.659	2.183.803	2.653.356	3.208.638	3.938.938	4.647.055	6
	2,00	2,16	2,25	2,34	2,50	2,59	
	1.827.200	2.358.777	2.865.952	3.465.726	4.254.539	5.019.393	7
	2,16	2,34	2,43	2,52	2,70	2,79	
	2.017.421	2.521.639	3.063.832	3.705.016	4.548.293	5.365.957	8
	2,39	2,50	2,60	2,70	2,89	2,99	
	2.139.798	2.674.602	3.249.684	3.929.763	4.824.194	5.691.457	9
	2,53	2,65	2,76	2,86	3,07	3,17	
	2.255.545	2.819.278	3.425.468	4.142.334	5.085.146	5.999.322	10
	2,67	2,79	2,90	3,02	3,23	3,34	
	2.365.636	2.956.883	3.592.661	4.344.517	5.333.347	6.292.142	11
	2,80	2,93	3,05	3,16	3,39	3,50	
	2.470.826	3.088.364	3.752.412	4.696.966	5.570.499	6.571.928	12
	2,93	3,06	3,18	3,42	3,54	3,66	
	2.571.717	3.214.471	3.905.634	4.888.757	5.797.959	6.840.280	13
	3,05	3,19	3,31	3,56	3,68	3,81	
	2.668.797	3.335.814	4.053.068	5.073.303	6.016.826	7.098.494	14
	3,16	3,31	3,44	3,70	3,82	3,95	
	2.762.467	3.452.896	4.195.324	5.251.367	6.228.007	7.347.639	15
	3,27	3,42	3,56	3,83	3,96	4,09	
	2.853.064	3.566.135	4.332.912	5.423.589	6.432.258	7.588.609	16
	3,38	3,53	3,67	3,95	4,09	4,23	
	2.940.871	3.675.888	4.466.264	5.590.507	6.630.220	7.822.159	17
	3,48	3,64	3,79	4,07	4,21	4,36	
	3.026.131	3.782.458	4.595.747	5.752.585	6.822.440	8.048.936	18
	3,58	3,75	3,90	4,19	4,34	4,48	
	3.109.054	3.886.106	4.721.682	5.910.219	7.009.391	8.269.495	19
	3,68	3,85	4,00	4,31	4,45	4,60	
	3.189.822	3.987.061	4.844.343	6.063.756	7.191.483	8.484.323	20
	3,78	3,95	4,11	4,42	4,57	4,72	
	3.268.595	4.085.521	4.963.974	6.213.501	7.369.077	8.693.844	21
	3,87	4,05	4,21	4,53	4,68	4,84	
	3.345.514	4.181.664	5.080.790	6.359.721	7.542.491	8.898.433	22
	3,96	4,14	4,31	4,63	4,79	4,95	
	3.420.704	4.275.646	5.194.979	6.502.654	7.712.006	9.098.423	23
	4,05	4,24	4,41	4,74	4,90	5,07	
	3.494.275	4.367.606	5.306.712	6.642.512	7.877.875	9.294.110	24
	4,14	4,33	4,50	4,84	5,01	5,17	
	3.566.330	4.457.669	5.416.140	6.779.486	8.040.323	9.485.762	25
	4,22	4,42	4,59	4,94	5,11	5,28	
	3.636.957	4.545.948	5.523.401	6.913.746	8.199.552	9.673.617	26
	4,31	4,51	4,68	5,04	5,21	5,39	
	3.706.239	4.632.546	5.628.618	7.045.448	8.355.748	9.857.893	27
	4,39	4,59	4,77	5,13	5,31	5,49	
	3.774.249	4.717.554	5.731.904	7.174.733	8.509.078	10.038.787	28
	4,47	4,68	4,86	5,23	5,41	5,59	
	3.841.055	4.801.057	5.833.361	7.301.730	8.659.692	10.216.478	29
	4,55	4,76	4,95	5,32	5,50	5,69	
	3.906.719	4.883.132	5.933.064	7.426.555	8.807.732	10.391.131	30
	4,63	4,84	5,03	5,41	5,60	5,79	
	3.971.297	4.963.850	6.031.158	7.549.316	8.953.324	10.562.897	31
	4,70	4,92	5,11	5,50	5,69	5,88	

Diameter ratio, losses, flow and speed of in water pipes at 60ºC

Diámetro exterior (mm)	Temperatura máxima del fluido (°C)		
	40...60	> 60...100	> 100...180
D ≤ 35	25	25	30
35 < D ≤ 60	30	30	40
60 < D ≤ 90	30	30	40
90 < D ≤ 140	30	40	50
140 < D	35	40	50

Minimum thickness of pipe insulation according to RITE

Annexed 5. Calculation of ducts



Loss diagram in circular air ducts

Datos técnicos						
Tamaño	L_{WA}	25 dB(A)	30 dB(A)	35 dB(A)	40 dB(A)	45 dB(A)
300 x 8	Q	155	183	215	260	306
	Δp	21	30	41	60	83
400 x 16	Q	240	280	325	390	455
	Δp	16	22	30	43	59
500 x 24	Q	265	325	390	470	570
	Δp	11	17	25	36	53
600 x 24	Q	400	480	570	675	800
	Δp	11	16	22	31	44
600 x 48	Q	480	585	700	840	1.000
	Δp	12	17	25	36	52
652 x 54	Q	500	590	720	825	1.000
	Δp	12	17	24	33	44
825 x 72	Q	790	950	1.140	1.365	1.625
	Δp	11	16	23	32	46

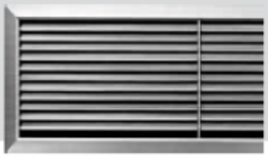
Calculados con plenum de conexión horizontal.

Definiciones:
L_{WA} en dB(A): Nivel de potencia sonora
Q en m³/h: Caudal de aire
Δp en Pa: Pérdida de carga

Losses due to diffusers in circular air ducts

Rejillas de retorno

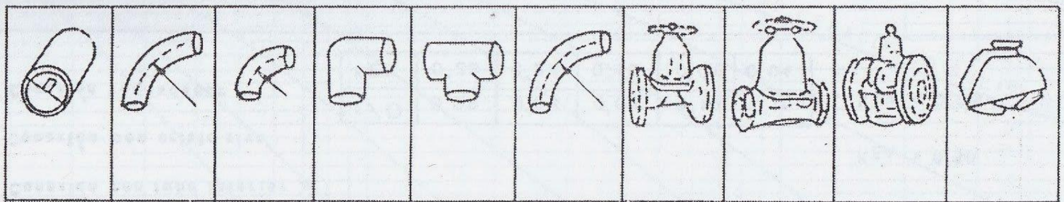
Serie AT (Rango de caudales 100 a 6.000 m³/h)



Datos técnicos con regulación abierta y lama a 0º

Caudal m³/h	H	L																					
	525															525		625		825		1.025	1.225
	425											425		525		625		825		1.025	1.225		
	325							325		425	525			625		825	1.025		1.225				
	225				225		325	425		525	625		825		1.025	1.225							
	165		225		325	425	525	625		825	1.025		1.225										
	125	225		325	425	525	625	825		1.025	1.225												
100	Δp	2																					
	dB(A)	<15																					
200	Δp	9	5	4	2																		
	dB(A)	24	19	17	<15																		
300	Δp	20	12	9	5	3	2																
	dB(A)	34	29	27	20	15	<15																
400	Δp		22	17	9	5	4	2															
	dB(A)		36	34	27	22	18	<15															
500	Δp			26	14	8	6	3	3	2													
	dB(A)			39	32	27	23	18	<15	<15													
600	Δp				20	12	9	5	4	3	2												
	dB(A)				37	32	28	22	18	17	<15												
700	Δp				27	17	12	7	5	4	3	2											
	dB(A)				41	36	32	25	22	21	17	<15											
800	Δp					22	16	9	7	6	4	2	2	2									
	dB(A)					39	35	29	25	24	21	16	15	<15									
900	Δp					27	20	11	9	7	5	3	3	2	2								
	dB(A)					42	38	32	28	27	24	19	18	16	<15								
1.000	Δp						24	14	11	9	6	4	3	3	2								
	dB(A)						41	34	31	30	26	21	21	19	16								
1.200	Δp							20	15	13	9	6	5	4	3	2							
	dB(A)							39	36	35	31	26	25	23	21	17							
1.400	Δp							27	21	17	12	8	6	5	4	3	2	2					
	dB(A)							43	40	39	35	30	29	27	25	21	16	15					
1.600	Δp								27	22	16	10	8	7	6	4	2	2	2				
	dB(A)								43	42	38	34	32	30	28	24	19	18	16				
1.800	Δp									28	20	12	11	9	7	5	3	3	2	2			
	dB(A)									44	41	36	35	33	31	27	22	21	19	17			
2.000	Δp										24	15	13	11	9	6	4	3	3	2			
	dB(A)										44	39	38	36	34	30	25	24	22	19			

Grid losses in circular air ducts



DIAMETRO INTERNO (m.m.)	CURVA 90° R-3D	CURVA 90° R-2D	CODO	TE	MANGUERA R-100	DIAFRAGMA ABIERTA	MANQUITO	MACHO PASO RECTO	TECH TAYLOR
	LONGITUD EQUIVALENTE EN m DE TUBO RECTO DE IGUAL RESISTENCIA AL FLUJO.								
25	0·52	0·70	0·82	1·77	0·30	2·56	—	0·37	—
32	0·73	0·91	1·13	2·38	0·40	5·29	—	0·49	—
40	0·85	1·10	1·31	2·74	0·49	3·44	1·19	0·58	—
50	1·07	1·40	1·68	3·35	0·55	3·66	1·43	0·73	—
65	1·28	1·65	1·98	4·27	0·70	4·60	1·52	0·85	—
80	1·55	2·07	2·47	5·18	0·85	4·88	1·92	1·04	0.20
90	1·83	2·44	2·90	5·79	1·01	—	—	1·22	—
100	2·13	2·77	3·35	6·71	1·16	7·62	2·19	1·40	0·23
115	2·41	3·05	3·66	7·32	1·28	—	—	1·58	—
125	2·71	3·66	4·27	8·23	1·43	13·11	3·05	1·77	0·30
150	3·35	4·27	4·88	10·06	1·55	18·29	3·11	2·13	0·37
200	4·27	5·49	6·40	13·11	2·41	19·81	7·92	2·74	0·82
250	5·18	6·71	7·92	17·07	2·99	21·34	10·67	3·47	0·61
300	6·10	7·92	9·75	20·12	3·35	28·96	15·85	4·08	0·76
350	7·01	9·45	10·97	23·16	4·27	28·96	—	4·88	0·91
400	8·23	10·67	12·80	26·52	4·88	—	—	5·49	1·04
450	9·14	12·19	14·02	30·48	5·49	—	—	6·22	1·16
500	10·36	13·11	15·85	33·53	6·10	—	—	7·32	1·25

NOTA: PARA CURVA 135° USAR VALOR CURVA 90° x 1.5

FIG. 17. LONGITUDES EQUIVALENTES DE SINGULARIDADES EN TUBOS

Equivalent length of circular air ducts per elbow

LONGITUD EQUIVALENTE EN ML DE ACCESORIOS PARA REDES DE CONDUCTOS

n=	0,326	0,53	
v (m/s)	REDUCCIÓN	DERIVACIÓN	SUMA
1	0,20	0,33	0,53
1,5	0,46	0,75	1,21
2	0,82	1,33	2,15
2,5	1,27	2,07	3,34
3	1,83	2,98	4,81
3,5	2,50	4,06	6,56
4	3,26	5,30	8,56
4,5	4,13	6,71	10,84
5	5,09	8,28	13,37
5,5	6,16	10,02	16,18
6	7,34	11,93	19,27
6,5	8,61	14,00	22,61
7	9,98	16,23	26,21
7,5	11,46	18,63	30,09
8	13,04	21,20	34,24
8,5	14,72	23,93	38,65
9	16,50	26,83	43,33
9,5	18,39	29,90	48,29
10	20,38	33,13	53,51
10,5	22,46	36,52	58,98

v (m/s)	REDUCCIÓN	DERIVACIÓN	SUMA
11	24,65	40,08	64,73
11,5	26,95	43,81	70,76
12	29,34	47,70	77,04
12,5	31,84	51,76	83,60
13	34,43	55,98	90,41
13,5	37,13	60,37	97,50
14	39,94	64,93	104,87
14,5	42,84	69,65	112,49
15	45,84	74,53	120,37
15,5	48,95	79,58	128,53
16	52,16	84,80	136,96
16,5	55,47	90,18	145,65
17	58,88	95,73	154,61
17,5	62,40	101,45	163,85
18	66,02	107,33	173,35
18,5	69,73	113,37	183,10
19	73,55	119,58	193,13
19,5	77,48	125,96	203,44
20	81,50	132,50	214,00

Equivalent length of circular air ducts for deviations and reductions

5-04 2010	**INTERPRETACION DE NORMATIVA: Caudales de aire de ventilación de locales**	RITE IT1.1

AIRE EXTERIOR PARA VENTILACIÓN DE LOCALES

1. Locales con ocupación humana permanente o habitual

En la tabla siguiente se indica, en función del uso del edificio o local, la categoría de calidad del aire interior IDA que se deberá alcanzar como mínimo (IT 1.1.4.2.2) y el caudal de aire exterior requerido por persona para cada IDA obtenido por el procedimiento simplificado "Método indirecto de caudal de aire exterior por persona" (IT 1.1.4.2.3 y tabla 1.4.2.1).

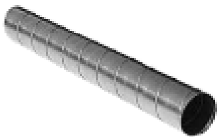
Uso del local y categoría de calidad de aire interior exigible		Con fumadores	Sin fumadores
Hospitales y clínicas Laboratorios Guarderías	IDA 1 (calidad óptima)	0,04 m^3 / s.per 40 dm^3 / s.per 144 m^3 / h.per	0,02 m^3 / s.per 20 dm^3 / s.per 72 m^3 / h.per
Oficinas Locales comunes de hoteles y similares Residencias de ancianos Residencias de estudiantes Salas de lectura Museos Salas de tribunales Aulas de enseñanza y asimilares Piscinas (*)	IDA 2 (buena calidad)	0,025 m^3 / s.per 25 dm^3 / s.per 90 m^3 / h.per	0,0125 m^3 / s.per 12,5 dm^3 / s.per 45 m^3 / h.per
Edificios comerciales Cines y teatros Salones de actos Habitaciones de hoteles y similares Restaurantes, cafeterías y bares Salas de fiestas Gimnasios y locales para el deporte (excepto piscinas) Salas de ordenadores	IDA 3 (calidad media)	0,016 m^3 / s.per 16 dm^3 / s.per 57,6 m^3 / h.per	0,008 m^3 / s.per 8 dm^3 / s.per 28,8 m^3 / h.per
	IDA 4 (calidad baja)	0,01 m^3 / s.per 10 dm^3 / s.per 36 m^3 / h.per	0,005 m^3 / s.per 5 dm^3 / s.per 18 m^3 / h.+per

(*) En piscinas climatizadas se utiliza el método de dilución.

Interpretation of the regulation: Air flow rates for premises ventilation

Conductos circulares galva

Conductos circulares



VENTAJAS
- Amplia gama disponible en stock.
- Espesor de las chapas y calidad de galvanización conformes a las normas de calidad.

CAMPO DE APLICACIÓN
- Todas las redes de distribución de aire.

MONTAJE
- Facilidad de montaje de los accesorios por encaje: los conductos son hembra, los accesorios son macho.
- Sujeción por abrazaderas, cinta perforada, carriles... (ver pág. 339 - 344).

DESCRIPCIÓN
- Conducto recto circular en chapa de acero galvanizado engatillado en hélice siguiendo la norma de fabricación de conductos EN 1506.
- Los espesores de acero utilizados para la fabricación de los conductos siguen la norma XP E 51-620 que fija los espesores mínimos por diámetros.
- Acero galvanizado conforme a la norma EN 10 142.
- Largo máximo 5 m.
- Conducto reforzado con nervio exterior para los diámetros ≥ 630 mm.

GAMA

Ø	Peso por m (Kg)	Espesor (mm)	Barra Estándar BS 3 m	Barra Estándar BS 5 m	El ml no estándar
			Código	Código	Código
125	1,74	0.5	11091243	11091263	11091203
150	2,08	0.5	11091244	11091264	11091204
160	2,22	0.5	11091245	11091265	11091205
200	2,90	0.5	11091246	11091266	11091206
250	4,31	0.6	11091247	11091267	11091207
315	5,43	0.6	11091248	11091268	11091208
355	6,12	0.6	11091249	11091269	11091209
400	9,20	0.8	11091250	11091270	11091210
450	10,35	0.8	11091256	11091271	11091216
500	11,50	0.8	11091251	11091272	11091211
560	12,87	0.8	11091257	11091277	11091217
630	14,48	0.8	11091252	11091273	11091212
710	16,32	0.8	11091258	11091278	11091218
800	22,98	1.0	11091253	11091274	11091213

Technical sheet of the manufacturer of the air-air ducts

Annexed 6. Technical data of the boilers

caldera polyvalente ADINOX

Tipo Baja Temperatura

DOSSIER TÉCNICO
DE INSTALACIÓN, USO
Y MANTENIMIENTO

05/2003

la llama azul ADISA

MODELO ADINOX BT Polyvalente

CONCEPTO		Uds.	100	120	150	180	220	270	330	399	500
Potencia útil	Máxima	kW	101,1	119,8	151,0	177,3	219,7	263,8	322,5	381,8	464,8
		Te	86,9	103,0	129,8	152,5	188,9	226,9	277,3	328,4	399,8
	Mínima potencia (ajuste modulante)	kW	33,6	39,8	50,2	59,0	73,0	87,7	107	127,0	154,6
		Te	28,9	34,3	43,2	50,7	62,8	75,5	92,2	109,2	132,9
	Primera etapa (ajuste Progresiva)	kW	50,8	60,2	75,9	89,1	110,4	132,6	162,1	191,9	233,8
		Te	43,7	51,8	62,3	76,6	94,9	114	139,4	165	201
Gas Natural (G20)	Caudal	m^3/h	9,9	11,7	14,8	17,4	21,5	25,8	31,5	37,3	45,5
	Presión nominal (mín. – máx.)	mbar	20 (18 - 45)								
	Caudal de humos	m^3/h	233,9	278	349,1	411	507,9	610,3	745,7	882,1	1076,4
Gas Propano (G31)	Caudal	m^3/h	4,3	5,1	6,4	7,5	9,3	11,2	13,7	16,2	19,8
		kg/h	8,5	10,1	12,7	14,9	18,5	22,2	27,1	32,1	39,1
	Presión nominal (mín. – máx.)	mbar	37 (35 – 45)								
	Caudal de humos	m^3/h	233,9	278	349,1	411	507,9	610,3	745,7	882,1	1076,4
Opción regulación quemador	Progresiva		SI	SI	SI	SI	SI	SI	SI	SI	SI
	Modulante		SI	SI	SI	SI	SI	SI	SI	SI	SI
Depresión chimenea en frio		mbar	0	0	0	0	0	0	0	0	0
Presión hidráulica máxima		bar	5	5	5	5	5	5	5	5	5
Peso de la caldera sin agua		kg	210	215	264	270	320	325	420	424	470
Capacidad de agua		litros	42	42	63	63	71	71	97	97	112
Caudal de agua	$\Delta T = 7°C$	m^3/h	12,4	14,7	18,6	21,8	27	32,4	39,6	46,9	57,1
	$\Delta T = 10°C$	m^3/h	8,7	10,3	13	15,2	18,9	22,7	27,7	32,8	39,9
	$\Delta T = 12°C$	m^3/h	7,2	8,6	10,8	12,7	15,7	18,9	23,1	27,4	33,3
Conexión eléctrica	Potencia régimen	W	550	660	770	770	770	880	880	990	1100
	Tensión	V	230 V a 50 Hz, monofásica y con toma de Tierra								

P.C.I. gas natural = 38,23 MJ/m^3
P.C.I. gas propano (GLP) = 88,00 MJ/m^3
Densidad del gas propano = 1.98 kg/m^3

Annexed 7. Technical data of the refrigerator group

BG/WRAT 1402 - 4828
Pf (kW) : 295 - 1076

CLIMAVENETA S.p.A.

BG/WRAT R407C

PRESTACIONES EN REFRIGERACIÓN — *COOLING CAPACITY PERFORMANCE*

B

3626

Ta	25	30	32	35	40	42	25	30	32	35	40	42	25	30	32	35	40	42
Tev	6,0						7,0						8,0					
Pf	873	818	797	766	716	696	901	846	824	792	741	721	931	874	852	819	766	-
Pa	246	261	266	275	288	293	250	265	271	279	293	298	254	270	276	284	298	-
Pat	284	298	304	312	326	331	288	303	309	317	331	336	292	307	313	322	336	-
Qev	150	141	137	132	123	120	155	146	142	136	128	124	160	150	147	141	132	-
Dpev	72	63	60	56	49	46	77	68	64	60	52	49	82	72	69	64	56	-
Tev	9,0						10,0						11,0					
Pf	960	902	879	846	792	-	990	931	907	873	818	-	1.020	959	936	901	845	-
Pa	258	274	280	289	303	-	262	279	285	294	308	-	266	283	289	299	314	-
Pat	296	312	318	327	341	-	300	316	323	332	346	-	304	321	327	337	351	-
Qev	165	155	151	146	136	-	171	160	156	150	141	-	176	165	161	155	146	-
Dpev	87	77	73	68	60	-	93	82	78	72	64	-	99	87	83	77	68	-

4408

Ta	25	30	32	35	40	42	25	30	32	35	40	42	25	30	32	35	40	42
Tev	6,0						7,0						8,0					
Pf	999	938	915	880	823	-	1.031	969	945	909	851	-	1.063	1.000	975	939	880	-
Pa	302	320	327	338	354	-	307	326	333	344	360	-	312	331	339	350	367	-
Pat	340	358	365	375	392	-	345	364	371	381	398	-	350	369	377	387	405	-
Qev	172	162	157	151	142	-	178	167	163	156	147	-	183	172	168	162	151	-
Dpev	52	46	43	40	35	-	55	49	46	43	38	-	59	52	49	46	40	-
Tev	9,0						10,0						11,0					
Pf	1.096	1.031	1.006	968	-	-	1.129	1.063	1.037	999	-	-	1.162	1.094	1.068	1.029	-	-
Pa	317	337	345	356	-	-	323	343	350	362	-	-	328	348	356	368	-	-
Pat	355	375	382	393	-	-	360	380	388	399	-	-	366	386	394	405	-	-
Qev	189	178	173	167	-	-	194	183	179	172	-	-	200	189	184	177	-	-
Dpev	62	55	53	49	-	-	66	59	56	52	-	-	70	62	59	55	-	-

4828

Ta	25	30	32	35	40	42	25	30	32	35	40	42	25	30	32	35	40	42
Tev	6,0						7,0						8,0					
Pf	1.151	1.079	1.051	1.010	944	919	1.188	1.115	1.087	1.045	977	-	1.227	1.152	1.123	1.080	1.011	-
Pa	330	349	357	368	385	392	335	355	363	374	392	-	341	362	369	381	399	-
Pat	380	400	407	418	435	442	386	406	414	425	442	-	391	412	420	431	449	-
Qev	198	186	181	174	163	158	205	192	187	180	168	-	211	198	193	186	174	-
Dpev	53	47	44	41	36	34	57	50	47	44	38	-	60	53	50	47	41	-
Tev	9,0						10,0						11,0					
Pf	1.265	1.189	1.159	1.115	1.045	-	1.304	1.226	1.196	1.151	1.079	-	1.344	1.264	1.233	1.188	-	-
Pa	347	368	376	387	406	-	352	374	382	394	413	-	358	380	388	401	-	-
Pat	397	418	426	438	456	-	402	424	432	444	463	-	408	430	439	451	-	-
Qev	218	205	200	192	180	-	225	211	206	198	186	-	232	218	213	205	-	-
Dpev	64	57	54	50	44	-	68	60	57	53	47	-	72	64	61	57	-	-

Ta [°C] - aire exterior
Tev [°C] - agua salida evaporador
Pf [kW] - potencia frigorífica
Pa [kW] - potencia absorbida compresores
Pat [kW] - potencia absorbida total
Qev [m³/h] - caudal agua evaporador
Dpev [kPa] - pérdida de carga evaporador
" - " Condiciones fuera de los límites de funcionamiento
NOTA: Los datos en el fondo se refieren a unidades con funcionamiento no silenciado

Ta [°C] - ambient temperature
Tev [°C] - evaporator output water temperature
Pf [kW] - cooling capacity
Pa [kW] - compressor power consumption
Pat [kW] - total power input
Qev [m³/h] - evaporator water flow
Dpev [kPa] - evaporator pressure drop
" - " Conditions outside the operating range
NOTE: Data on grey background: unit switched to non-silenced operation.

ELCAdoc 20/06/03 — CLIMAVENETA — B100AS_101_030A_CV_10_03_ES_GB — HFC R407C

Annexed 8. Air Handler Unit (AHU) datasheet

termoven
Equipos de Climatización

CLIMATIZADORES
SERIE CLA

Modelo	m3/h	Con enfriamiento			Sólo calor			Recup. rotativo		Entrada-Mezcla			Rec. Esta.	Vent.
		St.m2	A	B	St.m2	A	B	⊘BR	RR	E	M	M2	RE	SV
CLA-2007/1	1600	0,30	775	550	0,30	775	550	925	550	275	350	900	750	750
CLA-2007/2	2100	0,37	925	550	0,30	775	550	1075	550	275	350	900	750	750
CLA-2009/1	2800	0,49	925	700	0,40	775	700	1075	550	350	425	1050	975	825
CLA-2009/2	3450	0,58	1075	700	0,49	925	700	1075	550	350	425	1050	975	900
CLA-2010/1	4400	0,66	1075	775	0,56	925	775	1150	550	350	425	1050	1275	975
CLA-2012/1	6000	0,86	1375	775	0,66	1075	775	1375	550	350	425	1050	1275	975
CLA-2015/1	7200	1,05	1375	925	0,80	1075	925	1375	625	350	575	1275	1500	1125
CLA-2015/2	8500	1,30	1675	925	1,05	1375	925	1675	625	350	575	1275	1500	1125
CLA-2018/1	10200	1,53	1675	1075	1,24	1375	1075	1675	625	500	575	1275	1650	1275
CLA-2018/2	12500	1,65	1675	1150	1,32	1450	1075	1675	625	500	575	1275	1650	1275
CLA-2020/1	15000	2,07	1865	1340	1,89	1715	1340	1865	665	520	670	1500	1800	1350
CLA-2020/2	17000	2,25	2015	1340	1,89	1715	1340	2015	665	520	670	1500	1800	1500
CLA-2022/1	19000	2,53	2015	1490	2,23	1790	1490	2015	665	520	745	1650	1950	1500
CLA-2022/2	21000	2,73	2315	1490	2,23	1790	1490	2315	665	520	745	1650	1950	1575
CLA-2025/1	23500	3,03	2315	1565	2,67	2015	1565	2315	665	520	820	1875	2175	1650
CLA-2025/2	26000	3,42	2315	1715	2,88	2165	1565	2315	665	595	820	1875	2175	1650
CLA-2025/3	28500	3,75	2315	1865	3,10	2315	1565	2465	665	670	820	1875	2250	1650
CLA-2030/1	31000	3,91	2315	1940	3,46	2240	1790	2540	665	670	1045	2100	2250	1800
CLA-2030/2	33500	4,32	2540	1940	3,59	2315	1790	2690	665	670	1045	2100	2250	1800
CLA-2030/3	36000	4,59	2690	1940	3,59	2315	1790	2690	665	670	1045	2100	2250	1800
CLA-2030/4	38500	4,86	2840	1940	4,08	2615	1790	2840	665	670	1045	2100	2400	1800
CLA-2080/1	40800	5,26	2840	2090	4,08	2315	2015	3065	815	745	1120	2250	2400	1800
CLA-2080/2	45000	5,70	3065	2090	4,64	2615	2015	3065	815	745	1120	2250	2400	1950
CLA-2060/3	48500	6,14	3290	2090	4,83	2615	2090	3290	815	745	1120	2250	2550	1950
CLA-2090/1	52000	6,61	3290	2240	5,41	2915	2090	3290	815	745	1345	2550	2550	2100
CLA-2090/2	56000	7,09	3515	2240	5,41	2915	2090	3515	815	745	1345	2550	2550	2100
CLA-2090/3	60500	7,56	3740	2240	5,99	3215	2090	3740	890	745	1345	2700	2550	2100
CLA-2090/4	65000	8,10	3740	2390	6,58	3515	2090	3740	890	820	1345	2700	2550	2100
CLA-2100/1	70000	8,82	3815	2540	7,34	3515	2315	3815	890	895	1345	2700	2550	2250
CLA-2100/2	80000	10,80	4340	2540	8,00	3815	2315	4340	890	895	1420	2700	2550	2250

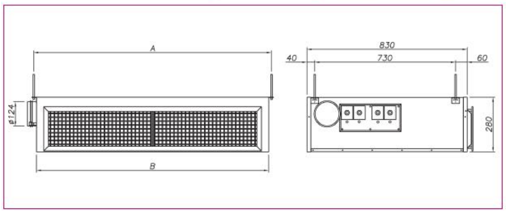
* Cotas mínimas

*** Cotas aproximadas, pueden variar

Annexed 9. Inductors datasheet

IHK-F

Los inductores de techo modelo IHK-F de Koolair son unidades terminales específicamente diseñadas para su empleo en hoteles y hospitales, donde la zona a climatizar no dispone de falso techo y cuya instalación se realiza en pasillo anexo. La impulsión de aire horizontal en una dirección y la entrada de aire inducido del local se realiza en la misma rejilla.

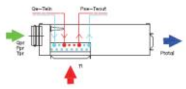


Características técnicas

Simbología

La simbología utilizada en las tablas de selección del inductor de techo IHK son las siguientes:

Q_{pr}	*Caudal de aire primario*
L_w-dB(A)	*Nivel de potencia sonora en dB(A)*
ΔP_{pr}	*Pérdida de carga en aire primario en Pa*
T_{pr}	*Temperatura del aire primario en °C*
T_R	*Temperatura del aire del local en °C*
ΔT_{pr}	*Diferencia de temperatura entre el aire del local y el aire primario (T_R - T_{pr})*
Q_W	*Caudal de agua en L/h*
ΔP_W	*Pérdida de carga del agua en la batería en kPa*
T_{WIN}	*Temperatura de entrada del agua en la batería °C*
ΔT_W	*Salto de temperatura del agua en la batería*
ΔT_{SWIN}	*Diferencia de temperatura entre el local y entrada de agua a la batería*
P_{pr}	*Potencia aportada por el aire primario en W*
P_{SW}	*Potencia aportada por la batería en W*
P_T	*Potencia total P_{pr} + P_{SW} en W*
X	*Alcance de la vena de aire en m, para una velocidad máxima en zona ocupada de 0,25 m/s, con ΔT = 0 °C (impulsión - ambiente)*



Serie IHK 11

Características técnicas. Tablas de selección

REFRIGERACIÓN - SISTEMA 2 TUBOS

Caudal de agua (Q_W) de 200 L/h

Para otros valores de caudal de agua corregir potencia en batería (P_{SW}) de tabla por factores indicados en la tabla anexa.

IHK -SISTEMA 2 TUBOS - REFRIGERACIÓN			
TAMAÑO	900	1200	1500
Q_W (l/h)	Factor de corrección de potencia en batería		
80	0,79	0,79	0,79
100	0,85	0,84	0,85
120	0,89	0,88	0,89
160	0,95	0,94	0,95
180	0,98	0,98	0,98
200	1,00	1,00	1,00
260	1,03	1,03	1,03
280	1,05	1,05	1,05
340	1,07	1,07	1,07

IHK -SISTEMA 2 TUBOS - REFRIGERACIÓN																		
TAMAÑO	TIPO TOBERA	Q_{Pr}		L_W - dB(A)	ΔP_{pr} (Pa)	X (m)	ΔT_{pr} (K)					ΔT_{SWIN} (K)						ΔP_W (kPa)
							6	7	8	9	10	6	7	8	9	10	12	
		l/s	m³/h				P_{pr} (W)					P_{SW} (W)						
900	P	6,9	25	<20	53	2,2	50	58	66	75	83	172	201	223	258	284	341	5.5
		9,2	33	23	92	2,8	66	77	88	99	110	212	244	277	315	349	418	
		11,1	40	28	136	3,5	80	93	106	120	133	245	281	321	362	403	483	
		12,5	45	31	172	3,9	90	105	120	135	150	267	307	352	395	440	528	
		13,9	50	34	212	4,3	100	116	133	150	166	288	332	381	427	476	571	
	M	12,5	45	<20	55	3,1	90	105	120	135	150	223	257	292	331	367	440	
		16,1	58	24	92	4,1	116	135	154	174	193	270	310	355	399	444	533	
		19,4	70	30	134	4,9	140	163	186	210	233	308	356	409	457	510	612	
		22,2	80	33	176	5,6	160	186	213	240	266	338	393	450	503	561	673	
		25,0	90	36	223	6,3	180	210	240	270	300	364	426	488	545	607	729	
	G	19,4	70	20	54	3,6	140	163	186	210	233	252	290	332	373	415	498	
		25,0	90	27	90	4,7	180	210	240	270	300	303	349	401	449	500	600	
		30,6	110	33	135	5,7	220	256	293	330	366	347	404	463	517	577	692	
		34,7	125	36	175	6,5	250	291	333	375	416	376	441	504	564	628	754	
		38,9	140	39	219	7,3	280	326	373	420	466	402	473	540	605	672	808	
1200	P	9,2	33	<20	50	2,4	66	77	88	99	110	223	258	299	335	377	453	7,0
		12,5	45	25	93	3,3	90	105	120	135	150	283	330	379	425	476	571	
		15,0	54	30	134	3,0	108	126	144	162	180	325	379	434	486	543	651	
		17,5	63	34	182	4,6	126	147	168	189	210	363	424	484	543	606	726	
		20,8	75	39	258	5,5	150	175	200	225	250	409	478	545	612	682	816	
	M	16,1	58	<20	50	3,5	116	135	154	174	193	286	333	383	429	480	576	
		20,6	74	25	81	4,4	148	172	197	222	246	343	400	457	513	573	686	
		25,6	92	31	126	5,5	184	214	245	276	306	399	466	532	597	665	797	
		30,0	108	35	173	6,4	216	252	288	324	360	444	519	590	663	739	884	
		36,1	130	40	251	7,7	260	303	346	390	433	497	582	661	744	828	991	
	G	25,0	90	22	49	3,0	180	210	240	270	300	323	377	431	483	540	648	
		30,6	110	27	73	4,9	220	256	293	330	366	373	436	497	557	622	745	
		40,3	145	35	127	6,4	290	338	386	435	483	448	524	596	671	747	894	
		47,2	170	39	175	7,5	340	396	453	510	566	495	579	657	740	823	985	
		52,8	190	42	218	8,4	380	443	506	570	633	528	618	701	790	878	1052	
1500	P	11,7	42	<20	53	2,7	84	98	112	126	140	285	328	376	422	471	566	8.5
		14,4	52	24	81	3,4	104	121	138	156	173	333	385	442	495	553	663	
		17,5	63	30	119	4,1	126	147	168	189	210	383	443	508	569	635	762	
		21,1	76	35	173	4,0	152	177	202	228	253	436	506	580	649	724	869	
		25,0	90	40	244	5,9	180	210	240	270	300	488	567	649	728	811	971	
	M	19,4	70	20	47	3,7	140	163	186	210	233	347	401	460	516	576	691	
		25,0	90	27	79	4,8	180	210	240	270	300	415	481	551	618	689	827	
		30,6	110	32	118	5,8	220	256	293	330	366	475	552	632	708	790	946	
		36,1	130	37	164	6,9	260	303	346	390	433	529	616	703	789	878	1052	
		41,7	150	41	219	7,9	300	350	400	450	500	577	672	767	861	957	1146	
	G	31,9	115	23	52	4,5	230	268	306	345	383	406	470	539	604	674	808	
		40,3	145	29	83	5,7	290	338	386	435	483	475	552	631	708	789	945	
		49,4	178	35	125	7,0	356	415	474	534	593	541	630	719	807	898	1076	
		58,3	210	40	175	8,3	420	490	560	630	700	597	696	794	891	990	1185	
		69,4	250	44	248	9,8	500	583	666	750	833	656	766	875	983	1089	1305	

Características técnicas. Tablas de selección

CALEFACCIÓN - SISTEMA 2 TUBOS

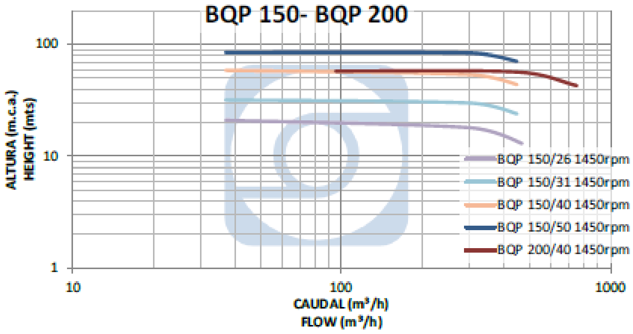
Caudal de agua (Q_W) de 200 L/h

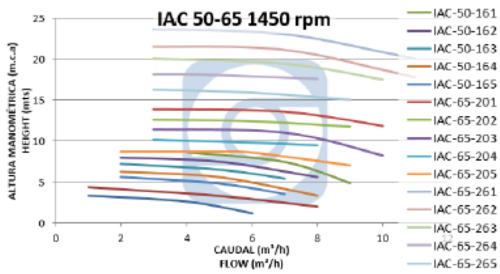
Para otros valores de caudal de agua corregir potencia en batería (P_{SW}) de tabla por factores indicados en la tabla anexa.

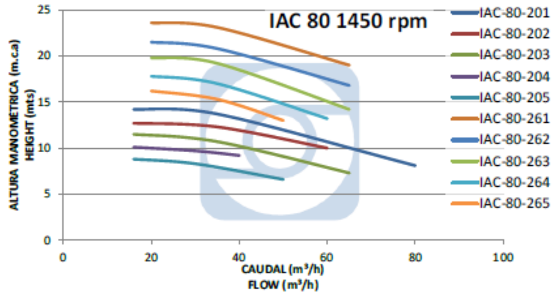
IHK -SISTEMA 2 TUBOS - CALEFACCIÓN			
TAMAÑO	900	1200	1500
Q_W (l/h)	Factor de corrección de potencia en batería		
80	0,81	0,81	0,81
100	0,86	0,86	0,86
120	0,89	0,89	0,89
160	0,96	0,96	0,96
180	0,98	0,98	0,98
200	1,00	1,00	1,00
260	1,03	1,03	1,03
280	1,04	1,04	1,04
340	1,06	1,06	1,06

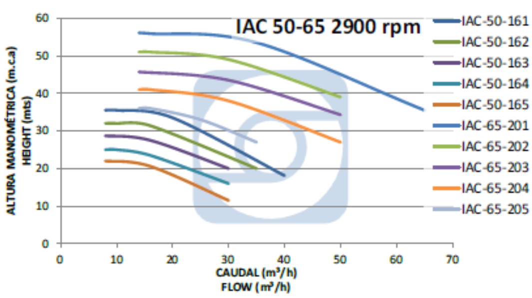
IHK -SISTEMA 2 TUBOS - CALEFACCIÓN																		
TAMAÑO	TIPO TOBERA	Q_{Pr}		L_W - dB(A)	ΔP_{pr} (Pa)	X (m)	ΔT_{pr} (K)					ΔT_{SWIN} (K)						ΔP_W (kPa)
							6	7	8	9	10	10	15	20	25	30	35	
		l/s	m³/h				P_{pr} (W)					P_{SW} (W)						
900	P	6,9	25	<20	53	2,2	50	58	66	75	83	223	337	451	566	680	792	5.5
		9,2	33	23	92	2,8	66	77	88	99	110	279	421	564	708	850	993	
		11,1	40	28	136	3,5	80	93	106	120	133	325	491	657	825	991	1158	
		12,5	45	31	172	3,9	90	105	120	135	150	357	539	721	905	1087	1271	
		13,9	50	34	212	4,3	100	116	133	150	166	387	584	782	981	1179	1379	
	M	12,5	45	<20	55	3,1	90	105	120	135	150	282	425	569	714	858	1002	
		16,1	58	24	92	4,1	116	135	154	174	193	345	520	696	874	1050	1227	
		19,4	70	30	134	4,9	140	163	186	210	233	399	602	805	1010	1214	1420	
		22,2	80	33	176	5,6	160	186	213	240	266	441	665	890	1117	1343	1571	
		25,0	90	36	223	6,3	180	210	240	270	300	481	725	971	1218	1464	1713	
	G	19,4	70	20	54	3,6	140	163	186	210	233	300	453	606	761	914	1068	
		25,0	90	27	90	4,7	180	210	240	270	300	366	552	739	927	1114	1303	
		30,6	110	33	135	5,7	220	256	293	330	366	427	644	861	1081	1299	1519	
		34,7	125	36	175	6,5	250	291	333	375	416	469	707	947	1188	1428	1671	
		38,9	140	39	219	7,3	280	326	373	420	466	510	768	1027	1289	1550	1813	
1200	P	9,2	33	<20	50	2,4	66	77	88	99	110	298	447	595	744	897	1047	7,0
		12,5	45	25	93	3,3	90	105	120	135	150	379	570	760	952	1146	1341	
		15,0	54	30	134	3,0	108	126	144	162	180	437	657	877	1098	1321	1548	
		17,5	63	34	182	4,6	126	147	168	189	210	492	739	987	1237	1487	1742	
		20,8	75	39	258	5,5	150	175	200	225	250	561	842	1125	1410	1695	1984	
	M	16,1	58	<20	50	3,5	116	135	154	174	193	366	551	734	919	1106	1295	
		20,6	74	25	81	4,4	148	172	197	222	246	443	666	888	1113	1338	1568	
		25,6	92	31	126	5,5	184	214	245	276	306	523	785	1049	1314	1580	1851	
		30,0	108	35	173	6,4	216	252	288	324	360	589	884	1181	1480	1779	2082	
		36,1	130	40	251	7,7	260	303	346	390	433	672	1007	1347	1687	2029	2373	
	G	25,0	90	22	49	3,0	180	210	240	270	300	389	584	780	976	1175	1376	
		30,6	110	27	73	4,9	220	256	293	330	366	454	683	912	1142	1373	1609	
		40,3	145	35	127	6,4	290	338	386	435	483	560	841	1123	1407	1692	1981	
		47,2	170	39	175	7,5	340	396	453	510	566	628	943	1260	1579	1899	2222	
		52,8	190	42	218	8,4	380	443	506	570	633	679	1019	1362	1707	2052	2400	
1500	P	11,7	42	<20	53	2,7	84	98	112	126	140	373	566	751	936	1127	1319	8.5
		14,4	52	24	81	3,4	104	121	138	156	173	443	668	889	1110	1335	1562	
		17,5	63	30	119	4,1	126	147	168	189	210	515	774	1032	1290	1551	1814	
		21,1	76	35	173	4,0	152	177	202	228	253	594	891	1190	1489	1790	2092	
		25,0	90	40	244	5,9	180	210	240	270	300	673	1008	1347	1687	2027	2369	
	M	19,4	70	20	47	3,7	140	163	186	210	233	442	667	888	1109	1334	1561	
		25,0	90	27	79	4,8	180	210	240	270	300	538	808	1079	1350	1622	1897	
		30,6	110	32	118	5,8	220	256	293	330	366	626	939	1254	1570	1887	2206	
		36,1	130	37	164	6,9	260	303	346	390	433	707	1059	1415	1773	2130	2490	
		41,7	150	41	219	7,9	300	350	400	450	500	780	1169	1563	1958	2353	2750	
	G	31,9	115	23	52	4,5	230	268	306	345	383	491	739	985	1232	1481	1732	
		40,3	145	29	83	5,7	290	338	386	435	483	587	881	1176	1472	1769	2068	
		49,4	178	35	125	7,0	356	415	474	534	593	683	1023	1367	1712	2057	2405	
		58,3	210	40	175	8,3	420	490	560	630	700	766	1148	1535	1923	2311	2701	
		69,4	250	44	248	9,8	500	583	666	750	833	860	1290	1724	2159	2595	3033	

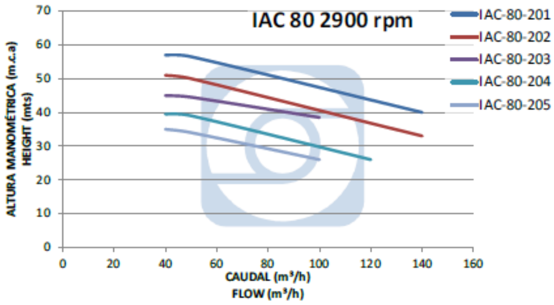
Annexed 10. Technical specifications pumps

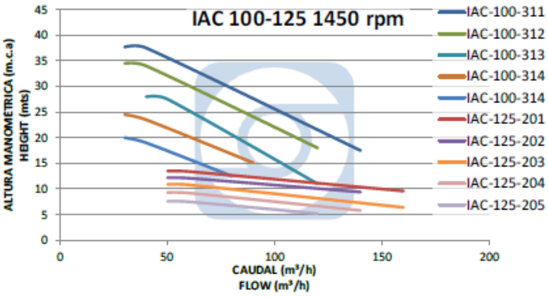












Part V. Bibliography

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DOCUMENT II.

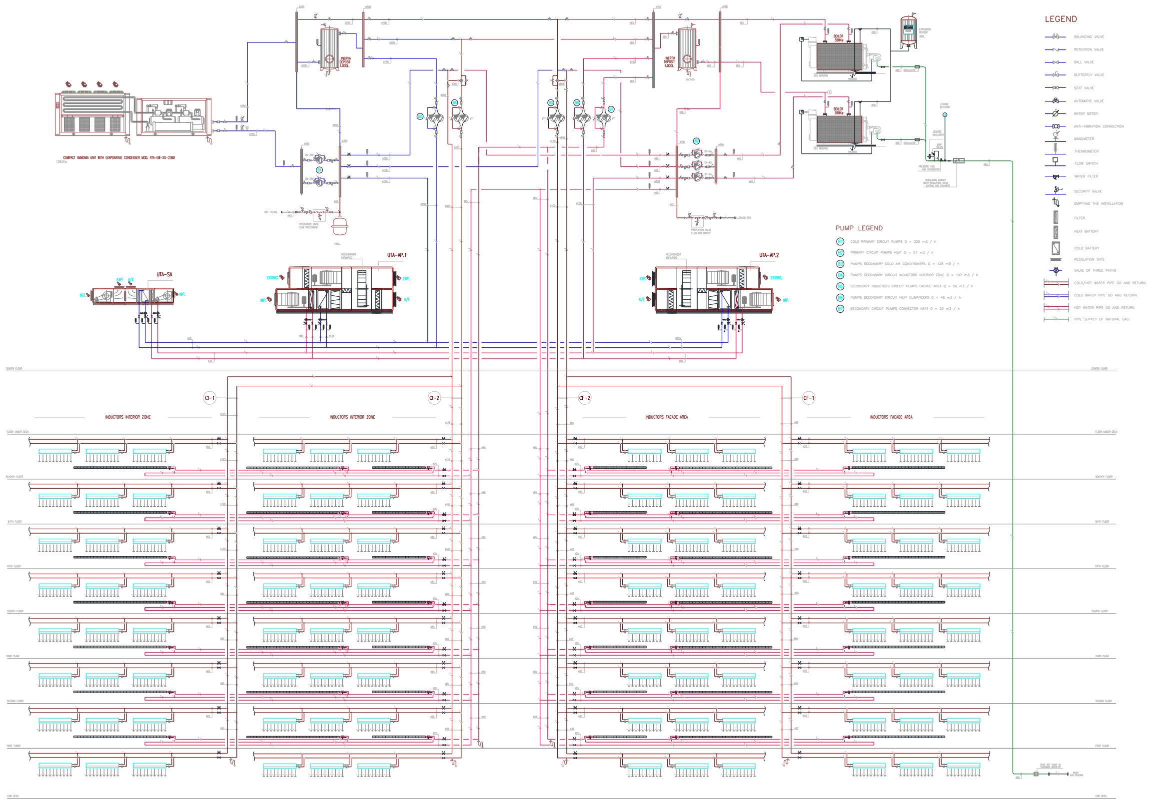
PLANS

Plans index

Part I. List of plans

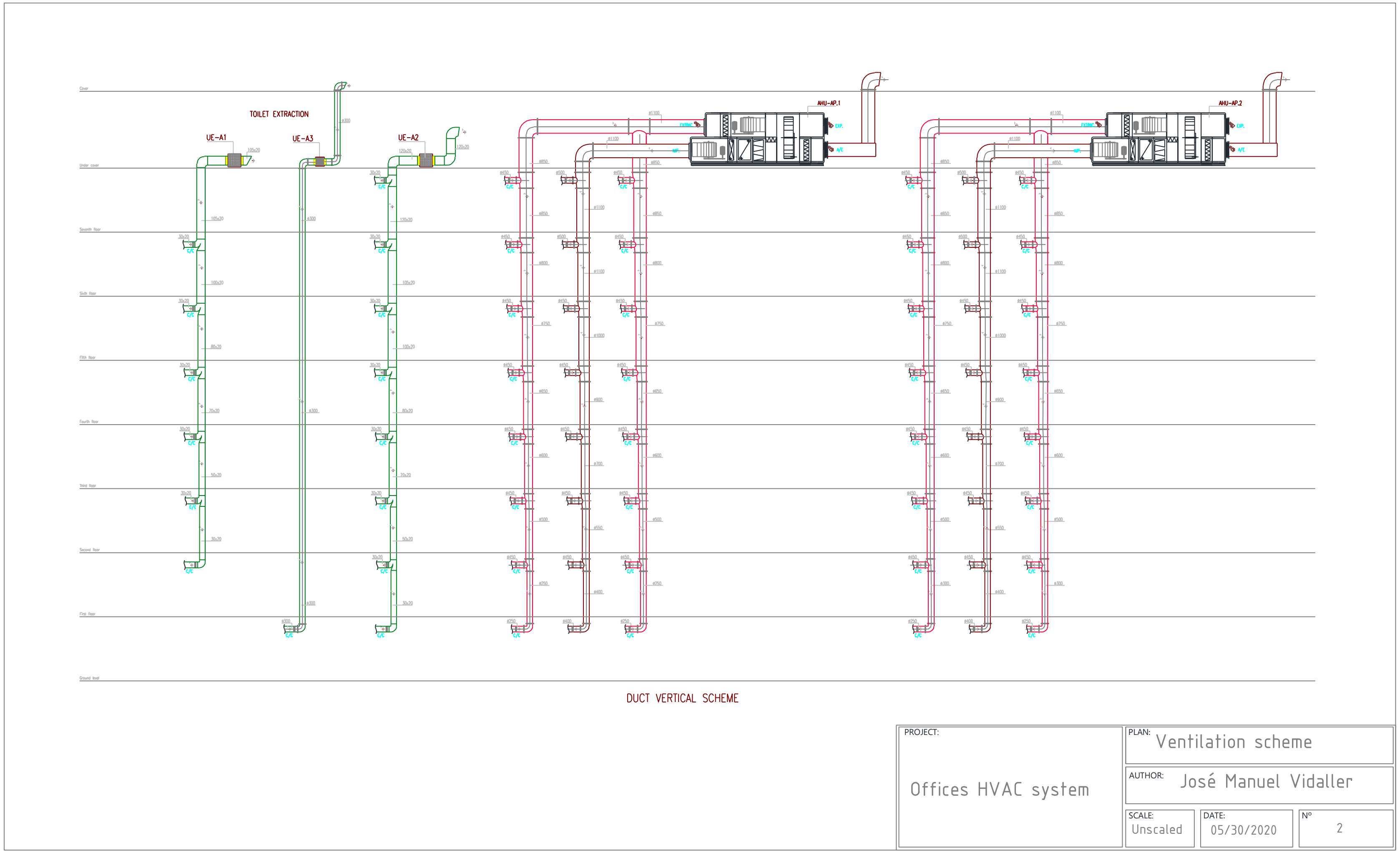
Index of planes

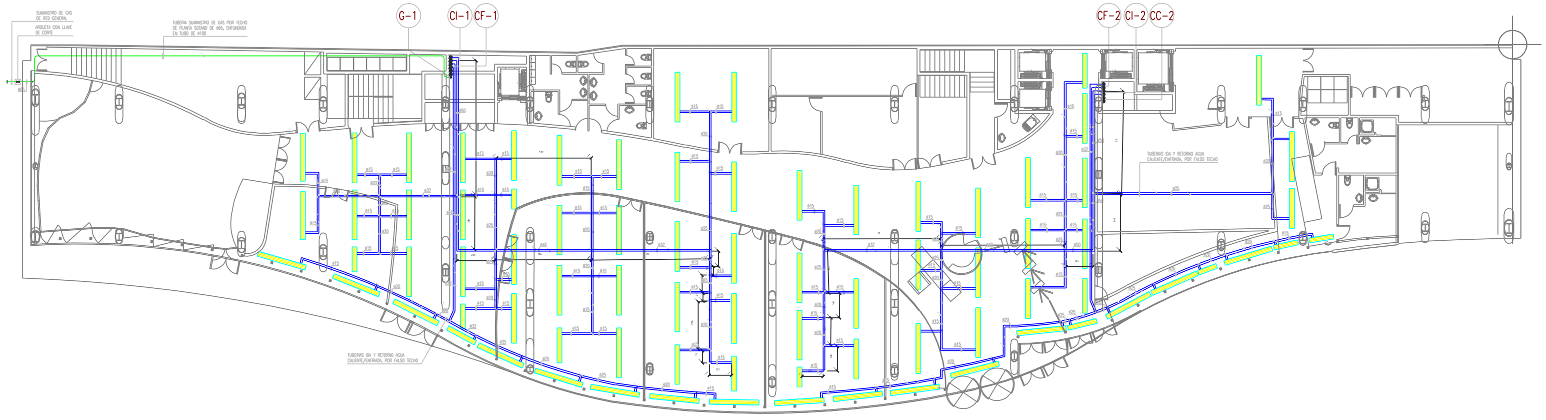
Part II. Plans



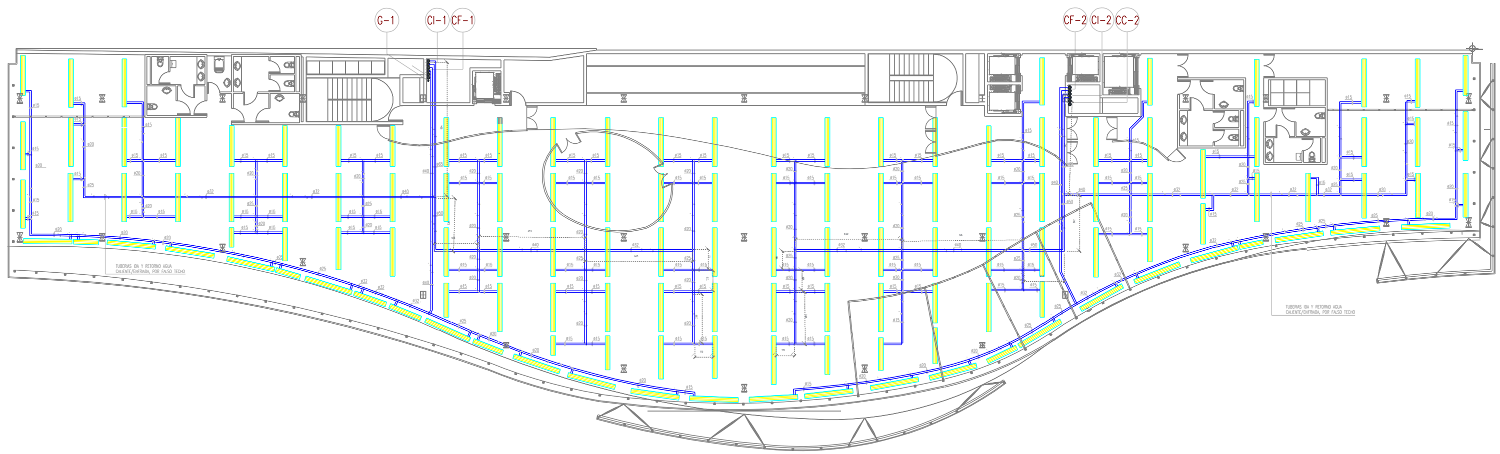
HYDRAULIC SCHEME FOR PRODUCTION OF CHILLED AND HOT WATER

PROJECT:	PLAN: Principle scheme		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
	SCALE: Unscaled	DATE: 05/30/2020	Nº 1

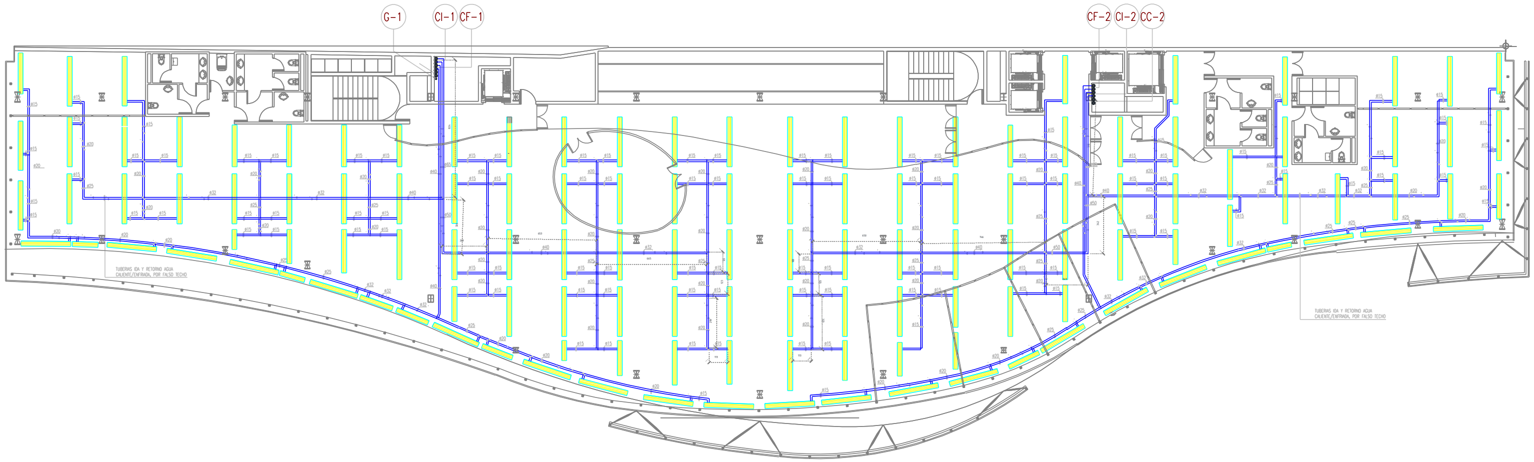

TOILET EXTRACTION
UE-A1
UE-A3
UE-A2
AHU-AP.1
AHU-AP.2
DUCT VERTICAL SCHEME
PROJECT:
Offices HVAC system
PLAN:
Ventilation scheme
AUTHOR:
José Manuel Vidaller
SCALE:
Unscaled
DATE:
05/30/2020
Nº
2



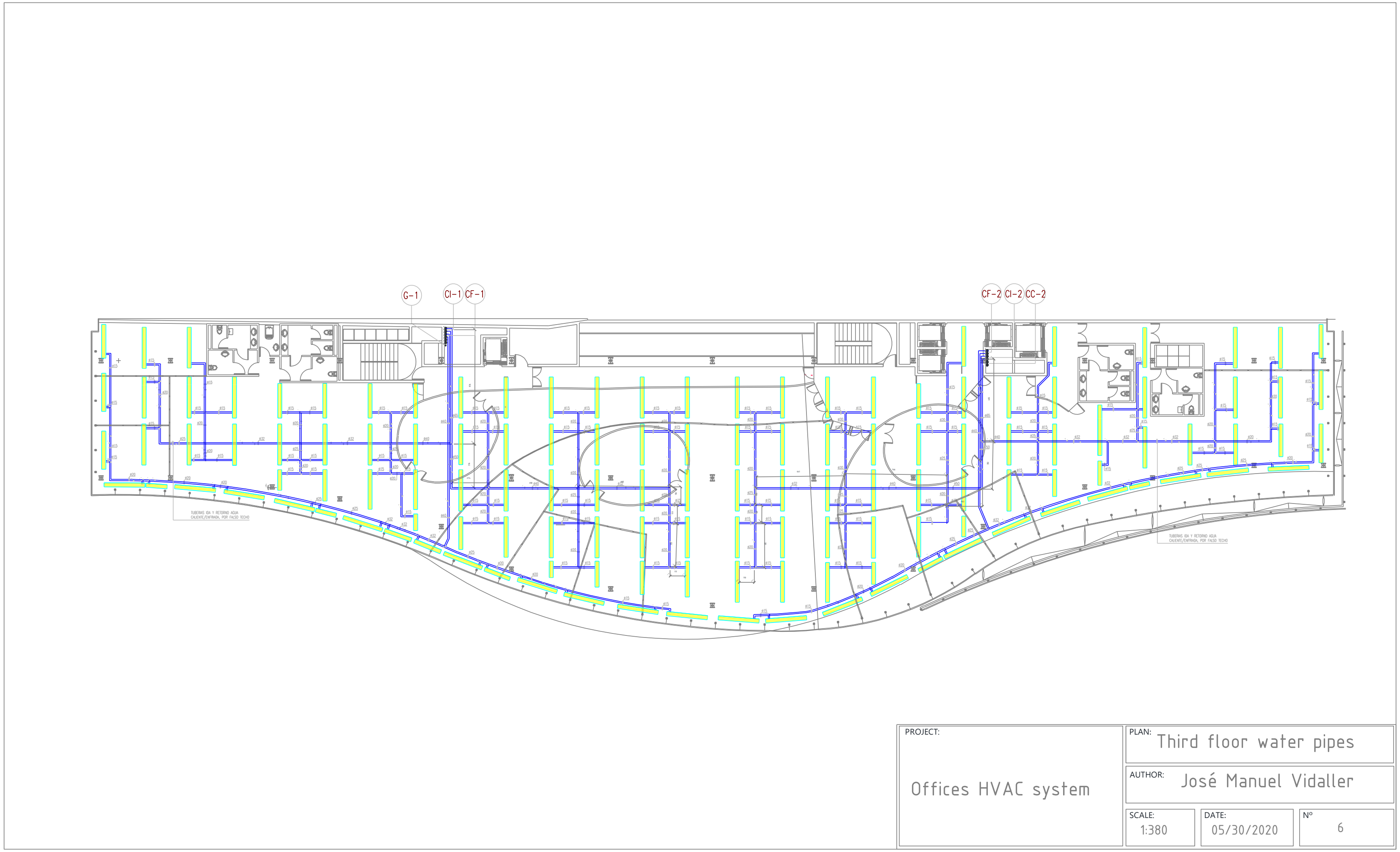
PROJECT:	PLAN:
Offices HVAC system	Ground floor water pipes
	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 · DATE: 05/30/2020 · Nº 3

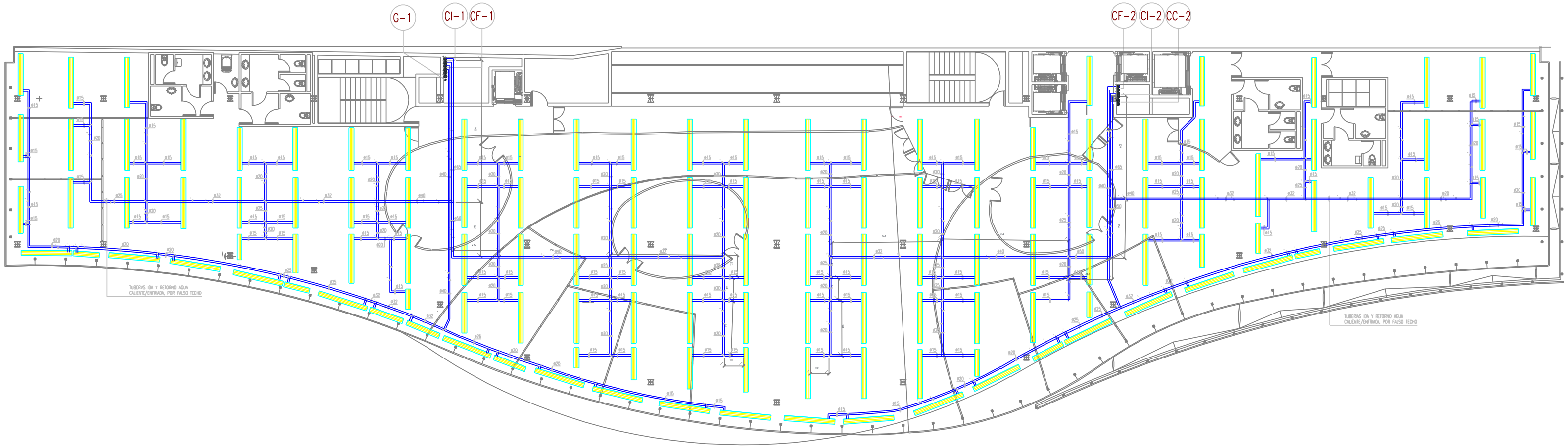


PROJECT: Offices HVAC system	PLAN: First floor water pipes
	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 · DATE: 05/30/2020 · Nº 4

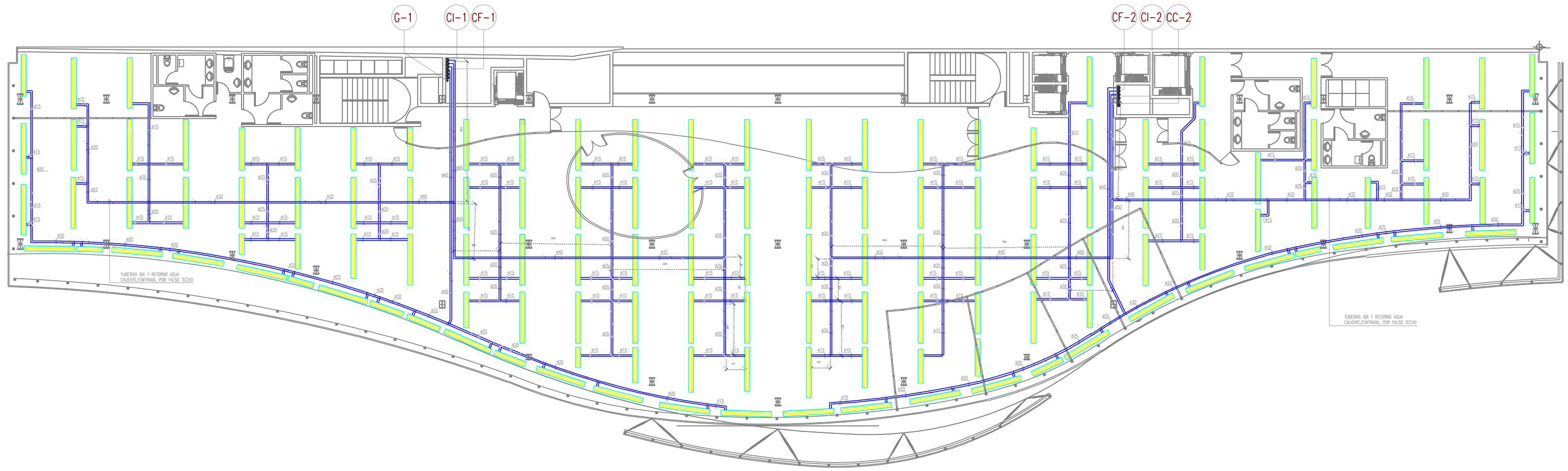


PROJECT: Offices HVAC system	PLAN: Second floor water pipes
	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 · DATE: 05/30/2020 · Nº 5

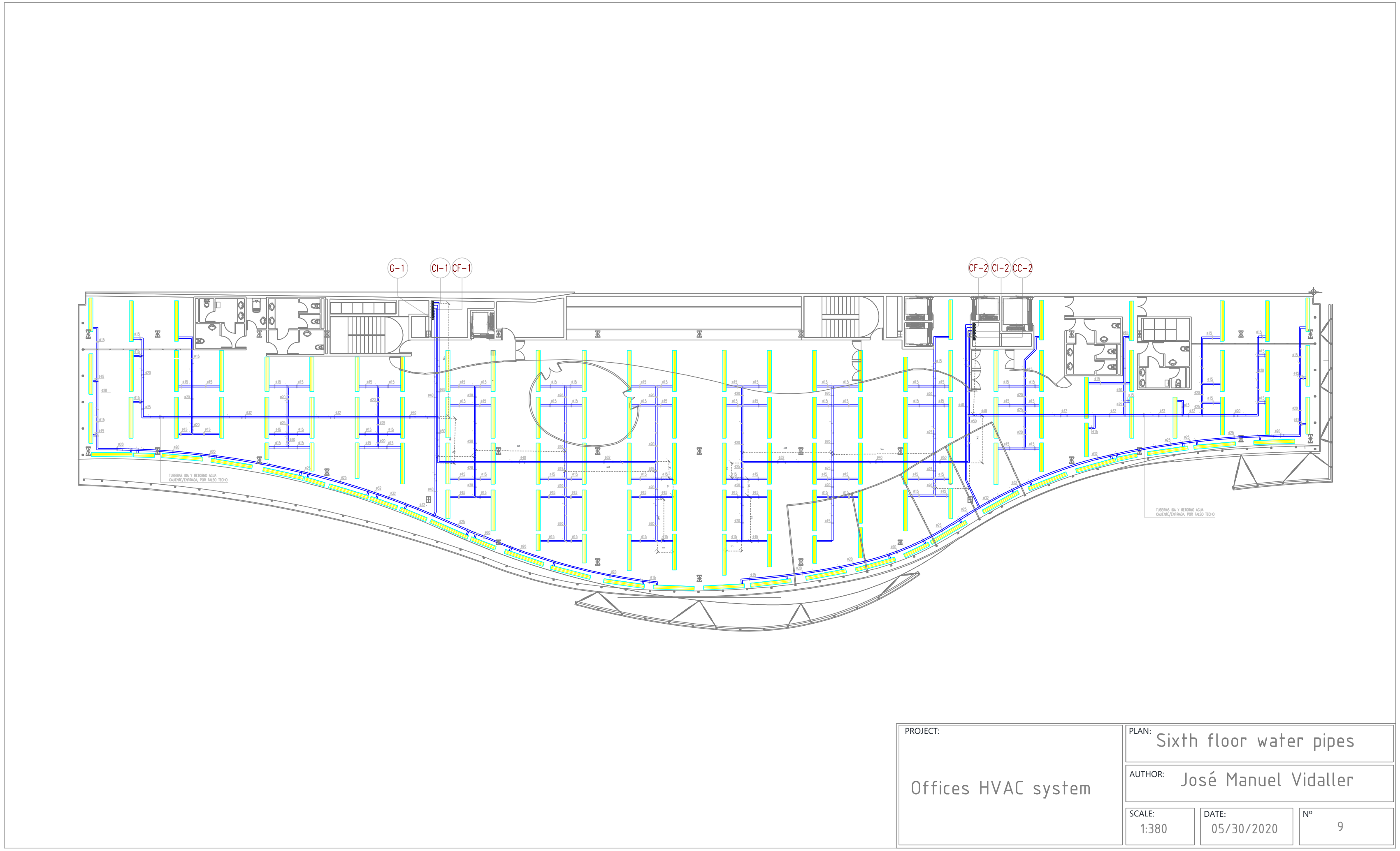

G-1
CI-1
CF-1
CF-2
CI-2
CC-2
PROJECT:
Offices HVAC system
PLAN:
Third floor water pipes
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
6

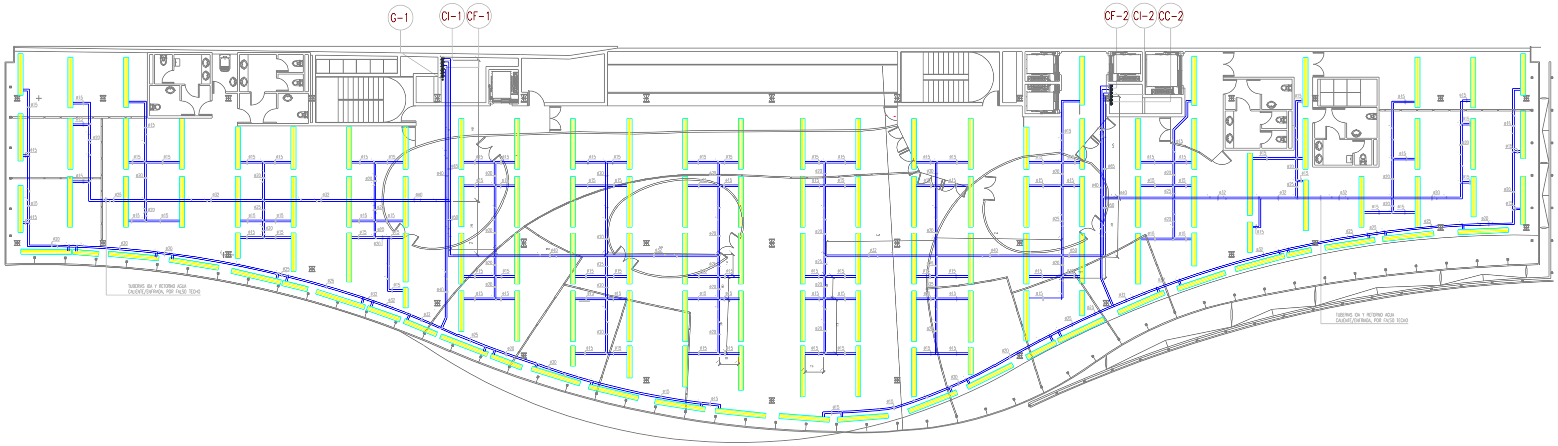


PROJECT:	PLAN: Fourth floor water pipes		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
	SCALE: 1:380	DATE: 05/30/2020	Nº 7



PROJECT: Offices HVAC system	PLAN: Fifth floor water pipes
	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 — DATE: 05/30/2020 — Nº 8


G-1
CI-1
CF-1
CF-2
CI-2
CC-2
PROJECT:
Offices HVAC system
PLAN:
Sixth floor water pipes
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
9



PROJECT:	PLAN: Seventh floor water pipes		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
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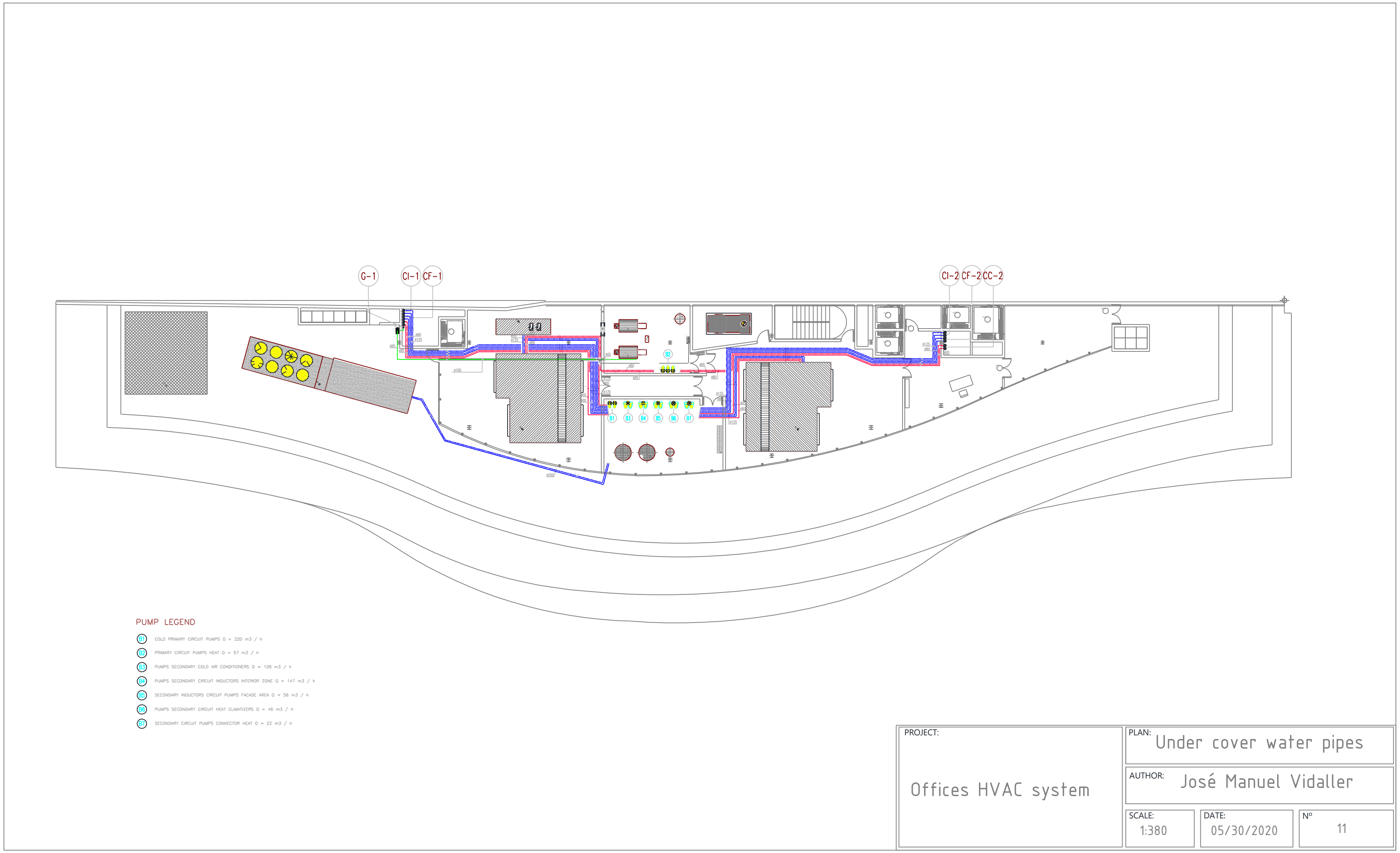
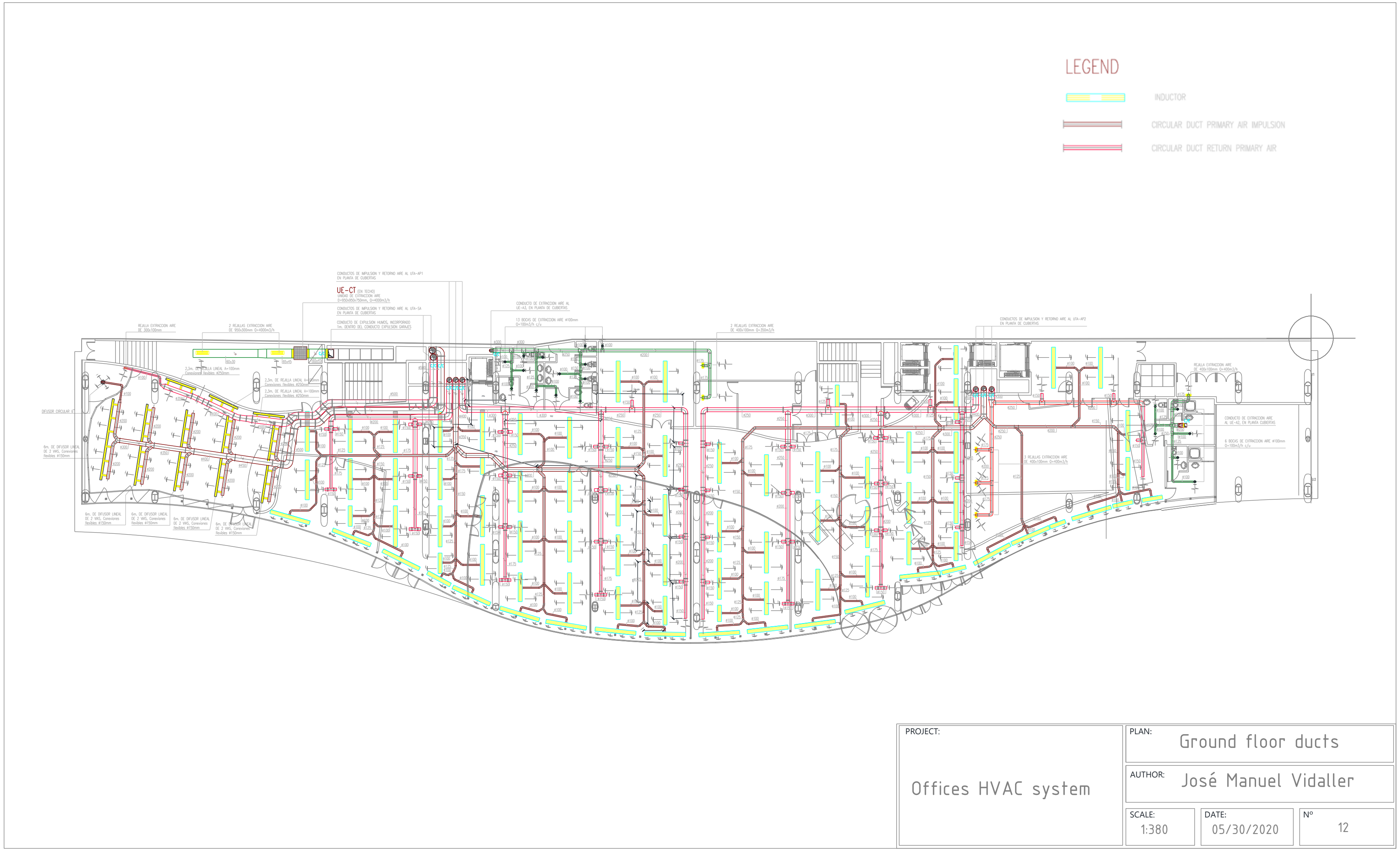
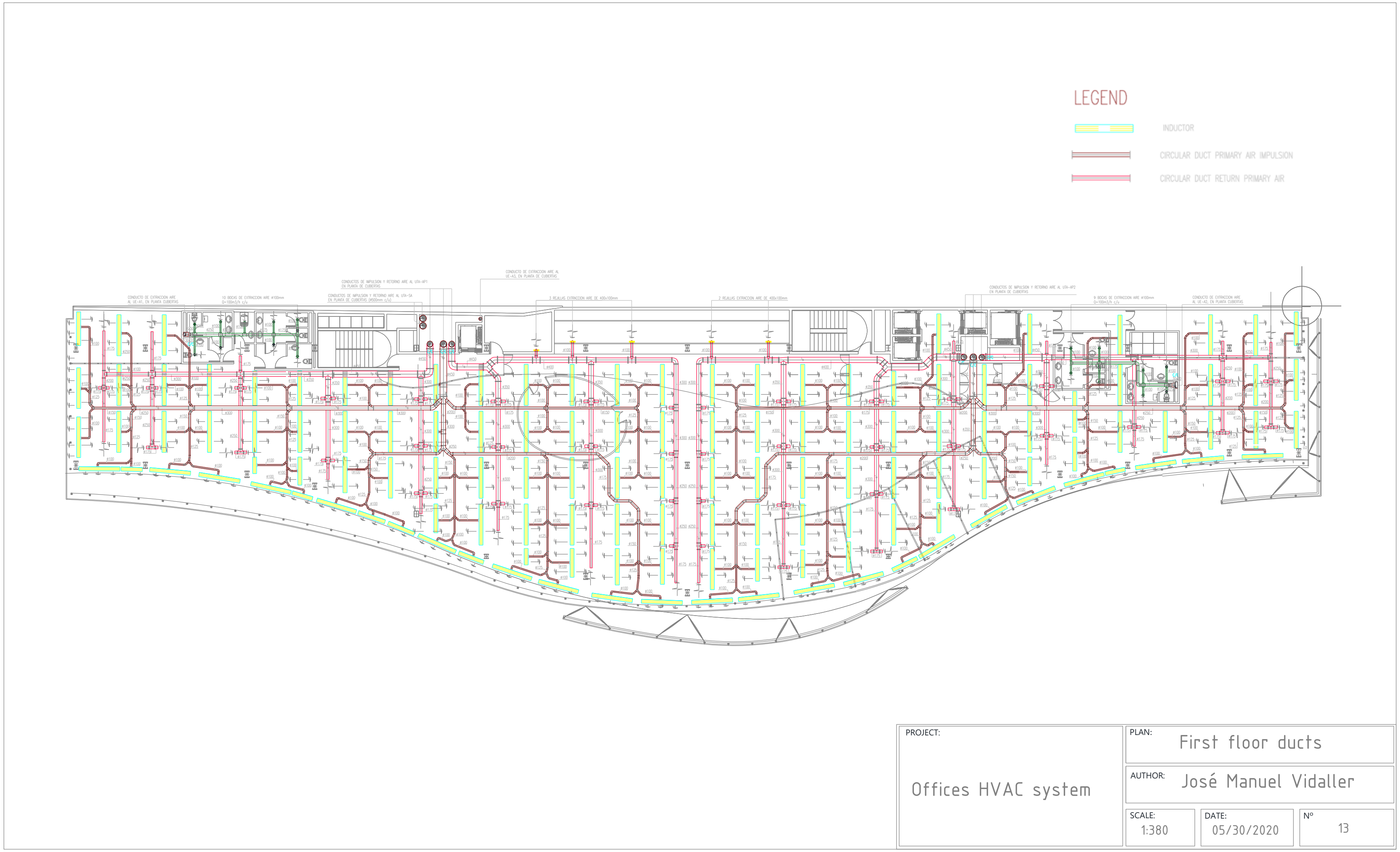
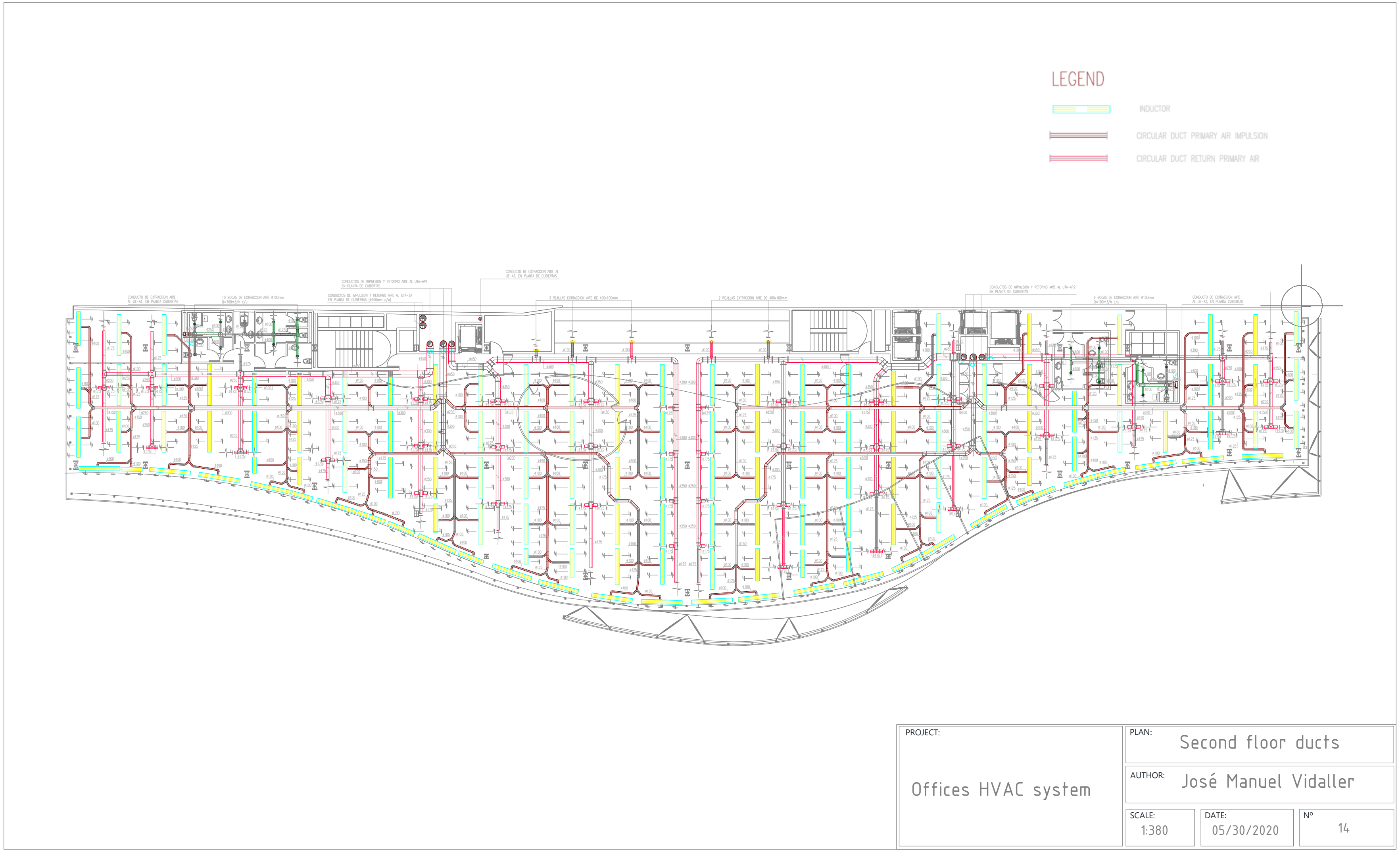
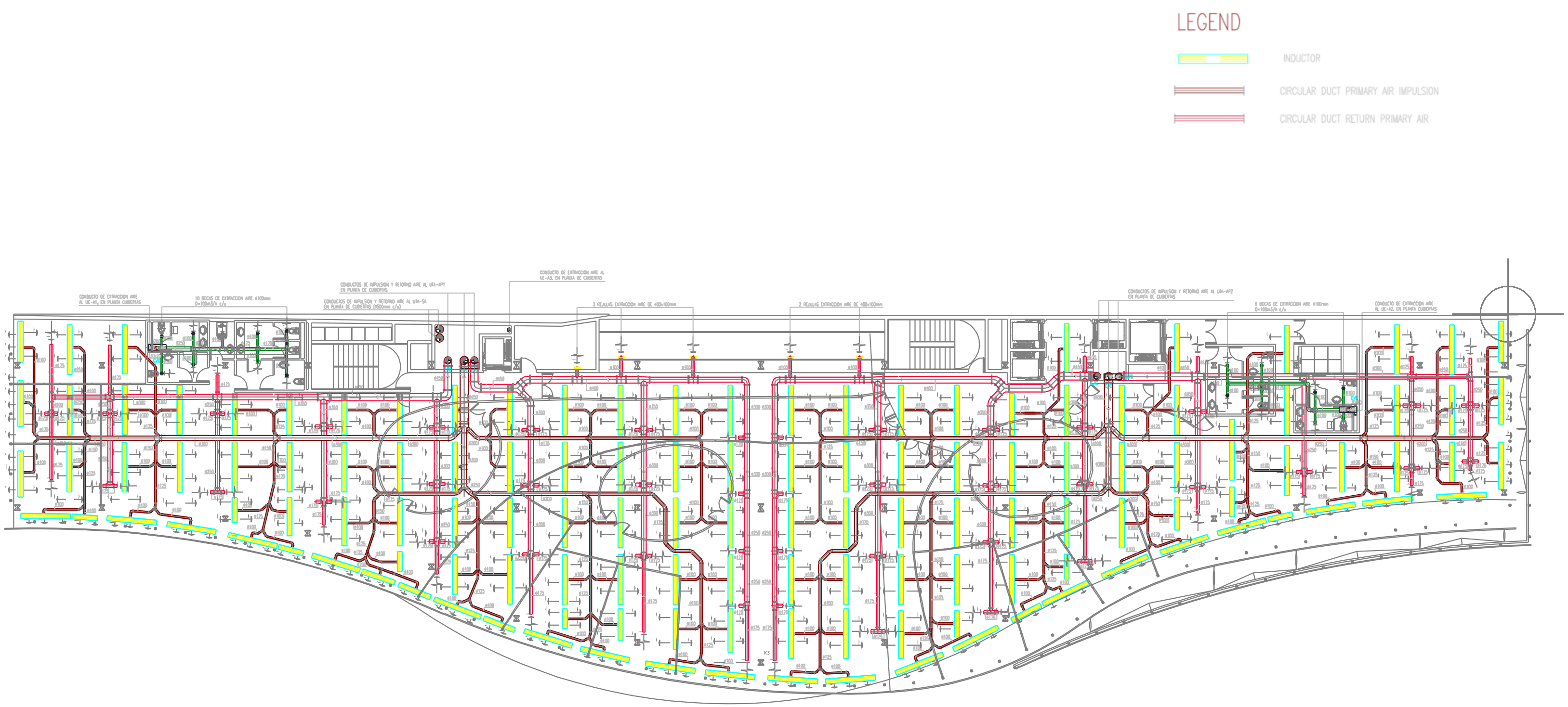

G-1
CI-1
CF-1
CI-2
CF-2
CC-2
PUMP LEGEND
B1 COLD PRIMARY CIRCUIT PUMPS Q = 220 m3 / h
B2 PRIMARY CIRCUIT PUMPS HEAT Q = 57 m3 / h
B3 PUMPS SECONDARY COLD AIR CONDITIONERS Q = 128 m3 / h
B4 PUMPS SECONDARY CIRCUIT INDUCTORS INTERIOR ZONE Q = 147 m3 / h
B5 SECONDARY INDUCTORS CIRCUIT PUMPS FACADE AREA Q = 56 m3 / h
B6 PUMPS SECONDARY CIRCUIT HEAT CLIMATIZERS Q = 46 m3 / h
B7 SECONDARY CIRCUIT PUMPS CONVECTOR HEAT Q = 22 m3 / h
PROJECT:
Offices HVAC system
PLAN:
Under cover water pipes
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
11

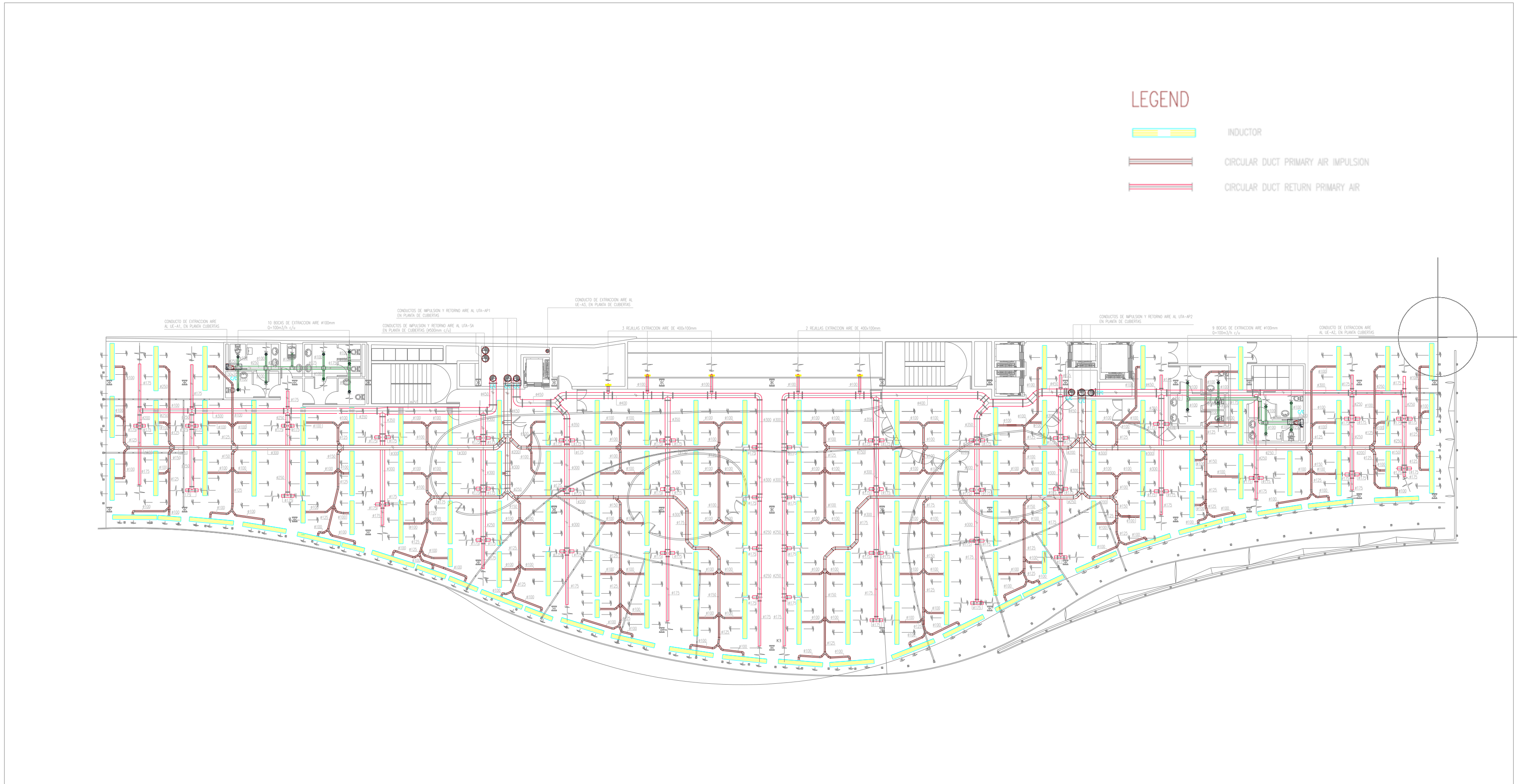

LEGEND
INDUCTOR
CIRCULAR DUCT PRIMARY AIR IMPULSION
CIRCULAR DUCT RETURN PRIMARY AIR
UE-CT
PROJECT:
Offices HVAC system
PLAN:
Ground floor ducts
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
12


LEGEND
INDUCTOR
CIRCULAR DUCT PRIMARY AIR IMPULSION
CIRCULAR DUCT RETURN PRIMARY AIR
PROJECT:
Offices HVAC system
PLAN:
First floor ducts
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
13

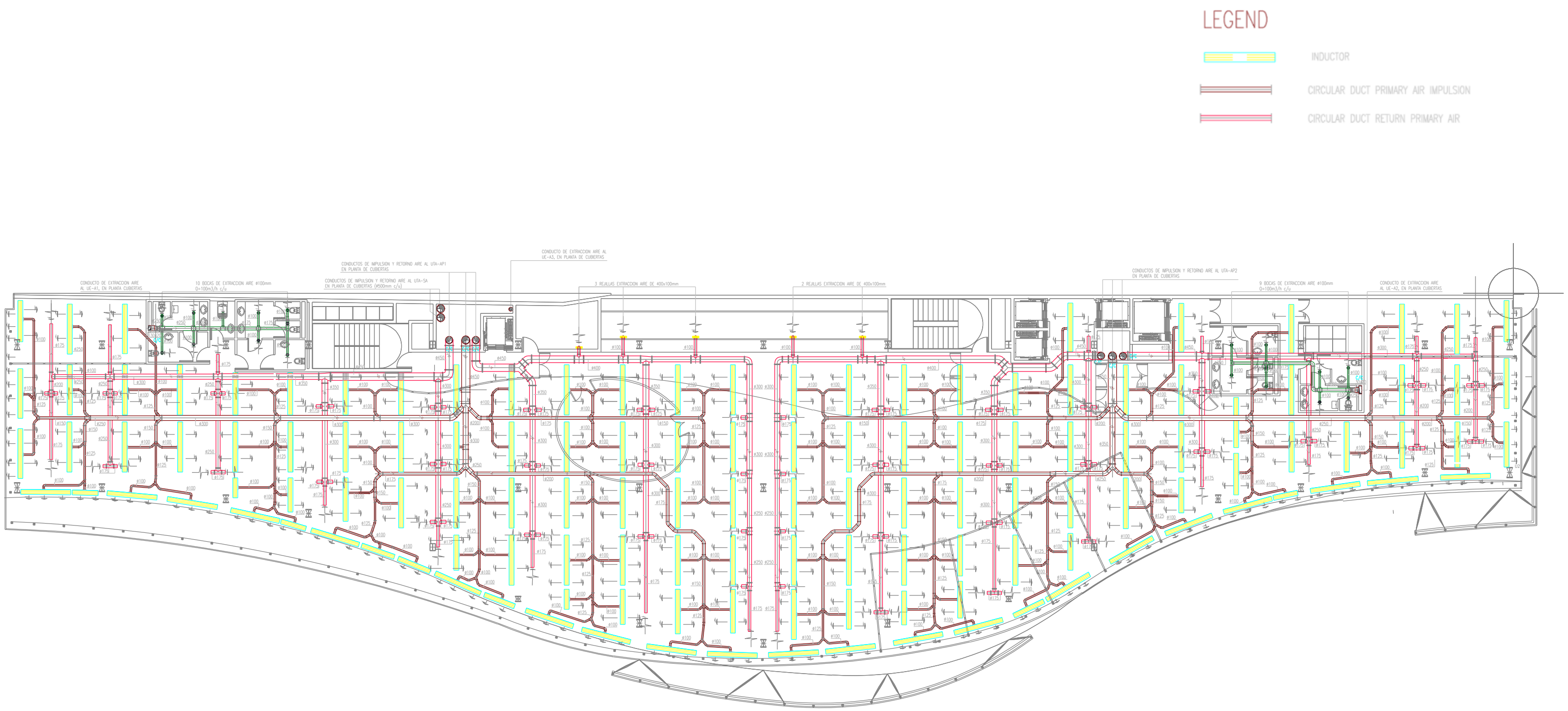

LEGEND
INDUCTOR
CIRCULAR DUCT PRIMARY AIR IMPULSION
CIRCULAR DUCT RETURN PRIMARY AIR
PROJECT:
Offices HVAC system
PLAN:
Second floor ducts
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
14



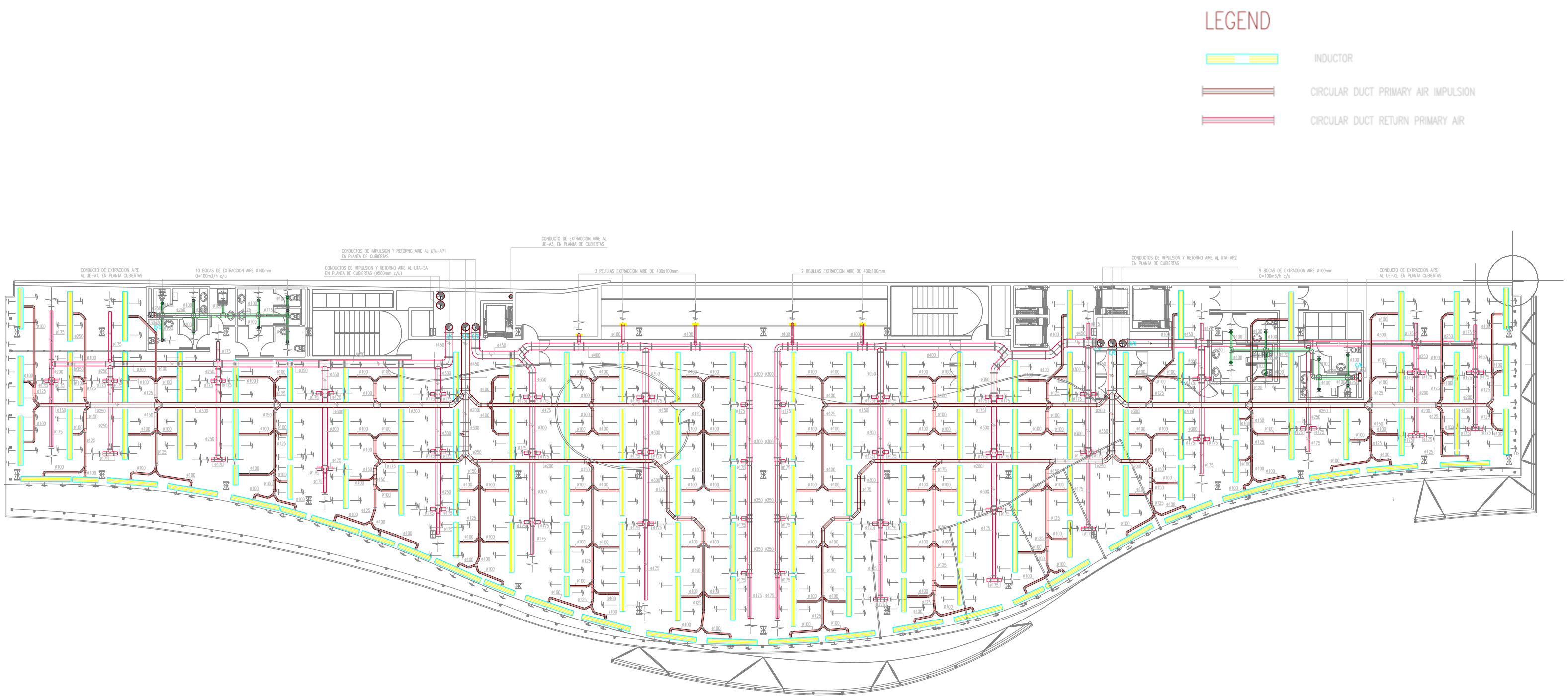
PROJECT:	PLAN: Third floor ducts
Offices HVAC system	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 · DATE: 05/30/2020 · Nº 15



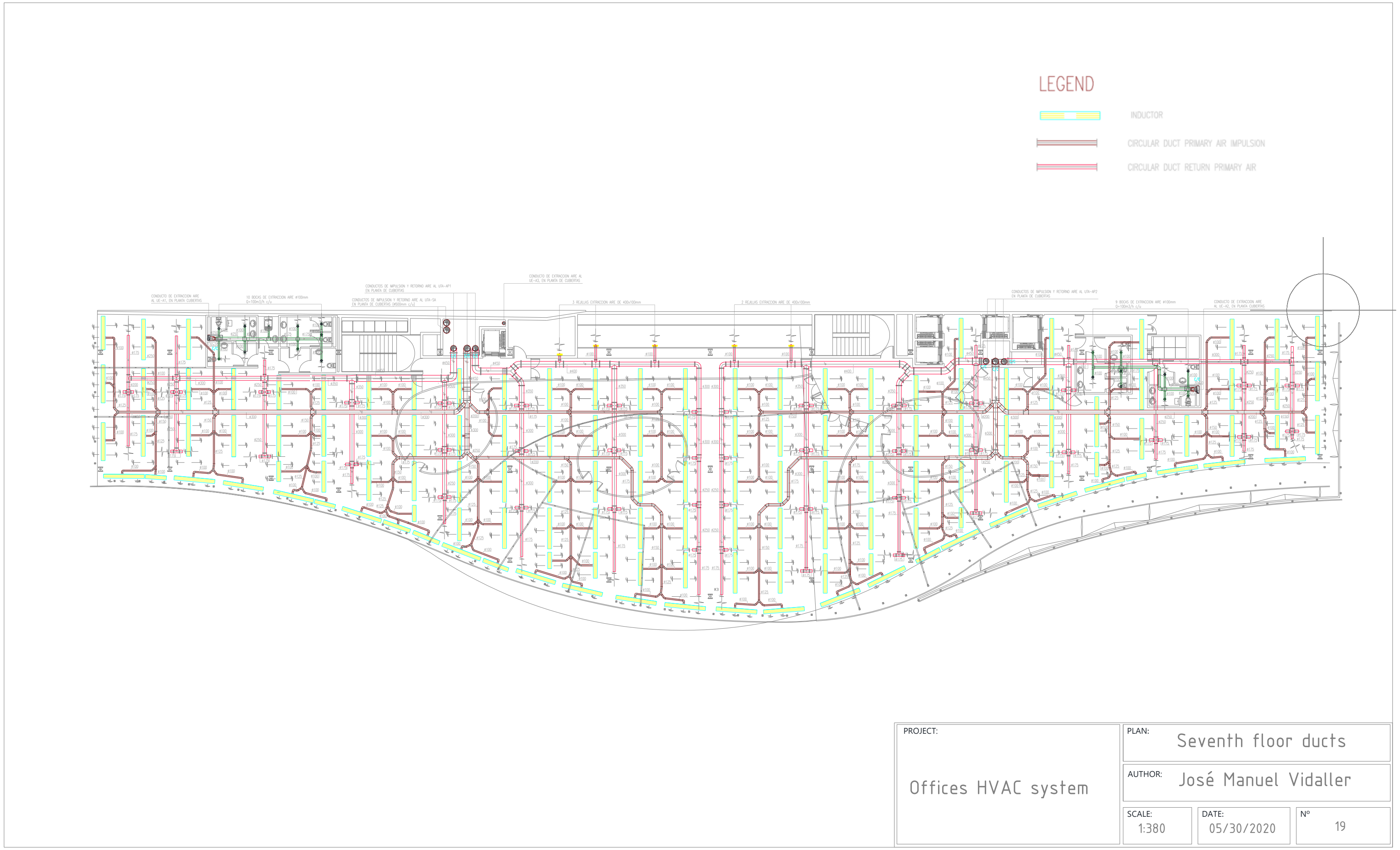
PROJECT:	PLAN: Fourth floor ducts		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
	SCALE: 1:380	DATE: 05/30/2020	Nº 16

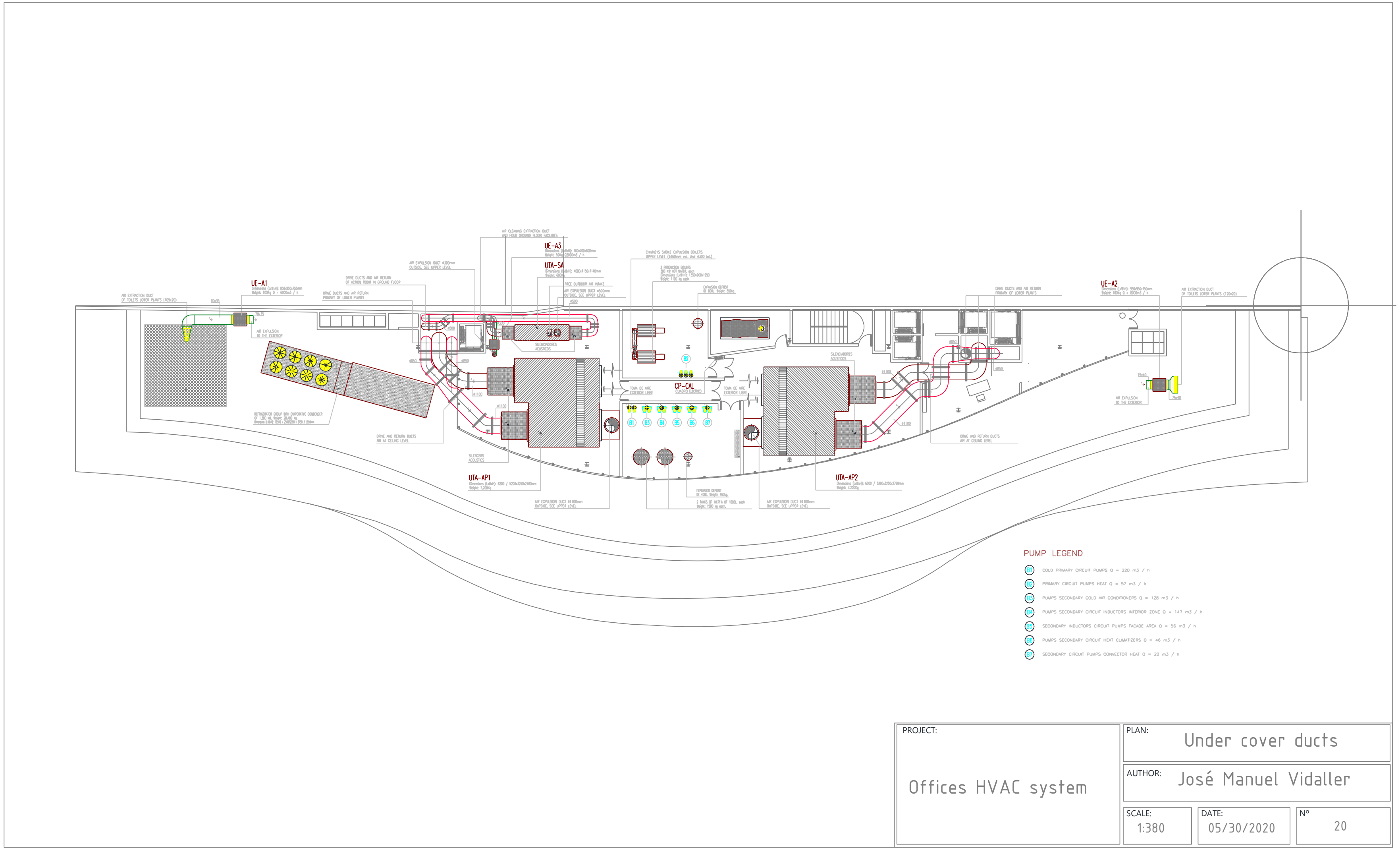


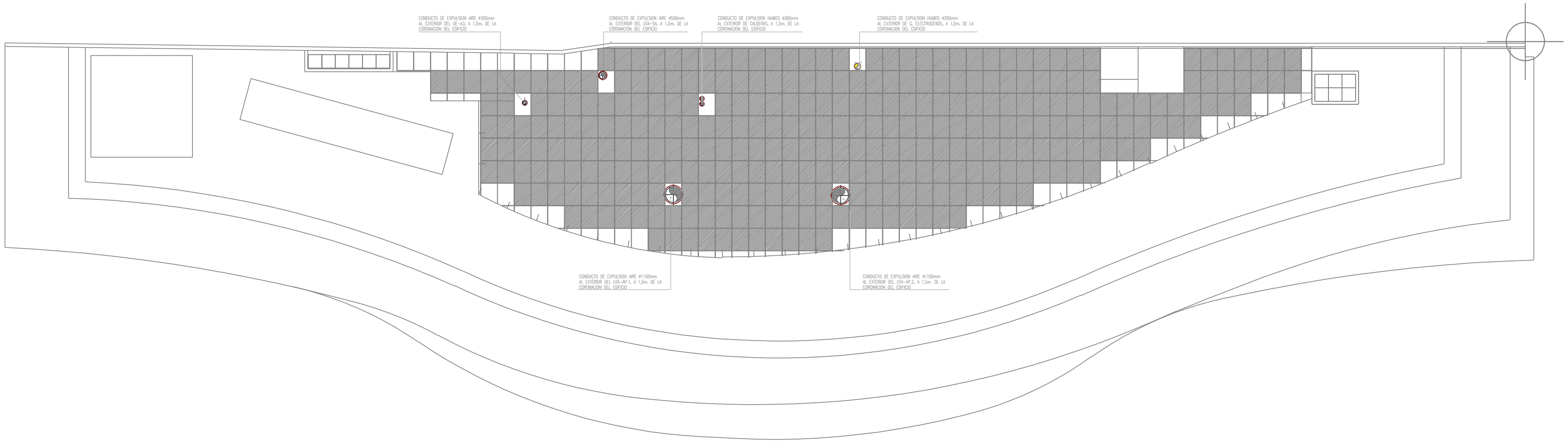
PROJECT:	PLAN: Fifth floor ducts		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
	SCALE: 1:380	DATE: 05/30/2020	Nº 17



PROJECT:	PLAN: Sixth floor ducts		
Offices HVAC system	AUTHOR: José Manuel Vidaller		
	SCALE: 1:380	DATE: 05/30/2020	Nº 18


LEGEND
INDUCTOR
CIRCULAR DUCT PRIMARY AIR IMPULSION
CIRCULAR DUCT RETURN PRIMARY AIR
PROJECT:
Offices HVAC system
PLAN:
Seventh floor ducts
AUTHOR:
José Manuel Vidaller
SCALE:
1:380
DATE:
05/30/2020
Nº
19


UE-A1
UE-A3
UTA-SA
UE-A2
CP-CAL
UTA-AP1
UTA-AP2
PUMP LEGEND
B1 COLD PRIMARY CIRCUIT PUMPS Q = 220 m3 / h
B2 PRIMARY CIRCUIT PUMPS HEAT Q = 57 m3 / h
B3 PUMPS SECONDARY COLD AIR CONDITIONERS Q = 128 m3 / h
B4 PUMPS SECONDARY CIRCUIT INDUCTORS INTERIOR ZONE Q = 147 m3 / h
B5 SECONDARY INDUCTORS CIRCUIT PUMPS FACADE AREA Q = 56 m3 / h
B6 PUMPS SECONDARY CIRCUIT HEAT CLIMATIZERS Q = 46 m3 / h
B7 SECONDARY CIRCUIT PUMPS CONVECTOR HEAT Q = 22 m3 / h
PROJECT: Offices HVAC system
PLAN: Under cover ducts
AUTHOR: José Manuel Vidaller
SCALE: 1:380
DATE: 05/30/2020
Nº 20



PROJECT: Offices HVAC system	PLAN: Cover
	AUTHOR: José Manuel Vidaller
	SCALE: 1:380 · DATE: 05/30/2020 · Nº 21

DOCUMENT III.

BUDGET

Budget index

Part I. Partial sums

BUDGET MECHANICAL FACILITIES MADRID OFFICES

CODE	UNIT	DESCRIPTION	UNITS	PRICE	TOTAL
Chapter 1		**COLD PRODUCTION**			
1.1	Un	AIR-COOLED CHILLER. REFRIGERATOR GROUP WITH EVAPORATIVE CONDENSER BG/WRAT R407C 4828. Model form CLIMAVENETA. Nominal power 1300 Kw. Weight: 20,400 kg. Dimensions (LxWxH): 12.540 x 2500/2390 x 3150 / 3550mm	1,00	225.206,53	225.206,53 €
1.2	Un	EXPANSION DEPOSIT 400L. SEDICAL. Weight: 450kg.	1,00	358,50	358,50 €
1.3	Un	TANK DEPOSIT 1000L	1,00	1.099,99	1.099,99 €
				SUBTOTAL	226.665,02 €
Chapter 2		**HEAT PRODUCTION**			
2.1	Un	ADISA BOILERS PRODUCTION HOT WATER ADINOX 339 BT OF 381 kW. Dimensions (LxWxH): 1350x900x1950. Weight: 1100 kg.	2,00	26.713,43	53.426,86 €
2.2	Un	EXPANSION DEPOSIT 800L. SEDICAL. Weight: 850kg	1,00	584,06	584,06 €
2.3	Un	TANK DEPOSIT 1000L	1,00	1.099,99	1.099,99 €
				SUBTOTAL	55.110,91 €
Chapter 3		**AIR HANDLING UNIT**			
3.1	Un	TERMOVEN AIR HANDLING UNIT CLA-2030/4. 38500 m3/h. Dimensions (LxWxH): 6200/5200x3250x2760mm. Weight: 7,200Kg	2,00	111.833,42	223.666,84 €
				SUBTOTAL	223.666,84 €
Chapter 4		**PUMP SET**			
4.1	Un	COLD PRIMARY CIRCUIT PUMPS. ELIAS BQP 150/26. 1450r.p.m. Q = 220m3/h. 10m.c.a.	2,00	994,01	1.988,02 €
4.2	Un	PRIMARY CIRCUIT PUMPS HEAT. ELIAS IAC-80-203. 1450r.p.m. Q = 57m3/h. 8m.c.a.	3,00	824,25	2.472,75 €
4.3	Un	SECONDARY COLD AIR CONDITIONERS PUMPS. ELIAS IAC-100-312. 1450r.p.m. Q = 128m3/h. 12m.c.a.	2,00	982,25	1.964,50 €
4.4	Un	SECONDARY CIRCUIT INDUCTORS INTERIOR ZONE PUMPS. ELIAS BQP 150/50. 1450r.p.m. Q = 147m3/h. 78m.c.a.	2,00	982,25	1.964,50 €
4.5	Un	SECONDARY INDUCTORS CIRCUIT PUMPS FACADE AREA. ELIAS BQP 150/50. 1450r.p.m. Q = 56m3/h. 73m.c.a.	2,00	824,25	1.648,50 €
4.6	Un	SECONDARY CIRCUIT HEAT CLIMATIZERS PUMPS. ELIAS IAC-80-202. 1450r.p.m. Q = 46m3/h. 12m.c.a.	2,00	780,26	1.560,52 €
4.7	Un	SECONDARY CIRCUIT PUMPS CONVECTOR HEAT. ELIAS BQP 50/250. 2900r.p.m. Q = 22m3/h. 69m.c.a.	2,00	712,01	1.424,02 €
				SUBTOTAL	13.022,81 €
Chapter 5		**INDUCTORS. TERMINAL ELEMENT**			
5.1	Un	KOOLAIR MODEL IHK-F (2-PIPE SYSTEM) CEILING INDUCTOR. Size 900	1.005,00	112,00	112.560,00 €
5.2	Un	KOOLAIR MODEL IHK-F (2-PIPE SYSTEM) CEILING INDUCTOR. Size 1200	542,00	131,60	71.327,20 €
5.3	Un	KOOLAIR MODEL IHK-F (2-PIPE SYSTEM) CEILING INDUCTOR. Size 1500	1.645,00	235,20	386.904,00 €
				SUBTOTAL	570.791,20 €

Chapter 6	**DIFFUSERS / GRIDS. TERMINAL ELEMENT**				
6.1	Un	KOSNER MULTIDIRECTIONAL DIFFUSER. Anodized aluminum. 60x60m. flow from 100 to 3800m3 / h. Galvanized steel regulating gate	25,00	11,51	287,75 €
6.2	Un	KOSNER MULTIDIRECTIONAL DIFFUSER. Anodized aluminum. 62x62m. flow from 60 to 810m3 / h. Galvanized steel regulating gate	18,00	8,42	151,56 €
6.3	Un	KOSNER MULTIDIRECTIONAL DIFFUSER. Anodized aluminum. 300x24m. flow from 100 to 3800m3 / h. Galvanized steel regulating gate	960,00	12,24	11.750,40 €
6.4	Un	KOSNER HORIZONTAL RETURN GRILLE 325x125m in aluminum with slats at 45º with 20mm pitch	240,00	6,48	1.555,20 €
6.5	Un	KOSNER HORIZONTAL RETURN GRILLE 225x125m in aluminum with slats at 45º with 20mm pitch	256,00	5,40	1.382,40 €
				SUBTOTAL	15.127,31 €

Chapter 7	**PIPELINES WITH INSULATION**				
7.1	m2	Black welded steel pipe type UNE-EN-10255 with insulation 15mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	369,36	11,05	4.081,43 €
7.2	m2	Black welded steel pipe type UNE-EN-10255 with insulation20mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	1.359,18	16,46	22.372,10 €
7.3	m2	Black welded steel pipe type UNE-EN-10255 with insulation 25mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	1.783,35	16,93	30.192,12 €
7.4	m2	Black welded steel pipe type UNE-EN-10255 with insulation 32mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	2.427,12	19,63	47.644,37 €
7.5	m2	Black welded steel pipe type UNE-EN-10255 40mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	2.690,64	21,91	58.951,92 €

7.6	m2	Black welded steel pipe type UNE-EN-10255 50mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	2.927,16	24,55	71.861,78 €
7.7	m2	Black welded steel pipe type UNE-EN-10255 with insulation 65mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	3.473,16	25,01	86.863,73 €
7.8	m2	Black welded steel pipe type UNE-EN-10255 with insulation 100mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	549,00	26,66	14.636,34 €
7.9	m2	Black welded steel pipe type UNE-EN-10255 with insulation 125mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	924,66	38,82	35.895,30 €
7.10	m2	Black welded steel pipe type UNE-EN-10255 with insulation 200mm for welding, for air conditioning circuits, including proportional part of supports, elbows, tees, sleeves, dilators, reductions, mounting accessories, etc., with primer in electrolytic lead and finished in enamel, including ARMAFLEX brand elastomeric foam shell or equivalent, thick according to current regulations, complete and installed according to drawings and specifications.	5.691,80	53,80	306.218,84 €
				SUBTOTAL	678.717,93 €
Chapter 8	**AIR DUCTS AND INSULATION**				
8.1	m2	ALDER galva circular ducts 100m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	154,24	15,12	2.332,11 €
8.2	m2	ALDER galva circular ducts 125m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.779,84	15,24	27.124,76 €

8.3	m2	ALDER galva circular ducts 150m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.655,04	15,84	26.215,83 €
8.4	m2	ALDER galva circular ducts 175m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	677,76	15,84	10.735,72 €
8.5	m2	ALDER galva circular ducts 200m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	344,32	15,84	5.454,03 €
8.6	m2	ALDER galva circular ducts 250m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.573,76	15,84	24.928,36 €
8.7	m2	ALDER galva circular ducts 300m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	3.923,20	16,24	63.712,77 €
8.8	m2	ALDER galva circular ducts 350m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	2.721,28	16,24	44.193,59 €
8.9	m2	ALDER galva circular ducts 400m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.775,36	16,24	28.831,85 €
8.10	m2	ALDER galva circular ducts 500m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	2.325,44	16,24	37.765,15 €

8.11	m2	ALDER galva circular ducts 550m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.696,60	16,24	27.552,78 €
8.12	m2	ALDER galva circular ducts 600m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	2.182,40	16,85	36.773,44 €
8.13	m2	ALDER galva circular ducts 650m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.745,92	16,85	29.418,75 €
8.14	m2	ALDER galva circular ducts 750m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	1.221,00	16,85	20.573,85 €
8.15	m2	ALDER galva circular ducts 800m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	343,20	16,85	5.782,92 €
8.16	m2	ALDER galva circular ducts 850m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	132,28	16,85	2.228,92 €
8.17	m2	ALDER galva circular ducts 900m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	615,84	16,85	10.376,90 €
8.18	m2	ALDER galva circular ducts 1000m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	171,60	17,52	3.006,43 €

8.19	m2	ALDER galva circular ducts 1100m. Straight circular duct in galvanized sheet steel screwed in a propeller following the duct manufacturing standard EN 1506. The steel thicknesses used for the manufacture of the ducts follow the standard XP E 51-620 that sets the minimum thicknesses by diameter. Galvanized steel according to EN 10 142 standard. Reinforced conduit with external rib for diameters ≥ 630 mm.	893,12	17,52	15.647,46 €
8.20	m2	External insulation of sheet steel air ducts, made of fiberglass type ISOVER IBR-55	25.932,20	12,14	314.816,91 €
				SUBTOTAL	365.039,13 €
Chapter 9	**MECHANICAL CONTROL AND MEASURING EQUIPMENT**				
9.1	Un	The mechanical control equipment is from the JC VALVULAS company and the measurement equipment from the TUBASYS company:	1,00	58.147,26	58.147,26 €
		balancing valve			
		retention valve			
		ball valve			
		butterfly valve			
		seat valve			
		automatic valve			
		water meter			
		anti-vibration connection			
		manometer			
		thermometer			
		flow switch			
		water filter			
		security valve			
		installation drain			
		valve of three paths			
				SUBTOTAL	58.147,26 €

TOTAL	2.206.288,41 €

Part II. General budget

BUDGET MECHANICAL FACILITIES MADRID OFFICES

CODE	DESCRIPTION	AMOUNT
Chapter 1	**COLD PRODUCTION**	226.665,02 €
Chapter 2	**HEAT PRODUCTION**	55.110,91 €
Chapter 3	**AIR HANDLING UNIT**	223.666,84 €
Chapter 4	**PUMP SET**	13.022,81 €
Chapter 5	**INDUCTORS. TERMINAL ELEMENT**	570.791,20 €
Chapter 6	**DIFFUSERS / GRIDS. TERMINAL ELEMENT**	15.127,31 €
Chapter 7	**PIPELINES WITH INSULATION**	678.717,93 €
Chapter 8	**AIR DUCTS AND INSULATION**	365.039,13 €
Chapter 9	**MECHANICAL CONTROL AND MEASURING EQUIPMENT**	58.147,26 €
	TOTAL	2.206.288,41 €