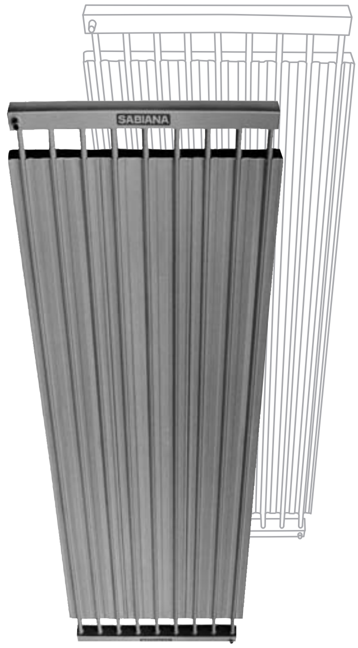
COMPLIANT WITH THE NEW EUROPEAN STANDARD EN 14037



Heating

DS Radiant Panel

PLANNING AND CALCULATION MANUAL

ICIM
ISO 9001 - Cert. n° 0545/3
Unit heaters
Radiant panels
Fan coils
Air handling units
Flues

SABIANA
ENVIRONMENTAL COMFORT

CONTENTS

Foreword

With the enforcement of the EUROPEAN STANDARD EN 14037, Sabiana SpA presents the new calculation manual for the DS radiant heating panels, with upgraded graphics and layout.
The new manual has been significantly expanded, so as to provide the heating system designer with a useful design tool and an aid for comparison against other types of heating systems.

To achieve this aim, the following topics have been covered:

- Reference to the mechanisms of "heat transmission" and to "ambient comfort".
- Calculation procedure for designing systems with radiant panels.
- Comparison between different types of systems, highlighting the legislative, technical and economic advantages and disadvantages.

The topics are explained and described with "common sense", underlining the fact that in heating technology, as in many other sciences, nothing is ever absolute: for any given solution there is always a counter-solution, and heating system consultants will be able to make the best choice based on their professionalism and experience.

The transmission of heat, from a warmer to a cooler body, may occur in three ways:

- Conduction.
- Convection.
- Radiation.

The transmission may occur also in a combination of ways.

CONDUCTION

Heat exchange by conduction occurs inside a body, where the energy is transferred, from one molecule to the next, without there being a significant movement of particles.

Considering a flat layer or material with a difference in temperature between the ends, it can be stated that the flow of heat will be:

- Inversely proportional to the thickness of the layer.
- Directly proportional to the time.
- Directly proportional to the surface area.
- Directly proportional to the temperature difference.
- Directly proportional to the conductivity of the material.
- Directly proportional to the relative humidity of the material (this is true for all permeable materials, such as insulating materials that, when impregnated, may lose their insulating capacity).

The exchange of heat, in homogeneous materials, will be:

$$Q = \frac{\lambda \bullet A \bullet (T2 - T1) \bullet H}{S}$$

where:
Q = quantity of heat transmitted (W/h)
λ = thermal conductivity of the material (W/m°C)
S = thickness of the layer (m)
A = surface area of the layer (m^2)
T1 = temperature of the cold surface (°C)
T2 = temperature of the hot surface (°C)
H = time (h)

Building materials are frequently composites (for example, the different types of hollow bricks and some types of floor slabs); consequently, the "equivalent thermal conductivity" method is often used, which represents the quantity of heat transmitted, by conductivity, through a unit cross-section of 1 m^2 with a temperature difference of 1°C. Indicating the equivalent thermal conductivity as C, the heat exchange, in composite materials, will be:

$$Q = C \bullet A \bullet (T2 - T1) \bullet H$$

where:
Q = quantity of heat transmitted (W/h)
C = equivalent thermal conductivity of the composite structure (W/ m^2 /°C)
A = surface area of the layer (m^2)
T1 = temperature of the cold surface (°C)
T2 = temperature of the hot surface (°C)
H = time (h)

CONVECTION

Heat exchange by convection occurs due to the mixing of the parts of fluids that have different densities, due to differences in the temperature.

Natural convection, between a fluid and the surface of a solid body at a different temperature, occurs when the particles of the fluid, coming into contact with the surface, change density, activating the movement that transfers the energy, both inside the fluid, and from the fluid to the solid.

Considering a flat surface in contact with a fluid, it can be stated that the flow of heat will be:

- Correlated to the type and the shape of the wall.
- Correlated to the type of fluid and consequently directly proportional to its specific heat and inversely proportional to its viscosity.
- Directly proportional to the speed of exchange.
- Directly proportional to the time.

If we ignore the effect of the “laminar” layer, the heat exchange between fluid and solid will be:

$$Q = \alpha \bullet A \bullet (T2 - T1) \bullet H$$

where:
Q = quantity of heat transmitted (W/h)
α = unit laminar conductivity
A = heat exchange surface (m^2)
T1 = temperature of the fluid (°C)
T2 = temperature of the fluid (°C)
H = time (h)

RADIATION

Heat exchange by radiation occurs due to electromagnetic waves, with a wavelength band normally in the field of infrared and therefore invisible radiation.

Each solid, liquid or gas emits, in all directions, energy that is transmitted, through the air, at the speed of light (≅300.000 km/s), to other surfaces that may absorb or reflect the radiation or allow it to pass.

Two bodies placed inside the same environment and in a position such that they “see each other” always exchange energy between one another, with the warmer body emitting more radiant energy than it absorbs (the opposite is true for the cooler body); the energy absorbed is converted into heat, and the energy transmitted can be replenished, by adding thermal energy, to make the exchange permanent.

Considering radiating bodies located one inside the other, where the “container” can act as a “black body”, thus annulling the “shape factor” that characterises the exchange between two bodies situated in a space where other bodies take part in the transmission of heat, the following can be stated:

- A body that is able to emit energy is also able to absorb it.
- The body that has the maximum capacity to emit energy also has the maximum capacity to absorb it.
- The energy emission or absorption capacity depends on the nature of the body and on the colour of the surface:
  - The capacity of metallic bodies increases as the angle of incidence increases from the normal angle.
  - The capacity of non-metallic bodies decreases as the incidence increases from the normal angle.
  - Dark-coloured surfaces have a higher capacity than light-coloured surfaces.

Considering two bodies at different temperatures, not shadowed, which exchange energy through the air (it must be remembered that gases such as carbon dioxide or water vapour both emit and absorb energy) the heat exchange will be:

$$Q = 5{,}73 \bullet A \bullet \in \bullet \left[\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4 \right] \bullet H$$

where:
Q = quantity of heat transmitted by radiation (W/h)
A = surface area of the hot body (m^2)
∈ = global emissivity coefficient of the surface of the hot body
T1 = temperature of the hot body (°Kelvin = °C + 273)
T2 = temperature of the cold body (°Kelvin = °C + 273)
H = time (h)

Ambient comfort is defined as a general attitude of satisfaction shown by a large majority of people who work inside an environment, and consequently based on the following parameters:

- Activity of the occupants (metabolism: expressed in “met”)
- Clothing of the occupants (clothing: expressed in “clo”)
- Ambient air temperature (dry bulb: expressed in °C)
- Ambient relative humidity (wet bulb: expressed in °C)
- Ambient air velocity (velocity in the occupied area: expressed in m/s)
- Radiant temperature of the walls (mean temperature: expressed in °C)

NB: in this phase, the effects of radiant asymmetry are ignored, and will be considered in the **following paragraphs** (Systems).

The relationships between the parameters, and their influence on the comfort of users, have been determined by the research team headed by Ole Fanger (technical University of Denmark), and are very important for our purpose; some further details will be useful, before proceeding with examples used to identify the most suitable design data for the “typical building” and for the various “systems techniques” compared.

EVALUATION OF COMFORT

The research team, headed by Ole Fanger, carried out a series of experimental surveys, subjecting a group of individuals to different degrees of thermal stress, so as to record the subjective vote of the effects, on the following scale:

- \- 3 = cold
- \- 2 = cool
- 0 = neutral
- \+ 1 = slightly warm
- \+ 2 = warm
- \+ 3 = hot

The results of the evaluations express what is called the PMV (Predicted Mean Vote), used to hypothesize the PPD (Predicted Percentage of Dissatisfied), which in turn establishes whether a certain ambient condition is acceptable; at this stage, the number of dissatisfied people that can be tolerated needs to be established, considering the following:

- It is impossible to go below 5%, as even PMV = 0 represents this percentage.
- The ISO 7730 standard specifies an acceptable PMV to be between – 0.5 and + 0.5, which implies a PPD of 10%.
- The ASRHAE 55 standard specifies an acceptable PMV value to be between – 0.85 and + 0.85, which implies a PPD of less than 20%.

EVALUATION OF THE PHYSICAL ACTIVITY OF THE OCCUPANTS

The metabolic rate of the human body, that is, the quantity of heat produced that must be disposed of in order to maintain a constant body temperature (37°C, with a tolerance of 0.5°C), depends on the physical activity carried out; to express this value, the unit of measure called “met” has been used, which is equal to:

$$1met = 58W / m^2 = 50Kcal / h / m^2$$

This unit of measure represents the specific metabolic rate that can be attributed to 1 m^2 of the surface of an adult male human body at rest; the effective metabolic rate will then depend on the type of activity and the surface area of the human body, calculated by Du Bois as 1.9 m^2 (average value).

EVALUATION OF CLOTHING

The main function of clothing is to provide thermal resistance for the outside surface of the human body, alleviating the reaction of the relative and well-known temperature control systems (vaso-motor, muscular, evaporation); the non-dimensional unit of measure, called “CLO” (from clothing) has been introduced to express the effects of clothing, and is equal to:

$$CLO = 0{,}155 m^2\ K / W\ 1$$

This unit of measure corresponds to the thermal resistance of typical European mid-season garments.

EVALUATION OF THE PARAMETERS OF THE MICRO-CLIMATE

The heat exchange between people carrying out activities and the environment they carry out such activities in occurs by the following mechanisms:

- Evaporation: latent heat produced by respiration and by the activities carried out (perspiration).
- Convection: sensible heat that depends, with a directly proportional relationship, on the temperature and on the air velocity.
- Radiation: sensible heat that depends, with a directly proportional relationship, on the mean radiant temperature of the surrounding surfaces.

Experiments carried out and the votes analysed have highlighted that within the comfort zone, variations in ambient relative humidity affect the exchange of heat by evaporation to an irrelevant extent and do not significantly modify the sensations of the people in the environment, who, on the other hand, become dissatisfied when the relative humidity is lower than 25% (disturbance to the mucous in the respiratory apparatus) and above 70% (feeling of nausea and increased perception of odours).

The reference values for determining the ideal ambient conditions, for established activity and clothing values, are therefore:

- Ambient air temperature.
- Air velocity environment.
- Mean radiant temperature of the surfaces.

Given that the above-mentioned values depend on both the constructional characteristics of the building and the specific features of the “systems techniques” chosen, as these determine both the air velocity in the occupied zones and the mean radiant temperature, the dissertation on the air velocity in the occupied zones can be left to one side, because it is usually a known datum and related to the type of system, leaving the formulae to calculate both the mean radiant temperature of the surfaces in the room and the operative temperature inside the room, that is, the temperature that expresses the thermal balance of the heat disposed of by the occupant, and specifically:

$$(1) \rightarrow Tp = Tpi - \frac{0{,}145 \bullet Qd}{St}$$

$$(2) \rightarrow To - \frac{Ta + Tp}{2}$$

<u>where:</u>

Qd = heating requirement of the room, due to losses (Wh)
St = total surface area of the 6 sides that border the room
Ta = ambient air temperature (°C)
To = operative temperature (°C)
Tp = mean radiant temperature of the surfaces (°C)
Tpi = temperature of the inside walls, which do not disperse heat, assumed as being equal to the air temperature (°C)
0,145 = thermal resistance of the internal laminar layer between air – wall (m^2 h °C/W)

NEW STANDARDS EUROPEAN EN 14037 and EN 12831

The new European EN 14037 standard defines the characteristics of the ceiling-mounted radiator panels (radiant heating panels) and the method for testing the heat output.

The main differences concern the test methodology (the same test cabin used for the radiators is adopted, without any air infiltration), the headers are insulated and both the heat output per linear metre (W/m) and the heat output of the pair of manifolds (W/pair of manifolds) is measured. The minimum acceptable water flow-rate per pipe depends on the return temperature and the type of manifold. No reduction coefficients are envisaged for the output according to the height of the building.

The new EN 14037 standard is a Harmonised European Standard and is published in the Official Journal of the European Union (OJ). It is a compulsory standard: the manufacturer is required to perform the tests in one of the four notified European laboratories, indicating the number of the test report for each model and confirming the compliance to the standard with the CE mark on the product/packaging.

The new European EN 12831 standard concerns the calculation of the heat loss of a building.
It was published in March 2003 and will be translated into all European languages.
The standard requires the use of the operative temperature (arithmetic average of the inside air temperature and the mean radiant temperature) as the inside temperature of the environment.
The heat loss must be calculated using this value.
Considering that two well-insulated buildings, one heated with radiant heating panels and an operative temperature of 15°C, the other heated with air systems and an air temperature of 18°C, give a similar feeling of comfort, due to the different temperature of the floor and the walls, for the correct calculation of the heat loss of the building it is fundamental to carefully define the room temperature with the final user, striving for energy savings for the same level of comfort, which may involve a temperature that is 3°C lower.
The EN 12831 standard in the English version, converted in the same way in France by the Association of Systems Designers, introduces the same concepts in Annex B.1, Table B.1, suggesting for large buildings with a height of over 5m, a difference of between 15% and 30% in the calculation of the total heat loss of the building depending on whether radiant heating panels or forced air heating systems are used.

If the inside air temperature differs considerably from the mean radiant temperature (e.g. with a radiant heating panel system), the same EN 12831 standard, in Annex B.2, suggests that the calculation of the part of the heat loss due to the infiltration of air, comparing the outside temperature with the inside air temperature and not with the operative temperature. In the example of an environment with an operative temperature of 15°C, mean radiant temperature of 17°C, inside air temperature of 13°C and outside air temperature of -15°C, adopting this suggestion involves a reduction of over 5% in the calculation of the heat loss due to the infiltration of outside air.

As highlighted above, the heat output of ceiling-mounted radiant panels is determined in a rather small test cabin, perfectly sealed, without the infiltration of outside air.
Adopting such heat output values in the sizing of a radiant heating panel system, when calculating the heat loss due to the infiltration of outside air, the number of air change volumes/hour must be minimised, depending on how well the building is sealed and how often and for how long the doors are opened, this value will range from a minimum of 0.1 to a maximum of 0.5 volumes/hour, except where there are clear indications to the contrary.

If the infiltration of air through the access doors is higher than the values indicated in the new standard, the use of appropriate hot air curtains is recommended *(see the Sabiana series STP Atlas air heaters)*.

The forced extraction of air due to exhaust systems fitted on production machinery or other systems must be balanced by introducing the same amount of air heated by Sabiana Atlas air heaters, fitted with outside air inlet ducts or similar systems. If more than 2 Vol/h of air is required, contact the Sabiana Technical Department.

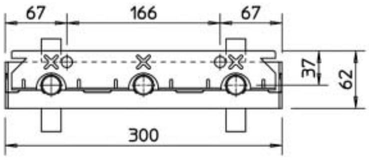
Therefore, by calculating the exact heat loss and knowing which heating system is used, all the components of the installation can be sized (heating plant, pumps, pipes and insulation, control systems) so as to significantly reduce the investment and running costs, while providing the unrivalled comfort guaranteed by the radiant heating panels.

Sabiana has developed detailed software for the sizing of radiant heating panel systems that is capable of rapidly simulating different solutions. The software is compatible with the most widespread CAD and word processing programs, and provides an indication of the costs of the components required.

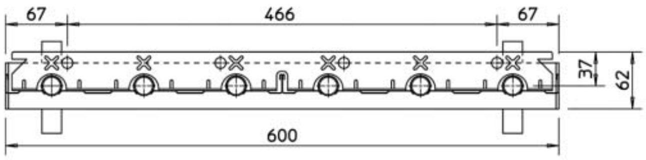
N.B.: In new buildings, in the first few months of operation there may be some difficulty in reaching the design ambient temperature.
This is due to the fact that the structure and the floors must dry out, that is, the quantity of water vapour they contain must be eliminated; this normally occurs over a few months of operation.
Once the structures are perfectly dry, best results in terms of comfort can be achieved.

MODULAR WIDTHS

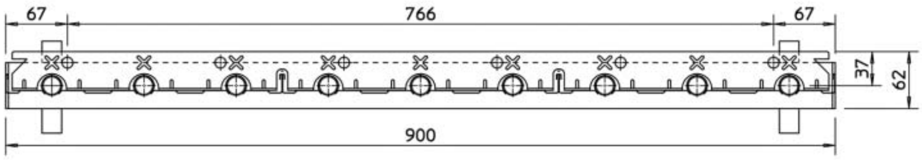
Model **DS3** - Ø 1/2” pipes spaced 100 mm. apart



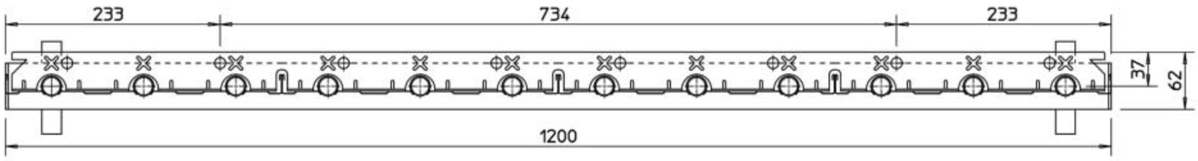
DS3-03



DS3-06

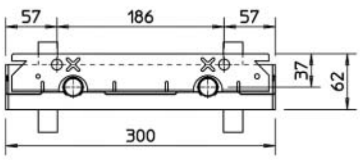


DS3-09

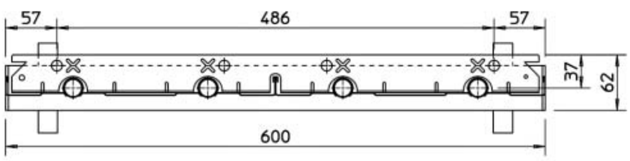


DS3-12

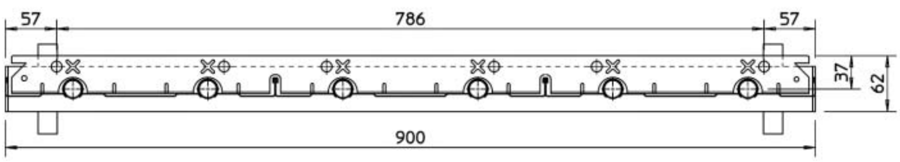
Model **DS2** - Ø 1/2” pipes spaced 150 mm. apart



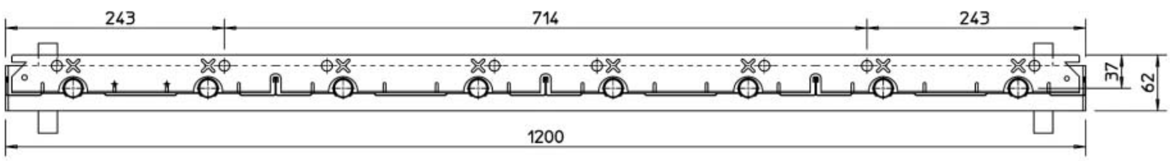
DS2-03



DS2-06

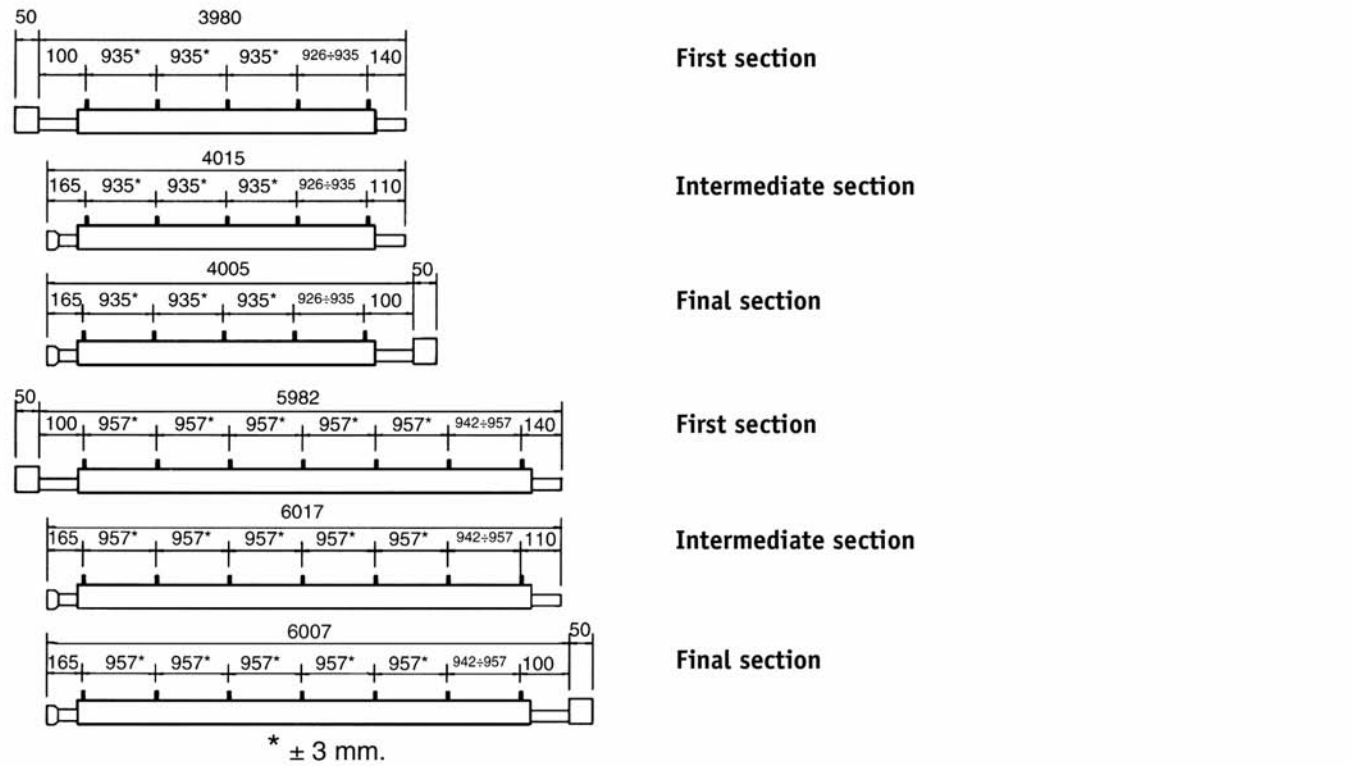


DS2-09



DS2-12

MODULAR LENGTHS



Odd lengths are available on request.

WEIGHT AND WATER CONTENT

			Water content lt/m		Volume l	Weight kg
Type	Standard kg/m	Special kg/m	Standard	Special	1 header	Full header
DS2-03	4,6	5,6	0,53	0,43	0,63	1,9
DS2-06	9,2	11,2	1,05	0,87	1,27	3,7
DS2-09	13,8	16,8	1,58	1,30	1,90	5,1
DS2-12	18,4	22,4	2,10	1,74	2,54	6,5
DS3-03	5,6	7,1	0,79	0,65	0,63	2,1
DS3-06	11,2	14,2	1,58	1,30	1,27	3,9
DS3-09	16,8	21,3	2,37	1,95	1,90	5,3
DS3-12	22,4	28,4	3,16	2,60	2,54	6,7

THERMAL EMISSION OF THE HEATING PANELS

Table of thermal emission for each meter of the different models of **DS** radiant panels in accordance to the European Standard EN 14037

Δtm (K)	DS2-03 W/m	DS2-06 W/m	DS2-09 W/m	DS2-12 W/m
20	51	90	126	170
22	57	100	141	189
24	63	111	155	209
26	69	122	171	229
28	75	133	186	250
30	81	144	201	270
32	87	155	217	291
34	93	166	233	312
36	100	177	249	333
38	106	189	265	355
40	112	200	281	376
42	119	212	297	398
44	125	223	314	420
46	132	235	330	442
48	139	247	347	464
50	145	259	364	486
52	152	271	380	509
54	159	283	397	531
55	162	289	406	543
56	165	295	415	554
58	172	307	432	577
60	179	319	449	600
62	186	331	466	623
64	193	344	484	646
65	196	350	493	657
66	200	356	501	669
68	207	368	519	692
70	214	381	537	716
72	221	394	555	739
74	228	406	572	763
76	235	419	590	787
78	242	432	608	810
80	249	444	627	834
82	256	457	645	858
84	263	470	663	883
86	271	483	681	907
88	278	496	700	931
90	285	509	718	955
92	292	522	737	980
94	300	535	755	1004
96	307	548	774	1029
98	314	561	792	1054
100	322	575	811	1078
102	329	588	830	1103
104	336	601	849	1128
106	344	614	868	1153
108	351	628	887	1178
110	359	641	906	1203
112	366	655	925	1228
114	374	668	944	1253
116	381	682	963	1279
118	389	695	983	1304
120	396	709	1002	1330
122	404	723	1021	1355
124	412	736	1041	1381
126	419	750	1060	1406
128	427	764	1080	1432
130	435	777	1099	1458
132	442	791	1119	1483
134	450	805	1138	1509
136	458	819	1158	1535
138	465	833	1178	1561
140	473	847	1198	1587

Δtm (K)	DS3-03 W/m	DS3-06 W/m	DS3-09 W/m	DS3-12 W/m
20	59	105	152	194
22	66	117	170	217
24	73	130	188	241
26	80	142	207	265
28	88	155	226	289
30	95	169	245	313
32	103	182	265	338
34	110	195	284	363
36	118	209	304	388
38	126	223	324	413
40	134	237	344	439
42	141	251	365	465
44	149	265	385	491
46	157	279	406	518
48	165	293	427	544
50	174	308	448	571
52	182	323	469	598
54	190	337	491	625
55	194	345	501	639
56	198	352	512	652
58	207	367	534	680
60	215	382	556	707
62	224	397	578	735
64	232	412	600	763
65	236	420	611	777
66	241	427	622	791
68	249	442	644	820
70	258	458	667	848
72	267	473	689	877
74	275	489	712	905
76	284	504	735	934
78	293	520	757	963
80	302	536	780	992
82	311	552	803	1021
84	320	568	827	1051
86	329	584	850	1080
88	338	600	873	1110
90	347	616	897	1139
92	356	632	920	1169
94	365	648	944	1199
96	374	664	968	1229
98	383	681	992	1259
100	393	697	1016	1290
102	402	714	1040	1320
104	411	730	1064	1351
106	420	747	1088	1381
108	430	763	1112	1412
110	439	780	1137	1443
112	449	797	1161	1474
114	458	813	1186	1505
116	468	830	1210	1536
118	477	847	1235	1567
120	487	864	1260	1598
122	496	881	1284	1629
124	506	898	1309	1661
126	515	915	1334	1692
128	525	932	1359	1724
130	535	950	1384	1756
132	544	967	1410	1788
134	554	984	1435	1819
136	564	1001	1460	1851
138	574	1019	1486	1883
140	583	1036	1511	1916

Δtm = difference between the mean water temperature and the room temperature.

DS radiant heating panels - Calculation procedure

THERMAL EMISSION OF THE HEADERS

Table of thermal emission of a **couple of headers** of the different models in accordance to the European Standard EN 14037

Δtm (K)	DS2-03 W	DS2-06 W	DS2-09 W	DS2-12 W
20	29	57	86	108
22	33	64	96	121
24	37	71	107	135
26	40	78	118	148
28	44	86	129	162
30	48	93	140	176
32	52	101	152	191
34	56	109	163	205
36	60	117	175	220
38	64	125	187	235
40	68	133	199	250
42	72	141	211	266
44	76	150	224	281
46	80	158	236	297
48	85	167	249	313
50	89	175	261	328
52	93	184	274	344
54	97	193	287	361
55	100	197	294	369
56	102	202	300	377
58	106	211	313	393
60	111	220	327	410
62	115	229	340	427
64	120	238	353	443
65	122	242	360	452
66	124	247	367	460
68	129	256	380	477
70	133	266	394	495
72	138	275	408	512
74	142	284	422	529
76	147	294	436	547
78	152	303	450	564
80	156	313	464	582
82	161	323	478	599
84	166	333	492	617
86	171	342	507	635
88	175	352	521	653
90	180	362	536	671
92	185	372	550	689
94	190	382	565	708
96	195	392	579	726
98	200	402	594	745
100	204	412	609	763
102	209	423	624	782
104	214	433	639	800
106	219	443	654	819
108	224	454	669	838
110	229	464	684	857
112	234	474	699	876
114	239	485	714	895
116	244	495	730	914
118	250	506	745	933
120	255	517	761	952
122	260	527	776	972
124	265	538	792	991
126	270	549	807	1011
128	275	560	823	1030
130	280	570	839	1050
132	286	581	854	1069
134	291	592	870	1089
136	296	603	886	1109
138	301	614	902	1129
140	307	625	918	1149

Δtm (K)	DS3-03 W	DS3-06 W	DS3-09 W	DS3-12 W
20	32	57	91	115
22	35	64	101	129
24	39	71	113	144
26	44	78	124	158
28	48	86	135	173
30	52	93	147	189
32	56	101	158	204
34	60	109	170	220
36	65	116	182	236
38	69	124	194	252
40	74	132	206	268
42	78	140	218	285
44	83	149	231	301
46	87	157	243	318
48	92	165	256	335
50	97	174	268	353
52	101	182	281	370
54	106	191	294	387
55	109	195	301	396
56	111	199	307	405
58	116	208	320	423
60	121	217	333	441
62	126	226	346	459
64	131	235	360	477
65	133	239	366	486
66	136	244	373	495
68	141	253	386	514
70	146	262	400	532
72	151	271	414	551
74	156	280	427	570
76	161	289	441	588
78	167	299	455	607
80	172	308	469	627
82	177	318	482	646
84	182	327	496	665
86	188	337	510	685
88	193	346	525	704
90	198	356	539	724
92	204	365	553	743
94	209	375	567	763
96	215	385	581	783
98	220	395	596	803
100	226	405	610	823
102	231	414	625	843
104	237	424	639	864
106	242	434	654	884
108	248	444	669	905
110	254	454	683	925
112	259	464	398	946
114	265	475	713	966
116	271	485	728	987
118	276	495	743	1008
120	282	505	757	1029
122	288	516	772	1050
124	294	526	788	1071
126	299	536	803	1092
128	305	547	818	1114
130	311	557	833	1135
132	317	568	848	1156
134	323	578	863	1178
136	329	589	879	1199
138	335	599	894	1221
140	340	610	909	1243

Δtm = difference between the mean water temperature and the room temperature.

THERMAL EMISSION

MODEL	Rated emission (*)	MODEL	Rated emission (*)
DS2-03	162 W/m	**DS3-03**	194 W/m
DS2-06	289 W/m	**DS3-06**	345 W/m
DS2-09	406 W/m	**DS3-09**	501 W/m
DS2-12	543 W/m	**DS3-12**	639 W/m

(*) Δtm = 55 K

Characteristics curves of the product taken from tests carried out as per the EN 14037 standard:

$$Q = K \bullet (\Delta Tm)^n$$

Q = emission W/m
K = heating coefficient of the unit
Δtm = difference between the mean water temperature and the room temperature
n = heating exponent of the unit

*Values **K** and **n** for the radiant panels*

MOD.	K	n	MOD.	K	n
DS2-03	1,6346	1,147	**DS3-03**	1,7367	1,1771
DS2-06	2,8547	1,1519	**DS3-06**	3,0624	1,1786
DS2-09	3,924	1,1577	**DS3-09**	4,4192	1,1807
DS2-12	5,4315	1,1489	**DS3-12**	5,7425	1,1757

*Values **K** and **n** for the headers*

MOD.	K	n	MOD.	K	n
DS2-03	0,80168	1,2033	**DS3-03**	0,81147	1,2221
DS2-06	1,39832	1,2349	**DS3-06**	1,47147	1,2196
DS2-09	2,21298	1,2198	**DS3-09**	2,60469	1,1849
DS2-12	2,82062	1,2161	**DS3-12**	2,93865	1,2237

The emission of the SABIANA **DS** radiant panels have been certified by the laboratory at the university of Stuttgard H.L.K. applying the harmonised European standard EN 14037, with the following report numbers:

Model DS2-03 Report No. DC203D12.1874
Model DS2-06 Report No. DC203D12.1873
Model DS2-09 Report No. DC203D12.1872
Model DS2-12 Report No. DC203D12.1871
Model DS3-03 Report No. DC203D12.1870
Model DS3-06 Report No. DC203D12.1869
Model DS3-09 Report No. DC203D12.1875
Model DS3-12 Report No. DC203D12.1867

In compliance with the requirements of EN 14037-1, Annex **ZA**, the heat outputs have been indicated in accordance with EN 14037-3. Subtracting 10% from the published values gives the heat outputs in accordance with EN 14037-2.

For emission with steam supply contact the Sabiana Technical Department.

CE EN 14037 STANDARD - Ceiling radiant panels

04 Maximum operating pressure: 4 bars

LENGTH OF RADIANT PANELS

Apart from the case in which certain structural needs (lights, dividing walls and beams etc.) or the LAY-OUT (shelves) must be observed, it is recommended to install radiant panels parallel to the longest side of the building to be heated.
This will allow the assembly of longer radiant panel sections therefore reducing the number of runs. This will have the consequence of less connections to the pipework which will acheive a lower installation cost. At the same time this will reduce the quantity of tubes necessary for the distribution of the heating fluid. Maximum length of radiant panels depends on the type of header and on water temperature:

with water up to 100°C	Header B	max 100 mtr
	Header D	max 50 mtr
with water between 100°C and 170°C	Header B	max 50 mtr

The radiant panel length must cover the whole area to be heated.
Free space between the end of radiant panels and the walls (or limit of the area to be heated) is normally between 1 and 2 metres. The following table shows the combination of panels with the different sections and the relevant lengths to make any specific length.

TABLE OF LENGTH COMPOSITIONS OF THE FIRST, INTERMEDIATE AND END PANELS (WITH STANDARD 4 AND 6 m MODULES)

Total length m	Composition		
	First section	Intermediate section	Final section
4	1 x 4 m		
6	1 x 6 m		
8	1 x 4 m		1 x 4 m
10	1 x 4 m		1 x 6 m
12	1 x 6 m		1 x 6 m
14	1 x 4 m	1 x 6 m	1 x 4 m
16	1 x 4 m	1 x 6 m	1 x 6 m
18	1 x 6 m	1 x 6 m	1 x 6 m
20	1 x 4 m	2 x 6 m	1 x 4 m
22	1 x 4 m	2 x 6 m	1 x 6 m
24	1 x 6 m	2 x 6 m	1 x 6 m
26	1 x 4 m	3 x 6 m	1 x 4 m
28	1 x 4 m	3 x 6 m	1 x 6 m
30	1 x 6 m	3 x 6 m	1 x 6 m
32	1 x 4 m	4 x 6 m	1 x 4 m
34	1 x 4 m	4 x 6 m	1 x 6 m
36	1 x 6 m	4 x 6 m	1 x 6 m
38	1 x 4 m	5 x 6 m	1 x 4 m
40	1 x 4 m	5 x 6 m	1 x 6 m
42	1 x 6 m	5 x 6 m	1 x 6 m
44	1 x 4 m	6 x 6 m	1 x 4 m
46	1 x 4 m	6 x 6 m	1 x 6 m
48	1 x 6 m	6 x 6 m	1 x 6 m
50	1 x 4 m	7 x 6 m	1 x 4 m

N.B. For the composition of odd lengths, contact the Sabiana Technical Department.

HEIGHT OF INSTALLATION

The **DS** radiant panels must be installed, based on the temperature of the hot water, **as low as possible** so as to reduce the loss of radiant heat due to the presence of dust in the air underneath the panels. With the exeption of the reduction in efficiency due to any micro-particles in suspension in air that may absorb a minimal part of the radiant emission, **there are no limits to the height of installation.**
In fact, if the height of installation of a hypothetical radiant ceiling were moved upwards, the surface that radiates heat onto the people below would increase proportionally to the square of the height above such people, while the intensity of radiation received by the people and emitted by each unit of the radiant ceiling would decrease proportionally to the square of the distance from the people: based on these laws of physics, the total radiant heat received by the people thus remains constant. Vice-versa, there are **limits in terms of the minimum height of installation of the radiant units,** according to the average temperature values of the hot water to ensure climate comfort.
The minimum recommended values, for the two models DS 2 and DS 3, are shown in the table below, valid for the horizontal installation and in the case of people working in stationary positions.

Lowest recommended height of installation (in m above the floor)

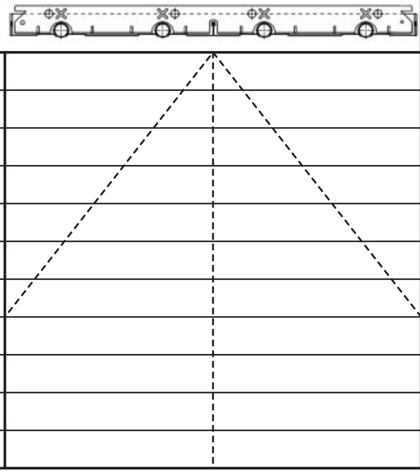
Mean water temperature °C	DS2-03	DS2-06 DS2-09	DS2-12	DS3-03	DS3-06 DS3-09	DS3-12
60°	3.00	3.10	3.20	3.10	3.20	3.30
70°	3.10	3.20	3.30	3.20	3.30	3.40
80°	3.20	3.30	3.40	3.30	3.50	3.60
90°	3.30	3.50	3.70	3.40	3.70	3.90
100°	3.40	3.70	3.90	3.50	4.00	4.20
110°	3.50	4.00	4.30	3.60	4.20	4.40
120°	3.60	4.20	4.50	3.70	4.40	4.70
130°	3.70	4.40	4.70	3.80	4.60	4.90
140°	3.80	4.60	5.00	3.90	4.80	5.20

RECOMMENDED FLUID TEMPERATURES IN ACCORDANCE TO THE HEIGHT OF INSTALLATION

For installation heights from 3 to 4 m, a mean fluid temperature of 50/60°C is recommended, with the use of model DS-03 and DS-06 heating panels.
The use of hot water from 70°C to 90°C is recommended for installation heights between 5 and 9 m, using model DS-06 DS-09 and DS-12 heating panels.
For higher installations, the use of superheated water is recommended, with model DS-09 and DS-12 heating panels.

DS radiant heating panels - Calculation procedure

Special attention must be paid when heating an environment used as a warehouse or for the storage of goods that may deteriorate with temperature (pharmaceutical products, food, etc.).
The table shows indicative radiation temperatures at the different panel distances.

DISTANCE m.	**DS3-09/DS3-12** 	MEAN WATER TEMPERATURE					
		80°	**90°**	**100°**	**120°**	**140°**	**160°**
0,5		32°	36°	40°	48°	55°	64°
1		24°	27°	30°	36°	40°	48°
2		23°	26°	29°	34°	39°	46°
3		22°	24°	27°	31°	37°	42°
4		20°	22°	25°	29°	34°	38°
5		19°	20°	23°	26°	30°	33°
6		18°	19°	21°	23°	25°	28°
7		18°	18°	19°	20°	21°	23°
8		18°	18°	18°	18°	19°	21°
9		18°	18°	18°	18°	18°	19°
10		18°	18°	18°	18°	18°	18°

These temperatures are taken with a globothermometric probe placed in the middle of the heated area under static atmosphere.
Design ambient temperature: 18°C
For the radiant panels models DS2-09/DS2-12, temperatures must be reduced by 15%.

The above values may vary considerably in function of air speed, humidity saturation, etc.

SELECTION OF THE MODEL

After determining the length of radiant panels it is possible to choose the suitable model.
Once the running conditions (air temperature, heat loss of area to be heated, water temperature, installation height) are known, it is possible to check the thermal output of various models on the table on page 14.
Example: assuming that the DS3-12 model is used (that is the one with the highest thermal emission), the total thermal power to be installed is divided by the panel thermal output for each linear metre (already de-rated from any correction factor) and the number of total metres for this model is found. Then by dividing this value by the maximum length of each panel, the number of panels to be installed will be calculated.

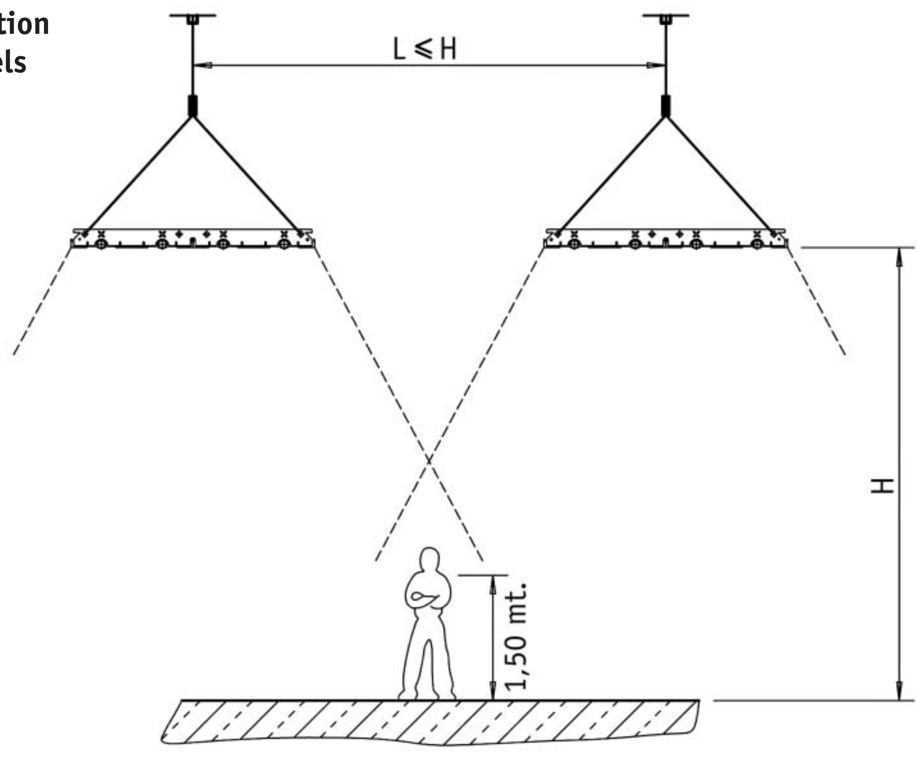
$$\frac{\text{Total power}}{\text{Output x m}} = \text{Tot. m} \qquad \frac{\text{Total m}}{\text{Length}} = \text{N° of panels}$$

The next stage, the heat output per metre must be multiplied by the total number of metres planned, and the total output of the heating panels calculated, to be added to the heat output of the headers (multiply the heat output of the individual pair of headers by the number of lines envisaged). The sum of the two values corresponds to the total output of the installation, which must cover 100% of the heat loss calculated.

The first check consists in verifying that the distance between two panels is lower than the installation height. If the distance between centres exceeds the installation height, the number of panels must be increased by using the type of radiant panel with a thermal emission immediately below the one of the model chosen before (e.g. DS2-12 instead of DS3-12) and by repeating the above-described procedure.

Tests and practice have shown that an even distribution of radiant heat over a central area in a building (where the cooling effect of the walls can be considered as 0) is achieved when the distance between **DS** panels is the same or less than the height from the floor.
For example when **DS** panels are installed at a height of 4m from the floor then the distance between the panels must be 4m or less to obtain the best heating coverage.

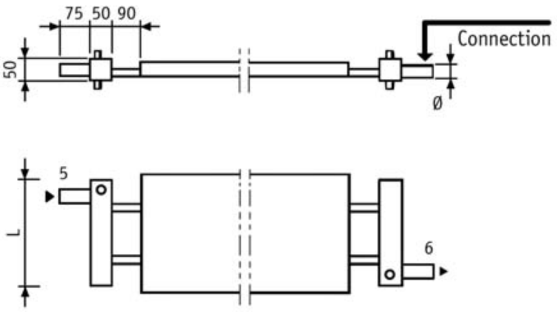
Correct installation
DS radiant panels



SELECTION OF THE HEADERS

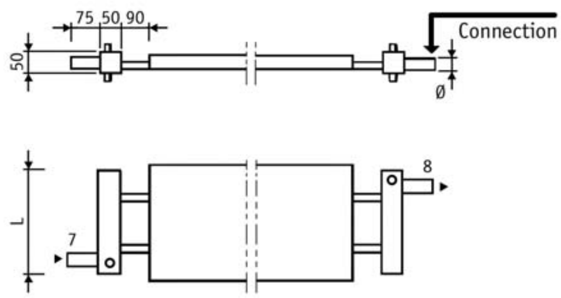
The first and final panels of each radiant DS include square-section headers, mechanically welded at the tube ends and incorporate 3/8 inch diameter BSP connections top and bottom pre-set for plugs or drain cocks and air vents. Hot water flows into the panel at one end of the header and returns at the end of another header: because of the small tube section the hot water speed in the tubes will always have a sufficient velocity. For ease of installation or if the need to increase the thermal fluid speed arises, the radiant DS allows water to flow and return at the same end of the header by using a "D" type header. This header is split in order to let the thermal fluid flow twice in the same panel, without posing problems for the varying thermal expansions of the two flow and return circuits because the radiant DS panel is composed of steel plate and tubes that can expand freely and independently. However this type of diaphram header is recommended only for hot water installations, with a water temperature drop lower than 20°C. By using the header "D" the panel flow and return can be connected to the flow tubes only on one side of the building, thus reducing the amount of pipework (and relevant brackets) to be installed.

Model B - Connections 5-6



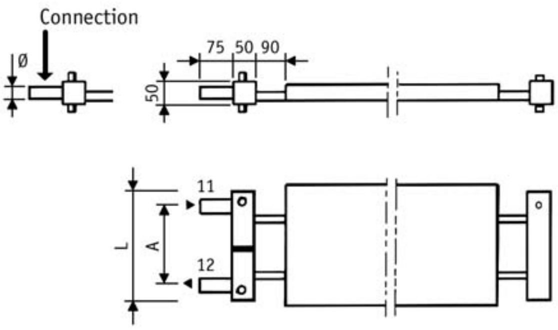
Mod.	L	Ø (standard)
03	300	1/2"
06	600	3/4"
09	900	1"
12	1200	1 1/4"

Model B - Connections 7-8



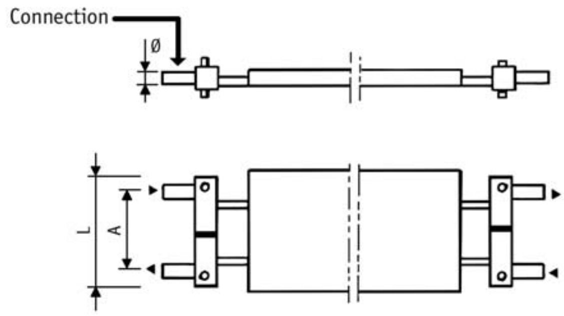
Mod.	L	Ø (standard)
03	300	1/2"
06	600	3/4"
09	900	1"
12	1200	1 1/4"

Model D



Mod.	L	A	Ø (standard)
03	300	200	1/2"
06	600	500	3/4"
09	900	800	1"
12	1200	1100	1 1/4"

Model D+D



Mod.	L	A	Ø (standard)
03	300	200	1/2"
06	600	500	3/4"
09	900	800	1"
12	1200	1100	1 1/4"

D and D+D headers:

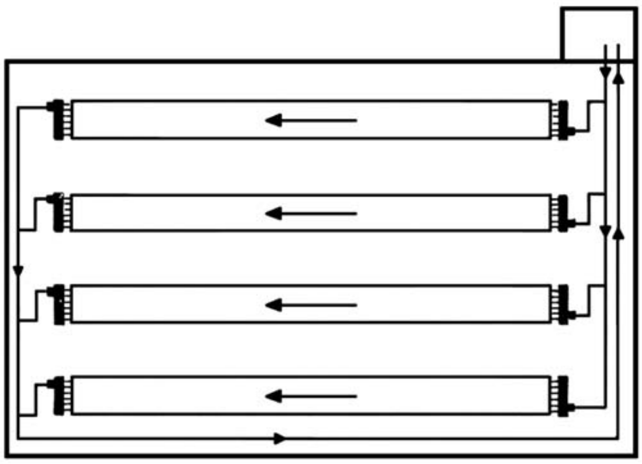
Distance between the connections: model 03 = 200 mm
06 = 500 mm
09 = 800 mm
12 = 1100 mm

D and D+D headers are not suitable for high temperature hot water or steam.

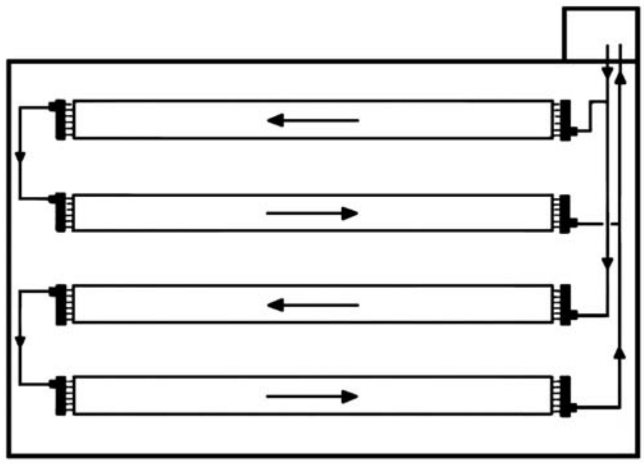
SELECTION OF THE WATER CIRCUIT

The type of water circuit must be chosen so as to minimise the amount of supply pipework, considering that the heating panels themselves carry the heating fluid ensuring a lower installed cost.
It is recommended to use the system compensated with the third pipe when there are more than 5 lines (or pairs of lines with header “B”, on which the first is the outlet and the second the return), so as to have better balance of the installation and a uniform distribution of the pressure drop.
Although, automatic flow-rate stabilisers can be used (*see Page 31*).
If using heating panels fitted with header “B”, the inlet of the installation must be located in the part of the building where there is the greatest heat loss (north side, near doorways, etc.).
Below are a number of diagrams showing the layouts of different types of water circuits.

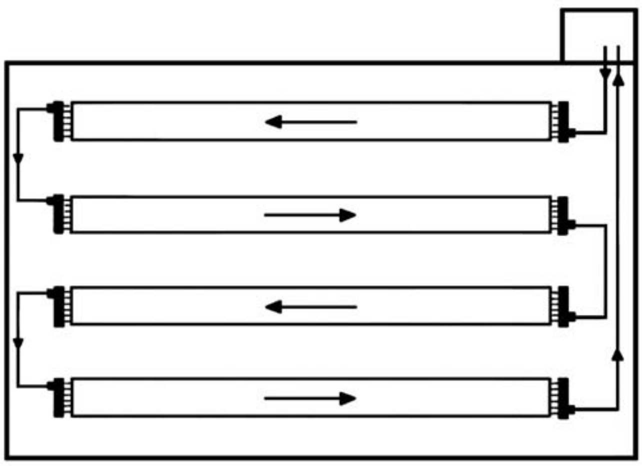
HEADER “B”
COMPENSATED LINES



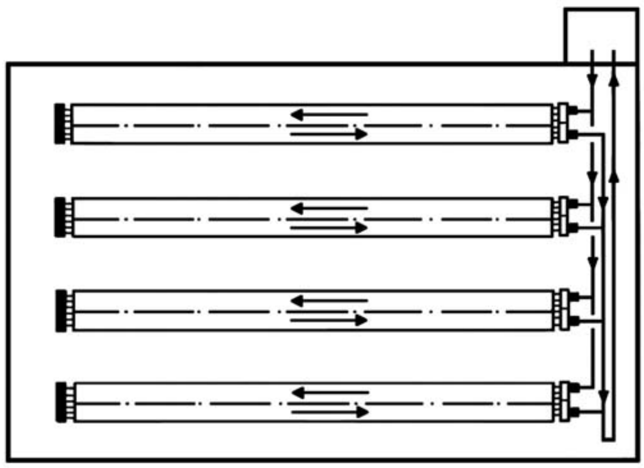
HEADER “B”
COUPLED LINES



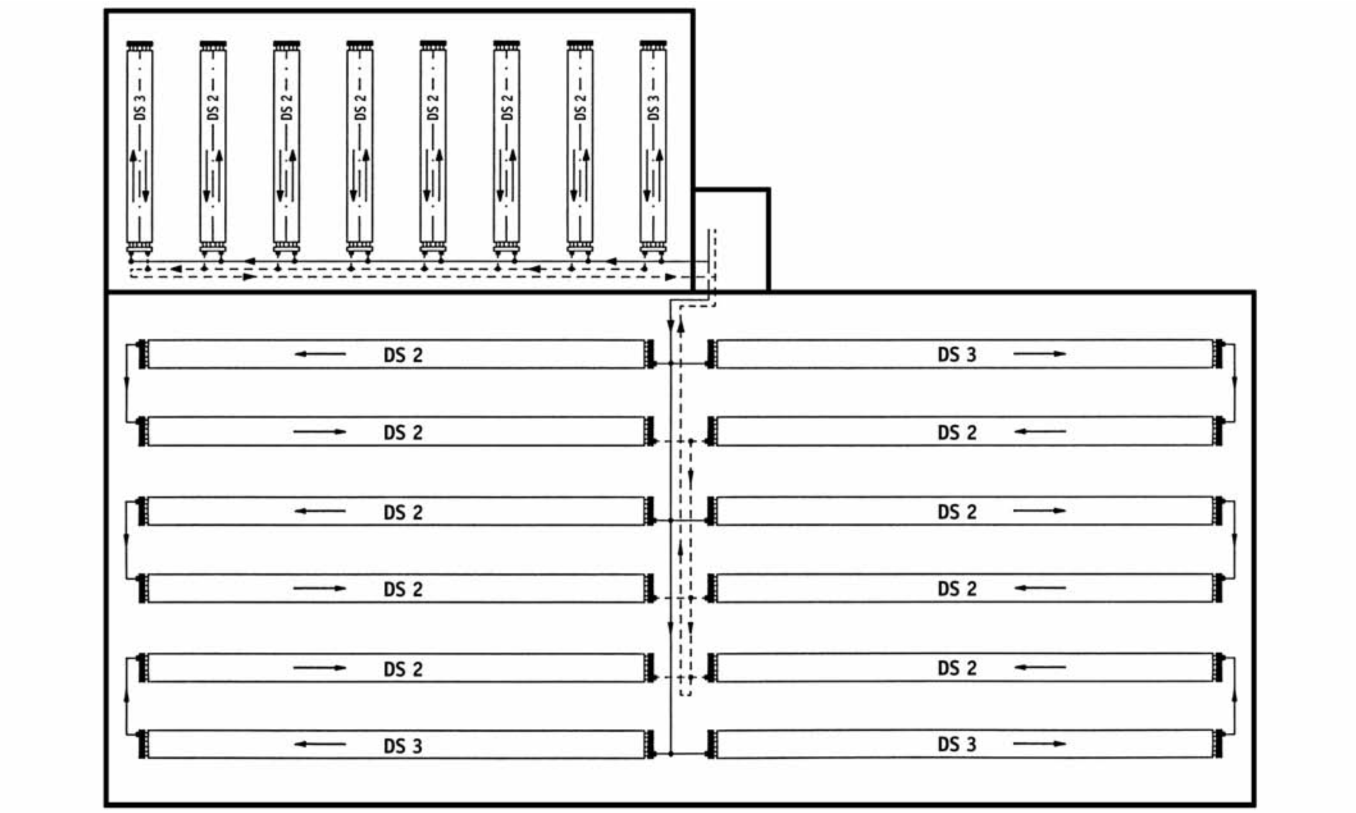
HEADER “B”
LINES IN SERIES



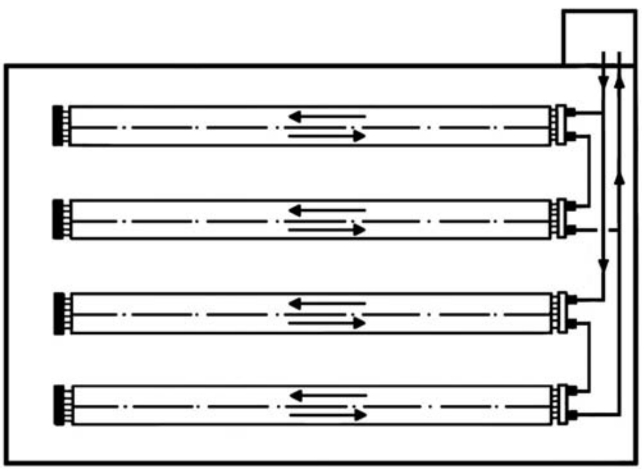
HEADER “D”
COMPENSATED LINES



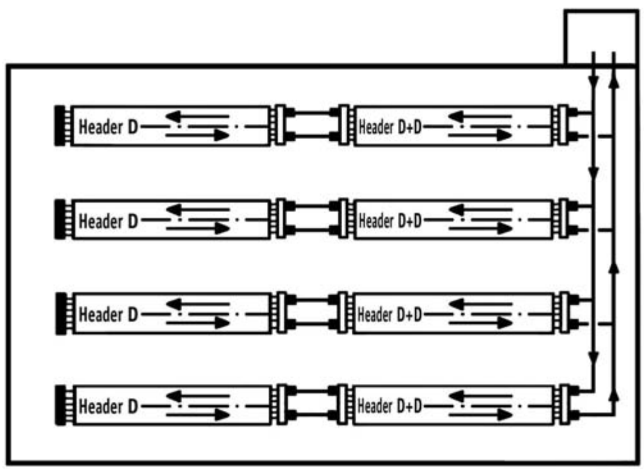
SYSTEM WITH THE HIGHEST OUTPUT HEATING PANELS NEAR THE PERIMETER WALLS COMPENSATED HEADERS "B" AND "D"



HEADER "D"
LINES IN SERIES



HEADERS "D + D"



MINIMUM FLOW-RATE OF THE HEATING FLUID

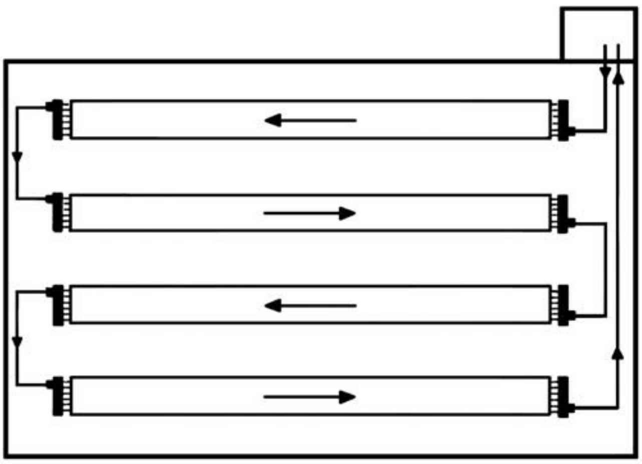
The heat outputs shown in the table on page 14 are valid as long as the minimum water flow-rate guarantees a condition of turbulence inside the pipes.
The following table indicates the minimum flow-rates according to the model of heating panels, the header and the hot water return temperature.
Water flow-rates below the minimum indicated must be avoided.

	Return temperature °C	DS2-03 (l/h)	DS2-06 (l/h)	DS2-09 (l/h)	DS2-12 (l/h)	DS3-03 (l/h)	DS3-06 (l/h)	DS3-09 (l/h)	DS3-12 (l/h)
HEADER B	30	240	480	720	960	360	720	1080	1440
	40	196	392	588	784	294	588	882	1176
	50	164	328	492	656	246	492	738	984
	60	140	280	420	560	210	420	630	840
	70	120	240	360	480	180	360	540	720
	80	106	212	318	424	159	318	477	636
	90	94	188	282	376	141	282	423	564
	100	86	172	258	344	129	258	387	516
	110	78	156	234	312	117	234	351	468
	120	70	140	210	280	105	210	315	420
	130	66	132	198	264	99	198	297	396
	140	60	120	180	240	90	180	270	360
HEADER D	30	120	240	360	480	240	360	600	720
	40	98	196	294	392	196	294	490	588
	50	82	164	246	328	164	246	410	492
	60	70	140	210	280	140	210	350	420
	70	60	120	180	240	120	180	300	360
	80	53	106	159	212	106	159	265	318

In the case of systems with short heating panels, a number of lines can be connected in series, so as to guarantee a sufficient water flow-rate *(SEE FIG. 1)*. Using this solution, the first heating panels supplied, which have a higher average temperature and therefore a higher heat output than the others, must be located in the part of building with the greatest heat loss.

Fig. 1

HEADER "B"



CONFIGURATION FLEXIBILITY

Standard version

The radiant panel tubes supplied for standard application are made from quality cold-rolled panels submitted to electric welding.
These tubes are electronically tested by the manufacturer and can be used for most standard applications in installations with working pressure of 10 bar and with a water maximum temperature up to 120°C.
Upon request, panels can be supplied for operation between 4 and 10 bars.

Special version

For special installation using high temperature hot water with high working pressures or to comply with specific requirements of specifications, "special" seamless tubes, 2.35 mm thick, are supplied.
These special tubes that are also submitted to specific testing can be installed in installations with a working pressure of up to 25 bar and with a heating fluid maximum temperature up to 180°C.

PRESSURE DROPS

The pressure drop is calculated using the following diagrams, based on the quantity of water that must flow though each heating panel.

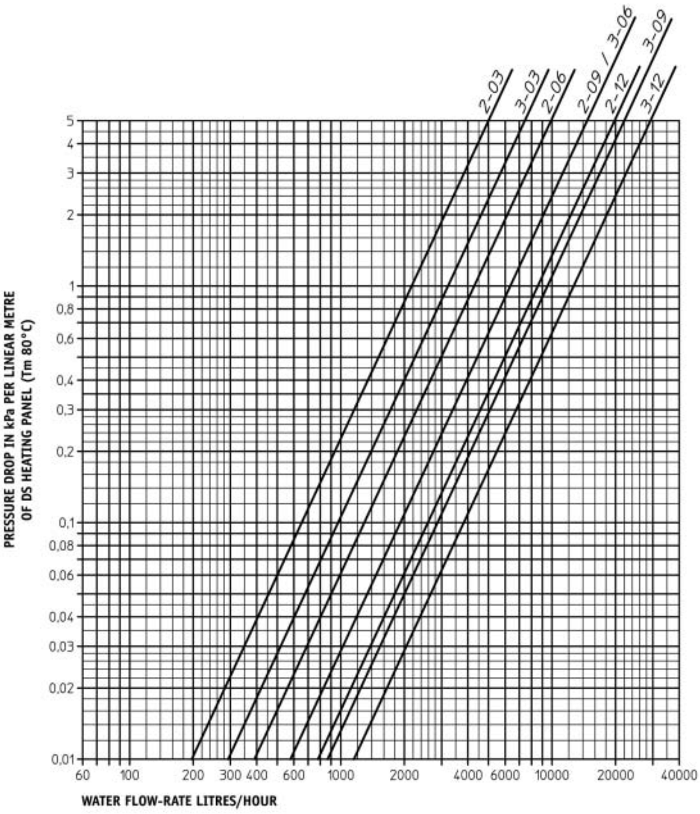
The total water flow-rate is calculated by multiplying the total heat output in W by the coefficient 0.86, and then dividing the value by the water temperature drop. This value must then be divided by the number of strips to calculate the water flow-rate for each individual strip. It is important to check that this flow-rate is not less than the minimum recommended value indicated in the table on page 24.

EXAMPLE: with a water flow of 2800 l/h, the model DS3-06 standard with “B” header has a pressure drop of 220 PA for each metre. This figure must be multiplied by the panel length in order to have the total water pressure drop.

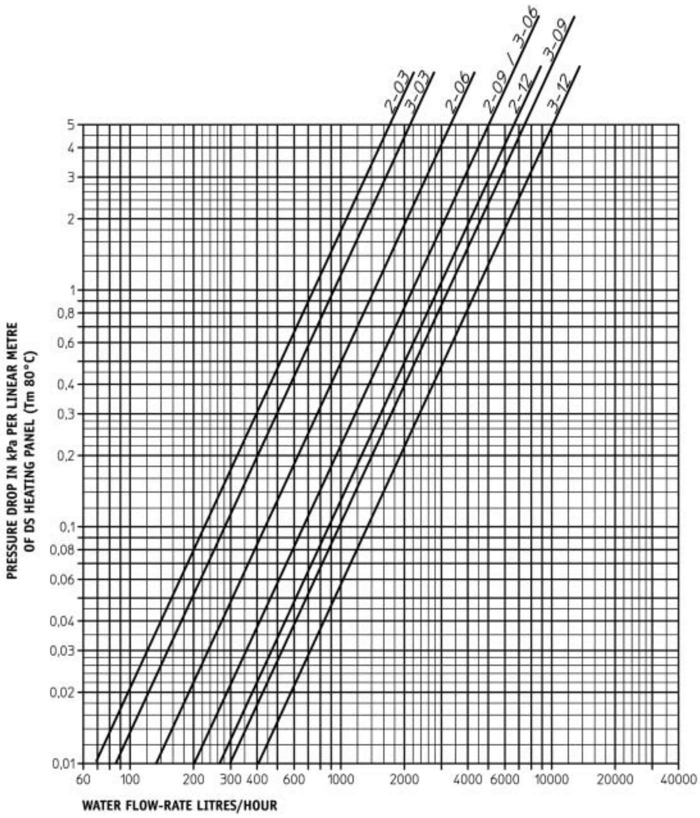
N.B.: as in all heating systems, when calculating the available pressure of the pump, only the circuit that supplies the heating panel furthest away from the boiler, and thus with the highest pressure drop, needs to be considered on the other hand for the water flow of the pump, the flow-rates required for all the heating panels in the system need to be added together.

STANDARD VERSION

HEADER B



HEADER D

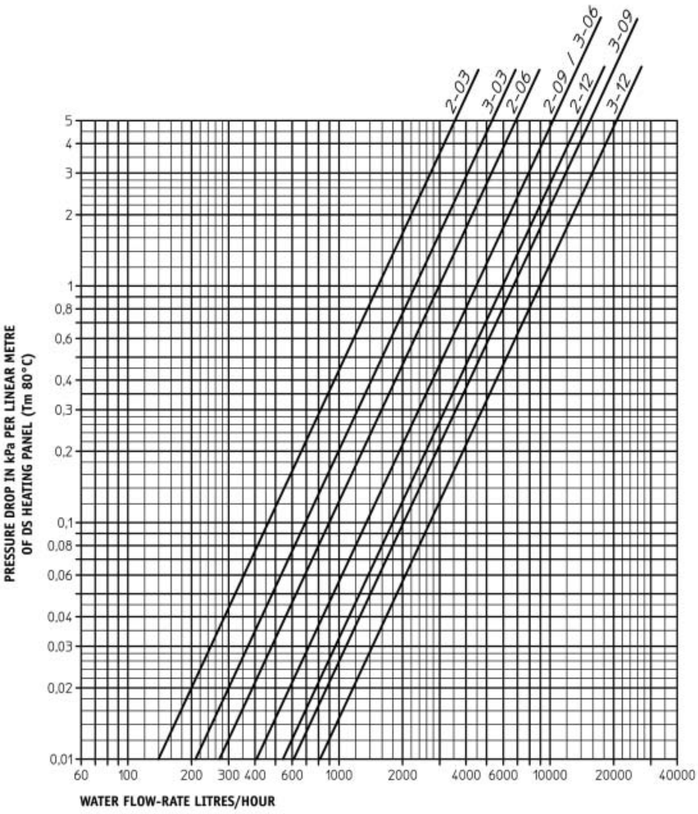


CORRECTION COEFFICIENTS FOR AVERAGE WATER TEMPERATURES OTHER THAN 80°C

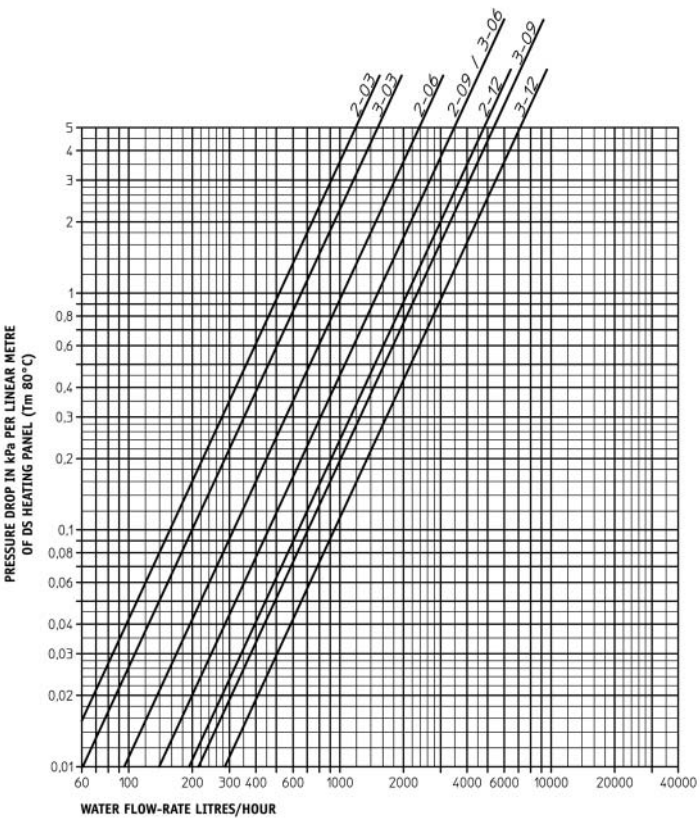
TEMPERATURE (°C)	60	100	120	140	160
MULTIPLIER (K)	1.12	0.92	0.90	0.87	0.85

SPECIAL VERSION

HEADER B



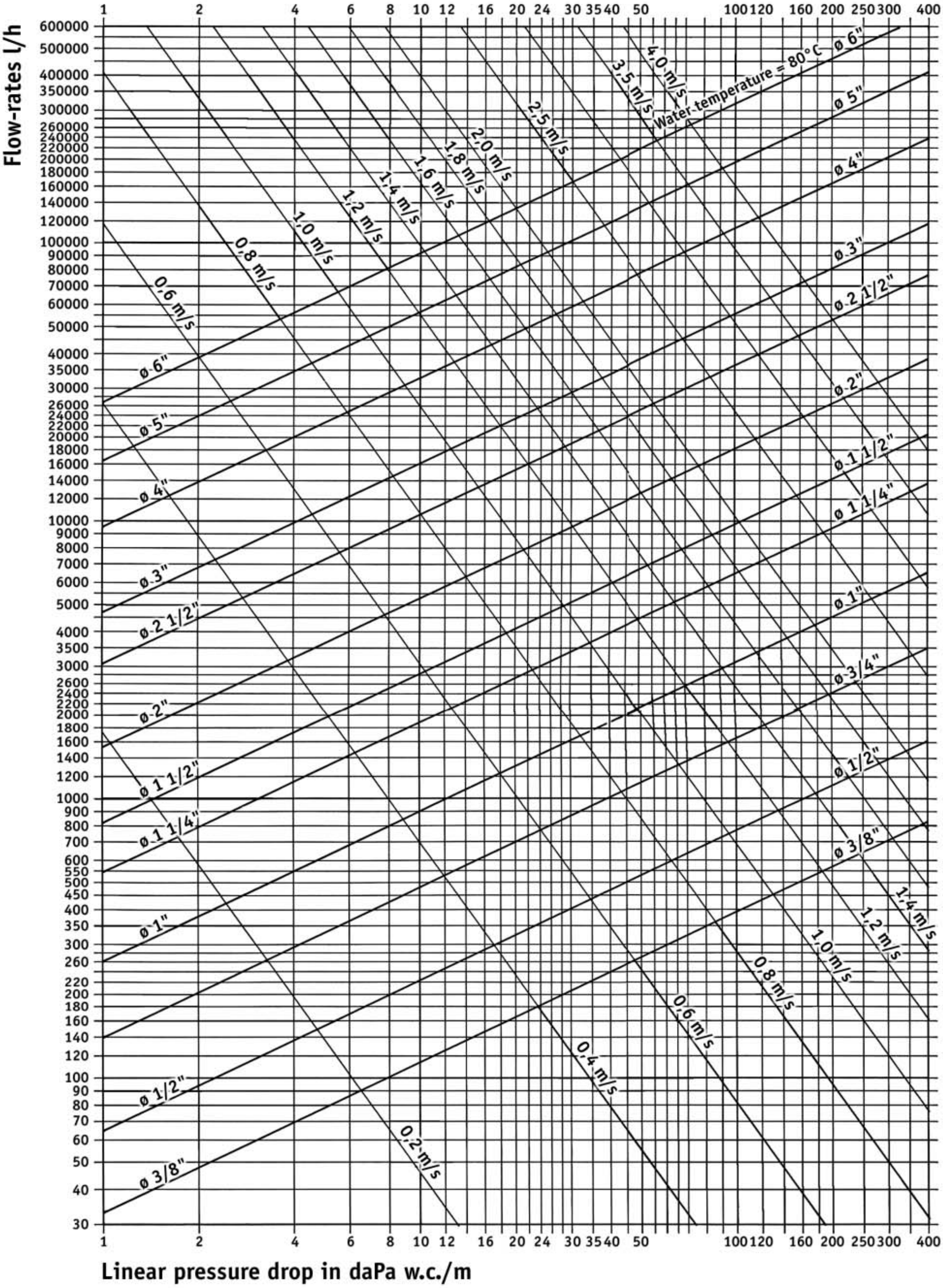
HEADER D



CORRECTION COEFFICIENTS FOR AVERAGE WATER TEMPERATURES OTHER THAN 80°C

TEMPERATURE (°C)	60	100	120	140	160
MULTIPLIER (K)	1.12	0.92	0.90	0.87	0.85

STEEL PIPES
DIAGRAM TO DETERMINE THE LINEAR PRESSURE DROP
PIPES WITH DIAMETER IN INCHES



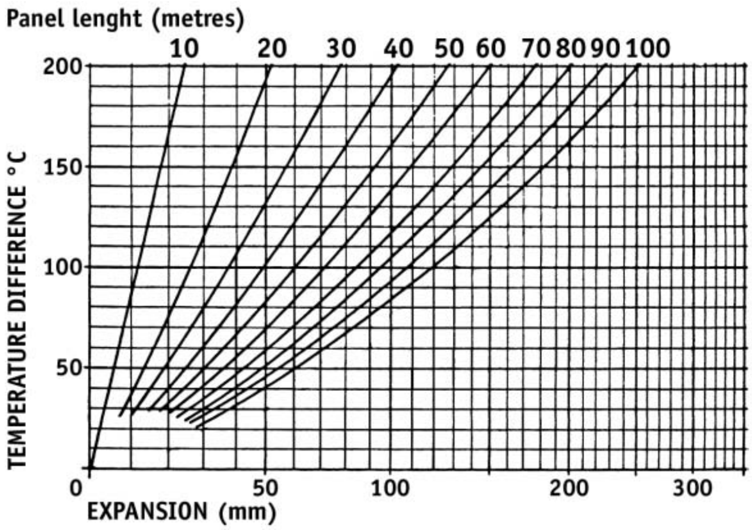
Produced with permission of “CALEFFI SPA”.

CHARACTERISTICS OF THE STEEL PIPES, DIAMETERS IN INCHES

diameter inches	outside diameter mm	inside diameter mm	outside surface m²/m	inside cross-section mm²	water content l/m	black pipe weight kg/m	galvanised pipe weight kg/m
3/8"	16,7	12,7	0,052	127	0,13	0,72	0,78
1/2"	21,0	16,3	0,066	209	0,21	1,08	1,16
3/4"	26,4	21,7	0,083	370	0,37	1,39	1,48
1"	33,2	27,4	0,104	589	0,59	2,17	2,30
1 1/4"	41,9	36,1	0,132	1.023	1,02	2,79	2,95
1 1/2"	47,8	42,0	0,150	1.385	1,38	3,21	3,40
2"	59,6	53,1	0,187	2.213	2,21	4,51	4,77
2 1/2"	75,2	68,7	0,236	3.705	3,70	5,76	6,12
3"	87,9	80,6	0,276	5.100	5,10	7,58	8,03
4"	113,0	104,9	0,355	8.638	8,64	10,88	11,58
5"	138,5	128,8	0,435	13.023	13,02	15,98	16,88
6"	163,9	154,2	0,515	18.665	18,67	19,01	20,02

THERMAL EXPANSION

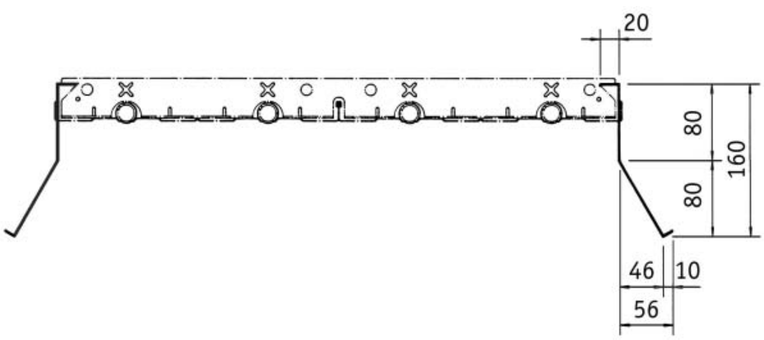
During operation radiant panels behave like all tubes used to convey hot fluids and they are subject to a different expansion depending on the panel length and on the heating fluid temperature.
To avoid excessive stress on the supporting points this expansion should be compensated for.
Compensation should be made near the header by using compensators or flexible couplings of a suitable length.
Absolutely avoid the expansion of the supply pipework which could affect the installation of the radiant panel.
The table below shows the expansion of a radiant panel in function of its length and of the difference between the panel initial temperature and the design working temperature.



"Duck Skirt" ANTI-CONVECTIVE SIDE SKIRT OPTION

Influence of the Duck Skirt anti-convective side skirts

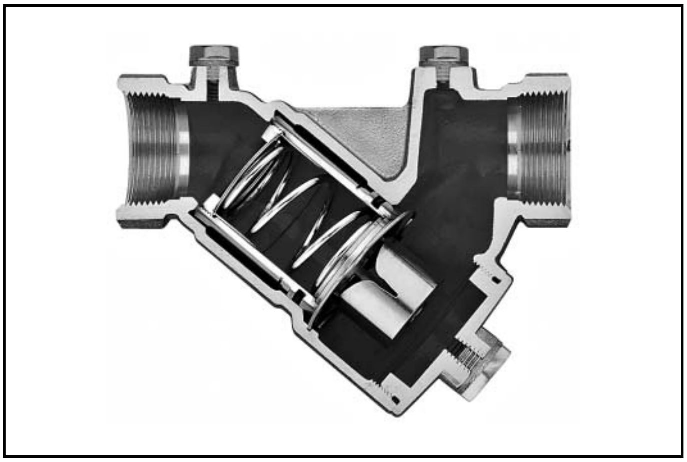
Adding the Duck Skirt anti-convective side skirts to the insulated horizontal radiant panels improves the ratio between radiant emission and total emission. In fact, the side skirt creates an effective obstacle to the convective draughts of the air in contact with the radiant surface, creating and maintaining a layer of still, hot air below the panel and thus preventing the surface from coming into contact and being cooled by the convective draught of cooler air.
One typical case of installation of the skirts is the zone heating by localised radiation of working areas not limited by walls in wide industrial buildings, where the lower emission of convective heat favours the reduction of utilised heating energy.
Another typical case involves the installation of radiant panels inside corridors between high racks.
In this case, the radiation is concentrated inside the corridor, limiting the heating of the items stocked on the shelves.

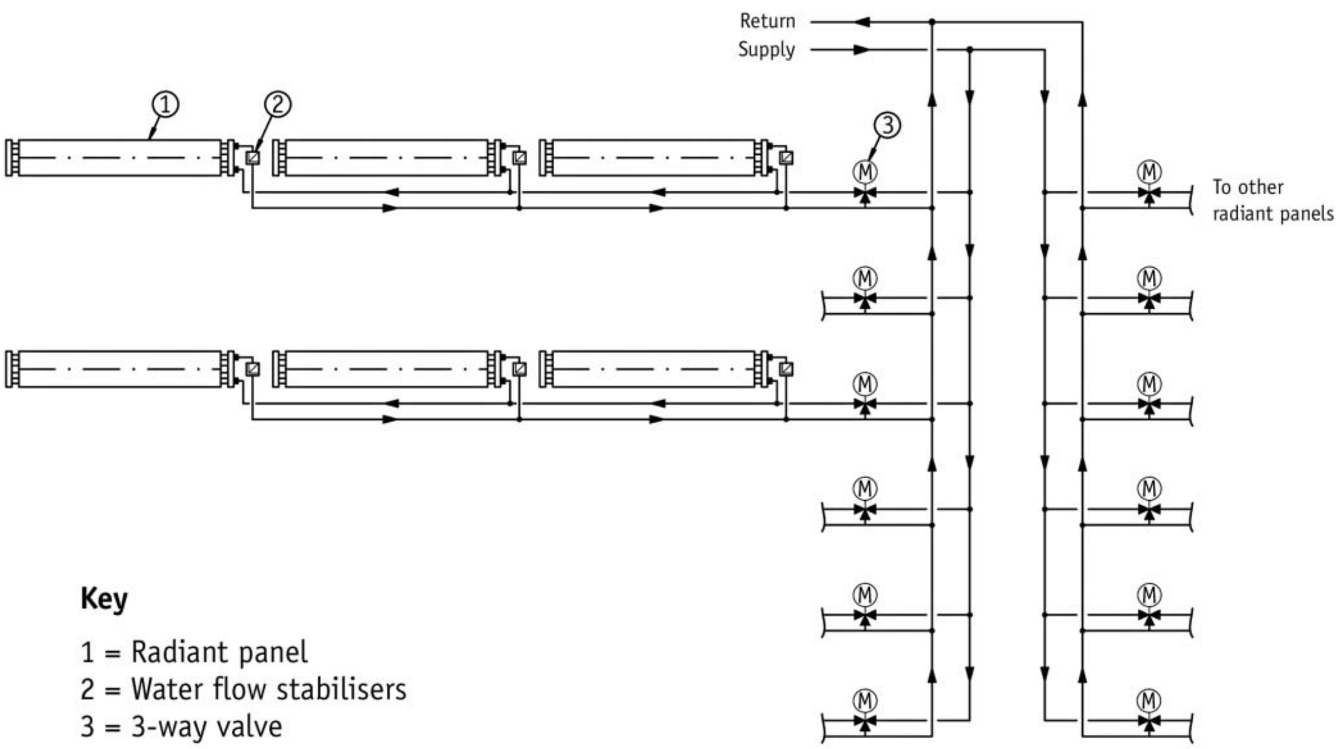


AUTOMATIC WATER FLOW STABILISERS

Automatic water flow stabilisers or regulating valves

In order to supply each radiant panel with its design water flow and consequently balance the water circuit, the return pipe from each radiant panel should be fitted with an automatic water flow stabiliser or regulating valve.
In this way, the balancing of the system is always guaranteed also during the opening/closing of the modulating 3-way valve serving each zone of radiant panels.





Key

1 = Radiant panel
2 = Water flow stabilisers
3 = 3-way valve

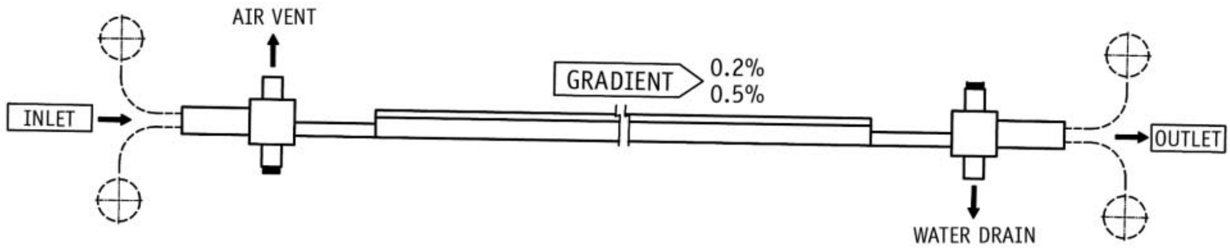
INCLINATION, AIR VENTS AND WATER DRAINS

The radiant panels have tubes connected **in parallel to the headers** and must be installed as follows:

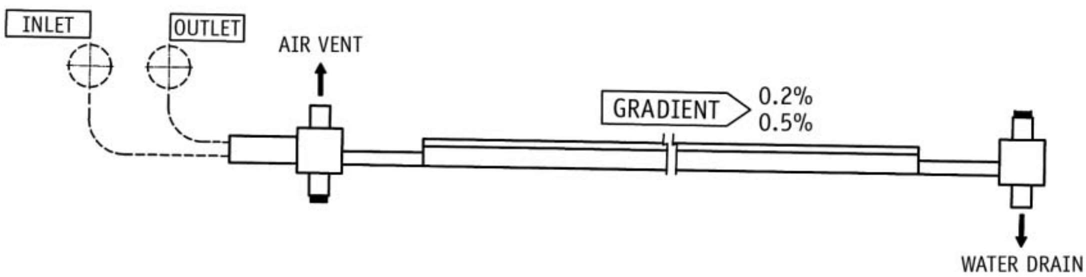
- The panels must have a slight lateral inclination upwards towards the inlet water connection.
- The panels must have a slight longitudinal inclination upwards towards the inlet water connection.

The highest point of the heating panel must be at the inlet water connection to allow for venting of air.
The lowest point must be at the outlet water connection to allow for draining when necessary.
The supply pipes to the heating panels must be designed so as to absorb the thermal expansions without affecting the radiators.

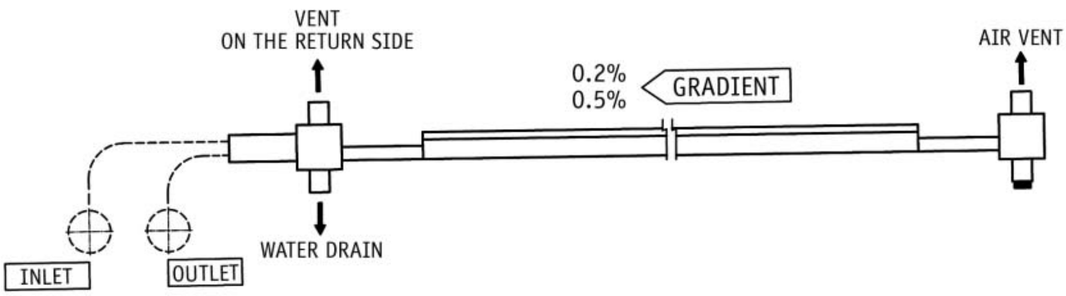
HEADER TYPE "B"



HEADER TYPE "D"
PIPES ABOVE THE PANELS



HEADER TYPE "D"
PIPES BELOW THE PANELS



TEMPERATURE CONTROL

The following pages indicate examples of temperature control that can be used for different types of heating panel systems.

In general, a suitable temperature control system must be able to:

– minimise the thermal differences of the building;

– guarantee that the room temperature is not exceeded.

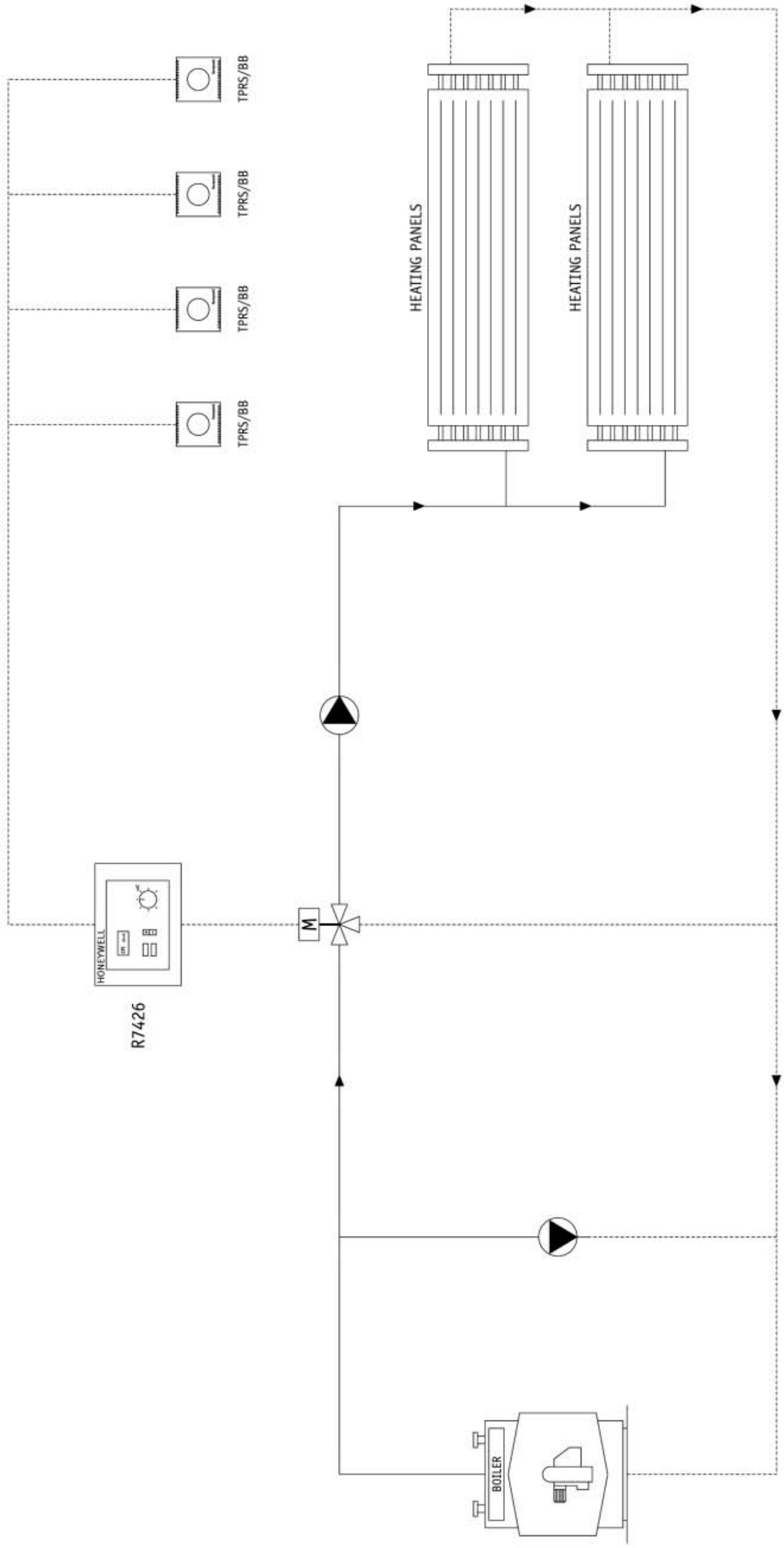
The extreme flexibility of the heating panel systems allows for rapid compensation whenever there is a minimum change in the outside or inside conditions, ensuring the design ambient conditions, and in turn resulting in significant energy savings.

Special attention needs to be paid to the choice of the mixing valve serving the heating panels and/or the speed at which the system water temperature changes. In fact, so as to avoid problems due to the different expansion of the pipes-panels, when starting from cold and when changing between the reduced temperature and the comfort temperature, the water outlet temperature can easily reach 45°C without limitation, as well as being able to increase from 45°C to 85°C with a gradient of 10°C each 3 minutes per heating panel fitted with header "B", and a gradient of 10°C each 4 minutes for heating panels with header "D".

Furthermore, at night or on weekends it is recommended to avoid totally shutting down the heating systems, but rather to feature an operating mode with a minimum room temperature setting.

N.B.: The following diagrams are based on the use of Honeywell temperature control systems.

BASIC CONTROL, WITHOUT BOILER CONTROL



BASIC CONTROL, WITHOUT BOILER CONTROL

The purpose of the control system is to control the temperature of an environment heated using heating panels.

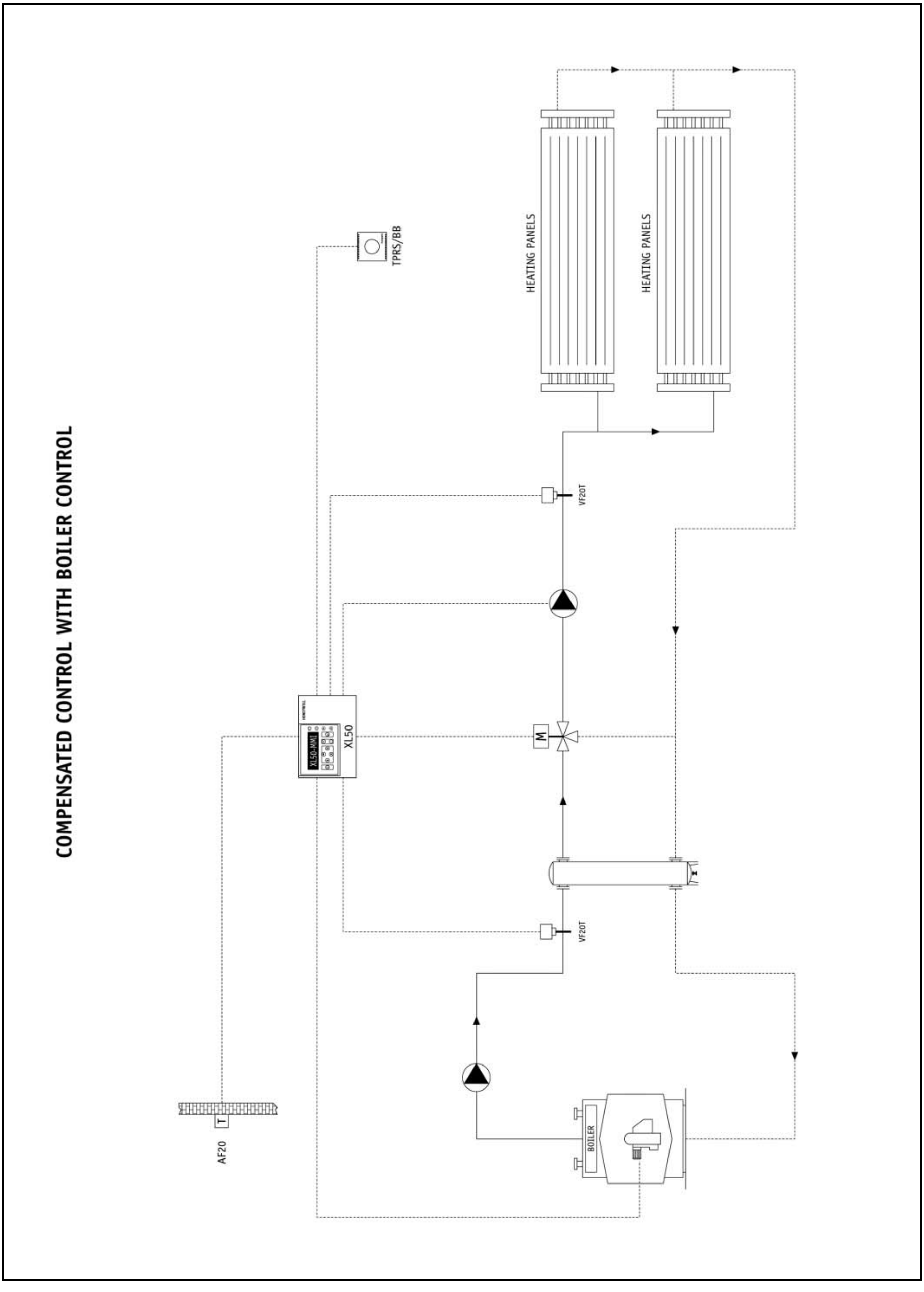
One or more black bulb temperature probes will be installed, depending on the dimensions of the room being heated. A series of probes is used to calculate the average of various points.

The value of the temperature measured by the probes (which corresponds to the effective radiation temperature generated by the heating panels) compared against the desired set point, will affect the opening of the mixing valve.

The controller does not manage the operation of the boiler.

Bill of materials:

- 1 CONTROLLER
- 1 THREE-WAY VALVE WITH SERVO CONTROL
- .... BLACK BULB PROBES


COMPENSATED CONTROL WITH BOILER CONTROL
TPRS/BB
HEATING PANELS
HEATING PANELS
VF20T
VF20T
XL50-MM1
XL50
M
BOILER
T
AF20

COMPENSATED CONTROL WITH BOILER CONTROL

The purpose of the control system is to control the temperature of an environment heated using heating panels, while also managing the start/stop of the boiler.

A probe complete with manual/automatic control and recalibrator will be installed in the room, so as to simply control the temperature set point set on the controller, as well as manually activate the timer program.

The preset value of the outlet water temperature also varies according to the outside air temperature (measured by an outside probe), using a compensation program able to choose the most suitable curve, depending on the conditions read by the probes.

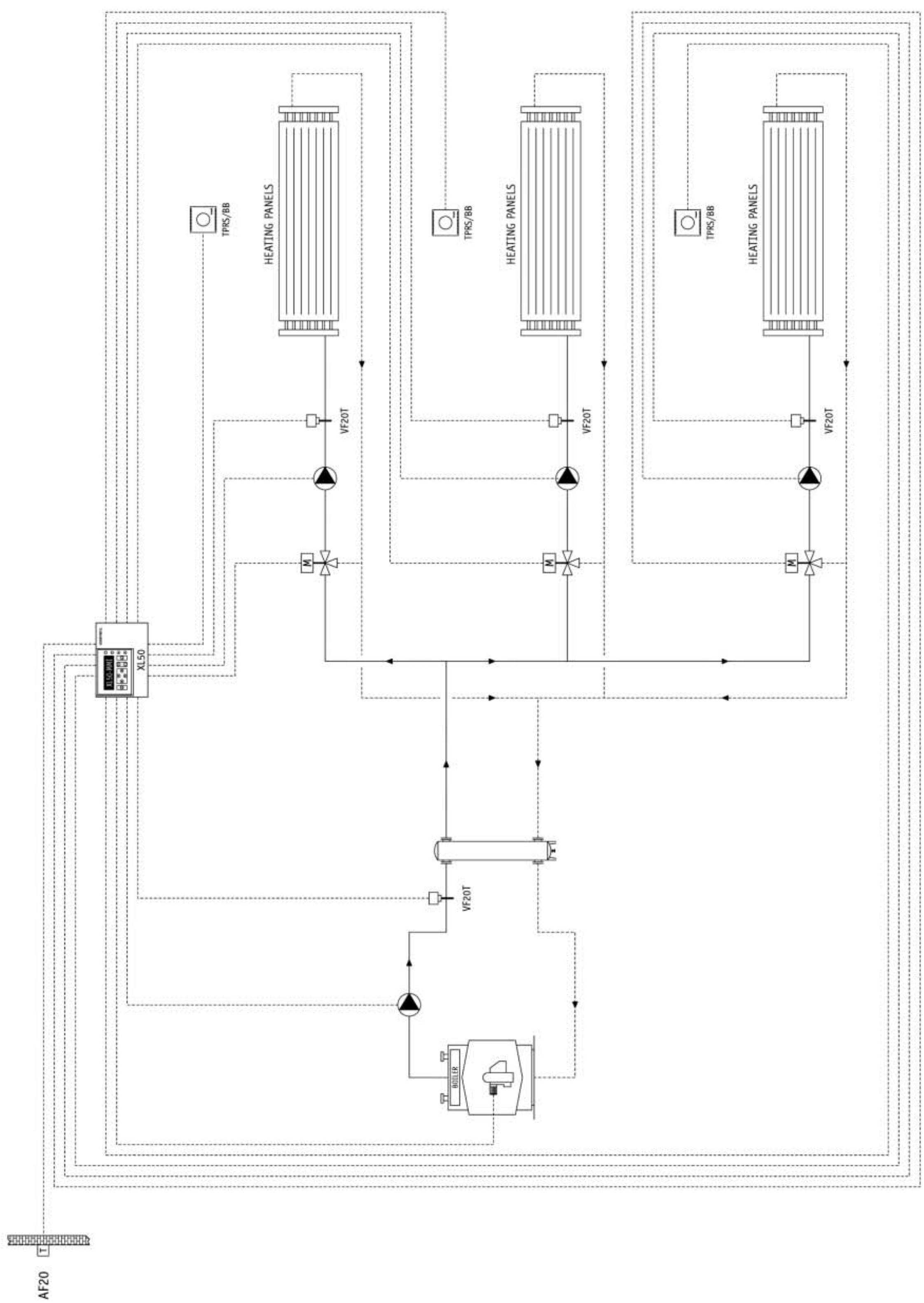
The controller will also be able to manage the operation of the heat generator, possibly connected as per the typical diagram provided, establishing a temperature set point designed to satisfy the outlet temperature requirements.

A daily/weekly/yearly operating program can be loaded onto the controller.

Bill of materials:

- 1 CONTROLLER
- 1 OUTSIDE PROBE
- 2 IMMERSION PROBES
- 1 THREE-WAY VALVE WITH SERVO CONTROL
- 1 BLACK BULB PROBE

MULTI-ZONE HEATING PANEL CONTROL WITH CONSTANT FLOW-RATE



MULTI-ZONE HEATING PANEL CONTROL WITH CONSTANT FLOW-RATE

The purpose of the control system is to control the temperature in a series of environments heated using heating panels, while also managing the operation of the boiler and maintaining a constant flow-rate in the installation.

A black bulb temperature probe will be installed in each room to measure the effective radiation temperature generated by the heating panels.

The controller will compare the temperature values in the various rooms against the set point, and will determine the opening of the corresponding mixing valves, while respecting the limits on the outlet temperature.

The controller will also be able to manage the operation of the heat generator, possibly connected as per the typical diagram provided, establishing a temperature set point designed to satisfy the outlet temperature requirements.

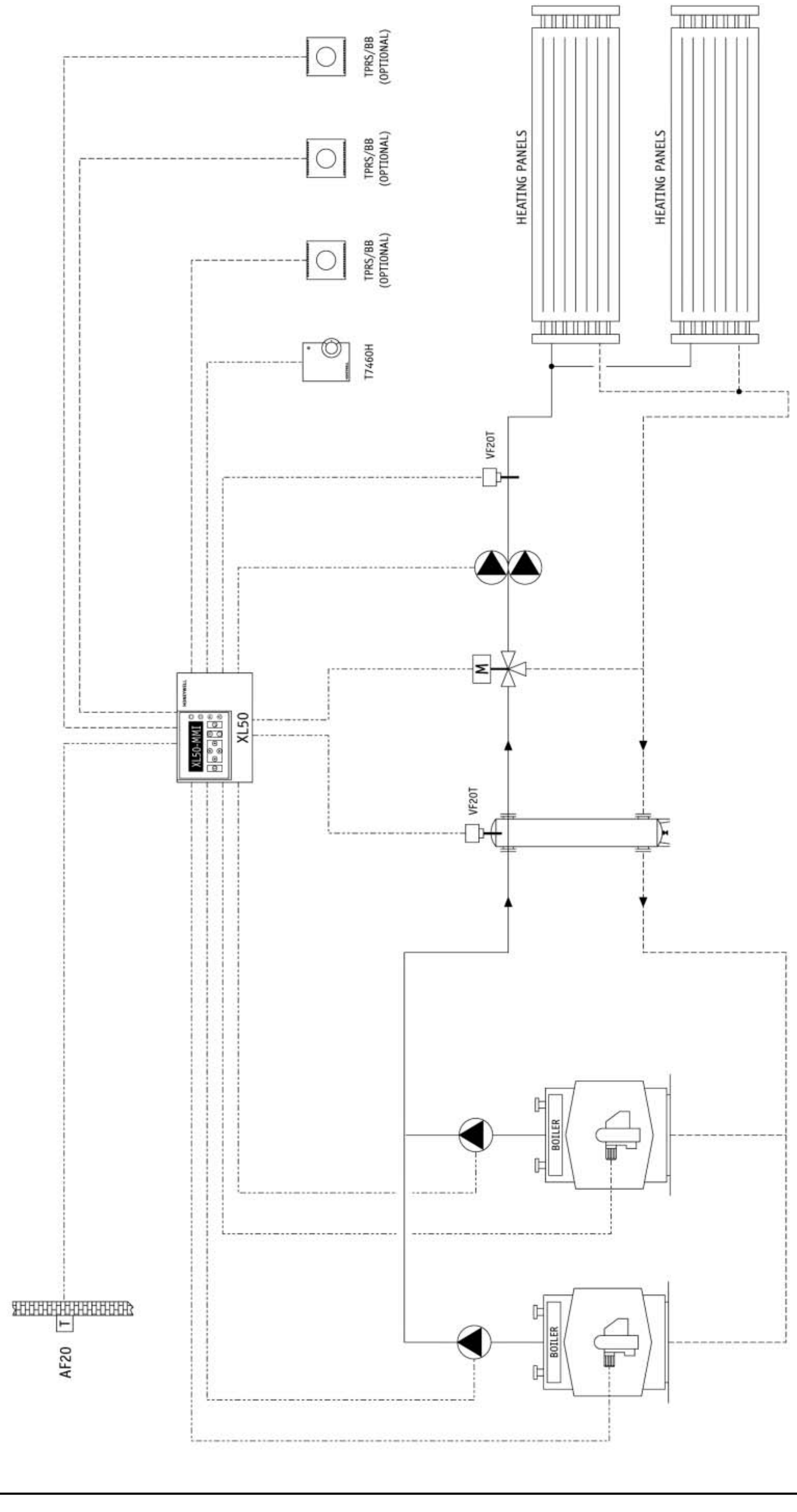
The outside temperature is important for performing the function that limits the starts and stops during the start-up phase, comparing the room temperature read against the temperature to be reached, and based on the outside temperature will determine the pre-start time. This function will be performed by a self-adapting process, during which the instrument will calculate the inertial trend of the structure so as to optimise the energy value.

A daily/weekly/yearly operating program can be loaded onto the controller.

Bill of materials:

- 1 CONTROLLER
- 1 OUTSIDE PROBE
- 4 IMMERSION PROBES
- 3 THREE-WAY VALVE WITH SERVO CONTROL
- 3 BLACK BULB PROBES

EXAMPLE OF CONTROL IN LARGE SYSTEMS



EXAMPLE OF CONTROL IN LARGE SYSTEMS

One or more black bulb temperature probes will be installed, depending on the dimensions of the room being heated. A series of probes is used to calculate the average of various points.

A further probe should be installed as manual/automatic control and recalibrator, and able to activate the timer program on the controller if necessary, as well as simply correct the temperature value.

The value of the room temperature, compared against the desired set point, will determine the opening of the mixing valve, while respecting the limits on the outlet temperature; these limits are due to the thermal gradient that the heating panels can support.

The controller will also be able to manage the operation of the heat generator, possibly connected as per the typical diagram provided, establishing a temperature set point designed to satisfy the outlet temperature requirements.

The outside temperature is important for performing the function that limits the starts and stops during the start-up phase, comparing the room temperature read against the temperature to be reached, and based on the outside temperature will determine the pre-start time. This function will be performed by a self-adapting process, during which the instrument will calculate the inertial trend of the structure so as to optimise the energy value.

A daily/weekly/yearly operating program can be loaded onto the controller.

Bill of materials:

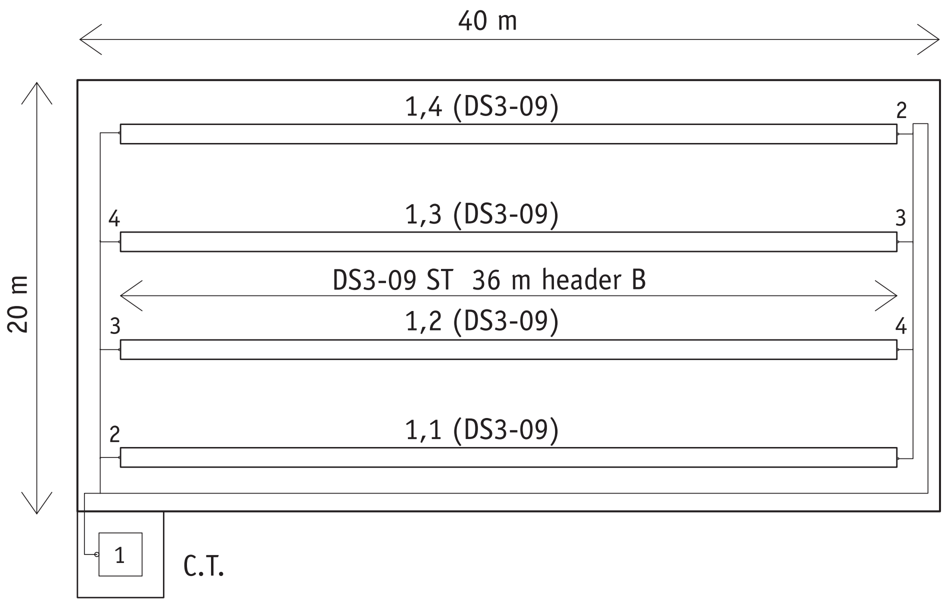
- 1 CONTROLLER
- 2 IMMERSION PROBES
- 1 OUTSIDE PROBE
- 1 SET POINT SELECTOR
- 3 BLACK BULB PROBES
- 1 THREE-WAY VALVE WITH SERVO CONTROL

CALCULATION AND DESIGN EXAMPLES

EXAMPLE 1: TECHNICAL SPECIFICATIONS

OUTLET TEMPERATURE 80°C
RETURN TEMPERATURE 70°C
TEMPERATURE DIFFERENCE 10°C

Floor area:	**800**	m^2	(40 m x 20 m)
Height of the zone:	**7**	m	
Volume of the zone:	**5600**	m^3	
Room temperature:	**18**	°C	
Heating requirement:	**69000**	W	



CHOICE OF THE HEATING PANELS

The environment being heated features just one zone. According to the height of installation and the heating fluid, we can use model DS-06, DS-09 or DS-12 heating panels.
The heating panels will be installed parallel with the long side of the building, and will be 36 m long.
In the design conditions, the model DS3-12 heating panels have an output of 666 W per linear metre.
The heating requirement (69,000 W) divided by the output per m (666 W) determines the need for 104 linear metres of model DS3-12 heating panels, that is, 3 lines measuring 36 linear metres each.
The first check to be performed, that is, the distance between the two lines, gives a value of 6.6 m (20 m divided by 3), a value that is greater than the height of installation (see page 20).
This solution is not recommended.
The same operations can be repeated using model DS2-12 (565 W) and DS3-09 (523 W) heating panels.
In both the first and second cases, 4 lines are required; model DS3-09 is then chosen, being less costly.
The heat output of the heating panels will be 75,312 W (4 x 36 x 523), added to the heat output of the headers of 1,252 W (313 x 4).
The total output of the installation will be 76,564 W.

WATER FLOW-RATE CALCULATION

The calculation of the water flow-rate must be performed based on the heat output required to heat the building, and not on the total heat output delivered by the heating panels.
In this case, the heating requirement is 69,000 W, with a water temperature difference of 10°C.
The required water flow-rate will be: (69,000 x 0.86 / 10) = 5,934 l/h.
Dividing the value calculated (5,934 l/h) by the number of heating panels envisaged (4), gives the water flow-rate for each individual heating panel (1,484 l/h); then check that this value is higher than the minimum flow-rate per heating panel shown in the table on page 24.

PRESSURE DROP CALCULATION

As calculated previously, each panel has a flow of 1,484 l/h. The heating panels will be installed in the "STANDARD" configuration, suitable for hot water systems.
The figure on page 26 shows a pressure drop of 0.03 kPa per linear metre, which, multiplied by the length of the line, gives a pressure drop value of 1.08 KPa in each line.
The sum of the pressure drop of the heating panels, plus the pressure drop of the supply circuit with the valves and the boiler, give the value required for sizing the motor-driven pumps.

Outlet network

Section	Length (m)	Dia.	Type of pipe	Flow-rate (kg/h)	V (m/s)	Pipe press. drop (daPa)
1 - 2	4,22	2"	Steel pipes as per UNI 7287	5936	0,72	48
2 - 3	5,00	2"	Steel pipes as per UNI 7287	4452	0,54	33
3 - 4	5,02	1.1/2"	Steel pipes as per UNI 7287	2968	0,58	51
4 - 1,4	5,81	1"	Steel pipes as per UNI 7287	1484	0,63	173
4 - 1,3	0,81	1"	Steel pipes as per UNI 7287	1484	0,63	16
3 - 1,2	0,83	1"	Steel pipes as per UNI 7287	1484	0,63	16
2 - 1,1	0,83	1"	Steel pipes as per UNI 7287	1484	0,63	16

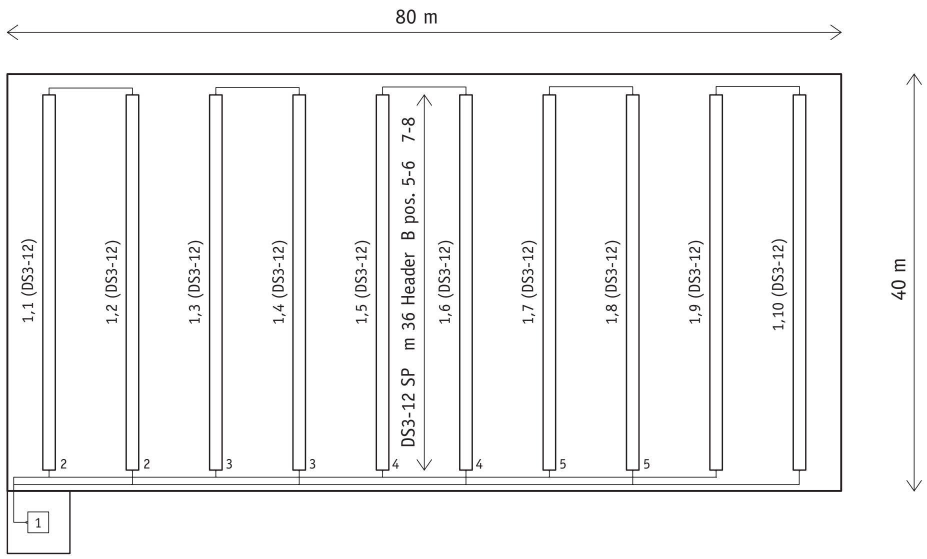
Return network

Section	Length (m)	Dia.	Type of pipe	Flow-rate (kg/h)	V (m/s)	Pipe press. drop (daPa)
1 - 2	59,52	2"	Steel pipes as per UNI 7287	5936	0,72	792
2 - 3	5,04	2"	Steel pipes as per UNI 7287	4452	0,54	34
3 - 4	4,96	1.1/2"	Steel pipes as per UNI 7287	2968	0,58	50
4 - 1,1	5,61	1"	Steel pipes as per UNI 7287	1484	0,63	169
4 - 1,2	0,59	1"	Steel pipes as per UNI 7287	1484	0,63	12
3 - 1,3	0,57	1"	Steel pipes as per UNI 7287	1484	0,63	11
2 - 1,4	0,59	1"	Steel pipes as per UNI 7287	1484	0,63	12

EXAMPLE 2: TECHNICAL SPECIFICATIONS

OUTLET TEMPERATURE 140°C
RETURN TEMPERATURE 110°C
TEMPERATURE DIFFERENCE 30°C

Floor area:	**3200**	m^2	(80 m x 40 m)
Height of the zone:	**10**	m	
Volume of the zone:	**32000**	m^3	
Room temperature:	**16**	°C	
Heating requirement:	**508000**	W	



Choice of the heating panels

The installation height of 9 m allows model DS3-12 to be chosen, which has the highest thermal emissions.
Supplying with superheated water at 140°C requires the use of heating panels in the "SPECIAL" version, with seamless pipes.
The heating panels, installed parallel with the short side of the building and measuring 36 m in length, in the design conditions have an output of 1,462 W per metre.
No reduction coefficient needs to be applied for the height of installation.
The division between the total heating requirement (508,000 W) and the output per linear metre (1,462 W) gives a requirement of 348 m for model DS3-12. Dividing 348 by the length of each line (36 m) gives the number of lines required (10).
The distance between the two heating panels will be 8 m, and consequently less than the height of installation.
The use of superheated water at 140°C excludes the possibility of using a type "D" header with diaphragm.
The same number of heating panels is used to make up circuits of heating fluid with two combined heating panels, one outlet and one return, using type "B" haeders, position 5/6 and 7/8.

The purchase order sent to SABIANA will be as follows:
10 DS3-12 lines — Special — 4 bar — welded — 36 linear metres — header B 5/6 and 7/8 —
diam. 1"1/4 — Insulation 40 mm — Ral 9010.

WATER FLOW-RATE CALCULATION

With a required heat output of 508,000 W and a temperature difference of 30°C, the total water flow requirement will be 14,562 l/h, which corresponds to 2,913 l/h for each of the 5 circuits of heating panels. This value is higher than the minimum recommended shown on page 24.

PRESSURE DROP CALCULATION

In the case of systems with combined heating panels, the quantity of water required by the two panels must be considered; in this case, the flow-rate in question is 2,913 l/h.
The table on page 27 shows that with this flow-rate, the pressure drop per linear metre for the DS3-12 is 0.12 KPa, and this value must be multiplied by the correction coefficient K = 0.90 for superheated water with an average temperature of 115°C.
As a result, 0.12 x 0.9 = 0.11 KPa per m multiplied by 72 m gives a pressure drop of 7.92 KPa for each circuit of combined heating panels.

Outlet network

Section	Length (m)	Dia.	Type of pipe	Flow-rate (kg/h)	V (m/s)	Pipe press. drop (daPa)
1 - 2	9,08	2.1/2"	Steel pipes as per UNI 7287	14565	1,06	155
2 - 3	15,96	2.1/2"	Steel pipes as per UNI 7287	11652	0,85	179
3 - 4	15,98	2.1/2"	Steel pipes as per UNI 7287	8739	0,64	105
4 - 5	16,00	2"	Steel pipes as per UNI 7287	5826	0,71	176
5 - 1,9	16,57	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	208
5 - 1,7	0,57	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	29
4 - 1,5	0,57	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	6
3 - 1,3	0,55	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	5
2 - 1,1	0,57	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	29

Return network

Section	Length (m)	Dia.	Type of pipe	Flow-rate (kg/h)	V (m/s)	Pipe press. drop (daPa)
1 - 2	16,36	2.1/2"	Steel pipes as per UNI 7287	14565	1,06	279
2 - 3	15,96	2.1/2"	Steel pipes as per UNI 7287	11652	0,85	179
3 - 4	16,02	2.1/2"	Steel pipes as per UNI 7287	8739	0,64	105
4 - 5	16,00	2"	Steel pipes as per UNI 7287	5826	0,71	176
5 - 1,10	17,31	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	216
5 - 1,8	1,25	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	12
4 - 1,6	1,25	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	12
3 - 1,4	1,27	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	12
2 - 1,2	1,23	1.1/2"	Steel pipes as per UNI 7287	2913	0,56	12

Definition example of "Typical building" and "Type of use"

The realistic comparison between the different "systems techniques" requires the identification of the characteristics of the building and the activities carried out inside as the uniform basis for determining both the heating requirement and the comfort of the occupants; the following is a summary of the data established or assessed corresponding to the building represented in the diagram, enclosed at the end of this chapter.

AMBIENT DATA

• Latitude	44,29°
• Longitude	11,20°
• Height above sea level	m 75
• Climatic zone	E
• "Winter" temperature-humidity conditions	-5°C 80% RH
• "Summer "temperature-humidity conditions	+33°C 43% RH
• Daily range of temperatures (summer)	12°C
• Day-degrees	2263
• Atmosphere	normal
• Wind	region B, zone 1,
• Prevalent direction	SW
• Speed	1,6 m/sec.

NB: the above class allows the following noise pollution values:

- Limit value of daytime sound emissions (6 ÷ 22) Leq 60 dB(A)
- Limit value of night-time sound emissions (22 ÷ 6) Leq 50 dB(A)
- Absolute limit value of daytime sound emissions (6 ÷ 22) Leq 65 dB(A)
- Absolute limit value of night-time sound emissions (22 ÷ 6) Leq 55 dB(A)
- Daytime quality value (6 ÷ 22) Leq 62 dB(A)
- Night-time quality value (22 ÷ 6) Leq 52 dB(A)

BUILDING STRUCTURES, WINDOWS AND DOORS

The characteristics of the building (surface area ≅ 2.000 m^2; volume ≅ 14.000 m^3) are considered as responding both to the standards in force on energy savings and to the operational needs for illumination, without dazzling, and specifically:

• Outside perimeter walls	prefabricated panels, composite structure of concrete + polystyrene (K ≤ 1,107 W/h/m^2/°C)
• Ground floor	industrial cement flooring on loose stone foundation (K ≤ 0,707 W/h/m^2/°C)

Definition example of "Typical building" and "Type of use"

- Roof — prefabricated panels, composite structure of pre-compressed concrete + polystyrene ($K \leq 1,078\ W/h/m^2/°C$)
- Perimeter windows and doors — metallic frame with insulating glass ($K \leq 3,088\ W/h/m^2/°C$)
- Skylights — translucent insulating polycarbonate elements ($K \leq 3,299\ W/h/m^2/°C$)
- Radiation shielding — SHADING factor $\leq 0,5$

OUTSIDE AIR (NATURAL VENTILATION)

The infiltration of outside air, through the walls, the permeability of the joints and the periodical opening of the doors and windows, is assumed to be $^1/_2$ Vol/h.

INSIDE LOADS

- **People:**
  Thirty people, performing light activities, uniformly distributed throughout the working area; the positive contribution of heat ("HEATING" phase) is not considered in the sizing calculations.

- **Light and power:**
  Divided uniformly and simultaneously, totalling 10 W per m2 of floor area; the positive contribution of heat ("HEATING" phase) is not considered in the sizing calculations.

- **Other sources of heat:**
  These are either non-existent or considered as negligible for the sizing calculations.

OPERATING PERIOD

The typical activity of workshops and industries, where light work is performed, is **"intermittent"**, with continuous operation lasting around 10 hours, and with optimised **preheating** lasting around 2 hours (average value).

Definition example of “Typical building” and “Type of use”

ACTIVITIES AND CLOTHING

- **Sedentary activities:**
  - “Light”, standing (machine tools): metabolism equivalent to 1.6 met, equal to 93 W/m^2 and 177 W per person.

- **Clothing:**
  - Overalls: thermal insulation equivalent to 1.5 CLO, with a clothing factor of 1.25 and a diffusion resistance factor of 0.75.

INSIDE COMFORT CONDITIONS

- Predicted Percentage of Dissatisfied (PPD) = +/- 5% (ISO 7730)
- Air temperature, dry bulb = 18°C (base value, from PPD)
- Mean radiant temperature = 18°C (variable value; see NB)
- Air velocity in the occupied zones = 0,1 m/sec. (variable value; see NB)
- Noise pollution = increase in residual noise ≤3 dB(A)

HEATING REQUIREMENTS OF THE BUILDING

- **Heat loss** = kW 170

- **Natural ventilation** = kW 50

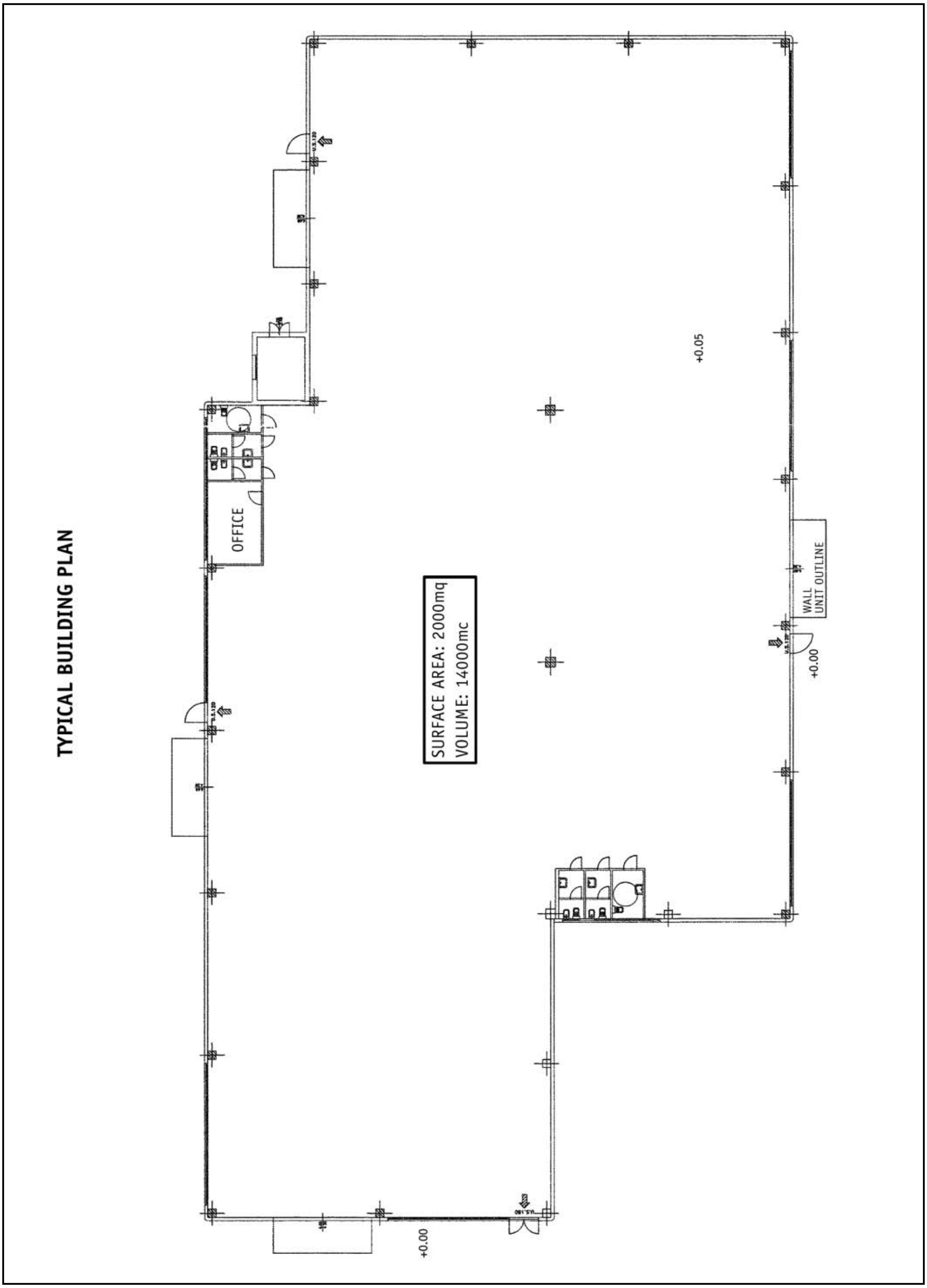
NB: the values shown above, determined for the period of stable operation in compliance with the UNI standards in force, will be adjusted (load to reach stable operation, comfort conditions) during the development of the “systems techniques”, when the specific features of such require.

PRIMARY ENERGY: TYPE AND COST

- **Electricity** = V 400/3;
  €/kWh 0,10

- **Fuel** = natural gas with NHV 9,940 W/Nm^3
  €/Nm^3 0,40

Definition example of "Typical building" and "Type of use"



SYSTEM WITH DIRECT PRODUCTION OF HEAT - HOT AIR GENERATORS

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 must be adjusted for the system to have the following specific features:
    ° not allow a mean radiant temperature of 18°C, but rather 16°C.
    ° increase the air velocity, in the occupied zone, to around 0.2 m/sec.
    To keep the Predicted Percentage of Dissatisfied (PPD) unchanged, the dry bulb temperature of the air must be raised from 18°C to 19°C.
  - noise pollution can be limited using silencers and thus kept within the established limits.
  - the processing dust, typical for the activities carried out inside the building, is lifted by the convective motion cause by the forced ventilation, with negative effects on the processes and the workers.

- Thermal gradient
  This system, which distributes hot air from the high parts of the building, causes natural stratification estimated at 0.9°C/m, hence giving an average value of 3°C, to be considered in the calculation of the heating requirements.
  The gradient can be reduced using additional mechanical ventilation systems (destratifiers), to be adopted after performing suitable "costs – benefits" analysis, as the advantages depend on the height and the shape of the room.

- Intermittent operation
  The system, featuring low thermal inertia and the absence of the risk of freezing, allows intermittent operation, which may cause an overload of 70 kW/h, in the phase when the system is reaching stable operation, in conditions of maximum load.

- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider both the different air temperature, required for the same level of comfort, and the average thermal gradient of 3°C, specifically:
  - heat loss = kW/h 200
  - natural ventilation = kW/h 58

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, as well as the average outside temperature, in the entire winter season, considering that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 1,630 kW/day.

- Thermal efficiency
  - combustion must take place without condensation and consequently with high flue gas temperatures; the maximum efficiency of 91% may decrease, on average, to 85%.

- the distribution of the air, which occurs substantially inside the area being heated, does not cause significant reductions in efficiency.

- Maintenance
  - preventive maintenance is necessary and normally quite straightforward, as all the components in question are installed in a central position and typically on ground level.
  - routine maintenance is limited to the periodical cleaning and replacement of the filters and the drive belts (fan – motor); the frequency of the cleaning operations is related to the amount of processing dust produced in the working areas.
  - special maintenance requirements are high as they may involve the replacement of the hot air generator, when the fault derives from the perforation of the combustion chamber.

- Reliability
  - the effectiveness of the installation essentially depends on the efficiency of the hot air generator, only one of which is installed, without a backup appliance, for the entire building or a significant area of such.
  - the perforation of the combustion chamber, which is a possible cause of faults, may be source of danger when the overpressure of the ventilating section is less than the overpressure of the combustion chamber: this means that air that is heated and distributed may be polluted with the products of combustion (carbon and nitrogen oxides).

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is feasible, using a mixing section fitted with outside air and intake dampers, if necessary motor-driven and activated in synch with the mechanical ventilation system.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is feasible if the air distribution system has been suitably oversized; the requirements for cooling operation can be completed by installing:
    ° Roof top units
    ° Ducts connecting to the existing air distribution system
    ° Dampers for switching operation

- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and thus the correlated inside comfort conditions and the average thermal gradient.
  - installation outside of the working area is recommended, for reasons of safety and noise pollution.
  - the flow-rate of air circulating must be determined so as to limit and adapt the temperature difference between the heated air and the effective room temperature.
  - the air must be distributed towards the occupied zones; the direction will be adjustable, so as to adapt it to the type of use, and will generally be inclined.
  - the temperature control system must control the ambient temperature, avoiding the overheating of the treated air; the use of a maximum air temperature limit is recommended, as is the use of proportional burners.
  - the use of mechanical ventilation systems (destratifiers) must be assessed by performing a “cost - benefits” analysis, in relation to the height and the shape of the room.

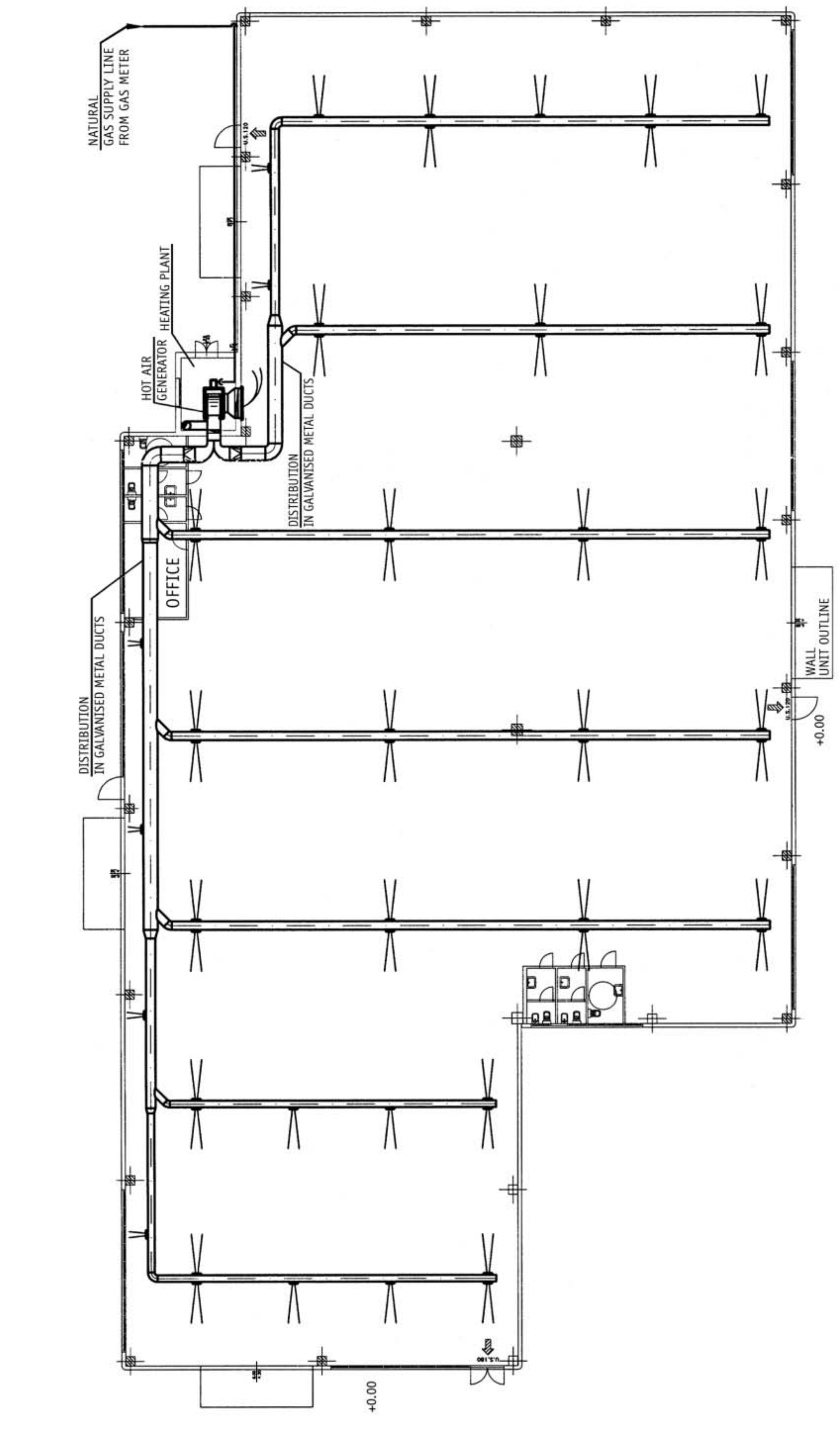
ECONOMIC OBSERVATIONS

- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 40.000,00
  - average market price, of configuration for cooling operation ≅ € 7.000,00

- Running cost
  The average daily heating requirements of 1,630 kW allow the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:
  - electricity € 950,00
  - fuel € 9.300,00
  - maintenance (preventive and routine) € 1.450,00

  Total €11.700,00

SYSTEM WITH DIRECT PRODUCTION OF HEAT – HOT AIR GENERATORS



SYSTEM WITH DIRECT PRODUCTION OF HEAT - CONTINUOUS GAS FIRED TUBE HEATERS

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 can be reduced by bringing the dry bulb temperature of the air to the value of 16°C, as this system allows the set mean radiant temperature to be exceeded.
  - noise pollution is limited.
  - the processing dust, typical for the activities carried out inside the building, circulates due to the limiting of the convective motion at floor level.

- Thermal gradient
  This system, which distributes the heat mostly by radiation in the high parts of the building, limits the thermal gradient to negligible values in the calculation of the heating requirements.

- Intermittent operation
  The system, featuring low thermal inertia and the absence of the risk of freezing, allows intermittent operation, which may cause an overload of 25 kW/h, in the phase when the system is reaching stable operation, in conditions of maximum load.

- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider the different air temperature, required for the equivalent level of comfort, specifically:
  - heat loss = kW/h 162
  - natural ventilation = kW/h 48

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, as well as the average outside temperature in the entire winter phase, and the fact that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 950 kW/day.

- Thermal efficiency
  - combustion must take place without condensation and consequently with high flue gas temperatures; the maximum efficiency of 91% may decrease, on average, to 85%.
  - the distribution of the heat, which occurs substantially inside the area being heated, does not cause significant reductions in efficiency.

- Maintenance
  - preventive maintenance is necessary and normally quite difficult, as all of the components in question are installed high above the ground.
  - routine maintenance is limited to the generation system and the system for the transport of the products of combustion.
  - special maintenance is limited, if the combustion values are checked regularly and kept within the limits required to prevent condensation and consequent corrosion.
  - the positioning of the generators outside involves increasingly frequent operations over the years due to the wear (oxidation) of the components.

- Reliability
  - the effectiveness of the installation essentially depends on the efficiency of the combustion system and the ventilation system, only one of which is installed, without a backup appliance, for the entire building or significant area of such.

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is not possible; if necessary, install separate yet complementary systems.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is not possible; if necessary, install separate yet complementary systems.
  - the inside room temperature may have significantly different values depending on whether the position is directly below the radiant panels or at the intermediate points between two radiant panels.

- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and thus the correlated inside comfort conditions and the negligibility of the thermal gradient.
  - the requirements can be calculated without vertical partitioning, as the overall emissions (convective and radiant) are completely useful.
  - the thermal emission, by convention, is limited by the insulation and the shape of the panel.
    The emitting surface is limited, and the heat transferred to the environment is always less than the requirement of the portion of building above the radiant panels, with a limitative effect due to the thermal gradient.
  - installation outside of the working area is recommended, for reasons of safety and noise pollution.
  - the path of the radiant circuit must respect the distances required by the standards in force, so as to avoid personal discomfort or the risks deriving from damage to structures, systems and materials.
  - the radiant circuits must be fitted with special expansion joints to absorb the high thermal expansion of the system.
  - the temperature control must be sensitive to radiation; bulb-type probes must used.

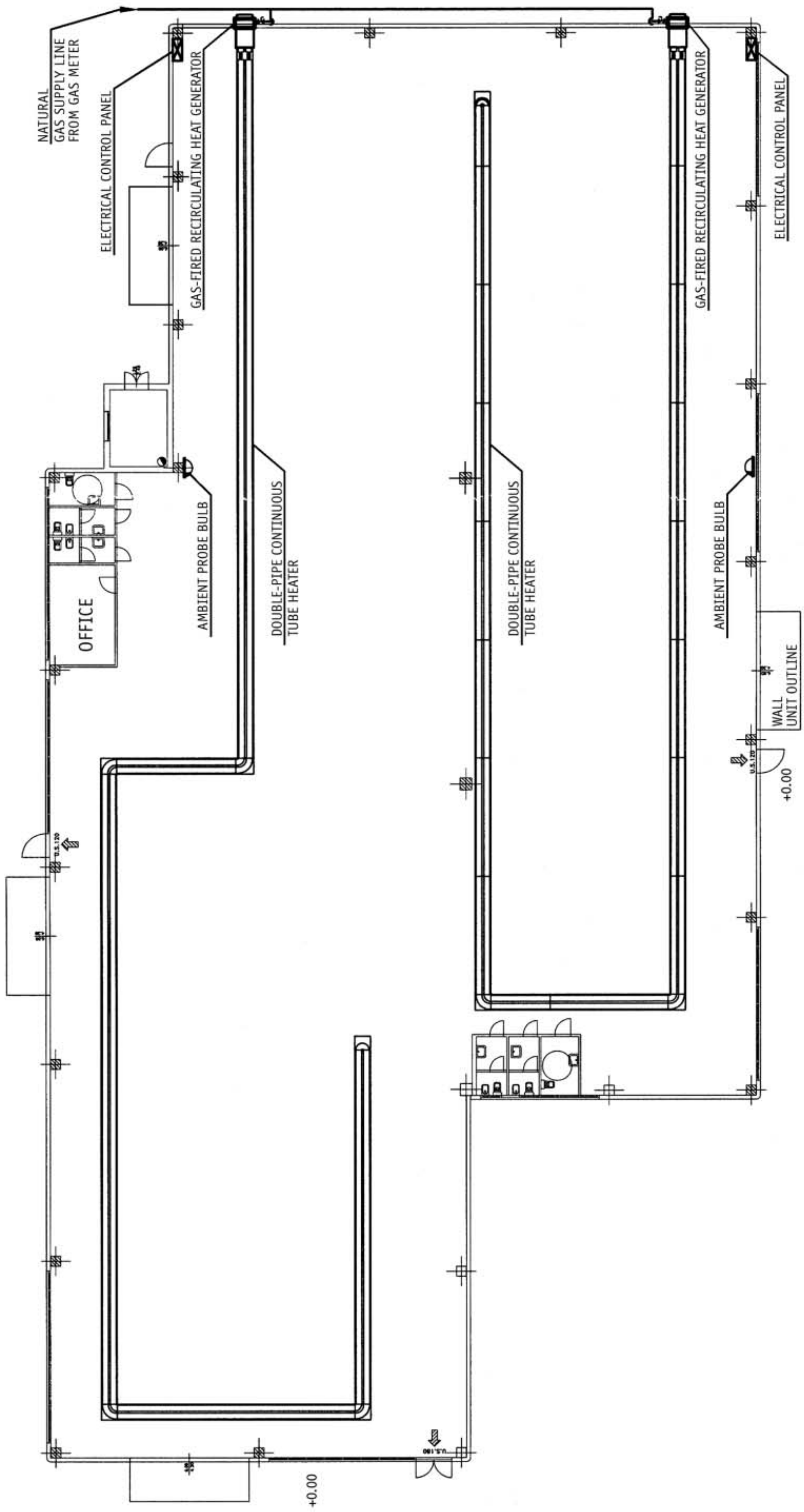
ECONOMIC OBSERVATIONS

- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 50.000,00

- Running cost
  The average daily heating requirements of 950 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:

- electricity	€ 1.700,00
- fuel	€ 6.500,00
- maintenance (preventive and routine)	€ 2.000,00
Total	**€ 10.200,00**

SYSTEM WITH DIRECT PRODUCTION OF HEAT – CONTINUOUS GAS FIRED TUBE HEATERS



SYSTEM WITH DIRECT PRODUCTION OF HEAT - GAS FIRED RADIANT TUBES

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 can be reduced by bringing the dry bulb temperature of the air to the value of 16°C, as this system allows the set mean radiant temperature to be exceeded.
  - noise pollution is limited.
  - the processing dust, typical for the activities carried out inside the building, decants due to the limiting of the convective motion at floor level.

- Thermal gradient
  This system, which distributes the heat mostly by radiation in the high parts of the building, limits the thermal gradient to negligible values in the calculation of the heating requirements.

- Intermittent operation
  The system, featuring low thermal inertia and the absence of the risk of freezing, allows intermittent operation, which may cause an overload of 25 kW/h, in the phase when the system is reaching stable operation, in conditions of maximum load.

- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider the different air temperature, required for the equivalent level of comfort, specifically:
  - heat loss = kW/h 162
  - natural ventilation = kW/h 48

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, both the average outside temperature of the entire winter phase, considering that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 950 kW/day.

- Thermal efficiency
  - combustion must take place without condensation and consequently with high flue gas temperatures; the maximum efficiency of 90% may decrease, on average, to 85%.
  - the distribution of the heat, which occurs substantially inside the area being heated, does not cause significant reductions in efficiency.

- Maintenance
  - preventive maintenance is necessary and normally quite difficult, as all of the components in question are installed high above the ground.
  - routine maintenance is limited to the generation system and the system for the transport of the products of combustion.
  - special maintenance is limited, if the combustion values are checked regularly and kept within the limits required to prevent condensation and consequent corrosion.
  - the high number of burners located in the working environment require increasingly frequent maintenance operations over the years.

- Reliability
  - the effectiveness of the installation, which essentially depends on the efficiency of the combustion systems and the system for the transport of the products of combustion, may even be sufficient when occasional faults arise, due to the partitioning of the sources.

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is not possible; if necessary, install separate yet complementary systems.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is not possible; if necessary, install separate yet complementary systems.
  - gas leak detection systems are required.

- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and thus the correlated inside comfort conditions and the negligibility of the thermal gradient.
  - the requirements can be calculated without vertical partitioning, as the overall emissions (convective and radiant) are completely useful.
  - the thermal emission, by convention, is limited by the insulation and the shape of the panel.
    The emitting surface is limited, and the heat transferred to the environment is always less than the requirement of the portion of building above the radiant tubes, with a limitative effect due to the thermal gradient.
  - the position of the radiant modules must respect the distances required by the standards in force, so as to avoid personal discomfort or the risks deriving from damage to structures, systems and materials.
  - the radiant modules must be fitted with special expansion joints to absorb the high thermal expansion of the system.
  - the temperature control must be sensitive to radiation; bulb-type probes must used.
  - the distribution of natural gas in pipelines outside of the building reduces but does not eliminate the risks deriving from occasional leaks and from possible stagnation in the upper parts of the building.

ECONOMIC OBSERVATIONS

- Installation cost

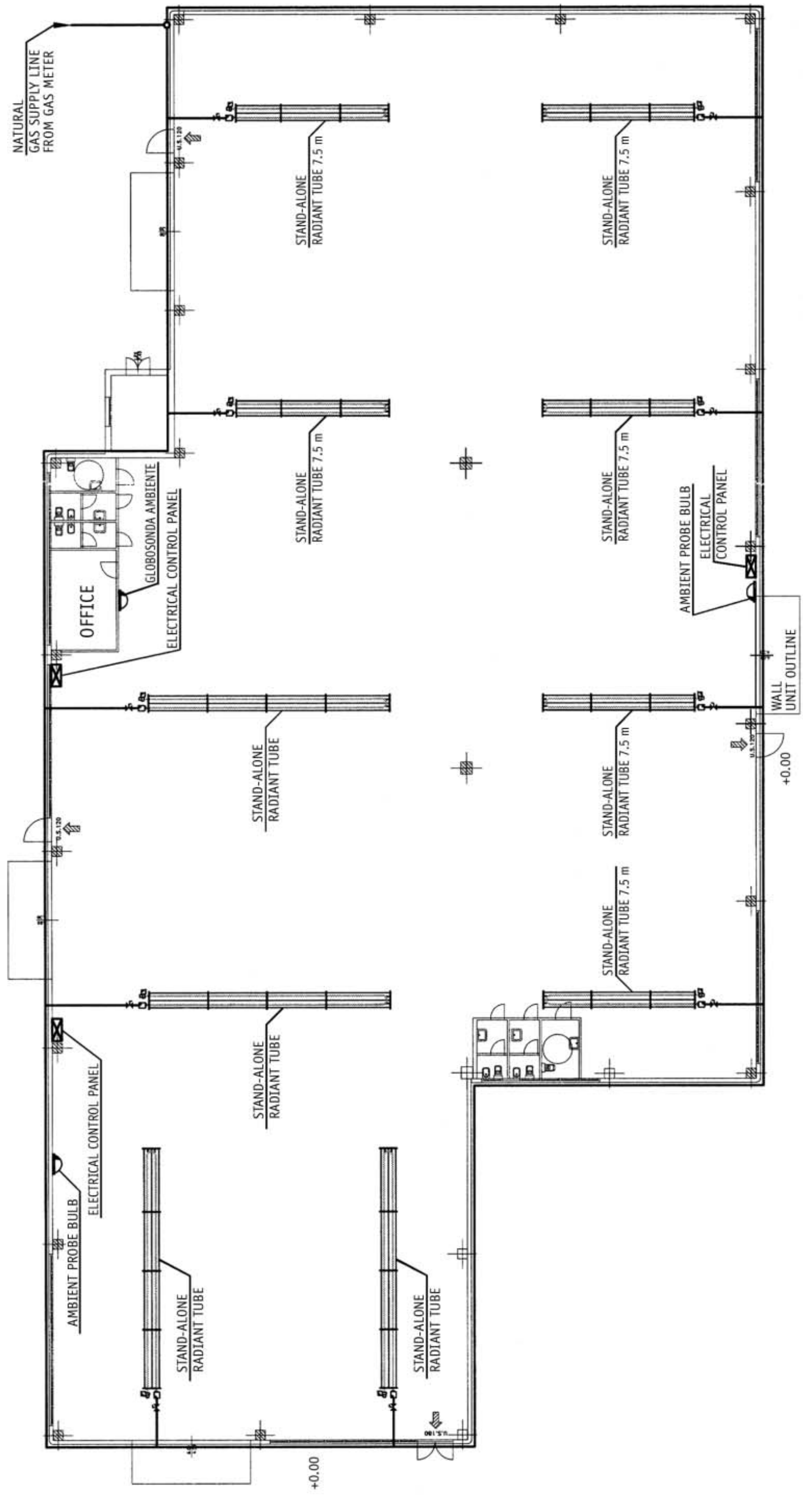
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 48.000,00

- Running cost

  The average daily heating requirements of 950 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:

- electricity	€ 900,00
- fuel	€ 6.500,00
- maintenance (preventive and routine)	€ 2.000,00
Total	**€ 9.400,00**

SYSTEM WITH DIRECT PRODUCTION OF HEAT – GAS FIRED RADIANT TUBES



SYSTEM WITH
INDIRECT PRODUCTION OF HEAT - CEILING MOUNTED UNIT HEATERS WITH VERTICAL DISCHARGE

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 must be adjusted for the system to have the following specific features:
    ° not allow a mean radiant temperature of 18°C, but rather 16°C.
    ° increase the air velocity, in the occupied zone, to around 0.2 m/sec.
    To keep the Predicted Percentage of Dissatisfied (PPD) unchanged, the dry bulb temperature of the air must be raised from 18°C to 19°C.
  - noise pollution is significant and hard to maintain within the established limits.
  - the processing dust, typical for the activities carried out inside the building, is lifted by the motion due to the forced ventilation, with negative effects on the processes, the employees and the air heaters, which become fouled, being made without filters.

- Thermal gradient
  This system, which distributes hot air from the high parts of the building (vertical discharge), causes natural stratification estimated at 0.9°C/m, hence giving an average value of 2.5°C, to be considered in the calculation of the heating requirements.
  The gradient can be reduced using additional mechanical ventilation systems (destratifiers), to be adopted after suitable “costs – benefits” analysis, as the advantages depend on the height and the shape of the room.

- Intermittent operation
  The system, featuring limited thermal inertia, allows intermittent operation, which may require precautions in terms of frost prevention, as well as involving overloading of 30 kW/h in the phase when the system is reaching stable operation, in conditions of maximum load.

- \- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider both the different air temperature, required for the same level of comfort, and the average thermal gradient of 2.5°C, and specifically:
  - heat loss = kW/h 195
  - natural ventilation = kW/h 57

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, both the average outside temperature of the entire winter phase, considering that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 1,500 kW/day.

- Thermal efficiency
  - combustion must take place without condensation and consequently with high flue gas temperatures; the maximum efficiency of 92% remains effective, as the use of two-stage burners allows an increase in output that compensates the decline in performance due to use.

- the distribution of the water, which occurs substantially inside the area being heated, does not cause variations due to “distribution efficiency”.

- Maintenance
  - preventive maintenance on the heating plant is necessary and normally quite straightforward, as all of the components are installed at ground level.
  - routine maintenance, for the cleaning of the air heaters, is essential, as it ensures the effectiveness of heat exchange; the cleaning operations are difficult because the components are installed at a height and often above working areas and machinery; the frequency and the difficulty of cleaning operations are correlated, in addition, to the quality of the processing (dust and vapours).
  - special maintenance is limited, as along as the routine maintenance operations are carried out regularly.

- Reliability
  - the efficiency of the installation essentially depends on the heat production systems; the partitioning of the requirement between two units in tandem ensures a good level of reliability.
  - the effectiveness of the installation essentially depends on the efficiency of the heat exchange and consequently on the cleaning of the air heaters, often neglected due to practical difficulties.

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is feasible, fitting some of the air heaters with a mixing section, complete with outside air and intake dampers, if necessary motor-driven and activated in synch with the mechanical ventilation system.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is feasible, both using specific air heaters (two-speed motors, larger coils, condensate collection trays), and suitably oversized compared to the heating requirement, as well as insulating the heat exchange fluid distribution circuits and creating condensate drain lines; the quality of the result will in any case be mediocre and probably feature non-uniform temperature, as well as currents of air.
  - simple integration with air curtains.

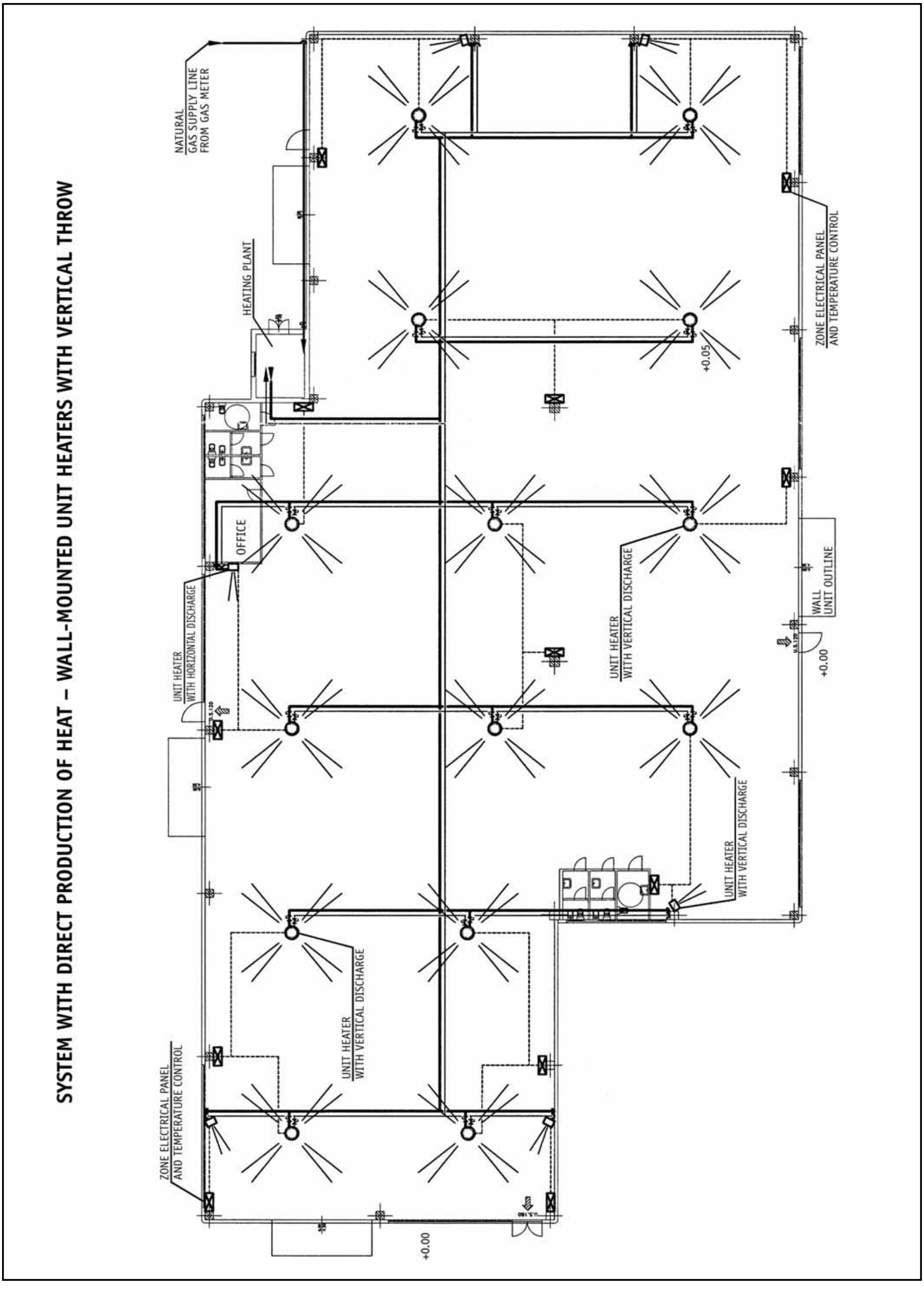
- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and consequently the inside comfort conditions and the average thermal gradient.
  - the air heaters must be sized so as to satisfy the heating requirement, moving a sufficient quantity of air to limit and control the temperature difference between the temperature of the heated air and the effective ambient temperature, at the height of the room (on average 3 Vol/h).
  - the position of the air heaters and the type of the diffusers available must ensure the uniform distribution of heat, with adequate penetration into the occupied zones.
  - the temperature control may control the ambient temperature independently for each zone covered by an air heater.
  - the use of mechanical ventilation systems (destratifiers) must be assessed by performing a “cost – benefits” analysis, as the advantages depend on the height and the shape of the room.

ECONOMIC OBSERVATIONS

- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 46.000,00
  - average market price of configuration for cooling operation ≅ € 10.000,00

- Running cost
  The average daily heating requirements of 1,500 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:

- electricity	€ 900,00
- fuel	€ 9.200,00
- maintenance (preventive and routine)	€ 1.000,00
Total	**€ 11.100,00**


SYSTEM WITH DIRECT PRODUCTION OF HEAT – WALL-MOUNTED UNIT HEATERS WITH VERTICAL THROW
NATURAL GAS SUPPLY LINE FROM GAS METER
HEATING PLANT
OFFICE
UNIT HEATER WITH HORIZONTAL DISCHARGE
UNIT HEATER WITH VERTICAL DISCHARGE
UNIT HEATER WITH VERTICAL DISCHARGE
UNIT HEATER WITH VERTICAL DISCHARGE
ZONE ELECTRICAL PANEL AND TEMPERATURE CONTROL
ZONE ELECTRICAL PANEL AND TEMPERATURE CONTROL
WALL UNIT OUTLINE
+0.05
+0.00
+0.00

SYSTEM WITH INDIRECT PRODUCTION OF HEAT - RADIANT FLOOR

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 can be reduced by bringing the dry bulb temperature of the air to the value of 16°C, as this system allows the set mean radiant temperature to be exceeded.
  - noise pollution is non-existent.
  - the processing dust, typical for the activities carried out inside the building, is moved within the occupied area due to convective motion created by the surface temperature of the floor (≅ 24°C).

- Thermal gradient
  This system, which substantially distributes the heat by radiation in the lower parts of the building, limits the thermal gradient to negligible values for the calculation of the heating requirements.

- Intermittent operation
  The system, featuring high thermal inertia, does not allow intermittent operation, but rather the reduction of the load at night.
  The thermal mass of the radiator panels in the current techniques (110 - 120 kg/m^2), significantly reduced compared to previous systems (230 - 250 kg/m^2), as the plate that transmits the heat is limited to the part above the insulating layer, is nonetheless still significant and such as to cause delays in STOP and START that make intermittent daily operation inconvenient.

- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider the different air temperature, required for the equivalent level of comfort, specifically:
  - heat loss = kW/h 162
  - natural ventilation = kW/h 48

  the values deriving from the heat loss of the floor do not cause an increase to the heating requirement, because the increase in temperature is compensated by the reduction of thermal transmission, due to the insulation adopted and used, as well as to assist the laying of the pipes.

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirement,** considering both the night-time reduction, and the influence of the phase required to reach stable weekly operating conditions, both the average outside temperature of the entire winter phase, considering that operation occurs during the daytime and night-time.
  The **average daily heating requirements** will therefore be 1,300 kW/day.

- Thermal efficiency
  - combustion may occur with condensation of the products of combustion, and consequently with very low flue gas temperatures; the maximum efficiency of 105% will decrease on average to 100% during operation.

- Maintenance
  - preventive maintenance is necessary on the heating plant and is normally quite straightforward, as all the components are installed at ground level.
  - routine and special maintenance are limited to the generation system and the system for the transport of the products of combustion.

- Reliability
  - the efficiency of the installation essentially depends on the heat production systems; the division of the thermal requirement between two tandem units ensures a good level of reliability.
  - the efficiency of the installation also depends on the seal and condition of the pipes; the use of multi-layer pipes gives higher quality, but the reliability and the repairability of the systems installed inside the structures are in any case lower than those of systems installed in view, inside the rooms.

- Flexibility
  - The design and development require greater need for coordination, as radiator panels interfere both with the building work and with any installations above the floor (drains, cable conduits...), as well as with the machinery.
  - the layout of the installation, installed inside the structures, is not flexible and adaptable to possible variants for the organisation of space or changes in use; in addition, the installation of machinery that needs to be fastened to the floor may interfere with the pipes.
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is not possible; if necessary, install separate yet complementary systems.
  - cooling operation is feasible; in this case, the system needs to be oversized, and systems to control the non-condensing surface temperature and dehumidification systems need to be used; this can also be used for renewal with conditioned air.
    The cooling effect of the floor panels will sufficiently compensate for the distributed thermal loads, however the convective effect of the floor will cause stratification of "cold" air in the lower parts, with sensations of discomfort for people.

- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and consequently the inside comfort conditions, and the small effect of the thermal gradient.
  - the characteristics of the thermal insulation, underneath the panels, limit heat loss to the ground, which only needs to be considered for the calculation of the generation systems and the distribution of the heat exchange fluid.
  - the sizing of the radiant floor panels must satisfy the heating requirement of the building, in terms of height.
  - the heat may be generated less expensively using condensing heating plants, operating with outside temperature compensation; the greater cost of installation will be balanced by the savings in running costs, in the short term of around 3 years.
  - the temperature control, in the "HEATING" phase, must control the heat carrier fluid temperature according to the outside air temperature and consequently with predetermined inverse proportionality (increase in the outside temperature = reduction of the heat carrier fluid temperature).

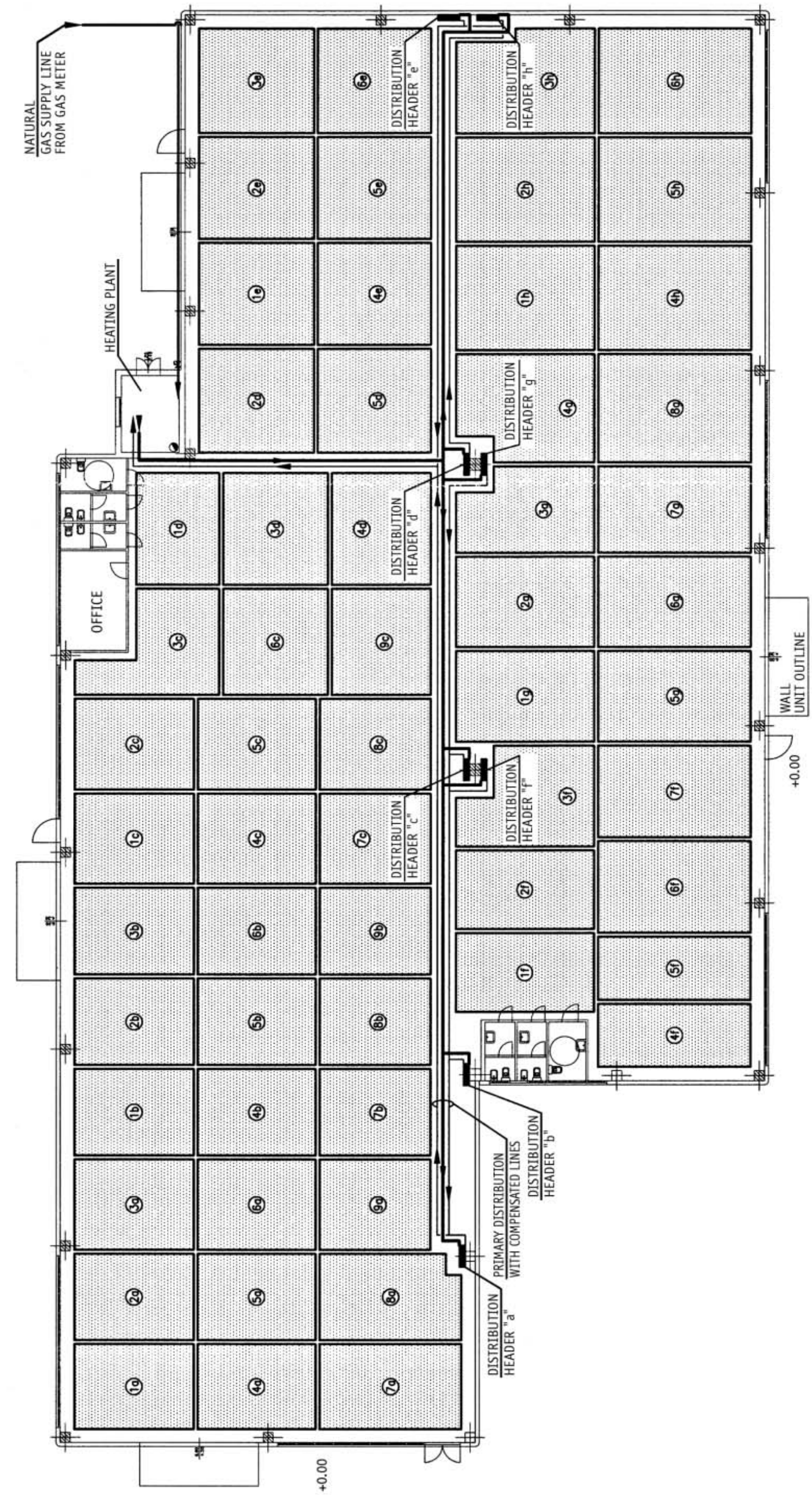
ECONOMIC OBSERVATIONS

- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 85.000,00
  - average market price of configuration for cooling operation ≅ € 5.000,00

  NB: the cost of development of the systems must be added to the greater cost of the building work deriving from the greater height of the floor, around 80 mm, and consequently the room.

- Running cost
  The average daily heating requirements of 1,300 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:
  - electricity € 900,00
  - fuel € 7.200,00
  - maintenance (preventive and routine) € 700,00

SYSTEM WITH INDIRECT PRODUCTION OF HEAT – RADIANT FLOOR



SYSTEM WITH INDIRECT PRODUCTION OF HEAT – HOT WATER RADIANT PANELS

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 can be reduced by bringing the dry bulb temperature of the air to the value of 16°C, as this system allows the set mean radiant temperature to be exceeded.
  - noise pollution is non-existent.
  - the processing dust, typical for the activities carried out inside the building, decants due to the limitation of the convective motion at floor level.
  - uniform distribution of the heat, without currents of air, and with uniform room temperature throughout the area being heated.

- Thermal gradient
  This system, which distributes the heat mostly by radiation in the high parts of the building, limits the thermal gradient to negligible values in the calculation of the heating requirements.

- Intermittent operation
  The system, featuring limited thermal inertia, allows intermittent operation, and may require precautions in terms of frost protection, as well as involving an overload of 50 kW/h in the phase when the system is reaching stable operation, in conditions of maximum load.

- Heating requirements of the building
  The values shown on page 48 must be adjusted to consider the different air temperature, required for the equivalent level of comfort, specifically:
  - heat loss = kW/h 162
  - natural ventilation = kW/h 48

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, both the average outside temperature of the entire winter phase, considering that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 950 kW/day.

- Thermal efficiency
  - combustion must take place without condensation and consequently with high flue gas temperatures; the maximum efficiency of 92% remains effective, as the use of two-stage burners allows an increase in output that compensates the decline in performance due to use.
  - the distribution of the water, which occurs substantially inside the area being heated, does not cause variations due to "distribution efficiency".

- Maintenance
  - preventive maintenance on the heating plant is necessary and normally quite straightforward, as all of the components are installed at ground level.
  - routine and special maintenance are limited to the generation system and the system for the transport of the heat exchange fluid, as the heating panels themselves are maintenance-free.

- Reliability
  - the efficiency of the installation essentially depends on the heat production systems; the division of the thermal requirement between two tandem units ensures a good level of reliability.
  - the average life of the heating panels is much longer than other types of systems.

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is easily feasible with the addition of air heaters with outside air intake.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is feasible; in this case, the system needs to be oversized, with the addition of thermal insulation on the main distribution pipes, systems to control the “non-condensing” surface temperature and dehumidification systems; this can also be used for renewal with conditioned air. The radiant and convective effect of the heating panels, in the “COOLING” phase, will allow the compensation for the thermal loads, uniformly and ensuring comfort, being free of stratification.
  - simple integration with air curtains.

- Warnings for sizing and selection
  (see “Calculation procedure” on page 10).

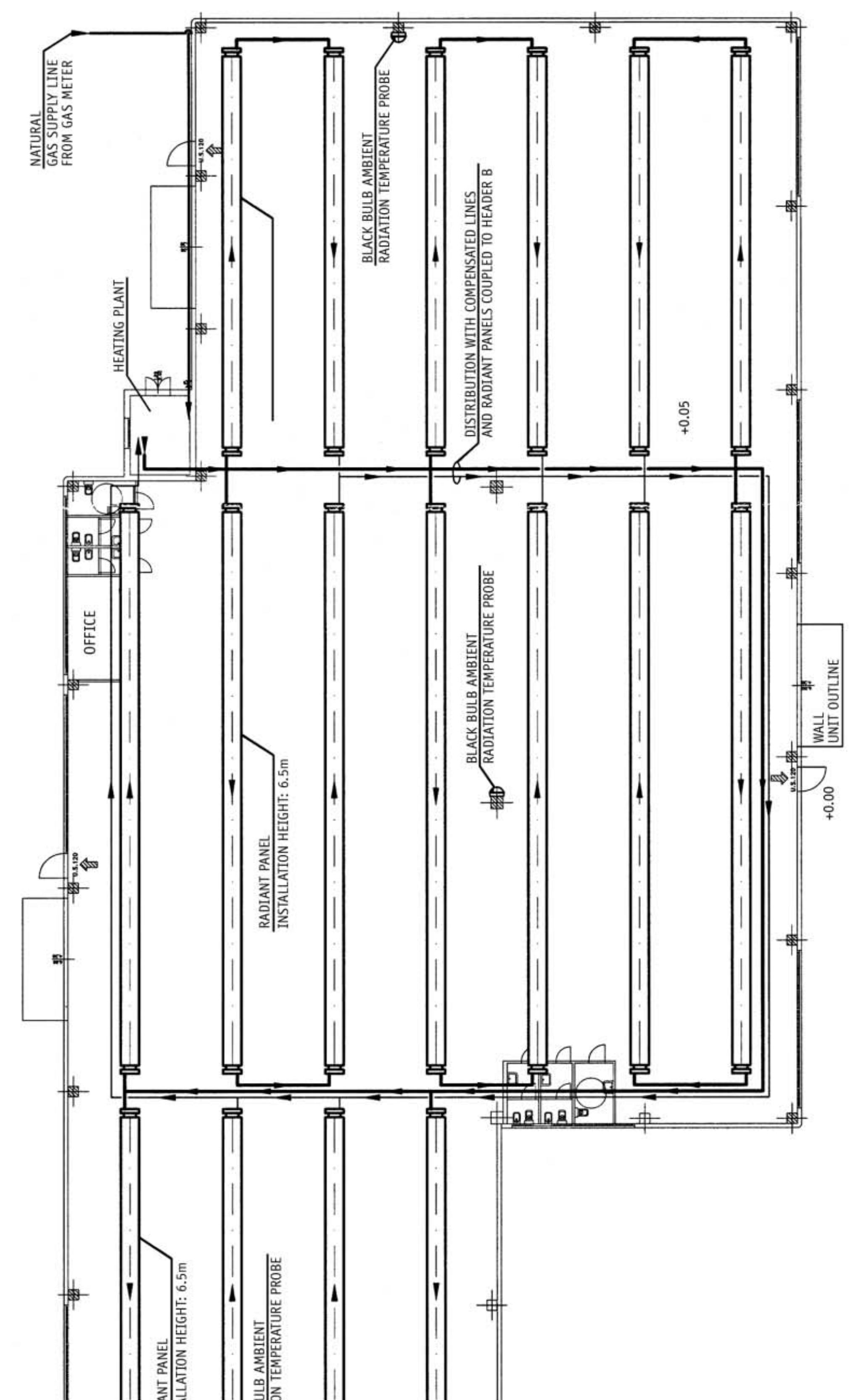
ECONOMIC OBSERVATIONS

- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:
  - average market price ≅ € 60.000,00
  - average market price
    of configuration for cooling operation ≅ € 10.000,00

- Running cost
  The average daily heating requirements of 1,150 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:

- electricity	€ 700,00
- fuel	€ 5.800,00
- maintenance (preventive and routine)	€ 500,00
Total	**€ 7.000,00**

SYSTEM WITH INDIRECT PRODUCTION OF HEAT - HOT WATER RADIANT PANELS



SYSTEM WITH INDIRECT PRODUCTION OF HEAT - AIR HANDLING UNIT

TECHNICAL AND FUNCTIONAL OBSERVATIONS

- Inside comfort conditions
  - The conditions summarised on page 48 must be adjusted for the system to have the following specific features:
    ° not allow a mean radiant temperature of 18°C, but rather 16°C.
    ° increase the air velocity, in the occupied zone, to around 0.2 m/sec.
    To keep the Predicted Percentage of Dissatisfied (PPD) unchanged, the dry bulb temperature of the air must be raised from 18°C to 19°C.
  - noise pollution can be limited using silencers and thus kept within the established limits.
  - the processing dust, typical for the activities carried out inside the building, is lifted by the convective motion cause by the forced ventilation, with negative effects on the processes and the workers.

- Thermal gradient
  This system, which distributes hot air from the high parts of the building, causes natural stratification estimated at 0.5°C/m, hence giving an average value of 1.5°C, to be considered in the calculation of the heating requirements.

- Intermittent operation
  The system, featuring low thermal inertia, allows intermittent operation, which may require precautions in terms of frost protection, as well as involving an overload of 50 kW/h, in the phase when the system is reaching stable operation, in conditions of maximum load.

- Heating requirements of the building
  The values shown in the paragraph 4.8 must be adjusted to consider both the different air temperature, required for the same level of comfort, and the average thermal gradient of 1.5°C, and specifically:
  - heat loss = kW/h 190
  - natural ventilation = kW/h 55

- Average daily heating requirements
  The heating requirement, determined and used to size the system, is related to the **average daily heating requirements,** considering both the overload to reach stable operation, and the duration of such overload phase, both the average outside temperature of the entire winter phase, considering that operation occurs during the daytime.
  The **average daily heating requirements** will therefore be 1.500 kW/day.

- Thermal efficiency
  - combustion may occur with condensation of the products of combustion, and consequently with very low flue gas temperatures; the maximum efficiency of 105% may decrease, on average, to 100% during operation.
  - the distribution of the water, which occurs substantially inside the area being heated, does not cause variations due to “distribution efficiency”.
  - the distribution of the air, which occurs substantially inside the area being heated, does not cause significant reductions in efficiency.

- Maintenance
  - preventive maintenance on the heating plant is necessary and normally quite straightforward, as all of the components are installed at ground level.
  - routine maintenance of the air handling unit is limited to the periodical cleaning and replacement of the filters and the drive belts (fan – motor coupling); the frequency of the cleaning operations

is related to the amount of processing dust produced in the working areas.
- special maintenance is limited.

- Reliability
  - the efficiency of the installation depends primarily on the heat production systems; the partitioning of the requirement between two units in tandem ensures a good level of reliability.
  - the effectiveness of the installation depends secondarily on the air handling unit; the periodical and diligent completion of the routine maintenance operations ensures a good level of reliability.

- Flexibility
  - renewal with fresh outside air, if required to make up for the discharge by any mechanical ventilation systems, is readily feasible, by installing the mixing section, fitted with outside air and intake dampers, if necessary motor-driven and activated in synch with the mechanical ventilation system.
  - the layout of the system is flexible and adaptable to the possible variants in terms of organisation of spaces or type of use.
  - cooling operation is feasible if the air distribution system has been suitably oversized.

- Warnings for sizing and selection
  - the requirements must be calculated considering the characteristics of the system and thus the correlated inside comfort conditions and the average thermal gradient.
  - the flow-rate of air circulating must be determined so as to limit and adapt the temperature difference between the heated air and the effective room temperature.
  - the air must be distributed towards the occupied zones, without causing disturbance.
  - the temperature control system must control the ambient temperature, avoiding the overheating of the air; the use of a maximum air temperature limit is useful to reduce stratification.
  - the heat may be generated less expensively using condensing heating plants, operating with outside temperature compensation; the greater cost of installation will be balanced by the savings in running costs, in the short term of around 3 years.

ECONOMIC OBSERVATIONS

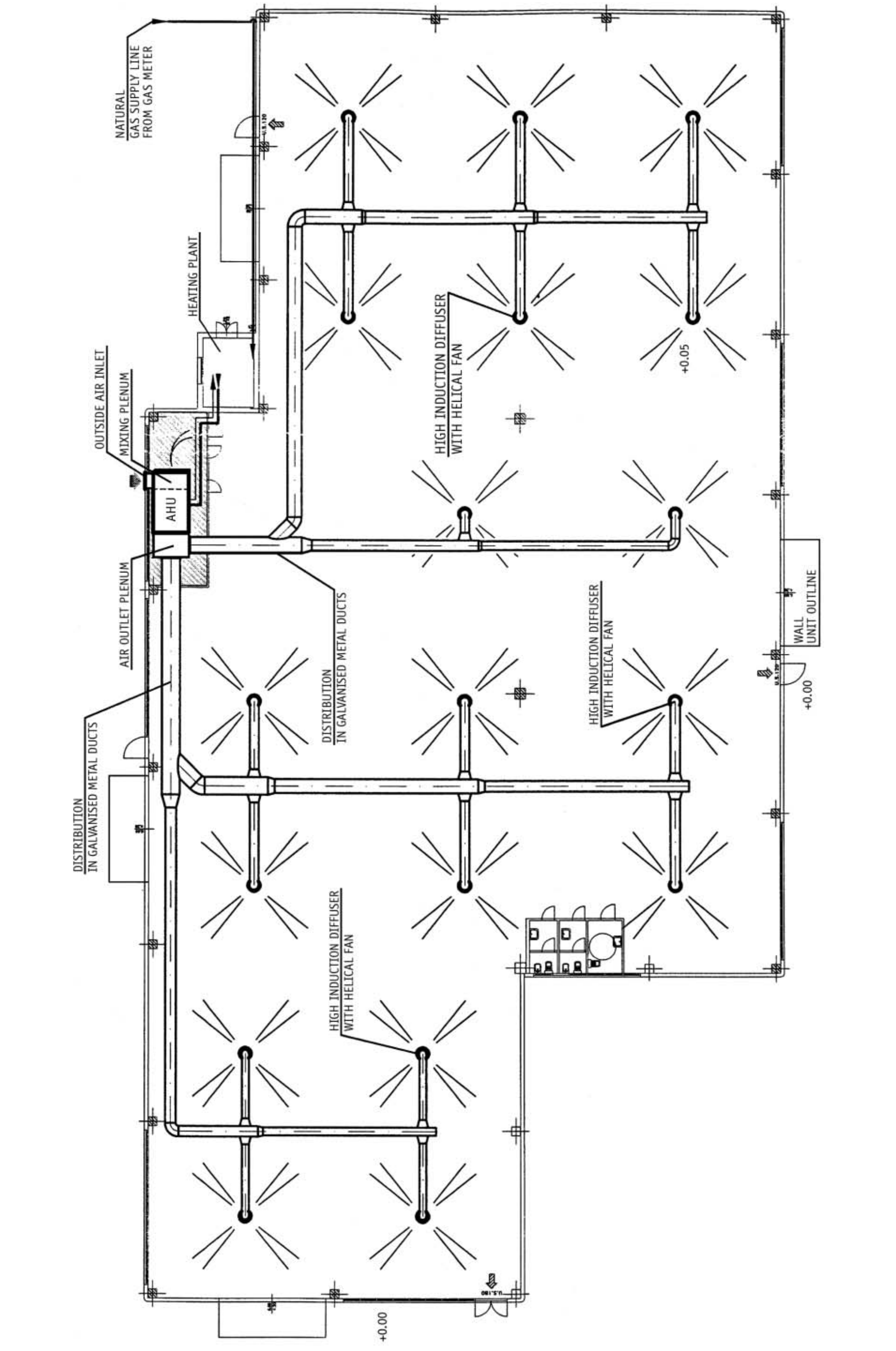
- Installation cost
  The development of the system, represented schematically in the drawing **enclosed at the bottom** of this paragraph, may have the following estimated value:

- average market price	≅ € 75.000,00
- average market price of configuration for cooling operation	≅ € 3.000,00

- Running cost
  The average daily heating requirements of 1,500 kW allows the annual running cost to be estimated, based on both the typical thermal efficiency of the system, and the operating period of 182 days (129 effective days, net of weekends and public holidays), typical for the climatic zone in question and specifically:

- electricity	€ 1.700,00
- fuel	€ 7.600,00
- maintenance (preventive and routine)	€ 1.400,00
Total	**€ 10.700,00**

SYSTEM WITH INDIRECT PRODUCTION OF HEAT - AIR HANDLING UNIT



Summary of the investment and routine management costs and product life expectation

		Hot air generator	Continuous gas fired tube heaters	Gas fired radiant tubes	Ceiling mounted heaters with vertical discharge	Radiant floor	Hot water radiant panels	Air handling unit
INVESTMENT	*Basic system*	€ 40.000,00	€ 50.000,00	€ 48.000,00	€ 46.000,00	€ 85.000,00	€ 60.000,00	€ 75.000,00
	Ready for cooling operation	€ 7.000,00	NOT FEASIBLE	NOT FEASIBLE	€ 10.000,00	€ 5.000,00	€ 10.000,00	€ 3.000,00
ROUTINE OPERATION	*Electricity*	€ 950,00	€ 1.700,00	€ 900,00	€ 900,00	€ 900,00	€ 700,00	€ 1.700,00
	Fuel	€ 9.300,00	€ 6.500,00	€ 6.500,00	€ 9.200,00	€ 7.200,00	€ 5.800,00	€ 7.600,00
	Maintenance	€ 1.450,00	€ 2.000,00	€ 2.0000,00	€ 1.000,00	€ 700,00	€ 500,00	€ 1.400,00
	TOTAL	**€ 11.700,00**	**€ 10.200,00**	**€ 9.400,00**	**€ 11.100,00**	**€ 8.800,00**	**€ 7.000,00**	**€ 10.700,00**
PRODUCT LIFE	*Years*	12 - 15	10 - 12	10 - 12	20 - 25	30 - 35	35 - 40	15 - 20

www.icim.it

CISQ is a member of IQNet
THE INTERNATIONAL CERTIFICATION NETWORK
www.iqnet-certification.com

IQNet, the association of the world's first class certification bodies, is the largest provider of management System Certification in the world. IQNet is composed of more than 30 bodies and counts over 150 subsidiaries all over the globe.

CERTIFICATO n.
CERTIFICATE No. **0545/3**

SI CERTIFICA CHE IL SISTEMA DI GESTIONE PER LA QUALITA' DI
WE HEREBY CERTIFY THAT THE QUALITY MANAGEMENT SYSTEM OPERATED BY

SABIANA S.p.A.

UNITA' OPERATIVE
OPERATIVE UNITS

Via Piave, 53 - 20011 Corbetta (MI)
Italia

E' CONFORME ALLA NORMA
IS IN COMPLIANCE WITH THE STANDARD

UNI EN ISO 9001:2000

PER LE SEGUENTI ATTIVITA'
FOR THE FOLLOWING ACTIVITIES

EA: 18

Progettazione, produzione e assistenza di apparecchiature per il riscaldamento e il condizionamento dell'aria (aerotermi, termostrisce radianti, ventilconvettori e unità trattamento aria) e canne fumarie.

Design, production and service of heating and air conditioning equipment (unit heaters, radiant panels, fan coil units and air handling units) and chimneys.

Riferirsi al Manuale della Qualità per l'applicabilità dei requisiti della Norma ISO 9001:2000.
Refer to Quality Manual for details of application to ISO 9001:2000 requirements.

Il presente certificato è soggetto al rispetto del regolamento per la certificazione dei sistemi di gestione per la qualità delle aziende.
The use and the validity of this certificate shall satisfy the requirements of the rules for the certification of company quality management systems.

Data emissione *First issue*	Emissione corrente *Current issue*	Data di scadenza *Expiring date*
10/06/1996	10/04/2006	09/04/2009

ICIM S.p.A. – PIAZZA A. DIAZ, 2 – 20123 MILANO

CISQ è la Federazione Italiana di Organismi di Certificazione dei sistemi di gestione aziendale

CISQ is the Italian Federation of management system Certification Bodies

SINCERT
ACCREDITAMENTO ORGANISMI DI CERTIFICAZIONE E ISPEZIONE
SGQ N° 004A
SGA N° 005D
PRD N° 004B
SCR N° 006F

Membro degli Accordi di Mutuo Riconoscimento EA e IAF
Signatory of EA and IAF Mutual Recognition Agreements

FEDERAZIONE CISQ
www.cisq.com

Heating

DS Radiant Panel

PLANNING AND CALCULATION MANUAL

M - EX - 10/07
COD. A4809100 B/10/07

SABIANA
ENVIRONMENTAL COMFORT

Sabiana s.p.a. • via Piave, 53 • 20011 Corbetta • Milano • Italy • phone +39.02.97203.1 r.a. / +39.02.97270429 / +39.02.97270576
fax +39.02.9777282 / +39.02.9772820 • www.sabiana.it • info@sabiana.it