MARIO DONINELLI

SYSTEMS WITH MANIFOLDS

Handbooks Caleffi

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This Third Caleffi Handbook looks at the problems of designing and installing Manifold systems.

Unlike the first two, this Handbook is in the form of a loose-leaf folder. We found this format useful so that the sections relating to the calculation programmes (i.e. the sections which "age" more easily due to the continuous evolution of programming languages) could be up-dated more easily.

The new Handbook also gives greater detail of the main lines of our publishing project, which has been evolved in line with developments, whilst taking into account the various arguments put forward.
In reality, from the start of the initiative, the aim was quite clear - to provide the customers in our market sector with useful publications which were easy to read and consult and were firmly based on real problems.

To achieve it, we made use of the invaluable help provided by everyone with an interest in our activities.
Their suggestions and support indicated the path we should follow. Thus these have always been - and continue to be - indicators for guiding the research and work which have led to the evolution of our products.
I should therefore like to thank all our colleagues and would like to emphasise that we at Caleffi greatly appreciate their help and feel especially close to them.
I also sincerely hope that this cooperation will continue, because it is essential for us to know the requirements of the customers we work for.
I would also say that the ability to meet such requirements is the most significant yardstick for measuring the value of our products and services.

Finally, I would like to express my thanks to Engineer Doninelli and all those who have been involved in the production of this Handbook.

Franco Caleffi
Chairman, CALEFFI S.p.A.

After examining problems and aspects of a general nature, such as the dimensioning of circuits and the selection of terminals, the purpose of this new Handbook is to handle a much more specific, specialised topic - the design of Manifold systems.
The subject will be broken down into three parts.

The ***First Part*** *examines the technical and service characteristics of these systems. Two methods of calculation will also be proposed (with both theoretical and practical development) for dimensioning branch circuits with guide temperature difference or predetermined diameters.*

The ***Second Part*** *presents the general structure of the calculation programme with the relevant options and command functions.*
The programme provides the simultaneous dimensioning of all branch circuits (from a Manifold). It also gives the possibility of carrying out further dimensioning of circuits, rebalancing the Manifold at a new head, or varying the maximum design temperature.

The Third and final part *gives some examples to give a clearer picture of the use of the programme and permit a comparison between the solutions obtained by the various calculation methods proposed.*

In order to use the calculation programme, it is not necessary to read all the items in the Handbook. In particular, you can omit or postpone reading the calculation methods given in the item ***"Dimensioning Manifold Systems"****.*
The theoretical calculation methods are given here with the main aim of illustrating laws, formulae and procedures on the basis of which systems can be rigorously calculated.
In addition to the theoretical side, some practical methods are then proposed, to show how to proceed, even manually, with carrying out "on site" checks and providing any variants or inclusions.

I should like to thank Marco Doninelli and Claudio Ardizzoia for their valued assistance. Finally, I should like to express my gratitude to Caleffi for offering me the help and support needed to complete this publication.

Mario Doninelli

NOTES

GENERAL STRUCTURE

Definitions, graphs, tables, formulae, command functions, examples and advice are given below under items (or headings).

Each item, while being linked to the general context, in practice stands alone. The connections between items are indicated by appropriate references: each reference is clearly shown in rounded brackets.

Graphs, tables and formulae have consecutive numbering linked only to the context of the item in which they are contained. Longer items, sometimes introduced by a short contents list, are broken down into chapters and sub-chapters.

DRAWINGS AND DIAGRAMS

The items are supplemented by drawings and diagrams which illustrate the essential functional aspects of the system, equipment and details described. No installation drawings are enclosed.

SIGNS, SYMBOLS AND ABBREVIATIONS

Signs and symbols (relating to mathematics, physics, chemistry, etc.) are those in current use. As far as possible, the use of abbreviations has been avoided; those which are used are specified in each case.

UNITS OF MEASUREMENT

The International System has not been rigidly applied. Traditional technical units of measurement have sometimes been used instead, as:

1. they are more immediate and understandable from the practical point of view;
2. they are the actual units of measurement referred to in the working language of the technicians and installers.

GREEK ALPHABET

Physical sizes, numeric coefficients and constants are often represented by letters of the Greek alphabet. These letters are shown below with their pronunciation .

Letters of the Greek Alphabet					
Upper Case	Lower Case	Name	Upper Case	Lower Case	Name
Α	α	alpha	Ν	ν	nu
Β	β	beta	Ξ	ξ	xi
Γ	γ	gamma	Ο	ο	omicron
Δ	δ	delta	Π	π	pi
Ε	ε	epsilon	Ρ	ρ	rho
Ζ	ζ	zeta	Σ	σ	sigma
Η	η	eta	Τ	τ	tau
Θ	θ	theta	Υ	υ	upsilon
Ι	ι	iota	Φ	φ	phi
Κ	κ	kappa	Χ	χ	chi
Λ	λ	lambda	Ψ	ψ	psi
Μ	μ	mu	Ω	ω	omega

NOTES

G E N E R A L   C O N T E N T S

Part one

GENERAL NOTES AND METHODS OF CALCULATION

Part Two

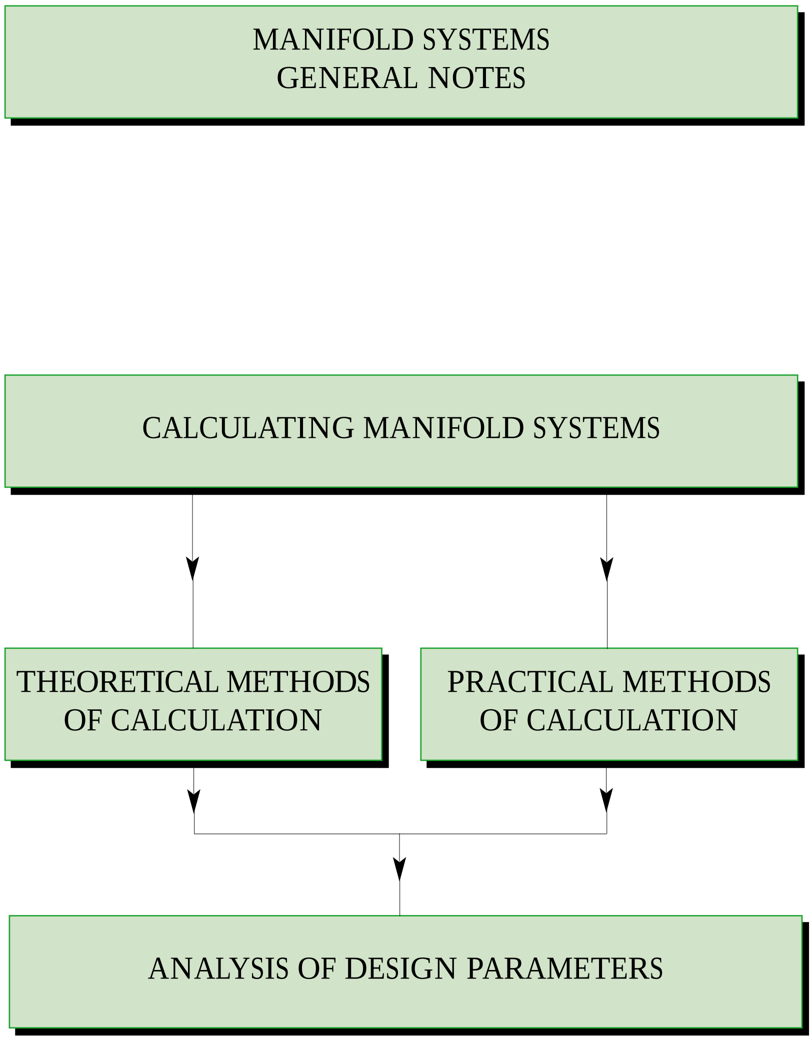
PROGRAMME FOR THE DIMENSIONING OF SYSTEMS WITH MANIFOLDS

Part Three

EXAMPLES OF CALCULATIONS

GENERAL NOTES
AND
METHODS OF CALCULATION

Summary Diagram



G E N E R A L   N O T E S

APPLICATIONS

ADVANTAGES OF MANIFOLD SYSTEMS

LIMITS AND DISADVANTAGES
OF MANIFOLD SYSTEMS

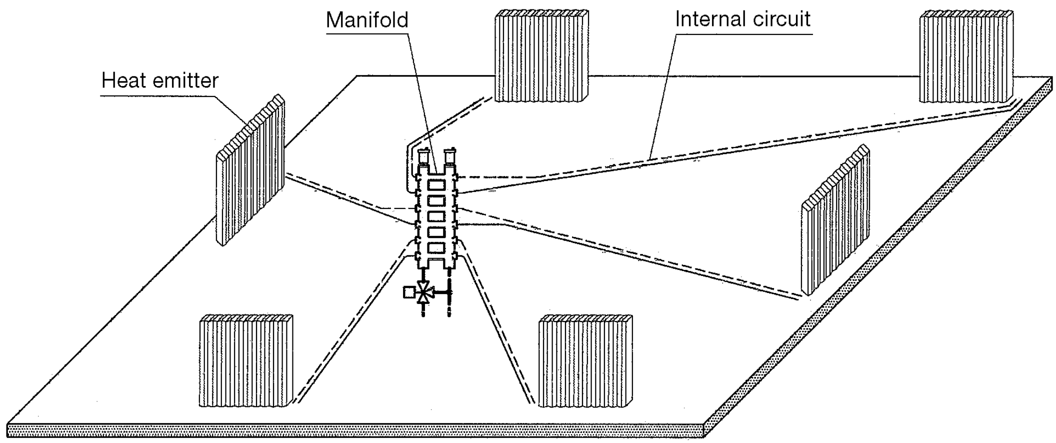
MANIFOLDS

INTERNAL CIRCUITS

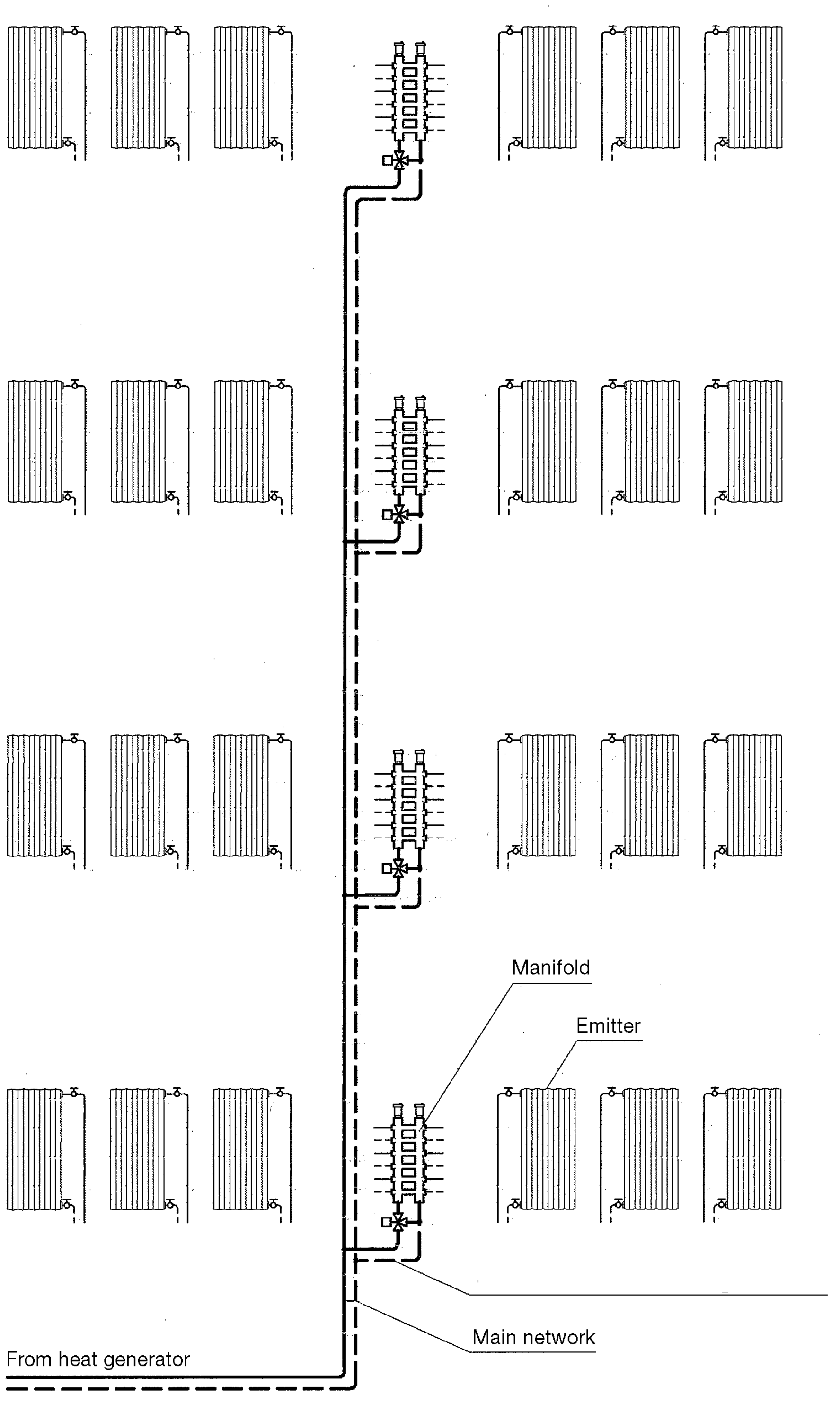
Manifold systems are also known as “web” systems due to the development and web-like effect of their internal circuits.

They consist essentially of:
- a heat generator,
- a main fluid distribution network,
- connecting branches between the main network and the manifolds,
- manifolds,
- internal circuits,
- heat emitters.

In graphical terms, they can be represented by the following diagrams:



Schematic diagram of the internal circuits



Layout diagram of a manifold system

APPLICATIONS

Manifold systems are used above all for the space heating of public buildings of a residential nature. They are also used in schools, hospitals, care homes, offices, hotels, gyms, libraries, museums, etc.

ADVANTAGES OF MANIFOLD SYSTEMS

In comparison with other systems, manifold systems can offer the following advantages:

1. The use of zoned systems.

   Unlike the traditional, dual pipe systems, manifold systems enable zones to be produced which are thermally independent of each other - in other words, zones where the required temperature can be maintained and the heat consumed measured.

2. Ease of installing pipes.

   The internal circuits of these systems require pipes of small diameter, in other words, pipes which are easy to bend and install.
   In addition, the fittings (to the Manifolds and heat emitters) are made with mechanically locking connections, and therefore no additional work, such as welding or soldering, requiring specialist personnel, is needed.

3. High heat output from heat emitters.

   At the same delivery temperature, manifold systems make it possible to keep the heat emitters at a temperature on average higher than can be obtained with ring systems. This makes it possible to use smaller, less expensive emitters.

4. Effective operation of thermostatic valves.

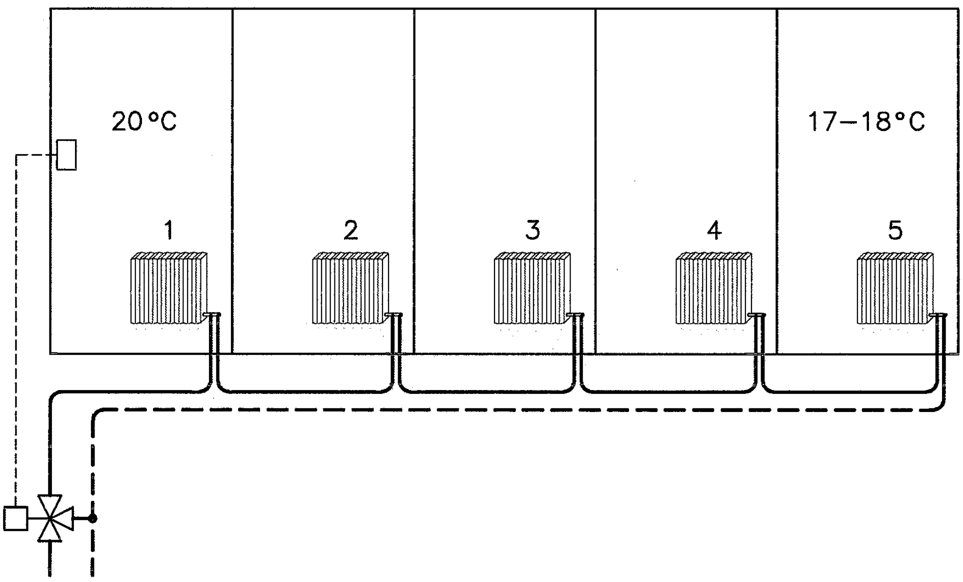
   Unlike ring systems, with 4-way valves, in manifold systems, the thermostatic valves are installed at a height variable from 80 to 100 cm. This means that the valves can easily be adjusted and that their sensors work at a thermally significant height.

5. Uniformity of operation of heat emitters and maintaining ambient temperature.

In manifold systems, the hot fluid is circulated simultaneously to all the heat emitters, which consequently come into operation at virtually the same time.

This is unlike ring systems, where the hot fluid circulates successively to the heat emitters, which thus come into operation at different times.
Imbalance of this nature can cause considerably differing internal temperatures, especially in the less cold seasons when the thermostat activates the circulation of the fluid only for very short periods, often shorter than is required to bring the system into operation.

In less cold seasons, for example, the first radiator on the diagram shown below can heat up, give off heat and deactivate the thermostat before the last radiator starts to heat up; ie. before the system can emit, regularly and homogeneously, the heat output for which it has been designed.



Ring distribution diagram

LIMITATIONS AND DISADVANTAGES OF MANIFOLD SYSTEMS

The limitations and disadvantages of manifold systems can be considered as:

1. The need to install independent circuits for each emitter.

   This restriction makes it practically impossible to use manifold systems in refurbishment projects where the flooring is not to be renewed. In these cases, the most suitable alternatives are generally ring systems with 4-way valves or injectors.

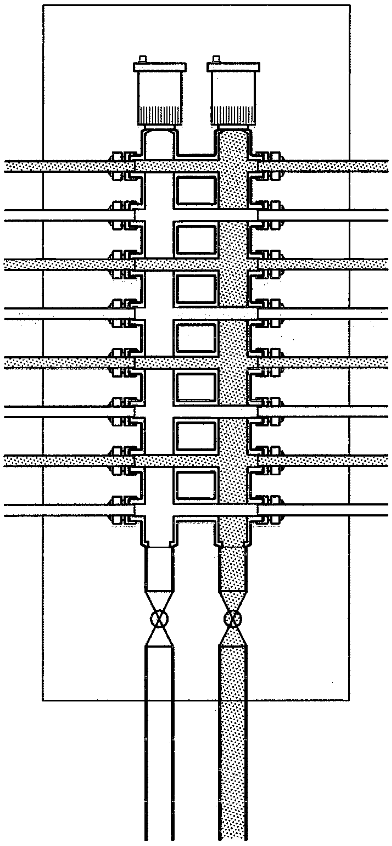
   - The 4-way valve solution is especially suitable when rings can be installed with flows of less than 350 - 400 l/h.
   - The solution with injectors, on the other hand, is suitable when rings with higher flows have to be installed, for example to heat large public rooms, or churches.

2. The requirement for more masonry work.

   The extensive “spider's web” of the internal circuits makes the operations necessary to protect the pipes from site damage more laborious than with other types of system.
   In addition, manifold systems require more committed wall layouts than those required for ring systems with 4-way valves.

MANIFOLDS

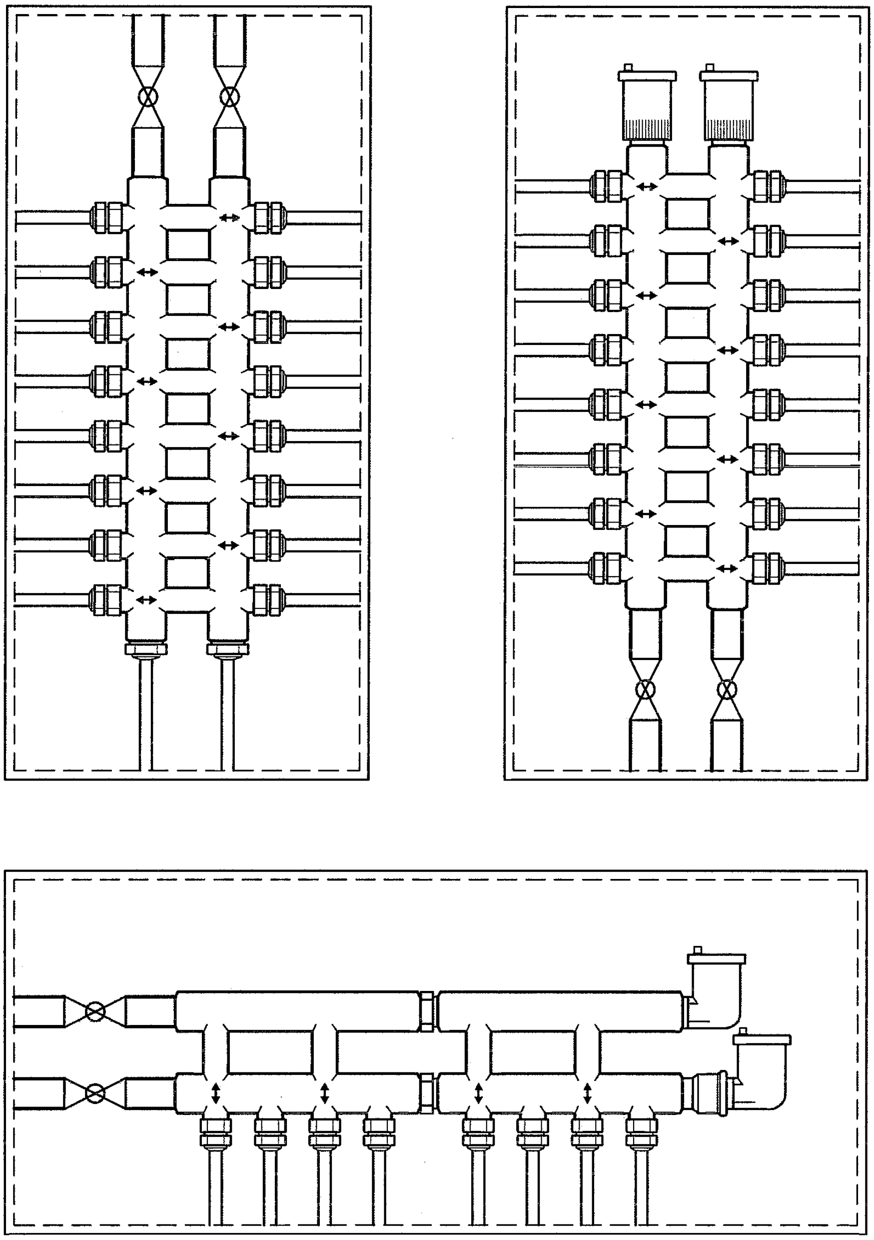
These normally have flow and return branches alternating to permit connection of the emitters without having to make the pipes cross over or overlap.



Diagrammatic representation of a typical manifold

To limit the lengths and complexity of the internal circuits, it is usually advisable to arrange manifolds in a central zone in relation to the emitters to be served.
It may be suitable (especially in centralised systems) to place the manifolds in stair wells or cavities where they can be inspected, ie. in positions where maintenance work can be carried out without the need to enter private premises.

The enclosures containing the manifolds must have **ventilation openings** when sensors or valves which do not withstand high temperatures are installed in them, for example electrically operated zone valves.



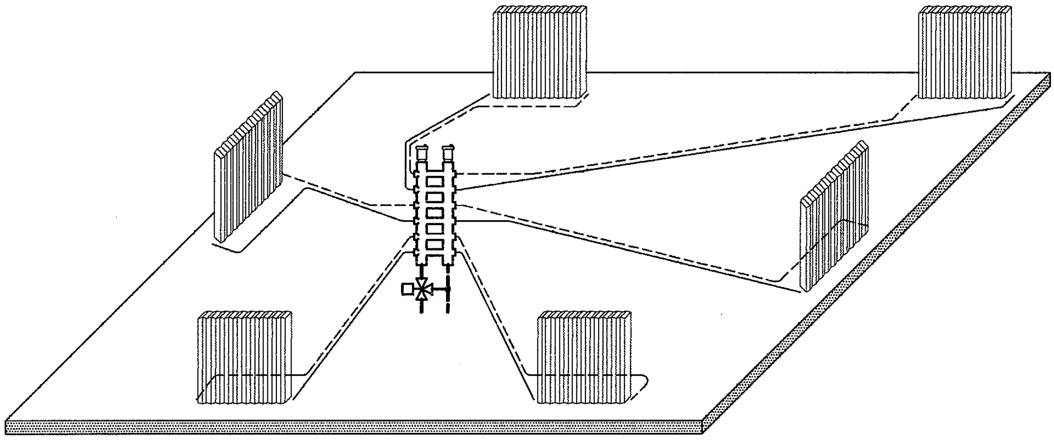
Examples of manifold installations

THE INTERNAL CIRCUITS

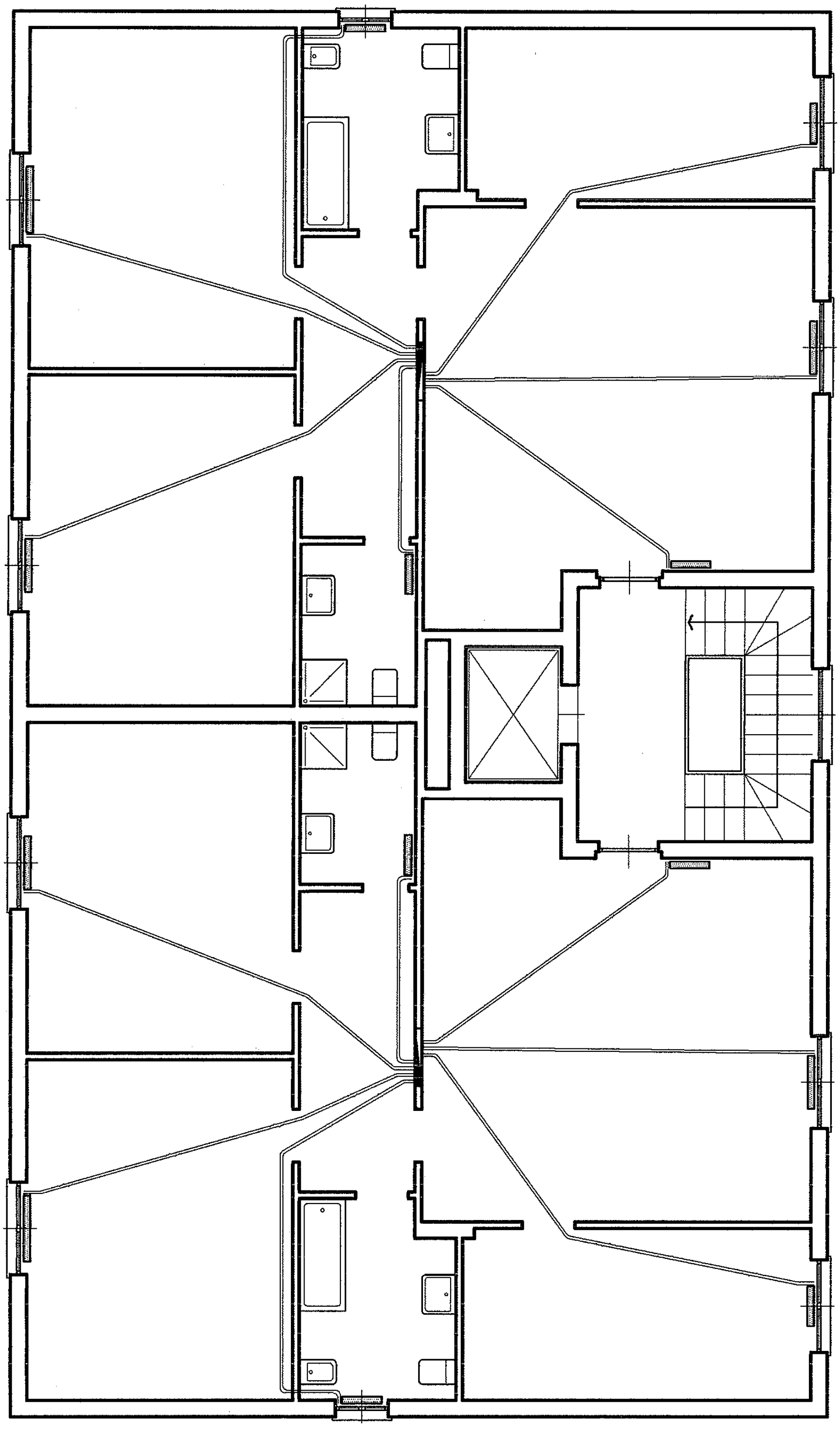
These can be made of copper, plastic or “mild” steel pipes.

For their routing, it is advisable to go through doors (see diagram on following page) unless this makes the routes too long.
Going through doors means that less masonry work is required and the pipes do not have to be threaded through holes - which is not always easy.

It is also advisable to connect the internal circuits to radiators with connections on the same side. Connections on opposite sides make it difficult to remove or add elements to sectional radiators and thus to vary their heat output if the original design is modified.

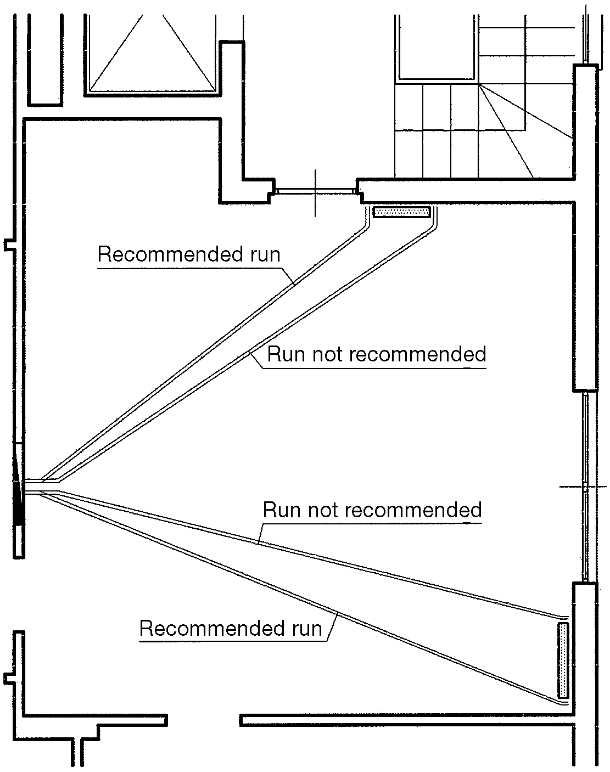


Example of connections not recommended



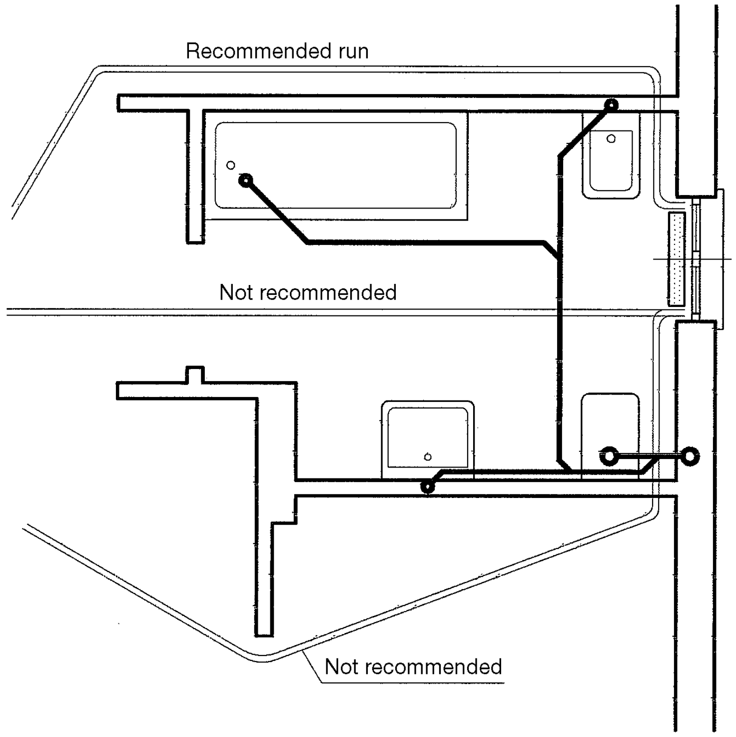
Example of routing of internal circuits

To allow for possible variations, in particular an increase in radiator elements, the connections to the radiators should be on the sides with possible limitations, eg. sides with adjacent doors, corners or pillars.



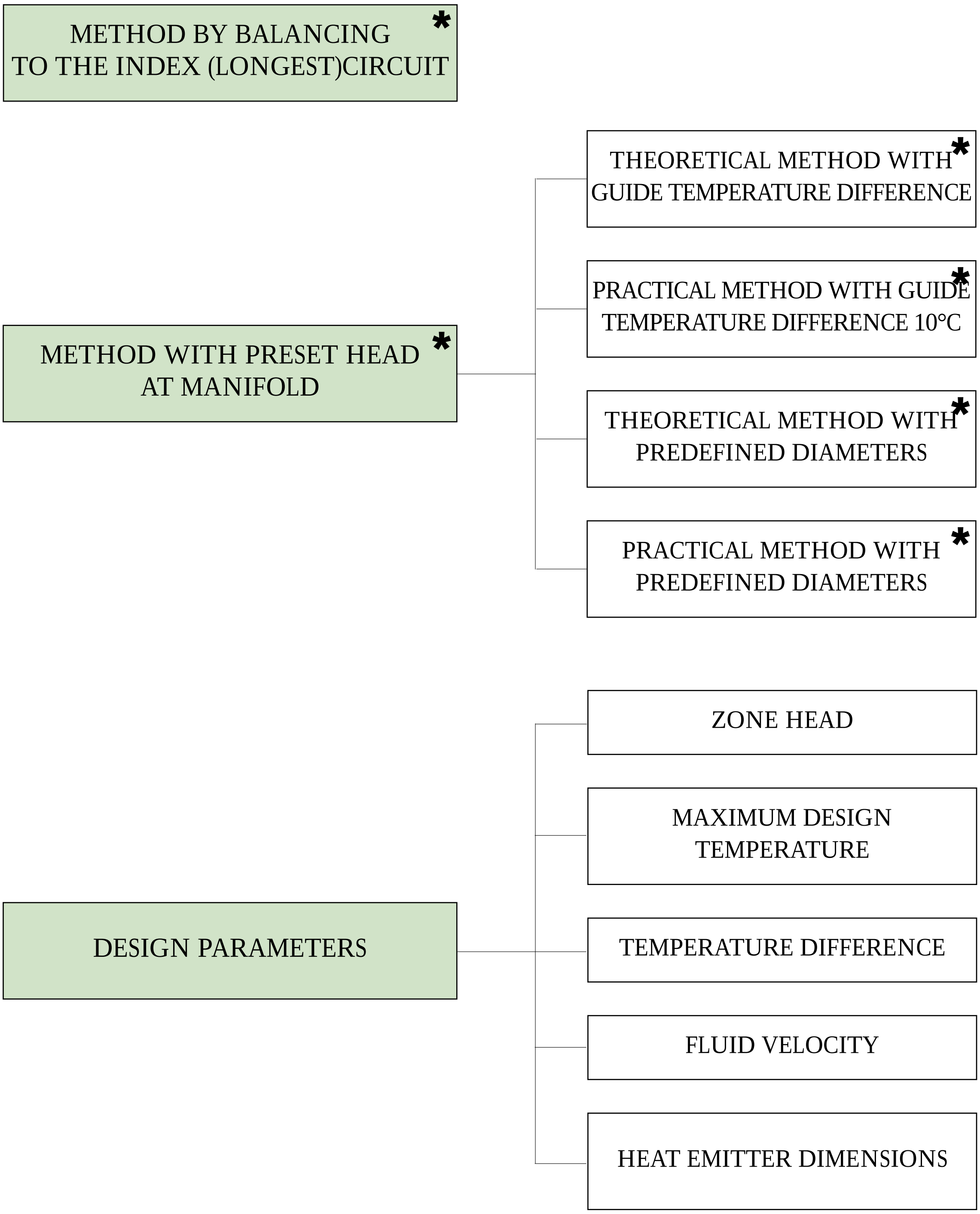
Connections between manifold and heat emitters

In addition, interference between internal circuit pipework and any water discharge piping should be avoided as shown in the drawing on the next page.



Connection of a heat emitter in a bathroom

DIMENSIONING OF MANIFOLD SYSTEMS



In order to be able to use the programme, you do not need to read the chapters and sub-chapters marked with an asterisk (see Preface).

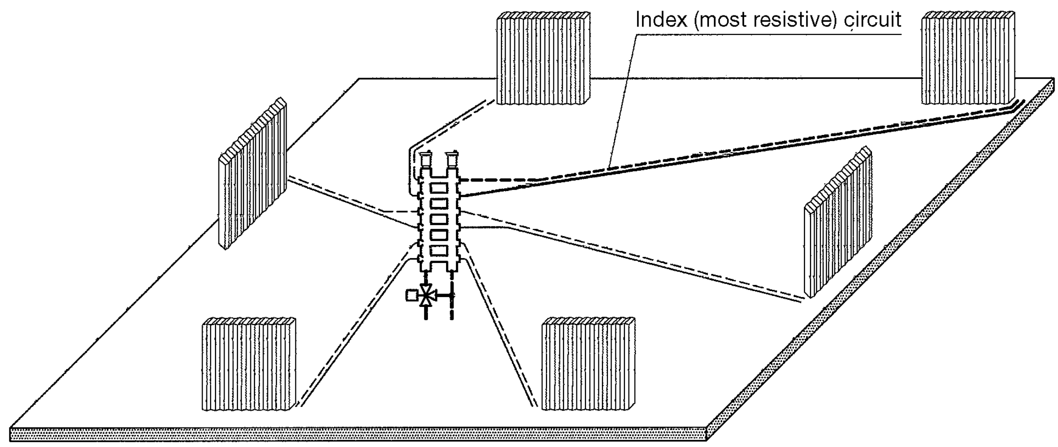
Essentially, two methods are used to dimension manifold systems:
- the method by balancing to the index (most resistive) circuit,
- the method with head preset at the manifold.

METHOD BY BALANCING TO THE INDEX CIRCUIT (1)

Using this method, the longest internal circuit is dimensioned on the basis of three factors:
- the heat output required,
- a predefined temperature difference (e.g. 10°C),
- a linear loss of head per metre of piping (e.g. 10 mm w.g.).

In the same way, the other branch circuits are then dimensioned and balanced at the head required by the index (most resistive) circuit.

This is a method substantially the same as that used to dimension the networks of traditional two-pipe systems (see 2nd Handbook, under the heading SIMPLE CIRCUITS).
It can be suitable for use in independent systems with a single manifold.
It is, however, rather laborious in systems with several manifolds, as even the various index circuits must be balanced at the head actually available at the connections of each manifold.



METHOD WITH PRESET HEAD AT MANIFOLD [(1)]

Using this method, each internal circuit is dimensioned and then balanced at the preset head at the manifold connections.

The internal circuits can be dimensioned either at the guide temperature difference (i.e. with an average reference difference) or at predefined diameters.

The dimensioning with predefined diameters is used above all to design plant with constant diameter internal circuits. These systems are very practical to install (because they require pipes and connections of a single diameter) and can be a good solution, especially in public buildings, where the heat emitters often have not very different heat outputs from each other (see example 2, section EXAMPLES OF CALCULATIONS).

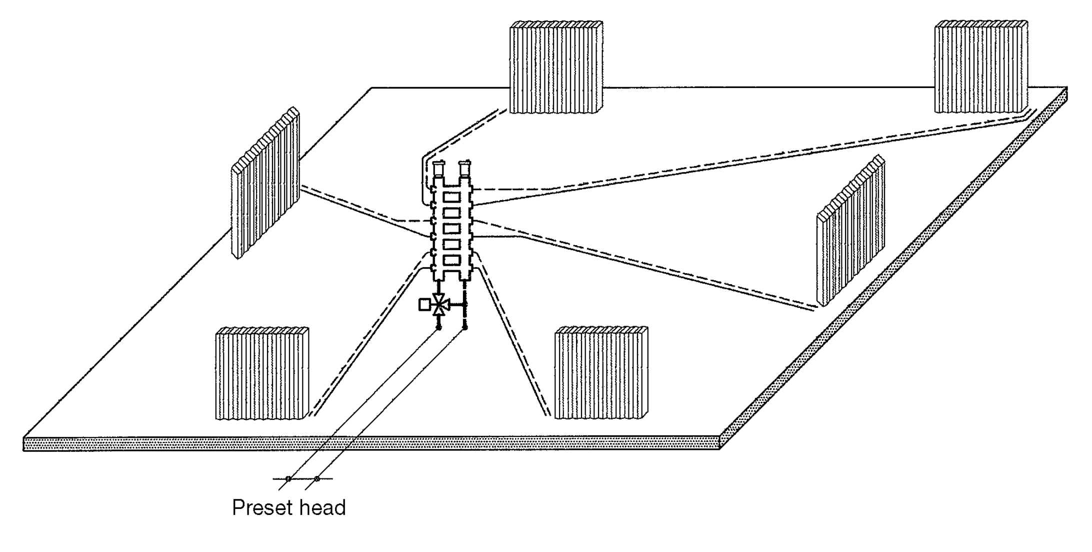
For dimensioning systems with a preset head at the manifold, four calculation procedures are proposed below, two theoretical and two practical:

Procedure A: Theoretical calculation with guide temperature difference;

Procedure B: Practical calculation with guide temperature difference;

Procedure C: Theoretical calculation with predefined diameters;

Procedure D: Practical calculation with predefined diameters.



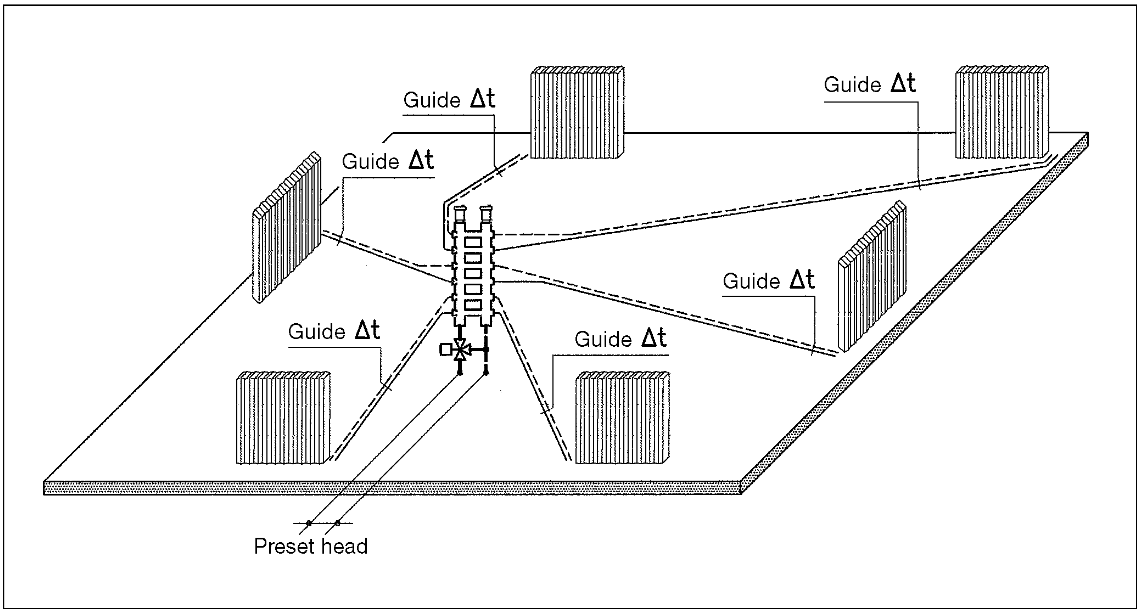
(1) There is no need to read this chapter (see Preface).

Procedure A

THEORETICAL CALCULATION WITH PRESET HEAD AND GUIDE TEMPERATURE DIFFERENCE [1]

The analysis and development of this method is broken down into the following phases:

A1. determination of the diameters relating to the internal circuits,
A2. determination of the flows as an initial approximation,
A3. dimensioning of the manifold,
A4. determination of the effective flows,
A5. dimensioning of the heat emitters.



A1 - Determination of the diameters relating to the internal circuits

A1.1 Using the formula (1), the theoretical flow through each circuit is calculated, i.e. the flow required to guarantee the guide temperature difference

$$G_t = \frac{Q}{1{,}16 \cdot \Delta t} \qquad (1)$$

where: G_t = theoretical flow through circuit, l/h
Q = heat output required, W
Δt = guide temperature difference, °C

[1] There is no need to read this sub-chapter (see Preface).

A1.2 The mean linear head loss is calculated for each circuit on the basis of the preset head. A sufficient approximation of this value can be calculated using the empirical formula:

$$r_m = \frac{H \cdot f}{L} \qquad (2)$$

where: f = 0,6 for circuits without thermostatic valves;
f = 0,4 for circuits with thermostatic valves.

And where: r_m = mean linear head loss of circuit, mm w.g./m
H = head at manifold connections, mm w.g.
L = length of circuit (flow and return), m

A1.3 The 'commercial' diameter of each circuit is determined, selecting the value which, on the basis of r_m, permits the closest match to the theoretical flow G_t.

A2 - Determination of the flows as an initial approximation

A2.1 The total head losses are calculated (H_{ct}) for each circuit on the basis of the theoretical flow, the diameter of the pipes, the total run of the circuit (length and bends) and the components to be used (types of valve and heat emitters).

A2.2 The flows through the circuits are calculated as an initial approximation, balancing the head losses (relating to the theoretical flow) at a head taken as equal to 90% of the preset head.
These flows (see 1st Handbook, BALANCING FLOW) can be calculated using the formula:

$$G_{a1} = G_t \cdot \left(\frac{0{,}9 \cdot H}{H_{ct}} \right)^{0{,}525} \qquad (3)$$

where: G_{a1} = initial approximation of circuit flow, l/h
G_t = theoretical flow through circuit, l/h
H = preset head at manifold, mm w.g.
H_{ct} = head losses defined in A2.1., mm w.g.

A3 - Dimensioning the manifold

A3.1 The sum of the flows calculated as an initial approximation (G_{a1}) in the previous paragraph is determined.

A3.2 When the total flow (as an initial approximation) through the manifold is known, its diameter is determined in such a way that the velocity of the fluid does not exceed a preset limit, for example 0.6 m/s.
Zone valves and on/off valves can also be dimensioned using these criteria.

A4 - Determination of the effective flow

A4.1 The total head (H_t) required at the manifold connections is calculated for the passage of the flow as initial approximation. This head is obtained by adding together the following:

- $0{,}9 \cdot H$ = theoretical head at the connections of the circuit for the passage of the flow in question;
- H_{cv} = loss of head of Manifold, of any zone valve and on/off valve.

A4.2 The circuit flows are calculated - as a second approximation - balancing the head determined above with that which is actually available. These flows (see 1st Handbook, BALANCING FLOW) can be calculated using the formula:

$$G_{a2} = G_{a1} \cdot \left(\frac{H}{H_t} \right)^{0{,}525} \qquad (4)$$

where:
G_{a2} = second approximation of circuit flow, l/h
G_{a1} = initial approximation of circuit flow, l/h
H = preset head at manifold connections, mm w.g.
H_t = head calculated in A4.1., mm w.g.

A4.3 Finally, the effective flows through the circuits are taken as equal to those calculated in second approximation.

A5 - Dimensioning the heat emitters

A5.1 the mean temperature of each heat emitter is calculated using the formula:

$$t_m = t_{max} - \left(\frac{\Delta t}{2} \right) \quad (5)$$

$$\Delta t = \frac{Q}{1{,}16 \cdot G} \quad (6)$$

where:
- t_m = mean temperature of heat emitter, °C
- t_{max} = max. design temperature, °C
- Δt = temperature difference across heat emitter, °C
- Q = required heat output, W
- G = circuit flow, l/h

A5.2 The output factor of each heat emitter is calculated (see formula in 2nd Caleffi Handbook).

A5.3 The configuration of the heat emitters is determined on the basis of the output required and their actual heat output.

Procedure B

PRACTICAL CALCULATION WITH PRESET HEAD AND TEMPERATURE DIFFERENCE 10°C [1]

The analysis and development of this method is broken down into the following phases:

B1. determination of the diameters relating to the internal circuits,
B2. dimensioning of the manifold,
B3. dimensioning of the heat emitters.

B1 - Determination of the diameters relating to the internal circuits

B1.1 The flow of each circuit is calculated, using formula (7), on the basis of the design temperature difference:

$$G = \frac{Q}{1{,}16 \cdot 10} = \frac{Q}{11{,}6} \qquad (7)$$

where: G = flow through circuit, l/h
Q = required circuit heat output, W

B1.2 The mean linear head loss is calculated for each circuit on the basis of the preset head, using the empirical formula:

$$r_m = \frac{H \cdot f}{L} \qquad (2)$$

using: f = 0,6 for circuits without thermostatic valves,
f = 0,4 for circuits with thermostatic valves.

And where: r_m = mean linear head loss of circuit, mm w.g./m
H = head at manifold connections, mm w.g.
L = length of circuit (flow and return), m

[1] There is no need to read this sub-chapter (see Preface).

B1.3 The diameter of each circuit is determined, selecting (using the tables of continuous loss of head) the value which, on the basis of r_m, gives the closest approximation to the required flow.

B2 - Dimensioning the manifold

B2.1 The total flow through the manifold is calculated, adding together the flows through each circuit.

B2.2 The diameter of the manifold is determined on the basis of the total flow. For the manifolds normally available from the trade, the following solutions can be adopted:

- diameter 3/4" for flows less than 800 l/h
- diameter 1" for flows between 800 and 1.600 l/h.

For flows higher than 1,600 l/h, the manifold is normally split. Any zone valve and on/off valves can be dimensioned in the same way.

B3 - Dimensioning the heat emitters

B3.1 The mean temperature of the heat emitters is calculated using the formula:

$$t_m = t_{max} - \left(\frac{10}{2}\right) = t_{max} - 5 \quad (8)$$

where: t_m = mean temperature of heat emitter, °C
t_{max} = max. design temperature, °C

B3.2 The output factor of the heat emitters is calculated (see formula in 2nd Caleffi Handbook).

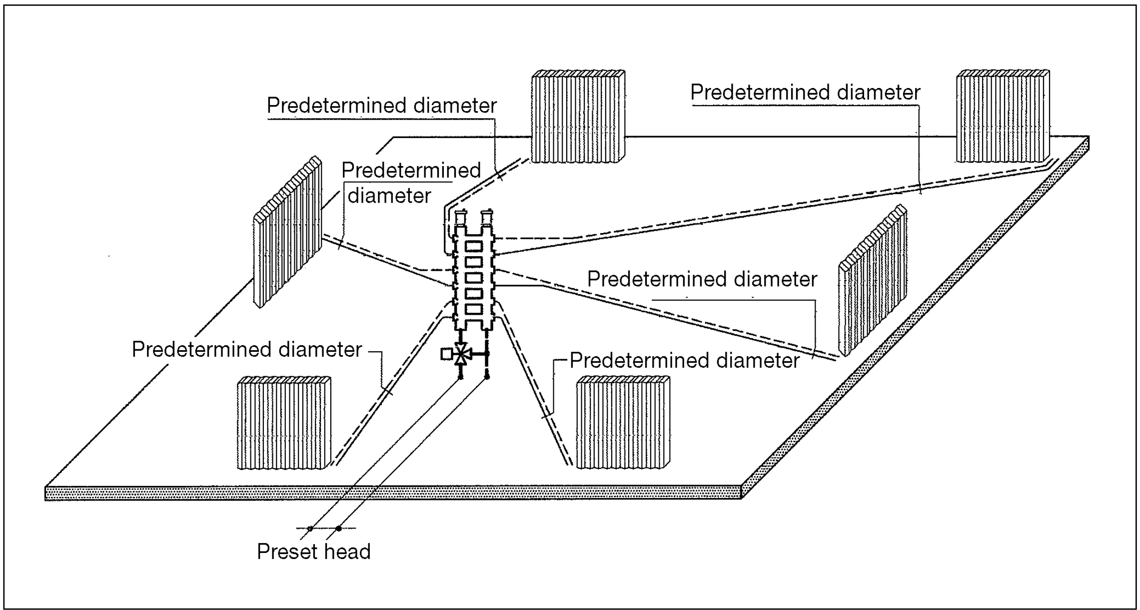
B3.3 The configuration of the heat emitters is determined on the basis of the output required and their actual heat output.

Procedure C

THEORETICAL CALCULATION WITH PRESET HEAD AND PREDEFINED DIAMETERS [1]

The analysis and development of this method is broken down into the following phases:

C1. selection of the diameters relating to the internal circuits,
C2. determination of the provisional flows as an initial approximation,
C3. determination of the provisional flows as a second approximation,
C4. dimensioning of the manifolds,
C5. determination of the effective flows,
C6. dimensioning of the heat emitters.



C1 - Selection of the diameters relating to the internal circuits

C1.1 Considering the normal heads adopted and a maximum temperature difference of 15°C, the following internal diameters can be adopted:

D_{int} = 8 mm for Q less than 1.400 W
D_{int} = 10 mm for Q between 1.400 and 2.500 W

For selections based on the dimensioning with constant diameters, see Example 2 in the section EXAMPLES OF CALCULATIONS.

[1] There is no need to read this sub-chapter (see Preface).

C2 - Determination of the provisional flows as an initial approximation

C2.1 The mean linear head loss is calculated for each circuit on the basis of the preset head. A sufficient approximation of this value can be calculated using the empirical formula:

$$r_m = \frac{H \cdot f}{L} \qquad (2)$$

where: f = 0,6 for circuits without thermostatic valves,
f = 0,4 for circuits with thermostatic valves.

And where: r_m = mean linear head loss of circuit, mm w.g./m
H = head at Manifold connections, mm w.g.
L = length of circuit (flow and return), m

C2.2 The flows through the circuits are calculated - as an initial approximation - on the basis of their diameters and the relative value of r_m.

C3 - Determination of the provisional flows as a second approximation

C3.1 The total head losses (H_{ct}) of each circuit are calculated on the basis of the first approximation flow, the pipe diameter, the total run of the circuits (length and bends) and the components to be used (type of valves and heat emitters).

C3.2 The circuit flows are calculated - as a second approximation - balancing the losses of head (relative to the first approximation flows) at a head taken as 90% of the preset head. These flows (see 1st Manual, BALANCING FLOW) can be calculated using the formula:

$$G_{a2} = G_{a1} \cdot \left(\frac{0{,}9 \cdot H}{H_{ct}} \right)^{0{,}525} \qquad (9)$$

where: G_{a2} = second approximation of circuit flow, l/h
G_{a1} = initial approximation of circuit flow, l/h
H = preset head at manifold connections, mm w.g.
H_{ct} = head losses calculated in C3.1, mm w.g.

C4 - Dimensioning the Manifold

C4.1 The sum of the flows calculated as a second approximation (G_{a2}), defined and calculated in the preceding paragraph, is determined.

C4.2 When the total flow of the Manifold is known (as a second approximation), its diameter is determined in such a way that the velocity of the fluid does not exceed a preset limit, such as 0.6 m/s.
Any zone valve and on/off valves can be dimensioned using the same criteria.

C5 - Determination of the effective flows

C5.1 The total head (H_t) required at the Manifold connections for the passage of the flow in the second approximation is calculated. This head is obtained by adding together the following :

- $0{,}9 \cdot H$ = theoretical head at the circuit connections for the passage of the flow in question,
- H_{cv} = loss of head of Manifold, any zone valve and on/off valves.

C5.2 As a third approximation, the circuit flows are calculated, balancing the head determined above with the actual available head. These flows (See 1st Handbook, BALANCING FLOW) can be calculated using the formula:

$$G_{a3} = G_{a2} \cdot \left(\frac{H}{H_t} \right)^{0{,}525} \quad (10)$$

where:
G_{a3} = third approximation of circuit flow, l/h
G_{a2} = second approximation of circuit flow, l/h
H = preset head at Manifold fittings, mm w.g.
H_t = head calculated under C5.1, mm w.g.

C5.3 Finally, the actual flows through the circuits are taken as being equal to those calculated as third approximation.

C6 - Dimensioning the heat emitters

C6.1 The mean temperature of each heat emitter is calculated using the formula:

$$t_m = t_{max} - \left(\frac{\Delta t}{2}\right) \qquad (5)$$

$$\Delta t = \frac{Q}{1{,}16 \cdot G} \qquad (6)$$

where:
t_m = mean temperature of heat emitter, °C
t_{max} = max. design temperature, °C
Δt = temperature difference across heat emitter, °C
Q = required heat output, W
G = circuit flow, l/h

C6.2 The output factor of each heat emitter is calculated (see formula in 2nd Caleffi Handbook).

C6.3 The configuration of the heat emitters is determined on the basis of the output required and their actual heat output.

Procedure D

PRACTICAL CALCULATION WITH PRESET HEAD AND PREDEFINED DIAMETERS [1]

The analysis and development of this method is broken down into the following phases:

D1. selection of the diameters relating to the internal circuits,
D2. determination of the provisional flows as an initial approximation,
D3. dimensioning of the manifold,
D4. dimensioning of the heat emitters.

D1 - Selection of the diameters relating to the internal circuits

D1.1 Considering the normal heads adopted and a maximum temperature difference of 15°C, the following internal diameters can be adopted:

D_{int} = 8 mm for Q less than 1.400 W
D_{int} = 10 mm for Q between 1.400 and 2.500 W

For selections regarding dimensioning with constant diameters, see Example 2 in the section EXAMPLES OF CALCULATIONS.

D2 - Determination of the provisional flows as an initial approximation

D2.1 The mean linear head loss is calculated for each circuit on the basis of the preset head. An adequate approximation of this value can be calculated using the empirical formula:

$$r_m = \frac{H \cdot f}{L} \qquad (2)$$

where: f = 0,6 for circuits without thermostatic valves;
f = 0,4 for circuits with thermostatic valves.

And where: r_m = mean linear head loss of circuit, mm w.g./m
H = head at manifold connections, mm w.g.
L = length of circuit (flow and return), m

[1] There is no need to read this sub-chapter (see Preface).

D2.2 The flows through the circuits are calculated - as an initial approximation - on the basis of their diameters and the relative value of r_m.

D3 - Dimensioning the Manifold

D3.1 The total flow through the Manifold is calculated, adding together the flows through each circuit.

D3.2 The diameter of the Manifold is determined on the basis of the total flow. For the Manifolds normally available from the trade, the following solutions can be adopted:

- diameter 3/4” for flows less than 800 l/h
- diameter 1” for flows between 800 and 1.600 l/h.

For flows higher than 1.600 l/h, the Manifold is normally split. Any zone valve and on/off valves can be dimensioned in the same way.

D4 - Dimensioning the heat emitters

D4.1 The mean temperature of each heat emitter is calculated using the formulae:

$$t_m = t_{max} - \left(\frac{\Delta t}{2}\right) \qquad (5)$$

$$\Delta t = \frac{Q}{1,16 \cdot G} \qquad (6)$$

where:
t_m = mean temperature of heat emitter, °C
t_{max} = max. design temperature, °C
Δt = temperature difference across heat emitter, °C
Q = required heat output, W
G = circuit flow, l/h

D4.2 The output factor of each heat emitter is calculated (see formula in 2nd Caleffi Handbook).

D4.3 The configuration of the heat emitters is determined on the basis of the output required and their actual heat output.

DESIGN PARAMETERS

These can be divided into two groups: the first containing the parameters required for dimensioning the system and the second the parameters to be determined and checked.

1 PARAMETERS REQUIRED FOR DIMENSIONING THE SYSTEM

- zone head (1);
- maximum design temperature;
- temperature difference (2);
- diameter of internal circuits (3);
- heat output required;
- ambient temperature;
- length from Manifold to heat emitters;
- hydraulic characteristics of the pipe, the Manifold and the valves;
- hydraulic and thermal characteristics of the heat emitters.

2 PARAMETERS TO BE DETERMINED AND CHECKED

- pipe diameters (if not pre-defined);
- diameters of Manifold and valves;
- velocity of fluid;
- dimensions of heat emitters;
- flow through circuits and Manifold.

The most interesting of these parameters from a design point of view are examined here.

(1) value required when dimensioning at preset head.
(2) value required when dimensioning at guide temperature difference.
(3) value required when dimensioning with pre-defined diameters.

ZONE HEAD

This is the head assumed to be available upstream from the Manifold. It is generally agreed that this value varies from:

– 800 to 1.200 mm w.g. for radiator systems with no thermostatic valves;

– 1.000 to 1.500 mm w.g. for radiator systems with thermostatic valves;

– 1.200 to 2.000 mm w.g. for systems with convectors and fan coils.

MAXIMUM DESIGN TEMPERATURE

This is the maximum temperature of the fluid distributed to the heat emitters. For this figure, variable values should be taken from:

– 70 to 80°C for traditional boilers;

– 50 to 60°C for condensing boilers and heat pumps;

– 60 to 75°C with district heating.

TEMPERATURE DIFFERENCE

This is the difference between the flow temperature of the fluid and its return temperature under design conditions. Generally, values are adopted which vary from:

– 10 to 15°C in systems with traditional boilers;

– 5 to 10°C in systems with condensing boilers and heat pumps;

– 15 to 20°C in systems connected to district heating schemes.

With condensing boilers and heat pumps (i.e. with heat sources which are intended to work only at low temperatures), a lower temperature difference is used to increase the heat output of the heat emitters.

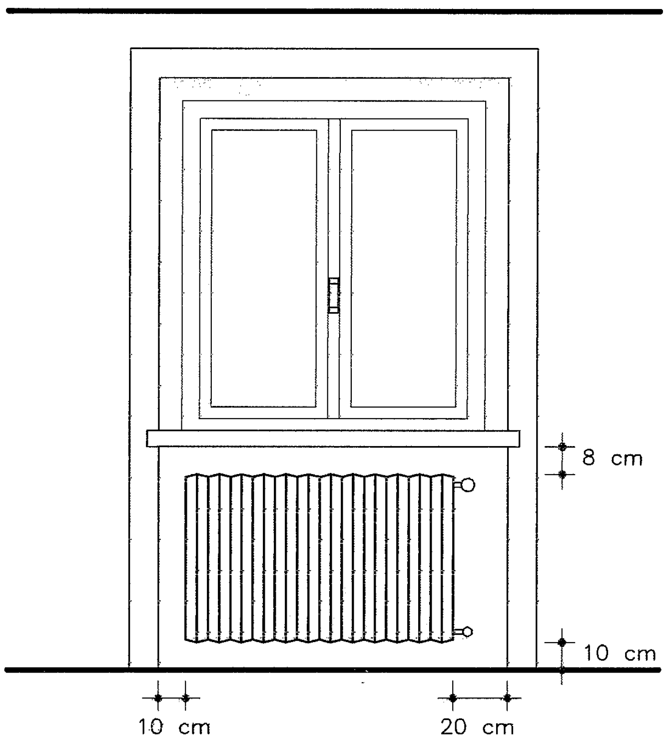
With district heating, on the other hand, (i.e. a system which, for technical and economic reasons, requires low return temperatures; for example under 60°C) a high temperature difference makes it possible to increase the flow temperature and thus the heat output of the heat emitters

VELOCITY OF THE FLUID

Solutions involving fluid velocities of over 0,70÷0,80 m/s should be avoided. Excessively high velocities can cause:
- noise,
- damage to the valves,
- erosion of the copper pipes, especially on tight bends.

DIMENSIONS OF HEAT EMITTERS

A check must be made that the dimensions of the heat emitters are compatible with the space available. Otherwise the type of heat emitter must be changed or split.



Installation of a radiator under a window
recommended distances

PROGRAMME FOR THE DIMENSIONING OF SYSTEMS WITH MANIFOLDS

PRINTER CONFIGURATION

MATERIALS ARCHIVES

GENERAL DATA ARCHIVES

MANAGEMENT OF PROJECT ARCHIVES

CALCULATION PROGRAMME

PRINTER CONFIGURATION

This option allows you to set the top and left hand margins of the page layout. It also allows you to carry out a printing test.

– Variable data:
- top margin (in lines)
- left hand margin (in characters)

– Fixed data:
- maximum number of characters per line = 66
- maximum number of lines per page = 58

There are three commands managing the inputting of the printed page:

F1	Saves without printing test

F2	Saves with printing test

ESC	Exits without saving

MATERIALS ARCHIVES

PIPES ARCHIVE

copper pipes
mild steel pipes
plastic pipes

ZONE VALVES ARCHIVE

2-way valves
3-way valves

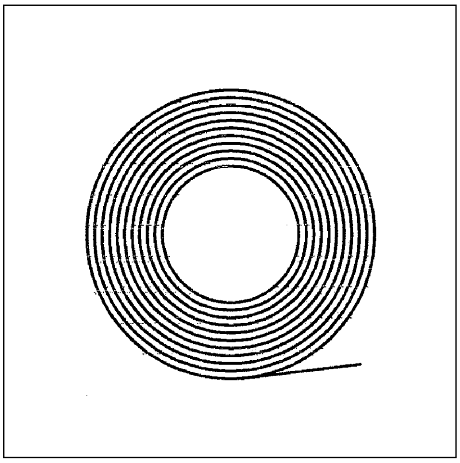
ARCHIVE OF VALVES FOR HEAT EMITTERS

normal valves
valves with thermostatic option
thermostatic valves
thermoelectric valves
lock shield valves

HEAT EMITTERS ARCHIVE

modular radiators
non-modular radiators
convectors
fan coils

PIPES ARCHIVE



Allows you to store and up-date the main characteristics of the pipes used for connection between the manifolds and the heat emitters.

Archive capacity: 15 sets of pipes.

ELEMENTS OF THE ARCHIVE

n	Archive number (storage code) - maximum value accepted: 15.
c	Pipe material: - 1 copper, - 2 mild steel, - 3 plastic.
Brand name	Brand names of pipes - available space 11 characters.
De	External diameter of pipe, mm - maximum value accepted: 24 mm. - value shown on screen to 1 decimal place.
Di	Internal diameter of pipe, mm - maximum value accepted: 22 mm. - value shown on screen to 1 decimal place.

Notes:

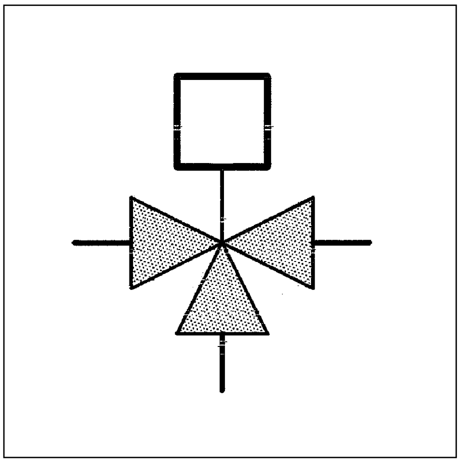
1. The diameters must be entered in order from the smallest to the largest.
2. If the series (of pipes) has fewer than the five diameters requested, the last in the series must be entered as zero.

COMMAND FUNCTIONS

The pipes archive can be managed by means of the following command functions:

↓↑ Scroll	Enables vertical scrolling on screen.
F1 New pipe series	Inserts a new pipe series.
F2 Modify	Modifies the elements of the pipe series except for the material type.
F3 Cancel	Cancels a set of pipes.
F5 Go to ...	Displays a specific series of pipes.
F6 Print	Prints the pipes in the archive.
F7 Save	Saves the up-dates of the archive.
ESC Exit without saving	Exits from the archive without saving.

ZONE VALVE ARCHIVE



Allows you to store and up-date (in groups of the same commercial series) the main characteristics of the zone valves.

Archive capacity: 20 groups.

The zone valve archive is also used by the programme for dimensioning systems with panels.

ELEMENTS OF THE ARCHIVE

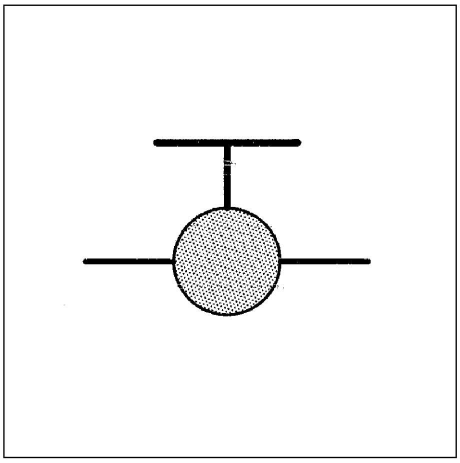
n	Archive number (storage code) - maximum value accepted: 20.
c	Zone valve type: - 2-way valves, - 3-way valves.
Brand Name	Brand names of valves - available space 11 characters.
Model	Valve group model - available space 14 characters.
$KV_{0,01}$ (3/4”)	Nominal flow rate of valve with Dn = 3/4”, l/h - maximum value accepted: 9999 l/h. - whole numbers only shown on screen.
$KV_{0,01}$ (1”)	Nominal flow rate of valve with Dn = 1”, l/h - maximum value accepted: 9999 l/h. - whole numbers only shown on screen.

COMMAND FUNCTIONS

The zone valve archive can be managed by means of the following command functions:

↓↑ Scroll	Enables vertical scrolling on screen.
F1 New valve group	Inserts a new valve group.
F2 Modify	Modifies the elements of the valve group excep for the valve type.
F3 Cancel	Cancels a valve group.
F5 Go to ...	Displays a specific valve group.
F6 Print	Prints the valves in the archive.
F7 Save	Saves the up-dates of the archive.
ESC Exit without saving	Exits from the archive without saving.

ARCHIVE OF VALVES FOR HEAT EMITTERS



Allows you to store and up-date (in groups of the same commercial series) the main characteristics of the valves for heat emitters.

Archive capacity: 50 groups.

The valves archive is also used by the programme for dimensioning systems with panels.

ELEMENTS OF THE ARCHIVE

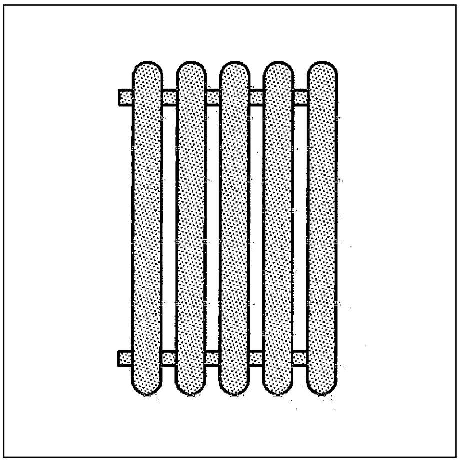
n	Archive number (storage code) - maximum value accepted: 50.
c	Valve types: - 1 normal valves, - 2 valves with thermostatic option, - 3 thermostatic valves, - 4 thermoelectric valves, - 5 lock shield valves.
Brand name	Brand names of valves - available space 11 characters.
Model	Valve group model - available space 11 characters.
$KV_{0,01}$ (3/8”)	Nominal flow rate of valve with Dn = 3/8”, l/h - maximum value accepted: 9999 l/h. - whole numbers only shown on screen.
$KV_{0,01}$ (1/2”)	Nominal flow rate of valve with Dn = 1/2”, l/h - maximum value accepted: 9999 l/h. - whole numbers only shown on screen.

COMMAND FUNCTIONS

The valves for heat emitters archive can be managed by means of the following command functions:

↓↑ Scroll	Enables vertical scrolling.
F1 New valve group	Inserts a new group of valves.
F2 Modify	Modifies the elements of the group of valves except for the relevant types.
F3 Cancel	Cancels a group of valves.
F5 Go to ...	Displays a specific group of valves.
F6 Print	Prints the valves in the archive.
F7 Save	Saves the up-dates of the archive.
ESC Exit without saving	Exits from the archive without saving.

HEAT EMITTERS ARCHIVE



Allows you to store and up-date the main characteristics of radiators, convectors and fan coils.

Archive capacity: 200 heat emitters.

This archive is also used by the programme for dimensioning systems with panels.

ELEMENTS OF THE ARCHIVE

n	Archive number (storage code) - maximum value accepted: 200.
c	Heat emitter types: - 1 modular radiators, - 2 non-modular radiators, - 3 convectors, - 4 fan coils.
Brand name	Brand names of heat emitters - available space 12 characters.
Model	Heat emitter model - available space 8 characters.
t_m	Heating fluid mean temperature, °C - max. accepted value: 99 °C. - whole numbers only shown on screen.
Q_n (*)	Nominal heat output, W - max. accepted value: 9999 W. - whole numbers only shown on screen.
l	Width of heat emitter, mm - size required only for non-modular heat emitters. - max. accepted value: 9999 mm. - whole numbers only shown on screen.

m — **Width of boss, mm**
- size required only for modular heat emitters.
- max. accepted value: 999 mm.
- whole numbers only shown on screen.

h — **Height of heat emitter, mm**
- max. accepted value: 9999 mm.
- whole numbers only shown on screen.

G_n (*) — **Nominal flow rate of heat emitter, l/h**
- required only for convectors and fan convectors.
- max. accepted value: 9999 l/h.
- whole numbers only shown on screen.

H_n (*) — **Heat emitter pressure differential, mm w.g.**
- required only for convectors and fan coils.
- max. accepted value: 9999 mm approx.
- whole numbers only shown on screen.

vol — **Water contained by basic element** (modular heat emitters) or by **the heat emitter** (non modular heat emitters), in litres
- max. accepted value: 99,99 l.
- value shown on screen to 2 decimal places.

(*) Definitions of Q_n, G_n, H_n

Q_n Nominal heat output: this is the heat output which the heat emitter exchanges with the external environment in test conditions.

G_n Nominal flow rate: this is the flow rate required to determine the nominal heat output of the heat emitter.

H_n Nominal pressure differential: this is the differential pressure required to pass the nominal flow rate through the heat emitter.

COMMAND FUNCTIONS

The heat emitters archive can be managed by means of the following command functions:

↓↑ Scroll	Enables vertical scrolling.
F1 New heat emitter	Inserts a new heat emitter.
F2 Modify	Modifies the elements of the heat emitter except for the relevant types.
F3 Cancel	Cancels the selected heat emitter.
F5 Go to ...	Displays a specific heat emitter.
F6 Print	Prints the heat emitters in the archive.
F7 Save	Saves the up-dates of the archive.
ESC Exit without saving	Exits from the archive without saving.

GENERAL DATA ARCHIVES

MAIN PARAMETERS ARCHIVE

zone head
project maximum temperature

ambient temperature

guide temperature difference

zone valve group code
heat emitter valves group code
lock shield valves group code
reference heat emitter code

maximum velocity of heating fluid

PIPES AND MANIFOLDS ARCHIVE

pipes group code

manifold model and brand name

3/4” manifold: internal diameter
” ” : entry csa
” ” : off take csa

1” manifold: internal diameter
” ” : entry csa
” ” : off take csa

MAIN PARAMETERS ARCHIVE

This makes it possible to predetermine the following parameters to be proposed as default for the dimensioning of the system:

1. Zone head (upstream from manifold)
   - values accepted from 500 to 5000 mm approx.
   - whole numbers only shown on screen.

2. Project maximum temperature
   - values accepted from 30 to 95°C.
   - whole numbers only shown on screen.

3. Ambient temperature
   - values accepted from 10 to 25°C.
   - whole numbers only shown on screen.

4. Guide temperature difference
   - values accepted from 2 to 30°C.
   - whole numbers only shown on screen.

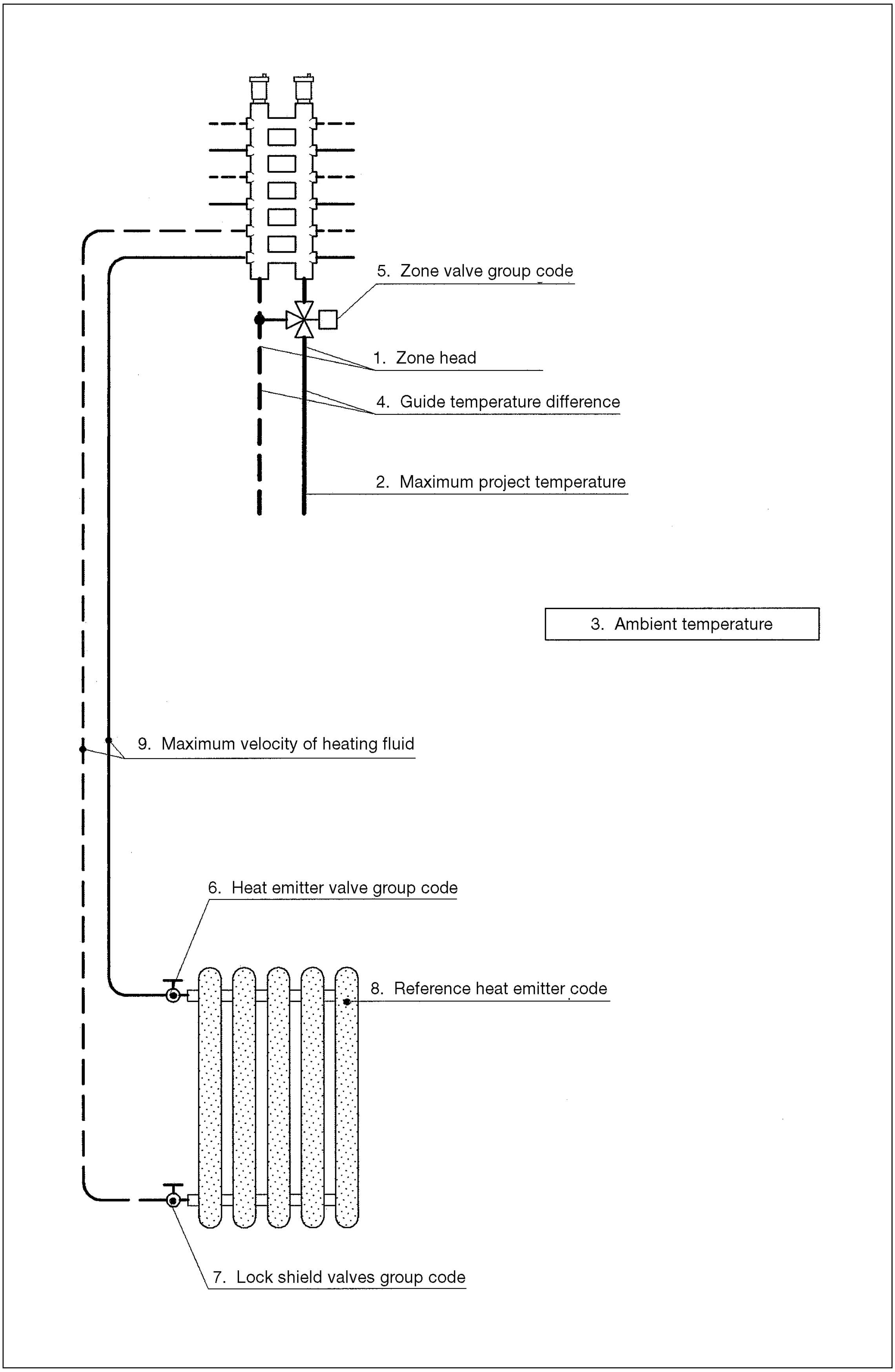
5. Zone valve group code
   - values accepted from 0 to 20.

6. Heat emitters valves group code
   - values accepted from 1 to 50.

7. Lockshield group code
   - values accepted from 1 to 50.

8. Reference heat emitter code
   - values accepted from 0 to 200.

9. Maximum velocity of heating fluid
   - values accepted from 0,50 to 1,50 m/s.
   - values shown on screen to 2 decimal places.



5. Zone valve group code
1. Zone head
4. Guide temperature difference
2. Maximum project temperature
3. Ambient temperature
9. Maximum velocity of heating fluid
6. Heat emitter valve group code
8. Reference heat emitter code
7. Lock shield valves group code

PIPES AND MANIFOLDS ARCHIVE

This makes it possible to predetermine types of pipe to be used and the main characteristics of the manifolds:

1. Pipe group code
   - values accepted from 1 to 15.

2. Brand name of manifold
   - available space 10 characters.

3. Manifold model
   - available space 10 characters.

4. Internal diameter of 3/4” manifold
   - values accepted from 20 to 30 mm.
   - values shown on screen to 1 decimal place.

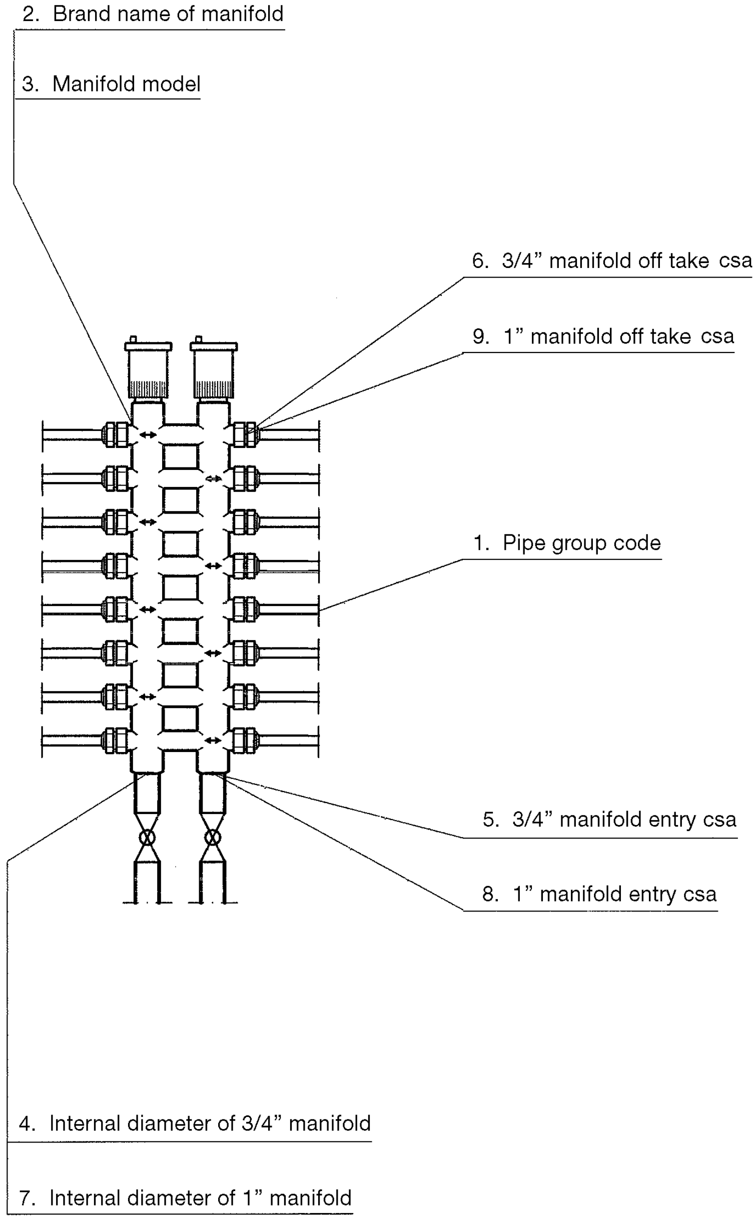
5. 3/4” manifold entry csa
   - values accepted from 1 to 30.
   - values shown on screen to 1 decimal place.

6. 3/4” manifold offtake csa
   - values accepted from 1 to 30.
   - values shown on screen to 1 decimal place.

7. Internal diameter of 1” manifold
   - values accepted from 25 to 35 mm.
   - values shown on screen to 1 decimal place.

8. 1” manifold entry csa
   - values accepted from 1 to 30.
   - values shown on screen to 1 decimal place.

9. 1” manifold offtake csa
   - values accepted from 1 to 30.
   - values shown on screen to 1 decimal place.


2. Brand name of manifold
3. Manifold model
6. 3/4” manifold off take csa
9. 1” manifold off take csa
1. Pipe group code
5. 3/4” manifold entry csa
8. 1” manifold entry csa
4. Internal diameter of 3/4” manifold
7. Internal diameter of 1” manifold

PROJECT ARCHIVE MANAGEMENT

This part of the programme makes it possible to store and recall the data (files) for each project processed.
The files are saved in a suitable archive and can be opened or called up with the options specified below.

CHARACTERISTICS OF THE ARCHIVE CONTAINING THE PROJECT FILES

- Resides on floppy disk to be inserted in drive A.
- Initiated by programme with suitable procedure.
- Maximum capacity 70 projects (actual capacity depends on the capacity of the floppy disk and the sizes of the project files).

MAIN OPTIONS FOR FILE MANAGEMENT

N New	• Opens a new project file on the floppy archive. • Stores the client recognition data and location of system. • Checks general data archives. • Starts up calculation programme.
V Old	• Calls up an existing project file on floppy disk. • Checks and corrects the client's recognition data and system location. • Starts up calculation programme, indicating last manifold calculated.
E Delete	• Deletes a project file.

CALCULATION PROGRAMME

First Part
MANIFOLD MANAGEMENT AND PROCESS PRINTING

Provides:

- manifold dimensioning start-up,
- general data archive check,
- modification of main parameters,
- examination of data on each manifold,
- modification of data on each manifold,
- print out of accepted solutions,
- print out of materials calculation.

Second part
MANAGEMENT OF INTERNAL CIRCUITS

Permits:

- entry of project data,
- modification of data input,
- dimensioning of internal circuits, based on:
  - guide temperature difference,
  - a constant diameter.

Third part
SELECTION OF SOLUTIONS PROPOSED

Permits:

- acceptance of solutions proposed,
- variation of project data,
- request for new dimensioning.

MANIFOLD MANAGEMENT AND PROCESS PRINTING

The following command functions are available for the manifold management and process printing part of the programme:

N	New manifold

Dimensions a new manifold.

S	Similar manifold

Used to dimension a new manifold with data similar to one which has already been calculated (e.g. calculation No. 2).

E	Examine manifold

Examines the data (project and calculation) relating to a specific manifold.

M	Modify manifold

Modifies the project data or accepted solutions for the branch circuits relating to a specific manifold.

F1	General data

- Checks the data of the general archives
- Also varies the data of the main parameters. However, it is not possible (once the project has started) to vary the data in the pipes and manifolds archive.

F6	Print project

Prints the solutions accepted and the metric calculation.

F10	End of task

Exits from calculation programme.

MANAGEMENT OF INTERNAL CIRCUITS

The following command functions are available for the internal circuits management:

↓↑ ⇄	Vary zone

Allows movement between cells of the spread sheet to be used for entering the project data.

Exec	Confirms

Confirms the project data entry and permits movement to the next cell.

V	Varies H_{zone}, t_{max}

Varies the zone head and the maximum project temperature.

Esc	Exits

Abandons dimensioning the manifold.

F1	Calculation with guide dt

Used to dimension the internal circuits on the basis of the proposed guide temperature difference.

D	Calculation with constant De

Used to dimension the internal circuits on the basis of a preset pipe diameter.

DIMENSIONING OF INTERNAL CIRCUITS

The internal circuits are dimensioned in three stages:

– project data acquisition,

– development of calculations,

– presentation of data processed.

ACQUISITION OF PROJECT DATA

The project data required can be broken down into two groups:

– data requested by programme: - data relating to the manifold,
- data relating to the internal circuits.

– data derived from the archives.

Data required relating to the manifold

Used to define the conditions on the basis of which the manifold feeds its branches. Data required:

Hzone (*)	Zone head (upstream of manifold) - values accepted from 500 to 5000 mm approx. - whole numbers only shown on screen.
tmax (*)	Maximum project temperature - values accepted from 30 to 95°C. - whole numbers only shown on screen.
cvz (*)	Zone valves group code - values accepted from 0 to 20. - for manifolds with no zone valve, put cvz=0.
N csc	Number of heat emitters - values accepted from 1 to 12.

(*) Data proposed as default on the basis of the predefined general parameters.

Data required regarding the internal circuit

Used to identify the conditions on the basis of which the internal circuit must be dimensioned. Data required:

Q — Heat output required
- maximum value accepted 9999 W.
- whole numbers only shown on screen.

L — Length (flow and return) of manifold-heat emitter pipes
- maximum value accepted 99 m.
- whole numbers only shown on screen.

ccs (*) — Heat emitter code
- values accepted from 1 to 200.

ta (*) — Ambient temperature
- values accepted: 10 to 25°C.
- whole numbers only shown on screen.

cv (*) — Code of valve group for heat emitters
- values accepted: 1 to 50.

DEVELOPMENT OF CALCULATIONS

For the dimensioning of the internal circuits, the programme can execute two different procedures with (1) guide temperature difference and (2) constant diameter.
If the guide temperature difference procedure is selected, the programme calculates the diameters of the internal circuits so that their actual temperature difference is as close as possible to the guide temperature difference. The characteristics of all the other components of the system are then determined on the basis of these diameters.
If, however, the constant diameter procedure is selected, the programme asks for the diameter with which the circuits are to be dimensioned and determines, on the basis of this diameter, the characteristics of all the other components of the system.

PRESENTATION OF THE DATA PROCESSED

The programme presents the solutions prepared on screen and indicates, in flashing characters, cases where the velocity of the fluid is higher than the recommended limit (see GENERAL PARAMETERS ARCHIVE).

(*) Default data on basis of predefined general parameters.

SELECTION OF THE SOLUTIONS PROCESSED

The following command functions are available for selection of the solutions processed:

V	Vary project data

Makes it possible to vary the project data and carry out new dimensioning of the internal circuits.

N	New dimensioning

Cancels all the project data and permits dimensioning of the internal circuits “from scratch”.

Esc	Exits without saving

Exits to the manifold management menu without saving the solutions processed.

F10	Accepts solution

– Accepts and stores the solutions processed (in project files).

– Also stores these solutions several times so that the materials in systems with the same internal circuits can be easily calculated - for example in multi-storey buildings or detached houses.

EXAMPLES OF CALCULATIONS

Example 1 - Dimensioning of a Manifold system by the theoretical method with guide temperature difference

Dimension (using the guide temperature difference theoretical method) a Manifold system for heating zones of housing represented on the next page. Consider:

– ta = 20°C ambient temperature

– heating requirement::

Room	No.	2nd floor W	1st floor W	mezzanine W
- living	1	2.900	2.420	2.660
- kitchen	2	1.180	990	1.090
- bathroom A	3	610	520	570
- bedroom A	4	1.430	1.150	1.290
- bedroom B	5	1.090	770	910
- bathroom B	6	310	250	290
- corridor	7	180	90	140

Solution:

The Caleffi Handbooks 99 software is used, and on the basis of this configuration, the system is broken down dimensionally into the following phases:

– Analysis and selection of data relating to the main parameters file

– Selection of pipes and Manifolds

– Positions of risers and Manifolds

– Positions and types of heat emitters

– Activation of project file

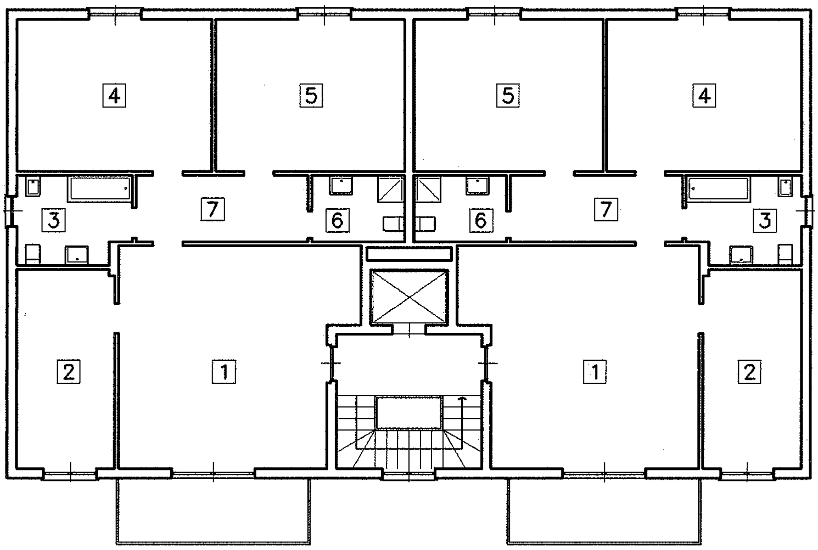
– Dimensioning of Manifolds and related branches - 2nd floor

– Dimensioning of Manifolds and related branches - 1st floor

– Dimensioning of Manifolds and related branches - mezzanine floor

– Printing calculation and symbols

– Dimensioning distribution network


4
5
5
4
3
7
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7
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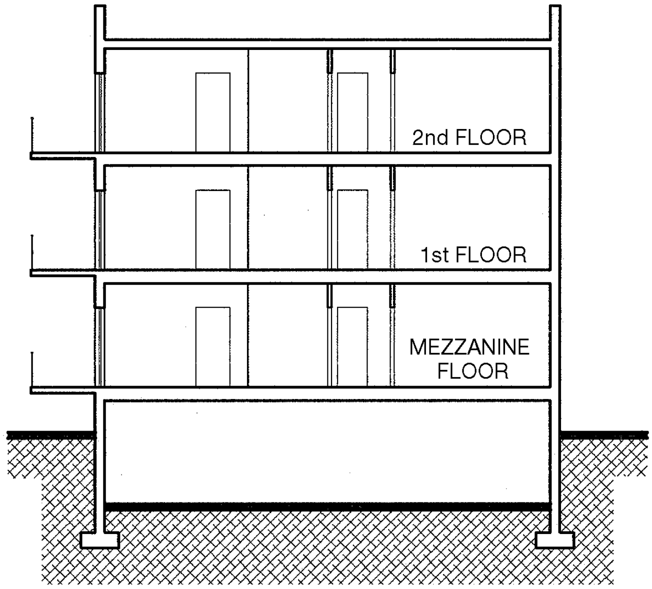
2
1
1
2

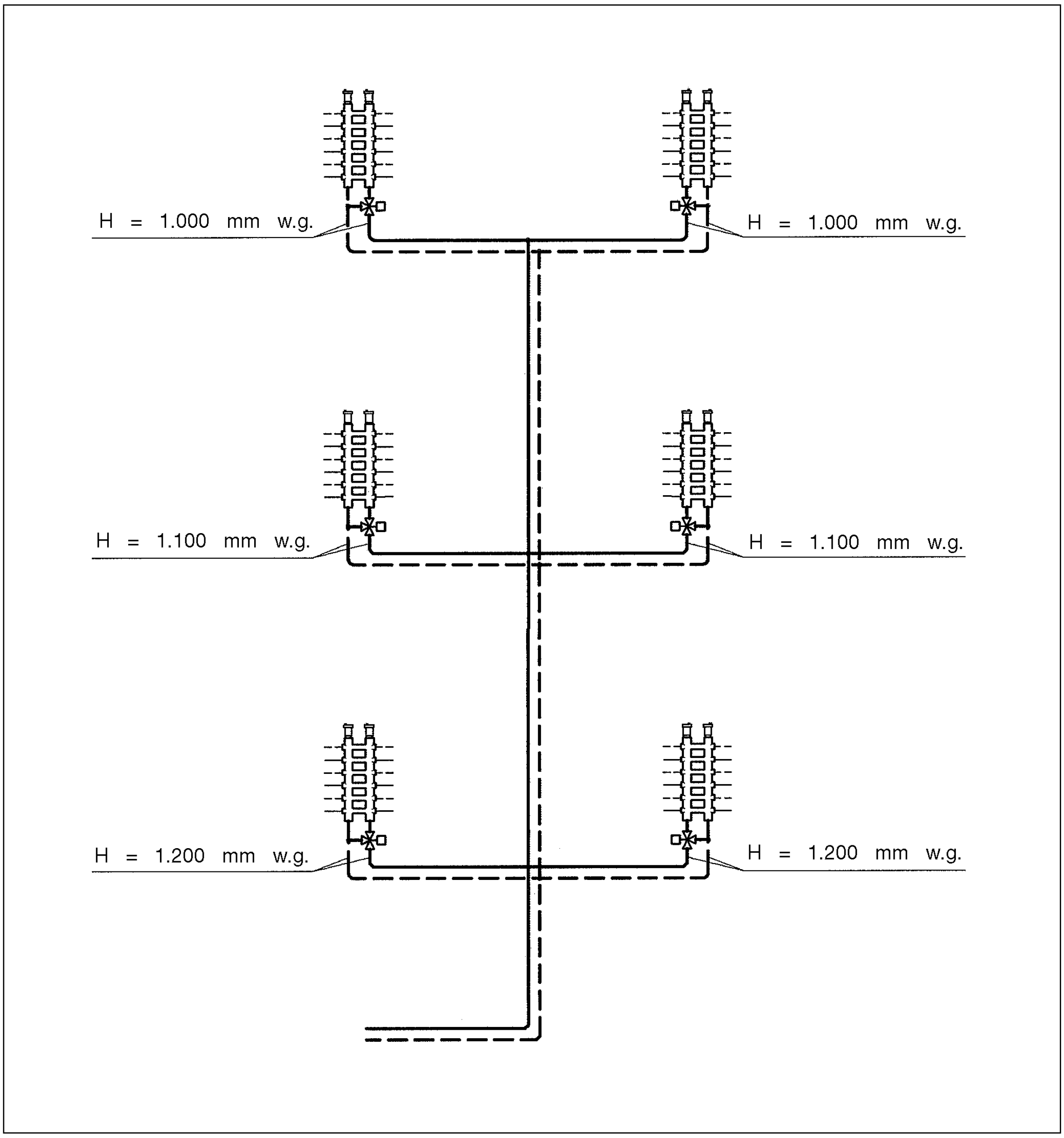

2nd FLOOR
1st FLOOR
MEZZANINE
FLOOR

Analysis and selection of data relating to the main parameters file

– Zone head

The main network is dimensioned using the practical calculation method illustrated under SIMPLE CIRCUITS, 2ND Handbook.
On the basis of this method (which takes the variation in head between floors as 100 mm w.g.) and in relation to the provisions of the item DIMENSIONING MANIFOLD SYSTEMS (sub-chapter ZONE HEAD), the following is taken:

H = 1.000 mm w.g. (2nd floor)
H = 1.100 mm w.g. (1st floor)
H = 1.200 mm w.g. (mezzanine)



– Maximum design temperature

This is taken as (see sub-chapter under DIMENSIONING OF MANIFOLD SYSTEMS):

t_{max} = 75°C.

– Guide temperature difference

This is taken as (see sub-chapter under DIMENSIONING OF MANIFOLD SYSTEMS):

Δt = 10°C.

– Zone valves

Caleffi model 6480/6460 3-way zone valves are used with the following characteristics:
- 3/4” valve $KV_{0,01}$ = 1.200 l/h
- 1” valve $KV_{0,01}$ = 3.000 l/h

These valves are already on file with the code number cvz = 1.

– Valves for heat emitters

Caleffi model 338/sq valves with thermostatic option are used with the following characteristics:
- 3/8” valve $KV_{0,01}$ = 222 l/h
- 1/2” valve $KV_{0,01}$ = 270 l/h

These valves are already on file with the code number cv = 2.

– Lock shield valves for heat emitters

Caleffi model 342/sq LSVs are used with the following characteristics:
- 3/8” valve $KV_{0,01}$ = 242 l/h
- 1/2” valve $KV_{0,01}$ = 399 l/h

These lock shield valves are already on file with the code number cd = 10.

– Heat emitters

Heat emitters with the characteristics stated below are used. They are assumed to be in the file already, with the code numbers shown below:

- file code	1	2	3
- trade name,	OMEGA	OMEGA	OMEGA
- model,	680/4	870/2	870/3
- mean test temperature,	80°C	80°C	80°C
- rated heat output,	145 W	105 W	148 W
- width,	60 mm	60 mm	60 mm
- height,	680 mm	870 mm	870 mm
- water content,	1,10 l	0,80 l	0,90 l

– Maximum velocity of fluid

This is taken as (see sub-chapter under DIMENSIONING OF MANIFOLD SYSTEMS):

v_{max} = 0,75 m/s

On the basis of the design data and the selections made, the following values are entered in the GENERAL PARAMETERS FILE:

GENERAL PARAMETERS FILE	
Zone head [mm w.g.]	1000
Maximum design temperature [°C]	75
Ambient temperature [°C]	20
Guide temperature difference [°C]	10
Zone valve group code	1
Heat emitter valve group code	2
Lock shield valve group code	10
Reference heat emitter code	1
Heating fluid max. vel. [m/s]	0,75

The zone head refers to the last floor, i.e. the one where the Manifolds dimensioning starts.

Selection of pipes and Manifolds

– Pipes

For connecting the Manifolds to the heat emitters, copper pipes of the following diameters are used:

- 8/10 mm
- 10/12 mm
- 12/14 mm
- 14/16 mm
- 16/18 mm

This set of pipes is assumed to be already on file with the code number: n = 1

– Manifolds

Caleffi single block coplanar Manifolds model 356/357 are used.

On the basis of the selections made, the following values are entered in the PIPES AND MANIFOLDS file.

PIPE AND MANIFOLD CHARACTERISTICS FILE	
Pipe group code	1
Manifold tradename	CALEFFI
Manifold model	356/357
3/4" Manifold: Internal diameter [mm]	20,0
Entry csa	3,0
off-take csa	6,5
1" Manifold: Internal diameter [mm]	26,0
Entry csa	3,0
off-take csa	6,5

Positions of risers and Manifolds

The riser and Manifold positions are those indicated in the drawing on the next page.

Positions and types of heat emitters

The positions of the heat emitters and the relative layout of the pipes, are shown in the drawing on the next page.

No radiators are provided for in the corridors, as (for heating) the heat given off by the Manifold boxes is considered sufficient.
In the living rooms, two radiators are used to ensure better distribution of the heat.
And in particular the heat output of the radiator near the entry door (i.e. radiator No. 1) is taken as 40% of the total output required. Thus we have:

2nd floor	Q = 2.900 W	Q_1 = 1.160 W	Q_2 = 1.740 W
1nd floor	Q = 2.420 W	Q_1 = 970 W	Q_2 = 1.450 W
mezzanine	Q = 2.660 W	Q_1 = 1.065 W	Q_2 = 1.595 W

The type of radiator (selected on the basis of relative position and available space) is shown in the following table:

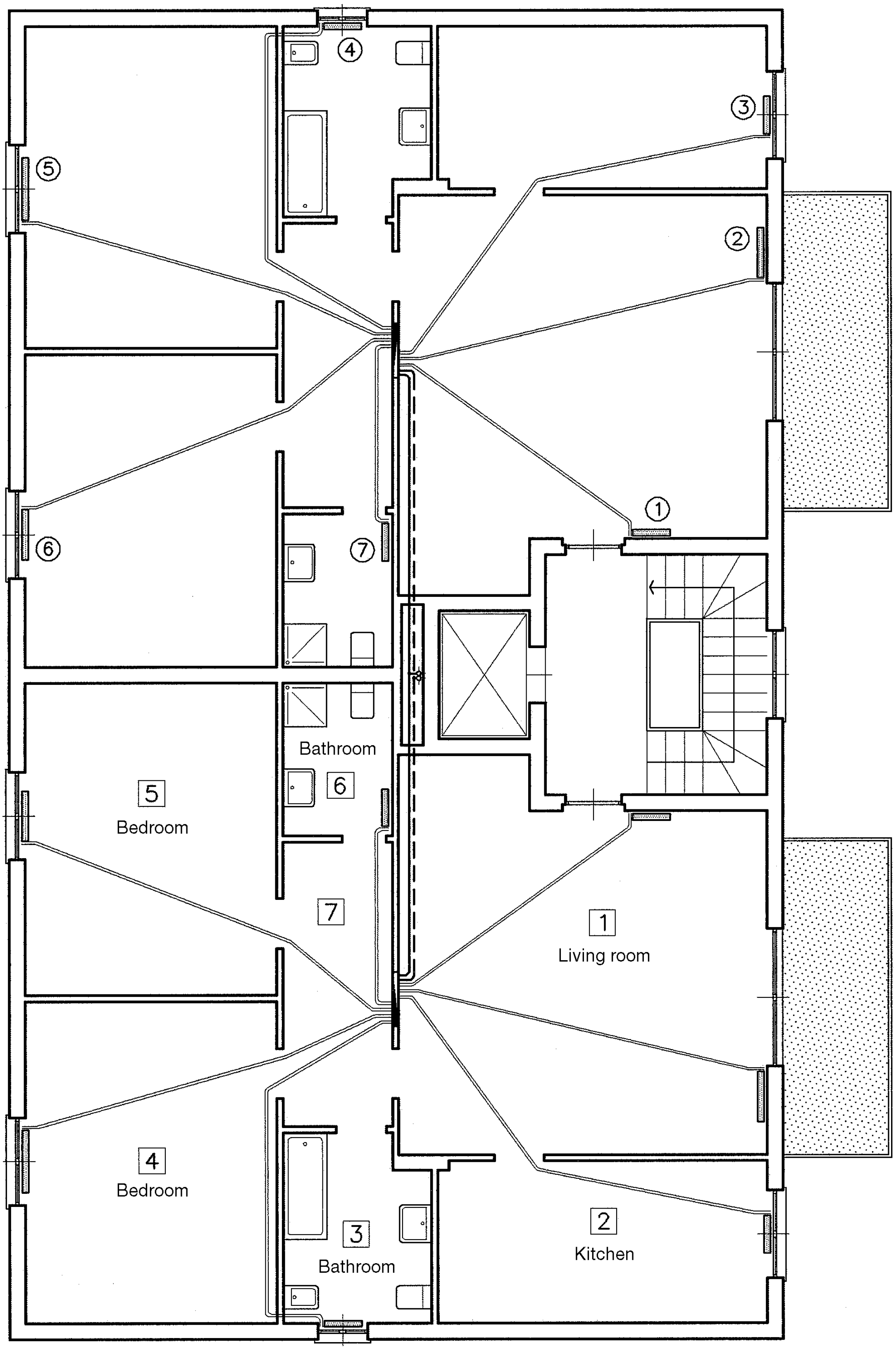
- Living room	1A	rad. = 1	type 870/3	cod. = 3
- Living room	1B	rad. = 2	type 870/3	cod. = 3
- Kitchen	2	rad. = 3	type 680/4	cod. = 1
- Bathroom	3	rad. = 4	type 680/4	cod. = 1
- Bedroom	4	rad. = 5	type 680/4	cod. = 1
- Bedroom	5	rad. = 6	type 680/4	cod. = 1
- Bathroom	6	rad. = 7	type 870/2	cod. = 2

Activation of project file

The design file is started by inputting:

Design filename:	COL-ES-1
Client name:	AA
Building location:	BB

Diagram showing layout of risers, manifolds and heaters



Dimensioning of Manifolds and related branches - 2nd floor

The following general data for the first Manifold is proposed by the programme on screen:

Hzone = 1.000 mm w.g.
tmax = 75°C
cvz = 1
N hem = 0 (number of heat emitters)

N hem = 7 is entered and the dimensioning of the branch circuits starts. For this purpose, the programme shows on screen the following dialogue window:

n	Q	L	ccs	ta	cv
1	-	-	1	20	2
2	-	-	1	20	2
3	-	-	1	20	2
4	-	-	1	20	2
5	-	-	1	20	2
6	-	-	1	20	2
7	-	-	1	20	2

On the basis of the values previously defined, the data in the window is supplemented and modified as follows:

n	Q	L	ccs	ta	cv
1	1160	10	3	20	2
2	1740	12	3	20	2
3	1180	15	1	20	2
4	610	15	1	20	2
5	1430	13	1	20	2
6	1090	14	1	20	2
7	310	8	2	20	2

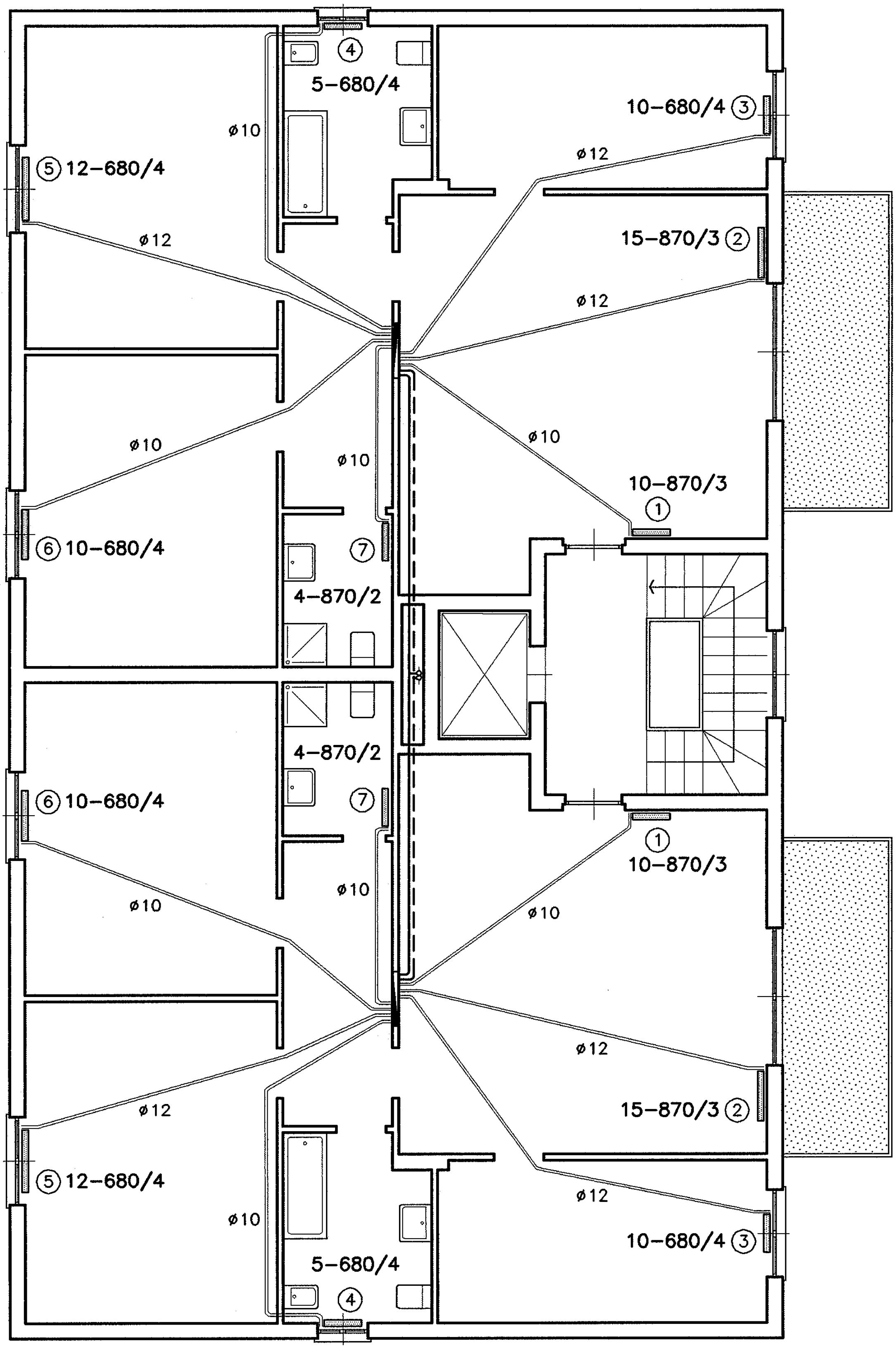
Then the processing of this data is commenced using function key F1, which permits the dimensioning with the guide temperature difference.

Finally, the solutions proposed on screen are accepted, once they show no reasons for invalidity, such as for example excessive space taken up by the radiators or excessively high fluid velocities.

The solutions are processed twice to allow the materials for both dwellings on the second floor to be calculated.

A drawing is then produced and a print prepared showing the results obtained (see symbols used for dimensioning Manifolds).

Second floor



MANIFOLD 1

tmax = 75°C — File: COL-ES-1

H = 1000 mm w.g. — number of accepted manifolds = 2

N	Q	L	De	Di	heat emitters		b	h
1	1160	10	10.0	8.0	OMEGA	10-870/3	600	870
2	1740	12	12.0	10.0	OMEGA	15-870/3	900	870
3	1180	15	12.0	10.0	OMEGA	10-680/4	600	680
4	610	15	10.0	8.0	OMEGA	5-680/4	300	680
5	1430	13	12.0	10.0	OMEGA	12-680/4	720	680
6	1090	14	10.0	8.0	OMEGA	10-680/4	600	680
7	310	8	10.0	8.0	OMEGA	4-870/2	240	870

Zone valve ... :	CALEFFI	6480/6460	Dn = 1"
Manifold ..... :	CALEFFI	356-357	Dn = 1"
Pipes .... :	Copper		

General data related to manifold			
Required head	1000 mm w.g.	Required output	7520 W
Manifold flow rate	882 l/h	Delivered output	7666 W
Mean temp. differ.	7.5°C	Water content	72 l

MANIFOLD 1

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	1160	20	3	80	107	0.60	9.4	0.796	1177	+17
2	1740	20	3	80	165	0.59	9.1	0.798	1772	+32
3	1180	20	1	80	152	0.54	6.7	0.823	1193	+13
4	610	20	1	80	90	0.50	5.9	0.832	603	-7
5	1430	20	1	80	160	0.57	7.7	0.813	1414	-16
6	1090	20	1	80	93	0.52	10.1	0.788	1142	+52
7	310	20	2	80	117	0.65	2.3	0.869	365	+55

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242

Dimensioning of Manifolds and related branches - 1st floor

The following general data for the second Manifold is proposed by the programme on screen:

Hzone = 1.000 mm w.g.
tmax = 75°C
cvz = 1
N hem = 0 (number of heat emitters)

Hzone = 1.100 mm w.g. (in accordance with the preset values for the 1st floor) and
N hem = 7

are entered and the dimensioning of the branch circuits starts. For this purpose, the programme shows on screen the following dialogue window:

n	Q	L	ccs	ta	cv
1	-	-	1	20	2
2	-	-	1	20	2
3	-	-	1	20	2
4	-	-	1	20	2
5	-	-	1	20	2
6	-	-	1	20	2
7	-	-	1	20	2

On the basis of the values previously defined, the data in the window is supplemented and modified as follows:

n	Q	L	ccs	ta	cv
1	970	10	3	20	2
2	1450	12	3	20	2
3	990	15	1	20	2
4	520	15	1	20	2
5	1150	13	1	20	2
6	770	14	1	20	2
7	250	8	2	20	2

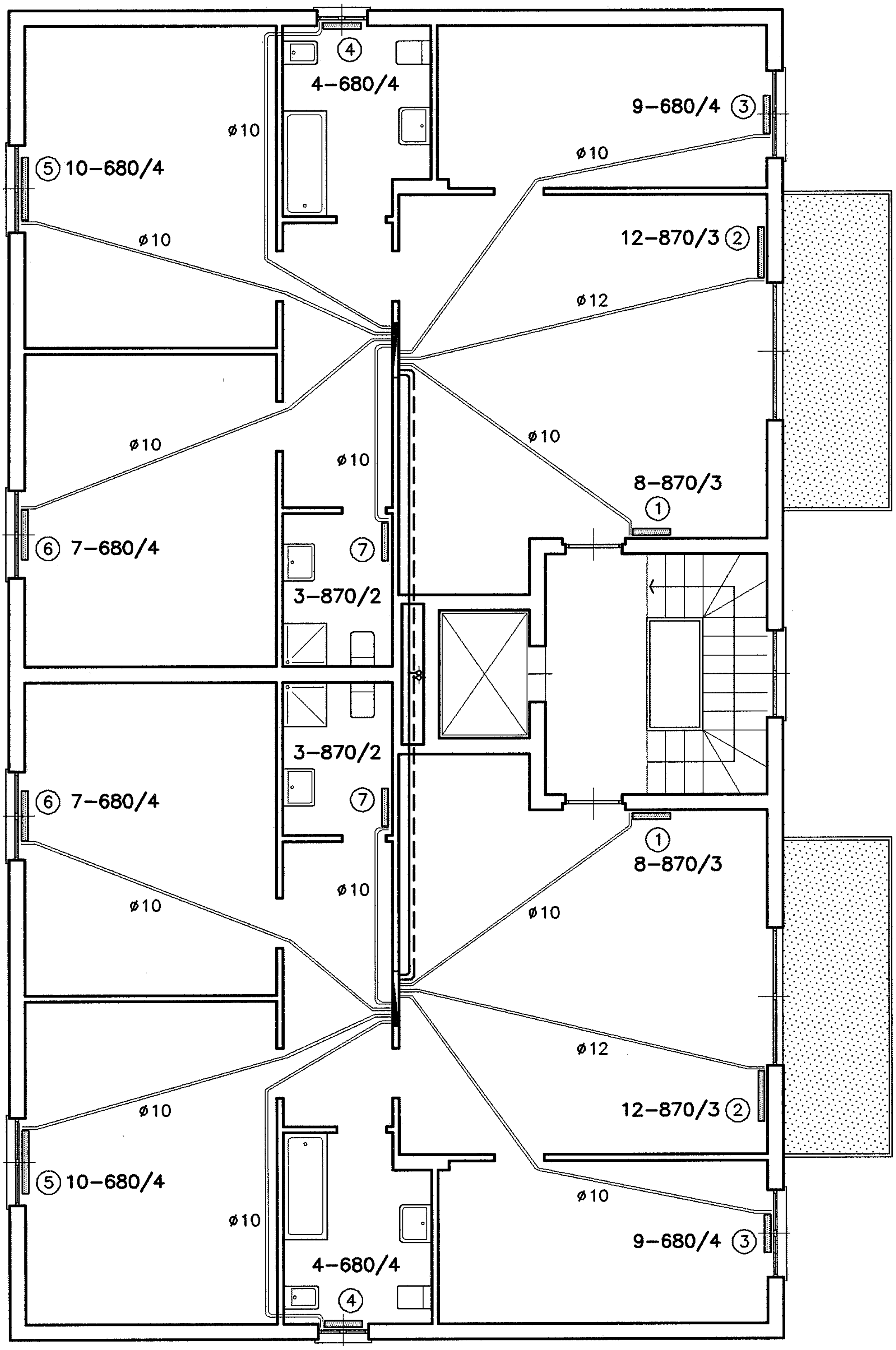
Then the processing of this data is commenced using function key F1, which permits the dimensioning with the guide temperature difference.

Finally, the solutions proposed on screen are accepted, once they show no reasons for invalidity, such as for example excessive space taken up by the radiators or excessively high fluid velocities.

The solutions are processed twice to allow the materials for both dwellings on the first floor to be calculated.

A drawing is then produced and a print prepared showing the results obtained (see symbols used for dimensioning Manifolds).

First floor


④
4–680/4
ø10
9–680/4 ③
⑤ 10–680/4
ø10
ø10
12–870/3 ②
ø12
ø10
ø10
ø10
8–870/3
①
⑥ 7–680/4
⑦
3–870/2
3–870/2
⑥ 7–680/4
⑦
①
8–870/3
ø10
ø10
ø10
ø12
ø10
12–870/3 ②
⑤ 10–680/4
ø10
ø10
9–680/4 ③
4–680/4
④

MANIFOLD 2

tmax = 75°C

H = 1100 mm w.g.

File: COL-ES-1

number of accepted manifolds = 2

N	Q	L	De	Di	heat emitters		b	h
1	970	10	10.0	8.0	OMEGA	8-870/3	480	870
2	1450	12	12.0	10.0	OMEGA	12-870/3	720	870
3	990	15	10.0	8.0	OMEGA	9-680/4	540	680
4	520	15	10.0	8.0	OMEGA	4-680/4	240	680
5	1150	13	10.0	8.0	OMEGA	10-680/4	600	680
6	770	14	10.0	8.0	OMEGA	7-680/4	420	680
7	250	8	10.0	8.0	OMEGA	3-870/2	180	870

Zone valve ... : CALEFFI 6480/6460 Dn = 3/4"

Manifold ..... : CALEFFI 356-357 Dn = 3/4"

Pipes .... : Copper

General data related to manifold			
Required head	1100 mm w.g.	Required output	6100 W
Manifold flow rate	749 l/h	Delivered output	6169 W
Mean temp. differ.	7.1°C	Water content	58 l

MANIFOLD 2

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	970	20	3	80	106	0.59	7.9	0.811	960	-10
2	1450	20	3	80	163	0.58	7.7	0.813	1444	-6
3	990	20	1	80	89	0.50	9.6	0.793	1035	+45
4	520	20	1	80	89	0.50	5.0	0.840	487	-33
5	1150	20	1	80	95	0.53	10.4	0.784	1137	-13
6	770	20	1	80	92	0.51	7.2	0.818	830	+60
7	250	20	2	80	115	0.64	1.9	0.873	275	+25

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242

Dimensioning of Manifolds and related branches - Mezzanine floor

The following general data for the third Manifold is proposed by the programme on screen:

Hzone = 1.000 mm w.g.
tmax = 75°C
cvz = 1
N hem = 0 (number of heat emitters)

Hzone = 1.200 mm w.g. (in accordance with the preset values for the mezzanine floor) and
N hem = 7

are entered and the dimensioning of the branch circuits starts. For this purpose, the programme shows on screen the following dialogue window:

n	Q	L	ccs	ta	cv
1	-	-	1	20	2
2	-	-	1	20	2
3	-	-	1	20	2
4	-	-	1	20	2
5	-	-	1	20	2
6	-	-	1	20	2
7	-	-	1	20	2

On the basis of the values previously defined, the data in the window is supplemented and modified as follows:

n	Q	L	ccs	ta	cv
1	1065	10	3	20	2
2	1595	12	3	20	2
3	1090	15	1	20	2
4	570	15	1	20	2
5	1290	13	1	20	2
6	910	14	1	20	2
7	290	8	2	20	2

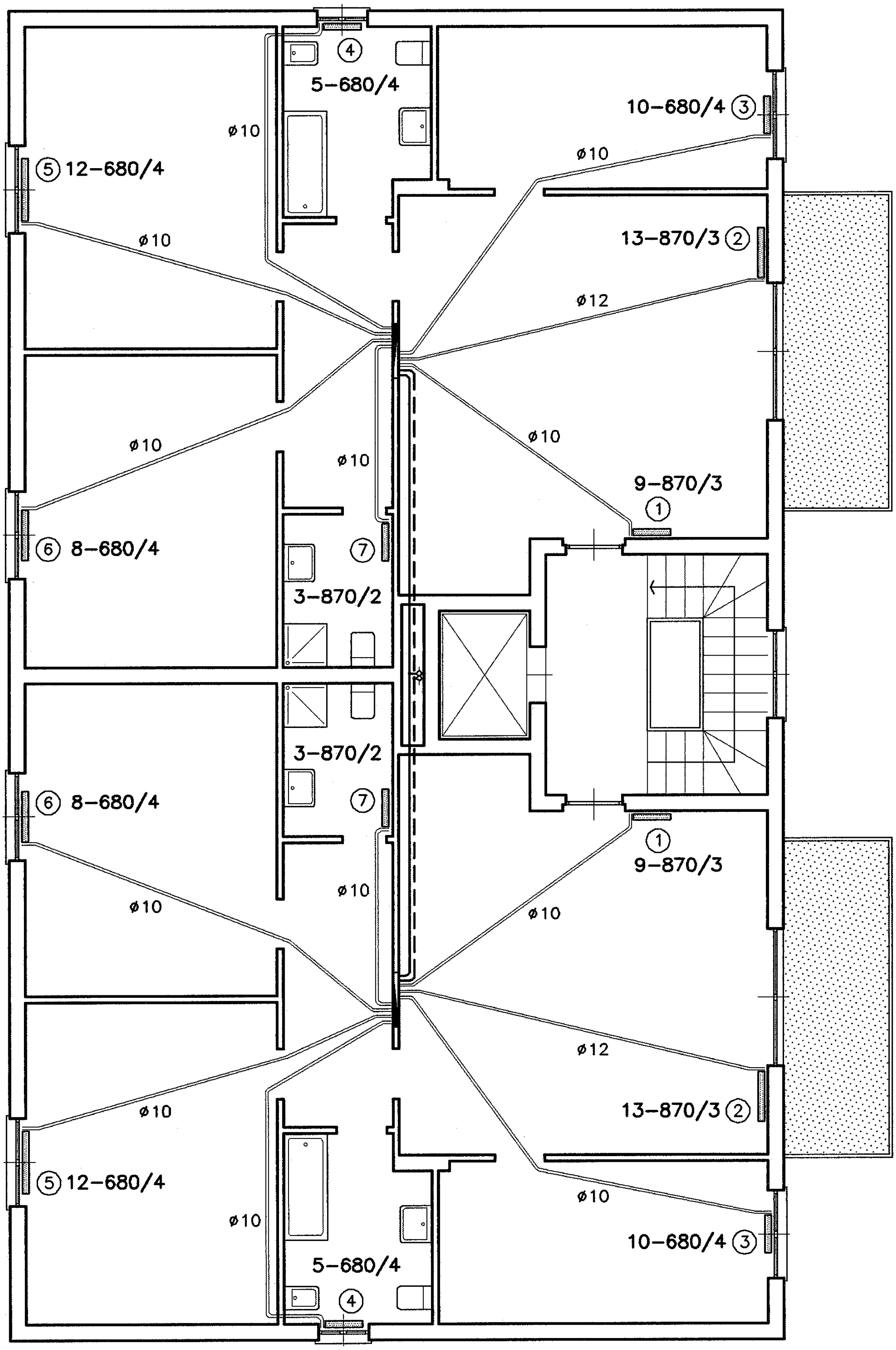
Then the processing of this data is commenced using function key F1, which permits the dimensioning with the guide temperature difference.

Finally, the solutions proposed on screen are accepted, once they show no reasons for invalidity, such as for example excessive space taken up by the radiators or excessively high fluid velocities.

The solutions are processed twice to allow the materials for both dwellings on the mezzanine floor to be calculated.

A drawing is then produced and a print prepared showing the results obtained (see symbols used for dimensioning Manifolds).

Mezzanine floor



MANIFOLD 3

tmax = 75°C

File: COL-ES-1

H = 1200 mm w.g.

number of accepted manifolds = 2

N	Q	L	De	Di	heat emitters		b	h
1	1065	10	10.0	8.0	OMEGA	9-870/3	540	870
2	1595	12	12.0	10.0	OMEGA	13-870/3	780	870
3	1090	15	10.0	8.0	OMEGA	10-680/4	600	680
4	570	15	10.0	8.0	OMEGA	5-680/4	300	680
5	1290	13	10.0	8.0	OMEGA	12-680/4	720	680
6	910	14	10.0	8.0	OMEGA	8-680/4	480	680
7	290	8	10.0	8.0	OMEGA	3-870/2	180	870

Zone valve ... : CALEFFI 6480/6460 Dn = 1"

Manifold ..... : CALEFFI 356-357 Dn = 1"

Pipes .... : Copper

General data related to manifold			
Required head	1200 mm w.g.	Required output	6810 W
Manifold flow rate	843 l/h	Delivered output	6998 W
Mean temp. differ.	7.2°C	Water content	66 l

MANIFOLD 3

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	1065	20	3	80	119	0.66	7.7	0.813	1082	+17
2	1595	20	3	80	183	0.65	7.5	0.815	1567	-28
3	1090	20	1	80	100	0.56	9.4	0.795	1153	+63
4	570	20	1	80	100	0.56	4.9	0.842	610	+40
5	1290	20	1	80	107	0.60	10.4	0.785	1365	+75
6	910	20	1	80	103	0.58	7.6	0.814	944	+34
7	290	20	2	80	130	0.72	1.9	0.873	275	-15

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242

Symbols, Sizes and Units of measurement

b	Base width of heat emitter	mm
ccs	Heat emitter code	-
cd	Code of lockshield group	-
cv	Code of valve group for heat emitters	-
dQ	Difference between required and delivered output	W
dt	Temperature difference	°C
De	External diameter of pipe	mm
Di	Internal diameter of pipe	mm
Dn	Nominal diameter of valves and lockshields . . .	inch
F	Efficiency factor of heat emitter	-
G	Flow rate	l/h
h	Height of heat emitter	mm
KV001	Nominal flow rate for dp = 0,01 bar	l/h
L	Pipe lenght (flow-return) manifold/heat emitter	m
N	Heat emitter number	-
Q	Required heat output	W
Qeff	Delivered heat output by heat emitter	W
ta	Ambient temperature	°C
tmp	Testing mean temperature of heat emitter	°C
tmax	Maximum design temperature	°C
v	Velocity of heating fluid	m/s

METRIC CALCULATION OF MATERIALS - Project file COL-ES-1

Zone valve	CALEFFI	6480/6460	Dn 3/4"	n.	2
Zone valve	CALEFFI	6480/6460	Dn 1"	n.	4
Manifold	CALEFFI	356-357 [7]	Dn 3/4"	n.	2
Manifold	CALEFFI	356-357 [7]	Dn 1"	n.	4
Pipe	Copper	10.0/ 8.0		m	394
Pipe	Copper	12.0/10.0		m	128
Valve	CALEFFI	338 sq	Dn 3/8"	n.	42
Lockshield	CALEFFI	342 sq	Dn 3/8"	n.	42
Heat emitter		OMEGA	680/4	n.	204
Heat emitter		OMEGA	870/2	n.	20
Heat emitter		OMEGA	870/3	n.	134

Dimensioning of distribution network

The distribution network is dimensioned using the method of constant linear head losses, taking as guide value r = 10 mm w.g./m and using TABLE 5 in the 1st Handbook, item STEEL PIPES.

The following is thus obtained:

– 2nd floor riser - Manifold connection pipes	G = 882 l/h	ø =	1”
– 1st floor riser - Manifold connection pipes	G = 749 l/h	ø =	1”
– mezzanine riser - Manifold connection pipes	G = 843 l/h	ø =	1”
– 1st floor - 2nd floor riser section	G = 882 · 2 = 1.764 l/h	ø =	1 1/4”
– 1st floor - mezzanine riser section	G = 1.764 + 749 · 2 = 3.262 l/h	ø =	1 1/2”
– mezzanine - heating centre riser section	G = 3.262 + 843 · 2 = 4.948 l/h	ø =	2”

The head required at the base of the circuit is determined (see practical methods, 1st Handbook) by adding together:

- the head required upstream from the last Manifold (Hzone);
- the continuous losses of head from the circuit (Hcont) considered conventionally as equal to the product of:
  - r = guide value of linear constant head loss,
  - l = circuit length;
- the localised head losses (Hloc) taken as equal to 60% of the continuous head losses.

The result is thus: - Hzone (2nd floor) = 1.000 mm w.g.

- Hcont = l · r = (la + lc + lo) · r = 40 · 10 = 400 mm w.g.

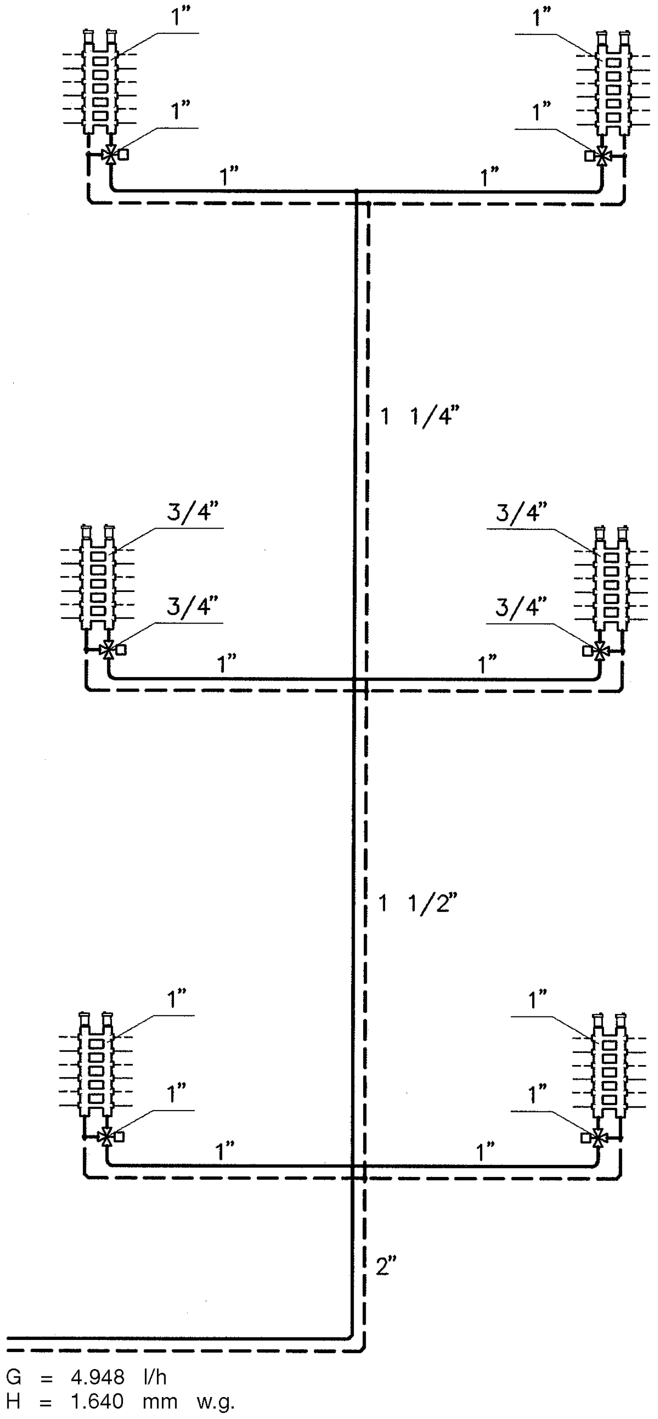
  where: la = 12 m length 2nd floor Manifold - riser connecting pipe
  lc = 12 m length riser pipes
  and assuming:
  lo = 16 m length heating centre - riser connecting pipes length

- Hloc = 400 · 0,6 = 240 mm w.g.

The head obtained at the base of the circuit is thus:

H = 1.000 + 400 + 240 = 1.640 mm w.g.

System sizing diagram



Example 2 - Dimensioning of a Manifold system using the theoretical methods with guide temperature difference and with constant diameter

Dimension (using the guide temperature difference theoretical method and with constant diameter) a single Manifold system with the following characteristics:

– t_a = 20°C ambient temperature
– t_{max} = 75°C max. design temperature
– H = 1.000 mm w.g. zone head

– heat output required: (Q) and length of pipes (L) connecting Manifold and radiators:

n	Q [W]	L [m]
1	1.250	12
2	1.800	10
3	1.400	16
4	700	15
5	1.450	16
6	1.120	10
7	980	12
8	660	16

– copper pipes in available diameters: 8/10, 10/12, 12/14, 14/16, 16/18 mm.

– cases to be considered: 1st dimensioning with guide temperature difference = 10°C
2nd dimensioning with constant diameter = 10 mm
3rd dimensioning with constant diameter = 12 mm

Solution:

The Quaderni Caleffi 99 software is used, developing the three cases provided for in a single design file. The following is considered in particular:
– manifold 1: dimensioning with guide temperature difference = 10°C
– manifold 2: dimensioning with constant diameter = 10 mm
– manifold 3: dimensioning with constant diameter = 12 mm

The exercise is broken down into the following phases:

– Analysis and selection of data regarding the main parameters file

– Selection of pipes and Manifolds

– Activation of project file

– Dimensioning with guide temperature difference = 10°C (Manifold No. 1)

– Dimensioning with constant diameter = 10 mm (Manifold No. 2)

– Dimensioning with constant diameter = 12 mm (Manifold No. 3)

– Table summarising the solutions prepared

– Comparison of the solutions obtained

Analysis and selection of data relating to the main parameters file

– Valves for heat emitters

Caleffi model 338/sq valves with thermostatic option are used with the following characteristics:
- 3/8” valve $KV_{0,01}$ = 222 l/h
- 1/2” valve $KV_{0,01}$ = 270 l/h

These valves are already on file with the code number cv = 2.

– Lock shield valves for heat emitters

Caleffi model 342/sq LSVs are used with the following characteristics:
- 3/8” valve $KV_{0,01}$ = 242 l/h
- 1/2” valve $KV_{0,01}$ = 399 l/h

These LSVs are already on file with the code number cd = 10.

– Heat emitters

To simplify comparison of the solutions, heat emitters of a single type are used, having the characteristics shown below:
- trade name, ... OMEGA
- model, ... 640/4
- mean test temperature, ... 80°C
- rated heat output, ... 145 W
- width, ... 60 mm
- height, ... 680 mm
- water content, ... 1,10 l

The heat emitter is assumed to be in the file already with the code number csc = 1.

– Maximum velocity of fluid

This is taken as (see sub-chapter under DIMENSIONING OF MANIFOLD SYSTEMS):
v_{max} = 0,75 m/s

On the basis of the design data and the selections made, the following values are entered in the GENERAL PARAMETERS FILE:

GENERAL PARAMETERS FILE	
Zone head [mm w.g.]	1000
Maximum design temperature [°C]	75
Ambient temperature [°C]	20
Guide temperature difference [°C]	10
Zone valve group code	0
Heat emitter valve group code	2
Lock shield valve group code	10
Reference heat emitter code	1
Heating fluid max. vel. [m/s]	0,75

Selection of pipes and Manifolds

– Pipes

The pipes are assumed to be in the file, with the code number n = 1.

– Manifolds

Caleffi single block coplanar **Manifolds model 356/357** are used.

On the basis of the selections made, the following values are entered in the PIPES AND MANIFOLDS file.

PIPE AND MANIFOLD CHARACTERISTICS FILE	
Pipe group code	1
Manifold tradename	CALEFFI
Manifold model	356/357
3/4” Manifold: Internal diameter [mm]	20,0
Entry csa	3,0
off take csa	6,5
1” Manifold: Internal diameter [mm]	26,0
Entry csa	3,0
off take csa	6,5

Activation of design file

The design file is started by entering:

Design filename:	COL-ES-2
Client name:	XX
Building location:	YY

Dimensioning with guide temperature difference = 10°C (Manifold No. 1)

The following general data for the first Manifold is proposed by the programme on screen:

Hzone = 1.000 mm w.g.
tmax = 75°C
cvz = 0
N hem = 0 (number of heaters)

N hem = 8 is entered and the dimensioning of the branch circuit is started by entering the following values:

n	Q	L	ccs	ta	cv
1	1250	12	1	20	2
2	1800	10	1	20	2
3	1400	16	1	20	2
4	700	15	1	20	2
5	1450	16	1	20	2
6	1120	10	1	20	2
7	980	12	1	20	2
8	660	16	1	20	2

Then the processing of this data is commenced using function key F1, which permits the dimensioning with the guide temperature difference. The solutions prepared are accepted.

Dimensioning with constant diameter = 10 mm (Manifold No. 2)

Using the “Similar Manifold” function, the same data is entered for the 2nd Manifold as for the first.
The processing of this data is then requested (entering De = 10 mm) with the function permitting dimensioning of circuits with constant diameter. Finally, the solutions prepared are accepted.

Dimensioning with constant diameter = 12 mm (Manifold No. 3)

Using the “Similar Manifold” function, the same data is entered for the 3rd Manifold as for the first.
The processing of this data is then requested (entering De = 12 mm) with the function permitting dimensioning of circuits with constant diameter. Finally, the solutions prepared are accepted.

A print-out is then produced, showing the results obtained.

MANIFOLD 1

tmax = 75°C | File: COL-ES-2

H = 1000 mm w.g. | number of accepted manifolds = 1

N	Q	L	De	Di	heat emitters		b	h
1	1250	12	10.0	8.0	OMEGA	11-680/4	660	680
2	1800	10	12.0	10.0	OMEGA	16-680/4	960	680
3	1400	16	12.0	10.0	OMEGA	12-680/4	720	680
4	700	15	10.0	8.0	OMEGA	6-680/4	360	680
5	1450	16	12.0	10.0	OMEGA	13-680/4	780	680
6	1120	10	10.0	8.0	OMEGA	10-680/4	600	680
7	980	12	10.0	8.0	OMEGA	9-680/4	540	680
8	660	16	10.0	8.0	OMEGA	6-680/4	360	680

Manifold ..... : CALEFFI 356-357 Dn = 1"

Pipes .... : Copper

General data related to manifold			
Required head	1000 mm w.g.	Required output	9360 W
Manifold flow rate	953 l/h	Delivered output	9666 W
Mean temp. differ.	8.7°C	Water content	98 l

MANIFOLD 1

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	1250	20	1	80	99	0.55	10.9	0.780	1244	-6
2	1800	20	1	80	175	0.62	8.9	0.801	1858	+58
3	1400	20	1	80	148	0.53	8.2	0.808	1406	+6
4	700	20	1	80	90	0.50	6.7	0.823	716	+16
5	1450	20	1	80	148	0.53	8.5	0.805	1517	+67
6	1120	20	1	80	107	0.60	9.0	0.799	1158	+38
7	980	20	1	80	99	0.55	8.5	0.804	1049	+69
8	660	20	1	80	87	0.49	6.5	0.825	718	+58

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242
8	2	3/8	222	thermost. option	10	3/8	242

MANIFOLD 2

tmax = 75°C

File: COL-ES-2

H = 1000 mm w.g.

number of accepted manifolds = 1

N	Q	L	De	Di	heat emitters		b	h
1	1250	12	10.0	8.0	OMEGA	11-680/4	660	680
2	1800	10	10.0	8.0	OMEGA	17-680/4	1020	680
3	1400	16	10.0	8.0	OMEGA	13-680/4	780	680
4	700	15	10.0	8.0	OMEGA	6-680/4	360	680
5	1450	16	10.0	8.0	OMEGA	14-680/4	840	680
6	1120	10	10.0	8.0	OMEGA	10-680/4	600	680
7	980	12	10.0	8.0	OMEGA	9-680/4	540	680
8	660	16	10.0	8.0	OMEGA	6-680/4	360	680

Manifold ..... : CALEFFI 356-357 Dn = 3/4"

Pipes .... : Copper

General data related to manifold			
Required head	1000 mm w.g.	Required output	9360 W
Manifold flow rate	731 l/h	Delivered output	9578 W
Mean temp. differ.	11.3°C	Water content	100 l

MANIFOLD 2

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	1250	20	1	80	95	0.53	11.4	0.775	1236	-14
2	1800	20	1	80	102	0.57	15.2	0.736	1815	+15
3	1400	20	1	80	84	0.47	14.4	0.744	1402	+2
4	700	20	1	80	86	0.48	7.0	0.820	713	+13
5	1450	20	1	80	84	0.47	15.0	0.739	1499	+49
6	1120	20	1	80	102	0.57	9.4	0.795	1152	+32
7	980	20	1	80	95	0.53	8.9	0.800	1044	+64
8	660	20	1	80	84	0.47	6.8	0.822	715	+55

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242
8	2	3/8	222	thermost. option	10	3/8	242

MANIFOLD 3

tmax = 75°C

File: COL-ES-2

H = 1000 mm w.g.

number of accepted manifolds = 1

N	Q	L	De	Di	heat emitters		b	h
1	1250	12	12.0	10.0	OMEGA	11-680/4	660	680
2	1800	10	12.0	10.0	OMEGA	16-680/4	960	680
3	1400	16	12.0	10.0	OMEGA	12-680/4	720	680
4	700	15	12.0	10.0	OMEGA	6-680/4	360	680
5	1450	16	12.0	10.0	OMEGA	13-680/4	780	680
6	1120	10	12.0	10.0	OMEGA	9-680/4	540	680
7	980	12	12.0	10.0	OMEGA	8-680/4	480	680
8	660	16	12.0	10.0	OMEGA	6-680/4	360	680

Manifold ..... : CALEFFI 356-357 Dn = 1"

Pipes .... : Copper

General data related to manifold			
Required head	1000 mm w.g.	Required output	9360 W
Manifold flow rate	1247 l/h	Delivered output	9623 W
Mean temp. differ.	6.7°C	Water content	98 l

MANIFOLD 3

N	Q	ta	ccs	tmp	G	v	dt	F	Qeff	dQ
1	1250	20	1	80	161	0.57	6.7	0.823	1313	+63
2	1800	20	1	80	171	0.61	9.1	0.799	1853	+53
3	1400	20	1	80	145	0.52	8.3	0.806	1402	+2
4	700	20	1	80	148	0.53	4.1	0.850	740	+40
5	1450	20	1	80	145	0.52	8.6	0.803	1514	+64
6	1120	20	1	80	171	0.61	5.6	0.834	1088	-32
7	980	20	1	80	161	0.57	5.2	0.838	972	-8
8	660	20	1	80	145	0.52	3.9	0.852	741	+81

N	cv	Dn	KV001	valve type	cd	Dn	KV001
1	2	3/8	222	thermost. option	10	3/8	242
2	2	3/8	222	thermost. option	10	3/8	242
3	2	3/8	222	thermost. option	10	3/8	242
4	2	3/8	222	thermost. option	10	3/8	242
5	2	3/8	222	thermost. option	10	3/8	242
6	2	3/8	222	thermost. option	10	3/8	242
7	2	3/8	222	thermost. option	10	3/8	242
8	2	3/8	222	thermost. option	10	3/8	242

Table summarising the solutions prepared

The main parameters relating to the solutions prepared are shown below:

– Internal circuit parameters:

General data			Solution with guide Δt = 10°C			Solution with De = 10 mm			Solution with De = 12 mm		
No	Q	L	De	G	el	De	G	el	De	G	el
1	1.250	12	10	99	11	10	95	11	12	161	11
2	1.800	10	12	175	16	10	102	17	12	171	16
3	1.400	16	12	148	12	10	84	13	12	145	12
4	700	15	10	90	6	10	86	6	12	148	6
5	1.450	16	12	148	13	10	84	14	12	145	13
6	1.120	10	10	107	10	10	102	10	12	171	9
7	980	12	10	99	9	10	95	9	12	161	8
8	660	16	10	87	6	10	84	6	12	145	6

– General parameters:

- G_t = System flow (see design processing)

G_t = 953 l/h (solution with guide Δt = 10°C)
G_t = 731 l/h (solution with De = 10 mm)
G_t = 1.247 l/h (solution with De = 12 mm)

- el = Total number of radiator elements

el = 83 (solution with guide Δt = 10°C)
el = 86 (solution with De = 10 mm)
el = 81 (solution with De = 12 mm)

- P_e = Weight of pipes (see linear weight of copper pipes, 1st Caleffi Handbook).

P_e = 65 · 0,25 + 42 · 0,31 = 29,27 Kg (solution with guide Δt = 10°C)
P_e = 107 · 0,25 = 26,75 Kg (solution with De = 10 mm)
P_e = 107 · 0,31 = 33,17 Kg (solution with De = 12 mm)

Comparison of solutions obtained

The solutions are compared by evaluating the percentage difference between the following values:
– elements needed for the composition of the heat emitters,
– weight of pipes,
– output required at Manifold connections (for fluid circulation).

The comparisons of the output required are carried out indirectly on the flow, as these two values have a relationship of linear proportionality (see 1st Caleffi Handbook, ELECTRIC PUMPS, formula No. 2).

– The solution with guide Δt = 10°C in comparison with De = 10 mm shows:
  - fewer elements: 3,6 %
  - greater weight of pipes: 8,6 %
  - greater output: 23,3 %

– The solution with guide Δt = 10°C in comparison with De = 12 mm shows:
  - more elements: 2,4 %
  - reduced weight of pipes: 13,3 %
  - lower output: 30,8 %

– The solution with De = 10 mm in comparison with De = 12 mm shows:
  - more elements: 5,8 %
  - reduced weight of pipes: 24,0 %
  - lower output: 70,6 %

Comments:

The comparative analysis and development of several solutions is particularly useful in medium to large systems; ie. the different outputs and costs - of construction and management - should be defined, and significant savings can thus be achieved for the system.

Example 3 - Dimensioning of a Manifold system using the practical method with preset head and temperature difference 10°C

Dimension (using the 10°C temperature difference with preset head practical method) a single Manifold system with the following characteristics:

– t_a = 20°C ambient temperature
– t_{max} = 75°C max. design temperature
– H = 1.000 mm w.g. zone head

– heat output required (Q) and length of pipes (L) connecting between Manifold and radiators:

n	Q [W]	L [m]
1	1.250	12
2	1.800	10
3	1.400	16
4	700	15
5	1.450	16
6	1.120	10
7	980	12
8	660	16

– copper pipes available in diameters: 8/10, 10/12, 12/14, 14/16, 16/18 mm.

Solution:

The calculation method described under DIMENSIONING MANIFOLD SYSTEMS, sub-chapter PROCEDURE B - PRACTICAL CALCULATION WITH PRESET HEAD AND TEMPERATURE DIFFERENCE = 10°C.

Using this method, the dimensioning of the system is broken down into the following phases:

– General selections

– Internal circuit flows

– Mean linear head losses in the internal circuits

– Diameters of internal circuits

– Diameter of Manifold

– Heat emitter output factor

– Dimensioning of heat emitters

General selections

– Valves for heat emitters

Valves with thermostatic option are used.

– Heat emitters

A single type of heat emitter is used, having the following characteristics:
- model, ... 640/4
- mean test temperature, ... 80°C
- rated heat output, ... 145 W
- width, ... 60 mm

Flows of internal circuits

These are calculated using formula (7) of the calculation procedure used. This formula gives:

– G_1 = 1.250 / 11,6 = 108 l/h
– G_2 = 1.800 / 11,6 = 155 l/h
– G_3 = 1.400 / 11,6 = 121 l/h
– G_4 = 700 / 11,6 = 60 l/h
– G_5 = 1.450 / 11,6 = 125 l/h
– G_6 = 1.120 / 11,6 = 97 l/h
– G_7 = 980 / 11,6 = 84 l/h
– G_8 = 660 / 11,6 = 57 l/h

807 l/h total flow

Mean linear head losses of internal circuits

This is calculated - on the basis of the preset head - using the formula (2) of the calculation procedure used. This formula produces:

– r_1 = 1.000 · 0,6 / 12 = 50 mm w.g./m
– r_2 = 1.000 · 0,6 / 10 = 60 mm w.g./m
– r_3 = 1.000 · 0,6 / 16 = 38 mm w.g./m
– r_4 = 1.000 · 0,6 / 15 = 40 mm w.g./m
– r_5 = 1.000 · 0,6 / 16 = 38 mm w.g./m
– r_6 = 1.000 · 0,6 / 10 = 60 mm w.g./m
– r_7 = 1.000 · 0,6 / 12 = 50 mm w.g./m
– r_8 = 1.000 · 0,6 / 16 = 38 mm w.g./m

Diameters of internal circuits

These are determined (para B1.3 of the calculation procedure used) by selecting the diameters which, on the basis of the mean linear head losses, produce the best approximation to the required flows. For this purpose, Table 4 of the 1st Handbook, COPPER PIPES, is used.

for r_1 = 50	the diameter	D_{e1} = 10 mm	comes closest to	G_1 = 108 l/h
for r_2 = 60	” ”	D_{e2} = 12 mm	” ” ”	G_2 = 155 l/h
for r_3 = 38	” ”	D_{e3} = 12 mm	” ” ”	G_3 = 121 l/h
for r_4 = 40	” ”	D_{e4} = 10 mm	” ” ”	G_4 = 60 l/h
for r_5 = 38	” ”	D_{e5} = 12 mm	” ” ”	G_5 = 125 l/h
for r_6 = 60	” ”	D_{e6} = 10 mm	” ” ”	G_6 = 97 l/h
for r_7 = 50	” ”	D_{e7} = 10 mm	” ” ”	G_7 = 84 l/h
for r_8 = 38	” ”	D_{e8} = 10 mm	” ” ”	G_8 = 57 l/h

Manifold diameter

On the basis of the conventions used (para B2 of the calculation procedure used) and on the basis of the flow of the Manifold (G = 807 l/h), we have:

Manifold diameter = 1”

Heat emitter output factor

The mean temperature of the heat emitters (t_m) is first calculated:

t_m = 75 – (10 / 2) = 70°C

From Table 1 (RADIATORS, 2nd Handbook), we then obtain:

F = 0,79

Dimensioning the heat emitters

For each heat emitter, the ratio (R) between the heat output required and the actual output of the base element is calculated.

When R is known, the number of elements (n. el.) is determined by considering the following cases:
- if the 1st decimal of R is less than n. el. take n.el = entire part of R,
- if the 1st decimal of R is not less than 3, take n. el. = first whole number larger than R.

This gives:

R_1 =	1.250 / (145 · 0,79) =	10,91	enter: No. of elements	=	11	radiator configuration: 11-680/4
R_2 =	1.800 / (145 · 0,79) =	15,71	” ” ” ”	=	16	” ” 16-680/4
R_3 =	1.400 / (145 · 0,79) =	12,22	” ” ” ”	=	12	” ” 12-680/4
R_4 =	700 / (145 · 0,79) =	6,11	” ” ” ”	=	6	” ” 6-680/4
R_5 =	1.450 / (145 · 0,79) =	12,66	” ” ” ”	=	13	” ” 13-680/4
R_6 =	1.120 / (145 · 0,79) =	9,78	” ” ” ”	=	10	” ” 10-680/4
R_7 =	980 / (145 · 0,79) =	8,56	” ” ” ”	=	9	” ” 9-680/4
R_8 =	660 / (145 · 0,79) =	5,76	” ” ” ”	=	6	” ” 6-680/4

Comments

The solutions obtained by the practical calculation method are very similar to those obtained by theoretical means in exercise 2.
In particular, these solutions have the same diameters for the Manifolds and the branch circuits, as well as the same configuration of the heat emitters. The only variation is the total flow rate through the system.
However this difference can easily be contained within the approximations which characterise the calculation of space heating systems (see 1st Handbook, TOTAL HEAD LOSSES)

Example 4 - Dimensioning of a Manifold system using the practical method with preset head and predefined diameters

Dimension (using the predefined diameter, preset head practical method) a single Manifold system with the following characteristics:

– t_a = 20°C ambient temperature
– t_{max} = 75°C max. design temperature
– H = 1.000 mm w.g. zone head

– heat output required (Q) and length of pipes (L) connecting between Manifold and radiators:

n	Q [W]	L [m]
1	1.250	12
2	1.800	10
3	1.400	16
4	700	15
5	1.450	16
6	1.120	10
7	980	12
8	660	16

– copper pipes available in diameters: 8/10, 10/12, 12/14, 14/16, 16/18 mm.

Solution:

The calculation method described under DIMENSIONING MANIFOLD SYSTEMS, sub-chapter PROCEDURE D - PRACTICAL CALCULATION WITH PRESET HEAD AND PREDEFINED DIAMETERS.

Using this method, the dimensioning of the system is broken down into the following phases:

– General selections

– Diameters of internal circuits

– Mean linear head losses in the internal circuits

– Flows of internal circuits

– Diameter of Manifold

– Heat emitter temperature difference

– Heat emitter output factor

– Dimensioning of heat emitters

General selections

– Valves for heat emitters

Valves with thermostatic option are used.

– Heat emitters

A single type of heat emitter is used, having the following characteristics:
- model, ... 680/4
- mean test temperature, ... 80°C
- rated heat output, ... 145 W
- width, ... 60 mm

Diameters of internal circuits

For all the branch circuits, 8/10 dia. Pipe is used.

Mean linear head losses from internal circuits

These are calculated using formula (2) of the calculation procedure used. This formula produces:

– r_1 = 1.000 · 0,6 / 12 = 50 mm w.g./m
– r_2 = 1.000 · 0,6 / 10 = 60 mm w.g./m
– r_3 = 1.000 · 0,6 / 16 = 38 mm w.g./m
– r_4 = 1.000 · 0,6 / 15 = 40 mm w.g./m
– r_5 = 1.000 · 0,6 / 16 = 38 mm w.g./m
– r_6 = 1.000 · 0,6 / 10 = 60 mm w.g./m
– r_7 = 1.000 · 0,6 / 12 = 50 mm w.g./m
– r_8 = 1.000 · 0,6 / 16 = 38 mm w.g./m

Internal circuit flows

When the diameters and mean linear head losses are known, the flows of the branch circuits are determined from Table 4 of the 1st Handbook, COPPER PIPES.

for r_1 =	50	and diameter	De_1 = 10 mm	we have:	G_1 = 92 l/h	
for r_2 =	60	” ”	De_2 = ” ”	” ”	G_2 = 102 l/h	
for r_3 =	38	” ”	De_3 = ” ”	” ”	G_3 = 79 l/h	
for r_4 =	40	” ”	De_4 = ” ”	” ”	G_4 = 81 l/h	
for r_5 =	38	” ”	De_5 = ” ”	” ”	G_5 = 79 l/h	
for r_6 =	60	” ”	De_6 = ” ”	” ”	G_6 = 102 l/h	
for r_7 =	50	” ”	De_7 = ” ”	” ”	G_7 = 92 l/h	
for r_8 =	38	” ”	De_8 = ” ”	” ”	G_8 = 79 l/h	
					G = 706 l/h	Total flow

Manifold diameter

On the basis of the conventions used (para D3 of the calculation procedure used) and on the basis of the Manifold flow (G = 706 l/h) we have:

Manifold diameter = 3/4”

Temperature difference across heat emitters

This is calculated using formula (6) of the calculation procedure used. This formula produces:

– $\Delta t_1 = Q_1 / (1{,}16 \cdot G_1) = 1.250 / (1{,}16 \cdot 92) = 12°C$
– $\Delta t_2 = Q_2 / (1{,}16 \cdot G_2) = 1.800 / (1{,}16 \cdot 102) = 15°C$
– $\Delta t_3 = Q_3 / (1{,}16 \cdot G_3) = 1.400 / (1{,}16 \cdot 79) = 15°C$
– $\Delta t_4 = Q_4 / (1{,}16 \cdot G_4) = 700 / (1{,}16 \cdot 81) = 7°C$
– $\Delta t_5 = Q_5 / (1{,}16 \cdot G_5) = 1.450 / (1{,}16 \cdot 79) = 16°C$
– $\Delta t_6 = Q_6 / (1{,}16 \cdot G_6) = 1.120 / (1{,}16 \cdot 102) = 9°C$
– $\Delta t_7 = Q_7 / (1{,}16 \cdot G_7) = 980 / (1{,}16 \cdot 92) = 9°C$
– $\Delta t_8 = Q_8 / (1{,}16 \cdot G_8) = 660 / (1{,}16 \cdot 79) = 7°C$

Heat emitter output factor

The mean temperature of the heat emitters (t_m) is first calculated, and then the relevant output factor, using Table. 1 from RADIATORS in the 2nd Caleffi Handbook.

– $t_{m1} = 75 - (12 / 2) = 69{,}0°C$ from which we obtain $F_1 = 0{,}78$
– $t_{m2} = 75 - (15 / 2) = 67{,}5°C$ ” ” ” ” $F_2 = 0{,}74$
– $t_{m3} = 75 - (15 / 2) = 67{,}5°C$ ” ” ” ” $F_3 = 0{,}74$
– $t_{m4} = 75 - (7 / 2) = 71{,}5°C$ ” ” ” ” $F_4 = 0{,}82$
– $t_{m5} = 75 - (16 / 2) = 67{,}0°C$ ” ” ” ” $F_5 = 0{,}73$
– $t_{m6} = 75 - (9 / 2) = 70{,}5°C$ ” ” ” ” $F_6 = 0{,}80$
– $t_{m7} = 75 - (9 / 2) = 70{,}5°C$ ” ” ” ” $F_7 = 0{,}80$
– $t_{m8} = 75 - (7 / 2) = 71{,}5°C$ ” ” ” ” $F_8 = 0{,}82$

Dimensioning of heat emitters

For each heat emitter, the ratio between the required heat output and the actual output of the base element is calculated.

When R is known, the number of elements (n. el.) is determined by considering the following cases:
- if the 1st decimal of R is less than 3 take n. el. = entire part of R,
- if the 1st decimal of R is not less than 3 take n. el. = first whole number larger than R.

This gives:

R_1 = 1.250 / (145 · 0,78)	=	11,05	enter: No. of elements	=	11	radiator configuration:	11-680/4
R_2 = 1.800 / (145 · 0,74)	=	16,78	” ” ” ”	=	17	” ”	17-680/4
R_3 = 1.400 / (145 · 0,74)	=	13,05	” ” ” ”	=	13	” ”	13-680/4
R_4 = 700 / (145 · 0,82)	=	5,89	” ” ” ”	=	6	” ”	6-680/4
R_5 = 1.450 / (145 · 0,73)	=	13,70	” ” ” ”	=	14	” ”	14-680/4
R_6 = 1.120 / (145 · 0,80)	=	9,66	” ” ” ”	=	10	” ”	10-680/4
R_7 = 980 / (145 · 0,80)	=	8,45	” ” ” ”	=	9	” ”	9-680/4
R_8 = 660 / (145 · 0,82)	=	5,55	” ” ” ”	=	6	” ”	6-680/4

Comments

The solutions obtained by the practical calculation method are very similar to those obtained by theoretical means in exercise 2.
In particular, these solutions give the same configurations for the heat emitters. The only variation is the total flow rate through the system.
However this difference can easily be contained within the approximations which characterise the calculation of space heating systems (see 1st Handbook, TOTAL HEAD LOSSES).

MANIFOLD SYSTEMS DATA SURVEY

CALEFFI HANDBOOKS SOFTWARE

Project File: __________________ Data: __________________

Client: __________________

Installer: __________________

System location: __________________

Manifold: __________________

Pipe types: __________________

Notes: __________________

INDIVIDUAL MANIFOLD DATA SURVEY

CALEFFI HANDBOOKS SOFTWARE

Project File:

Hcoll: mm w.g.

LS Valve code:

Manifold:

tmax: °C

Guide Δt: °C

cvz:

De cost.: mm

HEAT EMITTER BRANCH DATA SURVEY

N	Room	Q	L	Heat emitter (ccs)	ta	cv
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		
				( )		

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B I B L I O G R A P H Y

1 J. RIETSCHEL - W. RAISS
Traité de chauffage et de ventilation
Librairie Polytechnique Ch. Béranger - Paris and Liège

2 A. MISSENARD
Cours superior de chauffage, ventilation e conditionnement de l'air
Les Editionnes Eyrolles

3 PIERRE FRIDMANN
L'équilibrage des installations de chauffage
Special edition of CFP - CHAUD FROID PLOMBERIE

4 A. LIBERT
Le génie climatique de A à Z
Special edition of CFP - CHAUD FROID PLOMBERIE

5 W. F. HUGHES - J. A. BRIGHTON
Theory and problems of fluid mechanics
Collana SCHAUM - ETAS LIBRI

6 RANALD V. GILES
Theory and applications of fluid and hydraulic mechanics
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