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ISO 15748-2

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Ships and marine technology — Potable water supply on ships and marine structures —

Part 2: **Method of calculation**

Navires et technologie maritime — Approvisionnement en eau potable sur navires et structures maritimes —

Partie 2: Méthode de calcul

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 15748 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15748-2 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

ISO 15748 consists of the following parts, under the general title *Ships and marine technology — Potable water supply on ships and marine structures*:

— *Part 1: Planning and design*

— *Part 2: Method of calculation*

Annexes A, B, C and D of this part of ISO 15748 are for information only.

Ships and marine technology — Potable water supply on ships and marine structures —

Part 2: Method of calculation

1 Scope

This part of ISO 15748 applies to the planning, design and configuration of potable water supply systems on ships, stationary or floating marine structures and inland waterway crafts.

This part of ISO 15748 serves to determine the quantity of potable water to be carried on board, the capacity of the pressurized reservoirs and water heaters, the pumping capacity, etc.

NOTE In accordance with ISO 15748-1 plastic pipes are permitted but are rarely used at present due to the restrictive conditions laid down by the classification societies. Pressure losses in plastic pipes have not yet been included in ISO 15748 owing to their limited applicability.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15748. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15748 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 65, *Carbon steel tubes suitable for screwing in accordance with ISO 7-1*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

ISO 274, *Copper tubes of circular section — Dimensions*

ISO 1127, *Stainless steel tubes — Dimensions, tolerances and conventional masses per unit length*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 5620-1, *Shipbuilding and marine structures — Filling connection for drinking water tanks — Part 1: General requirements*

ISO 15748-1, *Ships and marine technology — Potable water supply on ships and marine structures — Part 1: Planning and design*

3 Potable water consumption

3.1 General

The consumption of potable water depends on the type of ship, underway time (time the crew and passengers are embarked), number of potable water dispensing and supply points and the cruising area.

Rough calculations of the daily potable water requirements should be based on the guide values in Table A.1.

Determination of potable water consumption with respect to the planned/existing dispensing points should be based on the guide values in Table A.2 for cargo ships and in Table A.3 for passenger ships.

3.2 Potable water requirements of technical equipment

The quantity of potable water required by other technical facilities including air conditioning equipment/plants for air humidification is to be taken from the information supplied by the manufacturer of the respective facility and added to the potable water consumption determined in accordance with 3.1.

3.3 Potable water consumption of commissary equipment

The following guide values for water consumption have been determined; detailed values shall be supplied by the manufacturer. The determined quantity shall be added to the values determined in accordance with 3.1.

- garbage grinders for food disposal = 20 l/min
- dishwashing machines = 3 l/rack up to 8 l/rack
- coffee and tea machines = 18 l/h to 120 l/h
- vegetable peeling and cleaning machines = 5 l/filling
- washing machines = 25 l/kg dry laundry

4 Potable water storage

Potable water storage and potable water distilling plants shall be provided in consultation with the contractor.

5 Determination and sizing of system components

The sizes of system components shall be determined taking into account:

- the pipe material to be used;
- the configuration of the potable water installations (pipelines, fittings, service devices);
- the calculation plans for cold water, hot water and circulation lines.

The sizing of components is calculated based on to the expected volume flow at the time of the maximum water comsumption = peak flow.

The values and information required for the calculations are listed in Tables A.4 to A.11 and in Figures A.1 to A.4.

The use of the forms supplied in annex B has proved helpful for the calculation process.

6 Flow rates

In order to prevent flow noises and pressure surges, flow rate limitations should be considered.

NOTE Two examples of flow rate limitation are given below.

Example 1

- 2,5 m/s in engine rooms and machinery trunks;
- 2,0 m/s in commissary spaces;
- 1,4 m/s in accommodation decks;
- 1,0 m/s in the hospital and close vicinity;
- 1,0 m/s in pump suction lines;
- 0,5 m/s in circulating lines.

Example 2

- 2,5 m/s for CuNi pipes with DN $\leqslant$ 65 (delivery);
- 2,0 m/s for CuNi pipes with DN 50 and steel pipes with DN $\leqslant$ 65 (delivery);
- 1,4 m/s for CuNi pipes with DN $\leqslant$ 25 and steel pipes with DN $\leqslant$ 32 (delivery); any material pipe with DN $\leqslant$ 65 (suction);
- 1,0 m/s for pipes with DN $\leqslant$ 15 (delivery); any material pipe with DN $\leqslant$ 32 (suction);
- 0,7 m/s for any material pipe with DN $\leqslant$ 15 (suction).

7 Supply pressure

The minimum system supply pressure (pump, water reservoir) is determined by adding the pressure losses due to:

- geodetic differences in altitude;
- pressure losses in the apparati;
- pressure losses from pipe friction and individual resistances;
- minimum flow pressure of 1,5 bar or, following greater demands at the highest dispensing point, plus 10 %. The pressure losses at the suction side shall be taken into consideration.

8 Generation and maintenance of pressure

8.1 General

Potable water may either be supplied directly, or indirectly, via pressurized water reservoirs. Direct supply is appropriate if large quantities of potable water per hour are consumed, e.g. on passenger ships. In all other cases mostly pressurized water reservoirs are used.

The decision as to which method of potable water supply is suitable depends on the peak demand for potable water and is also influenced by the arrangement, space requirements, weight etc. of the components or component groups within the entire supply system.

The limit for deciding between pressurized water reservoirs of direct pump supply lies between 30 m^3/h and 40 m^3/h.

Minimum supply pressure in accordance with clause 7 shall be ensured.

The design temperature for the system is 10 °C.

8.2 Pressurized water reservoirs

In order to keep the available quantity of water, i.e. the quantity between pump cut-ins and cut-offs, as great as possible, and to prevent frequent switchings of the pump, the water stored in the pressurized reservoirs is sufficiently pre-compressed with air.

This pre-compression shall be 0,3 bar less than the pump cut-in pressure. The pressure difference between cut-in and cut-off pressure shall be between 1 bar and 2 bar.

The switching frequency is usually between 6 and 8 switching events h^{-1}; however, 12 switching events h^{-1} shall not be exceeded.

The required reservoir capacity is to be determined in accordance with Figure A.4.

8.3 Supply pumps

8.3.1 General

The capacity of centrifugal pumps shall be such that when the cut-off pressure is reached the capacity corresponds to 110 % of the calculated maximum consumption (10 % margin). Reciprocating pumps shall be dimensioned for 120 % to 130 % of the maximum consumption rate determined.

Pumps with flat characteristic curves shall be selected. If several pumps are used, the cut-in and cut-off pressures of each pump shall be stepped with respect to each other, e.g. 4 bar, 3,5 bar, 3 bar.

Provisions shall be made for quantities of water supplied from continuous-action pumps but remaining unused to be fed back to the potable water reservoirs.

8.3.2 Pump suction lines

The guide values listed in Table A.4 are valid for steel pipes and do not include losses caused by pipe elbows, fittings, etc. These losses shall be taken into consideration.

8.3.3 Pump discharge lines

The pump discharge line connects the supply pump with the water reservoir via a shut-off fitting. The nominal width shall be determined in accordance with Table A.5.

9 Pipe diameters of distribution lines

The pipe diameters shall be determined as follows:

— ascertain the calculation flow at service points of pipe sections (for guide values see Table A.12);

— determine the sum flows for these pipe sections and allocate to the pipes;

— determine the peak flow for these pipe sections in accordance with Figure A.3;

— determine pipe diameters and pressure losses provisionally with the help of Figure A.1; if pressure losses are too high, larger diameters shall be selected;

or

by means of a more simple procedure by determining nominal widths from Table A.11 on the basis of the respective maximum flows.

10 Hot water requirements

The volume of hot water to be provided or to be kept in store shall be determined from the peak demand for mixed water using the following equations:

$$V_M = V_C + V_H \quad (1)$$

$$\frac{H}{C} = \frac{t_M - t_C}{t_H - t_M} \quad (2)$$

$$V_H = \frac{V_M}{H + C} \times H \quad (3)$$

where

V_M is the mixed water volume;

V_C is the cold water volume;

V_H is the hot water volume;

C is the cold water portion;

H is the hot water portion;

t_M is the mixed water temperature;

t_C is the cold water temperature;

t_H is the hot water temperature.

11 Water heaters

11.1 Determination of the necessary water heater volume

a) Continuous-flow water heaters

They shall be sized with respect to the peak demand for hot water.

b) Storage heaters

The size of storage heaters shall be selected so that the peak demand for hot water:

— on passenger ships can be heated in 4 h;

— on other ships can be heated in 2 h.

An additional heating facility which may be required for emergency use or during docking may be smaller in capacity. For passenger ships, it is recommended that the necessary hot water volume be divided between two or more water heaters.

The supply of hot water shall also be ensured in port.

11.2 Guide values for water heater volumes

Guide values for necessary water heater volume (depending on the load/number of persons), heating power and additional heating are listed in Table A.6.

12 Circulation lines and circulating pumps

12.1 Determination of nominal widths

The nominal widths of circulating lines depend on the nominal widths of the water supply lines. The respective guide values are listed in Table A.7.

For systems including several circulating lines, installation of restriction fittings in the direction of flow upstream of the shut-off fitting is recommended.

12.2 Determination of pump delivery flow

The pump delivery flow $\dot{V}_{\mathrm{UP}}$ required is determined from the total volume V_{tot} of the water supply and circulating lines (not including the storage reservoir or water heater capacities) and the number of water circulations per hour according to the following equation:

$$\dot{V}_{\mathrm{UP}} = n \times V_{\mathrm{tot}} \tag{4}$$

where

$\dot{V}_{\mathrm{UP}}$ is the pump delivery flow, in litres per hour;

n is the number of circulations per hour;

V_{tot} is the total volume of water supply and circulating lines, expressed in litres.

Circulating the hot water three times per hour is enough to prevent excessive cooling of the water. For the volume of water per meter of pipe see Tables A.8 to A.10.

12.3 Determining the head of the pump

The head of the pump required, H_{UP}, is determined from the sum of the pressure losses due to pipe friction and individual resistances in the longest circulation section plus 40 %.

The slight pressure losses due to the circulation flow through the water distributing lines and risers may be neglected in determining the head of a pump, H_{UP}.

12.4 Selection of pumps

Once the pump delivery and the required head, H_{UP}, have been determined, the adequate size of the pump shall be selected with the help of the pump diagram, which shall be supplied by the manufacturer.

If the operating point determined is between two pump-performance characteristics curves (P1 and P2 see Figure A.2), selection of the smaller pump is recommended for economic reasons.

13 Calculation example

A calculation example for the application of this part of ISO 15748 including tables and figures shown in annex A and the sheets shown in annex B, is given in annex C.

Annex A
(informative)

Tables and figures with useful information

Table A.1 — Guide values for potable water consumption in litre per person/bed and day

Type of ship		Group of persons embarked	Water consumption when fitted with	
			Flushing toilet system	Vacuum toilet system
Seagoing ship	Cargo ship	Crew/bed	220 l	175 l
	Passenger ship	Passenger/bed	270 l	225 l
	Luxury liner	Passenger/bed	—	275 l
	Ferryboat with cabins	Passenger/bed	205 l [a]	160 l [a]
		Passenger without bed	100 l	55 l
	Ferryboat without cabins	Passenger without bed	150 l	105 l
		Crew without bed	100 l	55 l
Inland waterway craft	Cargo ship	Crew/bed	Minimum 150 l	
	Passenger ship with cabins	Passenger/crew/bed	220 l	175 l
	Passenger ship without cabins	Crew/passenger	100 l	
Special-purpose ship	Research ship	per bed	220 l	175 l
	Federal armed forces tender and larger	Crew/bed	160 l	110 l
	Federal armed forces – smaller than tender	Crew/bed	100 l	55 l
Fishing vessel		Crew/bed	Minimum 150 l	
Offshore		Crew/bed	350 l	

[a] No shipboard laundry.

Table A.2 — Guide values for cargo ships water consumption at different service points per person and day

Service point	Consumption per use	Frequency of use	Consumption		
			Total quantity of water	Cold water	Hot water [a]
	l	per day	l/day	l/day	l/day
Wall-hung/pedestal wash basin	2	6 ×	12	5	7
Shower base	60	2 ×	120	50	70
Flushing W.C. [b]	10	6 ×	60	60	—
Vacuum W.C. [b]	1,2	6 ×	8	8	—
Urinal [b]	3	5 ×	15 [c]	15 [c]	—
Galley area	—	—	20	8	12
Laundry [b]	—	—	38	15 [d]	23
Cleaning	—	—	5	2	3

[a] At a hot water inlet temperature of 60 °C.

[b] If non-potable water is used the consumption of potable water decreases accordingly.

[c] The use of the urinals reduces the use of the WCs.

[d] Consumption of appliances with hot water connections.

Table A.3 — Guide values for passenger ships water consumption at different service points per person and day

Service point	Consumption per use	Frequency of use	Consumption		
			Total quantity of water	Cold water	Hot water [a]
	l	per day	l/day	l/day	l/day
Wall-hung/pedestal wash basin	2,5	8 ×	20	8	12
Shower base [d]	60	2 ×	120	50	70
Bath tub	150	1 ×	150	60	90
Flushing W.C. [b]	10	6 ×	60	60	—
Vacuum W.C. [b]	1,2	6 ×	8	8	—
Urinal [b]	3	5 ×	15 [c]	15 [c]	—
Galley dining rooms	—	—	25	10	15
Laundry [b]	—	—	75 to 100	30 to 40	45 to 60
Cleaning	—	—	20	8	12
Shower and swimming pool	—	—	10 [e]	—	—
Fresh water for swimming pool	—	—	10 [e]	—	—
Whirlpool	—	—	60 [e]	—	—
Sauna	60	1 ×	60	—	—

[a] At a hot water inlet temperature of 60 °C.

[b] If non-potable water is used the consumption of potable water decreases accordingly.

[c] The use of the urinals reduces the use of the WCs.

[d] If bath tubs and showers are provided, one use per day shall be anticipated.

[e] Additional quantity of water per user and day.

Table A.4 — Pump suction lines, nominal widths and maximum pipe lengths

Pump delivery flow	l/s	0,5	0,67	0,83	1,0	1,2	1,3	1,5	1,8	2,1	2,8	4,2	5,5	7,0	8,3
	m³/h	1,8	2,4	3,0	3,6	4,2	4,8	5,4	6,6	7,5	10	15	20	25	30
Nominal width	DN	**25**		**32**		**40**		**50**		**65**		**80**		**100**	
Suction lift	m	Length of pipe line (m)													
0		120	80	105	80	210	140	280	210	140	120	130	100	120	105
1		100	70	90	70	180	120	240	180	120	100	110	85	95	90
2		85	55	75	55	150	100	200	150	100	85	90	70	75	70
3		70	45	60	45	120	80	160	120	80	75	70	60	55	45

Table A.5 — Pump pressure lines, nominal widths

Pump delivery flow	l/s	0,5	0,67	0,83	1,0	1,2	1,3	1,5	1,8	2,1	2,8	4,2	5,5	7,0	8,3
	m³/h	1,8	2,4	3,0	3,6	4,2	4,8	5,4	6,6	7,5	10	15	20	25	30
Nominal DN width		**20**		**25**		**32**		**40**		**50**		**65**		**80**	

Table A.6 — Guide values for water heater volumes, heating power and additional heating

Number of persons	**Water heater volume**	**Heating power**	**Heating-up time from 10 °C to 65 °C**	**Quantity in l of mixed water of 40 °C to be produced in**		**Additional heating power**
	l	kW	min	1 h	2 h	kW
1 to 10	200	15	51	660	1 030	8
	300	10	115	680	930	5
11 to 20	400	30	51	1 320	2 060	15
	650	20	125	1 440	1 940	10
21 to 30	650	40	62	1 940	2 920	20
	1 000	20	192	1 960	2 450	10
31 to 50	1 000	40	96	2 450	3 440	20
	1 500	25	230	2 820	3 440	13
51 to 75	1 000	80	48	3 440	5 400	40
	1 500	60	96	3 680	5 160	30
	2 000	40	192	3 930	4 910	20
76 to 100	2 000	80	96	4 910	6 880	40
	3 000	40	288	5 400	6 380	20
101 to 150	3 000	100	115	6 880	9 330	50
	5 000	40	480	8 350	9 330	20
151 to 200	3 000	160	72	8 350	12 280	60
	5 000	100	192	9 820	12 280	50
201 to 300	5 000	200	96	12 280	17 200	60
	7 000	150	179	14 000	17 690	50
301 to 500	7 000	300	90	17 690	25 060	70
	10 000	200	192	19 650	24 570	60
501 to 700	7 000	400	67	20 140	29 970	80
	10 000	300	128	22 110	29 480	70
701 to 1 000	10 000	550	70	28 250	41 770	100

NOTE 1 As a rule, single water heaters with more than 3 000 l capacity are not used. For greater hot water demands, two or more water heaters of appropriate size, or continuous-flow heaters are provided.

NOTE 2 For every size of number of persons two possible decisions are shown.

NOTE 3 The column “Additional heating power” takes into consideration the hot water supply to be ensured in port (see 11.1).

Table A.7 — Guide values for nominal widths of circulating lines

Water supply line nominal width DN	Circulating line nominal width DN
12	12
15	12
20	12
25	12
32	12
40	20
50	20
65	25
80	25
100	32

NOTE The value given in Tables A.8 to A.10 are valid for those pipes included in ISO 15748-1.

Table A.8 — Water volume in steel pipes

Nominal width	Water volume in l/m in				
	Unalloyed steel pipes in accordance with				Stainless steel pipes in accordance with
	ISO 65		ISO 4200		ISO 1127
DN	Medium series	Heavy series	Seamless	Welded	
6	0,030	0,019	—	—	—
8	0,061	0,047	—	—	—
10	0,123	0,102	0,145	0,145	0,154
12	—	—	—	—	—
15	0,201	0,172	0,235	0,235	0,257
20	0,366	0,327	0,391	0,412	0,441
25	0,581	0,515	0,638	0,693	0,731
32	1,012	0,924	1,087	1,122	1,207
40	1,372	1,269	1,459	1,500	1,598
50	2,206	2,067	2,333	2,437	2,561
65	3,718	3,536	3,882	3,948	4,015
80	5,128	4,927	5,346	5,434	5,581
100	8,709	8,413	9,009	9,144	9,348

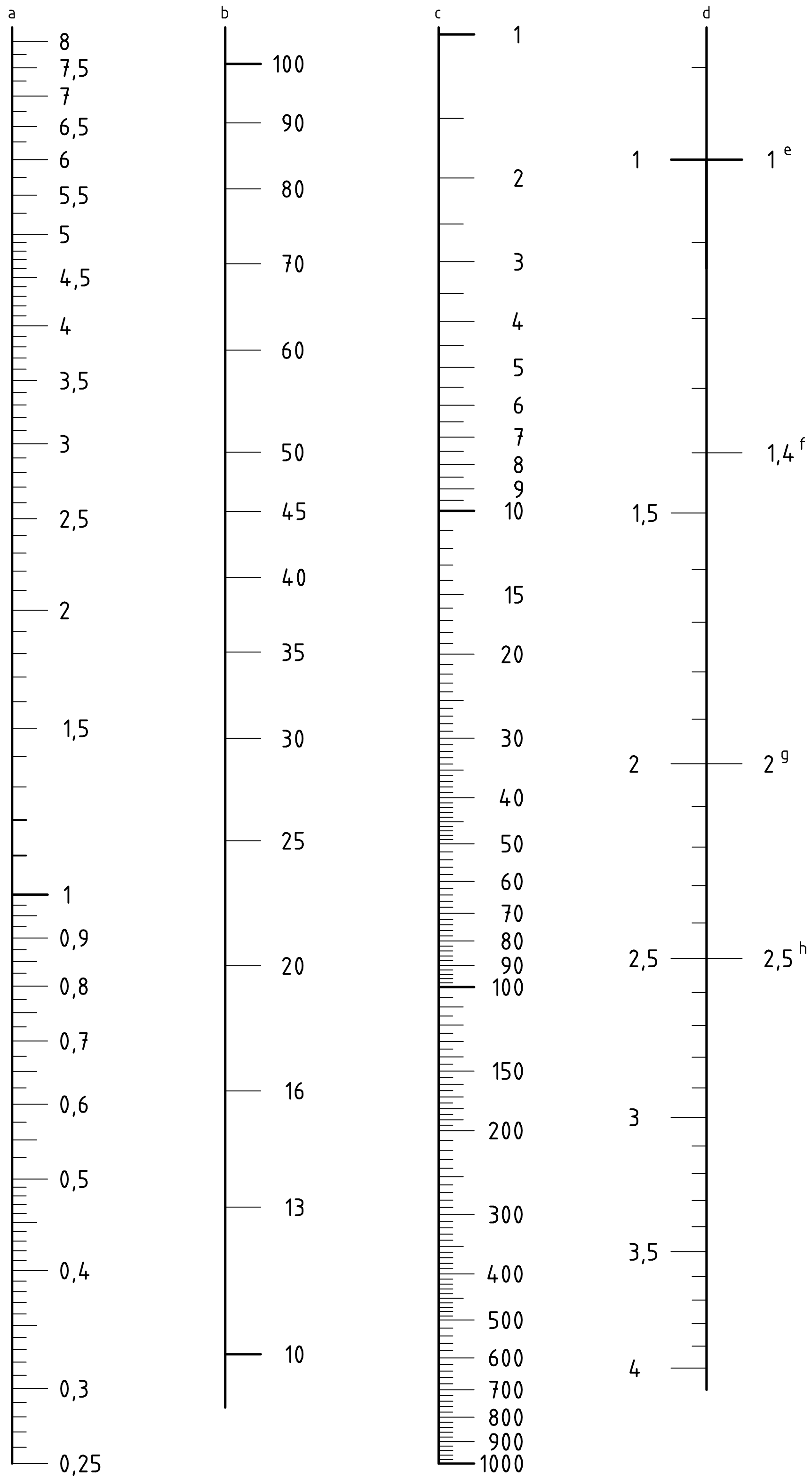
Table A.9 — Water volume in copper pipes

Nominal width	Water volume in l/m in pipes of	
	SF-Cu in accordance with ISO 274	CuNiFe dimensions in accordance with ISO 274
DN		
6	0,028	0,050
8	0,038	0,079
10	0,064	—
12	0,133	0,154
15	0,227	0,254
20	0,380	0,380
25	0,531	0,573
32	0,908	0,962
40	1,195	1,353
50	1,963	2,290
65	4,077	4,072
80	5,668	5,675
100	8,332	8,332

Table A.10 — Water volume in plastic pipes

Nominal width	Water volume in l/m in						
	Polybutene pipes	Polyethylene pipes			Polypropylene pipes	Polyvinylchlorid pipes	
	PB	PE-LD	PE-HD	PE-X	PP	PVC-C	PVC-U
DN	Outside diameters in accordance with ISO 161-1						
6	0,032	0,028	0,032	0,032	0,028	0,045	—
8	0,055	0,050	0,055	0,055	0,072	0,066	0,079
10	0,121	0,088	0,121	0,106	0,113	0,121	0,145
12	—	0,137	—	0,163	0,177	0,186	—
15	0,206	0,216	0,201	0,254	—	0,296	0,227
20	0,327	0,353	0,327	0,423	0,290	0,483	0,353
25	0,531	0,556	0,531	0,661	0,452	0,755	0,581
32	0,835	0,866	0,835	1,029	1,122	1,182	1,018
40	1,307	1,385	1,307	1,633	1,590	1,886	1,425
50	2,075	1,963	2,075	2,324	2,290	2,697	2,256
63	4,254	4,208	2,942	3,339	3,421	3,848	3,610
80	6,362	5,437	4,254	5,001	5,542	5,728	5,204
100	8,203	—	8,203	8,107	9,161	9,297	7,760

To facilitate the decision as to appropriate nominal widths of pipes, Table A.11 lists nominal pipe widths and respective pressure differential R as functions of flow rates for selected peak flows $\dot{V}_S$. This interdependence of the individual factors is based on the diagram presented in Figure A.1.



a Peak flow, $\dot{V}_s$, in l/s

b Internal pipe diameter, d_1, in mm

c Pressure differential, R (the pressure differences include losses in elbows, branches, valves, etc.)

d Flow rate, v, in m/s

e Hospital and close vicinity

f Accommodation data

g Commissary spaces

h Machinery spaces and trunk

Figure A.1 — Nomogram for determination of nominal pipe widths and pressure differentials for given peak flows and flow rates for copper and stainless steel pipelines

The values listed in Table 11 are rounded up/down.

Table A.11 — Peak flows, nominal widths, pressure differentials for copper and stainless steel pipelines

Peak flow V_S l/s	Flow rate v m/s							
	1		1,4		2		2,5	
	Nominal width DN	Pressure differential R mbar/m	Nominal width DN	Pressure differential R mbar/m	Nominal width DN	Pressure differential R mbar/m	Nominal width DN	Pressure differential R mbar/m
0,2	15	20,0	12	50	10	125	10	220
0,3	20	14,0	15	36	12	95	12	170
0,45	25	11,0	20	27	15	70	15	130
0,7	32	8,0	25	20	20	52	20	95
1,0	40	6,0	32	15	25	40	25	75
1,5	40/50	4,8	40	11,5	32	30	32	55
2,25	50	3,5	50	8,6	40	23	32	42
3,5	65	2,6	65	6,5	50	16,5	40	30
5,25	80	1,9	65	4,7	65	12	50	23
8,0	100	1,5	80	3,7	65	9,5	65	17

NOTE The pressure differentials mentioned include losses occurring at elbows, branchings, valves, etc. Pressure differentials due to pipe friction are only very small over a temperature range of up to 60 °C; this alteration of the pressure differential is negligible.

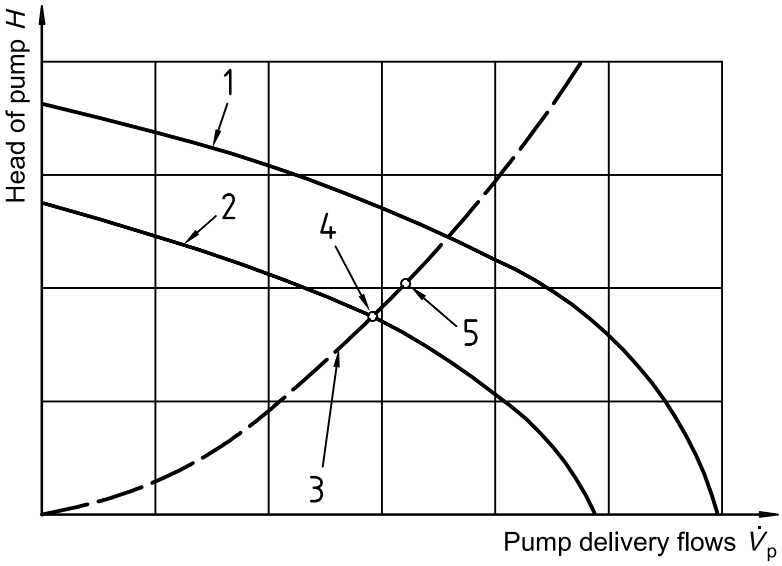
Table A.12 — Guide values for minimum flow pressures and calculation flow of standard potable water service points

Minimum flow pressure	Type of potable water service point	Calculation flow for withdrawal of		
		Mixed water [a]		Cold or heated potable water only
p_{minFl} bar		$\dot{V}_R$ cold l/s	$\dot{V}_R$ warm l/s	$\dot{V}_R$ l/s
	Output valves			
0,5	without bubbler [b] .... DN 15	—	—	0,30
0,5	DN 20	—	—	0,50
0,5	DN 25	—	—	1,00
1,0	with bubbler .... DN 10	—	—	0,15
1,0	DN 15	—	—	0,15
1,0	Shower heads for cleaning purposes .... DN 15	0,10	0,10	0,20
1,2	Flush valve for flushing W.C. .... DN 15	—	—	0,70
1,2	Flush valve for flushing W.C. .... DN 20	—	—	1,00
0,4	Flush valve for flushing W.C. .... DN 25	—	—	1,00
1,0	Flush valve for urinals .... DN 15	—	—	0,30
1,0	Household dishwasher .... DN 15	—	—	0,15
1,0	Household washing machine .... DN 15	—	—	0,25
—	Commissary machines and appliances (data according to manufacturer) .... DN . . .	—	—	—
	Mixer taps			
1,0	Shower bases .... DN 15	0,15	0,15	—
1,0	Bath tubs .... DN 15	0,15	0,15	—
1,0	Kitchen sinks .... DN 15	0,07	0,07	—
1,0	Pedestal wash bains .... DN 15	0,07	0,07	—
1,0	Bidets .... DN 15	0,07	0,07	—
1,0	Foot baths .... DN 15	0,07	0,07	—
1,0	**Mixer taps** .... DN 20	0,30	0,30	—
0,5	Flush tanks for flushing W.C. .... DN 15	—	—	0,13
1,5	Vacuum lavatory .... DN 15	—	—	0,30
1,0	Electrical water boiler .... DN 15	—	—	0,10

NOTE For supply points and apparati not included in this table and that are of the same type as those listed but with greater flows or minimum flow pressures than those given here, the data supplied by the manufacturer are to be taken into consideration when determining the required pipe diameter.

[a] The calculation flows for the withdrawal of mixed water are based on 15 °C for cold and 60 °C for hot drinking water.

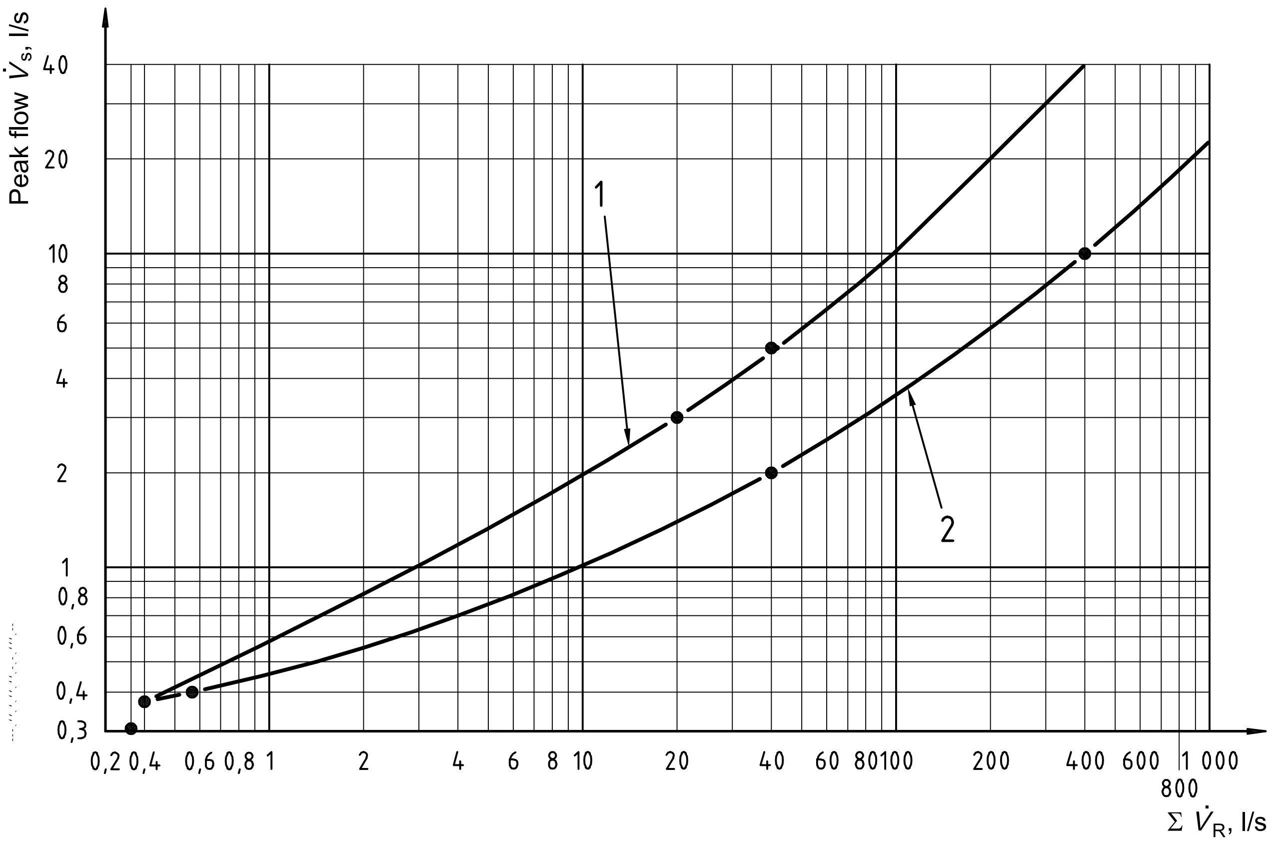
[b] For output valves without bubblers and with hose end fittings, a standard value for the pressure loss in the hose line (up to 10 m) and in the apparatus (e.g. high-pressure cleaner) connected is included in the minimum flow pressure. In this case, the minimum flow pressure increases by 1 bar to 1,5 bar.



Key

1 Pump performance characteristic (P1)
2 Pump performance characteristic (P2)
3 Pipeline characteristic
4 Computed operating point (BP)
5 Recommended operating point

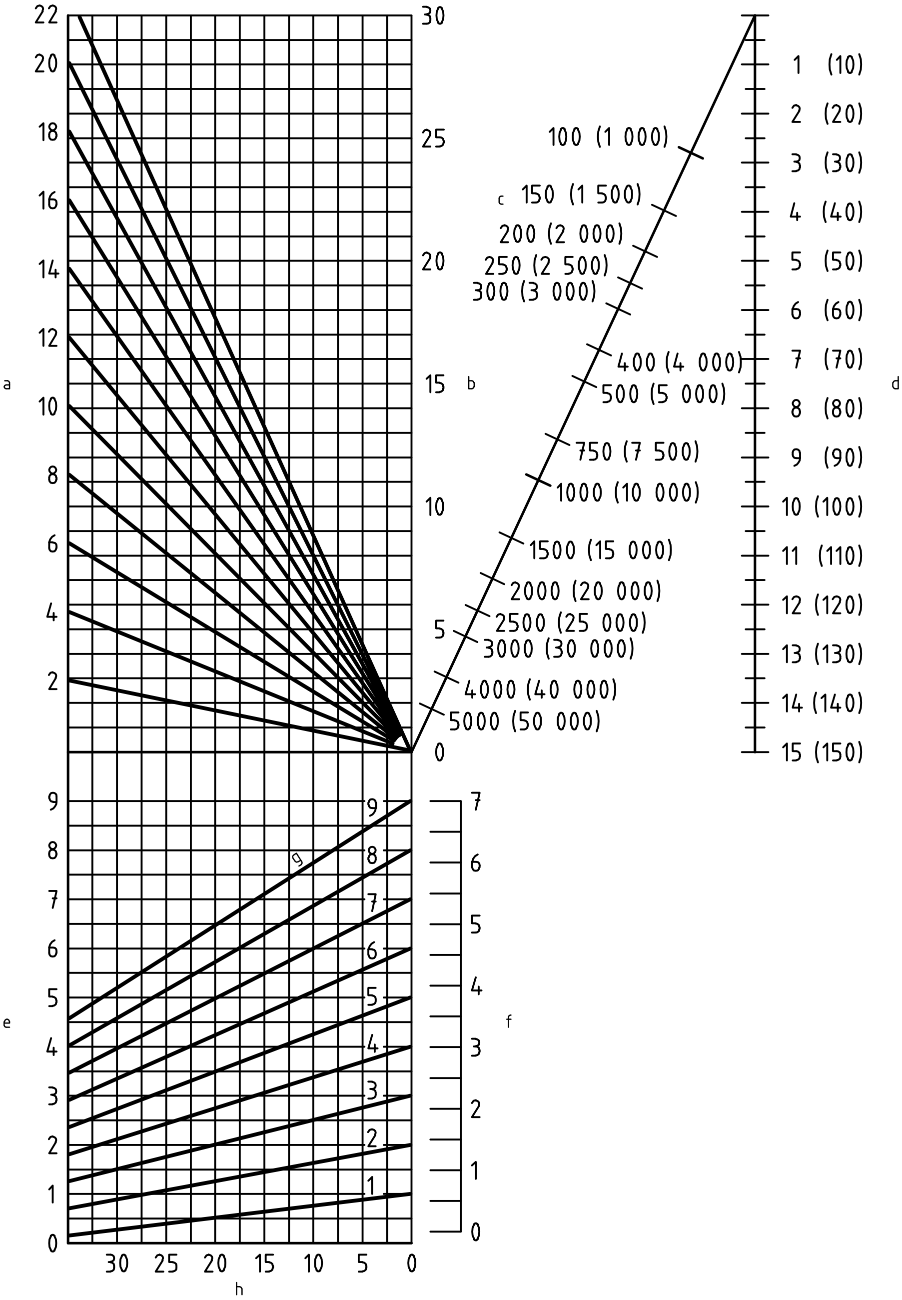
Figure A.2 — Selection of suitable pump size



Key

1 Passenger ship
2 Cargo ship

Figure A.3 — Peak flow $\dot{V}_s$ as a function of the sum flow $\Sigma \dot{V}_R$



a Switching frequency per h S

b $\frac{\text{Pump delivery flow}}{\text{Reservoir volume}} \times \frac{\dot{V}_\text{p}}{V_\text{D}} \times \frac{\text{m}^3}{\text{h} - \text{m}^3}$

c Reservoir volume V_D l

d Pump delivery flow $\dot{V}_\text{p} = \dot{V}_\text{Pmin}$ in m³/h

e Cut-in pressure p_E of the pump in bar

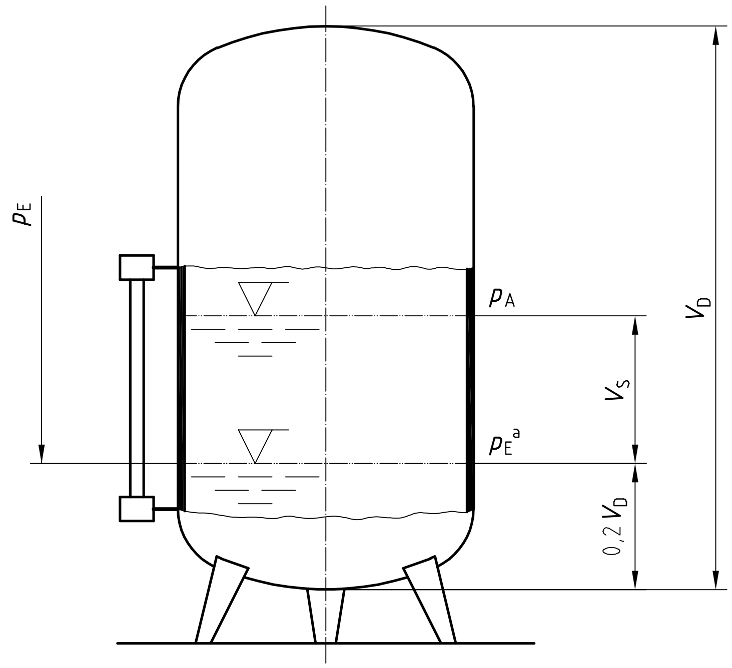
f Pre-pressure p_V in bar; for compressed air in the water reservoir

g Cut-out pressure p_A in bar

h Usable volume of water reservoir V_eff in %

$$V_\text{eff} = \frac{V_\text{s}}{V_\text{D}} \times 100$$

Figure A.4 — Functional diagram for determination of the size of water reservoirs



a p_E marking on the level indicator.

Figure A.5 — Determination of the size of the pressurized water reservoir

For computation of this value the equations (A.1) to (A.3) can be used:

$$\frac{V_s}{V_D} = \frac{p_A \times p_E}{p_A + p_E} \times 0{,}8 \quad \text{(A.1)}$$

$$p_V = 0{,}8 - p_E \times 0{,}2 \quad \text{(A.2)}$$

$$\frac{\dot{V}_p}{V_D} = \frac{V_S}{V_D} - 4 - S \quad \text{(A.3)}$$

where

p_A is the pump cut-off pressure in bar;

p_E is the pump cut-in pressure in bar;

p_V is the pre-pressure for compressed air cushions inside the water reservoir in bar;

$\dot{V}_p$ is the pump delivery in cubic metres per hour;

S is the pump switching frequency per hour (h^{-1});

V_D is the water reservoir volume in cubic metres;

V_S is the storage volume = maximum storable volume of water.

Annex B
(informative)

Form sheets for calculation

The user of this part of ISO 15748 may reprint the form sheets shown in annex B.

B.1 Form sheet for the determination the maximum flow by using the sum flow

Building No:											
Official in charge:					Date:				Sheet-No:		
Riser (trunk line) No.	Deck	Number	Outlet fitting combination of outlet fitting	Minimum flow pressure pressure loss	Calculated flow			Sum flow			
					Water		Mixed water	Deck line		Riser (trunk line)	
					cold	hot		cold	hot	cold	hot
				$p_{\text{min Fl}}$	$\dot{V}_R$	$\dot{V}_R$	$\dot{V}_R$	Σ	Σ	Σ	Σ
				mbar	l/s	l/s	l/s	l/s	l/s	l/s	l/s
1	2	3	4	5	6	7	8	9	10	11	12

B.2 Form sheet for the determination of pipe diameters and pressure losses

Building No.:												
Official in charge:							Date:			Sheet-No.:		
Trunk No.:				Type of pipe:				In accordance with:				
Cold water/Hot water												
From the pipe plan				Used provisional pipe diameter				Used changed pipe diameter				Difference
Line part	Length of pipe	Sum flow	Peak flow	Nominal diameter	Calculated flow speed	Pressure differential	Pressure loss	Nominal diameter	Calculated flow speed	Pressure differential	Pressure loss	Pressure loss
	l	Σ	$\dot{V}_s$		v	R	$l \times R$		v	R	$l \times R$	$\Delta(l \times R)$
TS	m	l/s	l/s	DN	m/s	mbar/m	mbar	DN	m/s	mbar/m	mbar	mbar
1	2	3	4	5	6	7	8	9	10	11	12	13

B.3 Form sheet for the calculation of a circulation system

Building No.:													
Offical in charge:							Date:				Sheet-No.:		
Potable water line cold/hot					Circulation line, calculation in accordance with clause 12								
Line part	Length of pipe	Nominal diameter	Water capacity per m pipe	Capacity	Line part	Length of pipe	Nominal diameter	Water capacity per m pipe	Capacity	Peak flow	Flow speed	Pressure differential	Pressure loss
	l		V/l	V		l		V/l	V	$\dot{V}_s$	v	R	$l \times R$
TS	m	DN	l/m	l	TS	m	DN	l/m	l	l/s	m/s	mbar/m	mbar
1	2	3	4	5	6	7	8	9	10	11	12	13	14

B.4 Form sheet for the calculation of the supply pressure

Building No.:								
Official in charge:		Date:		Sheet No.:				
Cold water/Hot water								
Information about the system: a) Connected to the supply use — Direct ☐ Indirect ☐		b) Central potable water heater ☐ — Sectional potable water heater ☐						
No.	Term	Symbol	Unit	Trunk				
				1	**2**	**3**	**4**	**5**
1	Pressure loss caused by geodetic difference in altitude	Δp_{geo}	mbar					
2	Pressure loss in apparatus e.g.							
	a) Pressure tanks	Δp_{PT}	mbar					
	b) Filter	Δp_{FIL}	mbar					
	c) Sterilization plant	Δp_{EH}	mbar					
	d) Dosing devices	Δp_{DOS}	mbar					
	e) Potable water heater	Δp_{TE}	mbar					
	f) Other apparatus	Δp_{Ap}	mbar					
3	Minimum flow pressure	$p_{\text{min Fl}}$	mbar					
4	Pressure loss of the lines from Form Sheet B.2	Δp_{LE}	mbar					
5	Sum of pressure losses from No. 1 to No. 4	$\Sigma\Delta p$	mbar					

Annex C
(informative)

Calculation example

C.1 General

The following example shows how to use formulae, tables and form sheets given in this part of ISO 15478.

The calculation example is given for a cargo ship with passenger cabins, with central supply of hot water.

All numbers in bold letters correspond to the clause number or Table number in the text or in annex A or annex B.

C.2 Basic for calculation

C.2.1 The following requirements, basics or values are given by the building contract, the general arrangement plan or similar documents:

a) cargo ship with a crew of eighteen members and six passenger cabins;

b) one standard sanitary unit per passenger cabin;

c) one room and one standard sanitary unit per crew member;

d) central supply of hot water by means of storage heaters;

e) supplied indirectly via pressurized water reservoir;

f) UV-sterilization plant.

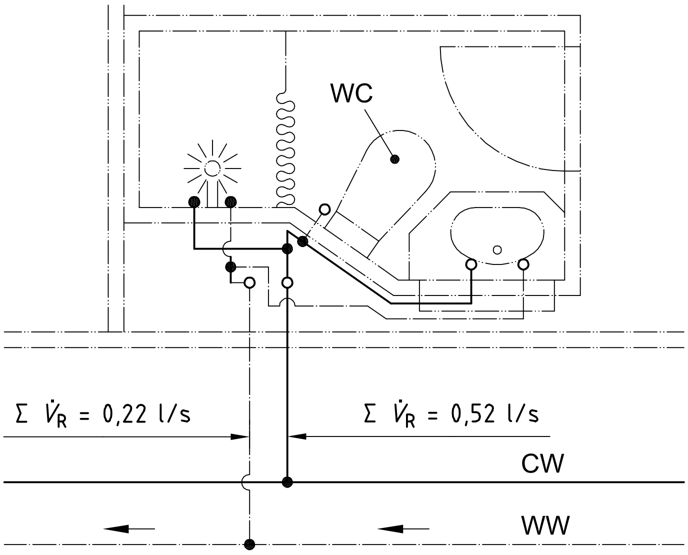
C.2.2 The following documents are to be established:

a) arrangement of potable water installations (equipment, piping, water consuming equipment, valves etc.) (see Figures C.1 and C.2);

b) calculation plan for potable water pipework for hot and cold water, (see Figure C.2);

c) calculation plan for circulating lines;

d) selection of type of pipes.



Key

CW cold water, trunk line
WW hot water, trunk line
WC vacuum WC

Service lines:

Trunk — wash basin	1,25 m horizontal + 1,5 m vertical = 2,75 m for CW and WW
Trunk — shower	1,25 m horizontal + 1,0 m vertical = 2,25 m for CW and WW
To the WC	≈ 2,0 m for CW (downwards)
Trunk — trunk line	0,75 m for CW and WW

Figure C.1 — Standard sanitary unit (sanitary cold and warm water supply)

C.3 Method of calculation

C.3.1 Determination of required potable water volume

— according to Table A.1 or Table A.2;

— potable water reservoirs according to clause 4.

C.3.2 Determination of the peak flow

The values are presented in the form sheet C.1, (see Table D.1).

— registration of all outlet fittings and service points with minimum flow pressure and calculated flow (for guide values see Table A.12).

— calculate and associate sum flows of line parts. Insert values in calculation plan Figure C.2.

— evaluate peak flow by the sum flow using diagram Figure A.3. Add consumption of permanent users (e.g. laundry) to the sum flow.

C.3.3 Determination of pipe diameters and of pressure losses

The values are presented in Table D.2 (see form sheet B.2).

— insert line parts and sum flows of line part taken from calculation plan Figure C.2 or form sheet B.1. The rating starts versus flow direction, beginning at the most distant outlet and ending at the pressure vessel or the pump;

— peak flows evaluated from the sum flows of line parts taken from diagram Figure A.3;

— determine preliminary pipe diameter and pressure differential R, based on pipe friction and the resistance of components, due to the peak flow and the permissible flow rates, using diagram Figure A.1 (The pressure differential include losses at elbows, branches, valves etc.);

— calculate pressure losses $l \times R$.

A simplified determination is possible using Table A.11.

Depending on the permissible flow rates, nominal diameters are associated with peak flows. Sum flow/part line should be selected in such a way that the resulting peak flows are as near as possible to those given in the Table A.11. By this means the determination of a longer part of the pipework and the calculation of the pressure losses is possible.

C.3.4 Calculation of the circulating system

See Table C.5.

The values are presented in form sheet B.3

— insert values taken from Table C.2 (see form sheet B.2 columns 1, 2 and 3);

— take nominal diameters of circulating lines from Table A.7 and allocate them to the distribution lines;

— calculate the volume of the potable water lines and the circulating lines with the values according to Tables A.8 to A.10 (without storage tanks and water heaters);

— calculate the pump delivery flow in accordance with 12.2;

— determine pressure losses with respect to the head of the pump in accordance with 12.3;

— check the flow rates (see clause 6).

C.3.5 Determination of pressure losses and of the necessary head of the pump (supply pressure)

The values are presented in Table C.6 (see form sheet B.4).

The necessary head of the pump is calculated in accordance with clause 7 for the higher value of the hot water and of the cold water.

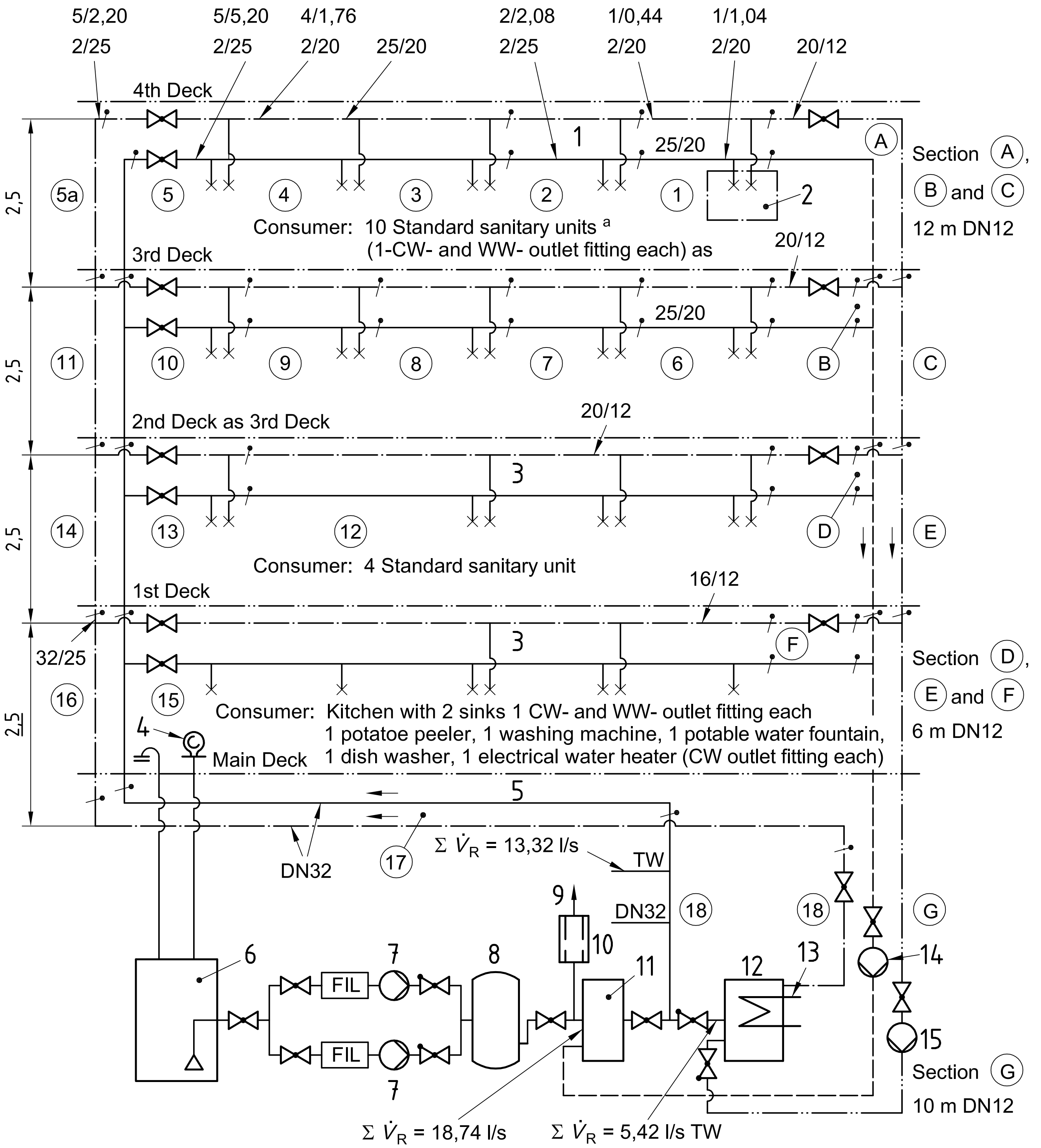
C.3.6 Determination of the capacity of the supply pump

The capacity of the pump is calculated in accordance with 8.3 using the peak flow given in Table C.1 (see form sheet B.1).

C.3.7 Determination of the pressurized water reservoir volume

Determine the pressurized water reservoir volume in accordance with 8.2, using the diagram in Figure A.4 with the pump capacity (see C.3.6) and the head of pump = cut-in pressure (see C.3.5) and the chosen cut-off pressure p_A = 6,25 bar and 12 switching events h^{-1}.

Dimensions in meters



Limitations of the single line parts: numbers and letters in circles represent line part information.

Example how to read: $\frac{1/1{,}04}{2/20} = \frac{\text{No. of the part line / sum flow } \Sigma\dot{V}_R \text{ in l/s}}{\text{length in m /nominal diameter}}$

Key

1 10 m length, 6 elbow

2 Standard sanitary unit
3 10 m length, 6 elbow 90°
4 Filling connection for potable water tanks (see ISO 5620-1)
5 15 m length, 6 elbow 90°, 5 m to main deck
6 Potable water reservoir
7 Potable water supply pump
8 Pressure vessel
9 Technical consumers
10 Pipe disconnector
11 Sterilization unit
12 Water heater
13 Heating media
14 Cold water circulating pump
15 Hot water circulating pump

CW = cold water; WW = hot water; TW = potable water

[a] Only 5 units are shown.

Figure C.2 — Example for a calculation scheme (the determined nominal diameters are recorded)

Table C.1 — Form sheet B.1 for the determination the maximum flow by using the sum flow

Building No:											
Official in charge:				Date:					Sheet-No:		
Riser (Trunk line) No.	Deck	Number	Outlet fitting combination of outlet fitting	Minimum flow pressure pressure loss	Calculated flow			Sum flow			
					Water		Mixed water	Deck line		Riser (Trunk line)	
					cold	hot		cold	hot	cold	hot
				$p_{\text{min Fl}}$	$\dot{V}_R$	$\dot{V}_R$	$\dot{V}_R$	Σ	Σ	Σ	Σ
				mbar	l/s	l/s	l/s	l/s	l/s	l/s	l/s
1	2	3	4	5	6	7	8	9	10	11	12
Standard sanitary unit as given in Figure C.1											
		1	Mixer tap wash basin	1 000	0,07	0,07					
		1	Mixer tap shower	1 000	0,15	0,15					
		1	Vacuum-WC	1 500	0,30						
					——	——					
					0,52	0,22					
5	3	10	Units					5,2	2,2		
10	2	10	Units					5,2	2,2		
11										10,4	4,4
13	1	4	Units					2,08	2,08		
14										12,48	5,28
15	Main deck	2	Kitchen sinks	1 000	0,14	0,14					
		1	Potato peeler	1 000	0,13						
		1	Dish washer	1 000	0,15						
		1	Electrical water heater	1 000	0,10						
		1	Water fountain	1 000	0,07						
		1	Washing machine	1 000	0,25						
					—	—					
					0,84	0,14		0,84	0,14		
16 + 17 Main lineCW										13,32	
WW											5,42
Total flow for CW and WW + permanent consumers = calculation volume18,74l/s + ... = ...											
By Σ = 18,74 l/s there is for cargo ships according to Diagram Figure A.3 a peak flow $\dot{V}_s \approx$ 1,4 l/s											

Table C.2 — Form sheet B.2 for the determination of pipe diameters and pressure losses

Building No.:

Official in charge: Date: Sheet-no.:

Trunk No.: Type of pipe: In accordance with:

Cold water

From the pipe plan				Used provisional pipe diameter				Used changed pipe diameter				Difference
Line part TS	Length of pipe l m	Sum flow Σ l/s	Peak flow $\dot{V}_s$ l/s	Nominal diameter DN	Calculated flow speed v m/s	Pressure differential R mbar/m	Pressure loss $l \times R$ mbar	Nominal diameter DN	Calculated flow speed v m/s	Pressure differential R mbar/m	Pressure loss $l \times R$ mbar	Pressure loss $\Delta\ (l \times R)$ mbar
1	2	3	4	5	6	7	8	9	10	11	12	13
Trunk	0,75	1,04	0,46	20	1,48	29	22	Connections for 2 standard sanitary units				
1	2,0	1,04	0,46	25	1,48	29	58					
2	2,0	2,08	0,55	25	1,15	13	26					
3	2,0	3,12	0,63	25	1,30	16	32					
4	2,0	4,16	0,71	25	1,47	21	42					
5	2,0	5,20	0,78	25	1,61	26	52					
5a	2,5	5,20	0,78	25	1,61	26	65					
							Σ = 297				297	
6		1,04				Same consumers as on the 3rd deck; and DN as on the 3rd deck. Consideration of pressure losses may be deleted, when sufficient flow pressure is available at the most distant outlet fitting at the most upper deck.						
7		2,08										
8		3,12 4,16										
9		5,20										
10												
11	2,5	10,4	1,02	25	2,09	45	113					
$l \times R$ = 113 value too high; new DN								32	1,26	12	30	(83)
12	5,0	1,04	0,46	20	1,48	29						
13	5,0	2,08	0,55	25	1,15	13						
14	2,5	12,48	1,10	25	2,25	52	130					
$l \times R$ = 130 value too high; new DN								32	1,38	14	35	(95)
15	10,0	0,84	0,41	16	2,05							
16	2,25	13,32	1,17	25	2,40	59	133					
$l \times R$ = 133 value too high; new DN								32	1,47	16	36	(97)
17	15,0	13,32	1,17	25	2,40	59	885					
$l \times R$ = 885 value too high; new DN								32	1,47	16	240	(645)
18	5,0	13,32	1,17	25	2,40	59	295					
$l \times R$ = 295 value too high; new DN								32	1,47	16	80	(215)
		$\frac{\text{Total pressure loss}}{\Delta\ \text{pressure loss}}$ by altered DN $\frac{1\,853}{1\,135}$										1 135
		Total pressure loss when DN altered									718	

Table C.3 — Simplified determination by using Table A.11

Part line	Pipe length	Sum flow	Peak flow	Nominal diameter	Calculated flow rate	Pressure differential	Pressure loss
TS	*l*	Σ	$\dot{V}_s$		*v*	*R*	*l* × *R*
	m	*l*/s	*l*/s	DN	m/s	mbar/m	mbar
Trunk line + 1	2,75	1,04	0,46	20	1,4	27	74,25
2 to 5a	10,5	5,20	0,78	25	1,4	20	210
6 to 10	the same as 2 to 5a						
11	2,5	10,4	1,02	32	1,4	15	37,5
12	5,0	1,04	0,46	20	1,4	27	
13	5,0	2,08	0,55	25	1,4	20	
14	2,5	12,48	1,10	32	1,4	15	37,5
15	10,0	0,77	0,41	20	1,4	27	
16 to 18	22,25	13,25	1,17	32	1,4	15	333,75
							Σ = 693

Table C.4 — Form sheet B.2 for the determination of pipe diameters and pressure losses

Building No.: Official in charge: Date: Sheet-No.:

Trunk No.: Type of pipe: In according with:

Hot water

From the pipe plan				Used provisional pipe diameter				Used changed pipe diameter				Difference
Line part	Length of pipe	Sum flow	Peak flow	Nominal diameter	Calculated flow speed	Pressure differential	Pressure loss	Nominal diameter	Calculated flow speed	Pressure differential	Pressure loss	Pressure loss
	l	Σ	$\dot{V}_S$		v	R	$l \times R$		v	R	$l \times R$	$\Delta (l \times R)$
TS	m	l/s	l/s	DN	m/s	mbar/m	mbar	DN	m/s	mbar/m	mbar	mbar
1	2	3	4	5	6	7	8	9	10	11	12	13
Trunk	0,75	0,44	0,37	20	1,20	20	15	Connections for 2 standard sanitary units				
1	2,0	0,44	0,37	20	1,20	20	40					
2	2,0	0,88	0,44	20	1,40	27	54					
3	2,0	1,32	0,49	20	1,58	35	70					
4	2,0	1,76	0,54	20	1,72	41	82					
5	2,0	2,20	0,58	25	1,20	14	28					
5a	2,5	2,20	0,58	25	1,20	14	35					
							Σ = 324				324	
6		0,44										
7		0,88				Same consumers as on the 3rd deck; $\dot{V}_S$ and DN as on the 3rd deck. Consideration of pressure losses may be deleted, when sufficient flow pressure is available at the most distant outlet fitting at the most upper deck.						
8		1,32										
9		1,76										
10		2,20										
11	2,5	4,40	0,73	25	1,51	23	58				58	
12	5,0	0,44	0,37	20	1,20	20						
13	5,0	0,88	0,44	20	1,40	27						
14	2,5	5,28	0,80	25	1,61	26	65				65	
15	10,0	0,14	0,14	12								
16	2,25	5,42	0,80	25	1,61	26	59				59	
17	15,0	5,42	0,80	25	1,61	26	390					
$l \times R$ = 390 value too high; new DN								32	1,01	7,5	112,5	(277,5)
18	5,0	5,42	0,80	25	1,61	26	130					
$l \times R$ = 130 value too high; new DN								32	1,01	7,5	37,5	(92,5)
		$\frac{\text{Total pressure loss}}{\Delta\ \text{pressure loss}}$ by altered DN $\frac{1\,026}{370}$										370
		Total pressure loss when DN altered 656									656	

Table C.5 — Form sheet B.3 for the calculation of a circulating system

Building No.:			Official in charge:					Date:			Sheet-No.:		
Drinking water line hot					Circulation line, calculation in accordance with clause 12								
Line part	Length of pipe	Nominal diameter	Water capacity per m pipe	Capacity	Line part	Length of pipe	Nominal diameter	Water capacity per m pipe	Capacity	Peak flow	Flow speed	Pressure differential	Pressure loss
	l		V/l	V		l		V/l	V	$\dot{V}_s$	v	R	$l \times R$
TS	m	DN	l/m	l	TS	m	DN	l/m	l	l/s	m/s	mbar/m	mbar
1	2	3	4	5	6	7	8	9	10	11	12	13	14
18	5,0	32	0,80	4,0	G	10	12	0,13	1,30	0,031	0,24	1,0	10,0
17	15,0	32	0,80	12,0									
16	2,25	25	0,49	1,11									
15	10,0	15	0,20	2,0									
14	2,5	25	0,49	1,23									
13	5,0	20	0,31	1,55									
12	5,0	20	0,31	1,55	DEF	6	12	0,13	0,78	0,016	0,12	0,35	2,1
11	2,5	25	0,49	1,23									
10	2,0	25	0,49	0,98									
9	2,0	20	0,31	0,62									
8	2,0	20	0,31	0,62									
7	2,0	20	0,31	0,62									
6	2,0	20	0,31	0,62									
5a	2,5	25	0,49	1,23									
5	2,0	25	0,49	0,98									
4	2,0	20	0,31	0,62									
3	2,0	20	0,31	0,62									
2	2,0	20	0,31	0,62									
1	2,0	20	0,31	0,62	ABC	12	12	0,13	1,56	0,016	0,12	0,35	4,2
		V = 32,82 l +3,64 l ——— $V_g = \Sigma V$ = 36,48 l =============						V = 3,64 l			$\Sigma\, l \times R$ = 16,3 mbar		

Volume of warm water line: 36,48 l

According to 12.2 the flow $\dot{V}_{UP}$ of the circulating pump is: $\dot{V}_{UP} = 3 \times \Sigma V$ to $\dot{V}_{UP} = 3 \times 36{,}48 \approx 110$ l/h

According to 12.3 the head of the pump H_{UP} of the circulating pump is: $H_{UP} = \Sigma\, l \times R \times 1{,}4$

$H_{UP} = 16{,}3 \times 1{,}4 = 23$ cm $\equiv$ 23 mbar

Table C.6 — Form sheet B.4 for the calculation of the supply pressure

Building No.:	Official in charge:			Date:		Sheet No.:		
Cold water Information about the system: Direct ☐ Indirect ☐	a) Connected to the supply use			b) Central potable water heater Sectional potable water heater ☐				
No.	**Term**	**Symbol**	**Unit**	**Trunk 1**	**2**	**3**	**4**	**5**
1	Pressure loss caused by geodetic difference in altitude	Δp_{geo}	mbar	1 475				
2	Pressure loss in apparatus e.g.							
	a) Pressure tanks	Δp_{PT}	mbar	30				
	b) Filter	Δp_{FIL}	mbar					
	c) Sterilization plant	Δp_{EH}	mbar	40				
	d) Dosing devices	Δp_{DOS}	mbar					
	e) Potable water heater	Δp_{TE}	mbar					
	f) Other apparatus	Δp_{Ap}	mbar					
3	Minimum flow pressure	$p_{min\ Fl}$	mbar	1 500				
4	Pressure loss of the lines from sheet B.2	Δp_{LE}	mbar	718				
5	Sum of pressure losses from No. 1 to No. 4[a] = minimum supply pressure	$\Sigma\Delta p$	mbar	3 763				

[a] The pressure losses of the pump suction line and the pump pressure line are not taken into consideration in this example.

Table C.7 — Form sheet B.4 for the calculation of the supply pressure

Building No.:	Official in charge:		Date:		Sheet No.:			
Hot water			b) Central potable water heater					
Information about the system:	a) Connected to the supply use		Sectional potable water heater ☐					
Direct ☐ Indirect ☐								
No.	Term	Symbol	Unit	Trunk				
				1	**2**	**3**	**4**	**5**
1	Pressure loss caused by geodetic difference in altitude	Δp_{geo}	mbar	1 475				
2	Pressure loss in apparatus e.g.							
	a) Pressure tanks	Δp_{PT}	mbar	30				
	b) Filter	Δp_{FIL}	mbar					
	c) Sterilization plant	Δp_{EH}	mbar	40				
	d) Dosing devices	Δp_{DOS}	mbar					
	e) Potable water heater	Δp_{TE}	mbar	170				
	f) Other apparatus	Δp_{Ap}	mbar					
3	Minimum flow pressure	$p_{min\ Fl}$	mbar	1 500				
4	Pressure loss of the lines from sheet C.2	Δp_{LE}	mbar	656				
5	Sum of pressure losses from No. 1 to No. 4[a] = minimum supply pressure	$\Sigma\Delta p$	mbar	3 871				

[a] The pressure losses of the pump suction line and the pump pressure line are not taken into consideration in this example.

C.3.8 Determination of the water heater volume

A 650 l water heater was chosen from Table A.6 with 40 kW heating power (see also 11.1)

C.3.9 Determination of the nominal diameters of suction-pipes and pressure pipes

Diameters were determined using Tables A.4 and A.5.

C.4 Synopsis of results

C.4.1 Minimum supply pressure of the system

From clause 7 the minimum supply pressure of the system is 110 % of the sum of all pressure losses.

From the calculation example of the form sheet B.4 the sum of the pressure losses

— of the CW — Part is 3 763 mbar;

— of the WW — Part is 3 871 mbar.

The minimum supply pressure in P_{minV} = 3 871 × 1,1 = 4 260 mbar.

C.4.2 Pump delivery flow

The peak flow $\dot{V}_s$ is derived from form sheet B.1 (see Table C.1) = 1,4 l/s. The pump delivering flow $\dot{V}_{pmin}$ is

— for centrifugal pumps: 1,10 × $\dot{V}_s$ = 1,10 × 1,4 = 1,54 l/s = 5,54 m^3/h

— for reciprocating pumps: 1,25 × $\dot{V}_s$ = 1,25 × 1,4 = 1,75 l/s = 6,3 m^3/h

} see 8.3

See C.4.3.

C.4.3 Pressure tank volume

— assumption: The cut-off pressure p_A shall be 2 bar higher than the cut-in pressure p_E (see 8.2)

$p_A = p_E + 2$; p_E = 4,25 bar

p_A = 6,25 bar

— assumption: number of switching events S = 12 per h (see 8.2)

— line sequence A-B-C-D and E-D show in F: V_D = 500 l

— additional results

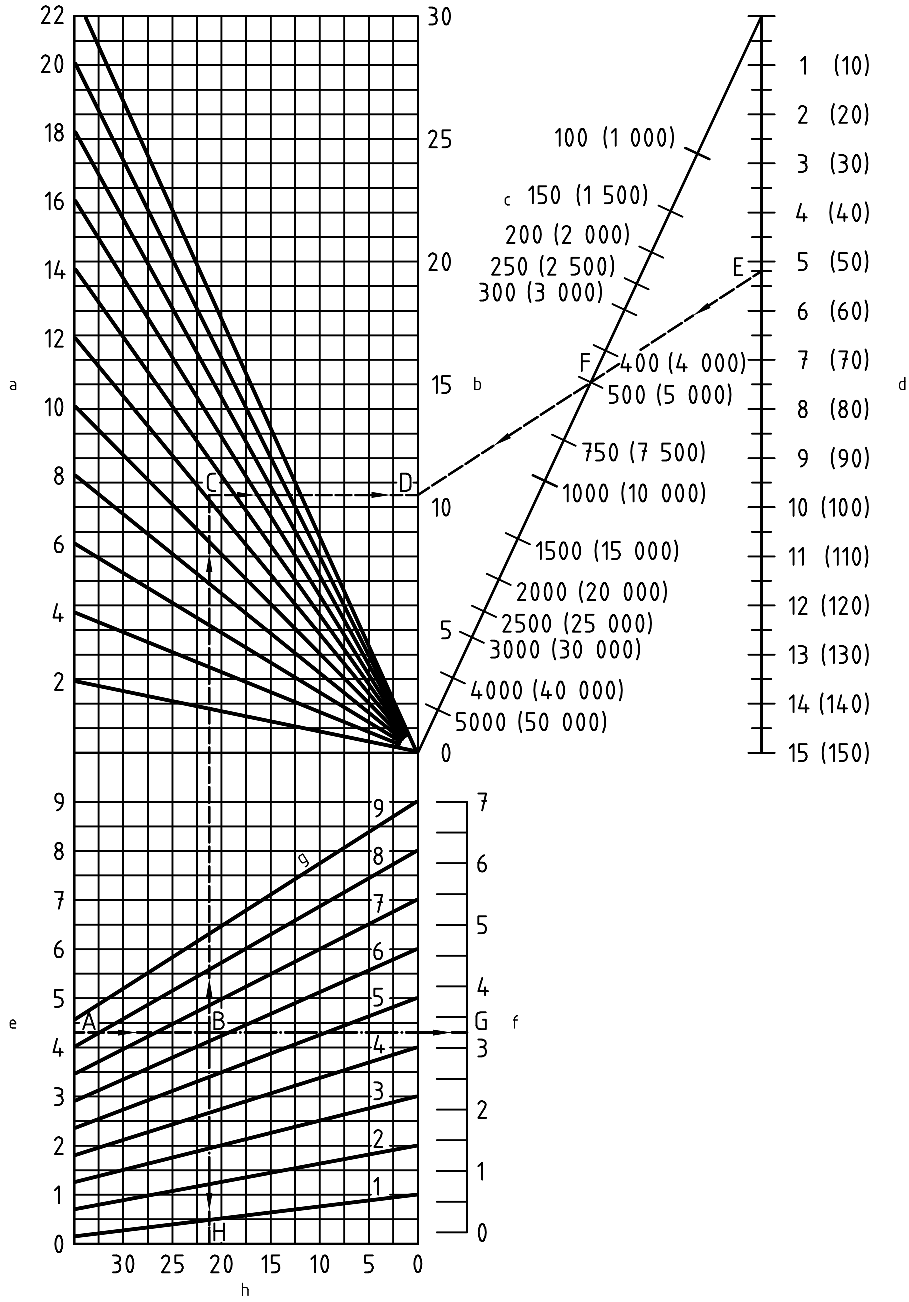
following line A-B shows in G a pre-pressure p_V = 3,2 bar

— following line C-B shows in H a usable part of $V_D = V_{eff}$ = 22 % and therefore a storage volume V_s = 110 l

Guide value V_D = 0,1 × $V_D = 0{,}1 \times \dot{V}_{p\,min} = 0{,}1 \times 5\,540 \approx 500$ l

C.4.4 Water heater

From Table A.6 a heater is selected with a volume of 650 l and a heating power of 40 kW.



a Switching frequency (S) per h

b $\frac{\text{Pump delivery flow } \dot{V}_p}{\text{Reservoir volume } V_D} \left(\frac{m^3}{h \times m^3}\right)$

c Reservoir volume V_D in l

d Pump delivery flow $\dot{V}_p = \dot{V}_{Pmin}$ in m³/h

e Cut-in pressure p_E of the pump in bar

f Pre-pressure p_V in bar; for compressed air cushion in the empty water reservoir

g Cut-out pressure p_A in bar

h Usable volume of water reservoir V_{eff} in %

$$V_{eff} = \frac{\text{storage volume } V_s}{\text{water reservoir volume } V_D} \times 100$$

Figure C.3 — Functional diagram for determination of the size of water reservoirs

C.4.5 Nominal diameters of suction and pressure lines

Nominal diameter of the suction line derived from Table A.4 for $\dot{V}_{\text{pmin}} \approx 5{,}5\,\text{m}^3/\text{h}$: DN 50

Nominal diameter of the pressure line derived from Table A.5 for $\dot{V}_{\text{pmin}} \approx 5{,}5\,\text{m}^3/\text{h}$: DN 40

NOTE The pressure line DN 40 will be split in the cold water line and the hot water line.

C.4.6 Circulating pump

From Table C.5 (form sheet B.3).

$\dot{V}_{\text{UP}}$ = 110 l/h; H_{UP} = 23 cm ≡ 23 mbar; select out of a catalogue

Internal pipe

Pressure

Peak flow

diameter

differential [a]

Flow rate

$\dot{V}_{\text{s}}$ in l/s

d_1 in mm

R in mbar/m

v in m/s

Peak flow

Pump delivery flows

Head of pump H

Fluid level indicator

Vacuum WC

CW trunk line

WW trunk line

Consumer:

10 Standard sanitary units [a]
(1 CW- and WW-outlet fitting each) as

Consumer:

4 standard sanitary unit

Maindeck

Consumer:

Kitchen with 2 sinks 1 CW- and WW-outlet fitting each
1 potatoe peeler, 1 washing machine, 1 potable water fountain,
1 dish washer, 1 electrical water heater (1 CW outlet fitting each)

Hospital and close vicinity

Accommodation decks

Commissary spaces

Machinery spaces and trunk

p_{E} Marking on the level indicator

Section G
10 m DN 12

Section A, B and C
12 m DN 12

Section D, E and F
6 m DN 12

[a] Only 5 units are shown

4th Deck 3rd Deck 2nd Deck as 3rd Deck 1st Deck Main Deck

Annex D
(informative)

Information concerning the installation of sanitary facilities

The following information serves as an example; it is based on statutory provisions.

The information represents the different necessities, required by different authorities.

The following shall be provided:

Per ship [1)]

— 3 water closets for ships under	1 000 GRT
— 4 water closets for ships under	5 000 GRT
— 6 water closets for ships over	5 000 GTR

Per accommodation unit [1)]

— 1 water closet	for up to 6 persons
— 1 washbasin	for up to 4 persons
— 1 shower or bath tub	for up to 6 persons

In communal/group facilities

— washroom for 6 persons [2)]	1 washbasin	for 2 persons [3)]
— bathroom for 10 persons [3)]	2 shower or bath tub	for 4 persons [2)]
1 foot bath		for 36 persons [3)]
— toilet room	1 washbasin	for 30 persons [3)]
1 WC for 25 persons [2)]		for 15 persons [3)]
1 urinal		for 30 persons [3)]
1 spit basin		for 50 persons [3)]

1) See "Official Journal of the European Communities", Trade Union of Seafarers (See-Berufsgenossenschaft), and Trade Union of inland Watermen (BSBG) rules.

2) See Construction Specification for Ships.

3) Handbook of Naval Architecture (Schiffbautechnisches Handbuch).

For passenger areas the minimum requirements are:

Per cabin unit

— 1 WC

— 1 washbasin

— 1 shower or bath tub

Communal/group facilities

— wash room1 washbasinfor 2 persons

— bathroom1 shower or bath tubfor 4 persons

— toilet room see Table D.1 and D.2

Table D.1 — Number of WC bowls and urinals

Number of persons			**Number of WCs and urinals**		
Total up to	Shared		For Ladies	For Gents	
	Ladies	Gents	W.C.	W.C.	Urinals
100	50	50	1	1	—
200	100	100	2	2	—
300	150	150	4	2	1
400	200	200	5	2	1
500	250	250	6	2	2
600	300	300	7	3	2
800	400	400	10	3	3
1 000	500	500	12	4	4
1 500	750	750	18	4	7
2 000	1 000	1 000	24	6	9
2 500	1 250	1 250	30	8	11

Table D.2 — Number of washbasins

Number of washbasins	With respect to the number of		
	W.C.s	Urinals	W.C.s and urinals
1	1	—	1
	—	1	1
	1	1	2
	1	2	3
	2	—	2
	2	1	3
	3	—	3
2	2	2	4
	2	3	5
	2	4	6
	4	—	4
3	3	4	7
4	4	6	10
5	4	10	14
8	20	—	20
NOTE At least one washbasin is to be provided per three items (W.C.s and urinals).			

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