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FROST PROTECTION OF BURIED WATER AND SEWAGE PIPES. THREE ARTICL--ETC(U)
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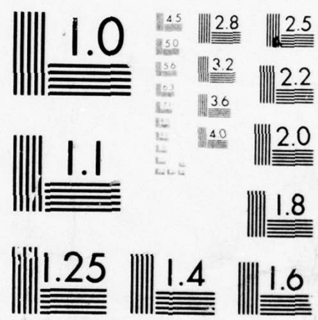

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FROST PROTECTION OF BURIED WATER AND SEWAGE PIPES

Three Articles

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COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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Two of the articles in this report discuss frost prevention for privately owned water and sewage pipes laid shallow (above the frost penetration level) in bedrock type terrain. The third article contains frost load data in tabular form for all communities in Norway. Emphasis has been placed on data which apply to frost prevention of structures in the ground, such as pipes, foundations, and roads.

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WATER AND SEWAGE PIPES
Frost prevention for privately owned pipes laid in bedrock

NBI[1] Publication (58)204

October 1976

0 GENERAL

01 This publication discusses frost prevention for privately owned water and sewage pipes laid shallow[2] in bedrock type terrain.

Bedrock type terrain is here defined as regions where the bedrock is either bare or covered by a very thin layer of loose soil materials.

02 Rock is a very good thermal conductor and the frost will penetrate to rather large depths. Frost prevention for pipes laid in bedrock is primarily a matter of maintaining the temperature above a certain level in the pipes themselves, since frost-heaves can not occur. This means, that the insulation should limit heat transfer from the pipes to their surroundings to an absolute minimum. On the other hand, the frost line (0 - isotherm) can be permitted to penetrate below the pipes.

03 One can distinguish between narrow and wide trenches in bedrock. A wide trench is defined as one where the back-fill materials are significant for frost prevention. The required trench width will then depend on the back-fill material. As

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1) Norges Byggforskningsinstitutt: Norwegian Building Research Institute

2) That is, above the frost penetration level. (Translator's notes)

a general rule, a rock trench is considered wide if the trench width at the surface exceeds twice the frost depth in the back-fill material. In narrow rock trenches, materials covering the pipes serve primarily as structural protection for the pipes.

04 Related publications:

NBI Aa.111: "Frost loads. Data for frost prevention"

NBI(58).203: "Water and sewage pipes. Frost prevention for privately owned pipes laid in the ground.

1 MATERIALS

11 Trench materials

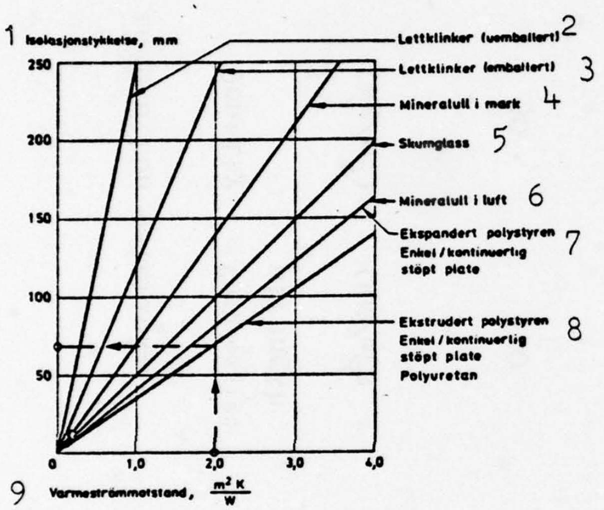
When pipes are laid in a shallow and narrow trench in rock, the thermal properties of the surrounding rock material are of significant importance only if the pipes are not insulated. It is then assumed that sufficient heat is given off by the pipes or electrical heating cables to prevent freezing. The choice of back-fill materials can then be based on structural and load considerations. Where the pipes pass through trafficated areas and a minimum covering thickness is desired, the most suitable choice is loosely packed fine crushed rock with grain sizes 5-8 mm or 8-12 mm placed around insulation and pipes. For the top layer one can use coarser gravel or crushed rock. This is also advantageous from a thermal point of view, since these materials have relatively low thermal conductivity.

Where pipes are not subjected to stress loads, it may be advantageous to use moist materials with high thermal capacitance for the back-fill, particularly in wide trenches.

However, the design diagrams for wide trenches in bedrock are based on use of sand and gravel as trench materials.

12 Insulation materials

Table 12 summarizes properties of various insulation materials, while Figure 12 shows the relation between insulation thickness and nominal thermal resistance.



1 Insulation thickness, mm
2 Light aggregate without moisture protection
3 Light aggregate with moisture protection
4 Mineral wool in the ground
5 Glass foam
6 Mineral wool in air
7 Expanded polystyrene, single, continuously cast slab
8 Extruded polystyrene, single, continuously cast slab. Polyurethane
9 Thermal resistance, m^2K/W

Figure 12 a
Relation between thermal resistance and insulation thickness for various insulation materials

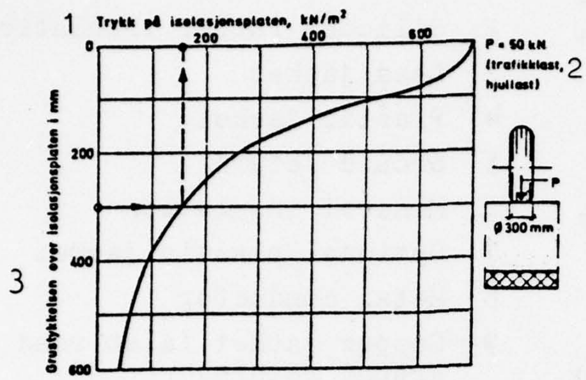
In cases where insulation is used for preventing frost in pipes under roads, etc., the same structural requirements apply as for road-bed insulation materials.

Figure 12 b shows required compressive strength of insulation materials used in roads, as a function of fill depth. When insulation is placed in locations where the pressure load is significantly lower, less pressure resistant insulation materials can be used.

Table 12
Properties of various insulation materials

Materials	Density (kg/m^3)	Compressive strength (kN/m^2)	Nominal thermal resistance (W/mK)	Moisture proofing*)
Expanded polystyrene - single/continously cast slab	30	150	0.04	0.2 mm thick plastic film
Extruded polystyrene - single/continously cast slab	28 - 45	250 - 700	0.035	0.2 mm thick plastic film whenever the insulation is less than 65 mm thick
Polyurethane	30 - 80	180 - 200	0.035	0.2 mm thick plastic film
Foam glass	125	450	0.05	None
Light, expanded aggregate, enclosed	300 - 700	Friction material	0.12	Enclosed in plastic bags
Light, expanded aggregate, not enclosed	350 - 700	Friction material	0.25	Should be placed in material with drainage
Mineral wool, in ground	24 - 200		0.07	Should be placed in material with drainage
Mineral wool, in air			0.04	

*) When use of a 0.2 mm thick plastic film is prescribed, the foil is to be placed on the side of the insulating layer which has the highest summer temperature (upper side).



1 Pressure on insulating plate, kN/m^2

2 P = 50 kN (traffic load, wheel load)

3 Gravel layer thickness above the insulation, mm

Figure 12 b
Required compressive strength of the insulation, as function of covering gravel layer thickness

13 Heating cables

Figure 13 shows different types of heating cables designed for placement outside or inside water pipes. Cables are available with resistance values ranging from a few milli-ohms to several hundred ohms per meter. The higher resistance values are suitable for short runs, while long pipes require low resistance values[1]. Heating cables are available with two or three conductors and more specialized types, e.g., with very high resistance per meter or with other thermal properties, can be obtained. Heating cables can be connected to electric outlets.

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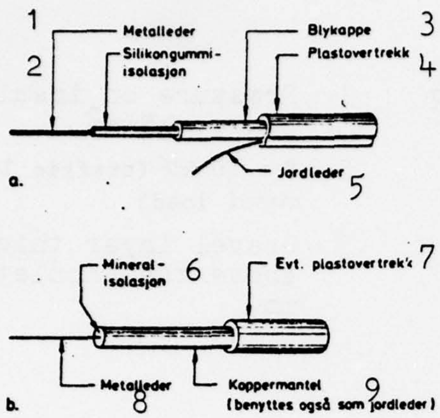
1) Per unit length



1. Metal conductor
2 Silicone rubber insulation
3 Lead jacket
4 Plastic jacket
5 Ground return
6 Mineral insulation
7 Optional plastic jacket
8 Metal conductor
9 Copper jacket (also used as ground return)

Figure 13
Different types of heating cables
a. Heating cable designed for use outside waterpipes
b. Heating cable designed for use also inside waterpipes

14 Pipe materials

For shallow water lines it is necessary to use pipes and joints which can withstand the stresses caused by freezing water. Materials with low thermal conductivity are also advantageous. This is true both for water and sewage pipes. Plastic pipes are thus particularly suitable for shallow water and sewage installations.

2 IMPLEMENTATION

21 Frost prevention methods

One important factor is whether a single pipe or several types of pipes are located in the same trench. If the pipes are placed significantly above the frost limit, thermal insulation will be required. The insulation must completely enclose the pipes. To minimize heat loss from the pipes, the outer surface of the insulation should be as small as possible. For a single pipe, this can be achieved by using some type of shell insulation. If several pipes are laid together, box-shaped insulation can be used. In cases where the pipes carry water intermittently, it is advantageous to imbed the pipes in a material capable of storing heat. This is particularly important when heat is to be transferred from sewage pipes to water or surface drain pipes. It is also necessary to imbed pipes which are subjected to mechanical stress.

22 Heat sources

When pipes are to be laid above maximum local frost depth, some supply of heat will be required. It is always advantageous if the pipe system itself can give off sufficient heat. This can be achieved by connecting all the houses in one row to a common branch pipe, rather than using separate connections to the main line for each dwelling. Sewage lines constitute the main heat source and should be laid close to the water pipes.

Figure 22 illustrates the amounts of heat which can be given off by smaller size water and sewage pipes in use. For water pipes one can normally tolerate a drop in temperature of 0.5 - 2.0°C along a shallow stretch. The acceptable drop depends on water source and must be determined for each individual case. Due to the high temperature of water fed through sewage pipes, these can normally tolerate a some-what larger temperature drop. However, since sewage pipes often are empty for long periods, e.g., at night, one should assume a temperature drop of the same magnitude as for water pipes. Figure 22 uses the average water flow per 24 hours during the frost period as a design parameter.

If the water flow is too low, the necessary heat can be supplied, e.g., by electrical heating cables. Even in extreme situations, when the pipes are placed very shallow or on the surface, the required energy can be kept very low by means of efficient insulation. A power of 2-5 W/m is normally sufficient. If the temperature sensor is in direct contact with the water pipe, very short operating times can be achieved for the heating cable.

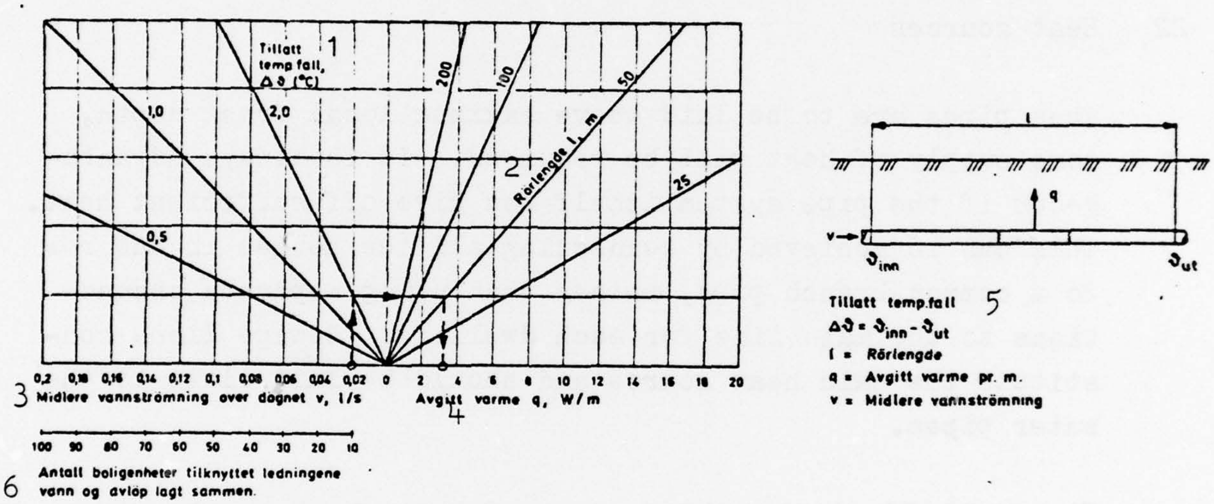


Figure 22
Heat loss from water and sewage pipes in use

23 Frost load

For pipes placed in shallow trenches in bedrock, ground temperature extremes will be determining for the design. One may experience the same frost quantities near the coast in Northern Norway as in Østlandet[1], while the yearly mean tem-

1) South-eastern Norway (Translator's note).

Legend:

Figure 22

1 Allowed temperature fall, $\Delta\vartheta$, ^oC
2 Pipe length, l (m)
3 Mean water flow over 24 hours, v, liters/sec
4 Heat loss, q, W/m
5 Allowed temperature fall

$\Delta\vartheta = \vartheta_{in} - \vartheta_{out}$

l = Pipe length

q = Heat loss per m

v = Mean water flow

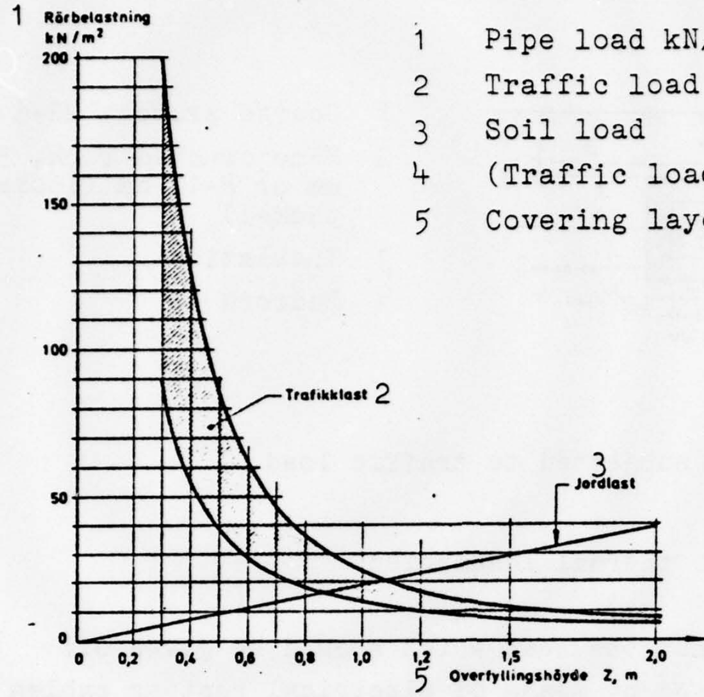
6 Total number of dwellings connected to water and sewer lines

peratures are different. The location having the highest yearly mean temperature will then have the lowest temperature in the upper layers of the ground. In shallow rock trenches it is necessary to consider more rapid variations in air temperature. This must be taken into account when using the design diagrams. They are plotted with maximum frost quantity (see Publication NBI Aa.111) as the only design parameter. This means that use of the diagrams for locations having small frost quantities and low yearly mean temperatures will lead to some degree of over-design, although not significant.

In cases where pipes are laid in snow-covered ground, the temperature variations at the ground surface will be attenuated. If the thickness and thermal conductance of the snow cover are known, the frost load at the surface can be reduced. However, if snow conditions are unknown, the design should be based on extremely cold winters and no snow.

24 Mechanical loads

The mechanical load on buried pipes, due to traffic, will increase sharply with decreasing thickness of the covering layer, see Figure 24 a. Pipes should thus, whenever possible, not be laid directly under road-beds but rather under edges, sidewalks or preferrably in free ground. In rock trenches, the cover material provides the primary protection against mechanical loads. A covering layer thickness of 0.3 - 0.5 m will thus be sufficient in free ground. If the pipes are laid under parking lots or other locations where traffic may occur, the covering layer should be at least 0.5 m thick. Pipes laid under heavily traveled roads or streets should be covered with a layer at least 0.8 m thick, assuming that plastic pipes are used.



1 Pipe load kN/m^2
2 Traffic load
3 Soil load
4 (Traffic load, wheel load)
5 Covering layer thickness, Z, m

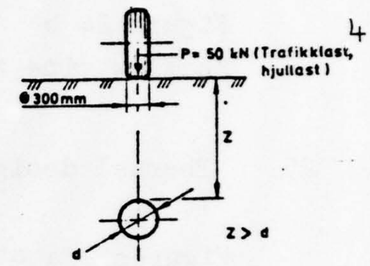
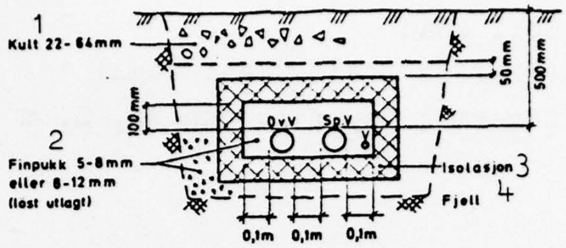


Figure 24 a
Loads on flexible pipes
When Z» d, the pipe load will approach the lower curve for traffic load

If the pipes pass through areas with traffic and one requires a minimum thickness for the covering layer of 0.5 m, trench materials should be selected as shown in Figure 24 b. Water and sewage pipes are here laid on the same level enclosed by box-type insulation. Compression can be avoided by using fine crushed rock with grain sizes 5-8 mm or 8-12 mm inside and around the insulating material. The cross-section of the latter can thereby be made smaller. For the upper layers one may use somewhat coarser gravel or crushed rock.



1. Coarse gravel, 22-64 mm
2. Fine crushed rock, 5-8 mm or 8-12 mm (loosely packed)
3. Insulation
4. Bedrock

Figure 24 b
Shallow pipe trench subjected to traffic load

25 Thermal design - no thermal insulation

Figures 25a and b show the heat which should be given off internally or supplied by means of electrical heating cables in order to prevent frost in a single pipe without thermal insulation laid in a narrow and wide rock trench, respectively.

Thickness of the covering layers are 0.5, 0.8, 1.2 and 1.6 m. Evidently, significant amounts of heat must in general be supplied to keep the pipes from freezing.

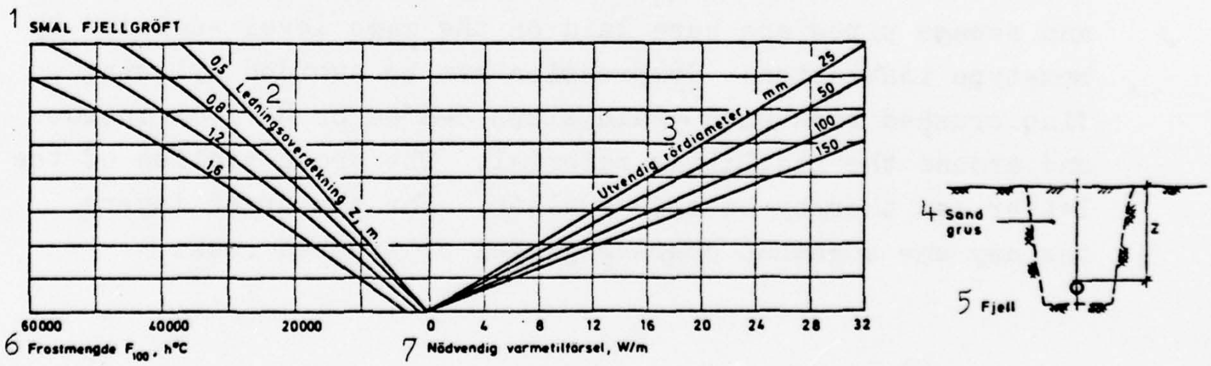


Figure 25 a
Required heat dissipation for preventing frost in a water pipe laid in a narrow rock trench, without insulation
Covering layer thickness: 0.5, 0.8, 1.2 and 1.6 m

Legends:

Figure 25 a

1 Narrow trench in bedrock
2 Covering layer thickness, Z, m
3 Outside diameter, mm
4 Sand, gravel
5 Bedrock
6 Frost quantity, F_{100}, h°C
7 Required heat supply, W/m

Figure 25 b

1 Wide trench in bedrock
2 Covering layer thickness, Z, m
3 Outside diameter, mm
4 Sand, gravel
5 Bedrock
6 Frost quantity, F_{100}, h°C
7 Required heat supply, W/m

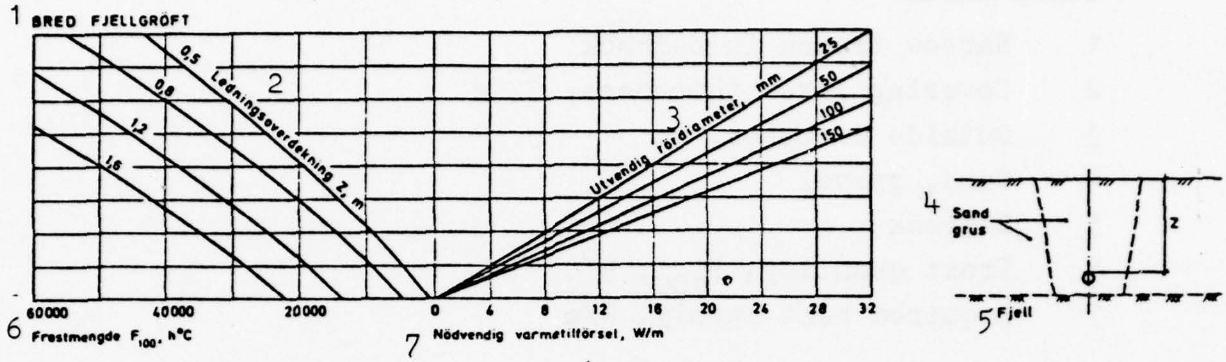


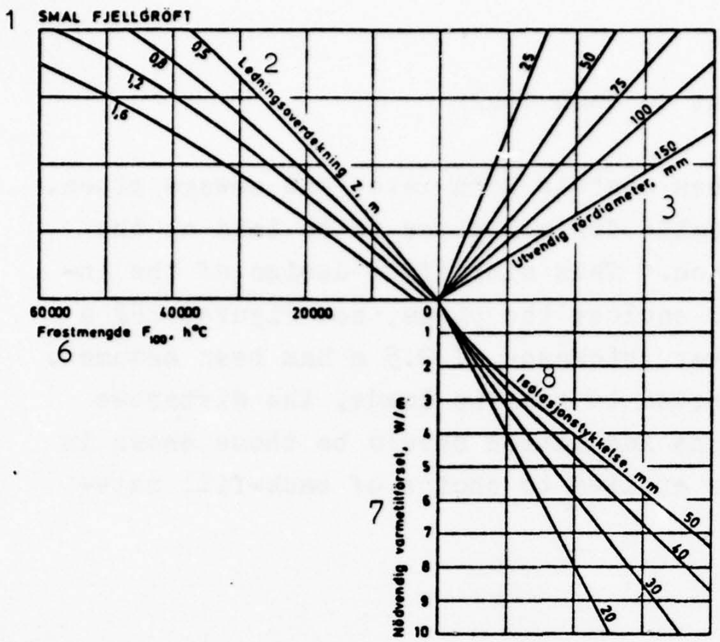
Figure 25 b
Required heat dissipation for preventing frost in a water pipe
laid in a wide rock trench, without insulation
Covering layer thickness: 0.5, 0.8, 1.2 and 1.6 m

26 Thermal design - with thermal insulation

261 Single pipe

The amount of insulation required to prevent frost in a single water pipe laid in a narrow or wide rock trench can be determined from Figures 261 a and b, respectively. Heat can either be given off by the pipe itself, when in use, or generated by an electrical heating cable. The covering layer thickness is 0.5, 0.8, 1.2 and 1.6 m. The insulation should be placed around the pipe to ensure minimum outer surface area.

For shallow plastic sewage pipes it is normally sufficient to use cylindrical insulating shells of 20 mm thickness.



1 Narrow trench in bedrock
2 Covering layer thickness,Z,m
3 Outside daimeter, mm
4 Sand, gravel
5 Insulation
6 Frost quantity, F_{100}; h^{O}C
7 Required water flow, W/m
8 Insulation thickness, mm

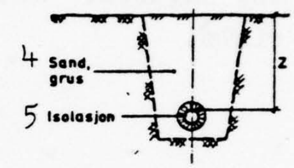
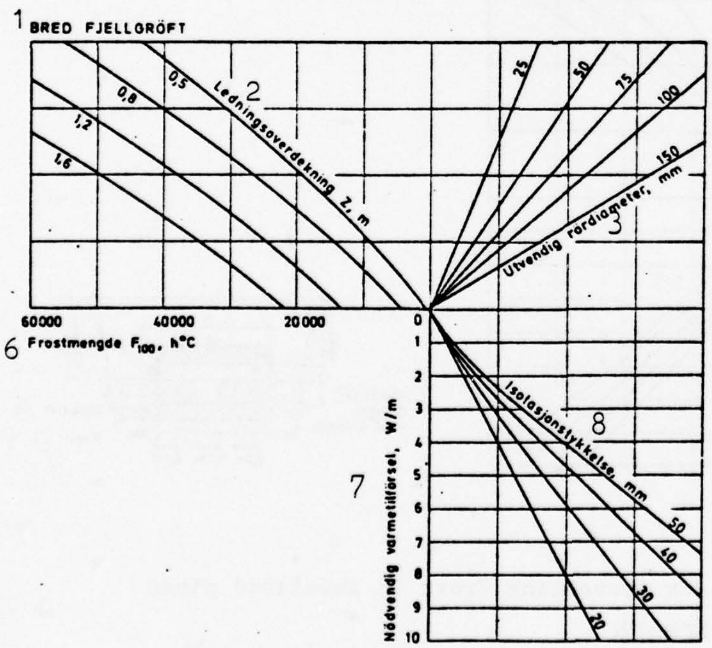


Figure 261 a

Required heat dissipation for preventing frost in a water pipe laid in a narrow rock trench, with insulation
Covering layer thickness: 0.5, 0.8, 1.2 and 1.6 m



1 Wide trench in bedrock
2 Covering layer thickness,Z,m
3 Outside diameter, mm
4 Sand, gravel
5 Insulation
6 Frost quantity, F_{100}, h^{O}C
7 Required water flow, W/m
8 Insulation thickness, mm

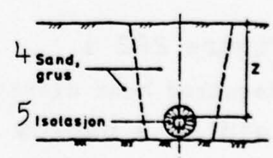


Figure 261 b

Required heat dissipation for preventing frost in a water pipe laid in a wide rock trench, with insulation
Covering layer thickness: 0.5, 0.8, 1.2 and 1.6 m

262 Several pipes laid next to each other

As a rule, pipe trenches contain both water and sewage pipes. The base-line design calls for all pipes to be laid at the same depth in the trench. This simplifies design of the insulation, which should enclose the pipes, see Figures 262 a and b. A covering layer thickness of 0.5 m has been assumed. If the pipes are subjected to traffic loads, the distances between pipes and to the insulation should be those shown in the figures. The same applies to choice of back-fill materials.

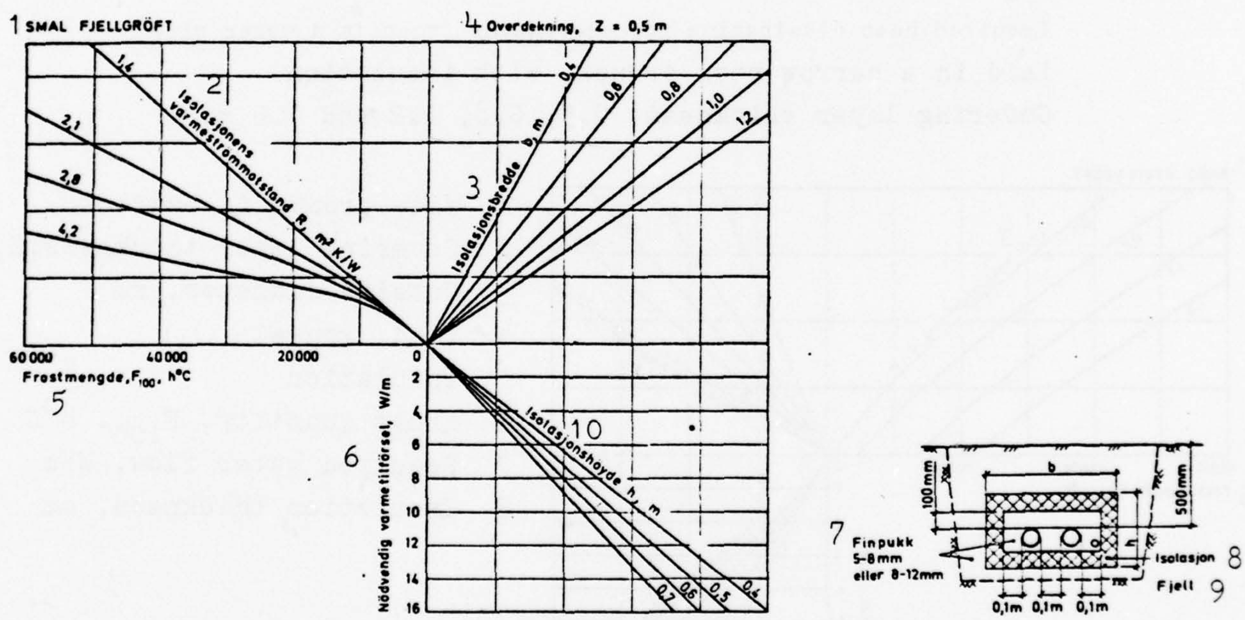


Figure 262 a

Required heat dissipation for preventing frost in insulated pipes laid in a narrow rock trench

Covering layer thickness: 0.5 m

Legends:

Figure 262 a

1 Narrow trench in bedrock
2 Thermal resistance of insulation, R, m, K/W
3 Insulation width, b, m
4 Covering layer thickness, Z = 0.5 m
5 Frost quantity, F_{100}, h°C
6 Required heat supply, W/m
7 Fine crushed rock, 5-8 mm or 8-12 mm
8 Insulation
9 Bedrock
10 Insulation height, m

Figure 262 b

1 Wide trench in bedrock
2 Thermal resistance of insulation, R, m^2 K/W
3 Insulation width, b, m
4 Covering layer thickness, Z = 0.5 m
5 Frost quantity, F_{100}, h°C
6 Required heat supply, W/m
7 Fine crushed rock, 5-8 mm or 8-12 mm
8 Insulation
9 Bedrock
10 Insulation height, m

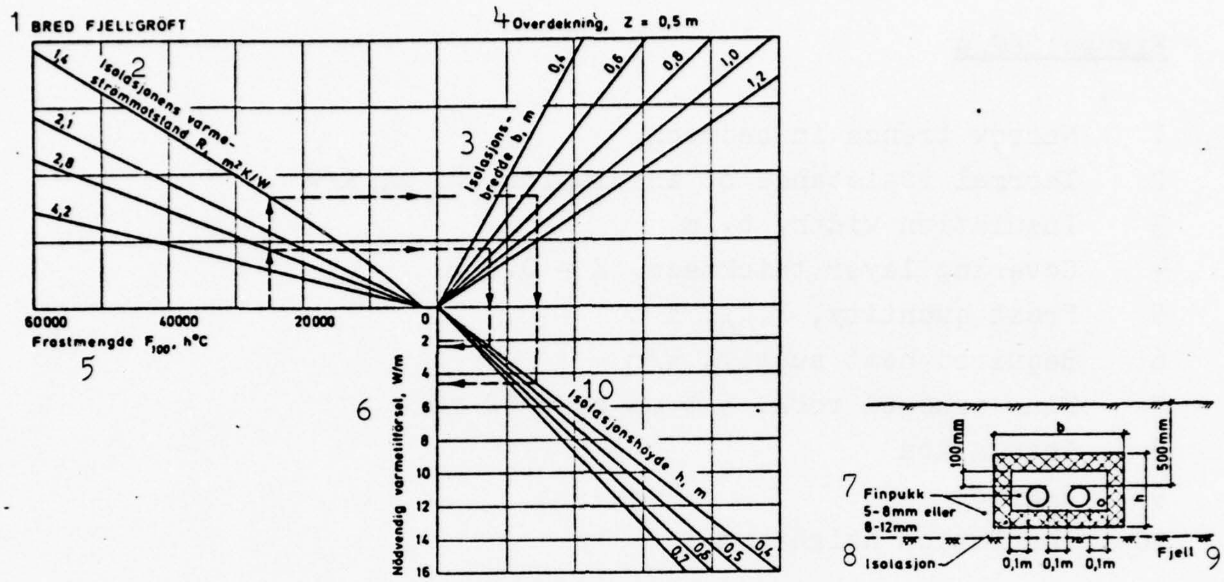


Figure 262 b

Required heat dissipation for preventing frost in insulated pipes laid in a wide rock trench

Covering layer thickness 0.5 m

Figures 262 a and b also show the amount of internal heat released for keeping the volume enclosed by the insulation from freezing, for different frost quantities and in narrow or wide rock trenches, respectively.

Figures 262 c and d show the required heat dissipation for covering layers with thicknesses 0.8, 1.2 and 1.6 m. It is evident that the heat requirements can be reduced significantly by increasing the thermal resistance of the insulating layer. At the same time, the outer surface area of that layer should be minimized.

Legends:

Figure 262 c

1 Narrow trench in bedrock
2 Thermal resistance of insulation, R, m^2K/W
3 Insulation width, b, m
4 Covering layer thickness, Z = 0.8, 1.2, 1.6m
5 Frost quantity, F_{100}, h^oC
6 Required heat supply, W/m
7 Sand, gravel
8 Insulation
9 Bedrock
10 Insulation height, m

Figure 262 d

1 Wide trench in bedrock
2 Thermal resistance of insulation, R, m^2 K/W
3 Insulation width, b, m
4 Covering layer thickness, Z = 0.8, 1.2, 1.6 m
5 Frost quantity, F_{100}, h^oC
6 Required heat supply, W/m
7 Sand, gravel
8 Insulation
9 Bedrock
10 Insulation height, m

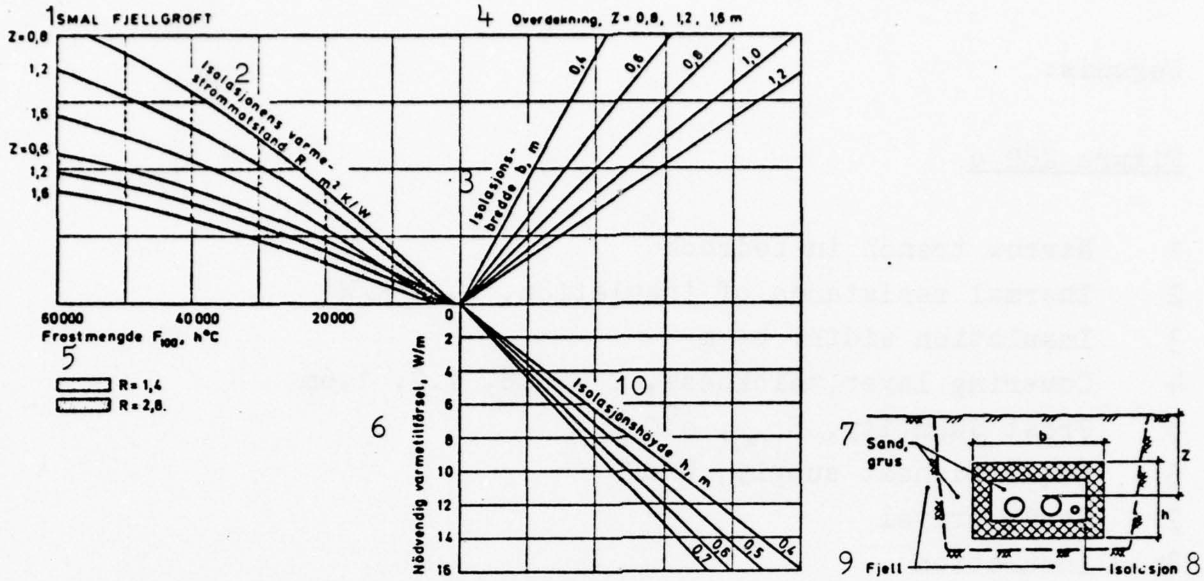


Figure 262 c

Required heat dissipation for preventing frost in insulated pipes laid in a narrow rock trench

Covering layer thickness: 0.8, 1.2 and 1.6 m

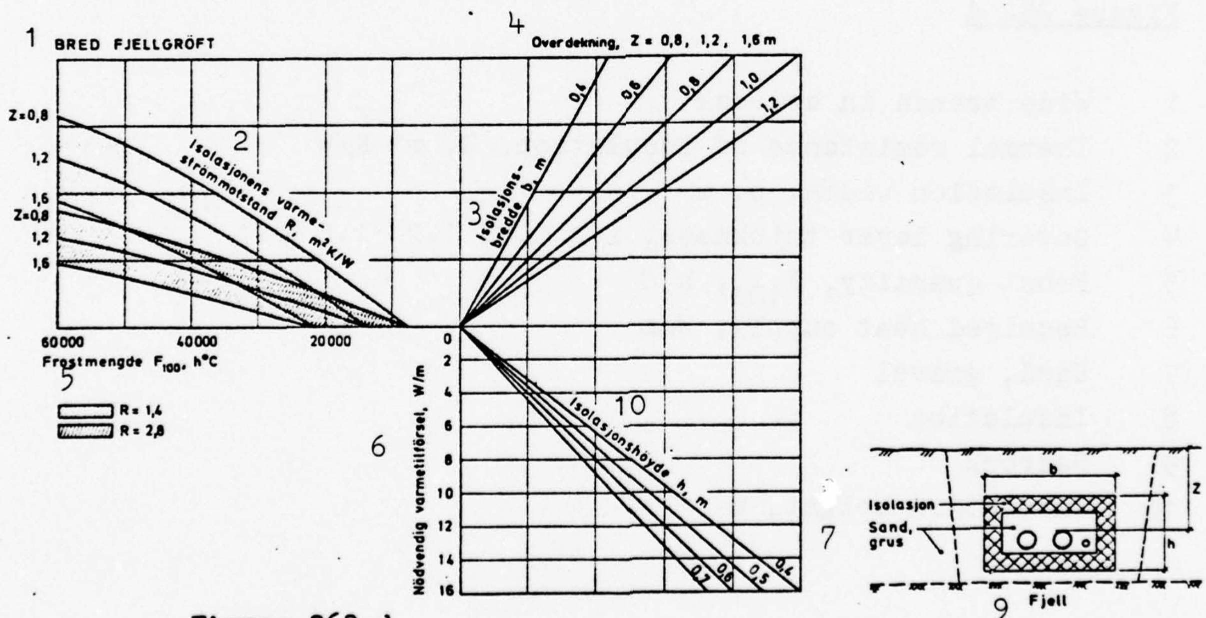


Figure 262 d

Required heat dissipation for preventing frost in insulated pipes laid in a wide rock trench

Covering layer thickness: 0.8, 1.2 and 1.6 m

Example:
A row of one family houses are to be built on bedrock and one wishes to place branch pipes under a reduced covering layer. The houses will be built near Oslo, where F_{max} = 25,000 h°C, see Publication NBI Aa.111.

The following general requirements should be placed on a pipe system laid under a covering layer of reduced thickness. First of all, heat loss due to ventilation of the sewage pipes should be reduced as far as possible. This means that the number of junction boxes should be as small as possible and that the boxes should be air-tight. It may also be desirable to use water locks[1)] or vacuum valves in the sewage pipes. To keep the amount of insulation low, the pipes should be laid on the same level (crossover[2]). The diameter of surface drain pipes should be kept small where possible. This can be achieved by allowing controlled amounts of water to leak out into the terrain at suitable locations. If these conditions are met, it is advantageous to place the pipes in a common insulating structure. It is also an advantage to run the pipes so that a common connection is made to a row of houses, rather than to each house separately. This ensures the highest possible water flow in each branch line.

The pipes are subjected to traffic loads and the covering layer will be at least 0.5 m thick. Each branch line is connected to a row of 10 dwellings. This may in some instances be too small a number to ensure a continous flow through the pipes at all times. However, during most winters, the heat given off by the pipes will be sufficient to prevent frost in the pipes. The average minimum water flow during a 24 hour period will be 0.02 liters/sec, see Figure 22. If a temperature drop of 2.0°C is allowed over the 50 m pipe run, Figure 22 shows an average heat of about 3.5 W/m given off by the pipes.

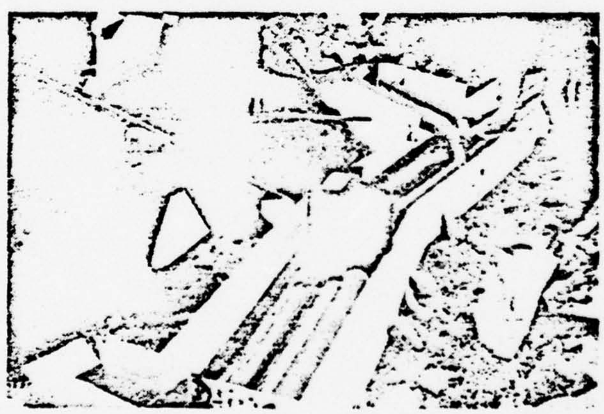
1) The type of trap used under a sink or toilet
2) Refers to the method of connecting branch lines illustrated by the last Figure. (Translator's notes)

When pipes are laid in a rock trench, the insulation should be box-shaped and enclose the pipes fully. In this case, an insulation width of 0.7 m and a height of 0.4 m will be sufficient to house the pipes, see Figure 24 b.

From Figure 12 b one finds that a 0.3 m thick covering layer on top of the insulation will subject the latter to a pressure of 160 kN/m^2, which means that expanded polystyrene should not be used for the top plate, see Table 12. When the pipes are placed in a wide rock trench and the covering layer is 0.5 m thick, 2.4 W/m must be supplied under extreme temperature conditions and for a thermal resistance in the insulation of 2.8 m^2 K/W, see Figure 262 b.

If the insulation has a thermal resistance of 1.4 m^2 K/W, a heat supply of 4.8 W/m will be required. For an internal heat generation of 3.5 W/m to be sufficient, the thermal resistance should be about 2.0 m^2 K/W, see Figure 262 b. For extruded polystyrene this means a thickness of about 70 mm, see Figure 12 a. In this case, no moisture protection is required. If this insulation thickness were used, the pipes would be protected against freezing under normal circumstances. However, due to the relatively small number of dwellings connected to each branch line, a serious situation could arise if several families are absent simultaneously during the winter months. It may thus be necessary to use an electrical heating cable as an extra insurance measure. This cable could for example be put in operation only when the pipes are frozen. Cables should be designed for a some-what higher power than that required to prevent freezing, e.g., 5-6 W/m, to ensure rapid thawing of the pipes. In case the heating cable must operate more or less permanently it could be controlled by a thermostat whose sensor is placed near the water pipes. That normally leads to heater activation only in those cases when the pipes are not used for extended periods.

Box-type insulation



Branch connection outside junction box

WATER AND SEWAGE PIPES
Frost prevention for privately owned pipes laid in the ground

NBI[1] Publication (58)203

October 1976

0 GENERAL

01 This publication discusses frost prevention for privately owned water and sewage pipes laid in the ground.

02 When pipes are laid shallow[2] in ground that is not prone to frost-heaves, it is sufficient to ensure that the pipes will not freeze. In materials prone to frost-heaves it may also be required that the ground below the pipes does not freeze. This is necessary in order to prevent frost damage and back-ups.

03 Related publications:
NBI Aa.111: "Frost loads. Data for frost prevention.", with Tables.
NBI(58).204: "Water and sewage pipes. Frost penetration for privately owned pipes laid in bedrock."

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1) Norges Byggforskningsinstitutt: Norwegian Building Research Institute.

2) That is, above the frost penetration level. (Translator's notes)

1 MATERIALS

11 Soil materials

Frost penetration depends critically on local soil materials. Water content and thermal conductivity of the materials determine frost penetration, particularly when the ground is frozen. For most materials, the thermal conductivity tends to increase with increasing water content and density. However, higher water content tends to reduce frost penetration, while increased thermal conductivity acts in the opposite direction. These factors will partially counteract each other with respect to frost penetration. Thus, for the same climate, the frost depth in these materials will be about the same, even if comparatively wide variations in water content occur. If sandy gravel is used as a reference material, it is possible to define correction factors for determining the frost depth in different types of materials, see Table 11 a.

A layer of material having low thermal conductivity above a moisture material presents an advantage. This can, for example, be obtained by means of drainage or an insulating layer. Another possibility for reducing frost penetration in pipe trenches is to change the surrounding soil material. The existing soil is replaced by materials having more desirable thermal properties, such as peat, clay, etc. For this method to be effective, either the replacement materials must be capable of retaining moisture or the trench must be wide enough to ensure a nearly one-dimensional heat flow near the center of the trench. The design curves assume base materials such as relatively dry clay and sandy gravel, with the properties shown in Table 11 b.

Where the ground consists of other soil materials, design data can be derived from those given for dry clay or sandy gravel. The depth is found from tables in publication NBI Aa.111 and correction factors are listed in Table 11 a. Corresponding frost quantity is given by Figures 23 a and b.

Table 11 a
Correction factors for determining frost depth in different materials.

Maximum frost depth for sandy gravel without snow cover, $Z_{sand/gravel}$ is obtained from tables in publication NBI Aa.111.
Frost depth = $Z_{sand/gravel} \cdot k_z$

Type of material	Correction factor k_z
1. Rock (crushed rock, rock fill, coarse gravel)	1.4
2. Sand and gravel (sandy gravel, coarse moraine)	1.0
3. Silt (fine moraine, sandy moraine)	0.85
4. Clay and mixed soils (moraine with clay)	0.7
5. Peat, bark	0.3

Table 11 b

Material parameters used for deriving the design curves

Type of material	Dry density ρ_d, kg/m^3	Thermal conductivity, W/mK λ frozen	λ unfrozen	Water content by weight W (percent)
Sand, gravel	1700	1.7	1.6	8
Clay	1500	1.3	1.6	20

12 Insulation materials

Table 12 summarizes properties of various insulation materials, while Figure 12 shows the relation between insulation thickness and nominal thermal resistance.

Table 12

Properties of various insulation materials

Materials	Density (kg/m^3)	Structural strength (kN/m^2)	Nominal thermal resistance (W/mK)	Moisture proofing*)
Expanded polystyrene - single/continously cast slab	30	150	0.04	0.2 mm thick plastic film
Extruded polystyrene - single/continously cast slab	28 - 45	250 - 700	0.035	0.2 mm thick plastic film whenever the insulation is less than 65 mm thick
Polyurethane	30 - 80	180 - 200	0.035	0.2 mm thick plastic film
Foam glass	125	450	0.05	None
Light, expanded aggregate, enclosed	300 - 700	Friction material	0.12	Enclosed in plastic bags
Light, expanded aggregate, not enclosed	350 - 700	Friction material	0.25	Should be placed in material with drainage
Mineral wool, in ground	24 - 200		0.07	Should be placed in material with drainage
Mineral wool, in air			0.04	

*) When use of a 0.2 mm thick plastic film is prescribed, the foil is to be placed on the side of the insulating layer which has the highest summer temperature (upper side).

Insulation materials are used in order to obtain high thermal resistance with a small amount of material. Insulation materials must meet certain requirements on structural strength and durability. They should also be capable of retaining their insulating properties over a reasonable length of time. In this respect, the ability to resist moisture is a key factor. Foam glass and extruded polystyrene have good resistance against water absorption. Polyurethane, expanded polystyrene, light expanded aggregates and mineral wool will in general rapidly absorb moisture unless special precautions are taken. Methods for moisture protection of insulation materials are illustrated in Figure 12 b.

The moisture barrier should normally be placed on the side of the insulating layer which has the highest summer temperature (upper side). If mineral wool is used without moisture barrier it should be placed in a well drained material.

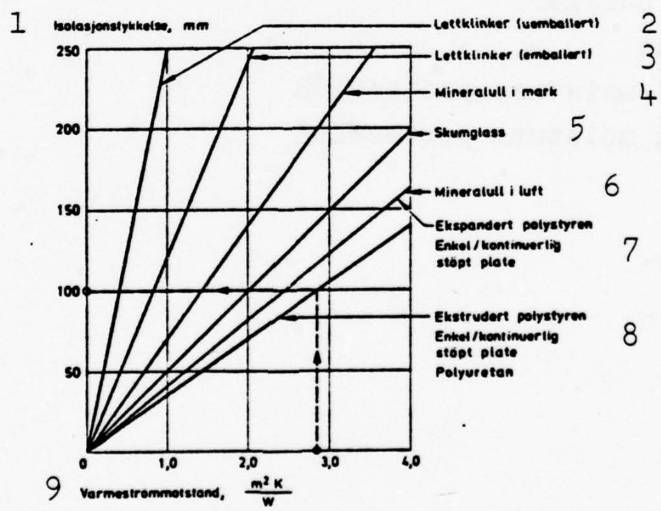


Figure 12 a
Relation between thermal resistance and insulation thickness for various insulation materials.

Legend:

Figure 12 a

1 Insulation thickness, mm
2 Light aggregate without moisture protection
3 Light aggregate with moisture protection
4 Mineral wool in the ground
5 Glass foam
6 Mineral wool in air
7 Expanded polystyrene. Single, continuously cast slab.
8 Extruded polystyrene. Single, continuously cast slab. Polyurethane
9 Thermal resistance, m^2 K/W

Figure 12 b

11 Wrap-around moisture protection
12 Moisture barrier
13 Insulation
14 Two-sided moisture protection
15 One-aided moisture protection

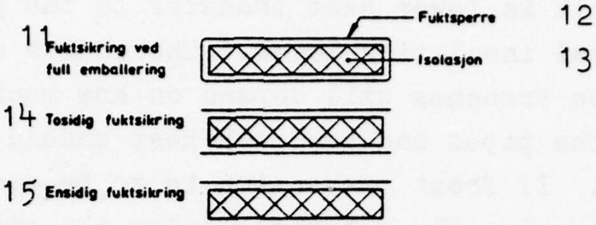


Figure 12 b
Methods for protecting insulation materials against moisture by means of moisture-tight foils. The moisture barrier is normally placed on the side which has the highest summer temperature (upper side).

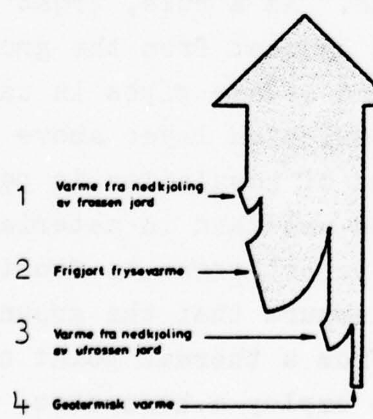
2 IMPLEMENTATION

21 Frost prevention methods

Traditionally, frost damage is prevented by placing pipes below maximum local frost depth. This requires accurate knowledge of factors which affect the frost depth. When pipes are laid significantly above the frost limit, thermal insulation must be employed. The insulation configuration is determined by heat flow conditions. As a rule, frost prevention in pipe trenches is aided by heat from the ground, as well as heat given off by water and sewage pipes in use. In such cases, a wide, horizontal insulation layer above the pipes may be suitable. This type of insulation is particularly advantageous when the pipes are laid in materials prone to frost-heaves. If the soil is not prone to frost-heaves, it will not be necessary to ensure that the ground below the pipes remains unfrozen. From a thermal point of view, it may then be advantageous to employ a horseshoe shaped insulation layer over the pipes. Such a configuration will result in lower heat transfer to the ground than for a horizontal insulation layer. The choice of insulation method for pipe trenches will depend on how much heat is given off by the pipes and how much heat should be supplied by the ground. If frost prevention is to be accomplished by ground heat only, the materials below the pipes must remain unfrozen.

22 Heat sources

When pipes are placed above local maximum frost depth, some supply of heat will be required. In pipe trenches, heat is normally supplied both from the ground and from water or sewage pipes being used. Heat supplied from the ground consists of several components, see Figure 22 a. As a rule, a disproportionate amount of insulation is required to prevent the 0-isotherm from penetrating the insulation layer in a pipe trench. A large portion of the available ground heat will consist of latent heat given off when soil materials below the insulation layer freeze. When one, as in the case of pipe trenches, can allow a certain amount of freezing below the insulation layer, the time of year when the insulation is laid down will not be important, as long as the ground below the insulation is unfrozen at that time.



1 Heat released by cooling of frozen soil
2 Released latent heat of freezing
3 Heat released by cooling of unfrozen soil
4 Geothermal heat

Figure 22 a
Available heat from the ground

Figure 22 b illustrates the amounts of heat which can be given off by smaller size water and sewage pipes in use. For water pipes one can normally tolerate a drop in temperature of 0.5 - 2.0 °C along a shallow stretch. The acceptable drop depends on the water source and must be determined for each individual case. Due to the high temperature of water that is fed through sewage pipes, these can normally tolerate a some-what larger temperature drop. However, since sewage pipes often are empty for long periods, e.g., at night, one should assume a temperature drop of the same magnitude as for water pipes. Figure 22 b uses the average water flow per 24 hours during the frost period as design parameter.

Heat from electrical cables may also be a contributing factor and such cables should be placed near the pipes, whenever possible. In special cases it may also be necessary to add heat by means of electrical heating cables.

23 Frost load

Frost load parameters used when designing pipe systems in the ground are the maximum frost quantity F_{100} and normal yearly mean temperature ϑ_m. The frost quantity F_{100} is statistically only exceeded once in a hundred years, see publication NBI Aa.111. When maximum frost quantity and yearly mean temperature are known for a given location, extreme values for frost penetration in sand, gravel and clay can be determined from Figures 23 a and b. For a certain frost quantity, the frost penetration is largest for low yearly mean temperatures. Frost penetration in relatively dry materials, such as sand or gravel, is very dependent on frost load variations. Maximum frost penetration in sand and gravel can thus give good indications on the local frost load on structures which depend only on ground

Legends:

<u>Figure 22 b</u>

1 Allowed temperature fall, $\Delta\vartheta$, ^{o}C
2 Pipe length, l (m)
3 Mean water flow over 24 hours, v , liters/sec
4 Heat loss, q, W/m
5 Allowed temperature fall
$\Delta\vartheta = \vartheta_{in} - \vartheta_{out}$
l = Pipes length
q = Heat loss per m
v = Mean water flow
6 Total number of dwellings connected to water and sewer lines

<u>Figure 23 a</u>

1 Sand, gravel
2 Frost quantity, F_{100}, $h^{o}C$
3 Frost depth, m
4 Yearly mean temperature, ^{o}C

heat for frost prevention. Empirical values for larger frost depths in sandy gravel are listed in tabular form in publication NBI Aa.111.

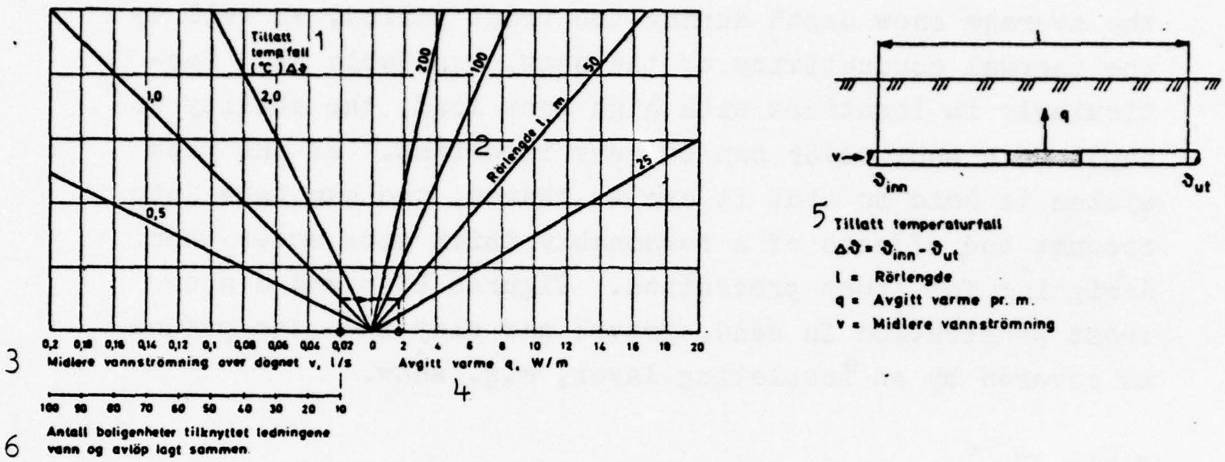


Figure 22 b
Heat loss from water and sewage pipes in use.

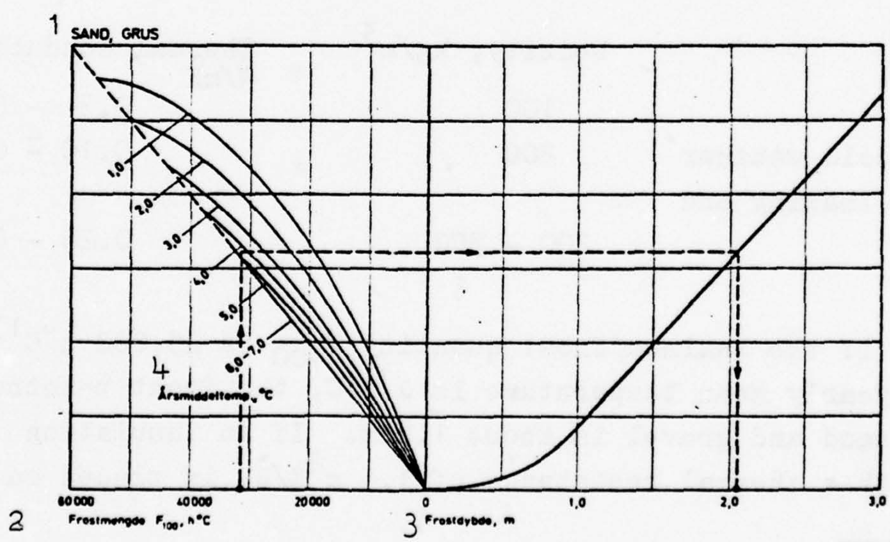


Figure 23 a
Frost penetration in sand and gravel

Where pipes are placed in snow-covered ground, the frost depth will be reduced significantly. Stable snow conditions lead to a higher yearly mean temperature in the ground than in the air. To evaluate the effects of snow, one must know the average snow depth during the frost period, as well as the thermal conductivity of the snow, see Table 23. Particularly in locations with high snow load, the ability to count on a snow cover can be very important. If the pipe system is laid so that it can be thawed, one can take into account the effects of a reasonably thick snow cover when designing for frost prevention. Figures 23 c and d show frost penetration in sand, gravel and clay when the ground is covered by an insulating layer, e.g. snow.

Table 23

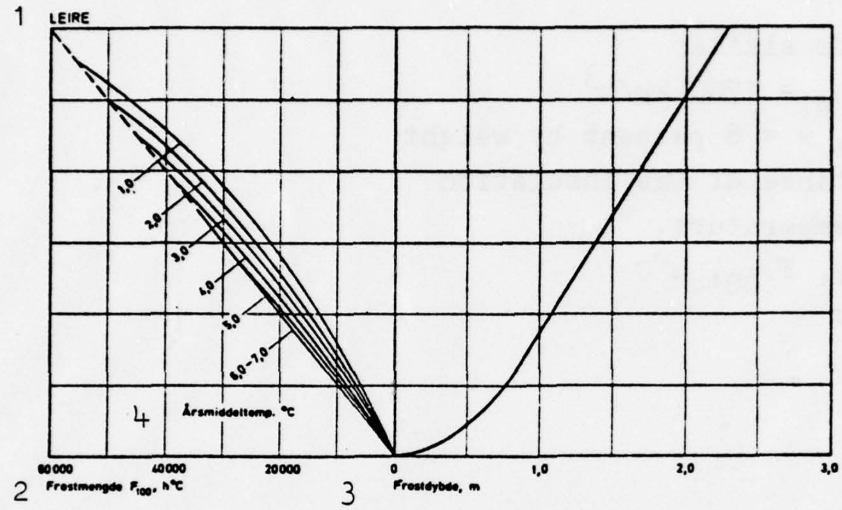
Thermal conductivity for snow with varying density
The conductivity also depends on snow quality for the same density

Snow	Density, kg/m^3	Thermal conducttivity, W/mK
New snow	100	0.8 - 0.22
Snow in cold weather	200	0.10 - 0.20
Repeated thawing and freezing	200 - 300	0.25 - 0.30

Example: If the maximum frost quantity F_{100} is 25,000 h°C[1)] and the yearly mean temperature is 4.5°C, the frost penetration in sand and gravel is about 1.8 m. If an insulation layer with a thermal resistance of 1.4 m^2K/W is placed on

1) h°C = degree-hours, Celsius (Translator's note)

the surface of the ground, the frost penetration in sand and gravel is reduced to approximately 0.5 m. This corresponds to a 140 mm thick layer of snow with a thermal conductivity of 0.1 W/mK.



1 Clay
2 Frost quantity, F_{100}, h°C
3 Frost depth (m)
4 Yearly mean temperature. °C

Figure 23 b
Frost penetration in clay

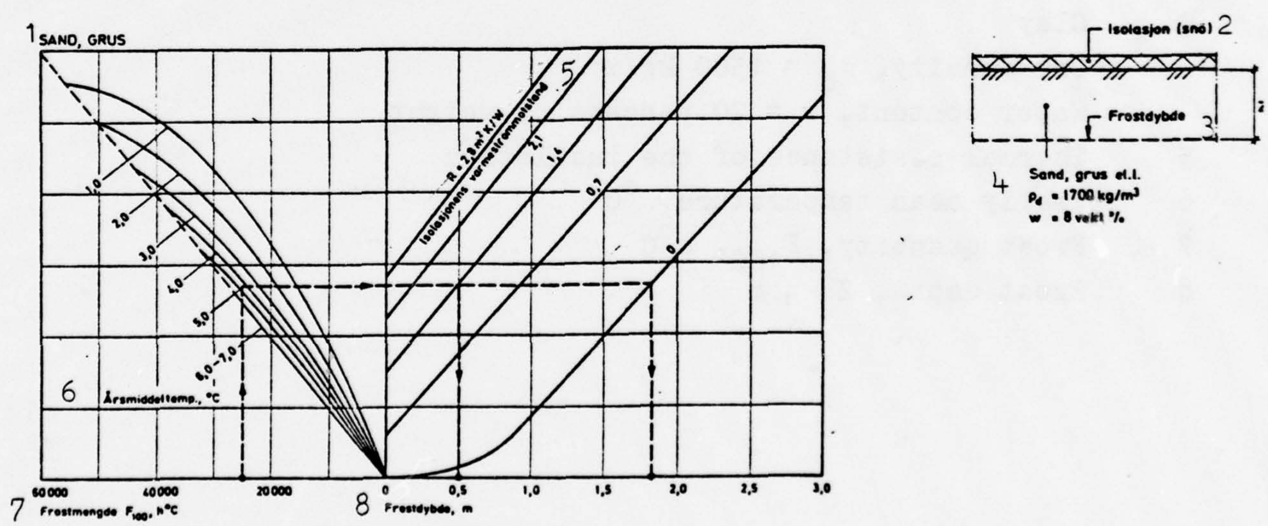


Figure 23 c
Frost penetration in insulated ground
Soil materials: Sand and gravel

Legends:

<u>Figure 23 c</u>

1 Sand, gravel

2 Insulation (snow)

3 Frost depth

4 Sand, gravel or similar
Dry density, ρ_d = 1700 kg/m^3
Water content, w = 8 percent by weight

5 Thermal resistance of the insulation

6 Yearly mean temperature, ^oC

7 Frost quantity, F_{100}, h^oC

8 Frost depth, m

<u>Figure 23 d</u>

1 Clay

2 Insulation

3 Frost depth

4 Clay
Dry density, ρ_d = 1500 kg/m^3
Water content, w = 20 percent by weight

5 Thermal resistance of the insulation

6 Yearly mean temperature, ^oC

7 Frost quantity, F_{100}, h^oC

8 Frost depth, Z , m

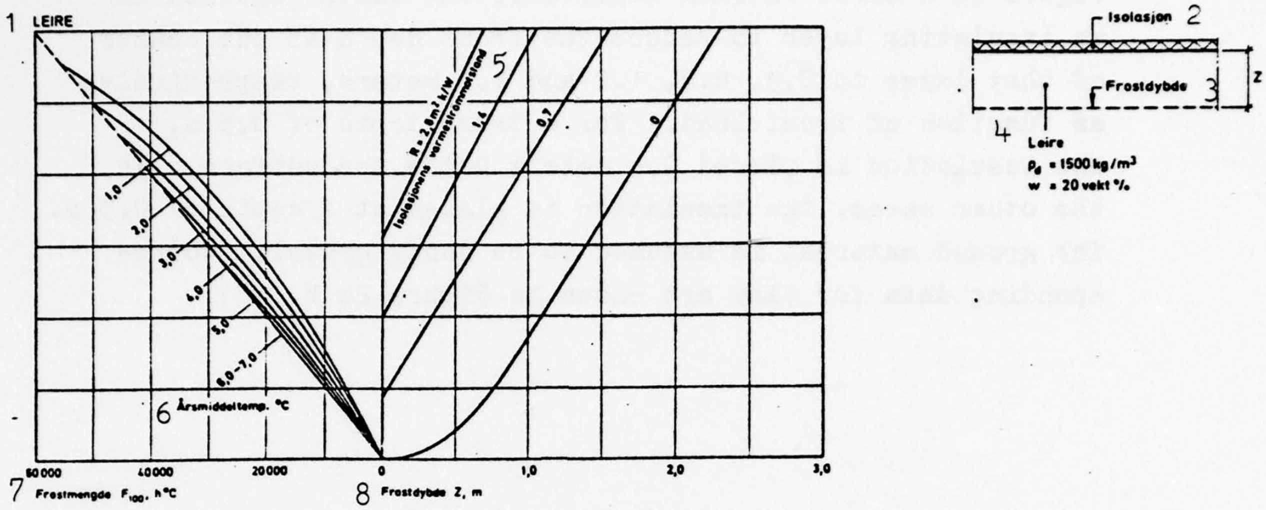


Figure 23 d
Frost penetration in insulated ground
Soil material: Clay

24 Thermal design - pipe trenches where no internal heat is generated

This case includes pipes carrying small quantities of water as well as intermittent or interrupted water flow. The traditional frost prevention method is to place the pipes below maximum local frost depth. This requires knowledge of ground conditions along the pipe route. From a thermal point of view, it is advantageous to utilize moist fill materials within the trench, such as peat, bark, clay etc. This is particularly true when the pipes are in a region with snow cover and thus only subjected to thermal load by the ground. If the pipes pass through regions without snow cover, it may be advantageous to use materials with low thermal conductivity for the upper layer of the fill, e.g. crushed rock or an insulation material. The choice of overlay fill materials may also be dictated by structural considerations.

Figure 24 a shows thermal resistance and width required in an insulating layer to reduce the frost depth at the center of that layer to 0.5, 0.8, 1.2 and 1.6 meters, respectively, as function of frost load. For a frost depth of 0.5 m, the insulation is placed 0.4 meters below the surface. In the other cases, the insulation is placed at a depth of 0.5 m. The ground material is assumed to be sandy gravel. Corresponding data for clay are shown in Figure 24 b.

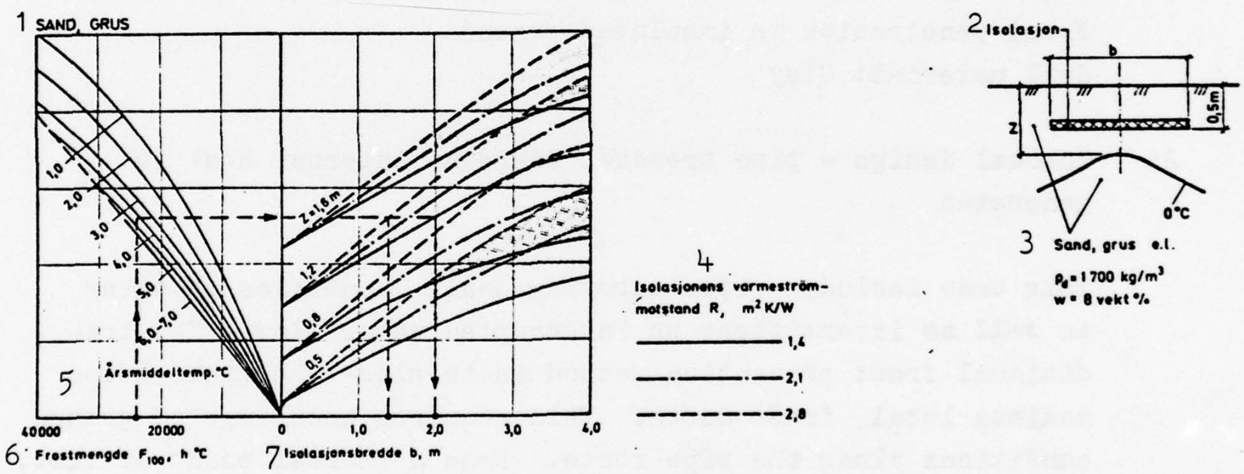


Figure 24 a
Insulation width and thermal resistance required for limiting frost depths to 0.5, 0.8, 1.2 and 1.6 m under the center of a horizontal insulation layer, as a function of frost load.
Soil material: Sand and gravel

Figure 24 a

1 Sand, gravel

2 Insulation

3 Sand, gravel or similar

Dry density, ρ_d = 1700 kg/m^3

Water content, w = 8 percent by weight

4 Thermal resistance of the insulation, R , m^2 K/W

5 Yearly mean temperature, °C

6 Frost quantity, F_{100}, °C

7 Insulation width, b, m

Figure 24 b

1 Clay

2 Insulation

3 Clay

Dry density, ρ_d = 1500 kg/m^3

Water contact, w = 20 percent by weight

4 Thermal resistance of the insulation, R , m^2 K/W

5 Yearly mean temperature, °C

6 Frost quantity, F_{100}, h°C

7 Insulation width, b , m

Figure 24 c

1 Sand, gravel

2 Insulation

3 Thermal resistance of insulation, R , m^2 K/W

4 Soil materials:

Sand, gravel and similar

Dry density, ρ_d = 1700 kg/m^3

Water content, w = 8 percent by weight

5 Yearly mean temperature, °C

6 Frost quantity, F_{100}, h°C

7 Insulation width, b, m

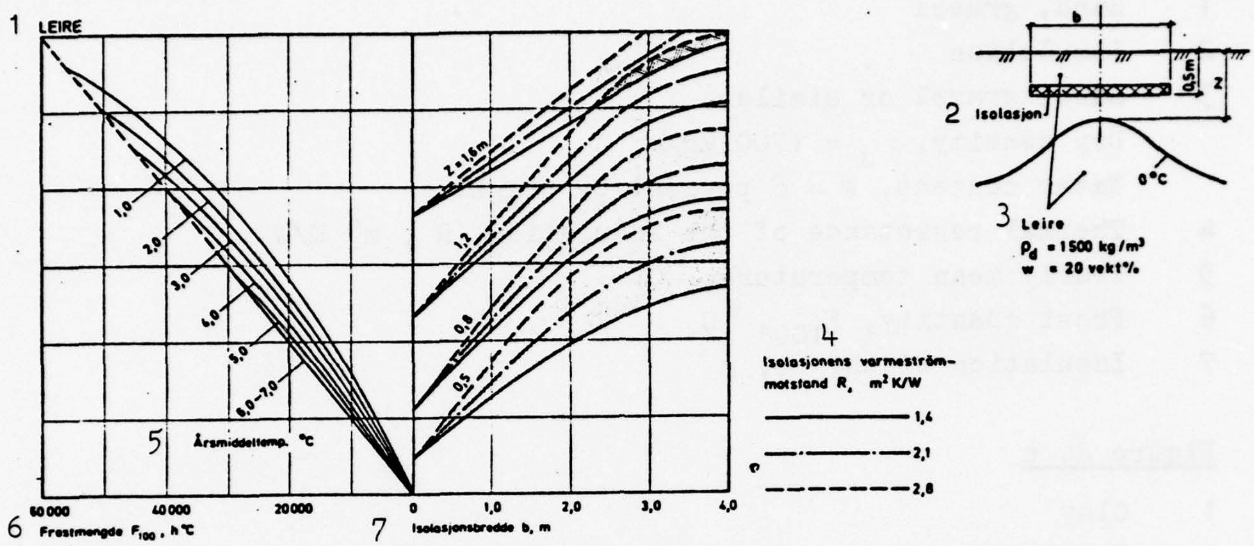


Figure 24 b
Insulation width and thermal resistance required for limiting frost depths to 0.5, 0.8, 1.2 and 1.6 m under the center of a horizontal insulation layer, as a function of frost load.
Soil material: Clay

For one-dimensional heat flow and a wide insulating layer, the largest total reduction in frost depth is obtained by placing the insulation as high up in the ground as possible. The largest effect of moist materials is also obtained when these are placed below the insulation layer. The heat flow in pipe trenches will normally be two-dimensional, unless wall and trench insulations are combined. In that case it will be better to place the insulating layer some-what deeper in the ground in order to reduce freezing from the sides and heat loss from materials below the insulation. This is due to the fact that most soil materials have significantly higher thermal conductivity when frozen than in the unfrozen state.

As a rule, the amount of insulation materials is reduced considerably by increasing the width of the insulation. On the other hand, excavating costs increase with trench width. Instead of increasing the width of the insulation one can form it like a horseshoe over the pipes. The insulation should then be extended downwards on both sides of the pipes. Figure 24 c shows width and thermal resistance required in a horseshoe-shaped insulation layer to reduce the frost penetration to 0.5, 0.8, 1.2 and 1.6 m, for different frost loads.

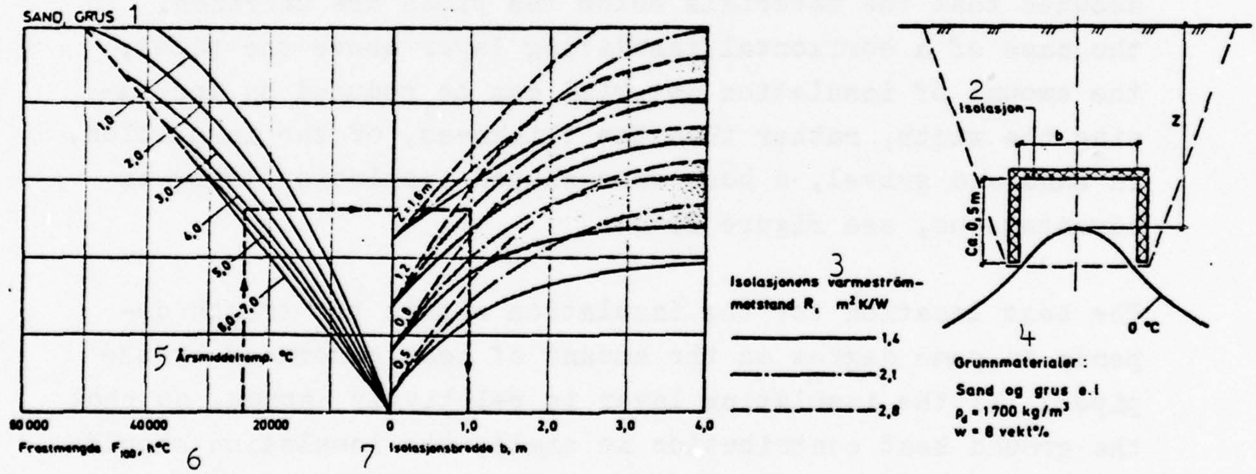


Figure 24 c
Insulation width and thermal resistance required for limiting frost depths to 0.5, 0.8, 1.2 and 1.6 m under the center of a horseshoe-shaped insulation layer, as a function of frost load.
Soil materials:Sand and gravel

In these cases, the ground heat alone provides the frost prevention. Materials below the pipes are thus always unfrozen. As evident from the diagrams, a relatively large amount of insulation is required in sand and gravel materials, when ground heat alone is relied upon for frost prevention.

25 Thermal design - pipe trenches where internal heat is generated

As a rule, heat given off from water and sewage pipes in use combines with ground heat to prevent freezing. This has been accounted for in Figures 25 a, b, and c, for insulation widths of 0.5, 0.8, 1.2 and 1.6 m. In clay materials it is in general most advantageous to use a horizontal layer of insulation above the pipes, see Figure 25 b. The diagram assumes that the materials below the pipes are unfrozen. In the case of a horizontal insulating layer above the pipes, the amount of insulation material can be reduced by increasing the width, rather than the thickness, of the insulation. In sand and gravel, a horseshoe-shaped insulation layer is advantageous, see Figure 25 c.

The best location for the insulation within the trench depends to some degree on the amount of heat generated by the pipes. If the insulating layer is relatively narrow, so that the ground heat contribution is small, the insulation should be placed close to the pipes. However, the pipes should be covered by other materials with a thickness of at least 0.2 m before the insulation is applied. When the ground is the principal source of heat, i.e., when the insulating layer is relatively wide, the latter can be placed higher in the trench. The insulation should be covered by other material that is at least 0.3 m thick. Sand and gravel materials are assumed not to be frost-heave prone. If one also in

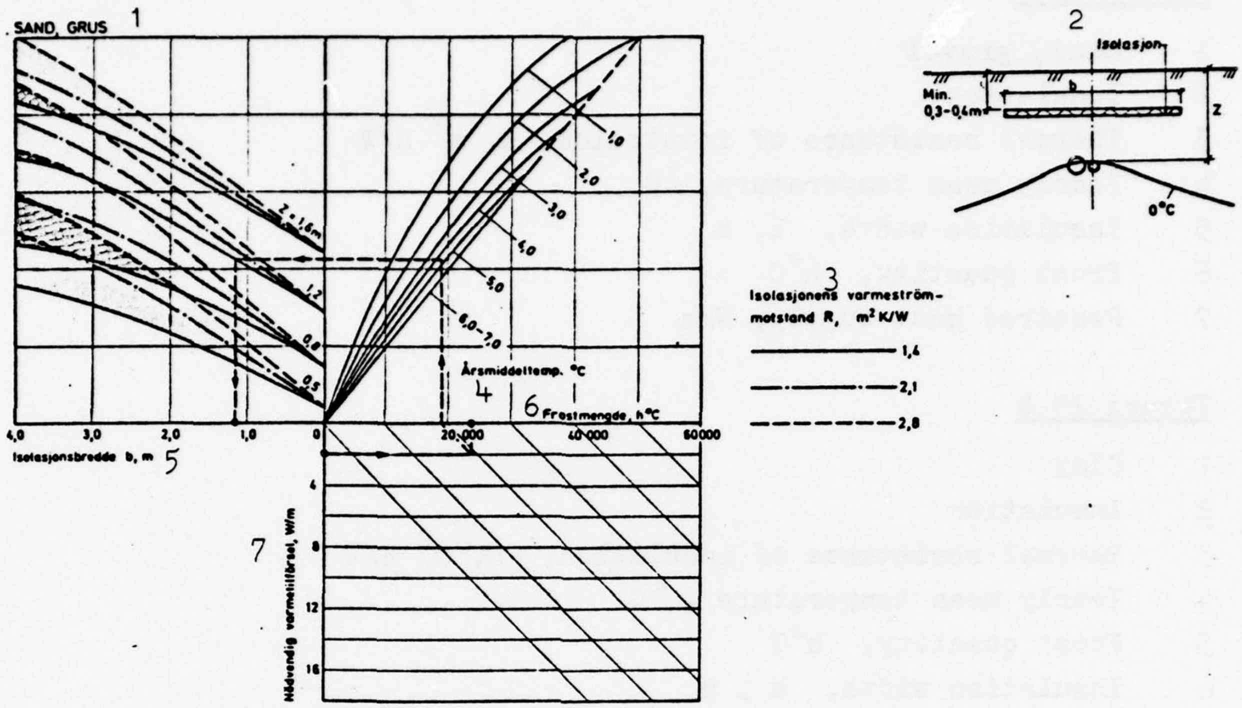


Figure 25 a

Required heat dissipation for frost prevention in pipes insulated by means of a horizontal insulating layer, as function of insulation width and thermal resistance
Soil materials: Sand and gravel
Pipe depth below surface, Z: 0.5, 0.8, 1.2 and 1.6 m

this case requires that no freezing occurs below the pipes, the ground will have to supply a significant portion of the required heat. This can be accomplished by increasing the width of the insulating layer. If that layer is designed to require a heat contribution from the pipes of 2-3 W/m, the materials below the pipes will not freeze. Unfrozen materials under the pipes can also be obtained if the heat generated by the pipes is 50 percent higher than the minimum values given by the diagrams.

Figure 25 a

1 Sand, gravel
2 Insulation
3 Thermal resistance of insulation, R, m^2 K/W
4 Yearly mean temperature, $^\circ$C
5 Insulation width, b, m
6 Frost quantity, h$^\circ$C
7 Required heat supply, W/m

Figure 25 b

1 Clay
2 Insulation
3 Thermal resistance of insulation, R, m^2 K/W
4 Yearly mean temperature , $^\circ$C
5 Frost quantity, h$^\circ$C
6 Insulation width, b , m
7 Required heat supply, W/m

Figure 25 c

1 Sand, gravel
2 Insulation
3 Thermal resistance of insulation, R, m^2 K/W
4 Yearly mean temperature, $^\circ$C
5 Insulation width, b, m
6 Frost quantity, h$^\circ$C
7 Required heat supply, W/m

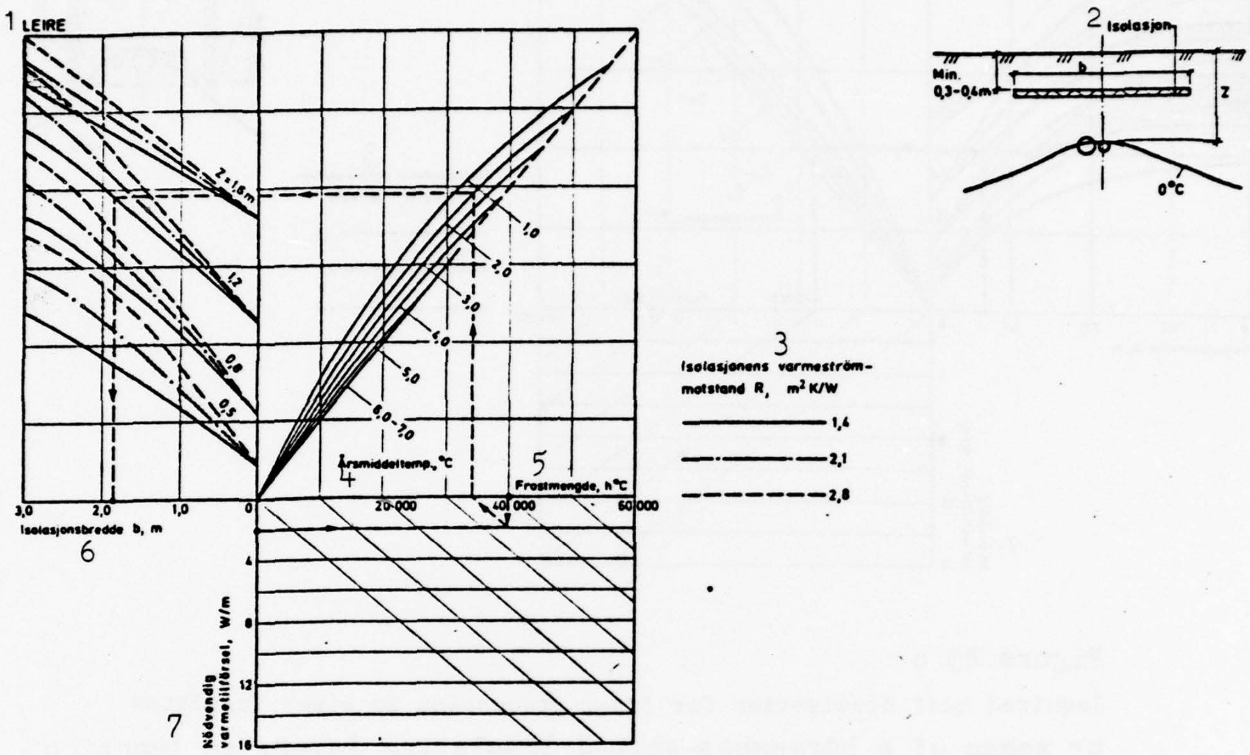


Figure 25 b

Required heat dissipation for frost prevention in pipes insulated by means of a horizontal insulating layer, as function of insulation width and thermal resistance

Soil material: Clay

Pipe depth below surface, Z: 0.5, 0.8, 1.2 and 1.6 m

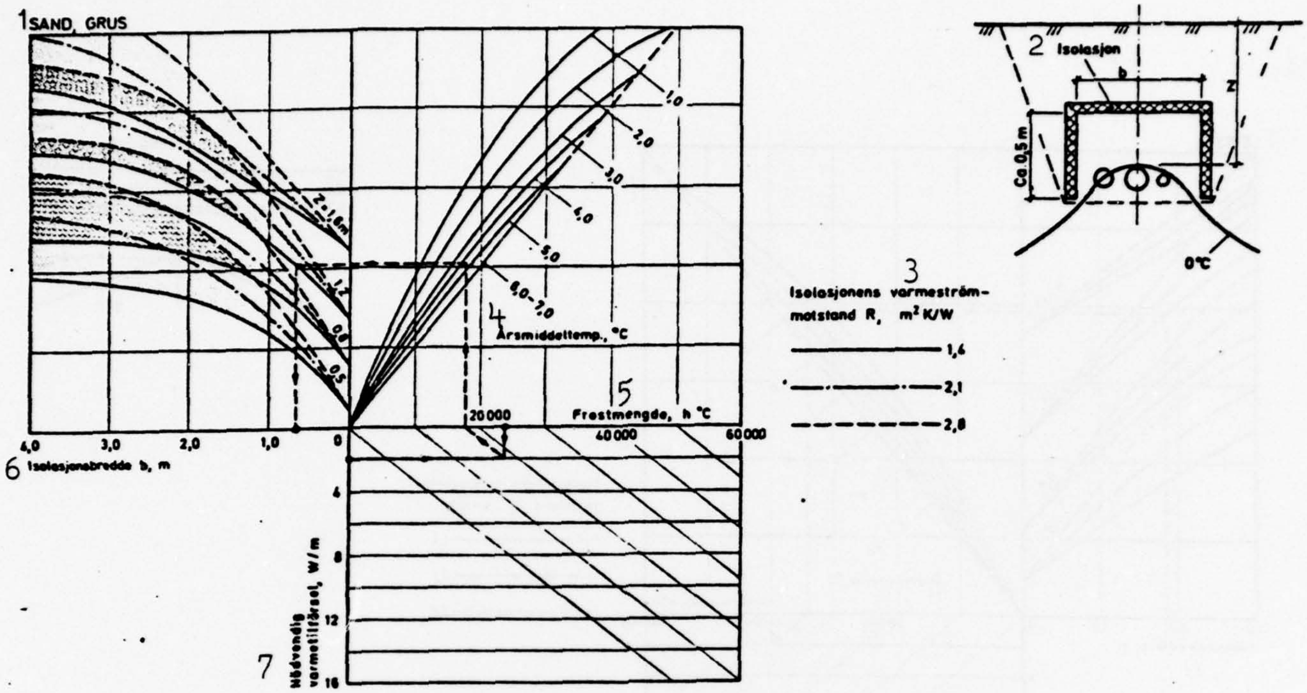


Figure 25 c

Required heat dissipation for frost prevention in pipes insulated by means of a horseshoe-shaped insulating layer, as function of insulation width and thermal resistance
Soil materials: Sand and gravel
Pipe depth below surface: 0.5, 0.8, 1.2 and 1.6 m

26 Examples

261 Ground conditions

A housing project is to be constructed in a region where ground conditions are some-what variable. The soil consists mainly of fine sand and silt with high water table. The latter has been measured and found to average about 1.2 m below the surface over the year. Most of the soil can be considered extremely prone to frost-heaves. Water content in other types of occurring materials has been found to be 10 percent by weight.

The houses are to be built with slab foundations[1]. The site is located in the community of Ullensaker. To avoid - - - [2], the trench depth is chosen to be 1.2 m. In this case, the most suitable choice of insulation for the pipe trenches would be one which prevents freezing of the pipes as well as frost-heaves.

Design frost quality, $F_{dim} = F_{100} = 32{,}000$ h°C

(see Publication NBI Aa.111)

For ground materials such as sand and gravel, the frost depth would be about 2.0 m. This can also be determined from Figure 23 a. If the ground consists of silt, the frost penetration will be reduced by a factor of 0.85, which results in a maximum frost depth of 1.7 m. Where, as in a few places, the ground material is fine sand, one can assume a local maximum frost depth of 1.8 m. (Figure 11 a)

A maximum frost depth of 1.8 m in sand or gravel corresponds to a frost quantity of about 24,000 h°C. This frost load can be used, as a good approximation, for designing the pipe system when the soil material fine silt/sand is encountered, rather than the, in this context, less favourable sandy gravel. (Figure 23 a)

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1) Literal translation "floor on the ground", i.e., no basements.

2) "Spunting" normally refers to dressing the walls of a trench with boards or other materials, primarily to prevent cave-ins. In this case, the context implies that trenches deeper than 1.2 m (average water table, see previous paragraph) would have to be dressed with U - channels (e.g. concrete) to keep ground water out. (Translator's notes)

262 Negligible heat generated by water and sewage pipes

Frost prevention by means of horizontal insulating layer:

Width of insulating layer: 1.4 m
Required thermal resistance: 2.8 m^2 K/W (Figure 24 a)
Required thickness, extruded polystyrene: 100 mm (Table 12)
expanded polystyrene: 120 mm (Figure 12 a)

If expanded polystyrene is used, moisture proofing is required.

Width of insulating layer: 2.0 m
Required thermal resistance: 1.4 m^2 K/W (Figure 24 a)
Required thickness, extruded polystyrene: 50 mm (Table 12)
The insulation must be protected against moisture (Figure 12 a)

By using the wider insulating layer, the volume is reduced by about 30 percent.

Frost prevention by means of horseshoe-shaped insulating layer:

Width of insulating layer 1.0 m
Required thermal resistance: 2.1 m^2 K/W (Figure 24 c)
Required thickness, extended polystyrene: 75 mm (Table 12)
No need for moisture protection (Figure 12 a)

263 Heat generated by water and sewage pipes

In a development where the houses are closely spaced, the pipe system is best designed so that several houses are connected to the same branch-pipe, see Figure 32. One can then base the thermal design on a certain heat being generated from the pipes.

In this case one may assume that each water and sewage pipe is connected to 10 dwellings. This results in a minimum flow rate, averaged over 24 hours, of 0.02 liters/sec. (Figure 22 b)

If a horizontal insulating layer is used:
Width 1.2 m, thermal resistance 1.4 m^2 K/W (Figure 25 a)
Required thickness, extruded polystyrene: 50 mm (Table 12)
The insulation should be protected against moisture (Figure 12 a)

If horseshoe-shaped insulation is used:
Width 0.7 m, thermal resistance 1.4 m^2 K/W (Figure 25 c)
Required thickness, extruded polystyrene: 50 mm (Table 12)
The insulation should be protected against moisture (Figure 12 a)

Width 1.0 m, thermal resistance 0.7 K/W (Figure 25 c)
Required thickness, extruded polystyrene: 25 mm (Table 12)
Moisture-proofing is required (Figure 12 a)

Due to relatively rapid moisture penetration in thin insulation slabs, the insulation should not be less than 40 - 50 mm thick.

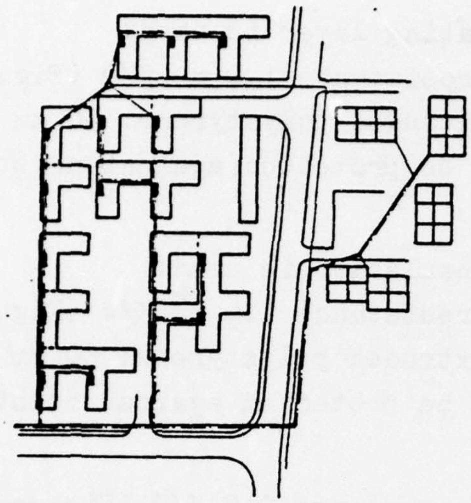

Figure 32
Pipe network suitable for closely spaced one family houses. Pipes should be placed under house foundations and, where-ever possible, away from road-beds.

Fig. 23 a

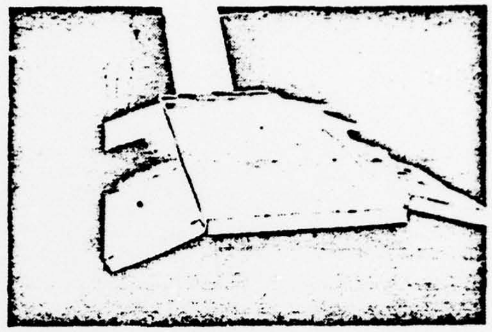

Fig. 24 a
Tabell 12
Fig. 12 a

Fig. 24 a
Tabell 12
Fig. 12 a

Fig. 24 c
Tabell 12
Fig. 12 a

Fig. 22 b

Fig. 22 b

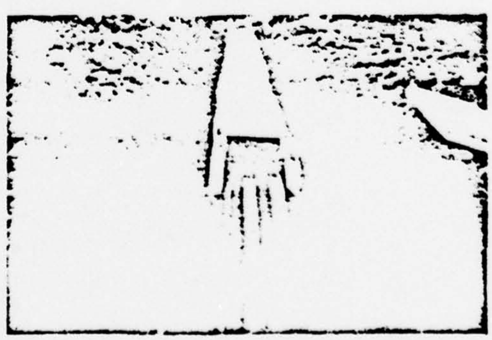

Fig. 25 a
Tabell 12
Fig. 12 a

Fig. 25 c
Tabell 12
Fig. 12 a

Fig. 25 c
Tabell 12
Fig. 12 a

FROST LOAD NBI[1] Publication Aa.111

Data for frost prevention, with tables

October 1976

0 GENERAL

01 This publication contains frost load data in tabular form for all communities[2] in Norway. Emphasis has been placed on data which apply to frost prevention of structures in the ground, such as pipes, foundations and roads.

02 Communities are arranged by fylke[3], using the official numbering system defined in 1975. Some of the measuring stations operated by the Meteorological Institute are included in the communities where they are located.

03 Data shown for the measuring stations are actually measured values. For other locations, the data are based on extrapolations from measurements at near-by stations in the network operated by the Meteorological Institute across the country.

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1) Norges Byggforskningsinstitutt: Norwegian Building Research Institute

2) "Kommune", here translated "Community", has all over Scandinavia replaced previous local administrative units such as cities, towns and villages.

3) "Fylke" is an administrative unit comprising several communities, similar to county in the US. (Translator's notes)

04 72 hour averages

ϑ_3 is the lowest average air temperature over a 72 hour period.

ϑ_3 is used when designing frost preventing structures for pipes in direct contact with the air, e.g., for open foundations, as well as for calculating heating requirements in buildings.

05 Frost quantity and yearly mean temperature

The frost quantity is the area between the temperature curve for the frost season and the line for 0°C, see Figure 05. Frost quantities are normally calculated form the monthly mean temperatures and is measured in degree-hours, h°C (hours multiplied by degrees Celsius).

Data on frost quantities over a number of years are used for determining the probability that a certain frost quantity will be exceeded.

F_2 - frost quantity which, on the average, occurs once in two years (approximately equal to the mean frost quantity).

F_5 - frost quantity which, on the average, occurs once in a five year period.

F_{10} - frost quantity which, on the average, occurs once in a ten year period.

F_{100} - frost quantity which, on the average, occurs once in a hundred years (approximately the maximum frost quantity).

The yearly mean temperature, ϑ_m, (average yearly temperature over a 30 year period) is also listed in the tables.

Frost quantity and yearly mean temperature are used when designing frost preventing structures for pipes, foundations and roads.

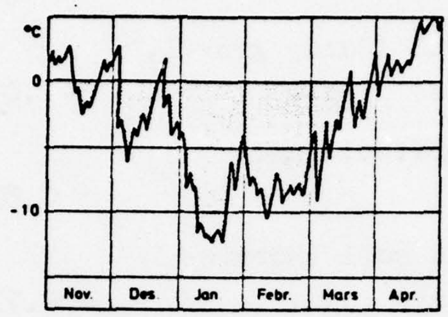

Figure 05
Relation between frost quantity and actual air temperature

06 Frost depth

The frost depths Z_{100} are calculated values, assuming sand and gravel to be the ground materials. Frost load parameters used are the frost quantity F_{100} and normal yearly mean temperature, ϑ_m. It is also assumed that the ground is not covered by snow. For ground materials other than sand and gravel, Figure 06 shows the correction factor used to determine frost depth.

$Z_{100} = Z_{100\ \text{sand, gravel}} \cdot k_z$

k_z = correction factor for different ground materials

Material	Correction factor, k_z
1. Rock (Crushed rock, rock fill, coarse gravel)	1.4
2. Sand and gravel (Sandy gravel, coarse moraine)	1.0
3. Silt (Fine moraine, sandy soil)	0.85
4. Clay and mixed soil (Moraine containing clay)	0.7
5. Peat	0.3

Figure 06
Correction factors for determining frost depth in different soil materials.

07 The effect of snow

A snow cover will significantly reduce the frost depth. To estimate the frost depth in ground covered by snow, the following relation can be used to find the ground surface frost quantity from that in the air:

$F_{surface} = k_F \cdot F_{air}$

k_F = correction factor for snow cover

Figure 07 shows the correction factor k_F as a function of the average snow cover thickness during the winter. Local conditions will determine whether or not a snow cover should be taken into account when designing for frost prevention, since large variations in snow depth may occur within small areas.

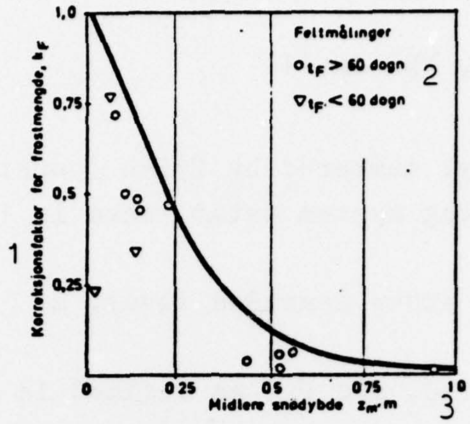

Figure 07
Correction factor for frost quantity at snowcovered surface, as function of average snow cover thickness throughout the winter.

Legends, NBI Aa.111

Figure 07

1 Correction factor for frost quantity, k_F
2 Field measurements
o $t_F^{1)} > 60$ days
▽ $t_F < 60$ days
3 Average snow cover thickness, Z_m, m

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1) The parameter t_F is not defined in the text, but is probably the number of days over which measurements are averaged. (Translator's note)

Legends for tables, NBI Aa.111

1 KOMMUNE = Community, numbered by fylke (county) according to an official numbering system established in 1975.

2 F.o.h. = Elevation above mean Sea level, m.

3 TEMP = temperatures ϑ_3 and ϑ_m, as defined in the text.

4 FROSTMENGDE = Frost quantity. F_2, F_5, F_{10} and F_{100} are defined in the text.

5 Z_{100} = Frost depth calculated for sand and gravel for the "maximum" frost quantity, F_{100}.

KOMMUNE	H o h	TEMP		FROSTMENGDE				
Fylkesvis ordnet med offisiell nummerering Ajourfort 1975		ϑ_1	ϑ_m	F_2	F_5	F_{10}	F_{100}	Z_{100}
	m	C		h C				m
01 ØSTFOLD								
0101 Halden		−22	6.0	7 000	13 000	18 000	22 000	1.6
− Brekke sluse	114	−24.3	5.5	9 100	15 200	20 300	24 300	
0102 Sarpsborg		−22	6.0	7 000	13 000	18 000	22 000	1.6
0103 Fredrikstad		−20	6.5	5 000	11 000	16 000	24 000	1.7
0104 Moss		−19	6.0	6 000	12 000	17 000	21 000	1.6
0111 Hvaler		−18	7.0	3 000	7 000	11 000	15 000	1.3
0113 Borge		−21	6.5	5 000	11 000	16 000	20 000	1.5
0114 Varteig		−22	6.0	7 000	13 000	18 000	22 000	1.6
0115 Skjeberg		−21	6.0	7 000	13 000	18 000	22 000	1.6
0118 Aremark		−24	5.0	10 000	16 000	21 000	25 000	1.8
0119 Marker		−25	5.0	12 000	18 000	23 000	28 000	1.9
0121 Romskog		−25	4.5	14 000	20 000	25 000	30 000	2.0
0122 Trogstad		−23	5.0	10 000	16 000	21 000	26 000	1.8
0123 Spydeberg		−22	5.0	10 000	16 000	21 000	26 000	1.8
0124 Askim		−22	5.5	10 000	16 000	21 000	26 000	1.8
0125 Eidsberg		−22	5.5	10 000	16 000	21 000	26 000	1.8
− Eidsberg	140	−21.4	5.4	10 100	16 200	21 300	26 400	
0127 Skiptvet		−22	5.5	10 000	16 000	21 000	26 000	1.8
0128 Rakkestad		−23	5.5	10 000	16 000	21 000	26 000	1.8
0130 Tune		−21	6.0	7 000	13 000	18 000	22 000	1.6
0131 Rolvsoy		−21	6.0	8 000	14 000	19 000	23 000	1.6
0133 Kråkeroy		−19	7.0	4 000	9 000	13 000	18 000	1.4
0134 Onsoy		−19	6.5	5 000	7 000	16 000	20 000	1.5
0135 Råde		−19	6.0	6 000	12 000	17 000	21 000	1.5
0136 Rygge		−19	6.0	5 000	11 000	16 000	20 000	1.5
0137 Våler		−21	6.0	7 000	14 000	20 000	24 000	1.7
0138 Hobol		−21	5.5	8 000	15 000	21 000	25 000	1.8
02 AKERSHUS								
0211 Vestby		−20	5.5	7 000	14 000	20 000	24 000	1.7
0213 Ski		−21	5.5	8 000	15 000	21 000	25 000	1.8
0214 Ås		−22	5.5	8 000	15 000	21 000	25 000	1.8
− Ås	95	−22.2	5.5	9 600	16 700	22 300	26 400	
0215 Frogn		−20	5.5	8 000	15 000	21 000	25 000	1.8
0216 Nesodden		−20	5.5	8 000	15 000	21 000	25 000	1.8
0217 Oppegård		−21	5.5	8 000	15 000	21 000	25 000	1.8
0219 Bærum		−20	6.0	11 000	15 000	18 000	26 000	1.8
− Fornebu	10	−19.3	6.4	10 100	13 200	20 300	24 300	
0220 Asker		−20	5.5	11 000	15 000	18 000	26 000	1.8
0221 Aurskog-Holand		−25	4.5	12 000	18 000	24 000	29 000	2.0
0226 Sorum		−24	4.5	12 000	18 000	25 000	29 000	2.0
0227 Fet		−23	5.0	11 000	18 000	24 000	28 000	1.9
0228 Rælingen		−23	5.0	11 000	18 000	24 000	28 000	1.9
0229 Enebakk		−23	5.0	11 000	18 000	24 000	28 000	1.9
0230 Lorenskog		−26	5.0	11 000	18 000	24 000	28 000	1.9
0231 Skedsmo		−22	4.5	12 000	19 000	25 000	29 000	2.0
0233 Nittedal		−22	5.0	14 000	21 000	27 000	31 000	2.0
0234 Gjerdrum		−22	4.0	15 000	22 000	28 000	32 000	2.1
0235 Ullensaker		−22	4.5	15 000	22 000	28 000	32 000	2.1
− Gardermoen	204	−22.0	4.3	16 000				
0236 Nes		−25	4.0	15 000	22 000	31 000	36 000	2.2
0237 Eidsvoll		−24	4.0	17 000	23 000	30 000	35 000	2.2
0238 Nannestad		−23	4.0	16 000	22 000	29 000	34 000	2.2
0239 Hurdal		−23	4.0	16 000	22 000	29 000	34 000	2.2
03 OSLO								
Byområder		−20	6.0	40 000	14 000	17 000	25 000	1.8
Boligomrader		−22	5.0	12 000	16 000	19 000	27 000	1.8
Marka		−24	4.0	14 000	18 000	23 000	29 000	2.0
− Blindern	94	−20.4	5.9	9 600	13 200	16 700	24 300	
− Tryvasshogda	512	−23.6	3.7	13 700	17 200	22 300	25 300	
04 HEDMARK								
0401 Hamar		−26	4.0	18 000	25 000	32 000	39 000	2.3
0402 Kongsvinger		−27	4.0	18 000	25 000	34 000	39 000	2.3
− Vinger	175	−26.4	4.3					
0412 Ringsaker		−25	4.0	20 000	27 000	33 000	41 000	2.4
0414 Vang		−27	3.0	20 000	27 000	33 000	41 000	2.5
0415 Loten		−27	3.5	20 000	27 000	34 000	41 000	2.4
0417 Stange		−25	4.0	18 000	25 000	32 000	39 000	2.3
0418 Nord-Odal		−27	4.0	18 000	25 000	34 000	39 000	2.3
0419 Sor-Odal		−27	4.0	18 000	25 000	34 000	39 000	2.3
0420 Eidskog		−25	4.0	15 000	22 000	31 000	36 000	2.2
− Skotterud	150		4.6					
0423 Grue		−27	3.5	20 000	27 000	36 000	41 000	2.4
0425 Åsnes		−29	3.5	21 000	28 000	37 000	42 000	2.5
− Flisa	183	−29.7	3.7	19 800	26 400	35 500	40 600	

KOMMUNE	H o h	TEMP		FROSTMENGDE				
Fylkesvis ordnet med offisiell nummerering Ajourfort 1975		ϑ_1	ϑ_m	F_2	F_5	F_{10}	F_{100}	Z_{100}
	m	C		h C				m
0426 Våler		−29	3.5	21 000	28 000	37 000	42 000	2.5
0427 Elverum		−29	3.0	23 000	30 000	39 000	44 000	2.6
0428 Trysil		−29	2.0	27 000	34 000	43 000	48 000	2.8
− Trysil	362	−26.9	2.2	26 000				
0429 Åmot		−30	2.5	26 000	32 000	42 000	47 000	2.7
− Rena	225	−31.3	2.6	27 000				
0430 Stor-Elvdal		−31	2.0	26 000	32 000	43 000	49 000	2.8
− Sor-Nesset	738		0.8	28 000				
− Koppang-Oyset	303		2.1	27 000				
0432 Rendalen		−31	2.5	25 000	30 000	42 000	48 000	2.7
− Ytre Rendal	253	−28.1	2.8	22 000				
0434 Engerdal		−31	1.0	29 000	34 000	46 000	52 000	3.1
− Drevsjo	675		0.6	32 000				
0435 Os		−40	0.5	31 000	36 000	48 000	54 000	3.2
0436 Tolga		−40	0.5	31 000	36 000	48 000	54 000	3.2
0437 Tynset		−37	0.5	32 000	37 000	49 000	55 000	3.2
− Tynset	483		0.4	34 000				
− Sæter i Kvikne	550	−36	1.6	23 000				
0438 Alvdal		−36	1.0	28 000	33 000	45 000	51 000	3.1
− Alvdal	485	−35	1.4	27 400	32 400	44 600	50 700	
0439 Folldal		−33	0.5	30 000	36 000	45 000	53 000	3.2
05 OPPLAND								
0501 Lillehammer		−25	4.0	23 000	30 000	36 000	44 000	2.5
− Lillehammer	226	−24.9	3.3	20 800	27 400	33 500	41 600	
0502 Gjovik		−25	4.0	18 000	25 000	30 000	36 000	2.2
0511 Dovre		−28	1.5	30 000	37 000	42 000	53 000	3.1
− Hjerkinn	953		0.5	27 000				
− Dombås	643	−26.4	1.7	22 300	29 400	34 500	45 600	
0512 Lesja		−25	1.5	25 000	32 000	37 000	48 000	2.9
− Lesjaverk	630		1.5	25 000				
0513 Skjåk		−24	1.0	24 000	31 000	36 000	42 000	2.9
0514 Lom		−25	1.5	24 000	31 000	36 000	42 000	2.8
0515 Vågå		−28	−2.0	26 000	34 000	39 000	44 000	2.7
− Vågåmo	371		2.6	24 000				
0517 Sel		−31	2.0	26 000	34 000	40 000	44 000	2.7
0518 Fron		−30	2.5	26 000	34 000	40 000	44 000	2.6
− Vinstra	241	−30.3	2.7	25 300	33 500	39 500	43 600	
0520 Ringebu		−30	3.0	24 000	32 000	38 000	42 000	2.5
0521 Oyer		−29	3.5	23 000	30 000	36 000	41 000	2.8
0522 Gausdal		−27	2.0	26 000	34 000	40 000	44 000	2.7
0528 Ostre Toten		−24	4.0	18 000	24 000	30 000	36 000	2.2
− Ostre Toten	217	−23.6	4.1	17 000				
0529 Vestre Toten		−24	3.5	20 000	26 000	32 000	38 000	2.3
0532 Jevnaker		−24	4.0	15 000	22 000	28 000	33 000	2.2
0533 Lunner		−24	3.0	16 000	23 000	29 000	34 000	2.3
0534 Gran		−25	3.0	17 000	23 000	30 000	35 000	2.3
0536 Sondre Land		−26	3.0	19 000	25 000	31 000	37 000	2.4
0538 Nordre Land		−27	2.5	22 000	28 000	34 000	40 000	2.5
0540 Sor-Aurdal		−27	2.5	20 000	28 000	34 000	39 000	2.5
0541 Etnedal		−27	1.0	26 000	34 000	40 000	45 000	3.0
0542 Nord-Aurdal		−28	1.5	25 000	33 000	39 000	44 000	2.8
− Åsbjorsbraten	634	−26.7	1.7	21 800	29 400	35 500	40 600	
0543 Vestre Slidre		−30	2.0	25 000	33 000	39 000	44 000	2.7
0544 Oystre Slidre		−30	2.0	25 000	33 000	39 000	44 000	2.7
0545 Vang		−29	2.5	25 000	33 000	39 000	44 000	2.6
06 BUSKERUD								
0601 Ringerike		−25	4.5	16 000	23 000	29 000	34 000	2.1
− Eggemoen	192		3.9	19 000				
0602 Drammen		−22	5.5	13 000	20 000	25 000	29 000	1.9
0604 Kongsberg		−24	4.5	15 000	23 000	28 000	31 000	2.0
− Kongsberg	172	−23.0	4.8	13 700	21 300	26 400	29 400	
0615 Flå		−27	2.0	21 000	30 000	36 000	41 000	2.6
0616 Nes		−28	2.0	26 000	35 000	41 000	46 000	2.8
− Nesbyen	165	−28.4	2.9	25 300	34 000	40 600	45 600	
0617 Gol		−28	1.5	25 000	34 000	40 000	45 000	2.9
0618 Hemsedal		−28	1.5	20 000	29 000	34 000	42 000	2.8
0619 Ål		−28	2.0	20 000	27 000	33 000	42 000	2.7
0620 Hol		−27	1.0	25 000	32 000	38 000	47 000	3.0
− Geilo-Geitestol	768	−25.8	1.0	22 800	29 400	35 500	44 600	
− Dagali	887	−25.8	1.0	25 000				
0621 Sigdal		−26	3.0	18 000	27 000	33 000	38 000	2.4
0622 Krodsherad		−27	3.5	17 000	25 000	31 000	35 000	2.2
0623 Modum		−24	5.0	16 000	23 000	28 000	31 000	2.0
0624 Ovre Eiker		−23	4.5	15 000	22 000	28 000	31 000	2.0
0625 Nedre Eiker		−23	5.0	14 000	21 000	27 000	30 000	2.0
0626 Lier		−22	5.5	13 000	19 000	23 000	29 000	1.9

KOMMUNE Fylkesvis ordnet med offisiell nummerering Ajourført 1975	H o h m	TEMP ϑ_1 C	ϑ_m	FROSTMENGDE F_2 h C	F_5	F_{10}	F_{100}	Z_{100} m
0627 Royken		−20	5,5	10 000	16 000	20 000	26 000	1,8
0628 Hurum		−19	6,0	8 000	14 000	18 000	24 000	1,7
0631 Flesberg		−26	3,5	20 000	27 000	32 000	36 000	2,2
– Svene	176	−26,9	3,7	19 000				
0632 Rollag		−27	3,0	20 000	27 000	32 000	36 000	2,3
0633 Nore og Uvdal		−27	1,5	24 000	32 000	38 000	44 000	2,8
07 VESTFOLD								
0702 Holmestrand		−19	6,0	7 000	13 000	18 000	22 000	1,6
0703 Horten		−18	6,5	5 000	10 000	15 000	20 000	1,5
0705 Tonsberg		−18	6,5	4 000	9 000	14 000	19 000	1,5
0706 Sandefjord		−18	6,5	4 000	10 000	15 000	19 000	1,5
– Torp	92		5,9	7 000				
0707 Larvik		−18	6,5	4 000	9 000	14 000	17 000	1,3
0708 Stavern		−18	7,0	4 000	8 000	12 000	16 000	1,3
0711 Svelvik		−20	6,0	10 000	17 000	22 000	26 000	1,8
0713 Sande		−21	6,0	9 000	16 000	21 000	25 000	1,8
0714 Hof		−21	6,0	10 000	17 000	22 000	26 000	1,8
0716 Våle		−19	6,0	6 000	12 000	18 000	22 000	1,6
0717 Borre		−18	6,0	6 000	12 000	17 000	21 000	1,5
0718 Ramnæs		−19	5,5	7 000	14 000	19 000	23 000	1,7
0719 Andebu		−20	5,5	7 000	13 000	19 000	23 000	1,7
0720 Stokke		−18	6,0	5 000	11 000	16 000	20 000	1,5
0721 Sem		−18	6,0	5 000	11 000	16 000	20 000	1,5
0722 Notteroy		−18	6,5	4 000	9 000	14 000	19 000	1,5
0723 Tjome		−18	7,0	3 000	7 000	11 000	15 000	1,2
– Færder	6	−17,2	7,5	2 000	6 100	10 100	14 200	
0725 Tjolling		−18	6,5	4 000	8 000	12 000	16 000	1,3
0726 Brunlanes		−18	6,0	5 000	10 000	13 000	17 000	1,3
0727 Hedrum		−18	6,0	6 000	12 000	17 000	21 000	1,5
0728 Lardal		−21	5,5	7 000	14 000	19 000	23 000	1,7
08 TELEMARK								
0805 Porsgrunn		−21	6,0	10 000	15 000	18 000	22 000	1,6
0806 Skien		−22	5,0	11 000	16 000	21 000	25 000	1,8
0807 Notodden		−26	3,5	13 000	19 000	27 000	29 000	2,0
0811 Siljan		−22	5,5	10 000	16 000	21 000	25 000	1,8
0814 Bamle		−20	6,0	6 000	10 000	13 000	17 000	1,3
0815 Kragero		−20	6,0	4 000	8 000	11 000	15 000	1,2
0817 Drangedal		−24	5,5	10 000	16 000	20 000	25 000	1,8
– Vefall	68	−24,5	5,8	10 100	15 700	20 300	25 300	
0819 Nome		−24	5,0	11 000	16 000	22 000	25 000	1,8
0821 Bø		−25	4,0	12 000	17 000	23 000	26 000	1,9
0822 Sauherad		−26	4,5	13 000	18 000	25 000	27 000	1,9
– Gvarv	24	−26,5	5,2	13 200	18 300	25 300	27 400	
0826 Tinn		−27	2,0	25 000	31 000	37 000	41 000	2,7
– Gaustadtop	1828		−4,3	48 000				
0827 Hjartdal		−26	2,5	15 000	21 000	27 000	31 000	2,3
0828 Seljord		−26	3,5	13 000	18 000	24 000	27 000	1,9
0829 Kviteseid		−25	5,0	12 000	17 000	21 000	25 000	1,8
0830 Nissedal		−23	5,5	10 000	15 000	20 000	25 000	1,8
– Tveitsund	252	−22,2	5,2	9 000				
0831 Fyresdal		−23	5,0	10 000	14 000	19 000	23 000	1,7
0833 Tokke		−23	5,0	11 000	16 000	20 000	24 000	1,7
– Dalen	77	−21,4	5,3	10 600	15 200	19 300	23 300	
0834 Vinje		−25	2,0	20 000	26 000	32 000	36 000	2,5
09 AUST-AGDER								
0901 Risor		−19	6,5	2 000	6 000	9 000	13 000	1,2
0903 Arendal		−19	7,0	1 000	5 000	8 000	12 000	1,1
0904 Grimstad		−19	7,0	1 000	5 000	8 000	12 000	1,1
0911 Gjerstad		−22	6,0	5 000	10 000	14 000	19 000	1,5
0912 Vegårshei		−21	6,0	5 000	9 000	12 000	16 000	1,3
0914 Tvedestrand		−20	6,5	2 000	6 000	9 000	13 000	1,2
0918 Moland		−20	7,0	1 000	5 000	8 000	12 000	1,1
0919 Froland		−20	6,0	5 000	9 000	13 000	16 000	1,3
0920 Oyestad		−19	7,0	1 000	5 000	8 000	12 000	1,1
0921 Tromoy		−19	7,0	1 000	5 000	8 000	12 000	1,1
0922 Hisoy		−19	7,0	1 000	5 000	8 000	12 000	1,1
0923 Fjære		−19	7,0	1 000	5 000	9 000	12 000	1,1
0924 Landvik		−19	7,0	1 000	5 000	9 000	12 000	1,1
0926 Lillesand		−19	7,0	1 000	5 000	9 000	12 000	1,1
0928 Birkenes		−20	6,0	5 000	9 000	13 000	16 000	1,3
0929 Åmli		−21	5,0	7 000	11 000	14 000	18 000	1,5
0935 Iveland		−21	6,0	5 000	9 000	13 000	16 000	1,3
0937 Evje og Hornnes		−21	6,0	5 000	9 000	13 000	16 000	1,3
0938 Bygland		−21	5,0	7 000	10 000	14 000	18 000	1,5
– Byglandsfjord	206	−21,4	5,7	7 100	10 600	14 700	18 300	
0940 Valle		−23	4,0	9 000	13 000	17 000	21 000	1,7
0941 Bykle		−23	4,0	10 000	15 000	19 000	23 000	1,8

KOMMUNE Fylkesvis ordnet med offisiell nummerering Ajourført 1975	H o h m	TEMP ϑ_1 C	ϑ_m	FROSTMENGDE F_2 h C	F_5	F_{10}	F_{100}	Z_{100} m
10 VEST-AGDER								
1001 Kristiansand		−20	7,0	2 000	7 000	10 000	13 000	1,2
– Kristiansand	22	−19,7	7,2	2 000	6 600	10 100	13 200	
1002 Mandal		−18	7,0	1 000	5 000	9 000	12 000	1,1
1003 Farsund		−18	7,5	1 000	5 000	9 000	12 000	1,1
– Lista	13	−17,5	7,6	1 000	2 000	5 600	8 100	
1004 Flekkefjord		−19	7,5	1 000	5 000	9 000	12 000	1,1
1014 Vennesla		−21	6,0	6 000	10 000	14 000	17 000	1,3
1017 Songdalen		−21	6,0	5 000	9 000	13 000	16 000	1,3
1018 Sogne		−19	7,0	1 000	6 000	9 000	12 000	1,1
1021 Marnardal		−21	6,5	4 000	9 000	12 000	15 000	1,3
1026 Åseral		−21	5,0	6 000	10 000	14 000	17 000	1,4
1027 Audnedal		−21	5,0	5 000	10 000	13 000	16 000	1,4
1029 Lindesnes		−18	7,0	1 000	6 000	9 000	12 000	1,1
– Lindesnes	10		7,6	1 000				
1032 Lyngdal		−19	6,5	1 000	6 000	9 000	12 000	1,1
1034 Hægebostad		−21	5,5	4 000	9 000	12 000	15 000	1,3
1037 Kvinesdal		−20	5,5	4 000	9 000	12 000	15 000	1,3
1046 Sirdal		−20	4,5	4 000	9 000	12 000	15 000	1,4
– Tonstad	57	−18,1	6,4	3 500	8 100	11 200	14 200	
11 ROGALAND								
1101 Eigersund		−17	7,5	0	3 000	6 000	11 000	1,1
1102 Sandnes		−16	7,5	0	2 000	3 000	7 000	0,9
1103 Stavanger		−16	7,5	0	2 000	3 000	7 000	0,9
– Stavanger	72		7,6	500	2 000	3 500	7 100	
1106 Hauge[illegible]d		−13	7,5	0	1 000	3 000	6000	0,9
1111 Sokn[illegible]		−18	7,0	0	3 000	6 000	11 000	1,1
1112 Lund		−19	6,5	1 000	5 000	8 000	12 000	1,1
1114 Bjerkreim		−17	6,5	1 000	5 000	8 000	12 000	1,1
1119 Hå		−17	7,5	0	1 000	3 000	7 000	0,9
– Obrestad	24	−17,1	7,2	1 000				
1120 Klepp		−15	7,0	0	1 000	3 000	7 000	0,9
1121 Time		−16	7,0	0	2 000	3 000	7 000	0,9
1122 Gjesdal		−17	6,0	1 000	4 000	7 000	12 000	1,1
1124 Sola		−15	7,5	0	1 000	3 000	7 000	0,9
– Sola	8		7,4	1 000	2 000	3 500	7 100	
1127 Randaberg		−15	7,5	0	2 000	3 000	7 000	0,9
1129 Forsand		−17	7,0	1 000	5 000	7 000	12 000	1,1
1130 Strand		−17	7,5	0	2 000	3 000	7 000	0,9
1133 Hjelmeland		−18	6,5	1 000	4 000	7 000	12 000	1,1
1134 Suldal		−20	5,0	5 000	9 000	12 000	16 000	1,4
– Fister	1		7,7	1 000				
1135 Sauda		−19	6,0	4 000	8 000	11 000	15 000	1,3
– Sauda	5	−19,0	6,2	4 100	8 100	11 200	15 200	
1141 Finnoy		−16	7,5	0	1 000	3 000	7 000	0,9
1142 Rennesoy		−15	7,5	0	1 000	3 000	6 000	0,9
1144 Kvitsoy		−14	7,5	0	1 000	2 000	6 000	0,9
1145 Bokn		−13	7,5	0	1 000	3 000	6 000	0,9
1146 Tysvær		−13	7,5	0	2 000	4 000	7 000	0,9
1149 Karmoy		−13	7,5	0	1 000	3 000	6 000	0,9
– Skudenes	7	−11,3	7,8	0				
1151 Utsira		−11	7,5	0	0	1 000	2 000	0,5
– Utsira	55	−12,0	7,6	0				
1154 Vindafjord		−16	7,5	0	2 000	3 000	7 000	0,9
12 HORDALAND								
1211 Etne		−16	6,0	2 000	5 000	8 000	13 000	1,2
1214 Olen		−15	7,0	0	2 000	4 000	7 000	0,9
1216 Sveio		−13	7,5	0	2 000	4 000	7 000	0,9
1219 Bomlo		−13	7,5	0	1 000	2 000	5 000	0,8
1221 Stord		−13	7,5	0	1 000	2 000	5 000	0,8
1222 Fitjar		−11	7,5	0	1 000	2 000	5 000	0,8
1223 Tysnes		−13	7,5	0	1 000	2 000	5 000	0,8
1224 Kvinnherad		−15	6,5	1 000	3 000	6 000	11 000	1,1
1227 Jondal		−15	6,0	1 000	3 000	5 000	11 000	1,1
1228 Odda		−17	5,5	5 000	8 000	11 000	16 000	1,3
– Svandalsflona	1048	−23,0	0,6	23 000				
1230 Ullensvang		−15	5,0	6 000	8 000	11 000	17 000	1,4
– Ullensvang forsoksgård	71	−15,0	6,9	1 500	3 000	5 600	11 200	
1233 Ulvik		−19	5,0	9 000	11 000	14 000	20 000	1,6
– Slirå	1300	−27,7	−2,0	36 000				
1234 Granvin		−19	5,0	8 000	10 000	13 000	19 000	1,6
1235 Voss		−23	4,5	10 000	14 000	18 000	24 000	1,8
– Voss	61	−22,7	5,2	10 600	14 200	18 300	24 300	
1238 Kvam		−16	6,0	1 000	3 000	5 000	11 000	1,1

KOMMUNE	H.o.h.	TEMP		FROSTMENGDE				
Fylkesvis ordnet med offisiell nummerering Ajourført 1975		ϑ_3	ϑ_m	F_2	F_5	F_{10}	F_{100}	Z_{100}
	m	C		h C				m
1241 Fusa		−13	6.0	1 000	2 000	4 000	8 000	1.0
1242 Samnanger		−13	5.5	5 000	7 000	10 000	15 000	1.3
1243 Os		−13	6.5	1 000	2 000	5 000	8 000	1.0
1244 Austevoll		−11	7.0	0	1 000	2 000	5 000	0.8
1245 Sund		− 9	7.0	0	1 000	2 000	5 000	0.8
1246 Fjell		− 9	7.0	0	1 000	2 000	5 000	0.8
1247 Askøy		−10	7.0	0	1 000	2 000	5 000	0.8
1248 Laksevåg		−10	7.0	0	1 000	2 000	5 000	0.8
1249 Fana		−11	7.0	0	2 000	3 000	5 000	0.8
1250 Arna		−12	5.0	1 000	3 000	6 000	8 000	1.0
1251 Vaksdal		−14	4.5	8 000	12 000	16 000	22 000	1.7
1252 Modalen		−14	5.0	5 000	8 000	13 000	19 000	1.6
− Modalen	104		5.7	4 000				
1253 Osterøy		−13	7.0	2 000	4 000	6 000	9 000	1.0
1255 Åsane		−11	7.0	0	2 000	3 000	5 000	0.8
1256 Meland		−10	7.0	.0	1 000	2 000	5 000	0.8
1259 Øygarden		− 9	7.5	0	1 000	2 000	5 000	0.8
1260 Radøy		− 9	7.0	0	1 000	2 000	5 000	0.8
1263 Lindås		− 9	6.5	1 000	3 000	5 000	7 000	0.9
1264 Austrheim		− 9	7.0	0	1 000	2 000	5 000	0.8
1265 Fedje		− 9	7.5	0	1 000	2 000	5 000	0.8
1266 Masfjorden		−11	6.0	1 000	2 000	4 000	7 000	0.9
13 BERGEN		−11	7.5	0	2 000	3 000	5 000	0.8
− Bergen - Fredriksberg	43	−10.2	7.8	500	2 000	3 500	5 100	
14 SOGN OG FJORDANE								
1401 Florø		− 9	7.0	0	1 000	3 000	5 000	0.8
1411 Gulen		− 9	7.0	0	1 000	3 000	5 000	0.8
− Takle	39		7.2	0				
1412 Solund		− 9	7.0	0	1 000	3 000	5 000	0.8
1413 Hyllestad		−10	7.0	0	1 000	3 000	5 000	0.8
1416 Høyanger		−13	7.0	0	2 000	3 000	5 000	0.8
1417 Vik		−14	6.5	1 000	3 000	4 000	6 000	0.9
− Vangsnes	53	−12.6	6.9	1 500	3 000	4 600	6 100	
1418 Balestrand		−17	6.0	3 000	6 000	9 000	12 000	1.1
− Fjærland	5	−20.1	5.4	7 000				
1419 Leikanger		−14	6.5	1 000	*4 000*	*7 000*	*10 000*	*1.1*
− Leikanger	22	−13.9	7.0	2 000				
1420 Sogndal		−16	6.0	4 000	7 000	10 000	13 000	1.2
1421 Aurland		−21	6.0	8 000	11 000	14 000	18 000	1.4
1422 Lærdal		−20	6.0	5 000	9 000	11 000	15 000	1.3
− Lærdal - Tjonum	36		6.1	5 100	8 600	11 200	15 200	
1424 Årdal		−22	4.5	8 000	12 000	14 000	18 000	1.5
1426 Luster		−18	4.0	10 000	14 000	16 000	19 000	1.6
− Luster sanatorium	484	−17.6	4.0	9 000	13 200	15 200	18 300	
− Fanaråken	2062		−5.6	56 000				
1428 Askvoll		−10	7.0	0	1 000	3 000	5 000	0.8
1429 Fjaler		−11	7.0	0	1 000	3 000	9 000	1.0
1430 Gaular		−15	5.5	4 000	7 000	10 000	13 000	1.2
1431 Jølster		−17	4.0	5 000	8 000	11 000	14 000	1.4
1432 Førde		−17	5.5	4 000	7 000	10 000	13 000	1.2
− Førde	3	−17.2	6.0	4 100	7 100	10 100	13 200	
1433 Naustdal		−16	5.5	4 000	7 000	10 000	13 000	1.2
1438 Bremanger		− 9	7.0	0	1 000	3 000	5 000	0.8
1439 Vågsøy		− 9	7.0	0	1 000	3 000	5 000	0.8
− Kråkenes Fyr	38	− 7.6	7.4	0				
1441 Selje		− 9	7.0	0	1 000	3 000	5 000	0.8
1443 Eid		−13	6.0	3 000	4 000	6 000	8 000	1.0
1445 Gloppen		−15	6.0	2 000	3 000	5 000	7 000	0.9
1448 Stryn		−16	5.5	4 000	6 000	9 000	13 000	1.2
− Oppstryn	201	−15.6	6.0	3 000	5 100	8 100	12 200	
15 MØRE OG ROMSDAL								
1501 Ålesund		−11	7.0	0	1 000	2 000	5 000	0.8
1502 Molde		−12	6.0	0	2 000	3 000	5 000	0.8
1503 Kristiansund		−11	7.0	0	1 000	2 000	5 000	0.8
1511 Vanylven		−11	6.0	0	1 000	3 000	5 000	0.8
1514 Sande		− 9	7.0	0	1 000	2 000	5 000	0.8
− Svinøy Fyr	39		7.2	0				
1515 Herøy		−10	7.0	0	1 000	2 000	5 000	0.8
1516 Ulstein		−10	7.0	0	1 000	2 000	5 000	0.8
1517 Hareid		−11	7.0	0	1 000	2 000	5 000	0.8
1519 Volda		−15	6.0	1 000	3 000	5 000	8 000	1.0
1520 Ørsta		−16	6.0	1 000	3 000	5 000	8 000	1.0
− Ørsta	40	−16.0	6.2	1 000				

KOMMUNE	H.o.h.	TEMP		FROSTMENGDE				
Fylkesvis ordnet med offisiell nummerering Ajourført 1975		ϑ_3	ϑ_m	F_2	F_5	F_{10}	F_{100}	Z_{100}
	m	C		h C				m
1524 Norddal		−13	6.0	2 000	3 000	5 000	9 000	1.0
− Tafjord	27	−12.5	7.2	2 000	3 000	4 600	9 100	
1525 Stranda		−13	6.0	2 000	4 000	6 000	9 000	1.0
1527 Ørskog		−13	6.0	1 000	3 000	5 000	8 000	1.0
− Skodje								
1528 Sykkylven		−13	6.0	1 000	3 000	5 000	8 000	1.0
1532 Giske		−10	7.0	0	1 000	2 000	5 000	0.8
1534 Haram		− 9	7.0	0	1 000	2 000	5 000	0.8
1535 Vestnes		−12	6.0	1 000	3 000	6 000	8 000	1.0
1539 Rauma		−18	6.0	3 000	5 000	8 000	10 000	1.1
1543 Nesset		−16	6.0	3 000	5 000	8 000	10 000	1.1
1545 Midsund		−11	6.5	1 000	2 000	3 000	6 000	0.9
1546 Sandøy		− 9	7.0	0	1 000	2 000	5 000	0.8
− Ona-Husøy	11	− 7.8	7.2	0	0	500	1 000	
1547 Aukra		−10	7.0	0	1 000	2 000	5 000	0.8
1548 Fræna		−10	6.5	1 000	3 000	4 000	6 000	0.9
1551 Eide		−11	6.5	1 000	2 000	3 000	6 000	0.9
1554 Averøy		−11	6.5	1 000	2 000	3 000	6 000	0.9
1556 Frei		−11	6.5	1 000	2 000	3 000	6 000	0.9
1557 Gjemnes		−13	6.0	1 000	3 000	5 000	8 000	1.0
1360 Tingvoll		−19	6.0	1 000	3 000	5 000	8 000	1.0
− Tingvoll	51	−19.4						
1563 Sunndal		−19	5.5	4 000	7 000	11 000	14 000	1.2
− Sunndal	195		4.4	10 600	13 200	17 200	20 300	
1566 Surnadal		−18	5.0	5 000	8 000	12 000	15 000	1.3
1567 Rindal		−19	4.5	7 000	12 000	15 000	18 000	1.5
1569 Aura		−16	5.5	1 000	3 000	6 000	8 000	1.0
1571 Halsa		−15	5.5	1 000	3 000	6 000	8 000	1.0
1572 Tustna		−13	5.5	1 000	3 000	4 000	6 000	0.9
1573 Smøla		−11	5.5	0	1 000	2 000	5 000	0.8
16 SØR-TRØNDELAG								
1601 Trondheim		−19	5.0	7 000	12 000	14 000	16 000	1.4
− Trondheim	127	−19.1	4.9	6 600	11 200	13 200	15 700	
1612 Hemne		−17	5.5	5 000	7 000	10 000	12 000	1.2
1613 Snillfjord		−17	5.5	4 000	6 000	9 000	11 000	1.1
1617 Hitra		−15	6.0	1 000	2 000	3 000	6 000	0.9
1620 Frøya		−13	6.0	1 000	2 000	3 000	6 000	0.9
− Sulen Fyr	28	−12.6	6.5	500	800	1 000	2 000	
1621 Ørland		−15	5.5	*2 000*	*4 000*	*5 000*	*7 000*	*0.9*
− Ørland	9	−15.1	5.9	2 500	4 100	5 600	7 100	
1622 Agdenes		−17	5.5	2 000	4 000	5 000	7 000	0.9
1624 Rissa		−17	5.5	4 000	7 000	9 000	11 000	1.1
1627 Bjugn		−16	6.0	2 000	4 000	7 000	9 000	1.0
− Vallersund	4		6.2	2 000				
1630 Åfjord		−17	5.5	2 000	4 000	7 000	9 000	1.0
1632 Roan		−16	5.5	2 000	5 000	7 000	9 000	1.0
1633 Osen		−16	5.5	2 000	5 000	7 000	9 000	1.0
1634 Oppdal		−26	2.0	15 000	20 000	23 000	26 000	2.2
1635 Rennebu		−23	2.5	14 000	20 000	23 000	25 000	2.0
− Berkåk	424	−22.7	2.8	15 200	21 300	24 300	26 400	
1636 Meldal		−19	4.0	10 000	16 000	19 000	21 000	1.7
1638 Orkdal		−19	5.0	6 000	11 000	13 000	15 000	1.3
1640 Røros		−40	0.5	30 000	38 000	45 000	55 000	3.2
− Røros	628	−39.8	0.5	30 400	38 500	45 600	55 800	
1644 Ålen		−36	1.5	14 000	21 000	23 000	27 000	2.3
1645 Haltdalen		−32	1.5	14 000	21 000	23 000	27 000	2.3
1648 Midtre Gauldal		−22	4.0	11 000	17 000	20 000	22 000	1.7
1653 Melhus		−19	4.5	7 000	12 000	16 000	18 000	1.5
1657 Skaun		−19	5.0	6 000	11 000	15 000	17 000	1.4
1662 Klæbu		−19	4.5	7 000	12 000	16 000	18 000	1.5
1663 Malvik		−19	5.0	6 000	11 000	13 000	15 000	1.3
1664 Selbu		−20	4.0	10 000	15 000	19 000	21 000	1.4
− Selbu	197	−20.0	4.5	8 600	13 200	17 200	19 800	
1665 Tydal		−32	2.0	14 000	19 000	23 000	27 000	2.2
− Stugudal	615		1.5	22 000				
17 NORD-TRØNDELAG								
1702 Steinkjer		−19	5.0	8 000	12 000	15 000	19 000	1.5
1703 Namsos		−18	5.0	6 000	9 000	12 000	15 000	1.3
− Namsos	20		5.2	6 000				
1711 Meråker		−23	3.0	10 000	15 000	20 000	23 000	1.9
− Meråker	218	−22.2	3.9	10 100	15 200	20 300	23 300	
1714 Stjørdal		−19	5.0	6 000	10 000	13 000	17 000	1.4
1717 Frosta		−19	5.5	6 000	9 000	12 000	15 000	1.3
1718 Leksvik		−18	5.5	6 000	9 000	12 000	15 000	1.3
1719 Levanger		−19	5.0	6 000	10 000	13 000	17 000	1.4
− Ytterøy	74	−18.5	5.3	6 100	9 600	12 200	15 200	
1721 Verdal		−20	5.0	6 000	10 000	13 000	17 000	1.4
− Sulstua	233	−22.1	3.0	16 000				

KOMMUNE Fylkesvis ordnet med offisiell nummerering Ajourført 1975	H o.h. m	TEMP ϑ_1 °C	ϑ_m	FROSTMENGDE F_2 h °C	F_5	F_{10}	F_{100}	Z_{100} m
1723 Mosvik		−19	5,5	6 000	9 000	12 000	15 000	1,3
1724 Verran		−18	5,0	7 000	11 000	14 000	18 000	1,5
1725 Namdalseid		−19	5,0	7 000	11 000	14 000	18 000	1,5
1729 Inderøy		−19	5,0	6 000	9 000	12 000	15 000	1,3
1736 Snåsa		−25	4,0	13 000	19 000	23 000	27 000	1,9
− Kjøbli	195	−27,3	3,4	13 700	19 300	23 300	27 400	
1738 Lierne		−32	1,0	25 000	29 000	36 000	41 000	2,9
− Nordli	403		1,1	25 300	29 900	36 500	41 600	
1739 Røyrvik		−28	1,5	25 000	29 000	36 000	41 000	2,8
1740 Namsskogan		−25	3,0	14 000	19 000	24 000	28 000	2,1
1742 Grong		−22	4,0	12 000	17 000	22 000	26 000	1,9
− Grong	72		4,0	12 000				
1743 Høylandet		−21	3,5	10 000	15 000	20 000	24 000	1,8
− Høylandet	23		3,5	17 000				
1744 Overhalla		−20	4,5	10 000	15 000	20 000	24 000	1,8
1748 Fosnes		−17	5,0	5 000	8 000	11 000	16 000	1,4
1749 Flatanger		−16	5,5	2 000	5 000	8 000	11 000	1,1
1750 Vikna		−15	5,5	1 000	3 000	6 000	10 000	1,1
1751 Nærøy		−16	5,5	2 000	5 000	8 000	13 000	1,2
1755 Leka		−15	5,5	1 000	3 000	6 000	10 000	1,1
18 NORDLAND								
1804 Bodø		−13	4,5	8 000	9 000	12 000	17 000	1,5
− Bodø	10	−12,9	4,6	5 600	8 100	11 200	16 200	
1805 Narvik		−15	3,5	11 000	13 000	17 000	25 000	1,9
− Narvik	32	−14,9	3,8	10 600	12 700	16 700	24 300	
− Bjørnefjell	514	−27,2	−1,2	38 000				
1811 Bindal		−18	4,5	5 000	8 000	12 000	18 000	1,5
1814 Brønnøy		−14	5,0	3 000	5 000	8 000	12 000	1,2
− Brønnøysund	5	−13,5	5,8	2 000	4 100	6 600	11 200	
1815 Vega		−13	5,5	2 000	4 000	7 000	11 000	1,1
1816 Vevelstad		−15	5,5	1 000	4 000	7 000	13 000	1,2
1818 Herøy		−13	5,5	2 000	4 000	7 000	11 000	1,1
1820 Alstahaug		−14	5,5	1 000	4 000	7 000	13 000	1,2
1822 Leirfjord		−16	5,0	3 000	6 000	9 000	15 000	1,3
1824 Vefsn		−18	3,5	13 000	16 000	21 000	27 000	2,0
− Mosjøen	2		4,1	12 000				
1825 Grane		−21	2,5	18 000	23 000	28 000	32 000	2,3
− Majavatn	352	−23,2	2,3	19 300	24 300	29 400	33 500	
1826 Hattfjelldal		−31	1,5	26 000	32 000	37 000	42 000	2,8
− Hattfjelldal	208	−30,5	1,5	26 000				
1827 Dønna		−13	5,5	2 000	4 000	7 000	11 000	1,1
1828 Nesna		−15	5,5	2 000	4 000	7 000	11 000	1,1
1832 Hemnes		−18	3,0	18 000	23 000	29 000	37 000	2,4
1833 Rana		−24	3,0	16 000	18 000	25 000	35 000	2,3
− Nerdal	51		3,1	16 200	18 800	25 300	35 500	
1834 Lurøy		−13	5,5	2 000	4 000	8 000	13 000	1,2
1835 Træna		−10	6,0	0	1 000	2 000	6 000	0,9
1836 Rødøy		−13	5,0	3 000	5 000	10 000	15 000	1,3
1837 Meløy		−13	5,0	3 000	5 000	10 000	15 000	1,3
− Glomfjord	39	−13,5	5,2	3 000	4 600	10 100	15 200	
1838 Gildeskål		−15	5,0	2 000	4 000	9 000	14 000	1,3
1839 Beiarn		−17	3,5	10 000	13 000	18 000	24 000	1,8
1840 Saltdal		−22	2,0	18 000	22 000	28 000	37 000	2,6
− Rognan	−28	−21,8						
1841 Fauske		−19	3,5	14 000	17 000	22 000	28 000	2,0
− Fauske	14	−19,3	4,1	9 100	12 200	16 700	23 000	
− Sulitjelma	151	−28,0	3,1	16 000				
1842 Skjerstad		−18	4,0	10 000	13 000	18 000	24 000	1,8
− Kletkovfjell	795		−0,9	30 000				
1845 Sørfold		−19	4,0	10 000	13 000	18 000	24 000	1,8
1848 Steigen		−11	4,5	4 000	6 000	10 000	15 000	1,4
− Grøtøy	6	−9,0	5,4	2 500	4 600	8 100	12 700	
1849 Hamarøy		−12	4,0	7 000	9 000	13 000	18 000	1,6
1850 Tysfjord		−16	3,5	10 000	13 000	18 000	24 000	1,8
− Drag	60		3,8	10 000				
1851 Lødingen		−11	4,0	7 000	10 000	13 000	18 000	1,6
− Offersøy	16	−10,8	4,4	5 600	8 100	11 200	16 200	
1852 Tjeldsund		−12	4,0	8 000	11 000	14 000	19 000	1,6
1853 Evenes		−13	3,5	9 000	11 000	15 000	21 000	1,7
1854 Ballangen		−14	3,5	10 000	13 000	17 000	24 000	1,8
1856 Røst		−7	5,5	0	1 000	2 000	6 000	0,9
− Skomvær Fyr	18	−6,6	5,5	0	1 000	2 000	6 100	
1857 Værøy		−7	5,5	0	1 000	2 000	6 000	0,9
1858 Moskenes		−8	5,0	1 000	3 000	5 000	12 000	1,2
1859 Flakstad		−9	5,0	1 000	3 000	5 000	12 000	1,2
1860 Vestvågøy		−10	5,0	3 000	5 000	8 000	14 000	1,3
1865 Vågan		−10	5,0	3 000	5 000	8 000	14 000	1,3
1866 Hadsel		−10	4,5	4 000	6 000	9 000	15 000	1,4
1867 Bø		−11	4,5	3 000	4 000	7 000	14 000	1,3
− Bø	7	−10,6	4,7	3 000				

KOMMUNE Fylkesvis ordnet med offisiell nummerering Ajourført 1975	H o.h. m	TEMP ϑ_1 °C	ϑ_m	FROSTMENGDE F_2 h °C	F_5	F_{10}	F_{100}	Z_{100} m
1868 Øksnes		−9	4,5	3 000	4 000	7 000	15 000	1,4
1870 Sortland		−9	4,5	4 000	6 000	9 000	16 000	1,4
1871 Andøy		−8	4,0	4 000	5 000	8 000	16 000	1,5
− Andenes	5		4,2	4 100	5 100	8 100	16 200	
19 TROMS								
1901 Harstad		−12	4,5	5 000	7 000	10 000	16 000	1,4
1902 Tromsø		−13	3,5	10 000	13 000	16 000	21 000	1,7
− Tromsø	102	−12,3	3,3	11 200	14 200	17 700	22 300	
1911 Kvæfjord		−11	4,5	7 000	9 000	12 000	18 000	1,5
1913 Skånland		−13	4,0	8 000	10 000	13 000	19 000	1,6
− Evenskjer	7		3,8	9 000				
1915 Bjarkøy		−11	4,5	6 000	8 000	10 000	16 000	1,5
− Sandsøy i Senja	17		4,4	4 100	5 600	8 100	14 200	
1917 Ibestad		−13	4,5	7 000	9 000	12 000	18 000	1,5
1919 Gratangen		−20	3,5	11 000	14 000	18 000	25 000	1,9
1921 Salangen		−21	3,5	12 000	15 000	19 000	26 000	1,9
1922 Bardu		−28	2,0	27 000	29 000	36 000	47 000	2,8
1924 Målselv		−20	2,0	27 000	29 000	36 000	47 000	2,8
− Bardufoss	76	−29,4	1,2	26 500				
− Dividalen	226	−22,7	1,0	28 400	30 400	40 600	54 800	
1925 Sørreisa		−18	3,0	12 000	16 000	19 000	26 000	2,0
1926 Dyrøy		−13	3,5	11 000	15 000	18 000	25 000	1,9
1927 Tranøy		−12	3,5	10 000	14 000	17 000	24 000	1,8
1928 Torsken		−10	3,5	8 000	11 000	14 000	20 000	1,7
1929 Berg		−10	3,5	10 000	13 000	16 000	21 000	1,7
1931 Lenvik		−13	3,5	11 000	15 000	18 000	25 000	1,9
− Gibostad	10	−12,8	3,3	10 600	14 200	17 700	24 300	
1933 Balsfjord		−21	3,0	15 000	18 000	22 000	29 000	2,1
1936 Karlsøy		−12	4,0	8 000	11 000	15 000	19 000	1,6
− Torsvåg	22	−8,9	4,1	3 000	5 100	7 600	10 100	
1938 Lyngen		−20	3,0	17 000	21 000	25 000	31 000	2,2
1939 Storfjord		−23	2,0	23 000	26 000	30 000	42 000	2,7
− Skibotn	46		2,9	15 000				
1940 Kåfjord		−21	2,0	23 000	26 000	30 000	42 000	2,7
1941 Skjervøy		−14	3,5	10 000	14 000	19 000	24 000	1,8
1942 Nordreisa		−19	2,0	23 000	26 000	30 000	42 000	2,7
− Nordreisa	4		1,9	21 000				
1943 Kvænangen		−19	2,0	25 000	28 000	32 000	44 000	2,7
20 FINNMARK								
2001 Hammerfest		−14	2,0	15 000	18 000	21 000	32 000	2,4
− Ham.fest radio	70		2,1	14 200				
2002 Vardø		−20	1,0	17 000	23 000	26 000	33 000	2,6
− Vardø	13	−20,2	1,6	14 200	20 300	23 300	30 400	
2003 Vadsø		−25	1,0	18 000	25 000	29 000	37 000	2,8
− Ekkerøy	7	−19,2	1,4	18 000				
2011 Kautokeino		−37	−2,0	51 000	56 000	65 000	76 000	
− Kautokeino	306	−36,7	−2,0	51 700	56 800	65 900	77 100	
− Siccajouvre	382	−37,3	2,3	50 700	56 600	67 900	79 100	
2012 Alta		−23	1,5	25 000	28 000	32 000	44 000	2,9
− Alta	4	−22,4	1,7	25 300	28 400	32 400	44 600	
2014 Loppa		−11	2,5	10 000	13 000	16 000	27 000	2,1
2015 Hasvik		−11	3,0	8 000	11 000	14 000	25 000	2,0
2016 Sørøysund		−13	3,0	9 000	12 000	15 000	26 000	2,0
2017 Kvalsund		−16	2,0	18 000	21 000	26 000	37 000	2,6
2018 Måsøy		−13	2,0	13 000	16 000	20 000	30 000	2,3
− Fruholmen	13		3,0	5 000				
2019 Nordkapp		−13	2,5	12 000	15 000	19 000	29 000	2,2
− Helnes Fyr	33		2,5	9 000				
2020 Porsanger (Lakselv)		−25	1,5	30 000	33 000	37 000	49 000	3,0
− Kistrand	12	−16,6	1,7	18 000				
2021 Karasjok		−42	−1,5	52 000	57 000	69 000	78 000	
− Karasjok	129	−42,4	−1,5	51 700	56 800	68 900	78 100	
2022 Lebesby		−22	1,5	25 000	28 000	33 000	44 000	2,9
2023 Gamvik		−17	1,5	17 000	20 000	24 000	34 000	2,6
− Slettnes Fyr	8		1,8	11 700	14 700	18 200	28 400	
2024 Berlevåg		−20	1,5	18 000	24 000	28 000	35 000	2,6
2025 Tana		−27	0,5	30 000	33 000	38 000	49 000	3,2
− Tana	5	−27,2	0,5	29 000				
− Rustefjelbma	9		0,1	34 000				
2027 Nesseby		−31	1,0	30 000	35 000	40 000	49 000	3,1
2028 Båtsfjord		−23	1,0	18 000	25 000	28 000	36 000	2,8
− Makaur Fyr	11		1,9	14 000				
2030 Sør-Varanger		−30	0,5	31 000	35 000	43 000	50 000	3,2
− Sør-Varanger	8		0,2	33 000				
− Kirkenes	5	−30,2	0,9	28 000				
− Pasvik	54		−0,3	40 000				