Permafrost zone covers a considerable part of the Russian territory, mainly its northern and eastern regions. The larger part of gas and oil fields are located in the territory. Construction and development of fields is associated with construction in permafrost conditions. The experience in construction and operation of engineering structures shows that their reliability can be provided only in case of proper consideration of thermal and mechanical interface between the structures foundations and soil bases. One of the methods to provide for buildings reliability lies in maintenance of frozen conditions of soil bases. Reliability of buildings and structures in permafrost areas is primarily defined by strength and stability of soil bases. Mechanical and strain properties of soil bases are to a great extent dependant on temperature and liquid limit of soil. Under the influence of “dangerous” geological processes of natural and technogenic type, temperature and liquid limit of bottom soil may vary significantly. Beginning from the end of 1990s seasonal cooling devices came to be commonly used for maintenance of frozen conditions of soil bases of buildings and structures. Construction of facilities of Yubileinoye field was the beginning of mass introduction of the devices. By now seasonal cooling devices are widely used in construction of gas industry facilities in permafrost areas.

Using of cooling devices allows providing for reliability of facilities in subsiding (while thawing) and low bearing capacity permafrost soils. Cooling by means of seasonal cooling devices forms icy soil mass that ensures bearing capacity of foundations in one or more cycles of winter cooling. Temperature of soil mass continues to decrease further. Modern designing of bases and foundations is associated with optimization of construction of foundation (depth, diameters of piles) and the measures taken to strengthen soils “thermally”. Artificial freezing (cooling) of soil makes it possible to raise bearing capacity of soil bases and therefore simplify construction solutions and “zero-cycle” construction process. And in a number of cases it allows reducing of construction period, material consumption, as well as cost of construction. The main technical solution for construction of foundations in permafrost is application of vented underground where seasonal cooling devices are installed (Fig. 1).
In cases when it is reasonable to construct a foundation of “flooring at the ground level” type, a combination of cooling systems and heat-insulating screens is used (Fig. 2).

Comparison of the results of modeling of thermal field of soil bases of foundations with seasonal cooling devices and without the above devices is given below in Figures 3 and 4, respectively.

Fig. 2. Schematic diagram of construction of a structure with flooring at the ground level using heat insulation and horizontal seasonal cooling devices

Fig. 3. Results of modeling a thermal field in the bases of a building with vented underground without seasonal cooling devices (a) and with installed seasonal cooling devices (b)
Cooling devices are used for construction of northern facilities with the purpose of:
- preconstruction freezing of soil-bases of buildings and structures;
- freezing of soil bases in the process of construction and operation;
- decrease of thermal effect of buildings and structures on soil bases in the process of operation;
- restoration of frozen conditions of soil in bases of buildings and structures that were built according to the first principle;
- creation of cutoff curtains;
- creation of frozen (thermal) curtains.

Cooling devices with heat carrier moving within the field of gravity, i.e. thermosyphons, are used in construction of facilities in the north. From the point of view of functionality seasonal cooling devices are “thermal diodes” that conduct “cold” during a cold period and do not conduct “heat” during a warm period. Differences in practical application and peculiarities of seasonal cooling devices led to a variety of structures, as well as type and size of stabilizers according to the above-mentioned variants of application. The following categories of devices can be pointed out:
- seasonally-acting vertical cooling devices;
- seasonally-acting horizontal (low-inclined) cooling devices;
- year-round acting cooling devices;
- seasonally/year-round acting cooling systems;

Vertical cooling devices are used for cooling the soil under buildings with vented undergrounds (Fig. 5), or along contour of a structure, or at supports of pipeline racks. The model of a seasonal cooling device with double V-type condenser (Fig. 6) is used for structures with vented underground that are less than 1 meter in height and increase of cooling efficiency. Structure of a number of cooling devices implies flexible connections, which due to metal hoses allow for their installation in vented underground, under site structures, etc., and also carryover of thermal stabilizer beyond the facility boundaries (Fig. 7).
Fig. 5. Seasonal cooling devices with one vertical condenser

Fig. 6. Seasonal cooling device with double V-type condenser

Fig. 7. Seasonal cooling device with flexible connection
The structures of year-round acting cooling devices are used, if it is necessary to generate cooling or freezing of soils in a warm period according to construction conditions or facilities operation. Year-round acting cooling devices are equipped with refrigerating machines of different types (refrigerating units, thermoelectric coolers) and condensers with ribbed part for device operation as seasonal cooling at air temperatures below zero. Different structures of year-round acting cooling devices are shown in Fig. 9.

Fig. 8. Seasonal cooling devices of horizontal type

Fig. 9. Structures of year-round acting cooling devices: a) with thermoelectric cooler; b) with replaceable condensate part; c) with refrigerating units
Cooling systems with natural cooling agent circulation are used for developing the structures. Pressure and direct flow of cooling agent is organized in the underground profile. Such a structure allows for increasing the length of underground heat exchanger up to several hundred meters. These systems (Figure 10) consist of cooling pipes, connection pipes, condensate block and hydraulic lock. The condensate block is an air cooling device, hydraulic lock is meant for provision of unit-direction motion of heat carrying agent in the systems. The cooling and connection pipes are used for cooling agent circulation. Horizontal cooling pipes are made of steel or polyethylene pipes. Cooling systems operate in a cold period, and it is also possible to connect mobile compressor-condensate units to them with the purpose of forcing cooling agent circulation, in case of necessity.

Subsurface seasonal cooling devices are used for freezing and thermal stabilization of soils of dams, gas producing wellheads and other structures (Fig. 11). Subsurface cooling device is a waterproof one-piece welded structure, filled with cooling agent, and having the depth of an underground part up to 100 m.
Apparently, the existing structures of seasonal cooling devices solve the main part of problems connected with construction of bases and foundations, but still there is a number of requirements to be observed while creating new perspective structures. The above-mentioned requirements are connected with different aspects:

– increase of efficiency of seasonal cooling devices;
– application of safe heat carrier;
– increase in performance of seasonal cooling devices during the period of facility construction.

Vapor-liquid cooling devices are the most effective seasonal cooling devices as provide higher intensity of inner processes heat exchange. However, in the complicated process of heat exchange from soil to atmosphere, the processes of heat transfer to air and heat conductivity in soil mass are the limiting ones. The intensity of inner heat transfer of vapor-liquid device is not determinative, and different types of vapor-liquid heat carriers become competitive. Extension of the period of operation of seasonal cooling devices is associated with terms of starting of operation of seasonal cooling devices. It should be provided that seasonal cooling devices start to operate while thawing in winter, as well as in autumn and spring months during night hours when air temperature is below zero.

Different process liquids can be used as heat carriers of cooling devices; in practice, freons are usually used, such as R22 (difluorochloromethane), R717 (ammonia) and R744 (hydrocarbon). Selection of proper process liquid is carried out, mainly, basing on the range of steam space operation temperatures. There are several acceptable process liquids for a certain temperature range.

Designing requirements testify to the fact that efficient operation of seasonal cooling devices is necessary for preconstruction preparation of soils and for the first years of facility operation. Small number of cooling devices is necessary for maintenance of the required temperature at further operation of the structure. It defines application of cooling devices of year-round acting type or development of methods of seasonal cooling devices extraction from soil, as well as their reuse.