SLOVENSKI STANDARD
SIST EN 1918-1:1999

01-januar-1999

Sistemi oskrbe s plinom - Podzemna plinska skladišča - 1. del: Funkcionalna priporočila za skladiščenje v vodonosnikih

Gas supply systems - Underground gas storage - Part 1: Functional recommendations for storage in aquifers

Gasversorgungssysteme - Untertagespeicherung von Gas - Teil 1: Funktionale Empfehlungen für die Speicherung in Aquiferen

Systeme d'alimentation en gaz - Stockage souterrain de gaz - Partie 1: Recommandations fonctionnelles pour le stockage en nappes aquiferes

Ta slovenski standard je istoveten z: EN 1918-1:1998

ICS:

75.200	Oprema za skladiščenje nafte, naftnih proizvodov in zemeljskega plina	Petroleum products and natural gas handling equipment

SIST EN 1918-1:1999 **en**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1918-1

February 1998

ICS 75.200

Descriptors: storage, natural gas, definitions, specifications, environmental protection, design, safety, leaktightness, inspection, maintenance, operating requirements, wells, tests

English version

Gas supply systems - Underground gas storage - Part 1: Functional recommendations for storage in aquifers

Système d'alimentation en gaz - Stockage souterrain de gaz - Partie 1: Recommandations fonctionnelles pour le stockage en nappes aquifères

Gasversorgungssysteme - Untertagespeicherung von Gas - Teil 1: Funktionale Empfehlungen für die Speicherung in Aquiferen

This European Standard was approved by CEN on 22 January 1998.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 1918-1:1998 E

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 234 "Gas supply", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 1998, and conflicting national standards shall be withdrawn at the latest by August 1998.

It is Part 1 of a standard on underground gas storage which includes the five following Parts:

Part 1 - Functional recommendations for storage in aquifers

Part 2 - Functional recommendations for storage in oil and gas fields

Part 3 - Functional recommendations for storage in solution mined salt cavities

Part 4 - Functional recommendations for storage in rock caverns.

Part 5 - Functional recommendations for surface facilities.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Use of aquifer storage

Unlike other energy sources, natural gas is distributed through a network of pipes and cannot be stored by consumers. Consequently, the distributor has the responsibility of adjusting supply to meet demand.

One of the principal means of adjusting supply to demand is through the use of underground storage facilities. Due to their substantial capacity, they can ensure:

- that peak consumption loads are met;
- seasonal adjustment, enabling gas to be supplied at a more or less constant rate throughout the year, whilst allowing for the significantly higher consumption in the winter than in the summer;
- the provision of security reserves intended to compensate for a potential interruption in supplies.

The performance of a storage facility is usually defined by two basic parameters:

- the working gas, which is the quantity of gas that may be withdrawn without jeopardizing the reconstitution of the stock required to meet the needs of the following gas withdrawal period;
- the peak flowrate, which is the maximum flowrate the storage facility can deliver under given operating conditions.

Technical description

Underground aquifer storage is the artificial creation of a natural gas deposit by displacing the water contained in the pores of a deep-laying aquifer with gas. The space forms a gas "bubble" which can be operated in alternate injection and withdrawal cycles. By their very nature, underground storage facilities in aquifers are closely related to oil and gas fields. Indeed, the exploration, installation and maintenance phases are based on oil and gas industry approved technology.

A suitable site for an underground aquifer storage facilityhas the following geological characteristics:

- a dome-shaped structure or structural trap with an adequate closure to ensure satisfactory containment of the gas-filled zone;
- a layer of soil or rock with a sufficient degree of porosity and permeability to form a reservoir of the desired capacity and productivity;l
- a layer of gastight soil or rock deposits, known as caprock, which directly covers the storage formation and prevents any vertical gas migration.

Figure 1 shows a cross-section of a zone combining such characteristics.

The search for such structures is largely based on documentary studies of available data (regional geological surveys, oil exploration), on geophysical measurements (made essentially during seismic surveys) and on well drilling (core sampling), logging and well testing). At each stage, a critical examination of all the data gathered results either in abandoning the structure, recognizing it as suitable for storage or identifying further studies or tests that are required.

Geological surveys are not limited to gas filling but can be extended according to the results obtained when drilling new wells or developing the gas zone in the course of operation.

Underground gas storage facilities in aquifers (see figure 1) consist of wells, which connect the aquifer and the surface, and surface installations.

Some wells are devoted to injection and withdrawal of gas; these are called operating wells. Monitoring wells monitor any extension of the gas zone and the quality of the water in the storage aquifer or watch over the upper aquifer.

The functions of surface installations are:

- gas transfer between the wells and the central station;
- gas treatment to meet the gas quality requirements of the network (dehydration, sweetening where necessary, possible odorization, filtering);
- gas compression or expansion to control the pressure difference between network pressure and storage pressure;
- metering of injected or withdrawn gas quantities.

Working principle

Gas injection

Gas is injected into the storage formation via the operating wells which provide communication between the zone used for storage and the surface. For the gas to displace the water contained in the pores of the reservoir rock, the injection pressure has to exceed the initial pressure in the aquifer. To avoid mechanical disturbance of overburden layers and gas penetration into the caprock, the pressure in the reservoir is not allowed to exceed a maximum value.

Because of the compressibility and viscosity of the water and the geometric extension of the aquifer horizon, there is a decrease in water movements and pressure changes with increasing distance from the gas injection area. Beyond a certain distance, these disturbances are scarcely noticeable.

Gas withdrawal - the concept of working gas

When gas needs to be withdrawn, the pressure at the operating wellhead is lowered to create a pressure drop from the formation into the well to commence production. As gas withdrawal progresses, the pressure in the gas phase drops below the aquifer pressure, the aquifer water starts to flow back and the gas water contact rises within the storage formation.

It is inevitable that, after a normal gas withdrawal operation, a large quantity of gas, known as cushion gas, will remain in the reservoir. A fraction of this gas remains trapped in the reservoir and the part which could be recovered is left to maintain sufficient pressure to ensure the desired flowrates and preclude well submergence. The cushion gas represents a volume equal to roughly half the total stored volume. The withdrawable gas volume is usually known as the working gas.

Caprock tightness

The gastightness of a caprock is based on the existence of capillary phenomena. Gas penetration into pores of very small diameter requires a pressure higher than the pressure of the water in the caprock. This excess pressure, called capillary threshold pressure, is a limiting value for the storage operation pressure.

1 Scope

This standard specifies procedures and practices which are safe and environmentally acceptable.

It covers the functional recommendations for design, construction, testing, commissionning, operation and maintenance of underground gas storage facilities in aquifers up to and including the wing valve of the wellhead.

The necessary surface facilities for underground gas storage are described in EN 1918-5.

In this context "gas" is any gaseous fuel which is in a gaseous state at a temperature of 15°C and under a pressure of 1 bar and which remains in a gaseous state under storage conditions.

This European Standard specifies common basic principles for gas supply systems. Users of this European Standard should be aware that more detailed national standards and/or codes of practice may exist in the CEN member countries.

This European Standard is intended to be applied in association with these national standards and/or codes of practice and does not replace them.

This standard is not intended to be applied retrospectively to existing facilities.

2 Definitions

For the purposes of this standard, the following definitions apply.

2.1 annulus

Space between two strings of pipes or between the casing and the borehole.

2.2 capillary pressure

Pressure difference between the non-wetting phase and the wetting phase in porous rock.

2.3 capillary threshold pressure

For homogeneous soil or rock, the excess gas pressure, in comparison to water, needed for gas to enter the largest pores.

NOTE: Its value (CTP) is measured experimentally in the laboratory. For example, for a cylindrical core sample: if p_1 is the pressure of the water that totally saturates the material when applied evenly to one of its faces (face 1), and p_2 is the pressure applied to the opposite face (face 2) by a gas, then CTP = $p_2 - p_1$, given that p_2 is the lowest value that eventually results in the appearance of a water movement on face 1, thus implying the entrance of gas in the capillary network of the core (face 2).

2.4 caprock

Oiltight and gastight layer covering a porous and permeable formation.

2.5 casing

Pipe or set of pipes that are screwed or welded together to form a string which is placed in the borehole for the purpose of supporting the sides of the bore(hole) and to act as a barrier preventing subsurface migration of fluids when the annulus between it and the borehole has been cemented.

2.6 casing shoe

Bottom end of a casing string.

EXAMPLE: Casing shoe is a reinforced collar of steel screwed or welded onto the bottom joint of casing to prevent abrasion or distortion of the casing as it forces its way past obstructions on the wall of the bore hole.

2.7 cementing

Operation whereby a cement slurry is pumped and circulated down a well through the casing and then upwards into the annular space between the casing and the open or cased hole.

2.8 closure

Vertical distance between the top of the structure and the spillpoint.

2.9 connected aquifers

Aquifers which are connected to the storage aquifer and thereby subject to changes of pressure caused by the storage operations.

2.10 core samples

Samples of soil or rock taken during a drilling operation in order to determine various parameters by laboratory testing.

2.11 drilling

All technical activities connected with the construction of a well.

2.12 formation

Body of rock characterized by a degree of homogeneous lithology which forms an identifiable geologic unit.

2.13 lithology

Study and description of rocks on the basis of colour, mineral composition, grain characteristics, and crystallization.

2.14 logging

Measurement of any physical parameter versus depth in a well.

2.15 minimum thickness of overburden

Shortest vertical distance separating the base of the caprock from the surface.

NOTE: This generally corresponds to the depth of the top of the reservoir, but this is not always the case (e.g. undulating landscape).

2.16 modelling

Generating the image of a structure from the information gathered.

2.17 overburden

All sediments or rock that overlie a geological formation.

2.18 permeability

Capacity of a rock to allow fluids to flow through its pores.

NOTE: It is measured experimentally and is usually expressed in darcy.

2.19 porosity

Volume of the pore space (voids) within a formation expressed as a percentage of the total volume of the material containing the pores.

2.20 reservoir simulation

Numerical modelling of a reservoir system to predict or to monitor the behaviour and movement of the fluids in the storage formation and in general the reservoir behaviour.

2.21 sand screens

Filters placed at the level of the storage formation in order to avoid the entrainment of sand particles during production.

2.22 saturation

Percentage of pore space occupied by fluid in the material.

2.23 seismic technology

Generationof acoustic waves underground, by mechanical shocks or vibrations. The depth of the underground layers may be estimated by measuring the time taken for the signal to be reflected from the various layers to the surface. Seismic surveys also help to determine the thickness of the layers and fault pattern.

2.24 spill-point

Highest structural position within a reservoir, above which hydrocarbons could leak and migrate out.

2.25 total compressibility

Combined effects of the actual compressibility of the water and soil or rock elasticity.

2.26 tubing

Pipe or set of pipes that are screwed or welded together to form a string, through which fluids are injected or withdrawn.

2.27 upper aquifer

Any aquifer overlying the caprock in the storage area.

2.28 well

Technical equipment of a wellbore from the wellhead to the bottom of the hole.

2.29 well testing

Taking pressure and flowrate measurements during flowing and shut-in periods to provide information about the characteristics of the layers investigated within a wide-ranging zone around the well and the capacity of the well.