SLOVENSKI STANDARD
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Infrastruktura za plin - Podzemna plinska skladišča - 4. del: Funkcionalna priporočila za skladiščenje v skalnih kavernah

Gas infrastructure - Underground gas storage - Part 4: Functional recommendations for storage in rock caverns

Gasinfrastruktur - Untertagespeicherung von Gas - Teil 4: Funktionale Empfehlungen für die Speicherung in Felskavernen

Infrastructures gazières - Stockage souterrain de gaz - Partie 4: Recommandations fonctionnelles pour le stockage en cavités

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EUROPEAN STANDARD

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English Version

Gas infrastructure - Underground gas storage - Part 4: Functional recommendations for storage in rock caverns

Infrastructures gazières - Stockage souterrain de gaz - Partie 4: Recommandations fonctionnelles pour le stockage en cavités minées

Gasinfrastruktur - Untertagespeicherung von Gas - Teil 4: Funktionale Empfehlungen für die Speicherung in Felskavernen

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European foreword

This document (EN 1918-4:2016) has been prepared by Technical Committee CEN/TC 234 “Gas infrastructure”, 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of an identical text or by endorsement, at the latest by September 2016 and conflicting national standards shall be withdrawn at the latest by September 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1918-4:1998.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

For a list of significant technical changes between this European Standard and EN 1918-4:1998, see Annex B.

This document is Part 4 of a European Standard on “Gas infrastructure - Underground gas storage” which includes the following five 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.*

Directive 2009/73/EC concerning common rules for the internal market in natural gas and the related Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks also aim at technical safety including technical reliability of the European gas system. These aspects are also in the scope of CEN/TC 234 standardization. In this respect, CEN/TC 234 evaluated the indicated EU legislation and amended this technical standard accordingly, where required and appropriate.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard covers the functional recommendations for design, construction, testing, commissioning, operation, maintenance and abandonment of underground gas storage (UGS) facilities in mined rock caverns up to and including the wellhead.

This European Standard does not cover the technology of lined rock.

NOTE 1 Even if not covered in this standard, the lined rock is an available technology.

This European Standard specifies practices which are safe and environmentally acceptable.

For necessary surface facilities for underground gas storage, EN 1918-5 applies.

In this context, "gas" is any hydrocarbon fuel:

— which is in a gaseous state at a temperature of 15 °C and under a pressure of 0,1 MPa (this includes natural gas, compressed natural gas (CNG) and liquefied petroleum gas (LPG). The stored product is also named fluid);

— which meets specific quality requirements in order to maintain underground storage integrity, performance, environmental compatibility and fulfils contractual requirements.

This European Standard specifies common basic principles for underground gas storage facilities. Users of this European Standard should be aware that more detailed standards and/or codes of practice exist. A non-exhaustive list of relevant standards can be found in Annex A.

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

In the event of conflicts in terms of more restrictive requirements in the national legislation/regulation with the requirements of this European Standard, the national legislation/regulation takes precedence as illustrated in CEN/TR 13737 (all parts).

NOTE 2 CEN/TR 13737 (all parts) contains:

— clarification of relevant legislation/regulations applicable in a country;

— if appropriate, more restrictive national requirements;

— national contact point for the latest information.

This European Standard is not intended to be applied retrospectively to existing facilities.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1918-5, *Gas infrastructure - Underground gas storage - Part 5: Functional recommendations for surface facilities*

3 Terms and definitions

3.1 Terms and definitions common to parts 1 to 4 of EN 1918

For the purposes of this document, the following terms and definitions apply. They are common to parts 1 to 4 of EN 1918.

3.1.1
abandoned well
well permanently out of operation and permanently plugged including removed surface facilities

3.1.2
annulus
space between two strings of pipes or between the casing and the borehole

3.1.3
aquifer
reservoir, group of reservoirs, or a part thereof that is fully water-bearing and displaying differing permeability/porosity

3.1.4
auxiliary well
well completed for other purposes than gas injection/withdrawal, e.g. water disposal

3.1.5
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 borehole and to act as a barrier preventing subsurface migration of fluids when the annulus between it and the borehole has been cemented and to connect the storage reservoir respectively cavern to surface

3.1.6
casing shoe
bottom end of a casing

3.1.7
cementing
operation whereby usually a cement slurry is pumped and circulated down a cementation string within the casing and then upwards into the annulus between the casing and the open or cased hole

3.1.8
completion
technical equipment inside the last cemented casing of a well

3.1.9
containment
capability of the storage reservoir or cavern and the storage wells to resist leakage or migration of the fluids contained therein

Note 1 to entry: This is also known as the integrity of a storage facility.

3.1.10
core sample
sample of rock taken during coring operation in order, e.g. to determine various parameters by laboratory testing and/or for a geological description

3.1.11
cushion gas volume
gas volume required in a storage for reservoir management purpose and to maintain an adequate minimum storage pressure for meeting working gas volume delivery with a required withdrawal profile and in addition in caverns also for stability reasons

Note 1 to entry: The cushion gas volume of storages in oil and gas fields may consist of recoverable and non-recoverable in-situ gas volumes and/or injected gas volumes.

3.1.12
drilling
all technical activities connected with the construction of a well

3.1.13
exploration
all technical activities connected with the investigation of potential storage locations for the assessment of storage feasibility and derivation of design parameters

3.1.14
formation

body of rock mass characterized by a degree of homogeneous lithology which forms an identifiable geologic unit

3.1.15
gas injection
gas delivery from gas transport system into the reservoir/cavern through surface facilities and wells

3.1.16
gas inventory
total of working and cushion gas volumes contained in UGS

3.1.17
gas withdrawal
gas delivery from the reservoir / cavern through wells and surface facilities to gas transport system

3.1.18
geological modelling
generating the image of a structure from the information gathered

3.1.19
indicator horizon
horizon overlying the caprock in the storage area and used for monitoring

3.1.20
landing nipple
device in a tubing string with an internal profile to provide for latching and sealing various types of plugs or valves

3.1.21
liner
casing installed within last cemented casing in the lowermost section of the well without extension to surface

3.1.22
lithology
characteristics of rocks based on description of colour, rock fabrics, mineral composition, grain characteristics, and crystallization

3.1.23
logging
measurement of physical parameters versus depth in a well

3.1.24
master valve
valve at the wellhead designed to close off the well for operational reasons and in case of emergency or maintenance

3.1.25
maximum operating pressure
MOP
maximum pressure of the storage reservoir or cavern, normally at maximum inventory of gas in storage, which has not to be exceeded in order to ensure the integrity of the UGS and is based on the outcome of geological/technical engineering and is approved by authorities

Note 1 to entry: The maximum operating pressure is related to a datum depth and in caverns usually to the casing shoe of the last cemented casing.

3.1.26
minimum operating pressure
minimum pressure of the storage reservoir or cavern, normally reached at the end of the decline phase of the withdrawal profile and for caverns is based on geomechanical investigations to ensure stability and limit the effect of subsidence and normally has to be approved by authorities and has not to be underrun

Note 1 to entry: The minimum pressure is related to a datum depth.

3.1.27
monitoring well
observation well
well for purposes of monitoring the storage horizon and/or overlying or underlying horizons for subsurface phenomena such as pressure fluctuation, fluid flow and qualities, temperature, etc.

3.1.28
operating well
well used for gas withdrawal and/or injection

3.1.29
overburden
all sediments or rock that overlie a geological formation

3.1.30
permeability
capacity of a rock to allow fluids to flow through its pores

Note 1 to entry: Permeability is usually expressed in Darcy. In the SI Unit system permeability is measured in m^2.

3.1.31
porosity
volume of the pore space (voids) within a rock formation expressed as a percentage of its total volume

3.1.32
reservoir
porous and permeable (in some cases naturally fractured) formation having area- and depth-related boundaries based on physical and geological factors

Note 1 to entry: It contains fluids which are internally in pressure communication.

3.1.33
saturation
percentages of pore space occupied by fluids

3.1.34
seismic technology
technology to characterize the subsurface image with respect to extent, geometry, fault pattern and fluid content applying acoustic waves, impressed by sources near to surface in the subsurface strata, which pass through strata with different seismic responses and filtering effects back to surface where they are recorded and analysed

3.1.35
string
entity of casing or tubing plus additional equipment, screwed or welded together as parts of a well respectively completion

3.1.36
subsurface safety valve
valve installed in casing and/or tubing beneath the wellhead or the lower end of the tubing for the purpose of stopping the flow of gas in case of emergency

3.1.37
tubing
pipe or set of pipes that are screwed or welded together to form a string, through which fluids are injected or withdrawn or which can be used for monitoring

3.1.38
well
borehole and its technical equipment including the wellhead

3.1.39
well integrity
well condition without uncontrolled release of fluids throughout the life cycle

3.1.40
well integrity management
complete system necessary to ensure well integrity at all times throughout the life cycle of the well, which comprises dedicated personnel, assets, including subsurface and surface installations, and processes provided by the operator to monitor and assess well integrity

3.1.41
wellhead
equipment supported by the top of the casing including tubing hanger, shut off and flow valves, flanges and auxiliary equipment, which provides the control and closing-off of the well at the upper end of the well at the surface

3.1.42
working gas volume
volume of gas in the storage above the designed level of cushion gas volume, which can be withdrawn/injected with installed subsurface and surface facilities (wells, flow lines, etc.) subject to legal and technical limitations (pressures, gas velocities, flowrates, etc.)

Note 1 to entry: Depending on local site conditions (injection/withdrawal rates, utilization hours, etc.) the working gas volume may be cycled more than once a year.

3.1.43
workover
well intervention to restore, increase production, repair or change the completion of a well or the leaching equipment of a cavern

3.2 Terms and definitions not common to parts 1 to 4 of EN 1918

For the purposes of this document, the following terms and definitions apply which are common to part 4 of EN 1918 only.

3.2.1
capillary threshold pressure
pressure needed to overcome the property of a porous rock saturated with a wetting phase (water) to block the flow of a non-wetting phase (gas)

3.2.2
concrete plugs
concrete structures constructed at end of excavation works for tightly closing off at cavern level all temporary drives to the cavern units and operation shafts

Note 1 to entry: Concrete plugs are gas tight. Water ingress towards the cavern remains possible but is limited.

3.2.3
gas tightness
adherence to a maximum leakage rate in an approved test procedure

3.2.4
numerical simulation
computer simulation of a system

Note 1 to entry: Applied for stability analysis, hydraulic flow pattern around an excavation.

3.2.5
operating shafts
vertical shafts connecting cavern to surface facilities, designed for setting all necessary equipment to operate and monitor the storage cavern

3.2.6
rock cavern roof
highest part in a rock cavern average cross section

4 General requirements

4.1 General

This clause gives general requirements for underground gas storage. More specific requirements for underground gas storage in mined rock caverns are given in Clauses 5, 6, 7, 8 and 9.

4.2 Underground gas storage

4.2.1 Overview and functionality of UGS

The EN 1918 covers storage of natural gas, Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG). Because of the relevance of underground gas storage of CNG, the major part of this introduction is related to this.

The underground gas storage is an efficient proven common technology and is in use since 1915. Underground gas storage (UGS) became an essential indispensable link in the gas supply chain for adjusting supply to meet short-term and seasonal changes in demand.

Natural gas produced from oil and gas fields is increasingly being used to supply energy requirements. As the gas supply from these fields does not match with the variable market demand natural gas is injected into subsurface storage reservoirs when market demand falls below the level of gas delivery or if there is an economic incentive for injection. Gas is withdrawn from storage facilities to supplement the supply if demand exceeds that supply or withdrawal is economically attractive.

The primary function of UGS is to ensure that supply is adjusted for peak and seasonal demand. Apart from this, the storage facilities can provide stand-by reserves in case of interruption of the planned supply. Increasingly, UGS is applied for commercial storage services.

Thus, in summary underground gas storage facilities can be used for:

— security of supply;

— providing flexibilities;

— balancing of seasonal demand variabilities;

— structuring of gas supply;

— provision of balancing energy for the optimization of transport grids;

— trading and arbitrage purpose;

— stand-by provisions and strategic reserves;

— structuring renewable energy sources – power to gas;