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FINDING COMMON GROUND®

Summary of Main Standards and Guidelines on Grouting Available in North America and Europe

Summary of the Main Standards and Guidelines on Grouting Available in North America and Europe

*Prepared by the
International Grouting Committee
of
Deep Foundations Institute*

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PREFACE AND ACKNOWLEDGEMENTS

This document was prepared by the DFI International Grouting Committee with the intent to provide a summary of main Standards and Guidelines available for the North America and Europe grouting industry. This document highlights the different approaches, methods and tools used internationally.

The DFI International Grouting Committee comprises all parties involved on a grouting project: owners, regulators, engineers, contractors, and manufacturers (equipment and materials). This document is not intended to cover every conceivable application or requirement of grouting. However, it does provide standard practice requirements for qualifications, materials, equipment, testing, and production procedures for the Professional Engineer to incorporate into their project specific requirements. The committee members are listed on page ii.

Special thanks to

- Raffaella Granata (Trevi S.p.A. Group) for the Soil and Rock Grouting sections.
- Ken Ivanetich (Keller) and Robert Essler (RD Geotech Ltd.) for the Jet Grouting section.
- Dominic Parmantier (Condon Johnson Associates) for the Compaction Grouting section.
- Christophe Justino (Soletanche) for the Testing of Grout Mixes section.

Paolo Gazzarrini (Sea to Sky Geotech) and Piero Roberti (Bauer Foundation Corp.)
DFI International Grouting Committee Co-Chairs

Note: Some of the documents summarized are covered by copyright. Blank cells in the tables indicate that no information is provided on the topic.

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K&S Engineers, Inc

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1. SOIL GROUTING

SOIL GROUTING	Institution / Code¹	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	U.S. Army Corps of Engineers (USACE) EM 1110-2-3506 (2017)	U.S. Bureau of Reclamation (USBR) Design Standard No. 13, (2014)	Construction Industry Research and Information Association (CIRIA) C774 (2018)	Association Française des Tunnels et de l'Espace Souterrain (AFTES) GT8R2F1 (2006)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch. 15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
	Country, Region	Europe including ² EU and IS, ISRSM, SN, ISS, SNV, TSE, UK	Austria	USA	USA	UK	France
	Copyright Status	Copyrighted	Public Access	Public Access	Public Access	Copyrighted	Public Access
	Year	2020 (supersedes the 2000 edition)	2017	2017	2014	2018	2006
	Type of Document	European Standard	Recommendation	Guidelines	Design Standards	Guidelines	Guidelines
	Comments / Scope	Available in English, French and German	Comments to EU Standards		Embankment Dams only	Reservoir Dams only	Translation of French

¹ See full reference in Section 6.

² European Union Countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and Iceland, Norway, Republic of North Macedonia, Serbia, Switzerland, Turkey, United Kingdom.

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	GLOSSARY	Annex A	5 Definitions	Annex C		XIV	
0	FIELDS OF APPLICATION	1		2	15.1.2	II - III	1
Note		<i>This standard is applicable to execution, testing, and monitoring of geotechnical grouting work.</i>	<i>Primarily discusses grouting technique applied in soil and rock</i>	<i>Detailed technical guidance and criteria for grouting applications</i>	<i>Technical requirements and processes for foundation grouting beneath embankment dams</i>		
1	PRELIMINARY SITE INVESTIGATION	5	5	6	15.4	2	2.2.2
Note	<i>In case of important grouting projects, the preliminary investigation should be carried out by a contractor specialized in site investigation.</i>						
1.1	SCOPE AND EVALUATION METHODS	5	5.1.2	6	15.4		
1.2	EXPLORATORY METHODS	5.1	5.1.3. Table 2	6.5	15.4.3 - 15.4.5		
1.3	FIELD AND LABORATORY TESTS	5.2 - 5.3	5.1.3. Table 3	Table 23-9	15.4.4		
2	DESIGN CONSIDERATIONS	7					
Note	<i>Definition of scope, geometry and features of grouting treatment is a client's designer's duty.</i>						

SOIL GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
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Note	<i>Outlining of hole patterns, method, technology, sequences, and mix design: typically, it is a client's designer's/engineer's duty (when "Method and Material Specifications" are applied). Conversely, it is a Specialized Contractor's duty when "Performance Specifications" are applied. When prescriptive specifications are in force (with prescription of method and material), the final result should be not considered as a responsibility of the Specialized Contractor.</i>						
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Note	<i>The “Grout Testing” topic is treated in detail in another specific Section (see below).</i>						
3.14	MATERIAL FOR TAM (SLEEVED PIPES)					7.9.6	
Note	<i>No references in the summarized documents. The pipe can be made of PVC, steel, fiberglass, or other suitable material. In all cases, its mechanical characteristics shall be compatible with the hole length and grouting pressure adopted (considering that the presence of seal grout). The quality of the sleeve rubber shall allow the execution of several grouting passes without enervation. The sleeve quality and manufacture shall allow the sleeve to go back to the original position after each pass (to perfectly cover the valve).</i>						
4	EXECUTION						
4.1	DRILLING	8.2	8.1	8.2	15.11		

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	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
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	Grout testing	9.2. Annex C Table C.1		23-6	15.10.3	8.1; 8.2; 8.3	3.3.1; 3.3.2
	Automated Grout data recording (and control)	9.3.1.4			15.13 and 15.16 Manual logging only	7.8; 7.9	4.8.2; Annex 4.2

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	Verification Boreholes	9.3.3.3			Something in 15.16		5.1.3
5.3	WORK DOCUMENTATION	10	10			8.6	Annex 5
6	PLANT AND EQUIPMENT	8	8	8 - 11		7 - 8	4.5.2; 4.5.4
6.1	GROUT MIXERS	8.3.2	8.2	10 - 2	15.12.1	7.2; 7.3; 7.4; 7.6	4.5
Note	<i>As per above documents, that batching and mixing plant shall be selected as function of the mix to be prepared. For cement base mixes the high turbulence-colloidal mixer is recommended. Paddle mixers alone are not satisfactory for producing high-quality HMG and should only be used for large backfilling or void-filling projects</i>						
6.2	INJECTION PUMPS	8.3.3	8.3			7.5; 7.7	
Note	<i>As a rule, piston pumps are adopted in soil grouting. This type of pump can operate at a wide range of pressures (2-70 bars). Thus, they can be used where high pressure are needed to break the seal-grout and open the TAM sleeves. Piston pump can also support certain classes of chemical grout as well as suspension made of cement or other granular material.</i>						
6.3	PACKERS	8.4.2		9 - 3.b	15.12.10	7.9.5	4.7.2
7	QUALITY CONTROL SYSTEM	9.3; 10	9; 10	12	15.16	8	5.2
8	HEALTH, SAFETY AND ENVIRONMENTAL	11				3.8; 4.5; 9	3.4; 4.11

2. ROCK GROUTING

ROCK GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
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	Type of Document	European Standard	Recommendation	Guidelines	Design Standards	Guidelines	Guidelines
	Comments / Scope	Available in English, French and German Language	Comments to EU Standards (2000)		Embankment Dams only	Reservoir Dams only	Translation of French GT8R2F1 (2006)

³ European Union Countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and Iceland, Norway, Republic of North Macedonia, Serbia, Switzerland, Turkey, United Kingdom.

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	GLOSSARY	Annex A	5 definitions	Annex C		XIV	
0	FIELDS OF APPLICATION	1		2	15.1.2	II - III	1
Note	<i>"Grouting is an engineering technique routinely used in the construction of underground structures and foundations" (from AFTES, 2006).</i>						
1	PRELIMINARY SITE INVESTIGATION	5	5	6	15.4	2	2.2.2
1.1	SCOPE AND EVALUATION METHODS	5.1 general requirements in EN 1997-1	5.1.2	6.1 and 6.3 6.1 general 6.3 planning consideration	15.4	2.1.1; 2.2.1	2.2.4
1.2	EXPLORATORY METHODS		5.1.3. Table 2 useful table	6.4 Table 6.1 General Selection	15 - 4.3 - 15-4.6 <i>Detailed</i>	2.1 - 2.6	2.2.2.1
1.3	FIELD AND LABORATORY TESTS	5.2 - 5.3 only field tests are mentioned	5.1.3. Table 3 Table 3 Details for field and lab tests	6.5 6.5 field test Table 7.3 lab tests	15.4.4 - 4.7 Field 15.4.4 - 4.6Lab 15.4.7	2.1.2 - 2.2.2	2.2.2.3 and 2.2.2.4 2.2.2.3 field tests 2.2.2.4 lab tests
Note	<i>The OGG comments includes the chapter 5.3 on geo-hydraulic fundamentals.</i>						
2	DESIGN CONSIDERATIONS	7 Basis standards are EN 1997-1; 1997-2; 1997-3	7	3.4 and 3.5 Feasibility Phase and Preconstruction Engineering and Design Phase	15.3	3	4
Note	<i>Definition of scope, geometry and features of the treatment is a client's designer's duty.</i>						

ROCK GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
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2.1	FUNDAMENTALS	7.2 Basis and objectives	7.2.1	3.1 Design principles	15.1.1	3.2 - 3.9	4.1
2.2	GOALS	7.2	7.2.2	Table 3-1; Table 3-2	15.1.2	3.1	4.1
2.3	DESIGN CHECKLIST		Appendix A.3.2				
Note	<i>OGG comments to EN 12715-2000: Appendix A.3.2, page 78 contains a full design checklist (with designer and contractor duties).</i>						
2.4	ROCK GROUTABILITY CRITERIA	Annex B, Table B.1	7.2.4	5-5 (?) and 7-7 5-5 flow criteria 7-7 (k)			4.9; Annex 3.1
2.5	GROUTING HOLE PATTERNS	7.3.2.5.2	7.3.1.2	15-6 (1)	15.6.7; 15.7.6	5.1.2	4.2; Table 4.1
2.6	ROCK GROUTING METHODS	7.3 Figure 1 Table 1	7.3.1; Table 13	15-5	15.6; 15.7	5.1.4	4.9.2 -3
	Max refusal pressure Criterion	7.6.2	7.3.4.2	15-10b; 15-11d	15-6 - 7.3		4.9.2

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Note	<i>Grouting is started with a flowrate commensurate with the permitted max pressure, using a grout with relative low cohesion, viscosity, and grain size (commensurate to the expected quality of rock). During grouting the pressure must be controlled, and its value must reach the pre-designed refusal pressure (at a predefined flow rate). Otherwise, grout cohesion (and eventually the particle size) is increased until the refusal pressure is reached. Refusal pressure must be the effective pressure i.e., neat of static and dynamic head losses.</i>						
	GIN Method	7.6.2; Annex A (glossary)	7.3.4.4			5.1.4	4.9.3
Note	<i>Literature about GIN (Grouting Intensity Number) Method, see Lombardi, 2002 and Kettle and Katterbach, 2015, 2016a and 2016b</i>						
	Amenability Theory (Apparent Lugeon)		7.3.4.1	5-2e; 7-7 L(2) pag.7-30; 15-4d; 15-8e(5)		Figure 7.30	
Note	<i>Amenability = Lu_{app} / Lu_{water} The amenability coefficient is an indication of the grout mixture's ability to permeate the fractures accessed by water during the water pressure test. When the two values are badly mismatched, it indicates that grout is not freely penetrating the fracture from the outset, and reconsideration of the mix constituents or proportions may be required. This evaluation shall be done in a preliminary phase, since when a grout is clogged by a thick grout it cannot be furtherly even using a thin grout. Apparent Lugeon does not provide information about the extent of grout travel, nor does it necessarily provide information on the completeness of filling. For example, a hole could be brought to rather rapid refusal with a thick grout, and it would show a very low final Apparent Lugeon value. However, there may have been very little penetration into the rock mass, and finer fractures may not have been grouted at all. This approach requires for routinely conducting water tests on all stages in advance of grouting.</i>						
Note	<i>Reference: Naudts, 2004</i>						
	Q/P ratio approach	7.6.2	7.3.4.2				
	Rock groutability vs. type of grout	Annex B.1, Table B.1		7.2	15.15.1	4.6; Tables 4.1, 4.6; 4.8	Appendix 3.1

ROCK GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
	Selection of initial grout/ multiple grouts and sequence	7.4.3.4		15 - 8e(5) 15 - 10	15.15.2	4.6	4.9.2.
Note	<i>The choice of mix/mixes (unique or multiple) and their sequential use are strictly correlated to the adopted grouting approach. E.g., When Max refusal pressure Criterion is adopted, a sequence of grout shall be used (as per need), to allow the reaching of the refusal pressure. When the GIN method is adopted, most of cases a unique grout is considered as suitable.</i>						
2.7	GROUT TAKE AND REACH		7.3.2				
2.8	ROCK GROUTING TERMINATION CRITERIA	7.6.2	7.3.4	15-10; 15-11	15.6.7 and 15.7.6	5.1.4 Fig.5.7	15.6.7.3
2.9	ROCK GROUTING PRESSURE LIMITS	7.5.4	7.3.4; 8.3	15-9	15.6.3 and 15.7.4		
	Pressure - rules of thumb			15-9d	15.4.4(11)		
Note	<i>USACE - EM 1110-2-3506, page 15-28: "On recent USACE projects (Dams), maximum safe grouting pressures have been established as 0.5 psi/ft for the overburden soil thickness and 1 psi/ft for depth into rock. These rules of thumb were developed based on experience". USBR - Design Standard N.13, page 15-11: "Rules of thumb" are not good substitutes for using data and judgment when making grouting decisions unless they are specifically developed for the site conditions."</i>						
Note	<i>Literature: Comparison between the USA and European approach is examined by Weaver (2000). Weaver's conclusions: "... it should seem evident that - rather than mindlessly following either "rule" grouting practitioners should base their selection of grout injection pressures on site specific factors, including - to the maximum extent feasible based upon grout hole logging and water test data - the conditions at each specific hole into which grout is to be injected."</i>						
3	MATERIALS AND GROUTS	6	6	7	15.10	4	3
3.1	CEMENTS	6.2.1	6.2.1.1	7-3	15.10.2.2	4.4.1	

ROCK GROUTING		Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
		Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
3.2	OTHER BINDERS		6.2.1	6.2.1.2	7-3	15.10.2.3	4.4.2	
3.3	MICROFINE BINDERS		3.1.18; 3.1.19; 3.1.20; Table B1	6.2.1.3	7-3	15.10.2.2.	4.4.1	3.1.1.6
3.4	WATER		6.2.4	6.2.2	7-3.c	15.10.2.1	4.4.3	
3.5	ADDITIVES AND ADMIXTURES		6.2.5	6.2.3	7-7	15.10.2.5 to 9	4.4.5	
3.6	CLAYS/BENTONITE		6.2.2	6.2.4	7-7	15.10.2.4	4.4.4	
3.7	SAND, GRAVEL		6.2.3			15.10.2.10		
3.8	OTHER FILLERS		6.2.3				4.4.2	
3.9	CHEMICAL GROUTS		6.2.5		11-2	15.10.1	4.5	3.1.2
3.10	CEMENT BASED SUSPENSIONS		6.3.2	6.3	7-1	15.10.3	4.3	3.1.1
3.11	SOLUTIONS		6.3.3		11-2		4.5	3.1.2.4 Annex 3.2
3.12	MORTARS / SANDED GROUTS		6.3.4		7-7 g	15.10.2.10	Table 4.1	3.1.1.4
3.13	MATERIAL AND GROUT TESTING		Annex C	6.4	7-7J, Table 7-3. 23-6a	15.4.7	8.1; 8.2; 8.3	3.3.1; 3.3.2; Annex 3.3
Note	<i>The "Grout Testing" topic is treated in detail in another specific Section (see below).</i>							

ROCK GROUTING		Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
		Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
3.14	MATERIAL FOR MPSP				Description and photo at §8-3 are not MPSP	Fig.15.9.1.2-2.	5.1.3 pag.97	
Note	<i>The pipe can be made of PVC or steel. In both cases, the mechanical characteristics shall be compatible with the hole length and grouting pressure adopted (considering that it is <u>not confined</u> by a seal grout). The quality of the sleeve rubber shall allow the execution of grouting passes without enervation. The sleeve quality and manufacture shall allow its return to the original position after each pass, to close the valve. The bag needs to be well fabricated and securely attached to the pipe.</i>							
4	EXECUTION	8	8				6 and 7	
4.1	DRILLING	8.2	8.1		9	15.11	6	4.3
	Recommendations on drilling methods	Very open	Recommends water flushing	Recommends not to use air		15.11.2	6.3; 6.4	
4.2	GROUTING PROCEDURES	8.3.3 - 8.5	8.3 and 8.4			15.15	5.1	4.6; 4.7
4.3	GROUTING SEQUENCES	8.5				15.14	3.10; 5.1	
4.4	PROBLEMS DURING GROUTING		7.3.1.2		15.5.c(2) 15.12	15.6.4.3; 15.15.3.4 15.15.5	5.1.3	

ROCK GROUTING		Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
		Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
Note	<i>Packer bypass</i>	<p><i>When grouting in an open hole the packer shall be long enough to minimize the risk of grout bypass through the medium being grouted.</i></p> <p><i>When rock quality is heavily fractured, the risk of packer significant bypassing is critical, and must be carefully inspected to be early detected. As soon a bypass is detected, the first approach is to move the packer downward/upward (about 0.5 m/2 ft) looking for a better quality of rock, able to prevent the bypass. If the new position is not successful, the packer must be repositioned (as said), until a portion of rock is achieved for a proper packer inflation.</i></p> <p><i>When the stability of rock and/or its fracture system preclude the use of packer without bypass, the descending stage (downstage) grouting method should be adopted.</i></p>						
Note	<i>Communication between holes</i>	<p><i>Communication between holes may occur, due to intercommunication of a fracture network (of sufficient size): the grout travels from the hole being injected to one or more adjacent holes. Usually, it happens when the distance between adjacent open boreholes is less than necessary in relation with the rock condition. To avoid such type of problems, the spacing between primary holes is to be chosen carefully, in relation with the rock condition. Concurrently, a minimum distance between open hole (being drilled and/or grouted at the same time) must be prescribed and respected.</i></p>						
Note	<i>Fluid loss during drilling</i>	<p><i>Fluid losses during drilling must be carefully detected and reported. When the fluid loss becomes significant, the drilling should be suspended, and the downstage grouting should be performed.</i></p>						
5	SUPERVISION AND CONTROL	9	9		15.13			
5.1	SUPERVISION	9.1-9.3				8		
5.2	MONITORING AND CONTROL	9.3	9.1	12		8	4.8	
	Monitoring of displacements	9.3.4	9.1		15.15.3.1	3.6	5.1.2.4	
	Permeability tests (Lugeon/Lefranc/Pumping tests)	5.2.6		5-2	15.4.4	2.2.2	5.1.3.5	

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	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
	Automated Drill parameter recording (Measurement while Drilling)	5.2.5 9.3.1.4 9.3.5		9-1.d	15.16 hole logging only	12 (foreseen for future update)	4.8.2
	Grout testing	9.2. Annex C Table C.1		23-6	15.10.3	8.1; 8.2; 8.3	3.3.1; 3.3.2
	Automated Grout data recording (and control)	9.3.1.4			15.13 and 15.16 Manual logging only	7.8; 7.9	4.8.2; Annex 4.2
	Verification Boreholes	9.3.3.3			Something in 15.16		5.1.3
5.3	WORK DOCUMENTATION	10	10			8.6	Annex 5
6	PLANT AND EQUIPMENT	8	8	8 - 11	15.11; 15.12	7 - 8	4.5.2; 4.5.4
6.1	DRILLING EQUIPMENT	8.2		8	15.11.2	6.2; 6.3; 6.4	
6.2	GROUTING PLANTS AND EQUIPMENT	8.3.1-8.3.2	8.2 - 8.3	10 and 11	15.12	7	4.5
	Grout mixers	8.3.2	8.2	10-2	15.12.1	7.2; 7.3; 7.4; 7.6	4.5
Note	<i>As per document above, the batching and mixing plant shall be selected as function of the mix to be prepared. For cement base mixes the high turbulence-colloidal mixer is recommended. Paddle mixers alone are not satisfactory for producing high-quality HMG and should only be used for large backfilling or void-filling projects</i>						
	Injection pumps	8.3.3	8.3	10-5	15.12.4	7.5; 7.7	
	Piston Pump and Progressive Cavity Pump			10-5b; 10-5c	15.12.4	7.5.1.; 7.5.4	

ROCK GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	Austrian Society for Geomechanics, (2017)	USACE EM 1110-2-3506 (2017)	USBR - Design Standard No.13, (2014)	CIRIA C774 (2018)	AFTES GT8R2F1 (2006)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>OGG - Expert Comments to EN 12715-2000</i>	<i>Engineering and Design - Grouting Technology</i>	<i>Ch.15: Embankment Dams - Foundation Grouting</i>	<i>Grouting for Reservoir Dams: Guidelines for Good Practice</i>	<i>Design and Execution of Grouting Works in Soil and Rock</i>
Note	<p><i>Over the last 50 years, all the specialized grouting companies in Europe have adopted the double acting piston pumps (unless a progressive cavity pump is needed for a very specific application e.g., void filling or where the maximum injection pressures are limited to 1-3 bars). Piston pumps provide capability of injecting grout at pressure from 2 up to 7 MPa and are suitable where the use of sanded grout is anticipated. Through their valve, these pumps self-regulate the flow rate. Modern computer-piloted piston pump can be regulated to within 1 bar, which is adequate accuracy and range for most of application. The piston pumps are in wide use on grouting projects, in Europe, Middle East, Asia and Africa. The standard practice in North America is to require the use of progressive cavity pumps (typically known by the trade names Mono or Moyno), being considered more suitable to maintain a nearly constant pressure throughout the grouting process. Multiple stage progressing pumps are available for use of applications in which pressures up to a max of 2 MPa are required. When using this type of pumps, the injection pressure and flow rate are regulated manually at the manifold valves; the use of a return line is needed, to compensate for excessive pump discharges. As a rule, USACE requires the use of progressive cavity pumps to inject HMG for permeation grouting. USBR (15.12.4) requires the use of progressive cavity pump on a foundation grouting project; USBR does not allow the use of piston pumps.</i></p>						
	Packers	8.4.2		9-3.b	15.12.10	7.9.5	4.7.2
	Real Time Controlling and Recording Devices	9.3.1.4		12	15.13	7.8; 7.9	4.7.3; 4.7.8; Appendix 4.2
7	QUALITY CONTROL SYSTEM	9 and 10	9 and 10	12	15.16	8	5.2
8	HEALTH, SAFETY AND ENVIRONMENTAL	11				3.8; 4.5; 9	3.4; 4.11

3. JET GROUTING

JET GROUTING	Institution / Code⁴	ASCE-Geo-Institute (ASCE, 2016)	Euro Norm EN12716-2018 (CEN, 2018)	Japan Jet Grout Association
	Title	Guideline Specifications (August 2016)	<i>Execution of special geotechnical works - Jet Grouting</i>	Jet-Grouting Technology (October 2005)⁵
	Country, Region	USA	Europe including ⁶ EU and IS, ISRSM, SN, ISS, SNV, TSE, UK	Japan
	Copyright Status	Public Access	Copyrighted	Public Access
	Year	2016	2018	2005
	Type of Document	Recommendation	European Standard	Guidelines
	Applications	Seepage Control (Dam, Levee, Contaminated sites, Environmental, Tunnelling (break-in/out, soil improvement for excavation), Underpinning, Shoring, Piling, Bottom Slabs for tanked, excavations, seismic soil improving against liquefaction, Other (slope stability, environmental encapsulation, bearing capacity improvement)		

⁴ These documents are the main standards that include jet grouting guidance. Additional documents are listed on the next page in which jet grouting is marginally described or is a standard for specific nation and may not be published in English.

⁵ The official document is available in Japanese only. The details presented in these tables were summarized from an unofficial English translation.

⁶ European Union Countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and Iceland, Norway, Republic of North Macedonia, Serbia, Switzerland, Turkey, United Kingdom.

OTHER JET-GROUTING DOCUMENTS ⁷	Country	Comments
USACE EM-1110-2-3506 (2017)	USA	Very generic with application and applicability.
CIRIA C774 (2018)	UK	Only Chapter 5.6
AGI (ITALY) (2012) Jet Grouting: Raccomandazioni (Italian only)	Italy	Detailed in all the sections, but not summarized here for language problem
Bureau of Reclamation Design Standards No.13- Embankment Dams (2014)	USA	Section 16.12 General detailed considerations
GD_MB_Bodenverbesserung, QA guidance for Soil Stabilization (Jet grouting, Soil Mixing and Permeation grouting)	Austria	Quality assurance
DIN 4093, 2015 Design of strengthened soil - Set up by means of jet grouting, deep mixing, or grouting (German only)	Germany	Design of strengthened soil– - Made by means of jet grouting, deep mixing, or grouting
EN 12716-2018	Australia	Australia adopts the European Norm EN 12716
Reinforced Ground Constructions Design Rules, Armed Grouted Structures. Rules of Architectural Design. (МИНИСТЕРСТВО СТРОИТЕЛЬСТВА СП) 291.1325800 (2017)	Russia	Not summarized here for lack of English translation

⁷ These documents marginally describe jet grouting, are standards for a specific nation, and/or may not be published in English.

JET GROUTING	Institution / Code	ASCE-GI	EN12716-2018	Japan – Jet Grout Association
	Title	Guideline Specifications (August 2016)	<i>Execution of special geotechnical works – Jet Grouting</i>	Jet-Grouting Technology (October 2005)
Note:		<i>Performance type specifications with commentaries and discussion on some major jet grouting topics</i>	<i>Standard for EU. Very rare comments.</i>	<i>More a design document Introduces the technology and discusses theory behind the technology.</i>
1	PRELIMINARY SITE INVESTIGATION			
	Geotechnical Information	Section 1.1.3. Not treated the details of preliminary site investigations.	In section 5. Reference to EN - 1997-2.	No references
	Obstructions	Section 1.1.3.5.8.	Section 7.2.5	
	Utilities	Section 1.1.3.3	Section 4.1.2 (referred to as services)	3.2.2(5)
2	DESIGN			
	Reference Documents	Section 1.2	Section 2	Chapter 2
	Overall jet grouting design and soil-cement engineering characteristics	Section 1.1.1.4. Engineer typically identifies treatment area, strength, and permeability.	Section 7 It seems the Engineer is responsible for everything. Not clear who is defining the jet grouting parameters.	Very well detailed design. Examples in Chapter 2.5 Shield tunnel Bottom Slab and excavation 2.3.1 Includes charts to assist in the selection of diameters and jetting parameters.
	Element design (diameter, etc.)	Section 1.1.2. Specialty Contractor typically responsible for column size, shape, and spacing	The section includes some minimum requirements.	Section 2.4.2 discusses column spacing
3	MATERIALS AND GROUTS			

JET GROUTING	Institution / Code	ASCE-GI	EN12716-2018	Japan – Jet Grout Association
	Title	Guideline Specifications (August 2016)	<i>Execution of special geotechnical works – Jet Grouting</i>	Jet-Grouting Technology (October 2005)
	Materials	Section 2.1 Materials	Section 6- Materials	Section 2.4.5, Minimal comment on page 76 point 5, page 77 point 2
	Grout mixes	Section 1.5.4 and Section 3.1.1- Specialty contractor to design grout mix and tests.	Section 9.3.8 and Annex C - Tests on grout mixes (bleed, setting time, Marsh funnel, UCS, etc.)	
	Grout mixer	Section 2.2.3 Grout Mixer		
	Mix design	Section 3.3.4 - Grout mix proportion (not defined tests).		
4	EXECUTION	Section 3	Section 8	
	General		Section 8.1.2. Important statement that the high pressure is not applied to the soil but only to create high energy to disaggregate the soil.	
	Definitions	Section 1.3	Section 3	
	Qualifications	Section 1.5.2 with a minimum experience.	It seems not specified contractor/personnel experience. Only generically in the introduction.	
	Test Program/Field test	Section 1.5.5, Section 3.1	Section 9.2	
	Supervision	Section 1.5.2.3	Section 7.1.7, 9.3.	
	Spoil/reflow/backflow	Section 1.5.6.2, Section 3.2.2 with rationale.	Section 8.6 and 9.3.4/5/6/7/8. No rationale.	Section 2.4.6, section 3.1.5

JET GROUTING	Institution / Code	ASCE-GI	EN12716-2018	Japan – Jet Grout Association
	Title	Guideline Specifications (August 2016)	<i>Execution of special geotechnical works – Jet Grouting</i>	Jet-Grouting Technology (October 2005)
	Sequences	Section 1.5.6.1, 3.2.4, 3.4.1.7	Section 7.1.5/6. No definitions of fresh-on-fresh nor Primary-Secondary-Tertiary holes	
	Method Statement	Section 1.5, as submittals	Section 8.1.5 with complete list of requirements	
	Measurement and Payment	Section 4. reviews measurement and payment items		
5	QUALITY CONTROL, QUALITY ASSURANCE, DATA RECORDING, VERIFICATION AND DOCUMENTATION			
	General	Section 3.3. Very well detailed	Annex C	Section 3.2
	Data recording	Section 2.2.8 with notes Section 3.3.2	Section 9.3 and 9.5.	
	Verification/Acceptance criteria	Section 3.5. Very well defined, with rationale.	Not defined	
	Installation records	3.5.1	Section 10.2.1	
	Coring (uniformity)	3.3.5, 3.5.2	Section 9.4.1	
	Hydraulic conductivity	3.3.6, 3.5.3	Section 7.4	
	UCS	3.5.4	Section 7.3 Annex A Determination of material strength.	2.4.1
	Overlapping	3.5.4		
	Deviation	3.5.6	Section 7.2.2b, Section 8.4	

JET GROUTING	Institution / Code	ASCE-GI	EN12716-2018	Japan – Jet Grout Association
	Title	Guideline Specifications (August 2016)	<i>Execution of special geotechnical works – Jet Grouting</i>	Jet-Grouting Technology (October 2005)
	Sampling quality		Detailed sampling quality definitions.	
	Documentation	Section 3.4	Section 10 and sample in Annex D	
6	PLANT AND EQUIPMENT	Section 2.2 (quite detailed) including real time monitoring and recording	In Section 8 (point 8.2 only). Not a lot of detail.	Section 3.1.3, 3.1.4, Section 1.2.2 discusses nozzle design.
7	HEALTH, SAFETY AND ENVIRONMENT		Section 11	
	Health	Not treated	11.1 Generic reference to legislation of various European Countries	Not treated
	Safety	1.5.6.3, included an important note.	In references, and 11.2. To be noticed that in EU exist a specific Standard EN 16228-6 related to jet grouting safety.	3.2.2
	Environment	Brief in 1.1.3.5.1	Section 11.3	

4. COMPACTION GROUTING

COMPACTION GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	American Society of Civil Engineers (2019)	American Society of Civil Engineers (1996)	USACE EM 1110-2-3506 (2017)	North Carolina Department of Transportation (2018)	Texas Department of Transportation (2004)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>Compaction Grouting Consensus Guide</i>	<i>Practical Guide to Grouting Underground Structures</i>	<i>Engineering and Design - Grouting Technology Chapter 27</i>	<i>Compaction Grouting Specifications</i>	<i>Compaction Grouting Specifications</i>
	Country, Region	Europe including EU and IS, ISRSM, SN, ISS, SNV, TSE, UK	USA	USA	USA	USA	USA
	Copyright Status	Copyrighted	Copyrighted	Copyrighted	Public Access	Public Access	Public Access
	Year	2020	2019	1996	2017	2018	2004
	Type of Document	European Standards	Guidelines	Guidelines	Guidelines	Specification	Specifications

COMPACTION GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	American Society of Civil Engineers (2019)	American Society of Civil Engineers (1996)	USACE EM 1110-2-3506 (2017)	North Carolina Department of Transportation (2018)	Texas Department of Transportation (2004)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>Compaction Grouting Consensus Guide</i>	<i>Practical Guide to Grouting Underground Structures</i>	<i>Engineering and Design - Grouting Technology Chapter 27</i>	<i>Compaction Grouting Specifications</i>	<i>Compaction Grouting Specifications</i>
	GLOSSARY	Annex A					
1.0	MATERIALS	6					
1.1	GROUT MIX	6.3.4. ≥15%passing 0.1mm slump 9±3 cm)	Slump < 1.5in. Typical UCS >100 psi			slump < 2-in	
1.2	CEMENT	6.2.1	Typical 6-12% by mass; Not required			Sec. 1003 - Type 5 grout mix with min 400# cement/cy	Generally, up to 12% cement by weight.
	Flyash	6.2.1					DMS-4610. Supplement natural fines with fly ash to reach specified fines content.
	Chemical Admixtures	6.2.5					DMS-4640. Do not use Calcium Chloride. Do not use bentonite or other clay of medium to high plasticity.

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	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>Compaction Grouting Consensus Guide</i>	<i>Practical Guide to Grouting Underground Structures</i>	<i>Engineering and Design - Grouting Technology Chapter 27</i>	<i>Compaction Grouting Specifications</i>	<i>Compaction Grouting Specifications</i>
1.3	AGGREGATES	6.2.3	Plate 1 - Grain Size 5% max clay. Less #40 shall have PI <15				Table 1 - 100% Passing 3/8. 10% -30% Passing No.200. Soil fines have LL <25 and PI<10.
1.4	WATER	6.2.4	ASTM C1602 Standard Specification for Mixing Water for Hydraulic Cement Concrete				421.2.D Water
2.0	DRILLING and GROUTING EQUIPMENT						
2.1	DRILLING EQUIPMENT	8.2	Drive, rotary, or rotary percussion. Water or air-foam flush.				Air or air-foam ONLY to install grout pipes. No other drilling fluids
2.2	GROUT CASING		1.75-3.0 I.D. Flush Joint Casing. Max length of 5-ft unless withdrawn by drill rig.			Min 2-in I.D. flush joint casing.	Min 2-in I.D. flush joint casing.

COMPACTION GROUTING	Institution / Code	Euro Norm EN 12715-2020, (CEN, 2020)	American Society of Civil Engineers (2019)	American Society of Civil Engineers (1996)	USACE EM 1110-2-3506 (2017)	North Carolina Department of Transportation (2018)	Texas Department of Transportation (2004)
	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>Compaction Grouting Consensus Guide</i>	<i>Practical Guide to Grouting Underground Structures</i>	<i>Engineering and Design - Grouting Technology Chapter 27</i>	<i>Compaction Grouting Specifications</i>	<i>Compaction Grouting Specifications</i>
2.3	CASING WITHDRAWAL SYSTEM						
2.4	GROUT BATCHER/MIXER	8.3.1 8.3.2	Continuous or batch mixing.			Volumetric concrete mixer required	Pugmill mixer or mixer approved by Engr. Mixer to achieve slump <2-in.
2.5	GROUT PUMP	8.3.3 7.3.2.5.1 Note	Piston pump. Piston not greater than 4 - in. 0.2 to 2 cubic ft/min up to 1000 psi. Pump controlled remotely at the header.			Able to pump 2-in slump at 1,000 psi up to 5 cubic ft/min.	Able to pump 2- in slump at 1,000 psi 0.1 to 5 cubic ft/min.
2.6	GROUT DELIVERY LINE	8.3.3	Min 2-in diameter of rigid pipe or hoses and fittings all rated to 2 times pumping pressure			Riser elbow minimum 1-ft radius.	Riser elbow minimum 1-ft radius. Minimum 2-in ID.

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2.7	PRESSURE GAGES	8.3.3	Gages at pump and header. Min 3-in diameter and maximum pressure < 150% or max pump pressure.			In line pressure gage protected from contamination near riser elbow.	Pressure gage graduated in 10 psi increments or less. Within 2% accurate certification.
	Flow Gages						Provide gage/meter capable of 0.5 cubic ft or less to measure grout pumped. Within 2%
3.0	DATA ACQUISITION and REPORTING	9.3					
3.1	LOGGED INFORMATION	10	Pressure and flow rate on 3 minutes intervals. Heave. Grout termination criteria.				Log of grout quantity per 5-ft of hole. Rate and pressure of grout injection
3.2	REAL-TIME COMPUTER MONITORING	9.3	If used, pressure transducer located on header at the top of the casing. Provide data in spreadsheet format to Engineer.				

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3.3	DAILY REPORT						
3.4	MOVEMENT MONITORING SYSTEM	9.3.4	Monitoring system with accuracy of 1/16-in used to monitor ground surface/structures within 30-ft of injection point.			Monitoring devices accurate to 0.01-in. horizontal and vertical	
4.0	DRILLING	8.2					
4.1	ESTABLISHING GROUT HOLES	7.3.5.2.2.	Intimate contact between casing and soil to prevent jacking casing and grout leakage.				Intimate contact between casing and soil to prevent premature upward movement of casing and
4.2	HOLE LOCATIONS	7.3.5.2.2.	No tolerance on location.			Install casing to within 5-degrees of specified orientation.	Install casing to within 5-degrees of specified orientation.
4.3	CONTROL OF DRILLING CIRCULATION FLUSH		Flush water to be captured and directed to disposal location.				

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	Title	<i>Execution of special geotechnical work - Grouting</i>	<i>Compaction Grouting Consensus Guide</i>	<i>Practical Guide to Grouting Underground Structures</i>	<i>Engineering and Design - Grouting Technology Chapter 27</i>	<i>Compaction Grouting Specifications</i>	<i>Compaction Grouting Specifications</i>
4.4	WATER INJECTION		Engineer may require or prohibit use of water.				
4.5	DRILLING LOG	9.3.5					
5.0	GROUT INJECTION	7 and 8					
5.1	DEPTH CONFIRMATION		Confirmed open grout hole by weight tape.				
5.2	SEQUENCE	8.4 8.5	Do not grout a hole within 12-ft of hole grouted in previous 12 hrs. Work upslope and away from retaining structures.			Install casing and grout primary holes prior to secondary holes.	Install casing and grout primary holes prior to secondary holes.
5.3	GROUT STAGING		Ascending stage. Stage length 1-ft to 4-ft.			Ascending 1-ft stages.	Ascending 2-ft stages.
5.4	ACCESS REQUIREMENTS						
5.5	INJECTION RATE		0.5 to 2.0 cubic ft/min at Engineer direction. Contractor to assume 1.5 cubic ft/min average.				0.1 to 5.0 cubic ft/min required. Do not exceed 2 cubic ft/min.

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5.6	GROUT REFUSAL CRITERIA	7.3.5.2.2. 7.6.2	-1000 psi header pressure for 3 min -sustained 500 psi header pressure -unwanted structure heave >1/8-in -stage ground heave of 1/16-in -total grout volume of				-grout pressure at header exceeds 200 psi -movement of structure -more than 2 cubic ft of grout injected per 2-ft stage with pressure >100 psi
5.7	IMPROPERLY GROUTED HOLES						
5.8	GROUT JACKING						
5.9	HOLE COMPLETION		Completed holes backfilled to surface with minimum 5 psi injection pressure.				
6.0	MEASUREMENT AND PAYMENT						
6.1	DRILLING					Paid by liner ft of casing measured as length of casing installed below ground surface.	Paid at unit price for "Drill Holes"

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6.2	GROUTING					Paid by cubic ft of grout injected thru grout casing.	Paid at unit price for "Compaction Grouting"

5. TESTING OF GROUT MIXES

TESTING OF GROUT MIXES	Institution / Code	American Society for Testing and Materials (ASTM) International	American Petroleum Institute (API)	Canadian Standard Association (CSA)	ISO International Organization for Standardization (ISO)	European Committee for Standardization (CEN)	Others
	Title	Standard Test Methods	Recommended Practice	Standards	International Standards	European Standards	National Standards/ Recommendation/ Guidelines
	Country, Region	ASTM Standards	API	Canada	International ⁸	Europe including ⁹ EU and IS, ISRSM, SN, ISS, SNV, TSE, UK	Others
	Copyright Status	Copyrighted	Copyrighted	Copyrighted	Copyrighted	Copyrighted	Various
	Year	Various	Various	Various	Various	Various	Various
	Type of Document	Standards for Test Methods	Recommended Practice for Testing Drilling Fluids	Standards for Test Methods	Standards	Standards	Various
	Comments / Scope	Various	API-13b 2009 is identical to ISO 10414.1:2008		ISO 10414.1:2008 Is identical to API-13b 2009	Available in English, French and German Language	

⁸ It is active in 165 Countries (almost all those recognized by UN)

⁹ European Union Countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and Iceland, Norway, Republic of North Macedonia, Serbia, Switzerland, Turkey, United Kingdom

TESTING OF GROUT MIXES	Institution / Code	American Society for Testing and Materials (ASTM) International	American Petroleum Institute (API)	Canadian Standard Association (CSA)	ISO International Organization for Standardization (ISO)	European Committee for Standardization (CEN)	Others
	Title	Standard Test Methods	Recommended Practice	Standards	International Standards	European Standards	National Standards/ Recommendation/ Guidelines
1	SPECIFIC GRAVITY	D4380-12 Mud Balance	API 13B-1:2009 Para 4 Mud Balance		ISO 10414.1:2008 Para 4 Mud Balance	EN 12715:2020 Annex C	
2	BLEEDING	C940-16		CSA A23.2 1B 250 mL graduated cylinder		EN 12715:2020 Annex C, Note R6 60 mm diameter 1000 ml graduated cylinder	(Italy) UNI 11152 § 11 CIRIA C774:2018 §8.2.3 EN 934-4:2009 Annex B UNI and CIRIA 60mm diameter graduated cylinder EN 934 deals with grouts - 50 mm diameter
	Apparent Viscosity (Marsh Cone)	D6910-19	API 13B-1:2009 Para 6.2 Flow cone nozzle diameter 3/16 inches		ISO 10414.1:2008 Para 6.2 Flow cone nozzle diameter 4.75 mm	EN 12715:2020 Annex C Note R1- R2	

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	Title	Standard Test Methods	Recommended Practice	Standards	International Standards	European Standards	National Standards/ Recommendation/ Guidelines
	Apparent Viscosity (Flow Cone)	C939-16 Flow cone nozzle diameter 12,75 mm		CSA A23.2 1B Flow cone nozzle diameter 13 mm		EN 445:2007 Para 4.3.1 EN 12715: 2020 Annex C Note R1- R2-R3 EN445: Flow cone nozzle diameter 10 mm EN12715: idem ASTM C939	
	Cohesion (Lombardi Plate)					EN 12715:2020 Annex C, Note R1 and R5	(Italy) UNI 11152 :2005: § 15 CIRIA C774:2018 § 8.2.2
	Viscosity/Cohesion (Rheometer)	D4016-14	API 13B-1:2009 Para 6.3 Plastic and Apparent Viscosity (cP) Yield Point (lb/1000fit ² or Pa)		ISO 10414.1:2008 Para 6.3 Plastic and Apparent Viscosity (cP) Yield Point (lb/1000fit ² or Pa)	EN 12715:2020 Annex C Note R1- R4	
	Cohesion Shear Vane	D4648-16				EN 12715:2020 Annex C Note R1	(UK) BS 1377-7 CIRIA C774: 2018 §8.2.2

TESTING OF GROUT MIXES	Institution / Code	American Society for Testing and Materials (ASTM) International	American Petroleum Institute (API)	Canadian Standard Association (CSA)	ISO International Organization for Standardization (ISO)	European Committee for Standardization (CEN)	Others
	Title	Standard Test Methods	Recommended Practice	Standards	International Standards	European Standards	National Standards/ Recommendation/ Guidelines
	Pressure-Filtration		API 13B-1:2009 Para 7.2 Reporting is Suitable for bentonite slurries only		ISO 10414.1:2008 Para 7.2 Reporting is Suitable for bentonite slurries only	EN 12715 Annex C, R7	(Italy) UNI 11152 § 16 CIRIA C774:2018 § 8.2.4 Reporting is Suitable for grout mixes
	Gel Time	D4648-16 Vane shear test			ISO 10414-1:2008 Annex B Shearometer Vane shear test	EN 12715:2020 Annex C, R9	(UK) BS 1377-7 CIRIA C774:2008 § 8.2.2
	Setting Time	C953-17 C191-19				EN 12715:2020 Annex C, R9; EN 196-3:2016 Vicat Needle/ Glass Beaker / Gel meter probe, depending on type of mix	
	Unconfined Compressive Strength	C942-15 D4832-02 depending on type of mix		CSA A23.2 1B Cubes 50x50x50 mm Constant load		EN 12715:2020 Annex C, Note R10	CIRIA C774 :2018 §8.3.2
	Permeability	D5084-16				EN 12715 Annex C, Note R11	(UK) BS 1377 (France) NF X30-442 NF X30-441 NF X30-443

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