Drilling Contractors Association (DCA)
Verband Güteschutz Horizontalbohrungen e.V.
Association des Entrepreneurs de Forage Dirigé

large scale drilling

small scale drilling

DCA Technical Guidelines

Information and Recommendations for the

Design, Construction and Documentation of HDD-Projects

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10 Quality Assurance

10.1 Quality Assurance

The successful completion of an HDD project depends on many factors which have been described above. In addition to the expertise of all project parties and the technical suitability of the equipment, successful project implementation depends on the subsoil conditions as well as the relevant knowledge of those conditions.

Based on the complexity of the HDD-project the following chapter lists several requirements for quality assurance (QA) in terms of planning, project management and execution.

The planned and organized implementation and documentation of those measures during the project should be established and recorded within an existing QA system of the participating parties.

10.2 Qualification of the Contractor

10.2.1 Personnel

The complexity of the HDD crossings and the special interest in their execution at a high-quality level require carefully trained personnel both in project management and in equipment operation. This includes drilling rig operators (drillers), site managers, and technical supervisors (specialist staff). As the length and diameter increase along with the associated size of the HDD rig spread, the complexity of an HDD drilling operation increases. In Germany in the education of specialist staff, differentiation is therefore made between personnel for HDD rigs with a pulling force ≤ 400 kN and personnel for HDD rigs with a pulling force > 400 kN. Other training models are pursued in other European countries. The essential tasks and responsibilities of the specialist staff are outlined in the following chapters.

10.2.2 Drilling Rig Operator

The drilling rig operator (also called the Driller) is responsible for the daily operation of the drilling rig. In most cases, he acts as the foreman of the drilling crew. He is also responsible for the detailed documentation of all drilling activities and the associated events on site.

10.2.3 Site Manager

Depending on the size or complexity of the drilling operation, the site manager can be responsible for one or more drilling projects simultaneously. He is responsible for the preparation, quality, and safety, the overall organization of the project, and day to day communication with the client and other stakeholders.

10.2.4 Technical Supervision (applicable only for Germany GW 302)

In Germany, the certification of HDD contractors is desirable or requested by many clients. The certification is offered by various certification service companies and is based on the worksheet GW 302 of the German Gas and Water Association "DVGW". One condition for the corresponding certification is proof of a certified technical supervisor employed exclusively by the company.

The technical supervisor is responsible for the technical planning and implementation of all HDD measures in the company and organizes all processes related to the quality and safety of the drilling work. He checks the application of the correct equipment, tools, drilling fluid parameters, etc., to ensure that the required quality and safety standards are met. He also ensures that qualified and experienced personnel are deployed.

10.3 Qualification of the Client/ Engineer

The client must have the necessary knowledge and experience for the successful planning and implementation of HDD projects. Planning should be carried out according to the guidelines explained in Chapter 4 (Project Planning). If the client does not have the necessary technical knowledge, or if the project engineering is not carried out by the client themselves, a suitably qualified planning engineer must be involved. This engineer must have the relevant technical knowledge and experience for the planning of HDD projects in accordance with the quality and safety requirements. During execution, the client or their representative must be capable of assessing the project's proceedings, including potential difficulties, to define further steps with the contractor.

10.4 Project-Specific Requirements

10.4.1 Project Categories

The complexity of a Horizontal Directional Drilling (HDD) project dictates the level of detail required in planning and soil investigations to ensure a successful installation. The degree of complexity is determined by project-specific circumstances and requirements, such as:

- Length of the HDD,
- Diameter of the borehole,
- Obligations and requests of third parties,
- Specifications of the pipe to be installed,
- Required accuracy (steering tolerances),
- Type and nature of obstacle to be crossed,
- Topography (e.g., significant height differences),
- Subsoil conditions and homogeneity, hydrogeological conditions,

- Existing infrastructure (e.g., buildings, masts, pylons, foundations, cables, pipelines, etc.),
- Other project-specific peculiarities.

In general, the complexity of an HDD crossing increases with its length and depth, as well as the diameter of the pipeline to be installed.

Based on the degree of complexity, HDD projects can be categorized for planning and execution.

To ensure the right approach to planning and execution of each HDD project, two categories are distinguished:

- Category 1: Standard HDD Projects.
- Category 2: Complex HDD Projects.

Category 1 HDD projects for the most part can be executed based on experience.

Category 2 HDD projects require significantly more time for planning, soil investigation, and preparation than Category 1 projects. They also require more resources for detailed planning and preparation up to project execution.

Table 11 below lists the criteria for categorizing HDD projects, based on the results and parameters agreed upon by industry experts. If only one criterion for complex projects is met, generally that project will be in category 2. In justified cases an expert planner can deviate from this rule in their overall evaluation.

Table 11: Criteria for categorising of HDD-projects

Criteria HDD-project-category	Category 1 Standard	Category 2 Complex
Length of Drilling	short, ≤ 300 m	long, > 300 m
Borehole diameter	small, ≤ 450 mm	large, > 450 mm
Level difference between entry and exit point	≤ 5 m	> 5 m
Cover/Distance	Minimum cover according to Section 4.1.2.3, Formula 1 with safety factor ≥1.2 maintained (Settlements/Raises)	Minimum cover according to the adja-cent requirement with safety factor <1.2
	Minimum cover according to Section 4.1.2.3, Formula 2 with safety factor ≥1.2 maintained (flushing pressure)	Minimum cover according to the adjacent requirement with safety factor <1.2
	Minimum distance to foreign facilities with safety factor ≥1.2 maintained	Minimum distance according to the adjacent requirement with safety factor <1.2
Soil type	Fine-grained soils, e.g. silt, fine sands, non-swelling clays	Coarse-grained soils with a gravel content ≥ 40% or indivi-dual blocks Rock >50 MPa Alternating hard and soft soil layers/rock
Soil condition	Homogeneous and fault-free	Heterogeneous, faulty, fissured
Work Surfaces, drilling techno-logy and pipe installation	Sufficient at the entry and exit points to drill the hole in accor-dance with the standard	Limited at the entry and exit points, so project-specific mea-sures must be taken
Permeability	< 10^{-4} m/s	≥ 10^{-4} m/s
Soil contamination	Not contaminated	Contaminated

Criteria HDD-project-category	Category 1 Standard	Category 2 Complex
Groundwater salinity	Fresh water (salinity <1g/l)	Sea and brackish water (salinity ≥ 1 g/l)
Permit procedure or conditions and requirements with regard to the obstacle to be overcome	Simple permit procedure, no adjustment of the standardized execution	Complex permit procedure, extensive obligations and requests from the permit procedure must be met during the project execution
Stabilization of the environment or the borehole before or during the laying of the pipeline	Not required	Casing /Increase of the entry or exit points level /Increase of the mud density or soil injection
Stabilization of the environment or the borehole after laying of the pipeline	Not required	Annular space grouting with special requirements
Drilling radius	Design radius according to Section 4.1.3 with additional safety factor ≥1.2	Design radius according to the adja-cent requirement with additional safety factor <1.2
Tolerances	Acc. Chapter 4.1.5	Stricter requirements than laid down in ch. 4.1.5

10.4.2 Project Requirements and Responsibilities

Table 12 below outlines the key elements required for planning and executing an HDD project. Further requirements may be stipulated in the contract conditions. In many projects, a main contractor assumes various tasks of the client. In the following table, the HDD contractor is meant with “Contractor” and either the project owner or the main contractor is meant with “Client”. The distribution of tasks and responsibilities serves as a guideline. In many small projects, various tasks are standard procedures that are determined by the crew on the construction site based on their experience and are not necessarily provided to the client prior to execution. Nevertheless, all listed aspects of job preparation must be covered by internal processes. It must be specified in the contract which points need to be recorded and provided in writing to the client.

Table 12: Compilation of the most important preparatory work for planning and implementation

Responsibilities	Area of Responsibility	Cat 1	Cat 2
Clarify the scope of required permits (see Chap. 3.1 and 3.2), authorizations, and specific regulations.	Client	x	x
Obtain permissions and follow the requirements in their conditions.	Client/Contractor	x	x
Specification of the coordinate (X, Y) and elevation system (Z) to be used.	Client		x
Details on accessibility.	Client	x	x
Establishing the conditions for the disposal of drilling cuttings and drilling fluid.	Client	x	x
Provision of a disposal concept.	Contractor	x	x
Obtain information on the location of neighboring buildings, underground infra-structures (cables, pipelines, foundations, slurry walls, etc.), and clarification of minimum distances.	Client	x	x
Details of the site area.	Client	x	x
Details of unexploded ordnance clearance.	Client	x	x
Photos, aerial photography.	Client		x
Layout plan of the pipeline to be laid (right of way).	Client	x	
Detailed location plan of the drilling route with the representation of the adjacent buildings, vegetation, poles, fences, land parcel boundaries, existing lines/cables, protected areas, foundations, sheet pile walls, etc.	Client		x
Terrain section.	Client	x	
Geotechnical longitudinal section with sequence of layers.	Client		x
Longitudinal and cross-section of the drilling line.	Client/Contractor		x
Coordination of the location of the entry and exit points.	Client/Contractor	x	x
HDD Procedure description (including drilling program, equipment to be used, schedule).	Contractor		x

Responsibilities	Area of Responsibility	Cat 1	Cat 2
Investigation of the actual location and level of the existing lines (cables, pipelines, etc.).	Contractor	x	x
Organization of the disposal of the drilling fluid/ drilling cuttings.	Contractor	x	x
Calculation of pipe stresses for operational conditions, preliminary estimate for the construction condition (e.g. pressure, pulling force, ground load, bending radii).	Client	x	x
Calculation of pipe stresses for installation conditions (e.g. pressure, pulling force, ground load, bending radii).	Contractor	x	x
Special requirements for the borehole survey system, if any.	Client		x
Determination of the borehole survey system to be used.	Contractor	x	x
Specification of the borehole diameter.	Contractor		x
Calculation and detailed drawing of the overbend.	Contractor		x
Specification of the drilling and flushing parameters (e.g. pump rate, drilling speed).	Contractor		x

10.4.3 Scope of Required Soil Investigations

Table 13 below generally indicates the necessary scope of subsoil investigations, depending on the categories defined above. Tables 14 and 15 list the specific requirements for works in non-consolidated formations and consoli-dated/rock formations, respectively.

Table 13: Scope of soil investigations (general)

Section	Content	Cat 1	Cat 2
Information on location	Topographic and hydrographic information	-	x
	Information on the history of the location	-	x
	Description of the geo-hydraulic conditions, data on water level fluctuations (groundwater and surface water) etc.	-	x (If applicable)
	Information on the riverbed, scouring, currents	-	x (If applicable)
	Climate data	-	x (If applicable)
Subsoil investigation	Investigation boreholes	o[1]	x
	Pressure or dynamic cone penetration tests	-	-
	(CPT/SPT/Menard or equivalent)	o[1]	x
	Extraction of soil and rock samples	o[2]	x
	Measurement of groundwater level	o[2]	x
	Measurement of pore water pressure	-	x
Laboratory analyses	Classification of soils	o[2]	x
	Rock classification	o[2] (If applicable)	x (If applicable)
	Information on strength properties	o[2] (If applicable)	x
	Investigation into potential contamination	o[2] (If applicable)	x (If applicable)
Geophysical investigations	Determination of layer boundaries, disturbances, and obstacles among others by geoelectric, seismic, hydroacoustic, electromagnetic measurements	-	optional[3]

Section	Content	Cat 1	Cat 2
Geotechnical report	Description and assessment of the subsoil	-	x
	Geological overview	-	x
	Description of the field and laboratory investigations carried out	-	x
	Evaluation of the investigation results	-	x
	Geological longitudinal section	-	x
	Assessment of hydrogeological conditions	-	x
	Recommendations for the execution of the planned installation process (Information on drillability, behavior of the subsoil under drilling conditions, hints at obstacles, information on possibly necessary further investigations)	-	x
Geotechnical proofs/ dimensioning	Evidence of borehole stability, arching effect, minimum coverage, allowable and required flushing pressures	-	optional[3]
	Dimensioning of the rig anchor in combination with the expected pull force	-	optional[3]
	Hydraulic calculations, ratio of solid content to pumped volume	-	optional[3]
	Pipe stresses under operating conditions including soil overburden and traffic loads (pipe structural analysis)	x	x

[1] If no project-specific soil investigation is carried out for category 1 projects, at least general information about the expected soil conditions from experience and/or comparable projects in the same region must be provided.

[2] If geotechnical boreholes were made.

[3] to be provided by HDD planner and/or HDD contractor (to be allocated in advance).

Table 14: Investigation scope for works in loose soil

Test	Parameter	Symbol	Unit	Cat 1	Cat 2
Classification	Minerals, abrasive properties	LCPC	g/t	-	x
	Grain size distribution	-	-	-	x
	Plasticity/consistency index	Ip, Ic	% / -	-	x
	Swelling capacity of clay minerals	Ia	- / %	-	x
	Content of organic admixtures	-	%	-	x
	Bulk density	γ	kN/m³	-	x
Strength and deformation properties	Shear strength, cohesion	c	kN/m²	-	x
	Shear strength, angle of internal friction	φ	°	-	x
	Shear strength, cohesion, un-drained	cu	kN/m²	-	x
	Modulus of elasticity, confined lat-eral expansion	E	kN/m²	-	x
	Cone resistance CPT	q_u	kN/m²	-	x
	Sleeve friction CPT	q_c	MPa	-	x
	Ratio of sleeve friction to cone re-sistance	f_r	-	-	x
Permeabilty	Pore water pressure	u	Pa	-	x
	Hydraulic gradient	i	‰	-	x
	Coefficient of permeability	k_f	m/s	-	x
Miscellaneous	Salt content	-	‰	-	x
	Impurities	-	-	on suspicion	on suspicion

Table 15: Recommended investigation scope in consolidated soils/rocks

Test	Parameter	Symbol	Unit	Cat 1	Cat 2
Classification	Mineralogy, abrasiveness	-	-	x	x
	Unconfined Compressive strength (UCS test or point load test)	φ C	MN/m^2	x	x
	Unconfined compressive strength	UCS	MN/m^2	x	x
	Compressive strength, point load strength	Is50	MN/m^2	x	x
	Shear strength, angle of internal friction	φ	°	-	x
	Shear strength, cohesion	c	kN/m^2	-	x
	(Brazilian test, indirect determination of tensile strength)	Θz	MN/m^2	-	x
	Joint structure/joint opening	RQD	-	x	x
	Bulk density	ρ	kN/m^2	-	x
	Water content, dry density	w, ρ	%, kN/m^2	-	x
	Overburden pressure	-	kN/m^2	-	x
	Description of layer boundaries	-	-	x	x
Permeability	Rock mass permeability	k	m/s	-	x
	Pore water pressure	u	kPa	-	x
	Hydraulic gradient	i	‰	-	x
Geochemistry	Salt content	-	‰	-	x

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