

# HORIZONTAL DIRECTIONAL DRILLING PULL FORCE AND SOIL FRACTURING

## INTRODUCTION:

Horizontal Directional Drilling (HDD) is a method of installing underground pipelines, cables and service conduit through trenchless methods. It involves the use of a directional drilling machine, and associated attachments, to accurately drill along the chosen bore path and back ream the required pipe.

Directional drilling is a three stage process:

1. Drilling a small diameter pilot hole;
2. Reaming the pilot hole and enlarge it to a size sufficient to safely install the lines;
3. Pullback of the pipe within the pre-reamed hole.

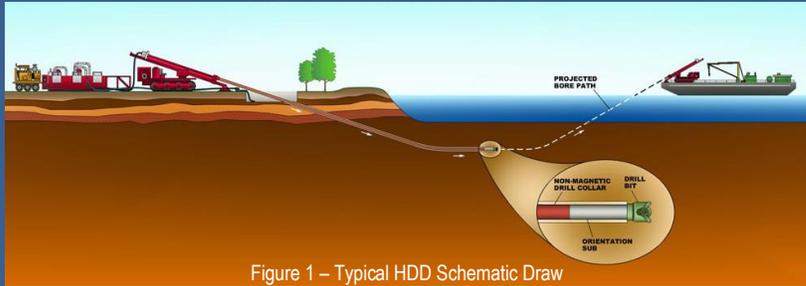


Figure 1 – Typical HDD Schematic Draw

## DESCRIPTION OF THE ANALYSIS:

Determination of the pull forces required for the placement of steel pipes in HDD projects based on the large deflection beam theory.

The method discretizes bore profile, and the tensile force increment along each segment is calculated by a set of equations taking into account:

- Frictional force between the pipe and bore surface in straight and curved sections;
- Pipe buoyant weight and mud drag between the pipe's outer surface and the drilling mud;
- Pipe bending stiffness reflects the excess frictional force developed between the pipe surface and the bore wall due to the effort required to fit a straight pipe segment into a curved bore;
- The capstan effect takes into account the increased bearing pressure caused by the pipe pulled against the inside surface of the bend.

In addition the stress check calculation for installation, hydrotest and incidental operating conditions (in accordance with ISO 13623 and DNVGL-ST-101).

## FINDINGS:

Incremental pull forces at each section and the relevant graphic.

Results shows the calculated pull forces and the correspondent forces increased by the safety factor.

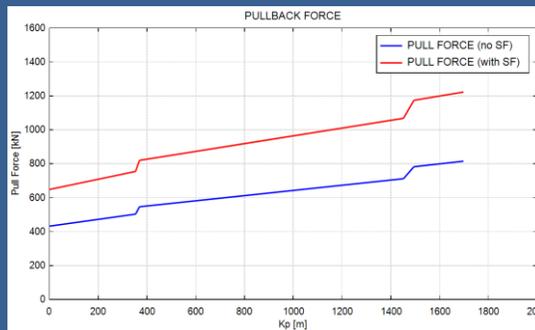


Figure 2 - Pull Force Vs KP Chart

## FRACTURING PROBLEMS:

The drilling mud is pumped from the drill bit under pressure during HDD operations. However, high drilling fluid pressures can cause inadvertent mud return or mud loss to the ground surface either as a result of tensile failure (frac-out) or unconfined shear failure (blowout) of the soil surrounding the borehole depending on the soil types, strength, and the initial stresses.

Legitimate concerns arise as a result of the pressurized fluid during horizontal directional drilling and the consequences of borehole collapse, mud loss or mud return through hydro-fracture or blowout failure.

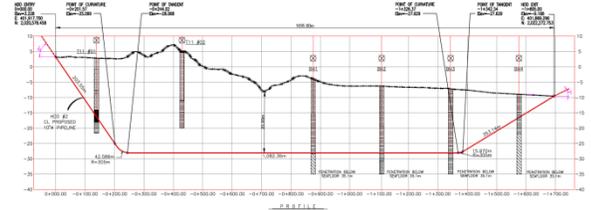


Figure 3 - Typical HDD Alignment Sheet profile

## DESCRIPTION OF THE ANALYSIS:

The analysis use the most common method to predict the hydro-fracture pressure for use in HDD.

This method compare:

- **Maximum Annular Pressure:** The drilling pressure of the mud in the annulus space assuming drilling conditions;
- **Limiting Mud Pressure:** The strength of the soil formation in the vicinity of the pipeline horizon provides resistance to annular pressure developed during the drilling process.

## FINDINGS:

The analysis provides a graphic with the variation of annulus pressure and limiting pressure along the HDD profile.

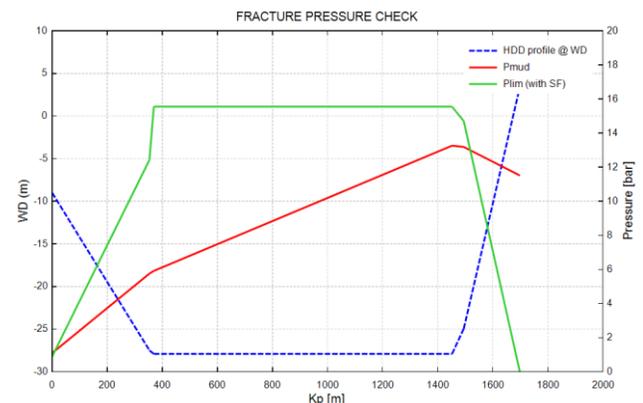


Figure 3 – Annular Vs Limiting Pressure, Elevation and Longitudinal KP Chart

PULL FORCE

SOIL FRACTURING

