



HERRENKNECHT



Tunnelling Systems

SLURRY MICROTUNNELLING METHODS AND HDD: ALTERNATIVES AND COMPLEMENTS

- › Jeremy Stenslie
- › Herrenknecht Tunnelling Systems USA



HERRENKNECHT IN GERMANY

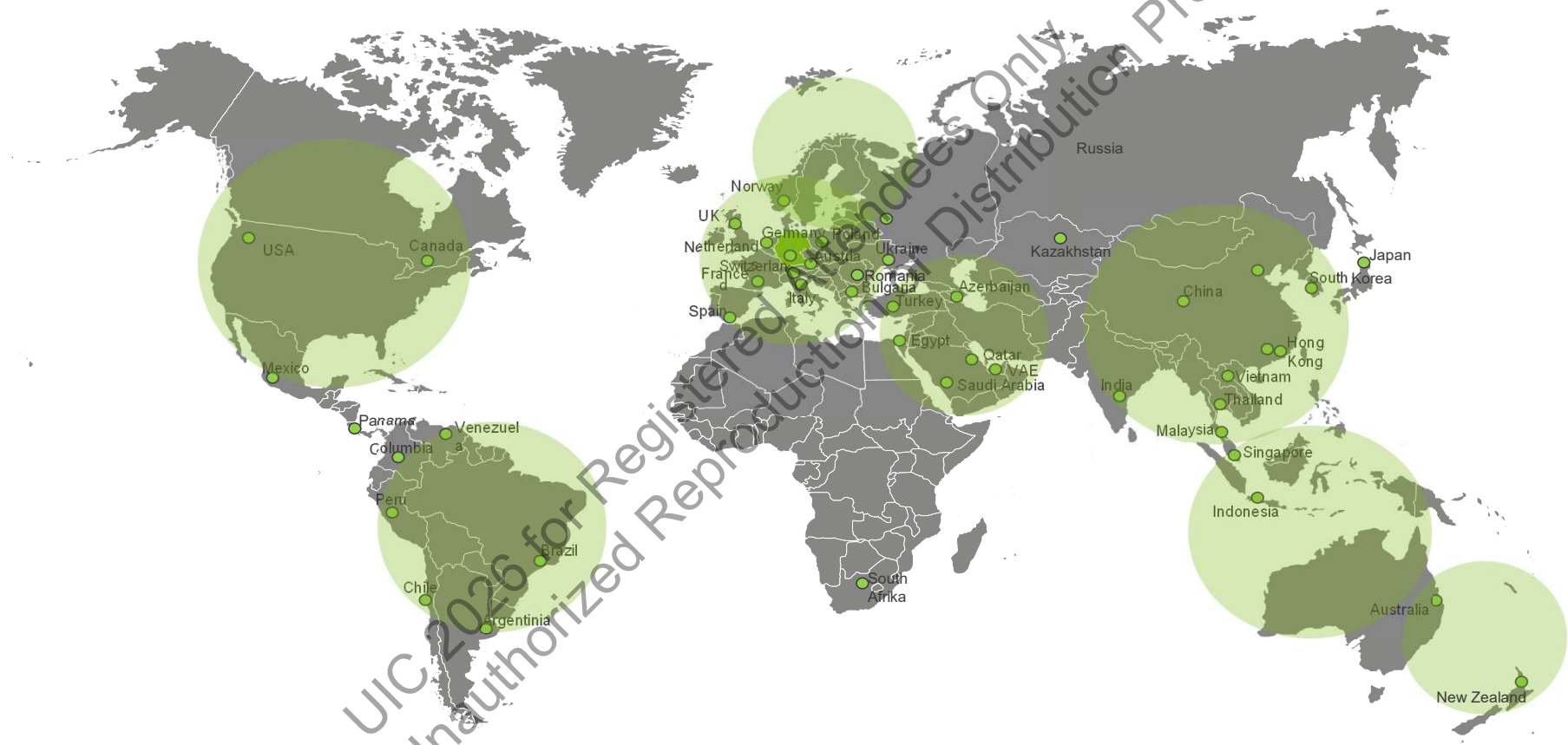
- › Strongly rooted in the location of Schwanau and the surrounding region
- › Around 2,400 employees work in Schwanau and Kehl, Germany
- › Our long-term and sustainable thinking is reflected in our support of education, environment and society

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WHY GOING TRENCHLESS?

- › Less emissions and impact on life on surface
- › No groundwater lowering needed
- › Lower settlement risk for roads and buildings
- › Better tunnel quality
- › Only way to cross rivers, traffic ways and buildings

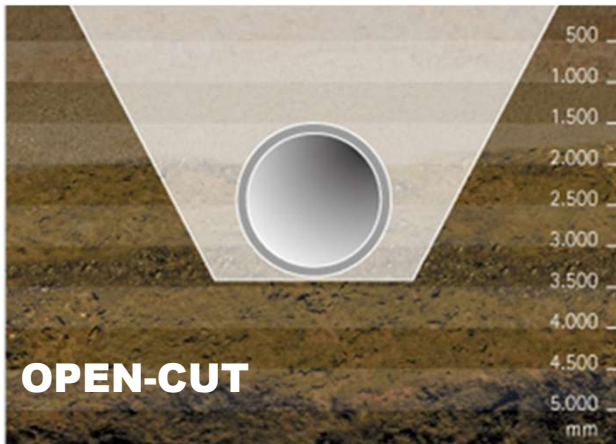


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OPEN-CUT VS TRENCHLESS CONSTRUCTION



OPEN-CUT

- › Surface intervention / Earth movement
- › Recultivation necessary
- › Operation of machinery
- › Construction time & costs



TRENCHLESS

- › Installation length vs. diameter
- › No surface intervention
- › Min. earth movement
- › Min. recultivation

Criteria

- › Protected areas
- › Crossing infrastructures
- › Compliance with distances
- › Construction time
- › Construction costs
- › Capacities on the market

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HERRENKNECHT UTILITY TUNNELLING



	HDD	E-Power Pipe®	Direct Pipe®	Pipe Jacking
Installation of cable / casing or steel pipeline	 <p>multi-stage Cable bundle or steel casing/pipeline</p>	 <p>two-stage HDPE single casings or bundle, steel casing/pipeline</p>	 <p>one-step steel casing/pipeline</p>	 <p>Indirect Cables/pipeline in tunnel</p>
Diameter	10" – 60"	10" – 28" < 36" with backreaming	28" – 60"	10" – 160"
Max. installation length	16,400 ft	6,500 ft	6,500 ft	6,500 ft +
Min. installation depth	10-15 x Ø Pipe (OD)	1.5 m (~5ft)	3 x Ø Pipe (OD)	2-3 x Ø Tunnel (OD)
Geology	Cohesive soil	All rock <30 MPa (4,000 psi) (temp. 150 MPa)	All rock <150 Mpa (22,000 psi)	All rock <400 MPa (58,000 psi)

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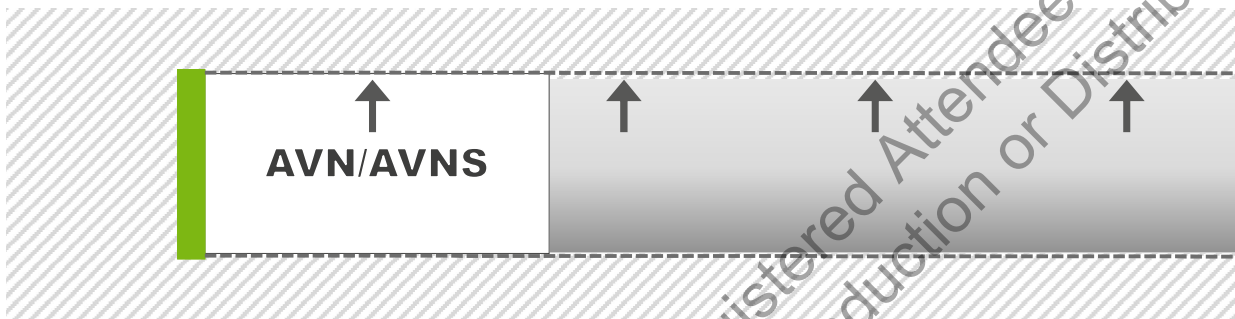
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MICROTUNNELLING VS. HDD BOREHOLE SUPPORT

HERRENKNECHT

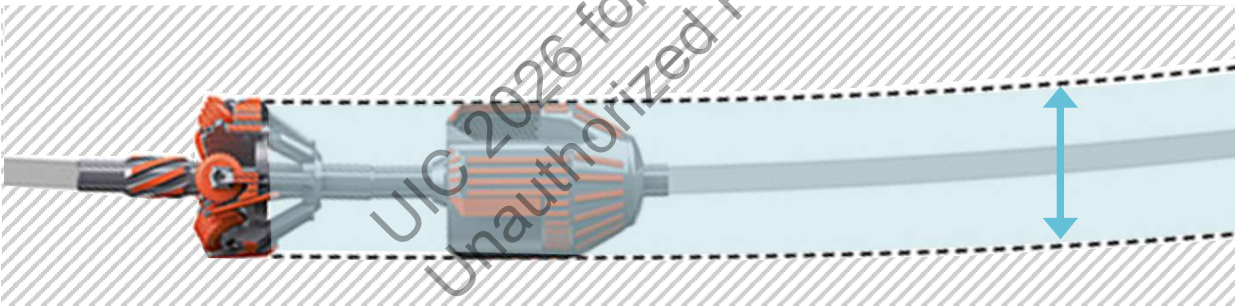
MICROTUNNELLING



Mechanical borehole support

By MTBM and jacking pipes;
During the overall installation
process

HORIZONTAL DIRECTIONAL DRILLING



Hydraulic borehole support

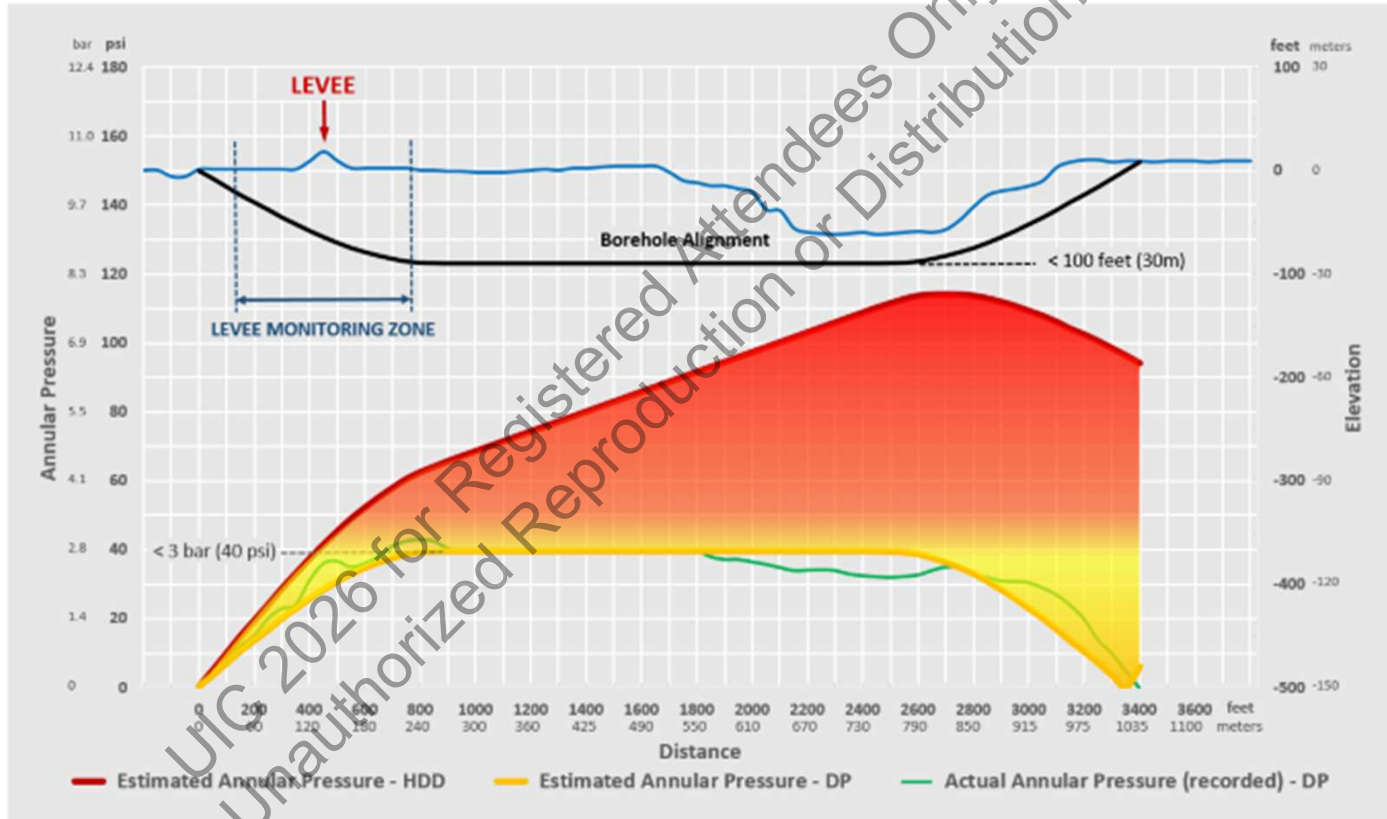
With bentonite suspension;
from reaming process until final
product pipe pullin

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DRILLING PROFILE

HDD VS MICROTUNNELING



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SLURRY MICROTUNNELLING METHODS WITH CONSTANT BOREHOLE SUPPORT

PIPE JACKING



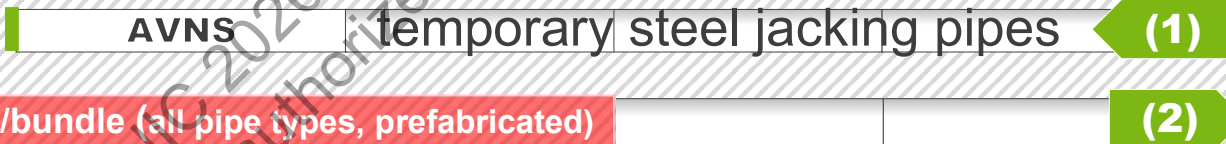
Jacking frame
compact jacking frame or main jacking station

DIRECT PIPE



Pipe Thruster
with clamping unit, tested for various coatings

E-POWER PIPE



Rack & Pinion Jacking frame
pushforce pilot bore (1), pullforce pipe pullin (2)

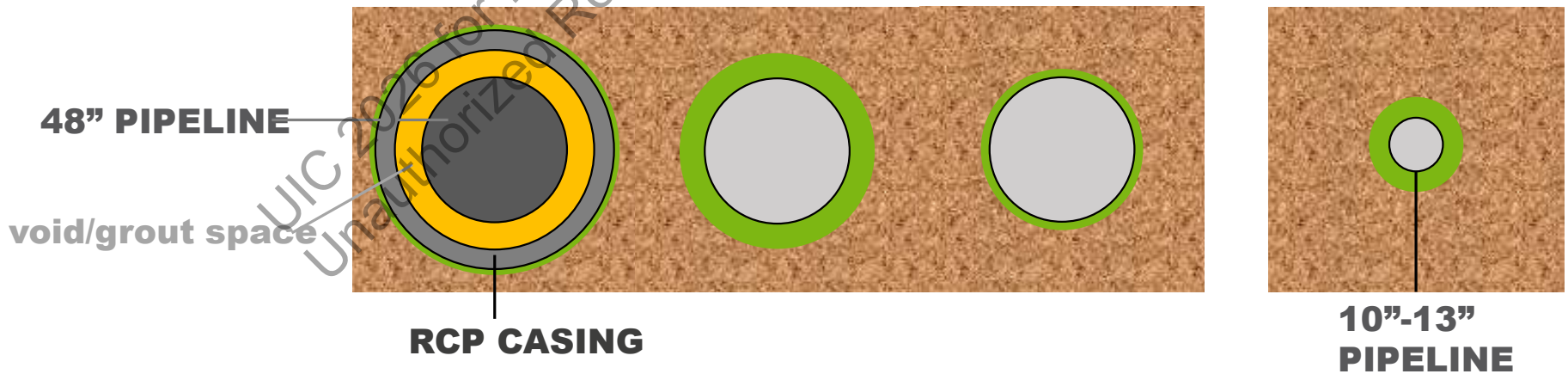
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BOREHOLE DIAMETER

48" PIPELINE INSTALLATION	PIPE JACKING (RCP CONCRETE PIPE)	HDD	DIRECT PIPE®	E-POWERPIPE® 11" EXTRAPOLATED TO 48"
Usual Size of Overcut in Relation to Pipeline Size	65 %	30 %	< 10%	45 % > 15 %
Borehole Diameter	~ 2,0 m (79 in)	~ 1,6 m (63 in)	~ 1,3 m (51 in)	~ 0,5 m (20 in) ~ 1,45 m (57 in)
Excavation Volume (per meter)	~ 3,2 m ³ (113 cu.ft)	~ 2,1 m ³ (74 cu.ft)	~ 1,4 m ³ (49 cu.ft)	~ 0,2 m³ (7 cu.ft) ~ 1,6 m ³ (56 cu.ft)



UTILITY TUNNELLING

HORIZONTAL DIRECTIONAL DRILLING



MODERN HDD JOBSITE



QUIET



SUSTAINABLE



CLEAN



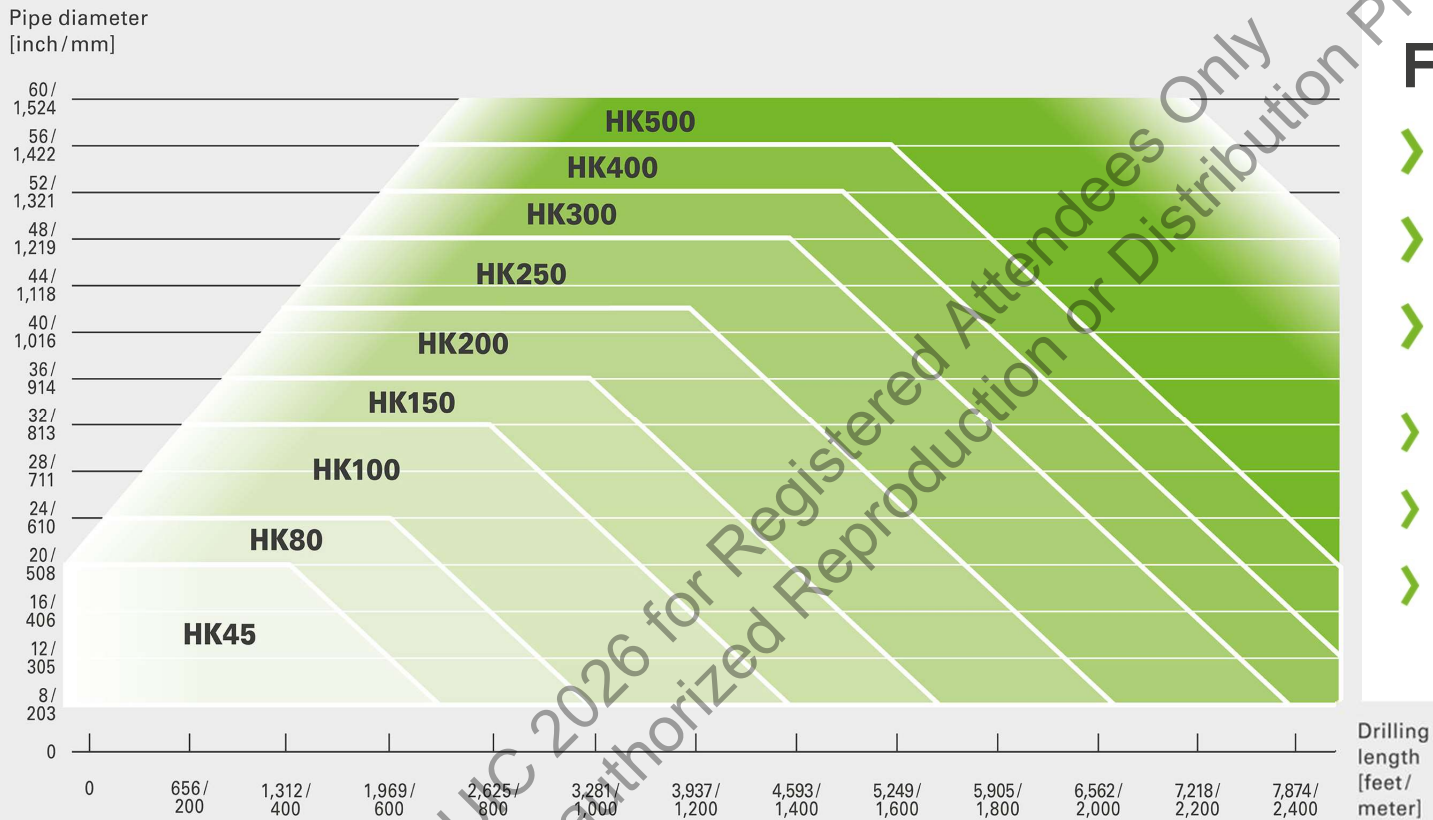
EFFICIENT

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HDD RIGS AND THEIR SELECTION



Factors for rig size:

- › Geologie
- › Length
- › Diameter
- › stability of product pipe
- › limits of drill pipe
- › limits of tooling

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RIG TYPES STANDARD

Compact Rigs **CK**

Trailer Rigs **T**

Modular Rigs **M**



Crawler Rigs **C**

Frame Rigs **F**



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UTILITY TUNNELLING

DIRECT PIPE



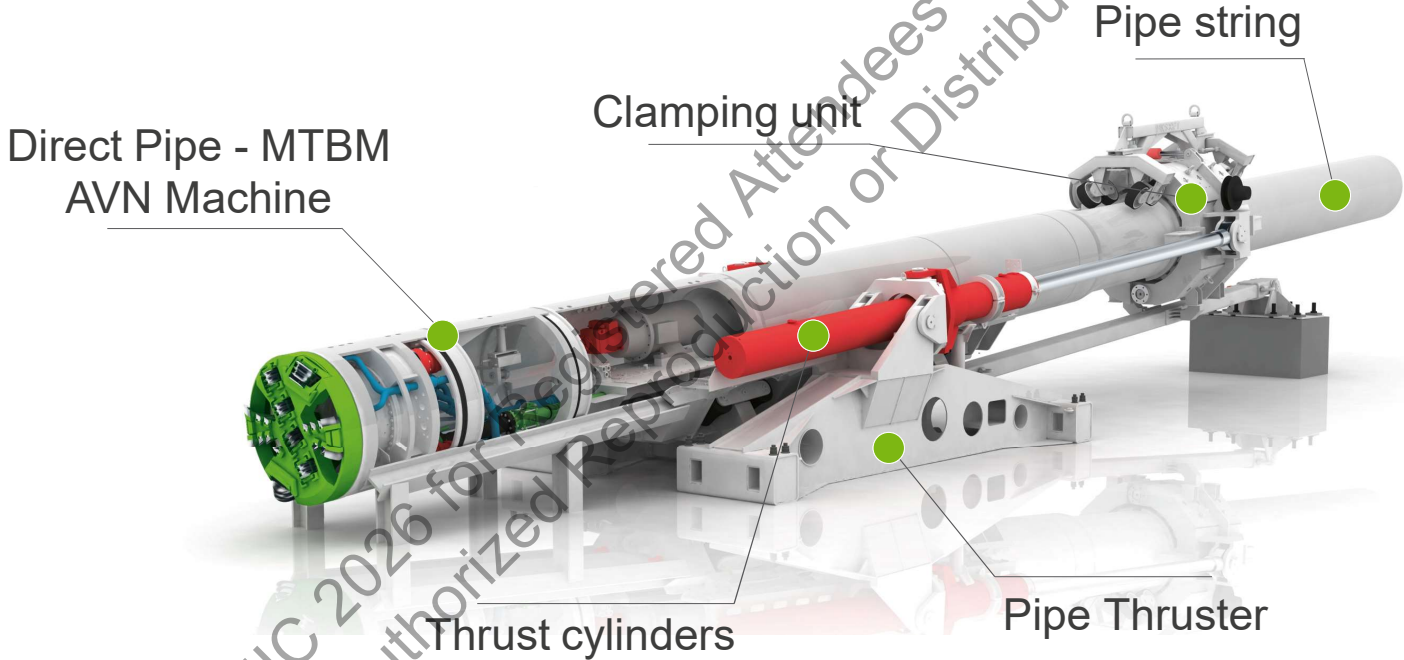
DIRECT PIPE® TECHNOLOGY

- › one-pass installation
- › min. frac out risk | borehole supported
- › high accuracy

24" up to 60" steel pipeline installations



MTBM AND PIPE THRUSTER AS DIRECT PIPE® KEY COMPONENTS



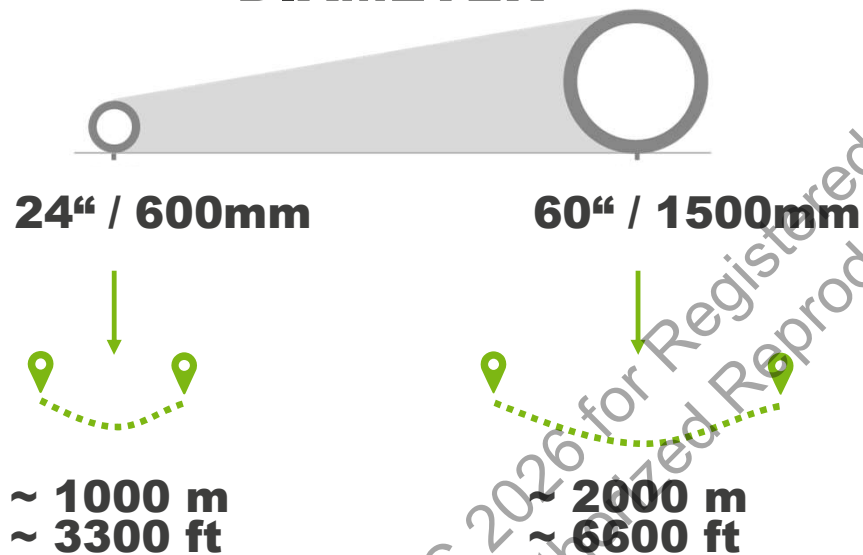
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DIRECT PIPE® APPLICATION RANGE

DIAMETER



Safe & Fast

- › on-surface or near-surface launch & exit pits
- › high advance rates

› Flexible

- › almost all conditions up to 150 MPa (21750 psi)

› Precise

- › guided & controlled drilling, incl. spatial curves and uphill/downhill elevation changes

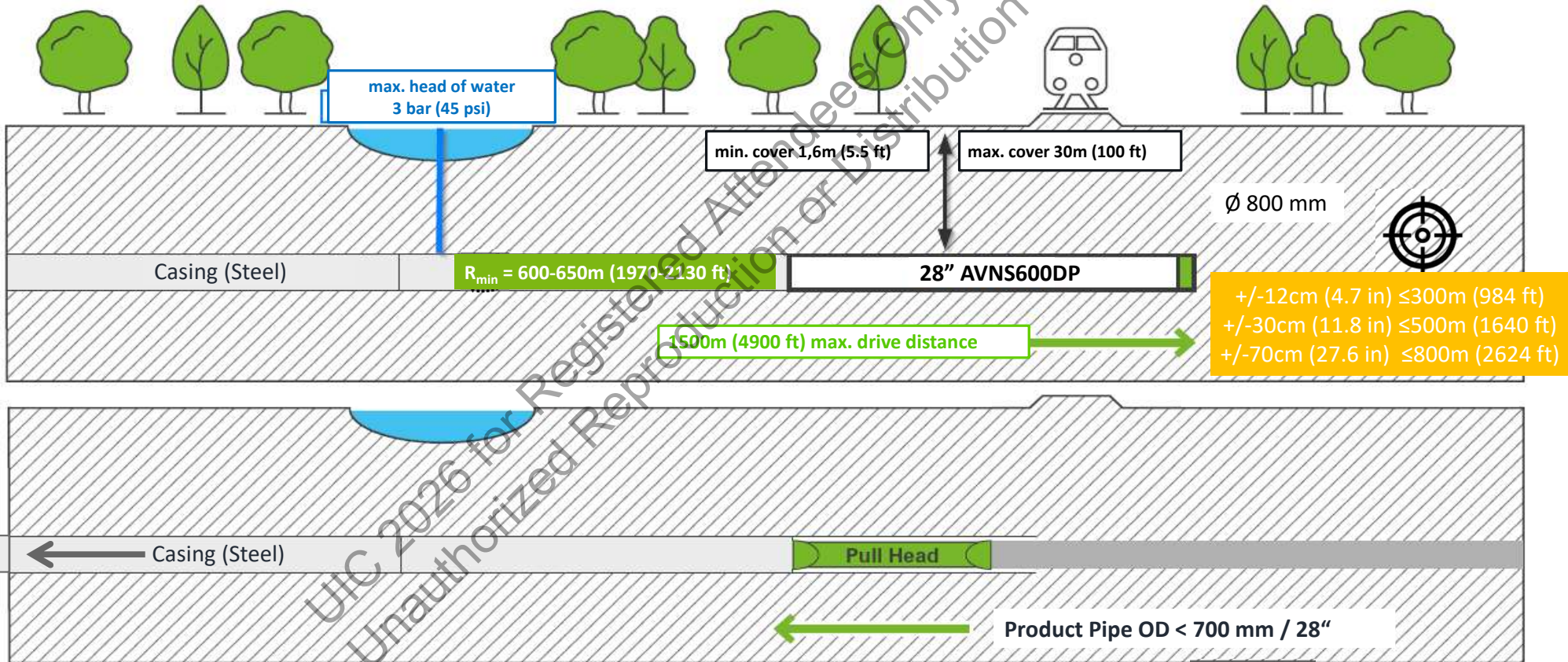
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Direct Pipe®

Instead of one-pass, single-step performing multi-step installations.



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DIRECT PIPE® SOLUTIONS FOR ALL GEOLOGIES

Pipeline Diameter	Direct Pipe® System	Drilling Distance	Geology							
			Clay	Sand < 2mm	Gravel < 63mm	Cobbles < 256mm	Boulders > 256mm	Rock < 100MPa	Hard Rock < 200MPa	
24"	AVNS 500	500 – 1,000 m* 1,640 – 3,280 ft*	AVNS-DP			AVNS-HR				
28"	AVNS 600	600 – 1,000 m* 1,969 – 3,280 ft*	AVNS-DP			AVNS-HR				
32"	AVNS 700	700 – 1,000 m* 2,297 – 3,280 ft*	AVNS-DP				AVNS-HR			
36"	AVN 800B	800 – 1,000 m* 2,625 – 3,280 ft*	AVN-DP					AVN-HR		
42"	AVN 800A	1,000 – 1,200 m* 3,280 – 3,937 ft*	AVN-DP						AVN-HR	
48"	AVN 1000	1,500 – 2,000 m 4,921 – 6,562 ft*	AVN-DP							AVN-HR
56"	AVN 1200	1,500 – 2,000 m 4,921 – 6,562 ft*	AVN-DP							
60"	AVN 1200	1,500 – 2,000 m 4,921 – 6,562 ft*	AVN-DP							

onshore vs. offshore
full-wet or full-dry recovery vs. semi-wet/semi-dry recovery

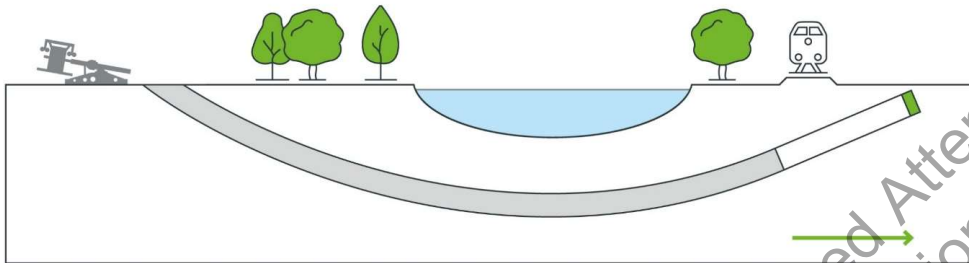
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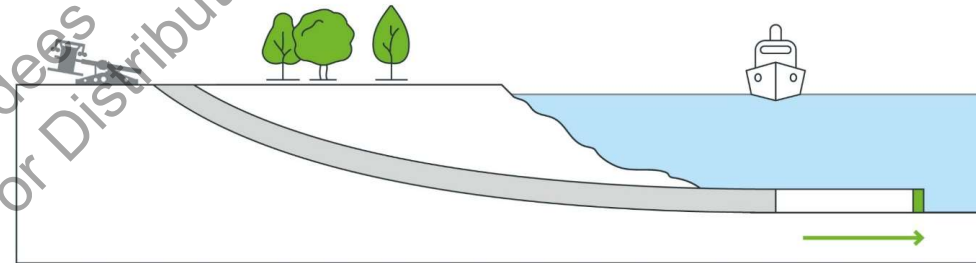


DIRECT PIPE® INSTALLATION OF STEEL PIPE

RIVER CROSSING



SEA OUTFALL



*Simultaneous excavation of borehole and installation of steel pipeline.

- › one-pass / single-step installation
- › permanent borehole support
- › high accuracy
- › minimum risk of inadvertent fluid returns (i.e. frac-outs)
- › less cover resulting in shallower crossings
- › less soil excavation compared to HDD or Pipe Jacking
- › single side entry means land-based operation
- › launch side = pipe side
- › independence from marine conditions at all times
- › minimum fluid release to marine environment

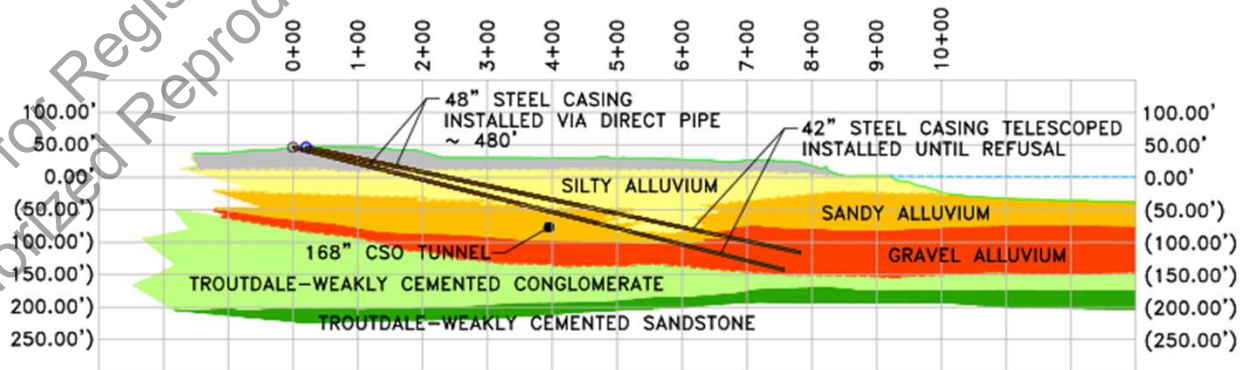
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DIRECT PIPE® AS HDD STARTER CASING

- 60" Casing installed through fill (~160')
- Retractable Cutterhead Using 40' Pipe Joints
- AVN800 DP, 48", HK500PT
- Length (2 installations)
 - Planned: 480'
 - Actual: 795' / 865'



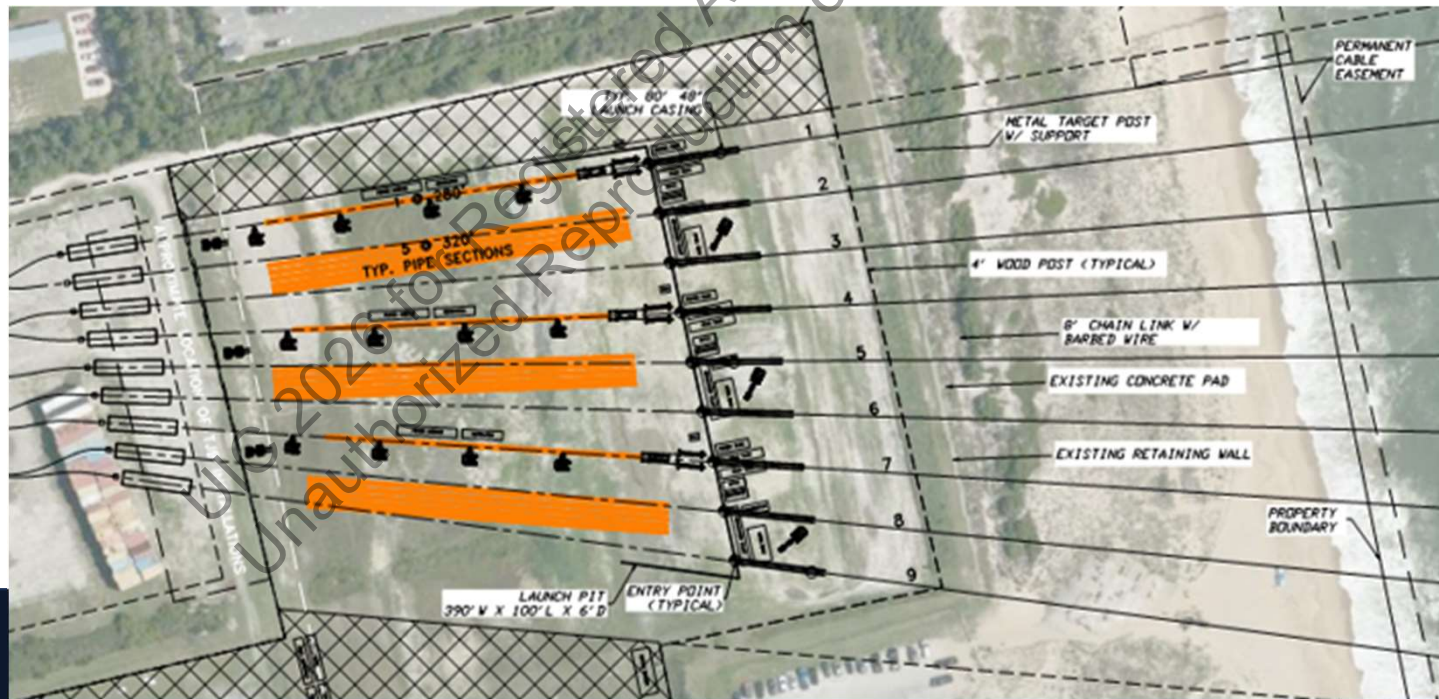
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Coastal Virginia Offshore Wind

- Direct Pipe Scope
 - 9 Installations & Extractions 42" Steel
 - 9 Installations of 36" HDPE Sliplining
 - 9 Marine Retrievals
- Schedule
 - January 2024 – March 2024 (3 of 9 Executed)
 - April 2024 – Military Shutdown – Complete Demob
 - May 2024 – July 2024 (Remaining 6 Executed)



DIRECT PIPE® SHORE APPROACH

- › M-2761M | M-2762M | M-2075M, AVN800DP, HK750PT
- › **42"** casing for cable landfalls
- › Geology: sand, clay
- › Length: **9x 550 m | 1,800 feet**
- › Jet Pump | Remote Recovery Module



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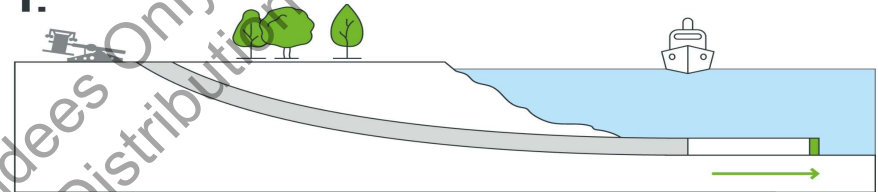


DIRECT PIPE® SHORE APPROACH



INSTALLATION OF HDPE PIPE EXAMPLE SEA OFFFALL

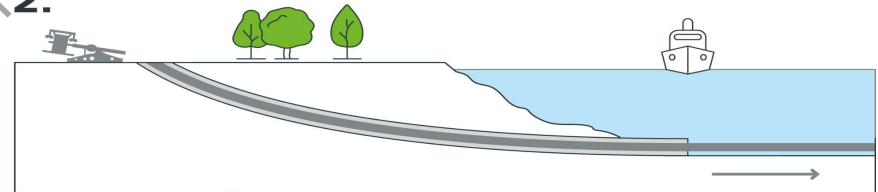
1.



Installation of steel pipe

Simultaneous excavation of borehole and installation of steel pipeline.

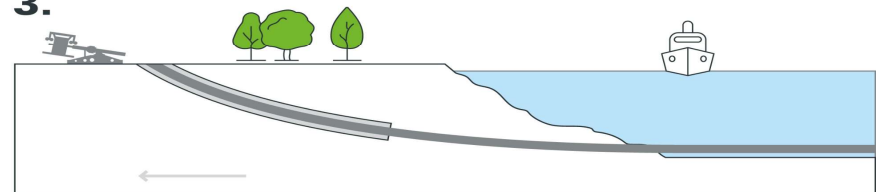
2.



Installation of HDPE pipe

Subsequent insertion of HDPE pipe into the steel pipe.

3.



Retraction of steel pipe with Pipe Thruster.

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ROCK TUNNELING WITH DIRECT PIPE®

- › M-2651M, AVN1200DP, 60", HK750PT
- › Length: 2,300 feet | 800 meters
- › Geology: Shale & Sandstone with **quartz veins up to 195 Mpa (~28,000 psi)**
- › Remote recovery module for offshore recovery of microtunnelling machine



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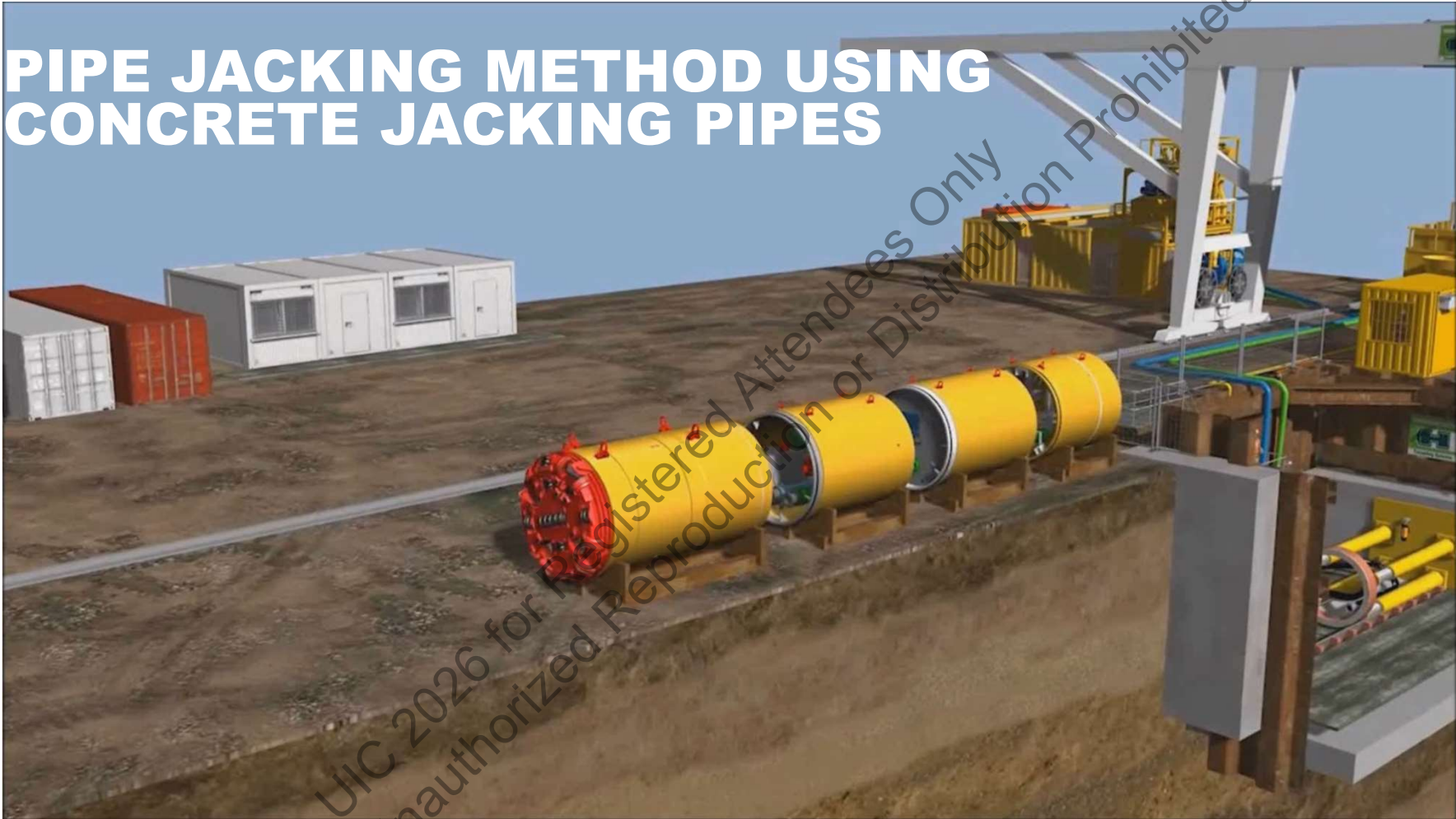


UTILITY TUNNELLING

PIPE JACKING



PIPE JACKING METHOD USING CONCRETE JACKING PIPES



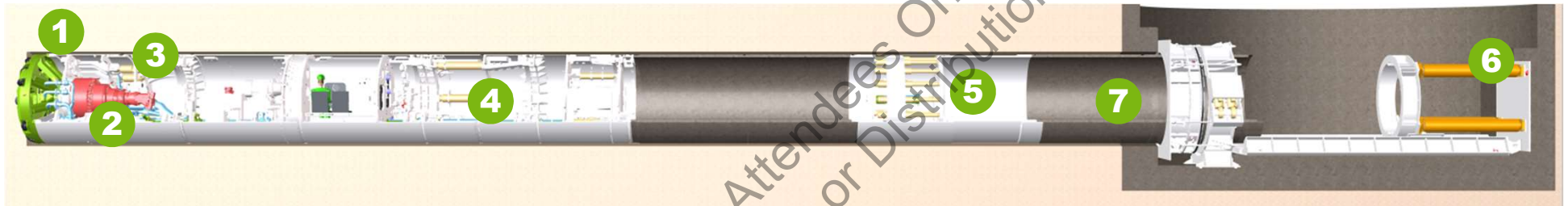
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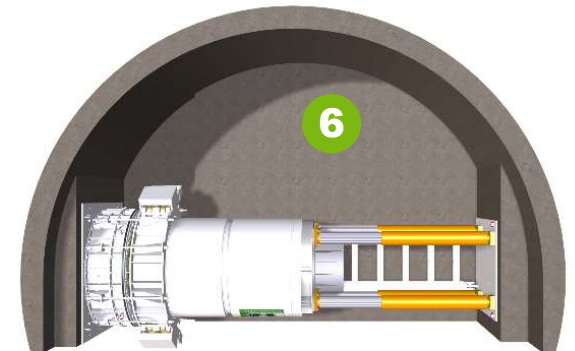
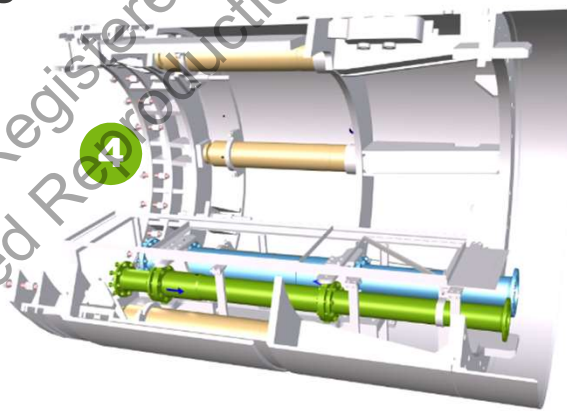
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SLURRY MTBM MACHINE DESIGN



- 1 Cutting wheel and cutter tools
- 2 Main bearing and main drive
- 3 Steering cylinders
- 4 Telecopic station
- 5 Intermediate jacking stations
- 6 Main jacking station
- 7 Jacking pipes

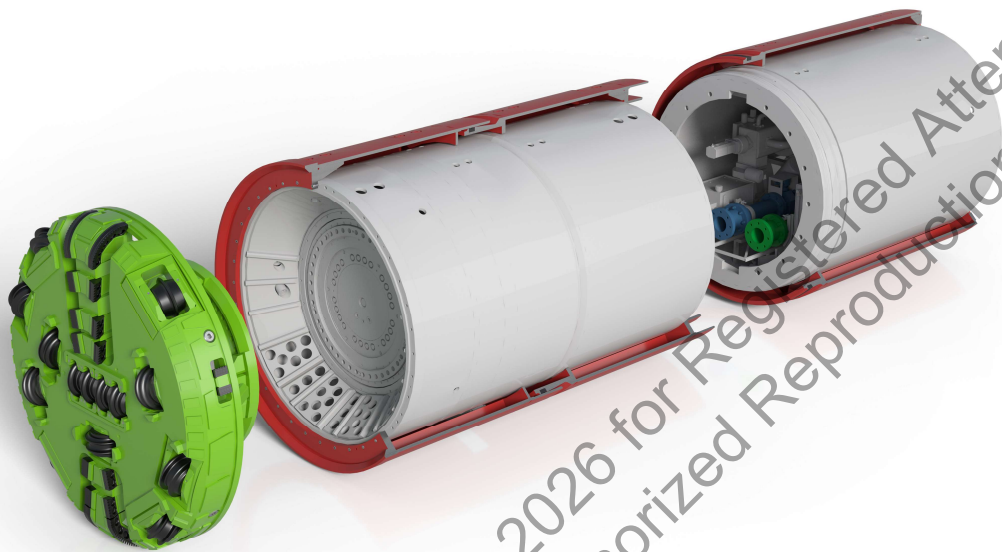


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PIPE JACKING FLEXIBLE DIAMETER WITH EXTENSION KIT



AVN type <i>Exemplary -</i>	Installed Pipe Diameter <i>Standard (mm/in)</i>	Installed Pipe Diameter <i>with extension kit (mm/in)</i>
AVN 600	760 / 29.9	860 / 33.8
AVN800A	960 / 37.8	1,090 / 42.9
AVN800B	1,090 / 42.9	1,280 / 50.4
AVN1000	1,280 / 50.4	1,490 / 58.7
AVN 1200	1,490 / 58.7	1,720 / 67.7
AVN 1600	1,940 / 76.4	2,120 / 83.5
AVN1800	2,120 / 83.5	2,400 / 94.5
AVN 2000	2,400 / 94.5	3,000 / 118.1
AVND 2500	3,000 / 118.1	3,600 / 141.7

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CUTTING WHEEL AND WEAR RESISTANCE

- › Cutting wheel design and tooling adapted to ground conditions
- › Hardfacing for cutter wear protection

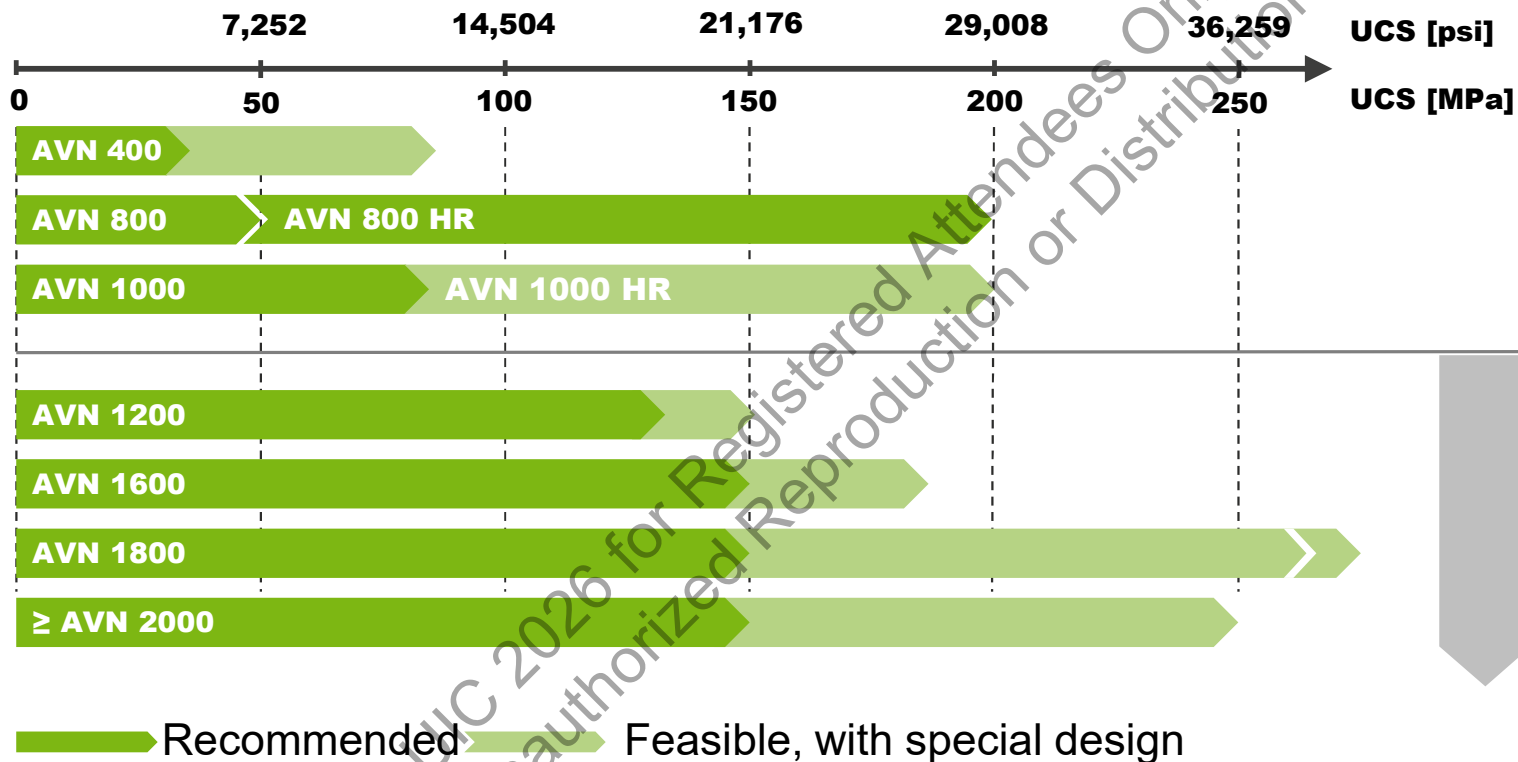


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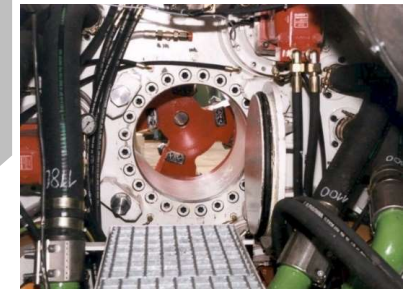
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AVN MACHINE RANGE FOR SLURRY PIPE JACKING IN HARD ROCK



With access
to excavation chamber
for tool change

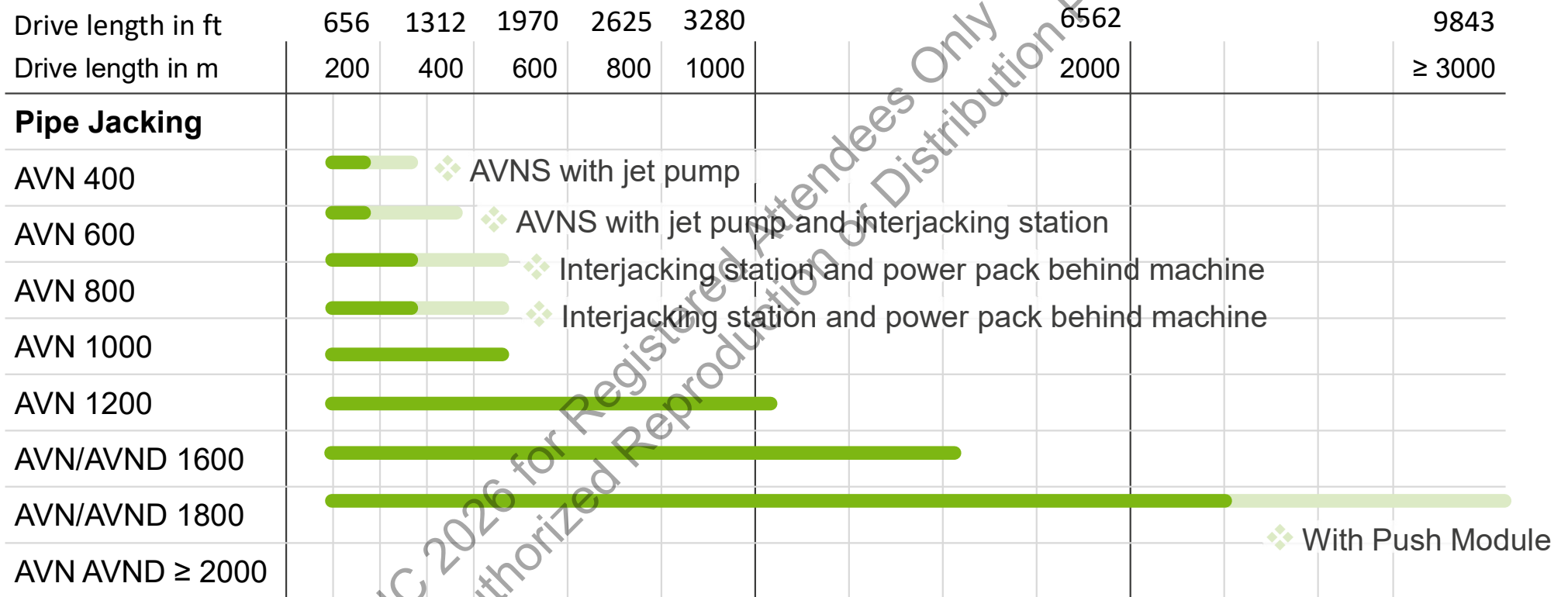


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DIAMETERS AND DRIVE LENGTH



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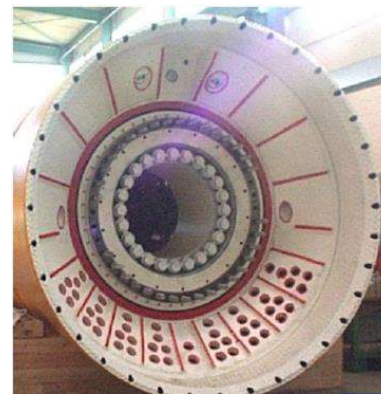
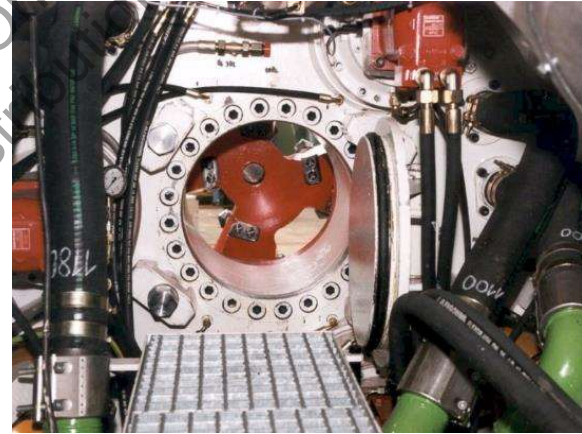
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LONG-DISTANCE PIPE JACKING

- Face access for inspection > AVN1200 | OD ~60"

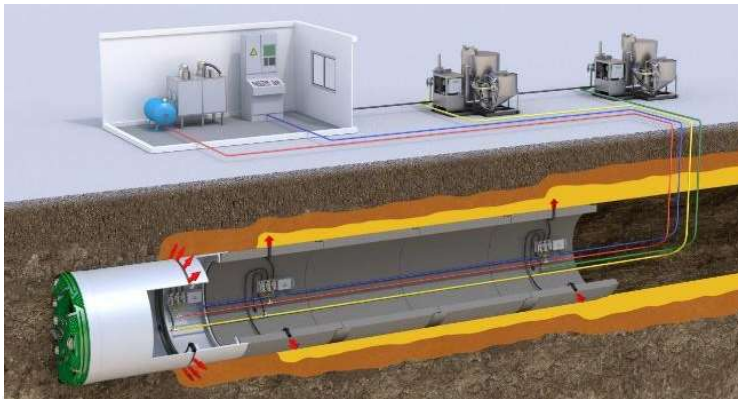


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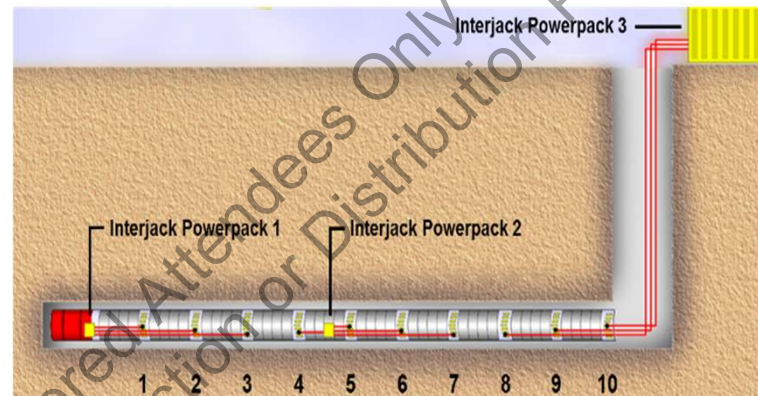


KEEPING JACKING AND FRICTION FORCES LOW



Bentonite lubrication system

- › reduce skin friction
- › adapt to changing geology



Interjacking stations

- › regular intervals
- › reduce jacking forces
- › dismantled when finished



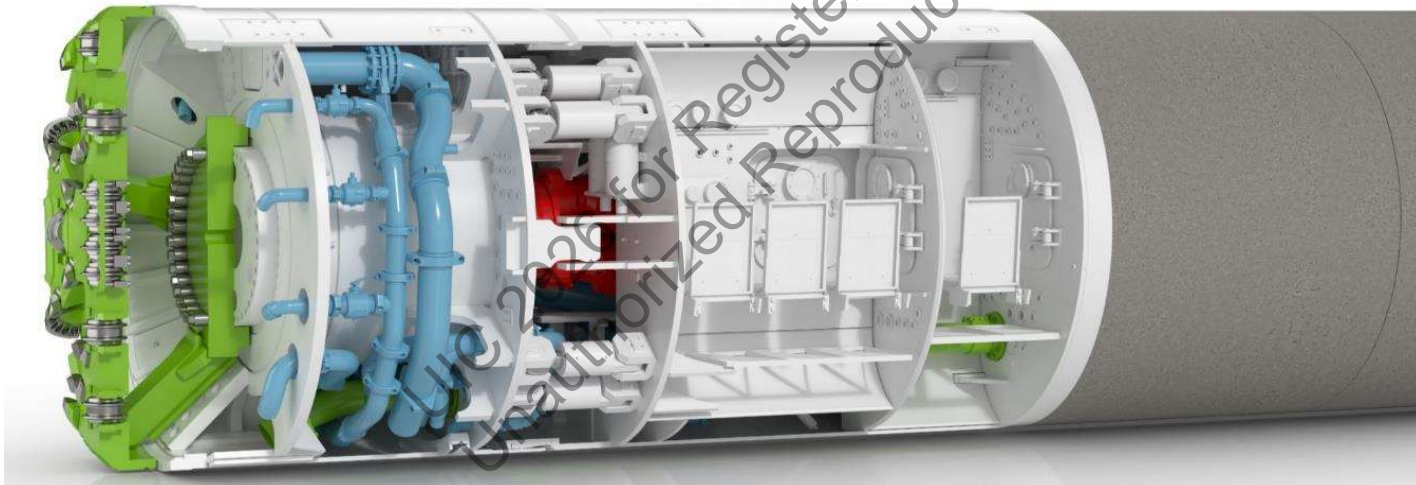
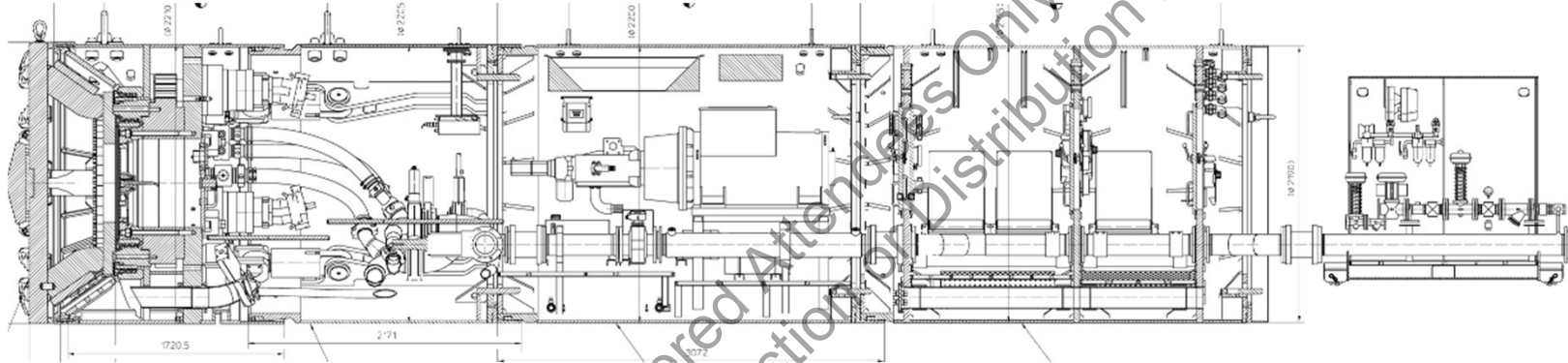
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LONG-DISTANCE PIPE JACKING

- Hyperbaric Interventions > OD ~70"



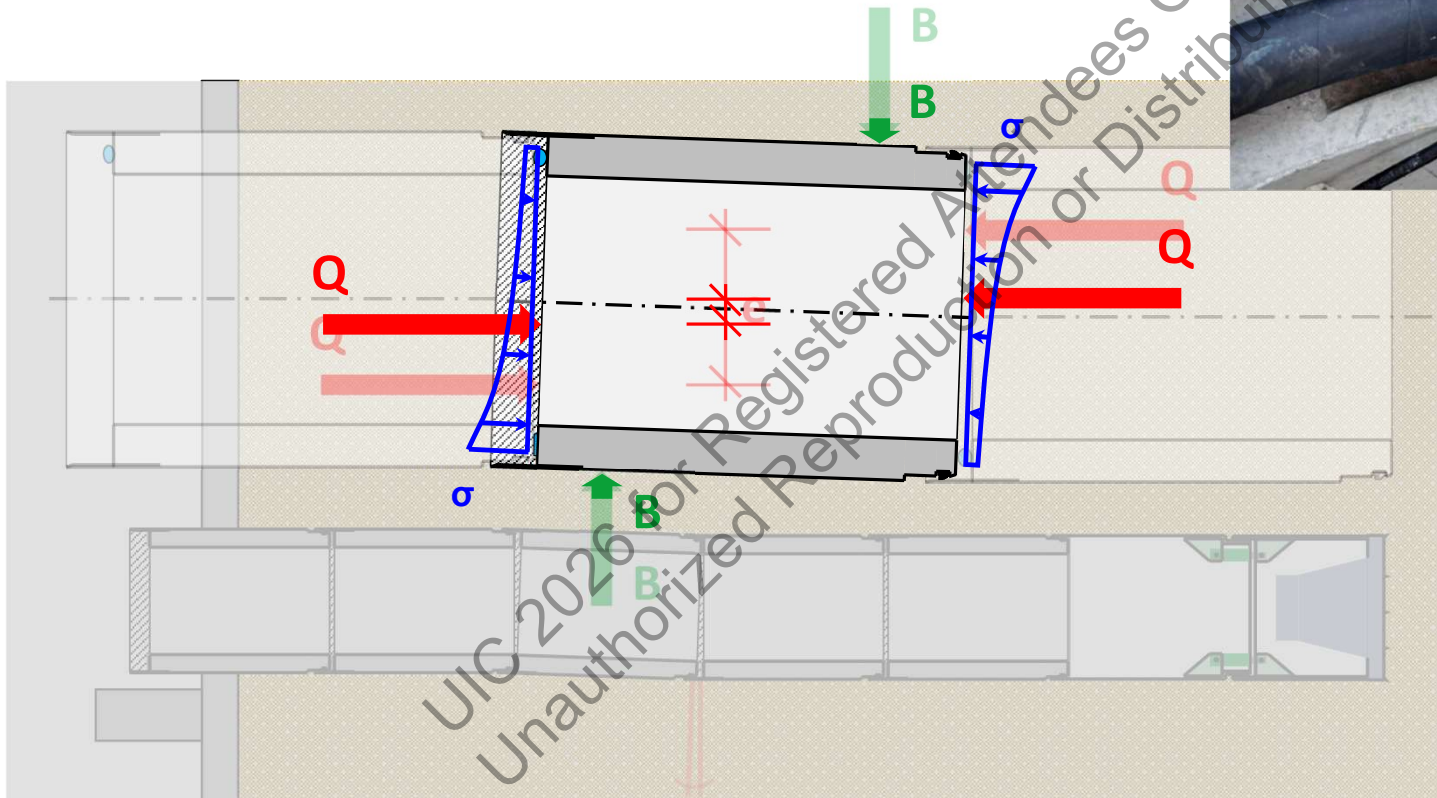
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LONG-DISTANCE PIPE JACKING

Jackcontrol Hydraulic Joint for Curved Drives



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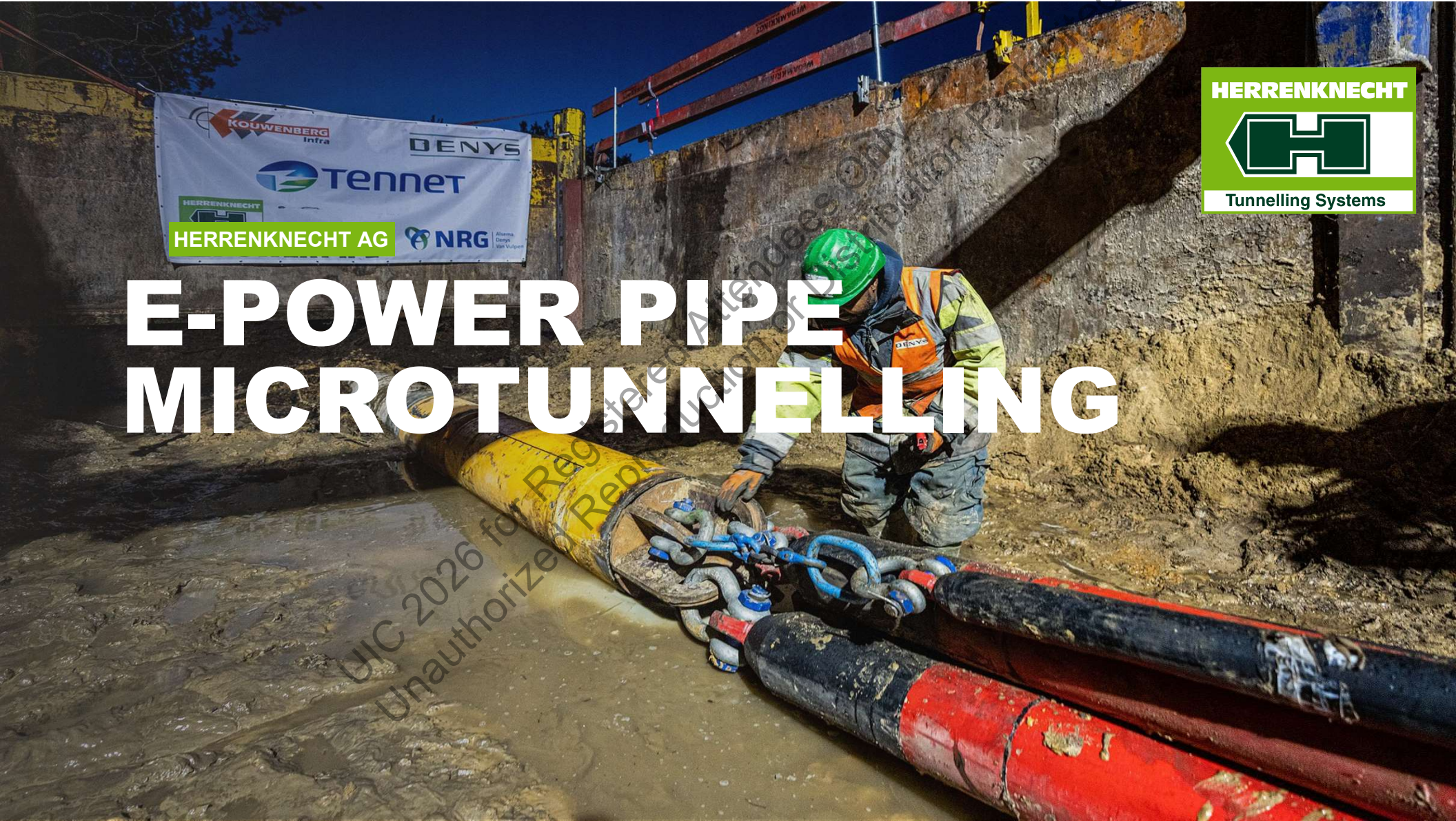


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Tunnelling Systems

E-POWER PIPE MICROTUNNELLING



E-POWER PIPE® JOBSITE INSTALLATION

**JACKING
FRAME**

AVNS 350XB

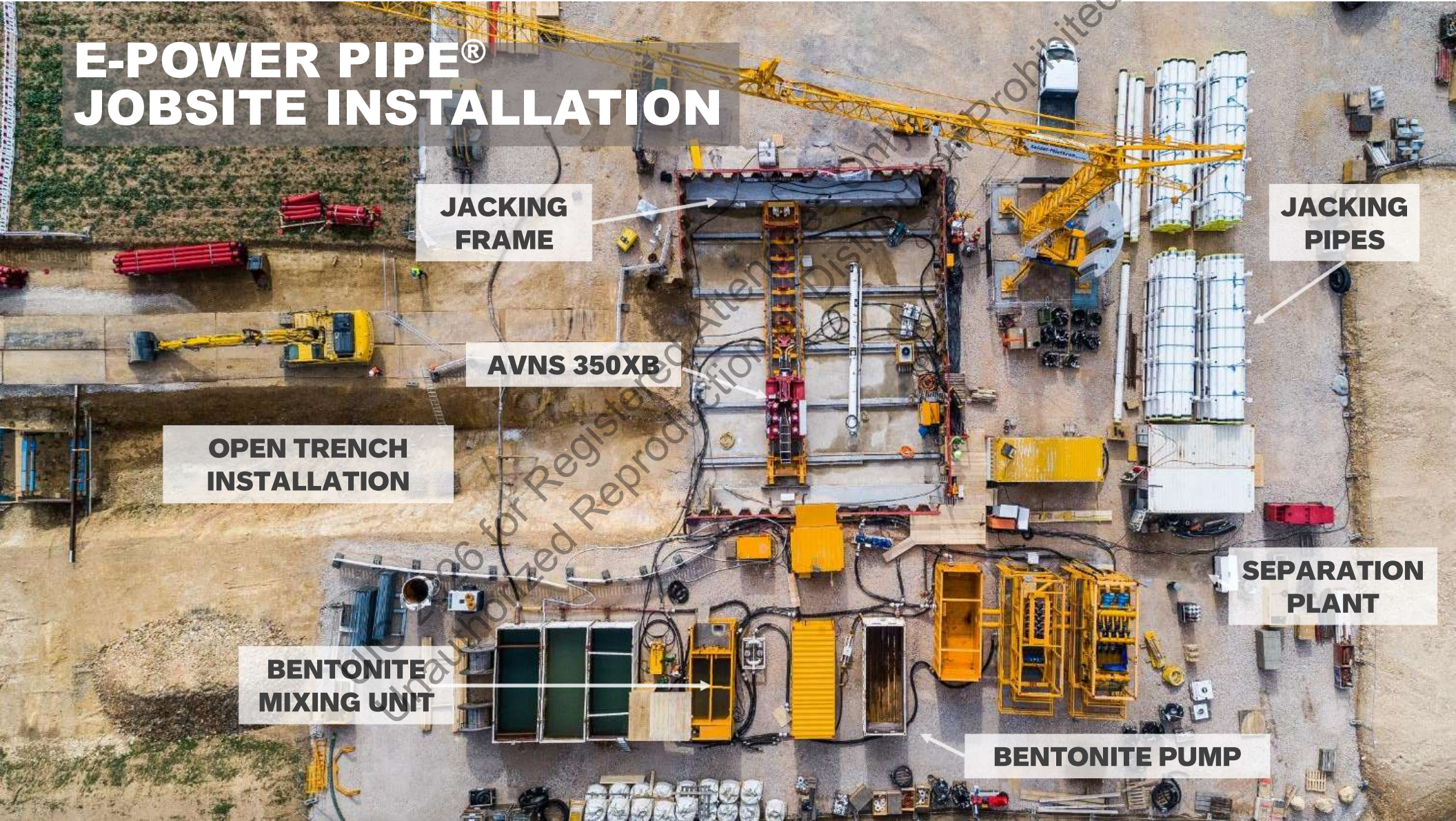
**OPEN TRENCH
INSTALLATION**

**BENTONITE
MIXING UNIT**

BENTONITE PUMP

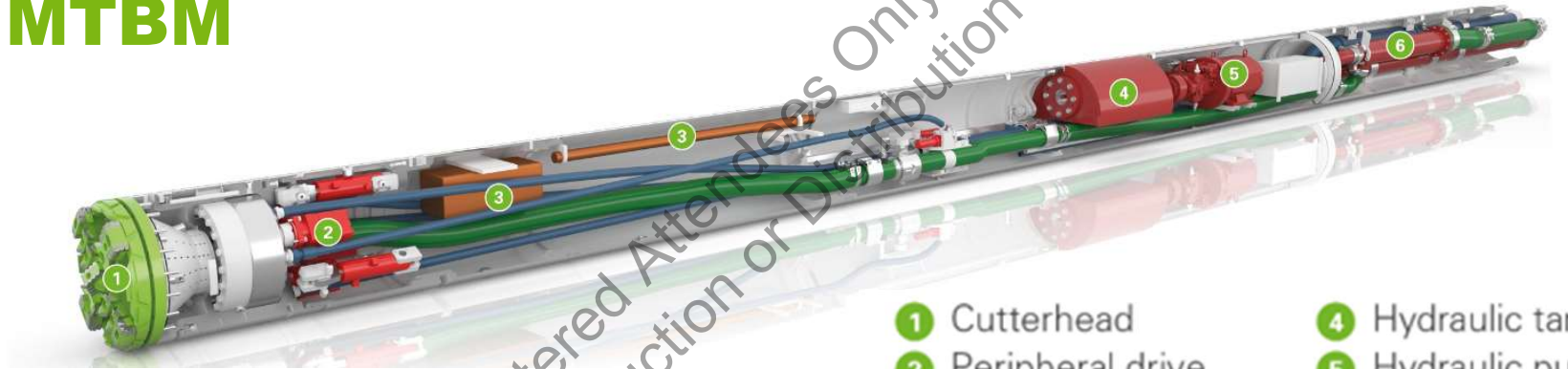
**JACKING
PIPES**

**SEPARATION
PLANT**

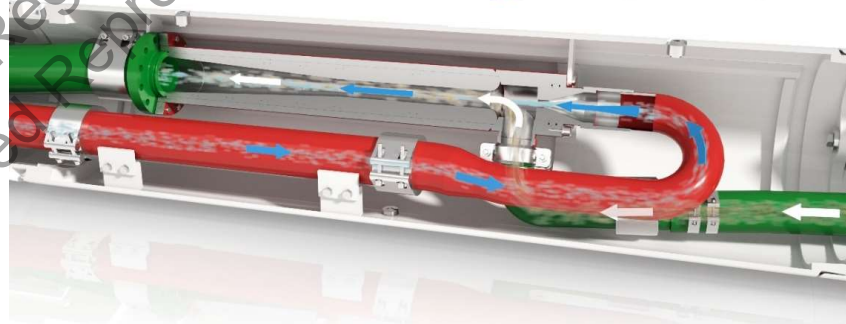


SLURRY MICROTUNNELLING WITH JET PUMP

AVNS MTBM



- 1 Cutterhead
- 2 Peripheral drive
- 3 Navigation system
- 4 Hydraulic tank
- 5 Hydraulic pump
- 6 Jet pump

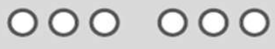
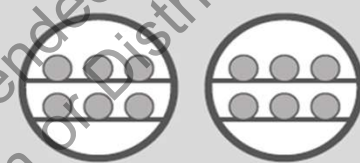



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CLOSING THE TECHNOLOGY GAP FOR UNDERGROUND CABLE INSTALLATION

		SEPARATE INSTALLATION 250 mm			CASING TUNNELS Ø 1,500 mm			CASING TUNNEL Ø 3,000 mm		
										
Technology:	Ø in mm	Shallow	Accuracy	Length > 1,000 m	Shallow	Accuracy	Length > 1,000 m	Shallow	Accuracy	Length > 1,000 m
> Pipe Jacking	250-4,000									
> Segmental Lining	2,300-4,000									
> HDD	250-1,500									
> Direct Pipe®	700-1,500									
> Pipe Express®	900-1,500									

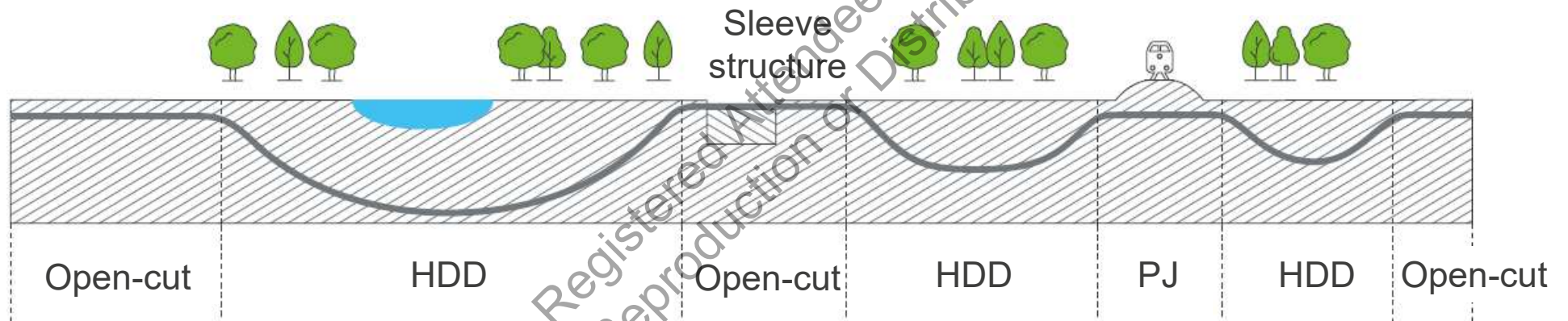
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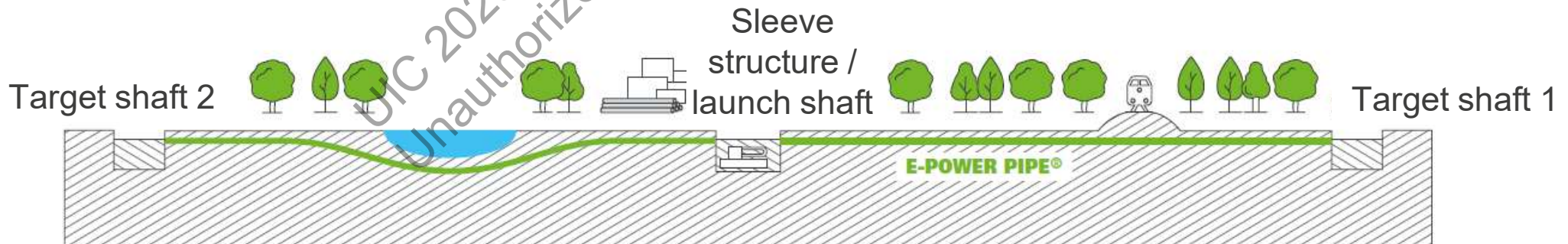


TRENCHLESS OPTIONS FOR UNDERGROUND CABLES

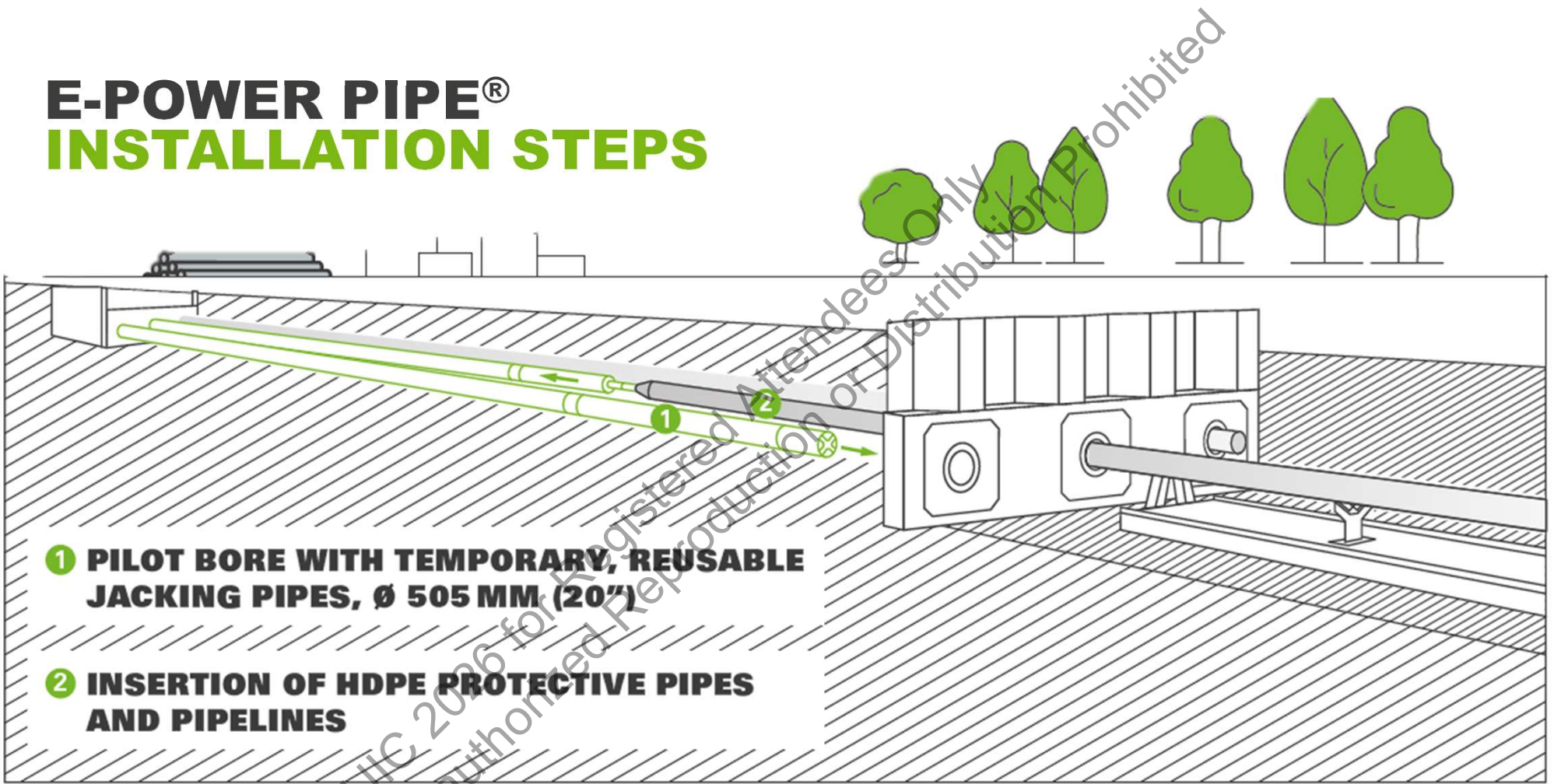
Planning of 3.6 km for cable protective pipe with **METHOD MIX**



Alternative with **E-POWER PIPE**



E-POWER PIPE® INSTALLATION STEPS



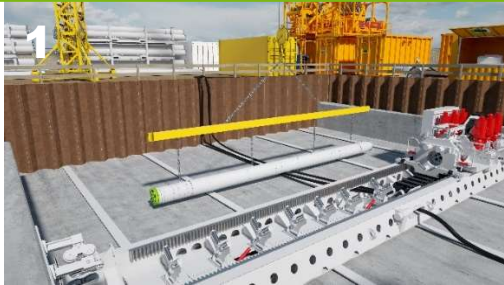
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E-POWER PIPE® INSTALLATION STEPS

I PILOT BORE with AVNS and temporary jacking pipes



1 Installation of jacking frame in launch shaft



2 Soil excavation with AVNS & pipe jacking process



3 Handling & coupling of temporary steel jacking pipes



4 Precise breakthrough at target point

II PULL-IN



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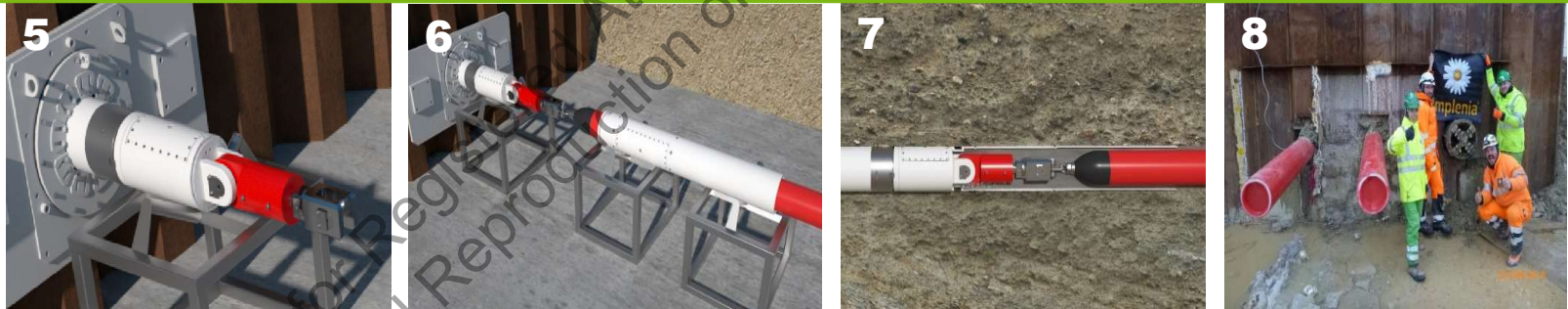


E-POWER PIPE® INSTALLATION STEPS

I PILOT BORE



II PULL-IN of protective pipe or pipeline



Dismantling of AVNS and connection of pullhead

Connection of prefabricated pipe to pullhead

Pullback process by jacking frame in launch shaft

Pulling completed

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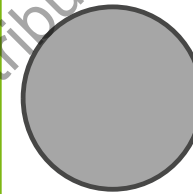
E-POWER PIPE® APPLICATION FIELDS

10"-18"

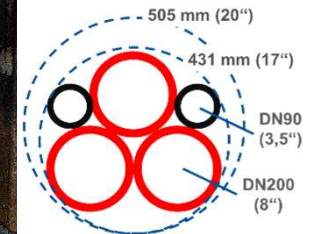


- › Drilling diameter: **505 mm | 20"**
- › Drive length: **≤ 2,000 m | 6,500 ft**
- › Near surface installation: overburden **≥ 1.5 m | 5 ft**
- › Precise, parallel installation: distance **≥ 1.0 m | 3 ft**
- › Grouting of annulus during pullback

SMALL-DIAMETER STEEL PIPELINES



HDPE PROTECTIVE PIPE | SINGLE INSTALLATION OR BUNDLE PULLING IN BOREHOLE



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