PILE RUN RISK ASSESSMENT

Shinaiu Offshore Wind Farm - All WTG Locations + OSS

HYUNDAI ENGINEERING SOLUTIONS INC.

Hammer: MENCK MHU 1900S (249t, 1900kJ) | ISFOG2025-516 | Alm & Hamre (2001)

PRELIMINARY - Rev 00 DRAFT

PROJECT OVERVIEW

Scope

Pile run risk assessment for 26 WTG locations + 1 OSS
Hammer: MENCK MHU 1900S (249t air, 200t submerged, 1900kJ)
Vibratory driving through soft upper layers, then impact driving
CPT-based SRD analysis using Alm & Hamre (2001)
Pile run dynamics using Sun et al. (2022) energy equation
Rate-dependent SRD sensitivity using Vergote et al. (2025, ISFOG2025-319)
Comparison with COWI Design Report LB SRD (Appendix B)
Static pile capacity check using ICP-05 simplified method

Key References

ISFOG2025-516 (Kashichenula et al. - Heerema Marine Contractors)
SU-FOU-SS-RPT-1071 Rev.0 Design Report - Pile Installation
DR_SU-OSS-SS-RPT-1003 Rev.A OSS Drivability Design Report
Menck Operating Manual 0698-13012 Rev.E (MHU 1900S)
Alm & Hamre (2001) - SRD with friction fatigue
Sun et al. (2022) - Energy equation for pile run dynamics
Vergote et al. (2025, ISFOG2025-319) - Rate-dependent SRD
DeJong & Randolph (2012) - Backbone curve for drainage transition

Risk Classification

OK (Green): Vibro depth >4m below pile run end - adequate margin, monitor during installation
CAUTION (Amber): Vibro depth 0-4m below pile run end - close margin, monitoring advised
ATTENTION (Red): Pile run extends below vibro depth - monitoring essential, soft units below vibro
Classification based on comparing vibro hammer target depth vs pile run velocity profile (MEAN SRD)

SRD & PILE RUN METHODS - OVERVIEW

1. Alm & Hamre - Friction Fatigue (AH-FF)

CPT-based SRD method from Alm & Hamre (2001)
Shaft friction degrades exponentially with distance from pile tip (friction fatigue)
Non-Cohesive: K-based lateral stress, Cohesive: CPT sleeve friction as initial value
Generally gives LOWER SRD than AH-NFF because friction is reduced behind the tip

2. Alm & Hamre - No Friction Fatigue (AH-NFF)

Same base formulation as AH-FF but WITHOUT friction fatigue degradation
Full initial shaft friction mobilised along entire pile length
Gives HIGHER SRD than AH-FF - represents an upper estimate of driving resistance
Useful as upper bound check for pile run assessment

3. MEAN SRD

Arithmetic mean of AH-FF and AH-NFF: MEAN = (AH-FF + AH-NFF) / 2
Provides a balanced central estimate of SRD across all methods
Used as the PRIMARY method for risk classification (OK / CAUTION / ATTENTION)

Lower Bound SRD (0.8x) - Used for Pile Run Assessment

Per Design Report Section 8.2: LB = 0.80 x Best Estimate SRD
Pile run risk is assessed against the Lower Bound SRD, representing the most conservative scenario
Risk classification: compares vibro target depth vs depth where pile run velocity reaches zero
OK = vibro >4m below pile run end | CAUTION = 0-4m margin | ATTENTION = pile run extends past vibro

4. Vergote et al. (2025) - Rate-Dependent SRD

ISFOG2025-319 (DEME Offshore / Cathie Group) - newest method
Key innovation: soil resistance CHANGES with pile velocity during a run
Uses backbone curve (DeJong & Randolph 2012) to transition SRD
from drained (CPT rate) to undrained (pile run speed)
In contractive soils (loose sand): undrained resistance is LOWER
-> pile runs FURTHER than conventional methods predict
In dilative soils (dense sand): undrained resistance can INCREASE
-> may arrest pile run sooner (capped by cavitation limit)
Uses AH-FF as the drained base, then scales with velocity
cv from site-specific oedometer tests (clay: 6.3e-8 m^2/s)
State parameter ψ from Robertson (2010) for Q_dr/Q_ud ratio
Shown as SENSITIVITY CHECK alongside the primary methods

5. Energy Balance - Pile Run Velocity

Sun et al. (2022) energy equation: v = sqrt(2 * Ek / m)
Driving force = pile weight + hammer weight - SRD - drag
Velocity computed at each depth step using finite differences

PILE & HAMMER SPECIFICATIONS

Pile Geometry (All Locations)

Outer Diameter: 3.500 m
Wall Thickness: variable 45-70 mm (nominal 70 mm for SRD)
Inner Diameter: 3.360 m
Pile weights (Wp): from Design Report Appendix B
Range: 0.58 MN (WTG-26) to 2.49 MN (WTG-16)
Pile lengths: 14.7 m (WTG-26) to 56.2 m (WTG-01)

MENCK MHU 1900S Hammer

Ram weight: 92 tonnes
Hammer housing: 158 tonnes
Total weight (air): 249 tonnes (2443 kN)
Total weight (submerged): 200 tonnes (1962 kN)
Maximum rated energy: 1900 kJ
Source: Menck OM 0698-13012 Rev.E & adaptation docs

Installation Sequence

Step 1: Vibratory hammer (Cape Holland CV-320-5) drives pile through soft upper layers to vibro target depth
Step 2: Vibro hammer detached, MENCK MHU 1900S impact hammer positioned on pile
Step 3: Impact driving to target embedment depth
Vibro target depths from Design Report Appendix B - ensures pile stability against pile run when impact hammer placed

SRD METHODOLOGY

Alm & Hamre (2001) - AH-FF

With friction fatigue (exponential decay)
Cohesive: fsi = fs_CPT, fres = 0.004*qc*(1-0.0025*qc/sv0')
Non-Cohesive: K = 0.0132*(qc/sv0')*(sv0'/100)^0.13
fsi = K*sv0'*tan(29deg), fres = 0.2*fsi
Shape factor: k = sqrt(qc/sv0')/80
qf = fres + (fsi-fres)*exp(k*(d-z_tip))
LB = 0.80x, UB = 1.25x (per Design Report Sec 8.2)

Alm & Hamre (2001) - AH-NFF

Without friction fatigue
Unit shaft: qf = fsi (full initial friction everywhere)
Same end bearing as AH-FF
Gives HIGHER SRD than AH-FF (no decay)

MEAN = (AH-FF + AH-NFF) / 2
Provides balanced estimate between both methods

Pile Run Dynamics - Sun et al. (2022)

Energy balance: ISFOG2025-516 Eq. 1
0.5*(mp+chi*mh)*(vi^2-v(i-1)^2) = [Wp+xi*Wh-SRD-Fd]*dz
Phase 1: pile only | Phase 2: pile+hammer (xi=0.2 then 1.0)
Pile run when SRD < Wp + W_hammer

Static Capacity (ICP-05 simplified)

Long-term capacity after soil setup
Sand: fs = 0.023*qc*(sv0'/qc)^0.3*tan(29), cap 150 kPa
Clay: fs = fs_CPT (full, no fatigue)
Always higher than SRD (reference line on plots)

RESULTS SUMMARY - ALL LOCATIONS

WTG	Type	Cat.	Length (m)	Weight (t)	Embedment (m)	Vibro Depth (m)	Wp (kN)	W_total (kN)	AH-FF Vmax (m/s)	AH-FF RunEnd (m)	AH-FF Margin (m)	AH-FF Risk	AH-NFF Vmax (m/s)	AH-NFF RunEnd (m)
WTG-01	DP	2	56.2	236.5	52.3	22.0	2320	4282	8.3	18.0	4.0	CAUTION	8.1	17.0
WTG-02	DP	2	46.5	236.5	45.0	17.0	2320	4282	7.7	14.5	2.5	CAUTION	7.6	13.8
WTG-03	DP	2	47.5	183.5	46.0	18.0	1800	3762	5.9	13.2	4.8	OK	5.7	12.0
WTG-04	IP	2	42.0	177.4	40.5	19.0	1740	3702	7.4	16.0	3.0	CAUTION	7.2	15.2
WTG-05	DP	2	53.5	210.0	52.0	17.0	2060	4022	4.8	8.2	8.8	OK	4.7	7.5
WTG-06	IP	2	36.4	152.9	34.9	18.0	1500	3462	3.7	2.8	15.2	OK	3.3	2.8
WTG-07	IP	2	39.5	166.2	37.9	18.0	1630	3592	6.4	13.2	4.8	OK	6.4	12.5
WTG-08	IP	2	37.6	181.4	36.0	30.8	1780	3742	6.0	14.8	16.0	OK	5.9	12.8
WTG-09	IP	1	39.5	176.4	38.0	19.0	1730	3692	6.0	8.0	11.0	OK	6.0	8.0
WTG-10	IP	1	39.6	163.1	38.1	27.0	1600	3562	13.5	2.2	24.8	OK	11.3	2.2
WTG-11	IP	2	26.7	110.1	25.2	15.0	1080	3042	4.7	11.0	4.0	CAUTION	4.6	10.2
WTG-12	IP	2	37.9	156.0	36.4	16.0	1530	3492	3.5	8.2	7.8	OK	3.3	7.2
WTG-13	IP	2	20.9	87.7	17.1	13.0	860	2822	2.6	3.2	9.8	OK	2.6	3.2
WTG-14	IP	3	21.7	90.7	20.2	14.2	890	2852	4.9	10.2	3.9	CAUTION	4.8	9.8
WTG-15	DP	1	53.8	212.0	52.3	27.0	2080	4042	9.7	25.5	1.5	CAUTION	9.6	24.0
WTG-16	DP	1	50.0	253.8	48.5	24.0	2490	4452	9.6	18.5	5.5	OK	9.6	18.0
WTG-17	IP	3	17.7	76.5	16.2	10.2	750	2712	3.6	2.2	8.0	OK	2.4	2.2
WTG-18	IP	2	25.3	104.0	23.8	17.8	1020	2982	4.8	12.8	5.1	OK	4.7	11.5
WTG-19	IP	2	42.0	172.3	40.5	19.0	1690	3652	7.4	19.5	-0.500	ATTENTION	7.3	18.8
WTG-20	IP	2	42.2	174.3	40.7	16.0	1710	3672	4.3	9.0	7.0	OK	4.2	8.0
WTG-21	IP	2	49.2	204.9	47.7	20.0	2010	3972	5.6	12.0	8.0	OK	5.4	10.8
WTG-22	DP	1	51.9	201.8	48.5	24.0	1980	3942	7.6	17.2	6.8	OK	7.4	16.2
WTG-23	IP	1	40.2	170.2	38.7	30.0	1670	3632	9.3	24.5	5.5	OK	9.2	21.2
WTG-24	DP	1	44.4	242.6	42.5	15.0	2380	4342	7.0	14.8	0.200	CAUTION	6.5	14.2
WTG-25	IP	1	35.1	157.0	33.6	17.0	1540	3502	3.5	6.2	10.8	OK	3.3	6.2
WTG-26	IP	3	14.7	59.1	13.2	5.3	580	2542	3.2	4.5	0.800	CAUTION	3.2	4.5
OSS	OSS	0	37.5	226.3	35.5	25.0	2220	4182	7.8	17.8	7.2	OK	7.6	16.8

SUMMARY PLOTS - ALL LOCATIONS

Pile run risk has been assessed at all 26 WTG and 1 OSS locations using multiple

CPT-based SRD methods (Alm & Hamre 2001) and energy-based pile run dynamics (Sun et al. 2022)

The primary mitigation measure is the use of a vibratory hammer (Cape Holland CV-320-5) to

pre-install piles through the soft upper layers. This mitigation is effective at the majority of locations.

Risk classification based on MEAN SRD (vibro depth margin vs pile run end):

21 locations OK | 5 locations CAUTION (WTG-02, -04, -15, -24, -26) | 1 location ATTENTION (WTG-19)

An additional sensitivity analysis using the Vergote et al. (2025) rate-dependent SRD method

confirms that pile run distances could extend 2-5m further in contractive soils due to

transition from drained to undrained conditions at high velocities. This supports the use of

conservative vibro target depths as specified in the Design Report.

Monitoring of penetration rates during installation is recommended at all locations, with enhanced monitoring and geotechnical supervision at CAUTION and ATTENTION locations (compared to the COWI suggest penetration when possible deeper penetration using vibro hammer is suggested as the deeper penetration would increase any residual risk against pile run)

PILE RUN RISK ASSESSMENT - MENCK MHU 1900S (249t, 1900kJ)
Risk based on margin between vibro target depth and pile run end depth

OK (margin > 4m)
CAUTION (margin 0-4m)
ATTENTION (run past vibro)

	AH-FF	AH-NFF	MEAN	VERGOTE
WTG-01 (Vibro: 22.0m)	Vmax=8.3 m/s CAUTION (margin 4.0m)	Vmax=8.1 m/s OK (margin 5.0m)	Vmax=8.2 m/s OK (margin 4.5m)	
WTG-02 (Vibro: 17.0m)	Vmax=7.7 m/s CAUTION (margin 2.5m)	Vmax=7.6 m/s CAUTION (margin 3.2m)	Vmax=7.6 m/s CAUTION (margin 2.8m)	
WTG-03 (Vibro: 18.0m)	Vmax=5.9 m/s OK (margin 4.8m)	Vmax=5.7 m/s OK (margin 6.0m)	Vmax=5.8 m/s OK (margin 5.5m)	Vmax=6.5 m/s OK (margin 4.2m)
WTG-04 (Vibro: 19.0m)	Vmax=7.4 m/s CAUTION (margin 3.0m)	Vmax=7.2 m/s CAUTION (margin 3.8m)	Vmax=7.3 m/s CAUTION (margin 3.5m)	Vmax=7.6 m/s CAUTION (margin 2.5m)
WTG-05 (Vibro: 17.0m)	Vmax=4.8 m/s OK (margin 8.8m)	Vmax=4.7 m/s OK (margin 9.5m)	Vmax=4.7 m/s OK (margin 9.0m)	Vmax=6.3 m/s OK (margin 7.0m)
WTG-06 (Vibro: 18.0m)	Vmax=3.7 m/s OK (margin 15.2m)	Vmax=3.3 m/s OK (margin 15.2m)	Vmax=3.3 m/s OK (margin 15.2m)	Vmax=4.3 m/s OK (margin 9.8m)
WTG-07 (Vibro: 18.0m)	Vmax=6.4 m/s OK (margin 4.8m)	Vmax=6.4 m/s OK (margin 5.5m)	Vmax=6.4 m/s OK (margin 5.2m)	Vmax=6.7 m/s OK (margin 4.2m)
WTG-08 (Vibro: 30.8m)	Vmax=6.0 m/s OK (margin 16.1m)	Vmax=5.9 m/s OK (margin 18.1m)	Vmax=5.9 m/s OK (margin 17.3m)	Vmax=7.5 m/s OK (margin 12.8m)
WTG-09 (Vibro: 19.0m)	Vmax=6.0 m/s OK (margin 11.0m)	Vmax=6.0 m/s OK (margin 11.0m)	Vmax=6.0 m/s OK (margin 11.0m)	Vmax=6.4 m/s OK (margin 6.0m)
WTG-10 (Vibro: 27.0m)	Vmax=13.5 m/s OK (margin 24.8m)	Vmax=11.3 m/s OK (margin 24.8m)	Vmax=12.4 m/s OK (margin 24.8m)	Vmax=8.5 m/s ATTENTION (margin -2.0m)
WTG-11 (Vibro: 15.0m)	Vmax=4.7 m/s CAUTION (margin 4.0m)	Vmax=4.6 m/s OK (margin 4.8m)	Vmax=4.7 m/s OK (margin 4.2m)	Vmax=4.9 m/s CAUTION (margin 3.8m)
WTG-12 (Vibro: 16.0m)	Vmax=3.5 m/s OK (margin 7.8m)	Vmax=3.3 m/s OK (margin 8.8m)	Vmax=3.4 m/s OK (margin 8.2m)	Vmax=5.0 m/s OK (margin 5.8m)
WTG-13 (Vibro: 13.0m)	Vmax=2.6 m/s OK (margin 9.8m)	Vmax=2.6 m/s OK (margin 9.8m)	Vmax=2.6 m/s OK (margin 9.8m)	Vmax=2.8 m/s OK (margin 8.5m)
WTG-14 (Vibro: 14.2m)	Vmax=4.9 m/s CAUTION (margin 3.9m)	Vmax=4.8 m/s OK (margin 4.4m)	Vmax=4.8 m/s OK (margin 4.2m)	Vmax=4.9 m/s CAUTION (margin 3.9m)
WTG-15 (Vibro: 27.0m)	Vmax=9.7 m/s CAUTION (margin 1.5m)	Vmax=9.6 m/s CAUTION (margin 3.0m)	Vmax=9.6 m/s CAUTION (margin 2.2m)	Vmax=9.9 m/s ATTENTION (margin 0.0m)
WTG-16 (Vibro: 24.0m)	Vmax=9.6 m/s OK (margin 5.5m)	Vmax=9.6 m/s OK (margin 6.0m)	Vmax=9.6 m/s OK (margin 5.8m)	Vmax=10.0 m/s CAUTION (margin 2.8m)
WTG-17 (Vibro: 10.2m)	Vmax=3.6 m/s OK (margin 7.9m)	Vmax=2.4 m/s OK (margin 7.9m)	Vmax=2.4 m/s OK (margin 7.9m)	Vmax=6.6 m/s OK (margin 6.4m)
WTG-18 (Vibro: 17.8m)	Vmax=4.8 m/s OK (margin 5.1m)	Vmax=4.7 m/s OK (margin 6.3m)	Vmax=4.7 m/s OK (margin 5.8m)	Vmax=4.9 m/s OK (margin 4.8m)
WTG-19 (Vibro: 19.0m)	Vmax=7.4 m/s ATTENTION (margin -0.5m)	Vmax=7.3 m/s CAUTION (margin 0.2m)	Vmax=7.3 m/s ATTENTION (margin 0.0m)	Vmax=7.8 m/s ATTENTION (margin -1.0m)
WTG-20 (Vibro: 16.0m)	Vmax=4.3 m/s OK (margin 7.0m)	Vmax=4.2 m/s OK (margin 8.0m)	Vmax=4.3 m/s OK (margin 7.5m)	Vmax=4.8 m/s OK (margin 6.5m)
WTG-21 (Vibro: 20.0m)	Vmax=5.6 m/s OK (margin 8.0m)	Vmax=5.4 m/s OK (margin 9.2m)	Vmax=5.5 m/s OK (margin 8.8m)	Vmax=5.9 m/s OK (margin 7.8m)
WTG-22 (Vibro: 24.0m)	Vmax=7.6 m/s OK (margin 6.8m)	Vmax=7.4 m/s OK (margin 7.8m)	Vmax=7.5 m/s OK (margin 7.2m)	Vmax=7.7 m/s OK (margin 6.2m)
WTG-23 (Vibro: 30.0m)	Vmax=9.3 m/s OK (margin 5.5m)	Vmax=9.2 m/s OK (margin 8.8m)	Vmax=9.3 m/s OK (margin 7.5m)	Vmax=9.7 m/s CAUTION (margin 3.5m)
WTG-24 (Vibro: 15.0m)	Vmax=7.0 m/s CAUTION (margin 0.2m)	Vmax=6.5 m/s CAUTION (margin 0.8m)	Vmax=6.7 m/s CAUTION (margin 0.5m)	Vmax=7.4 m/s ATTENTION (margin -4.0m)
WTG-25 (Vibro: 17.0m)	Vmax=3.5 m/s OK (margin 10.8m)	Vmax=3.3 m/s OK (margin 10.8m)	Vmax=3.4 m/s OK (margin 10.8m)	Vmax=5.5 m/s OK (margin 5.5m)
WTG-26 (Vibro: 5.3m)	Vmax=3.2 m/s CAUTION (margin 0.8m)	Vmax=3.2 m/s CAUTION (margin 0.8m)	Vmax=3.2 m/s CAUTION (margin 0.8m)	Vmax=3.9 m/s ATTENTION (margin -1.2m)
OSS (Vibro: 25.0m)	Vmax=7.8 m/s OK (margin 7.2m)	Vmax=7.6 m/s OK (margin 8.2m)	Vmax=7.7 m/s OK (margin 7.8m)	Vmax=7.8 m/s OK (margin 7.0m)

KEY FINDINGS & RECOMMENDATIONS

Key Findings

All 26 WTG + OSS locations analysed with MENCK MHU 1900S

Pile run risk identified at most locations due to soft upper soils (qt < 2 MPa)

MITIGATION: vibratory hammer pre-installation drives piles through soft layers to a target depth where SRD exceeds system weight - this effectively prevents uncontrolled pile run when the impact hammer is placed

21 of 27 locations classified as OK (vibro depth provides >4m margin)

5 locations classified as CAUTION (WTG-02, -04, -15, -24, -26) - margin 0-4m

1 location classified as ATTENTION (WTG-19) - pile run may extend to vibro depth

COWI LB SRD comparison shows good agreement with HESI AH methods

Static capacity (ICP-05) confirms adequate long-term bearing resistance at all locations

Recommendations

- **Ensure vibro target depth is reached before hammer changeover - this is the primary safeguard against pile run**
- **Monitor penetration rate during vibratory installation at all locations**
- **ATTENTION locations (WTG-19): geotechnical engineer on site during hammer placement, apply hammer weight gradually with crane support, be prepared for additional penetration when releasing crane load**
- **CAUTION locations (WTG-02, -04, -15, -24, -26): standard monitoring with awareness of soft units at depth, verify vibro target depth achieved**
- **Vergote et al. (2025) rate-dependent sensitivity analysis shows pile run may extend 2-5m further in contractive soils - supports conservative vibro depth targets set in the Design Report**
- **Maintain installation records for all piles**

Notes

Pile weights from Design Report Appendix B (partly submerged, variable wall thickness sections)

Vibro target depths from Design Report Table 9-1 / Appendix B

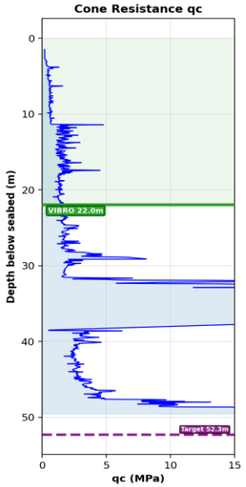
MHU 1900S hammer (lighter than MHU 2400S used in Design Report) - gives lower combined weight

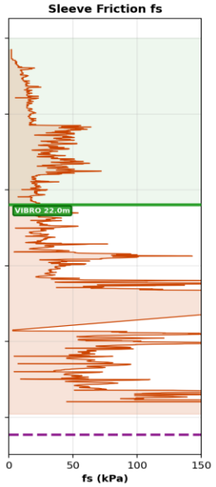
SRD bounds: LB = 0.80x BE, UB = 1.25x BE (per Design Report Section 8.2)

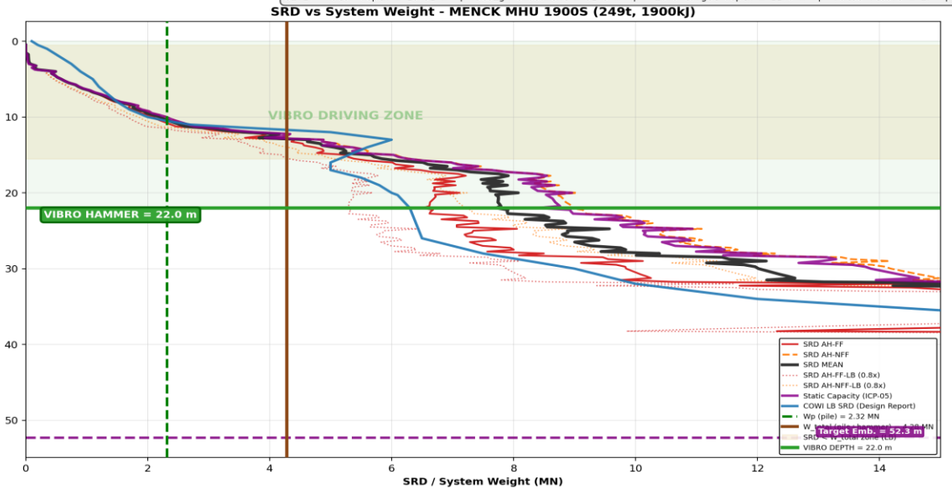
PILE RUN ASSESSMENT - WTG-01

PILE RUN RISK ASSESSMENT - WTG-01 (DP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 56.2 m | Wp = 2.32 MN (2320 kN, 236.5 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 4282 kN (4.28 MN)
SITE: Water depth = 26.52 m | Design embedment = 52.3 m | Vibro target depth = 22.0 m | False floors = 17 | True arrest = 38.6 m

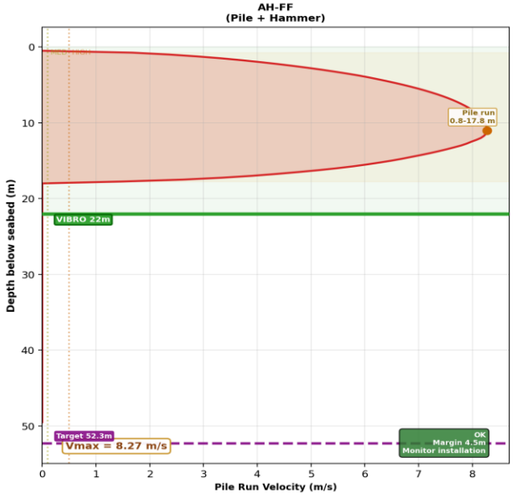


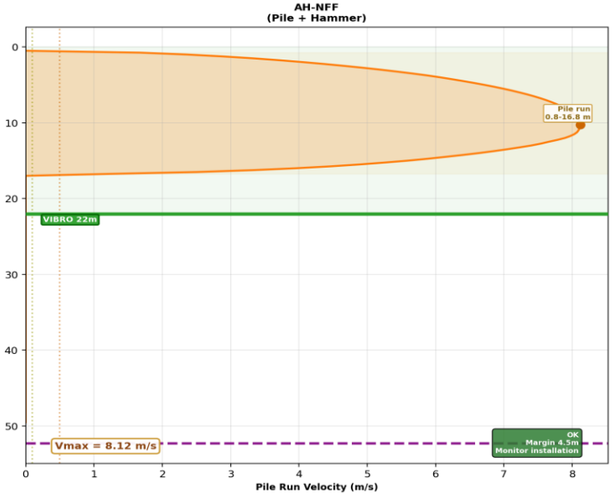


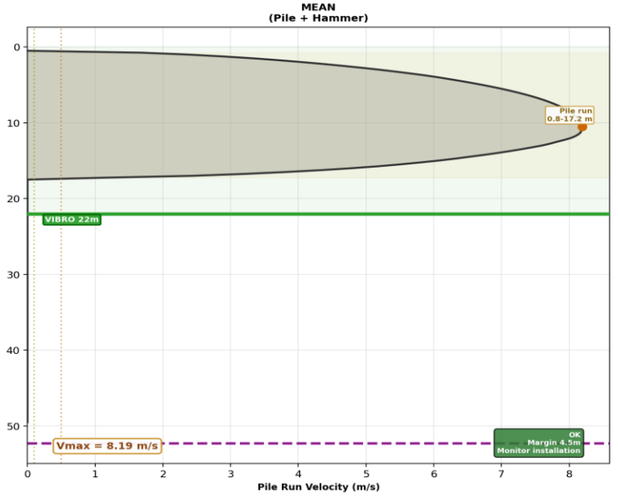


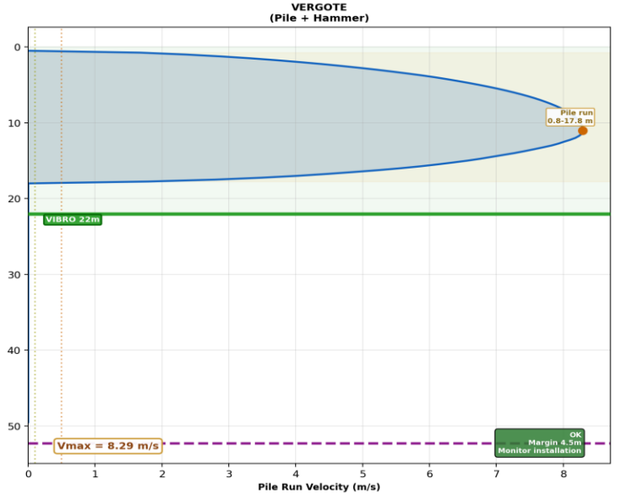
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	13.0	0.8 - 18.0	8.27	OK
AH-NFF	12.2	0.8 - 17.0	8.12	OK
MEAN	**13.0**	**0.8 - 17.5**	**8.19**	OK
VERGOTE	**13.0**	**0.8 - 18.0**	**8.29**	OK





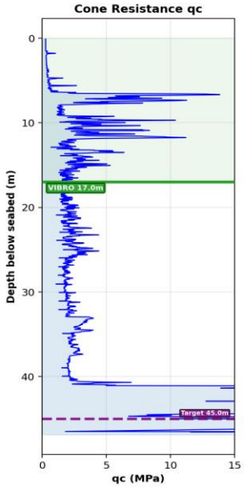


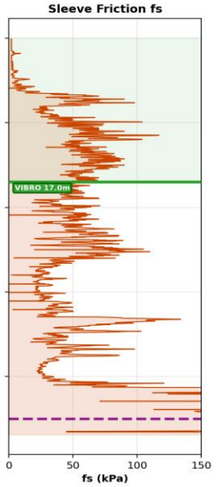


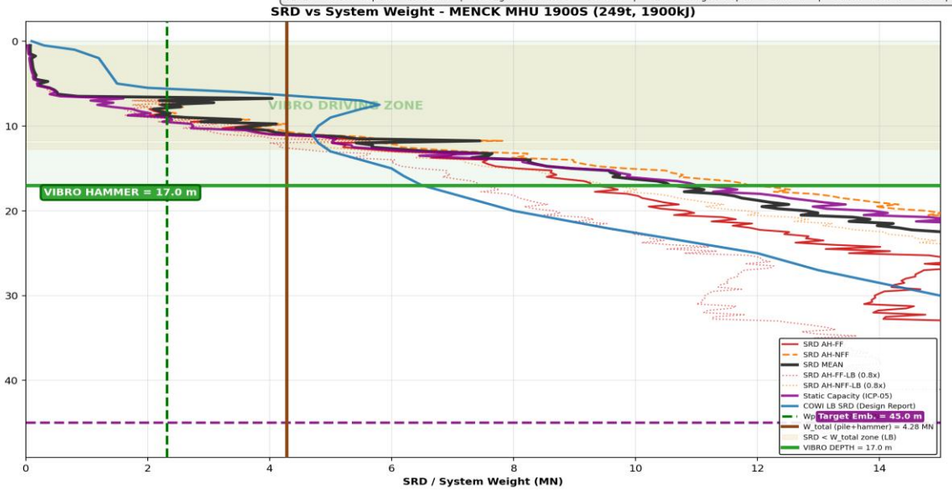
PILE RUN ASSESSMENT - WTG-02

PILE RUN RISK ASSESSMENT - WTG-02 (DP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 46.5 m  |  Wp = 2.32 MN (2320 kN, 236.5 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 4282 kN (4.28 MN)
SITE:  Water depth = 15.90 m  |  Design embedment = 45.0 m  |  Vibro target depth = 17.0 m  |  False floors = 35  |  True arrest = 39.9 m
```

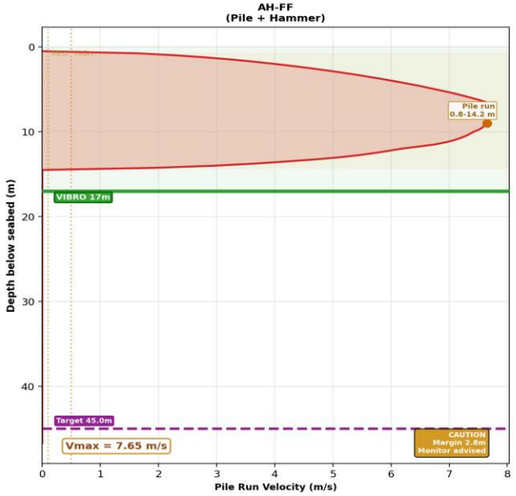


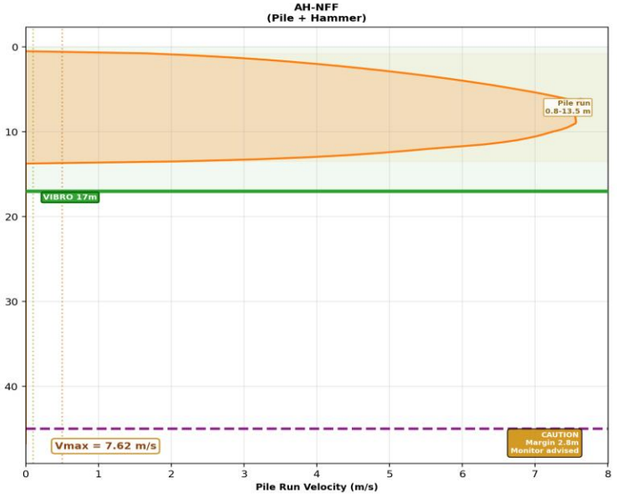


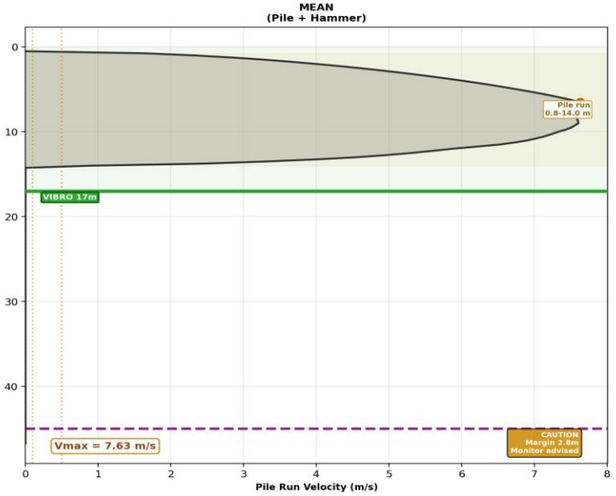


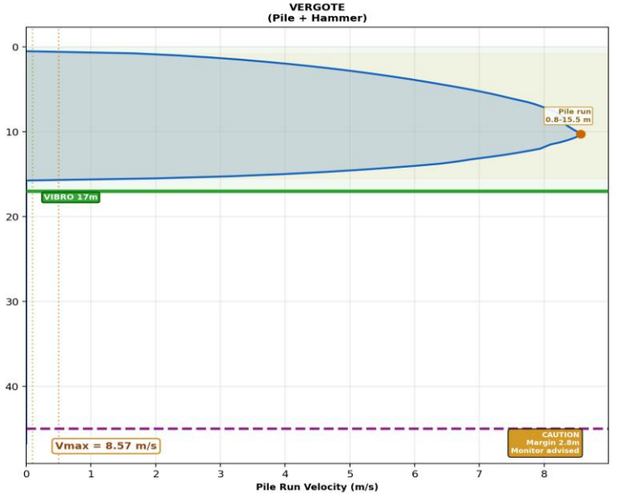
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	11.2	0.8 - 14.5	7.65	CAUTION
AH-NFF	9.8	0.8 - 13.8	7.62	CAUTION
MEAN	**11.0**	**0.8 - 14.2**	**7.63**	CAUTION
VERGOTE	**11.2**	**0.8 - 15.8**	**8.57**	CAUTION





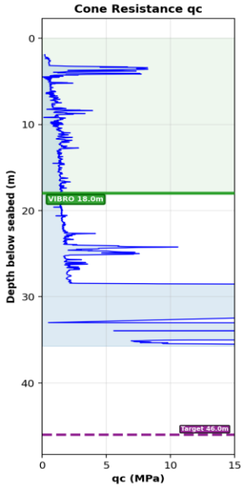


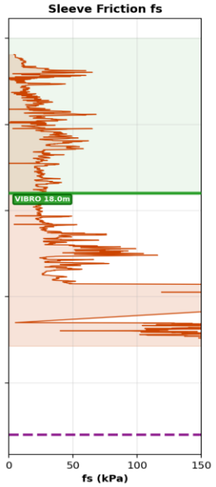


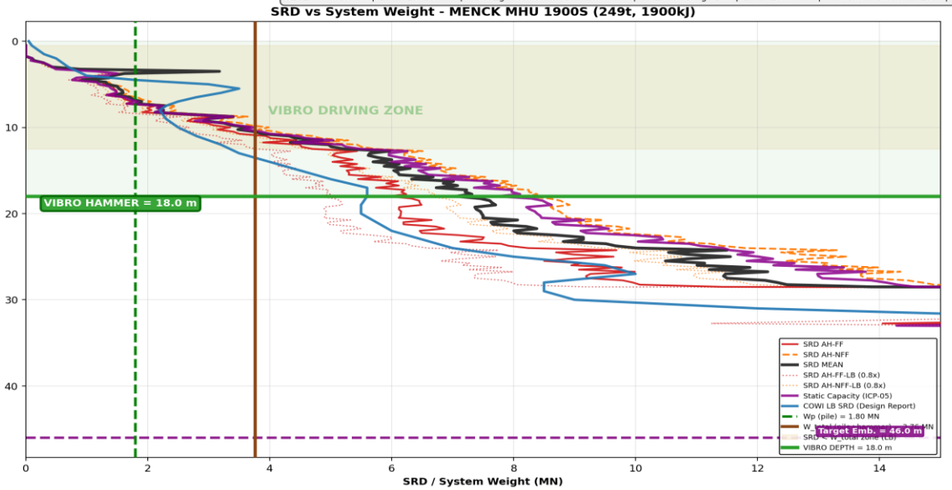
PILE RUN ASSESSMENT - WTG-03

PILE RUN RISK ASSESSMENT - WTG-03 (DP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 47.5 m  |  Wp = 1.80 MN (1800 kN, 183.5 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 3762 kN (3.76 MN)
SITE:  Water depth = 29.45 m  |  Design embedment = 46.0 m  |  Vibro target depth = 18.0 m  |  False floors = 13  |  True arrest = 28.0 m
```

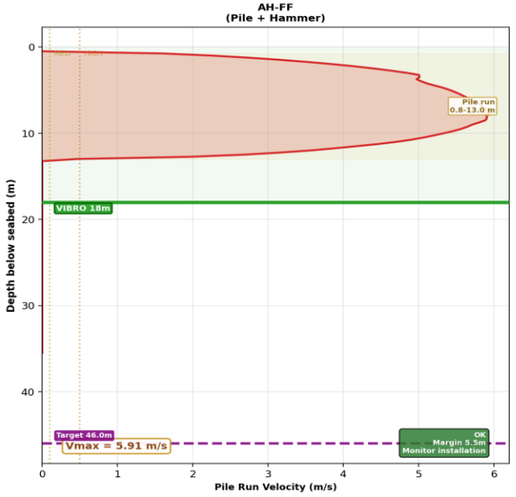


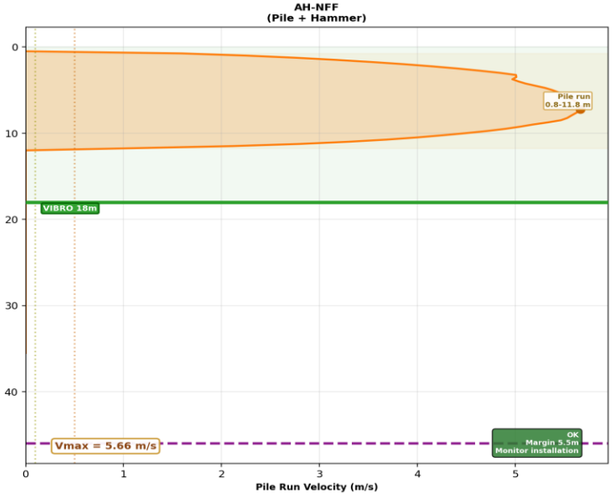


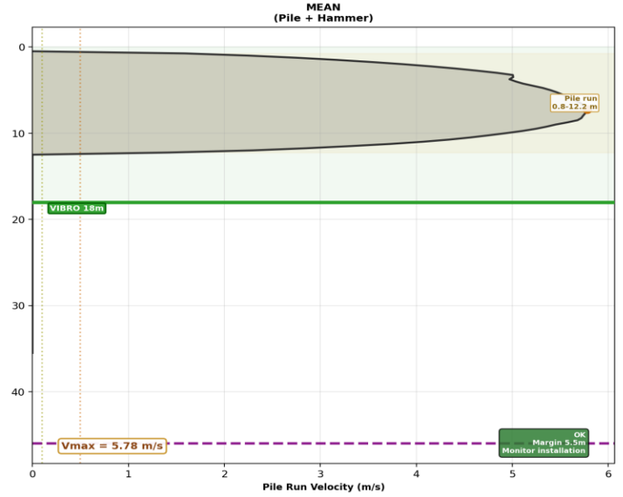


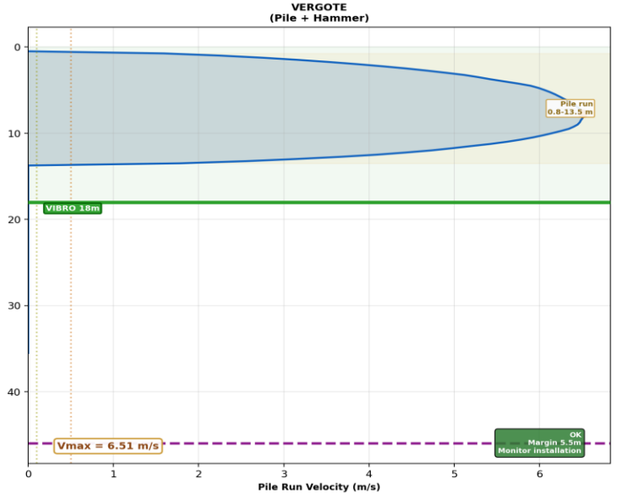
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	11.0	0.8 - 13.2	5.91	OK
AH-NFF	10.0	0.8 - 12.0	5.66	OK
MEAN	**10.8**	**0.8 - 12.5**	**5.78**	OK
VERGOTE	**11.0**	**0.8 - 13.8**	**6.51**	OK





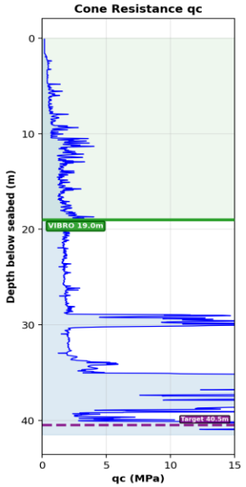


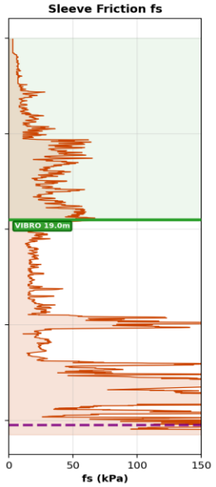


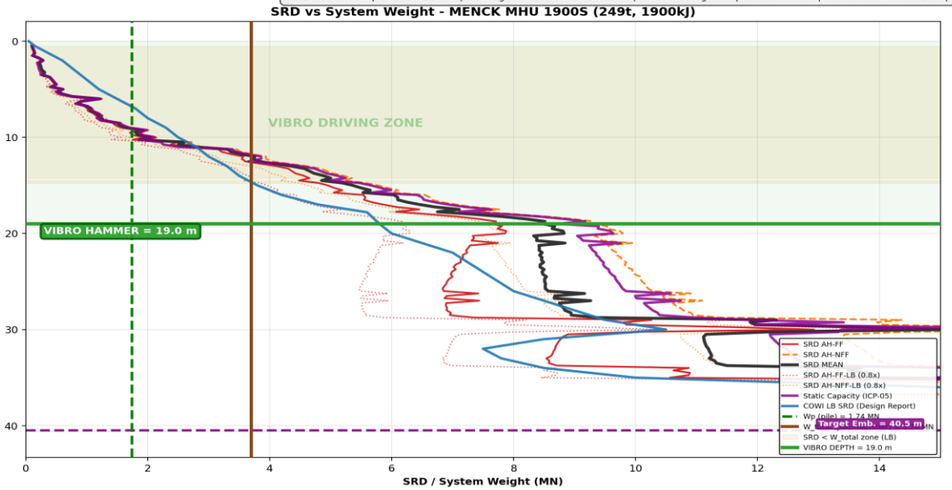
PILE RUN ASSESSMENT - WTG-04

PILE RUN RISK ASSESSMENT - WTG-04 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 42.0 m | Wp = 1.74 MN (1740 kN, 177.4 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3702 kN (3.70 MN)
SITE: Water depth = 23.12 m | Design embedment = 40.5 m | Vibro target depth = 19.0 m | False floors = 24 | True arrest = 33.2 m

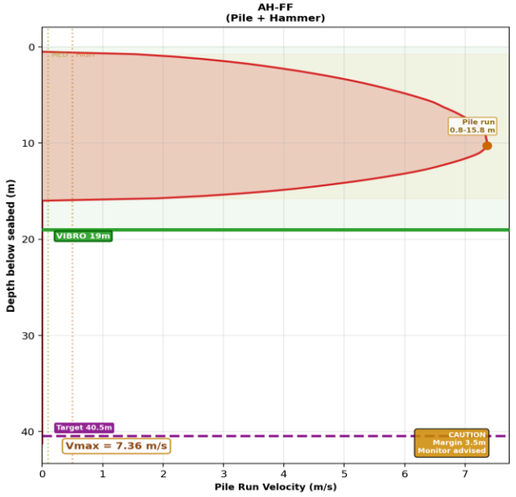


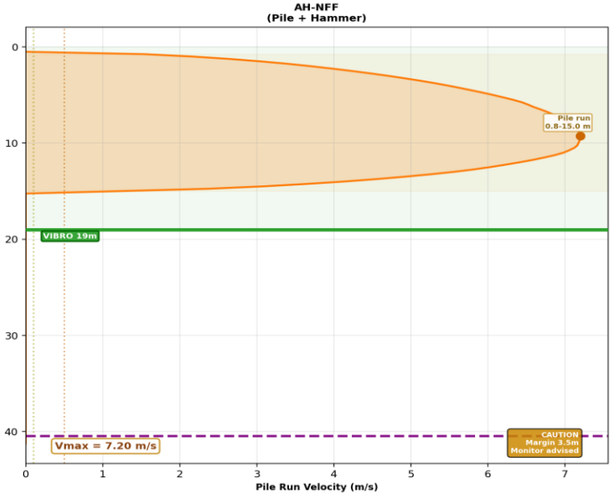


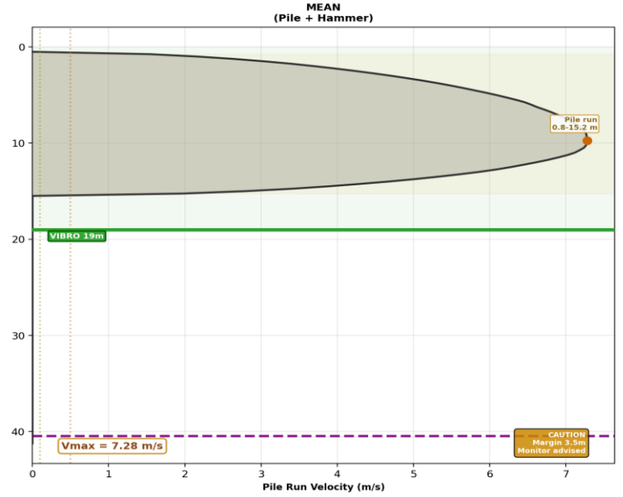


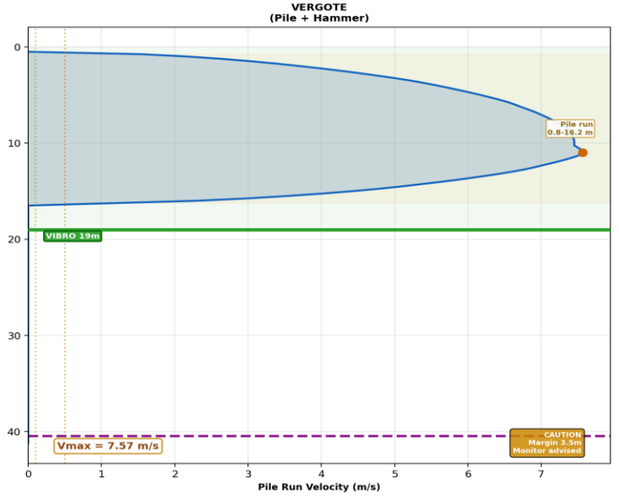
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	12.8	0.8 - 16.0	7.36	CAUTION
AH-NFF	11.8	0.8 - 15.2	7.20	CAUTION
MEAN	**12.0**	**0.8 - 15.5**	**7.28**	CAUTION
VERGOTE	**12.8**	**0.8 - 16.5**	**7.57**	CAUTION





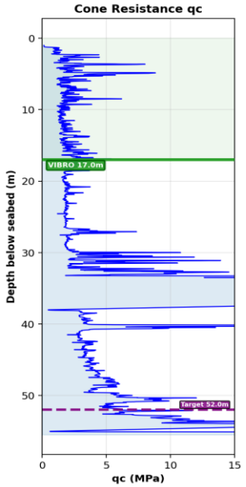


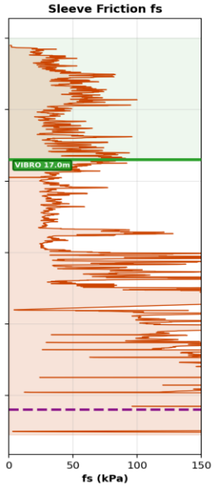


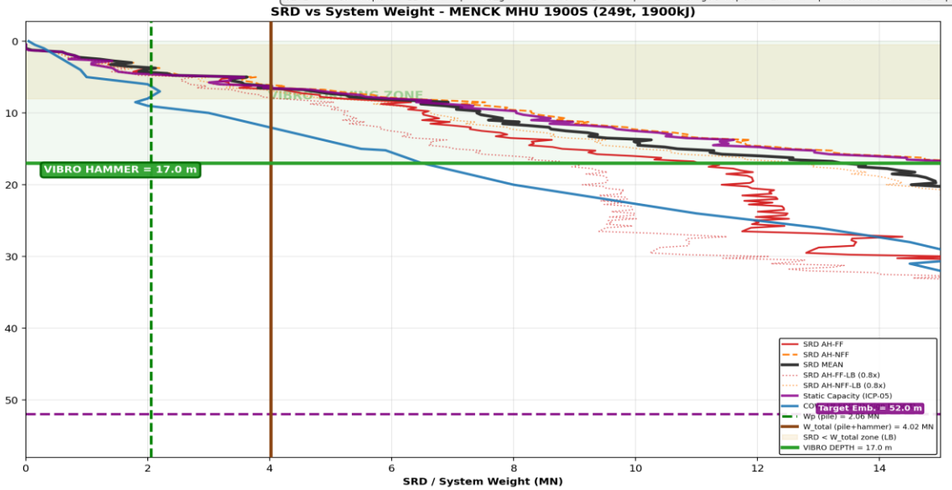
PILE RUN ASSESSMENT - WTG-05

PILE RUN RISK ASSESSMENT - WTG-05 (DP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 53.5 m | Wp = 2.06 MN (2060 kN, 210.0 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 4022 kN (4.02 MN)
SITE: Water depth = 22.50 m | Design embedment = 52.0 m | Vibro target depth = 17.0 m | False floors = 41 | True arrest = 38.1 m

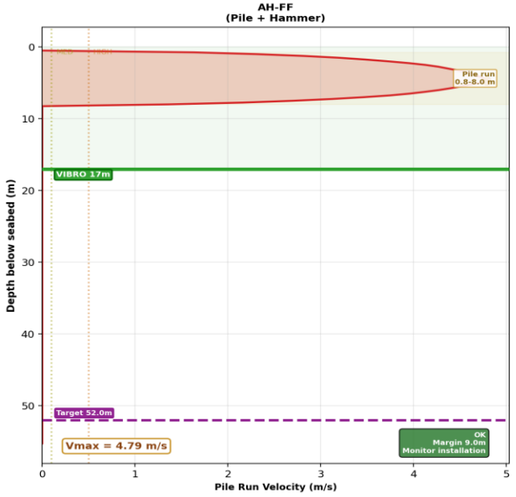


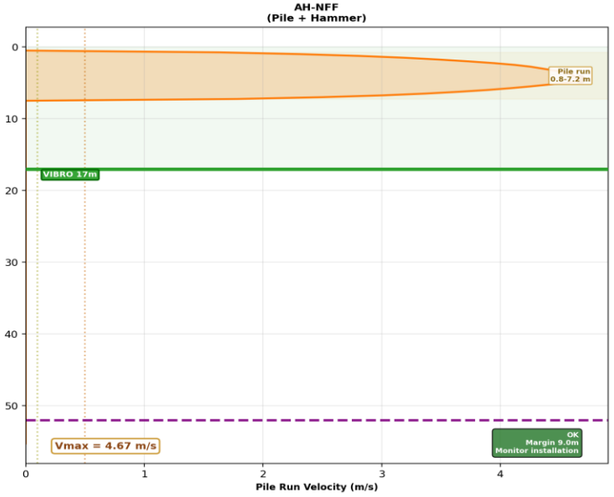


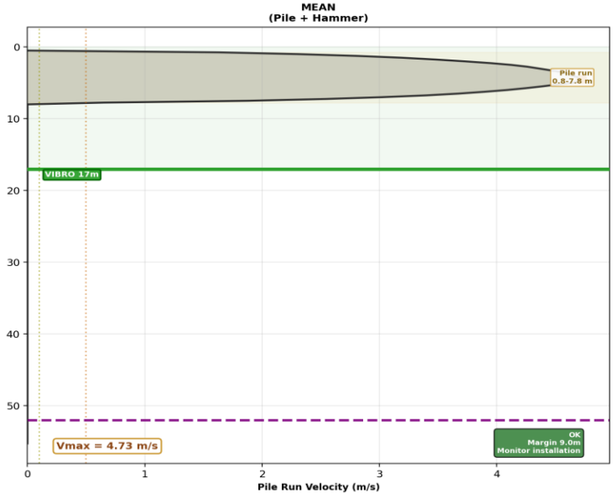


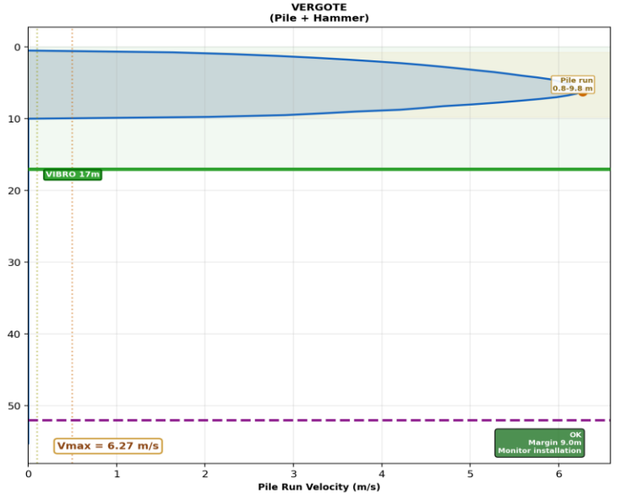
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	6.8	0.8 - 8.2	4.79	OK
AH-NFF	6.2	0.8 - 7.5	4.67	OK
MEAN	**6.8**	**0.8 - 8.0**	**4.73**	OK
VERGOTE	**6.8**	**0.8 - 10.0**	**6.27**	OK





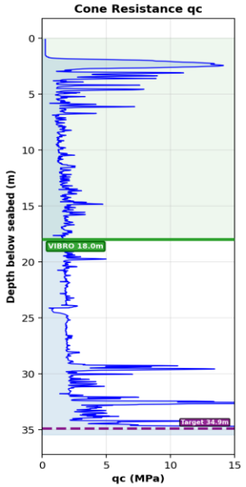


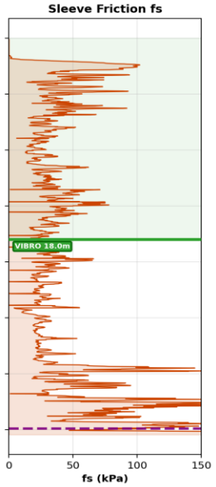


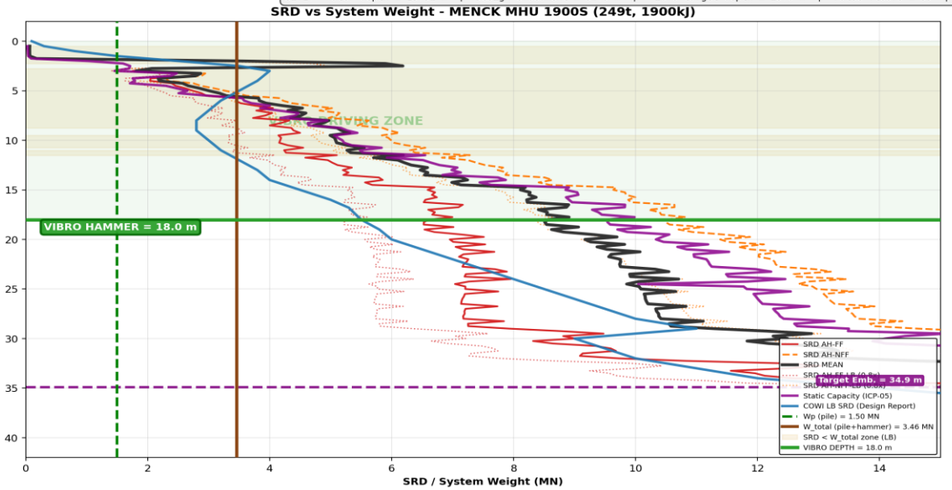
PILE RUN ASSESSMENT - WTG-06

PILE RUN RISK ASSESSMENT - WTG-06 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 36.4 m  |  Wp = 1.50 MN (1500 kN, 152.9 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 3462 kN (3.46 MN)
SITE:  Water depth = 23.31 m  |  Design embedment = 34.9 m  |  Vibro target depth = 18.0 m  |  False floors = 39  |  True arrest = 31.8 m
```

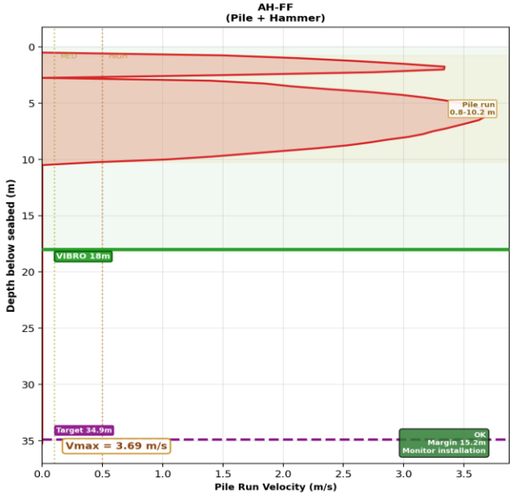


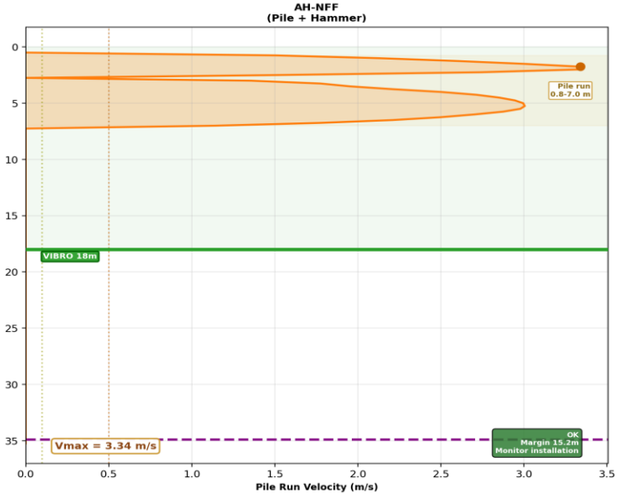


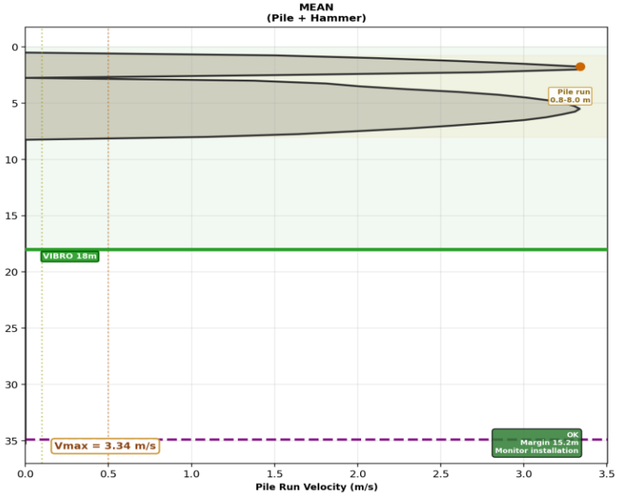


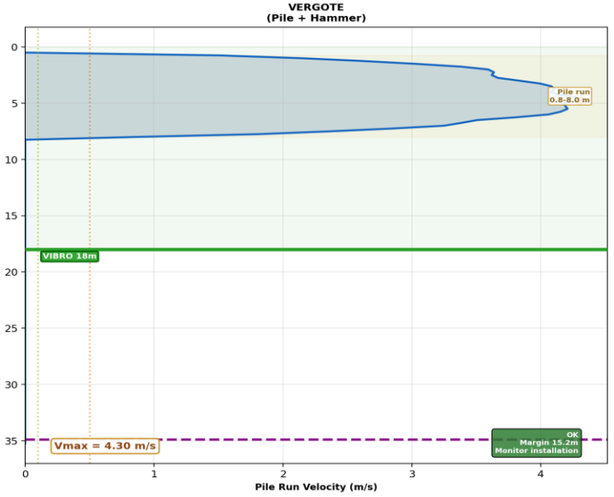
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	2.0	0.8 - 2.8	3.69	OK
AH-NFF	2.0	0.8 - 2.8	3.34	OK
MEAN	**2.0**	**0.8 - 2.8**	**3.34**	OK
VERGOTE	**2.0**	**0.8 - 8.2**	**4.30**	OK





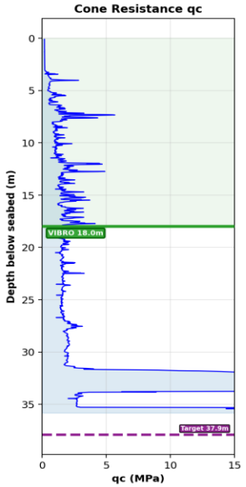


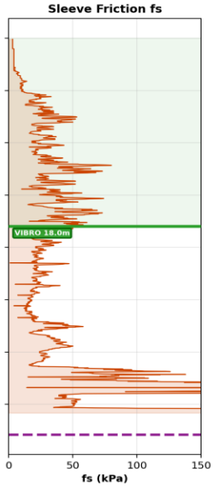


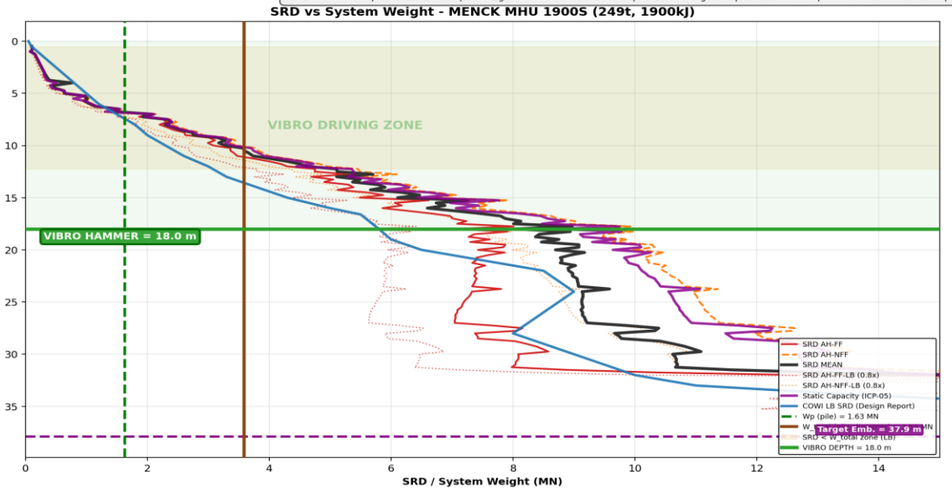
PILE RUN ASSESSMENT - WTG-07

PILE RUN RISK ASSESSMENT - WTG-07 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 39.5 m | Wp = 1.63 MN (1630 kN, 166.2 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3592 kN (3.59 MN)
SITE: Water depth = 24.26 m | Design embedment = 37.9 m | Vibro target depth = 18.0 m | False floors = 29 | True arrest = 31.3 m

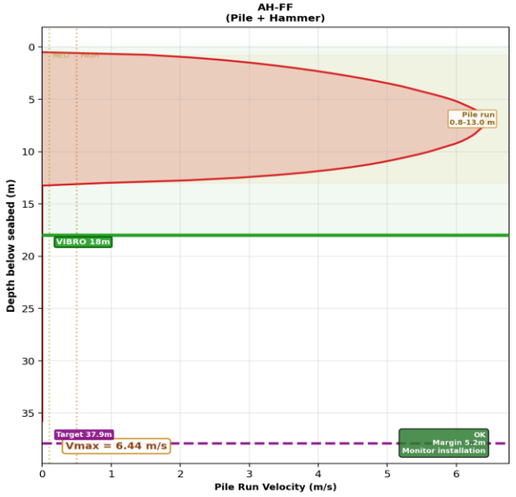


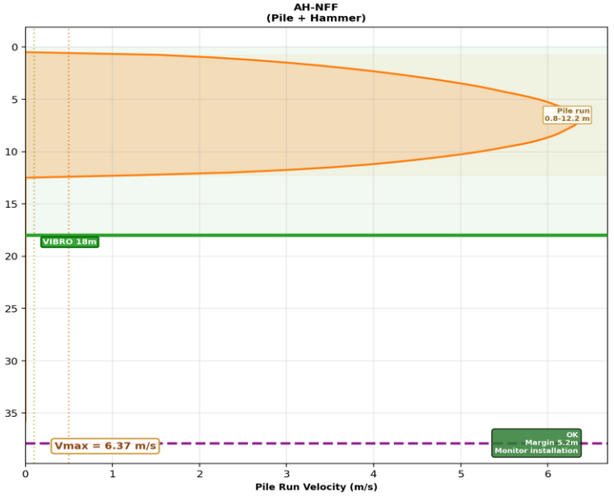


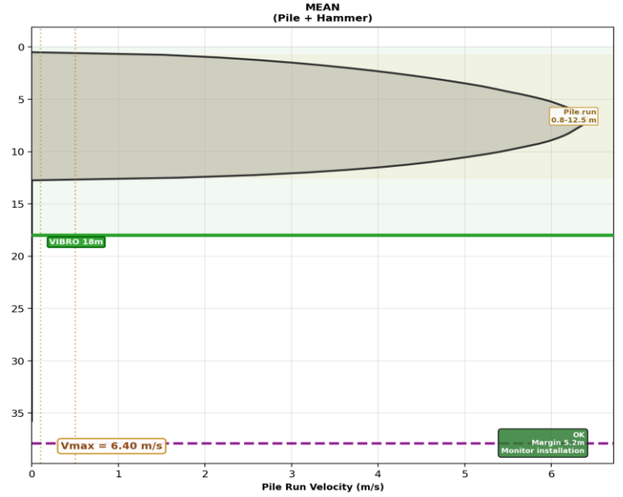


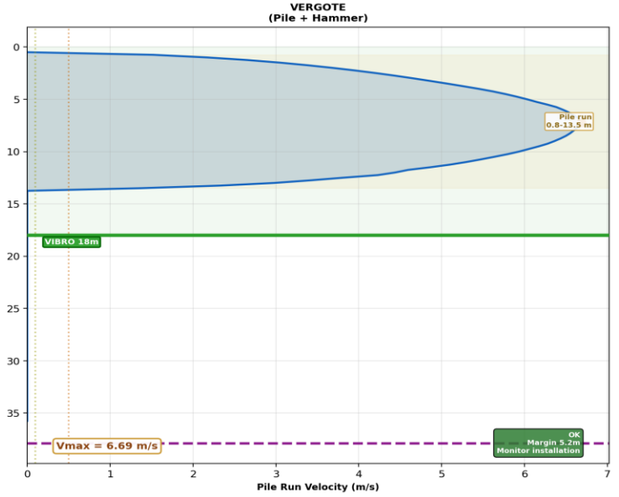
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	11.2	0.8 - 13.2	6.44	OK
AH-NFF	10.2	0.8 - 12.5	6.37	OK
MEAN	**10.5**	**0.8 - 12.8**	**6.40**	OK
VERGOTE	**11.2**	**0.8 - 13.8**	**6.69**	OK





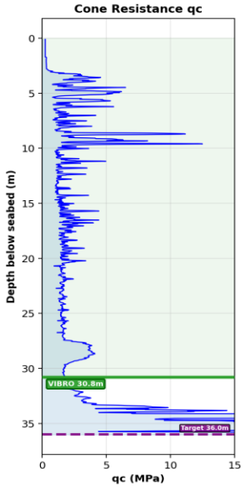


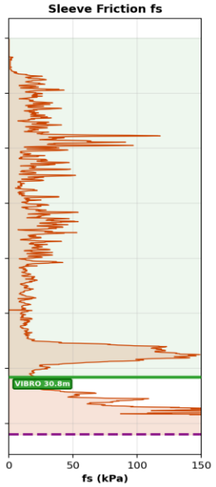


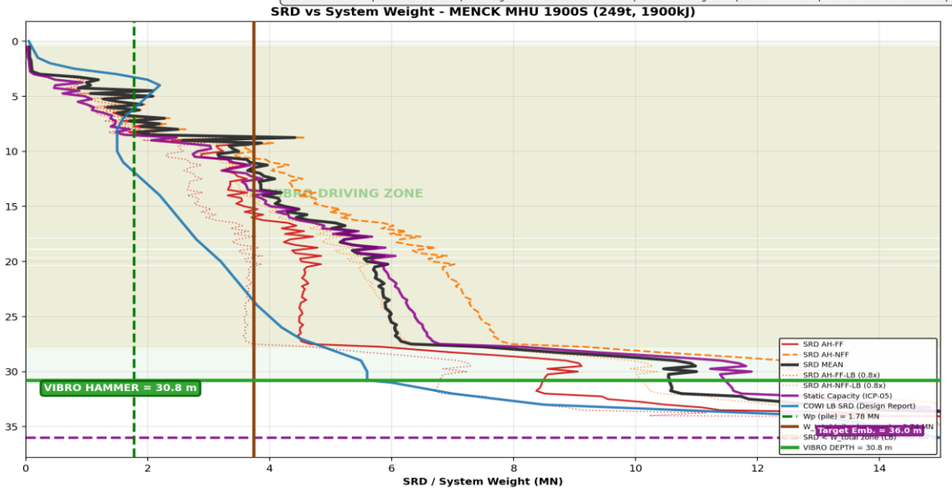
PILE RUN ASSESSMENT - WTG-08

PILE RUN RISK ASSESSMENT - WTG-08 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 37.6 m | Wp = 1.78 MN (1780 kN, 181.4 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3742 kN (3.74 MN)
SITE: Water depth = 18.91 m | Design embedment = 36.0 m | Vibro target depth = 30.8 m | False floors = 35 | True arrest = 31.9 m

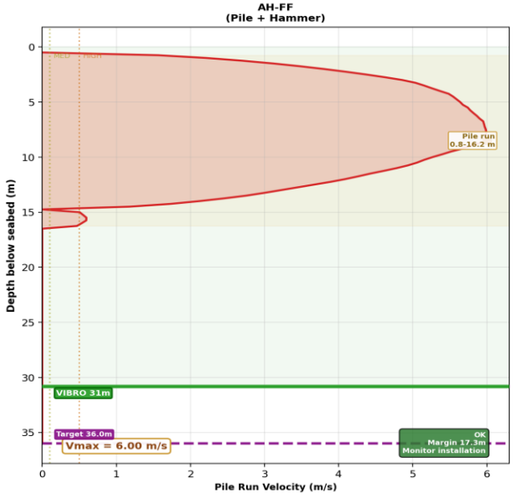


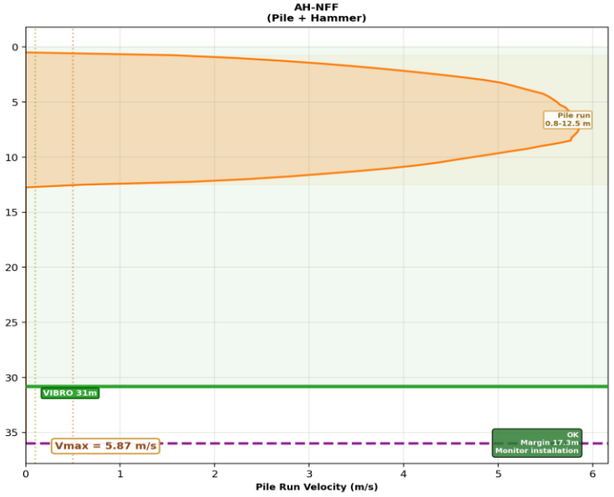


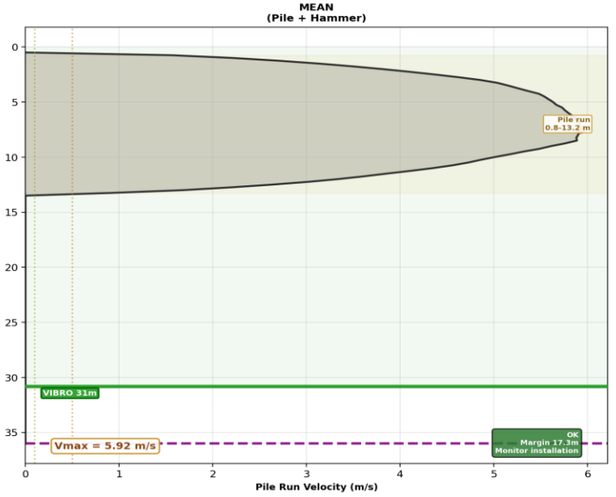


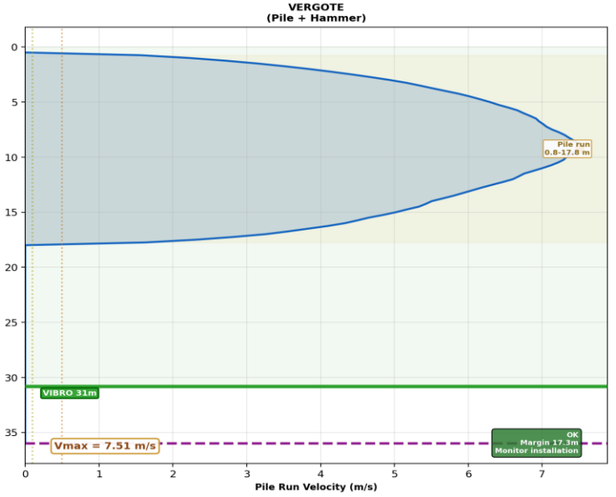
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	8.8	0.8 - 14.8	6.00	OK
AH-NFF	8.8	0.8 - 12.8	5.87	OK
MEAN	**8.8**	**0.8 - 13.5**	**5.92**	OK
VERGOTE	**8.8**	**0.8 - 18.0**	**7.51**	OK





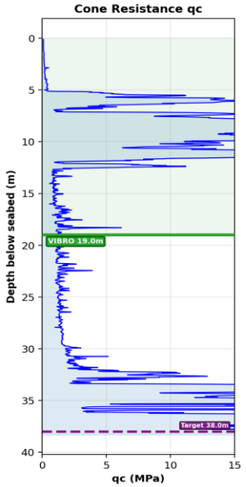


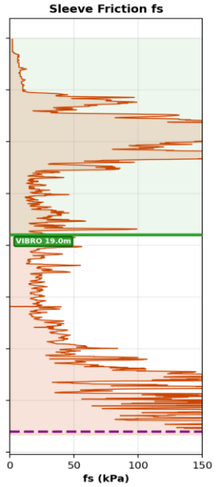


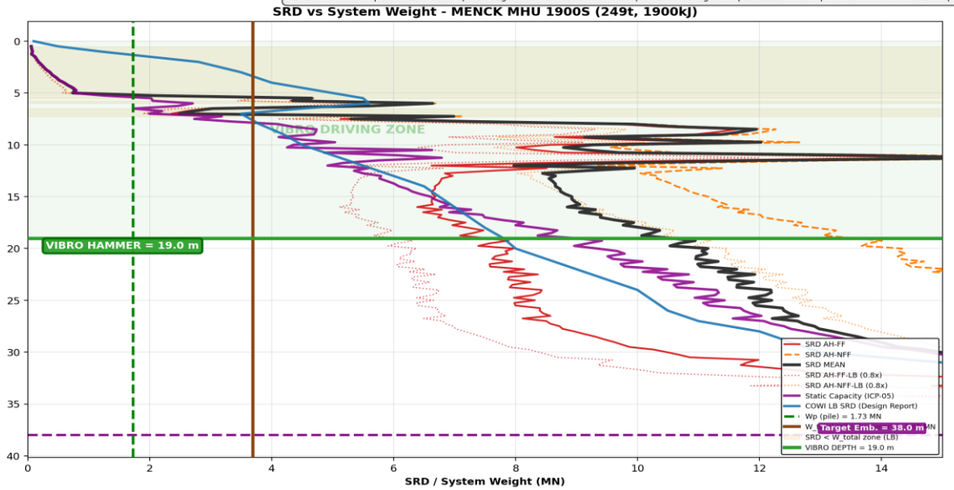
PILE RUN ASSESSMENT - WTG-09

PILE RUN RISK ASSESSMENT - WTG-09 (IP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 39.5 m | Wp = 1.73 MN (1730 kN, 176.4 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3692 kN (3.69 MN)
SITE: Water depth = 17.87 m | Design embedment = 38.0 m | Vibro target depth = 19.0 m | False floors = 13 | True arrest = 30.6 m

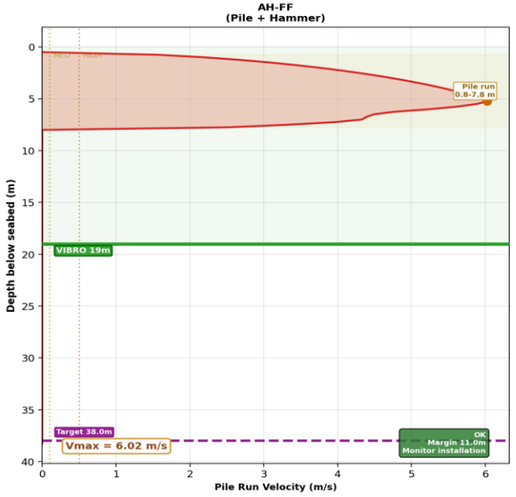


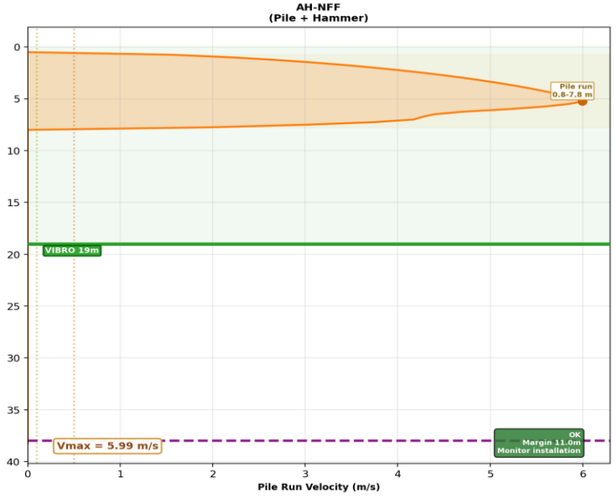


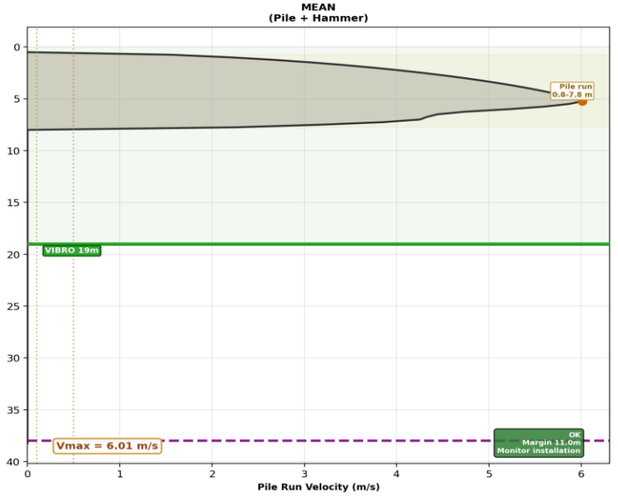


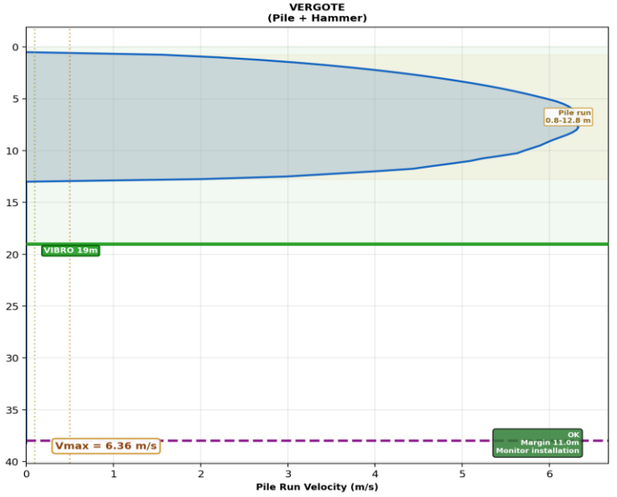
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	5.5	0.8 - 8.0	6.02	OK
AH-NFF	5.5	0.8 - 8.0	5.99	OK
MEAN	**5.5**	**0.8 - 8.0**	**6.01**	OK
VERGOTE	**5.5**	**0.8 - 13.0**	**6.36**	OK





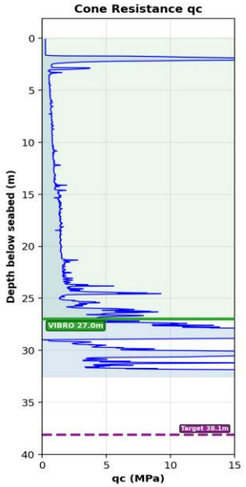


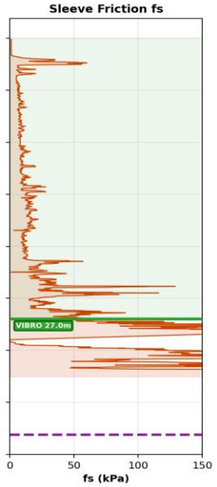


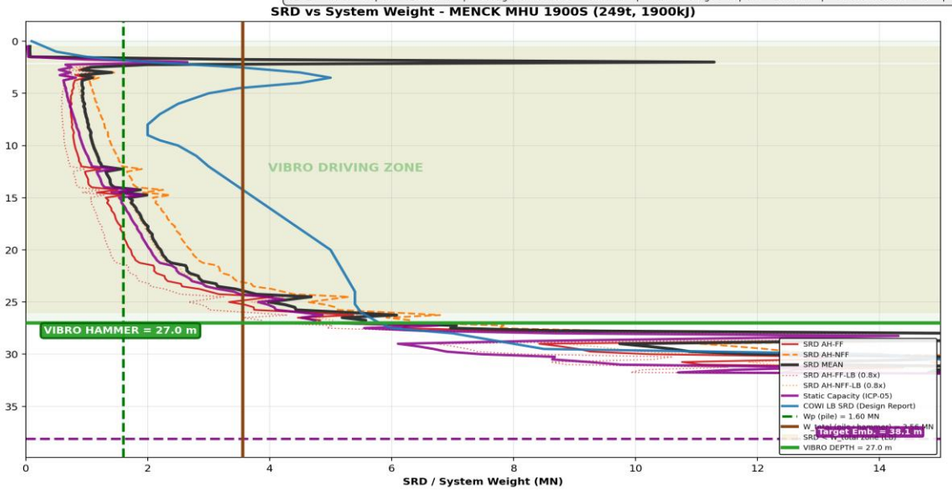
PILE RUN ASSESSMENT - WTG-10

PILE RUN RISK ASSESSMENT - WTG-10 (IP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 39.6 m | Wp = 1.60 MN (1600 kN, 163.1 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3562 kN (3.56 MN)
SITE: Water depth = 29.68 m | Design embedment = 38.1 m | Vibro target depth = 27.0 m | False floors = 9 | True arrest = 29.1 m

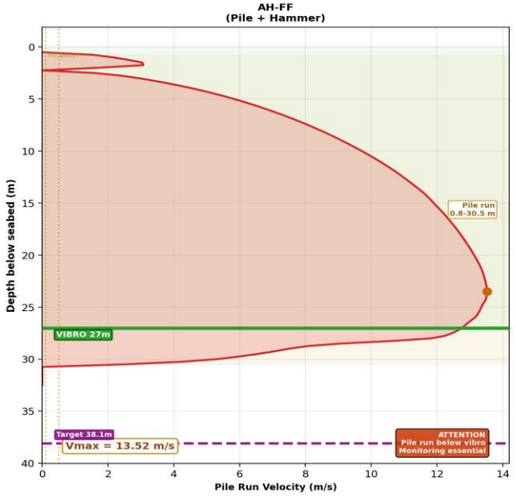


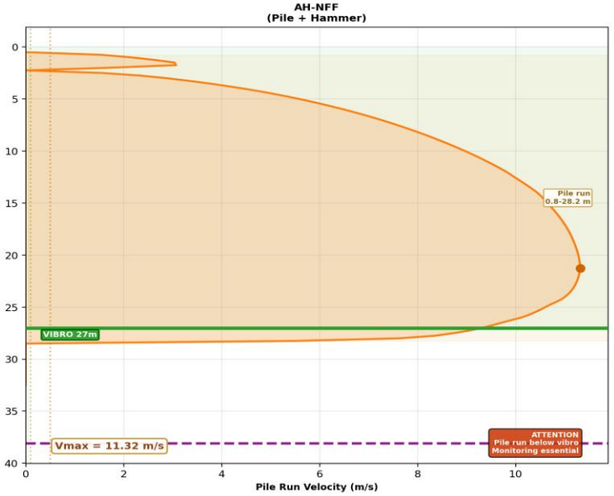


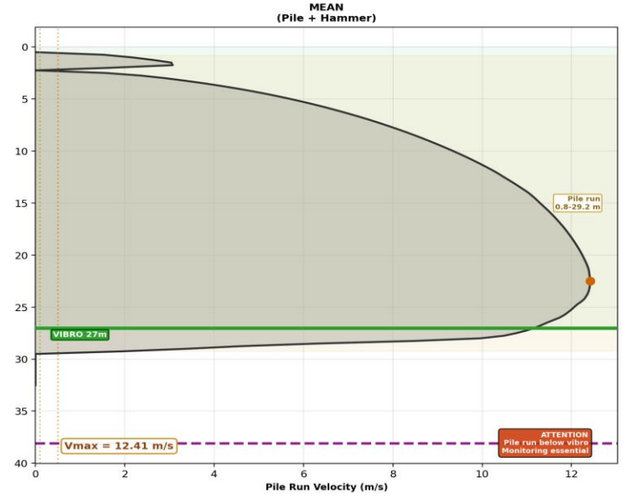


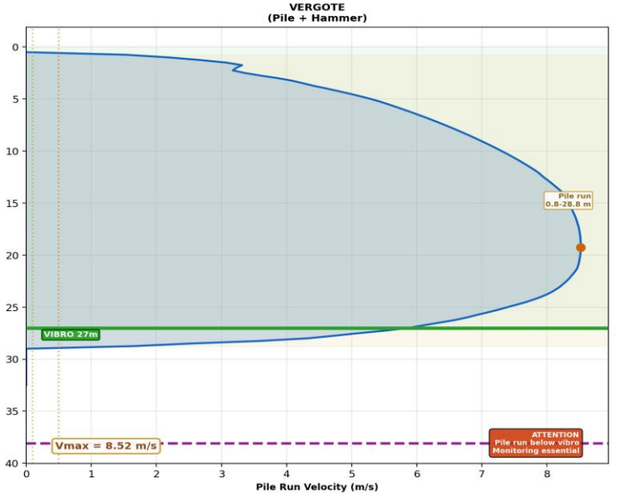
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	2.0	0.8 - 2.2	13.52	ATTENTION
AH-NFF	2.0	0.8 - 2.2	11.32	ATTENTION
MEAN	**2.0**	**0.8 - 2.2**	**12.41**	ATTENTION
VERGOTE	**2.0**	**0.8 - 29.0**	**8.52**	ATTENTION





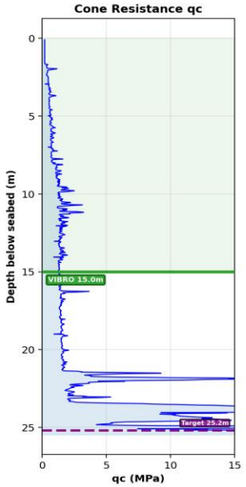


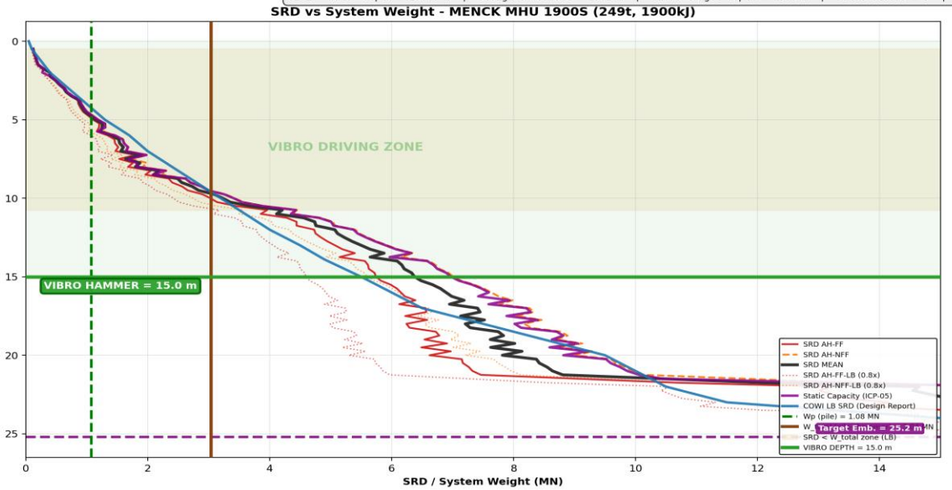


PILE RUN ASSESSMENT - WTG-11

PILE RUN RISK ASSESSMENT - WTG-11 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

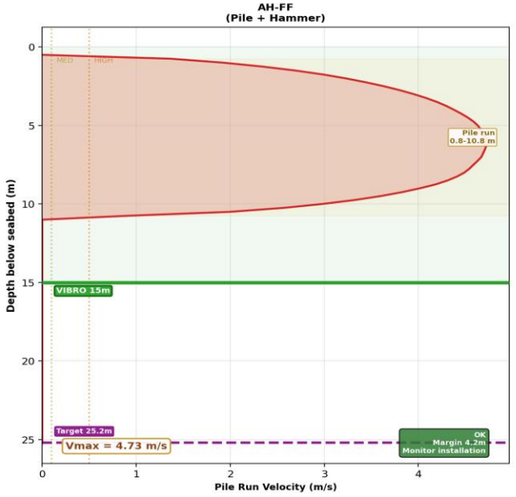
```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 26.7 m  |  Wp = 1.08 MN (1080 kN, 110.1 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W_hammer(sub) = 1962 kN  |  W_total = 3042 kN (3.04 MN)
SITE:  Water depth = 29.46 m  |  Design embedment = 25.2 m  |  Vibro target depth = 15.0 m  |  False floors = 5  |  True arrest = 22.6 m
```

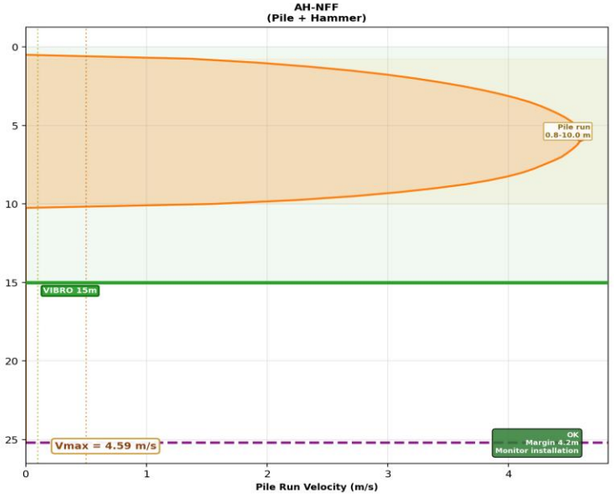


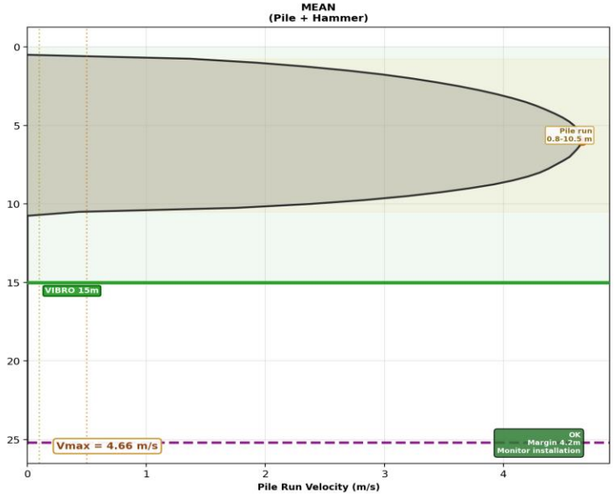


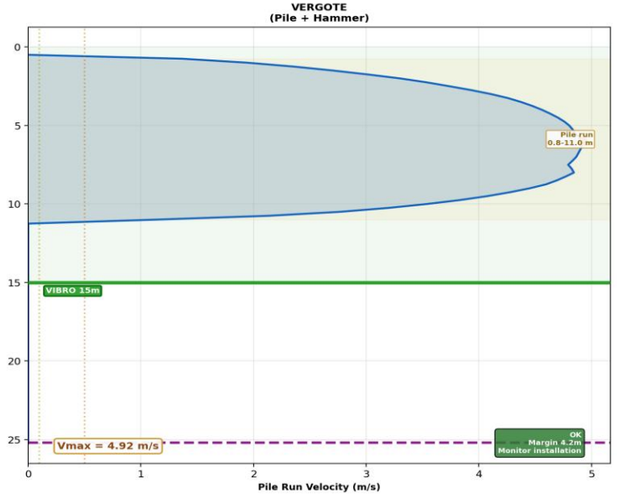
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	10.2	0.8 - 11.0	4.73	OK
AH-NFF	9.8	0.8 - 10.2	4.59	OK
MEAN	**9.8**	**0.8 - 10.8**	**4.66**	**OK**
VERGOTE	**10.2**	**0.8 - 11.2**	**4.92**	**CAUTION**





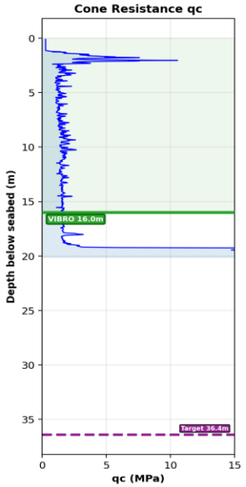


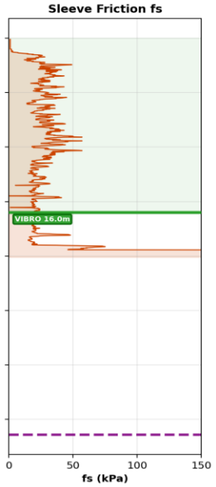


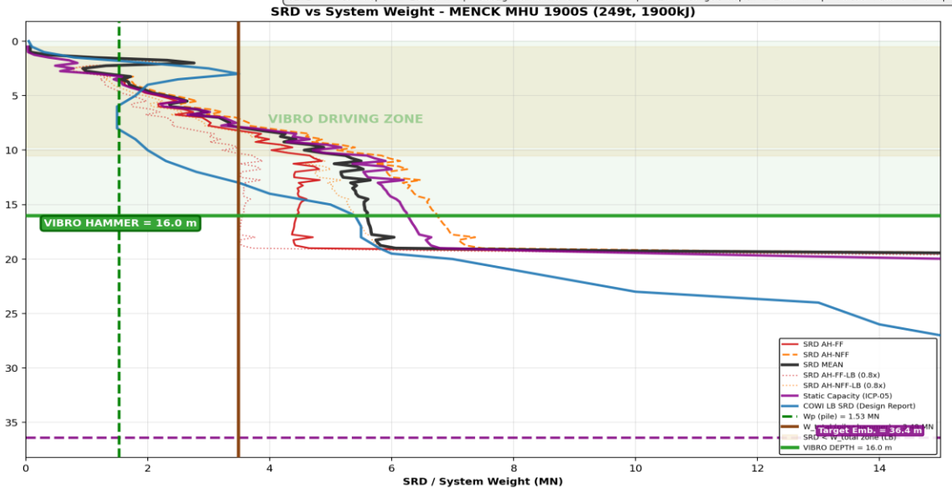
PILE RUN ASSESSMENT - WTG-12

PILE RUN RISK ASSESSMENT - WTG-12 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 37.9 m | Wp = 1.53 MN (1530 kN, 156.0 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3492 kN (3.49 MN)
SITE: Water depth = 29.43 m | Design embedment = 36.4 m | Vibro target depth = 16.0 m | False floors = 8 | True arrest = 18.9 m

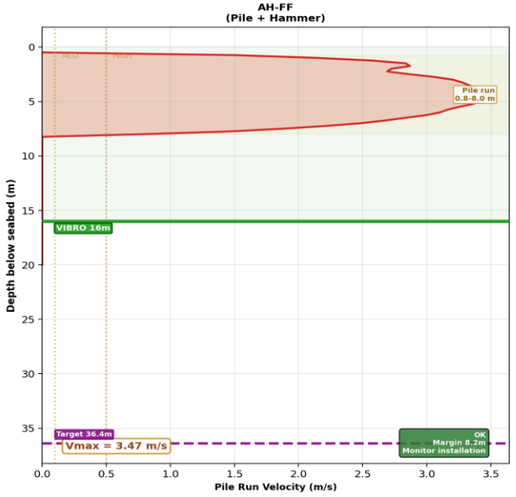


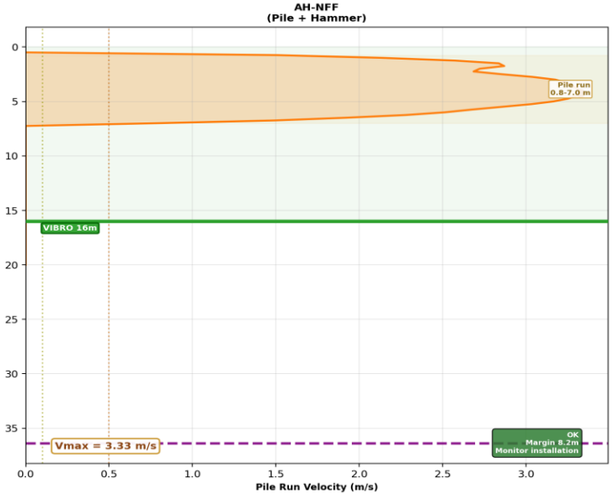


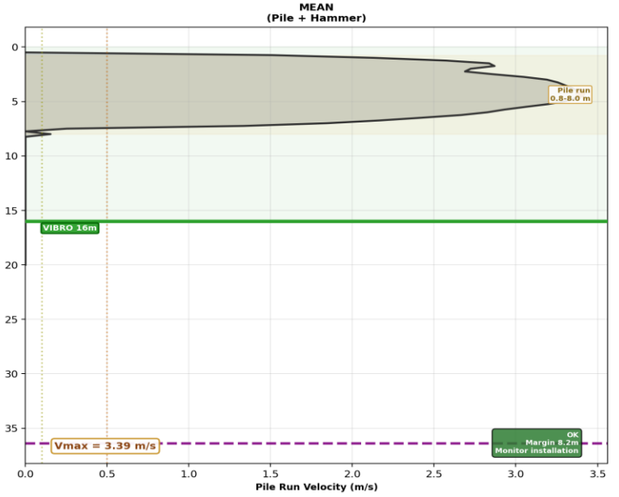


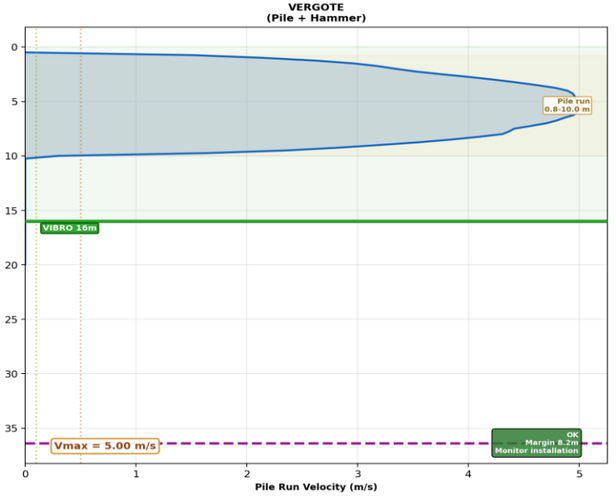
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	8.2	0.8 - 8.2	3.47	OK
AH-NFF	7.2	0.8 - 7.2	3.33	OK
MEAN	**8.0**	**0.8 - 7.8**	**3.39**	OK
VERGOTE	**8.2**	**0.8 - 10.2**	**5.00**	OK





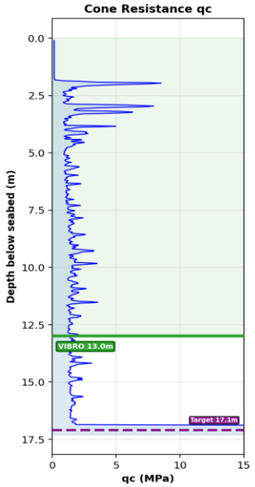


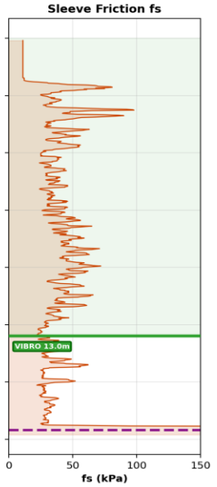


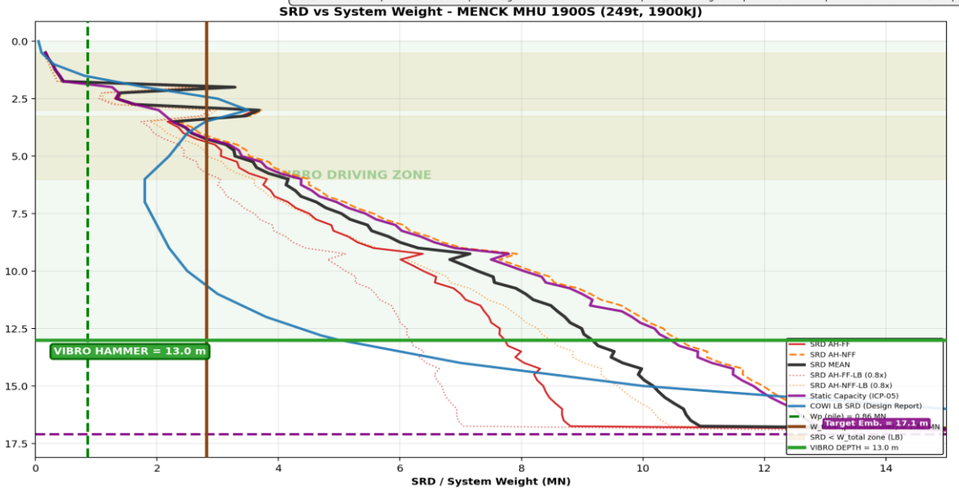
PILE RUN ASSESSMENT - WTG-13

PILE RUN RISK ASSESSMENT - WTG-13 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 20.9 m | Wp = 0.86 MN (860 kN, 87.7 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 2822 kN (2.82 MN)
SITE: Water depth = 26.44 m | Design embedment = 17.1 m | Vibro target depth = 13.0 m | False floors = 17 | True arrest = 16.8 m

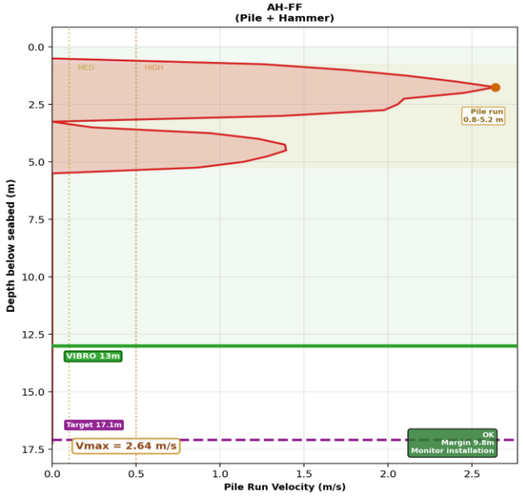


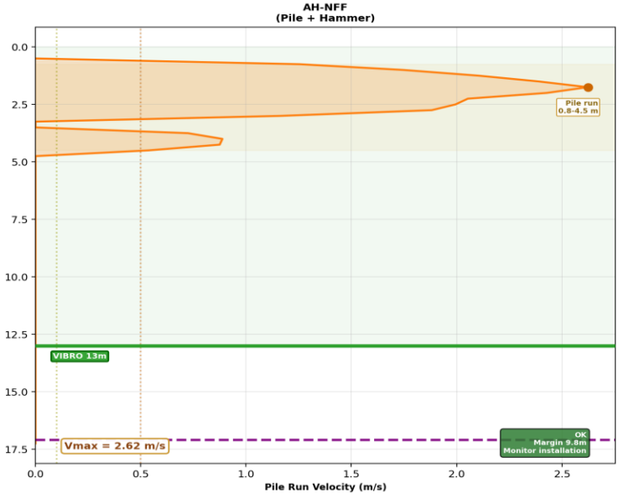


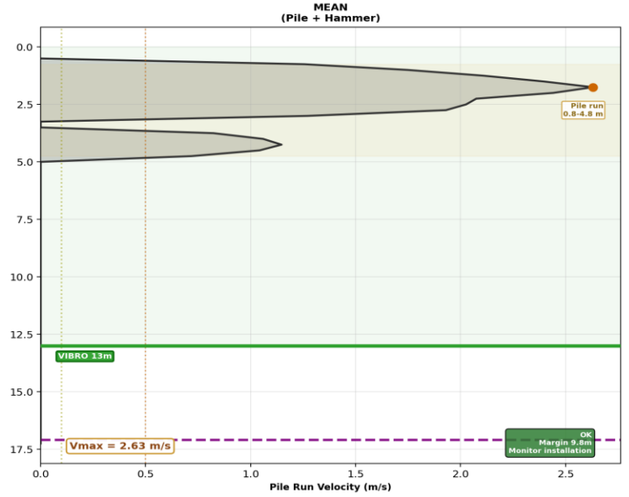


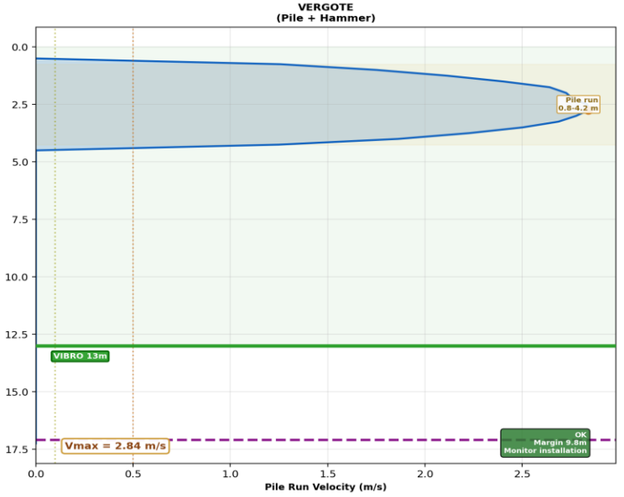
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	2.0	0.8 - 3.2	2.64	OK
AH-NFF	2.0	0.8 - 3.2	2.62	OK
MEAN	**2.0**	**0.8 - 3.2**	**2.63**	OK
VERGOTE	**2.0**	**0.8 - 4.5**	**2.84**	OK





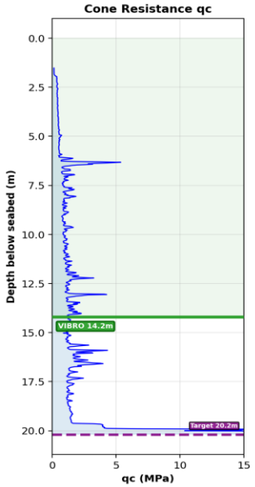


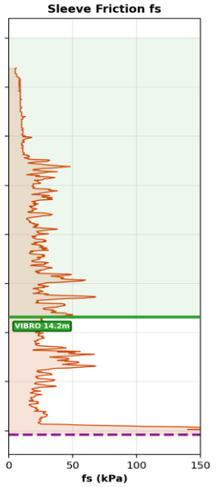


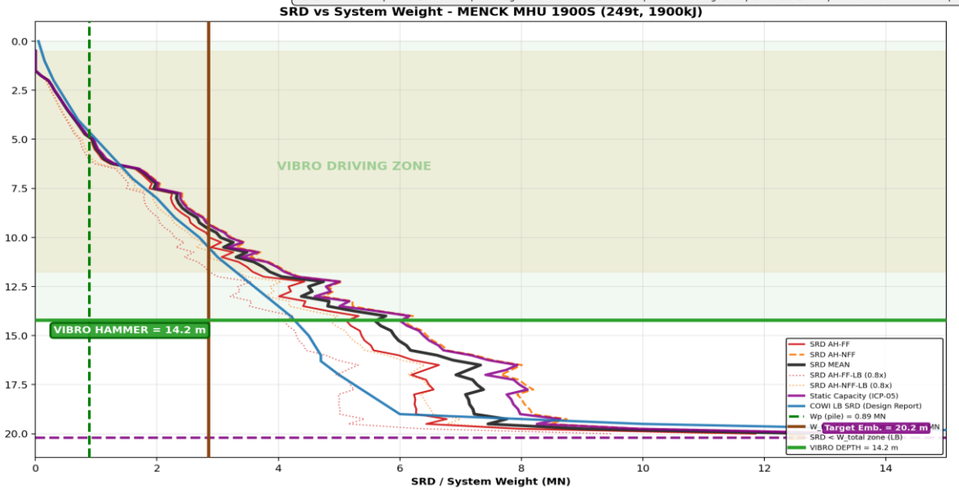
PILE RUN ASSESSMENT - WTG-14

PILE RUN RISK ASSESSMENT - WTG-14 (IP) | Design Report Category: Cat 3
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 21.7 m | Wp = 0.89 MN (890 kN, 90.7 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 2852 kN (2.85 MN)
SITE: Water depth = 23.67 m | Design embedment = 20.2 m | Vibro target depth = 14.2 m | False floors = 8 | True arrest = 19.6 m

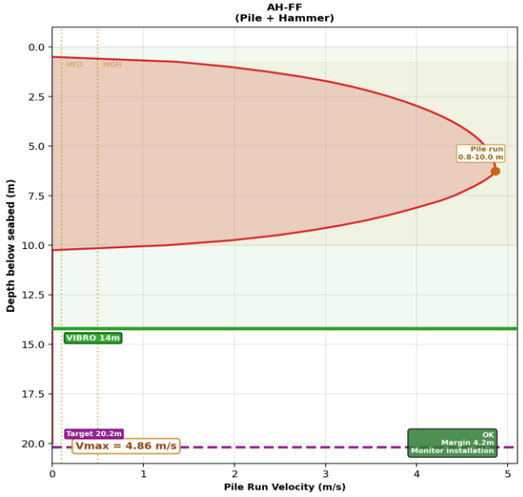


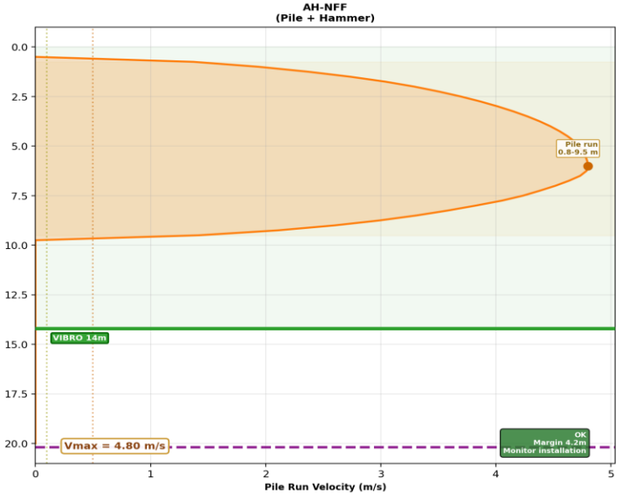


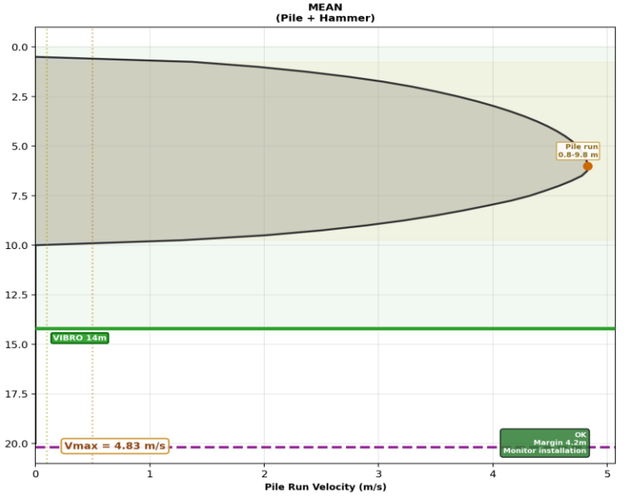


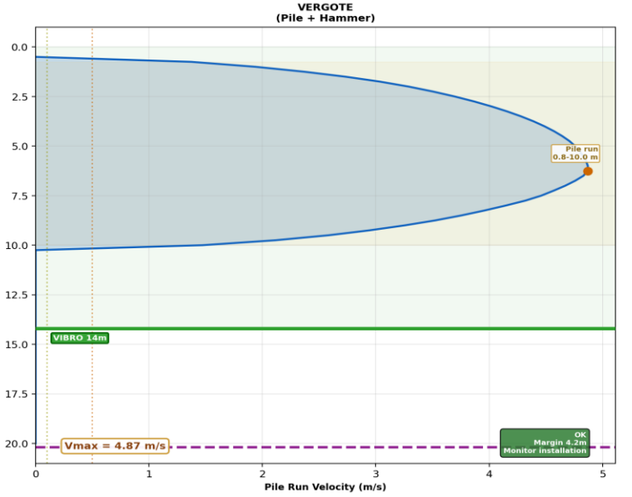
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	10.0	0.8 - 10.2	4.86	CAUTION
AH-NFF	9.5	0.8 - 9.8	4.80	OK
MEAN	**9.8**	**0.8 - 10.0**	**4.83**	**OK**
VERGOTE	**10.0**	**0.8 - 10.2**	**4.87**	**CAUTION**





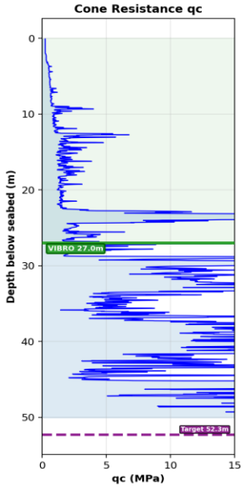


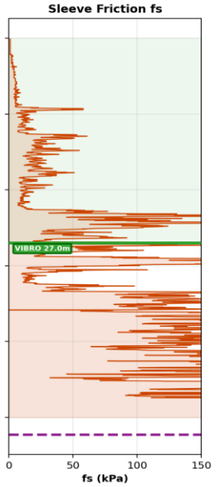


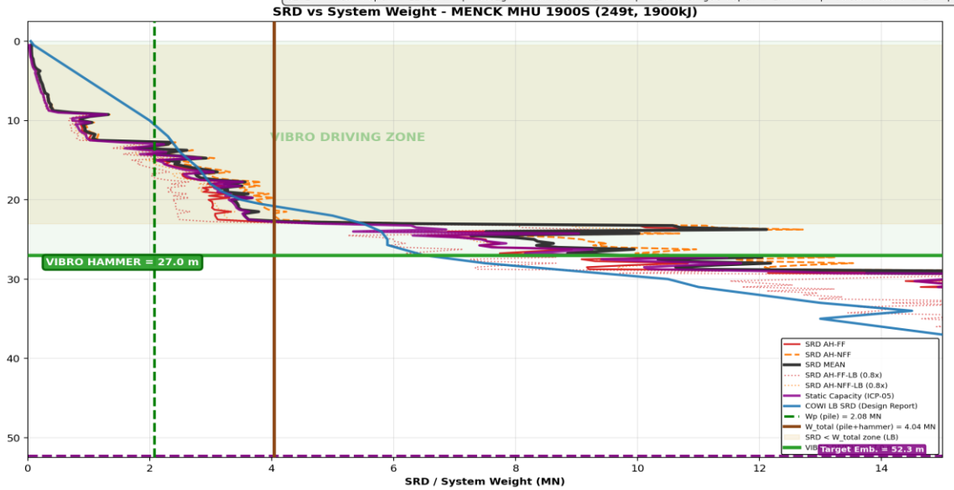
PILE RUN ASSESSMENT - WTG-15

PILE RUN RISK ASSESSMENT - WTG-15 (DP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 53.8 m | Wp = 2.08 MN (2080 kN, 212.0 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 4042 kN (4.04 MN)
SITE: Water depth = 21.18 m | Design embedment = 52.3 m | Vibro target depth = 27.0 m | False floors = 16 | True arrest = 28.7 m

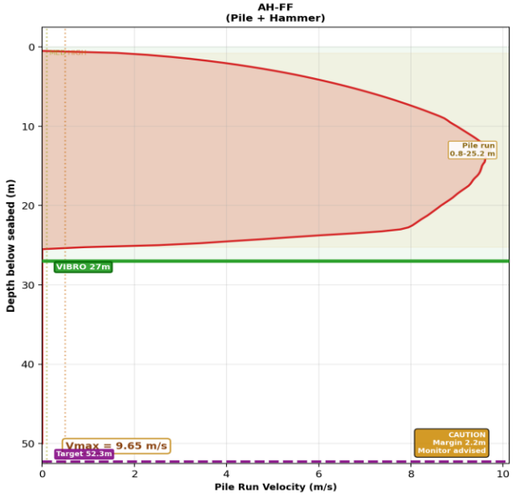


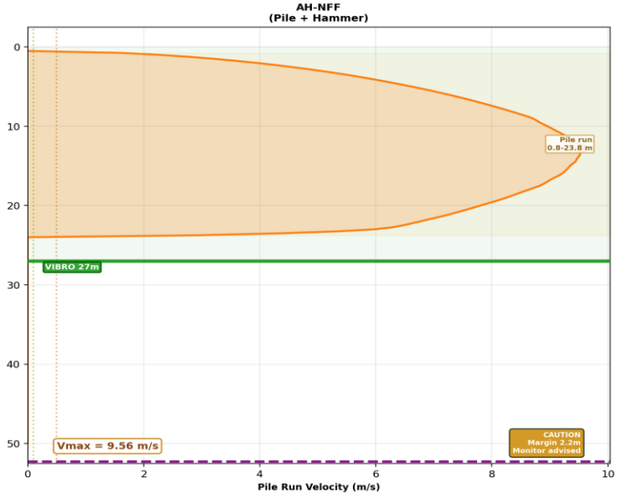


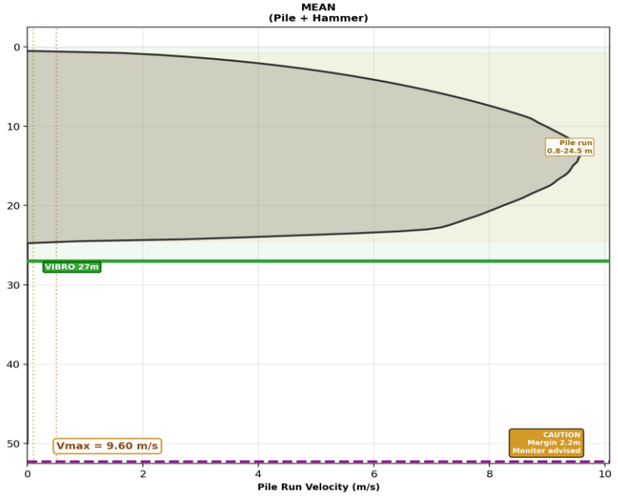


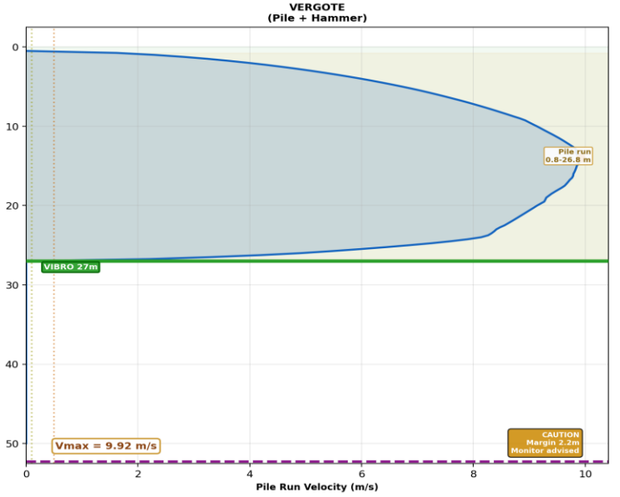
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	23.0	0.8 - 25.5	9.65	CAUTION
AH-NFF	21.5	0.8 - 24.0	9.56	CAUTION
MEAN	**22.8**	**0.8 - 24.8**	**9.60**	CAUTION
VERGOTE	**23.0**	**0.8 - 27.0**	**9.92**	CAUTION





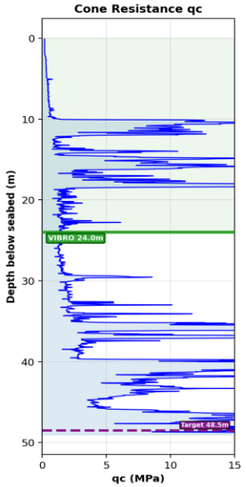


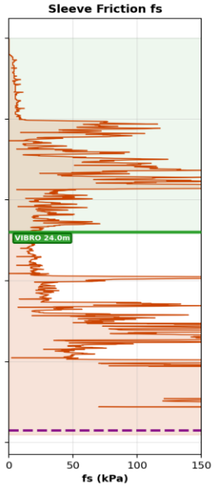


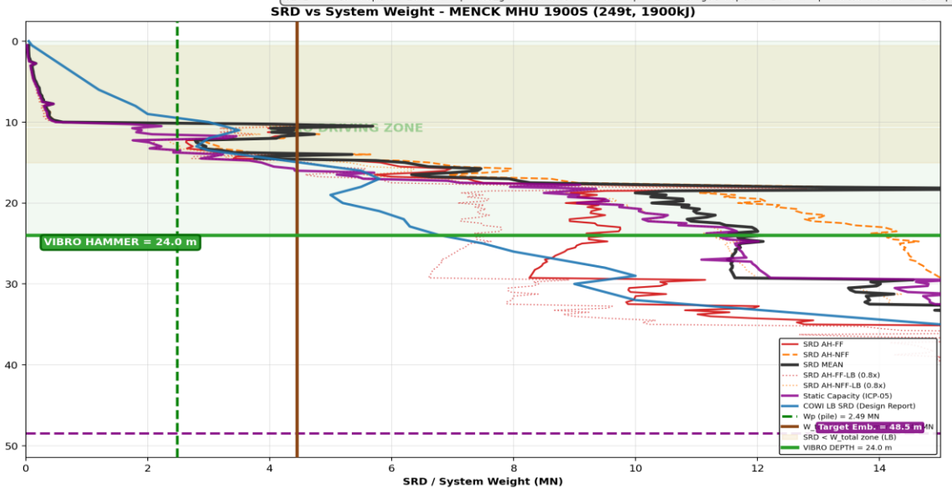
PILE RUN ASSESSMENT - WTG-16

PILE RUN RISK ASSESSMENT - WTG-16 (DP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 50.0 m | Wp = 2.49 MN (2490 kN, 253.8 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 4452 kN (4.45 MN)
SITE: Water depth = 16.98 m | Design embedment = 48.5 m | Vibro target depth = 24.0 m | False floors = 18 | True arrest = 33.8 m

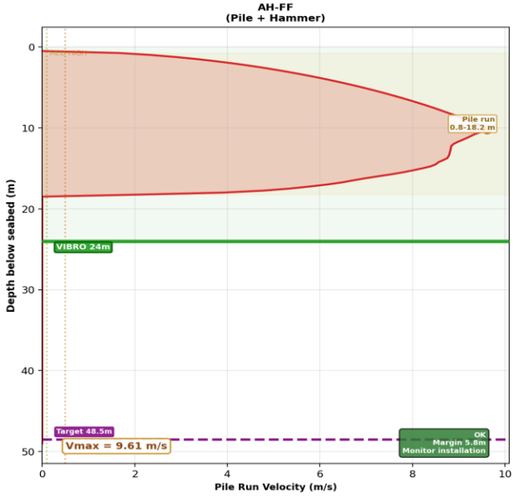


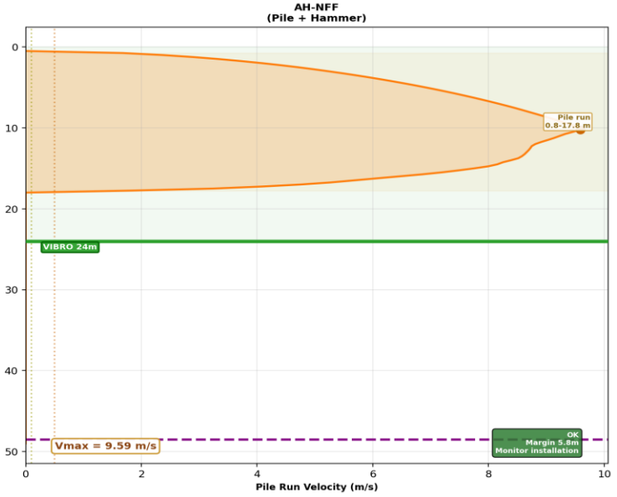


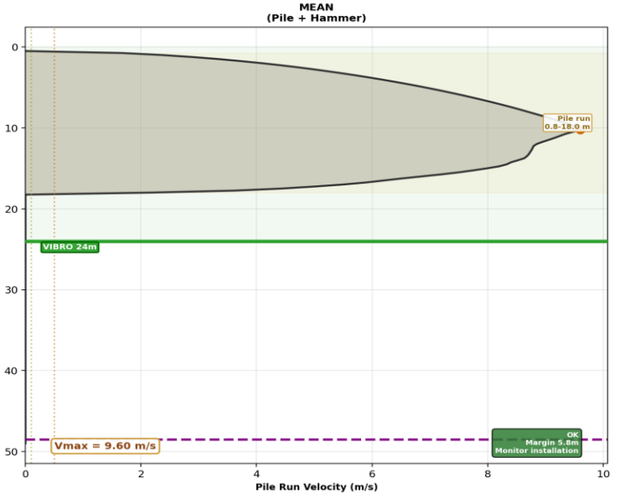


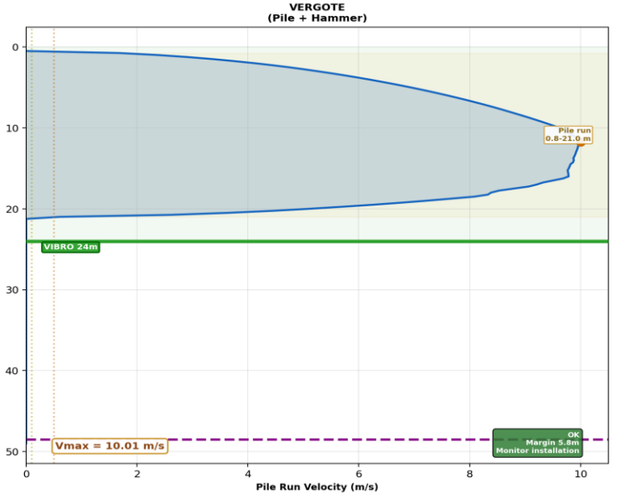
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	10.5	0.8 - 18.5	9.61	OK
AH-NFF	10.5	0.8 - 18.0	9.59	OK
MEAN	**10.5**	**0.8 - 18.2**	**9.60**	**OK**
VERGOTE	**10.5**	**0.8 - 21.2**	**10.01**	**CAUTION**





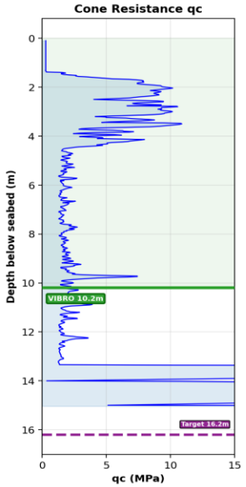


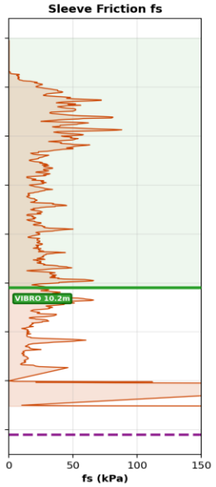


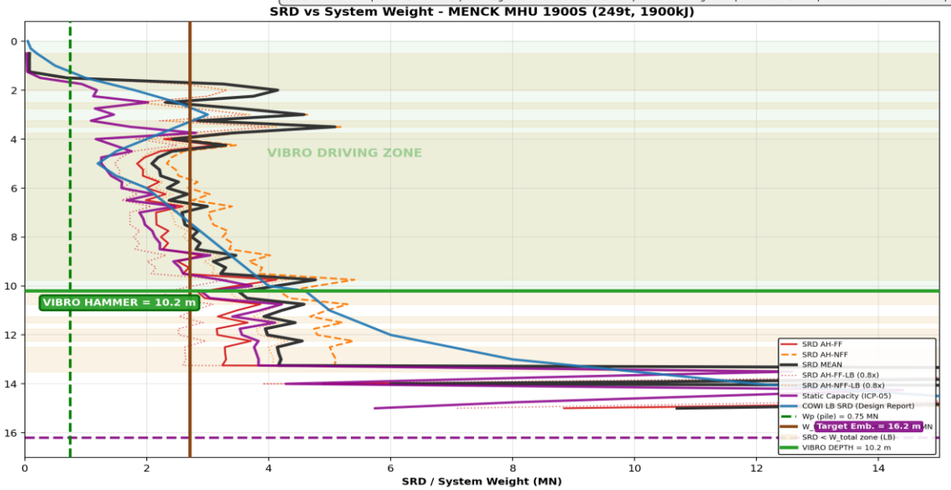
PILE RUN ASSESSMENT - WTG-17

PILE RUN RISK ASSESSMENT - WTG-17 (IP) | Design Report Category: Cat 3
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 17.7 m | Wp = 0.75 MN (750 kN, 76.5 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W_hammer(sub) = 1962 kN | W_total = 2712 kN (2.71 MN)
SITE: Water depth = 23.56 m | Design embedment = 16.2 m | Vibro target depth = 10.2 m | False floors = 16 | True arrest = 13.3 m

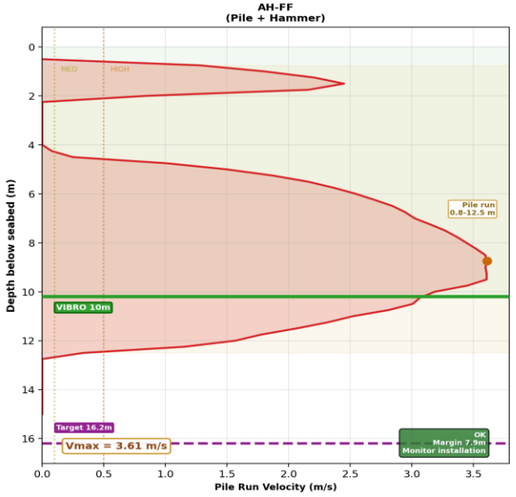


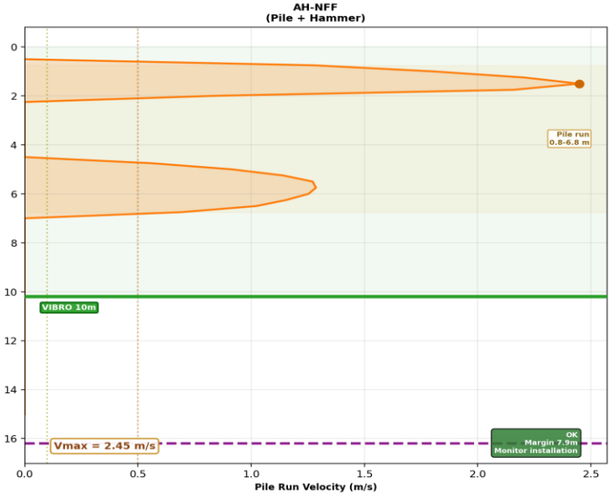


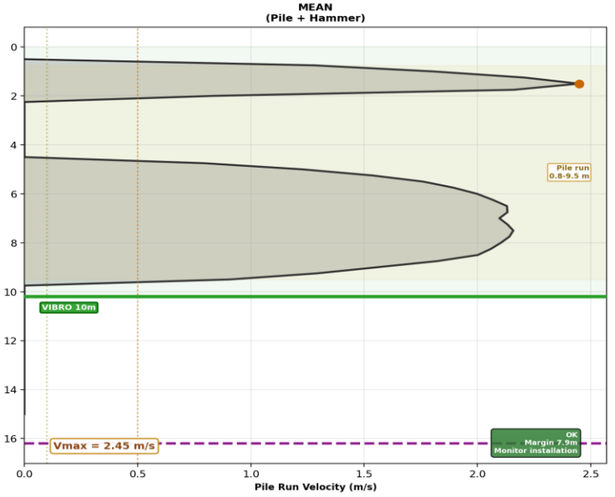


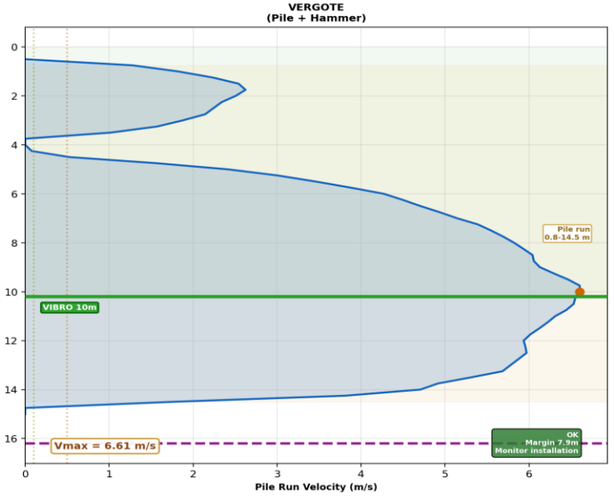
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	1.8	0.8 - 2.2	3.61	ATTENTION
AH-NFF	1.8	0.8 - 2.2	2.45	OK
MEAN	**1.8**	**0.8 - 2.2**	**2.45**	**OK**
VERGOTE	**1.8**	**0.8 - 3.8**	**6.61**	**ATTENTION**





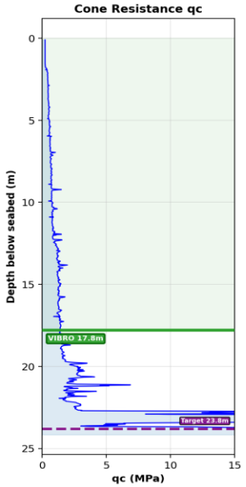


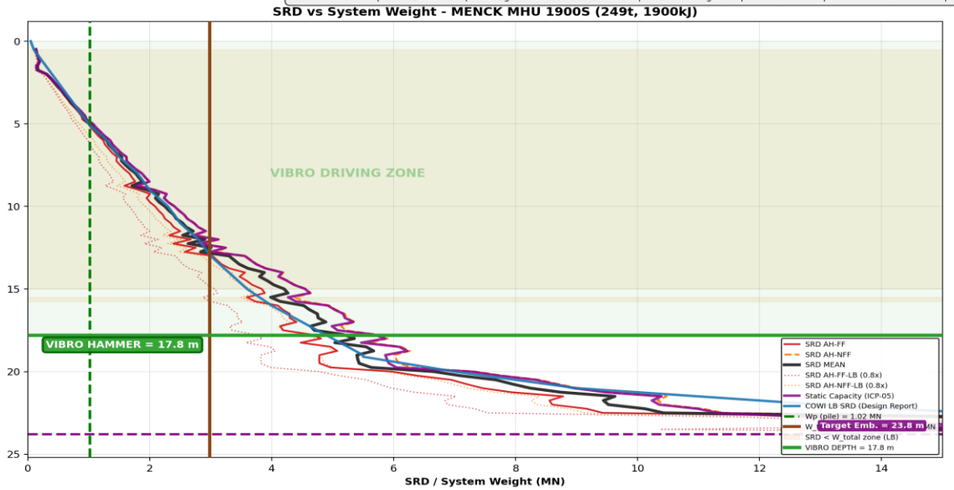


PILE RUN ASSESSMENT - WTG-18

PILE RUN RISK ASSESSMENT - WTG-18 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

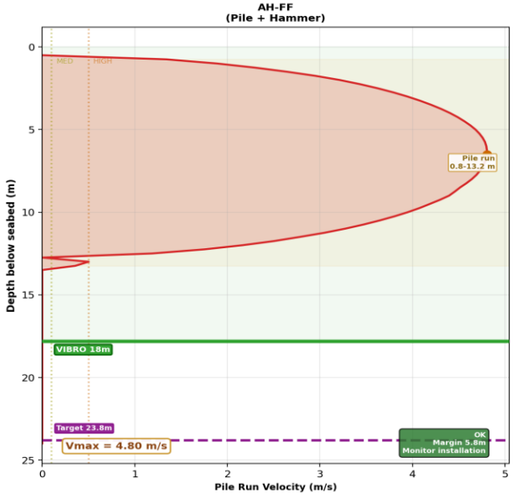
PILE: OD = 3.5 m | WT = 70 mm | Length = 25.3 m | Wp = 1.02 MN (1020 kN, 104.0 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W_hammer(sub) = 1962 kN | W_total = 2982 kN (2.98 MN)
SITE: Water depth = 29.79 m | Design embedment = 23.8 m | Vibro target depth = 17.8 m | False floors = 3 | True arrest = 22.1 m

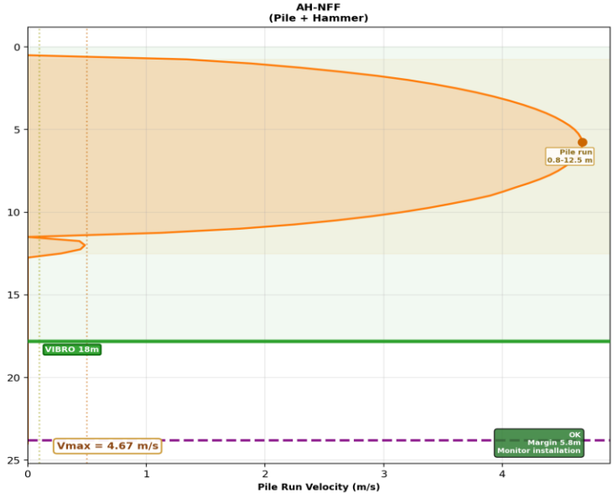


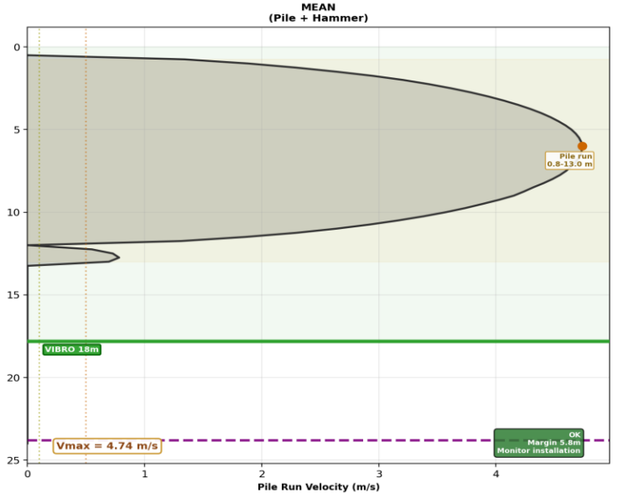


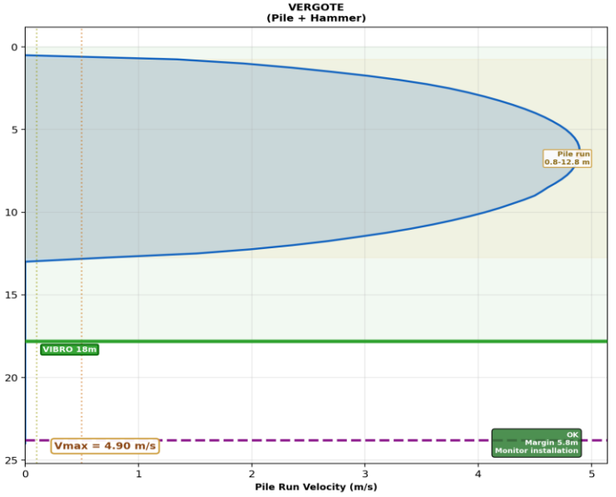
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	13.0	0.8 - 12.8	4.80	OK
AH-NFF	12.0	0.8 - 11.5	4.67	OK
MEAN	**12.5**	**0.8 - 12.0**	**4.74**	OK
VERGOTE	**13.0**	**0.8 - 13.0**	**4.90**	OK





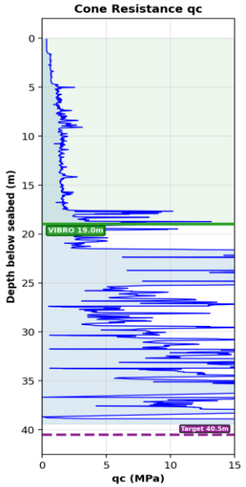


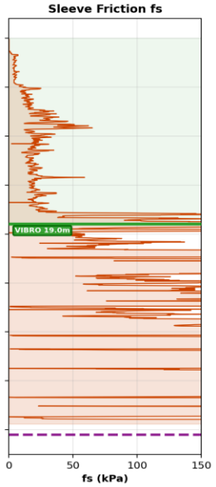


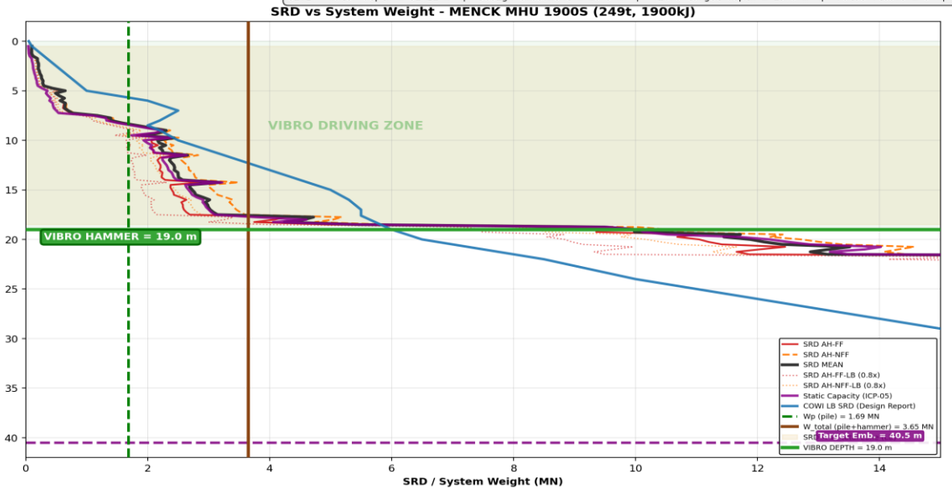
PILE RUN ASSESSMENT - WTG-19

PILE RUN RISK ASSESSMENT - WTG-19 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 42.0 m | Wp = 1.69 MN (1690 kN, 172.3 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3652 kN (3.65 MN)
SITE: Water depth = 31.21 m | Design embedment = 40.5 m | Vibro target depth = 19.0 m | False floors = 8 | True arrest = 38.8 m

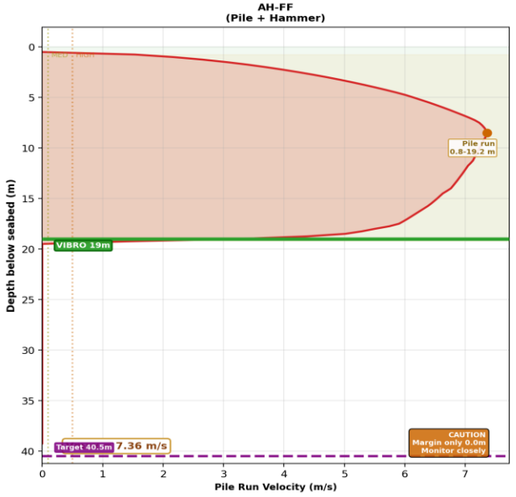


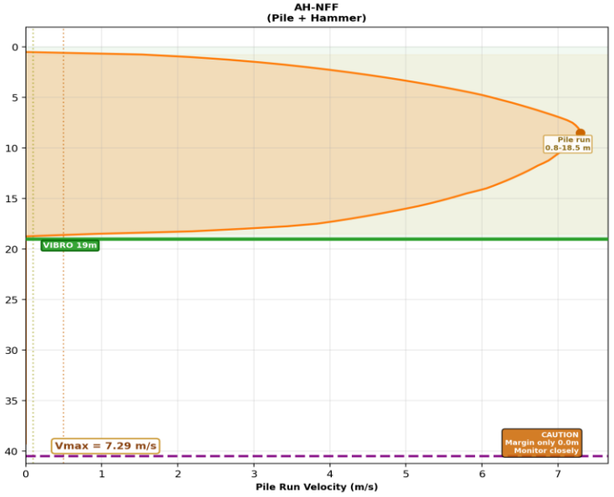


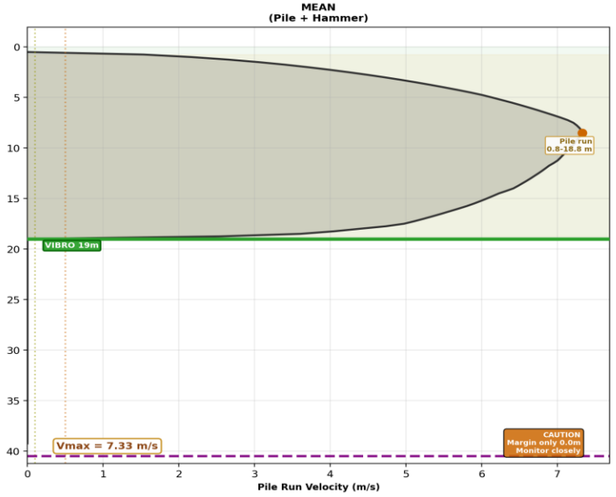


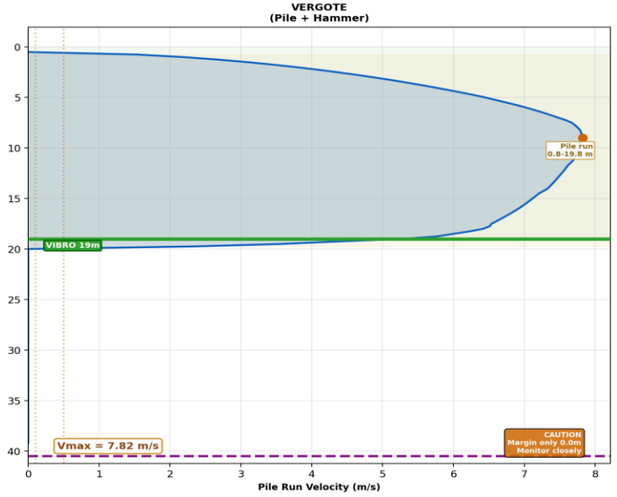
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	17.8	0.8 - 19.5	7.36	ATTENTION
AH-NFF	17.8	0.8 - 18.8	7.29	CAUTION
MEAN	**17.8**	**0.8 - 19.0**	**7.33**	CAUTION
VERGOTE	**17.8**	**0.8 - 20.0**	**7.82**	ATTENTION





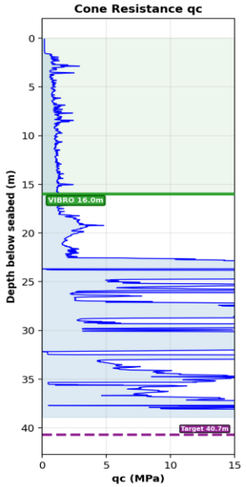


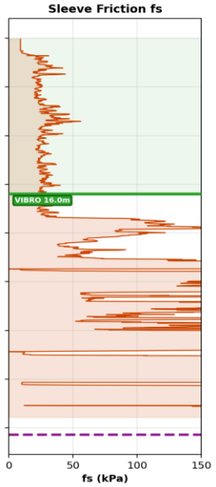


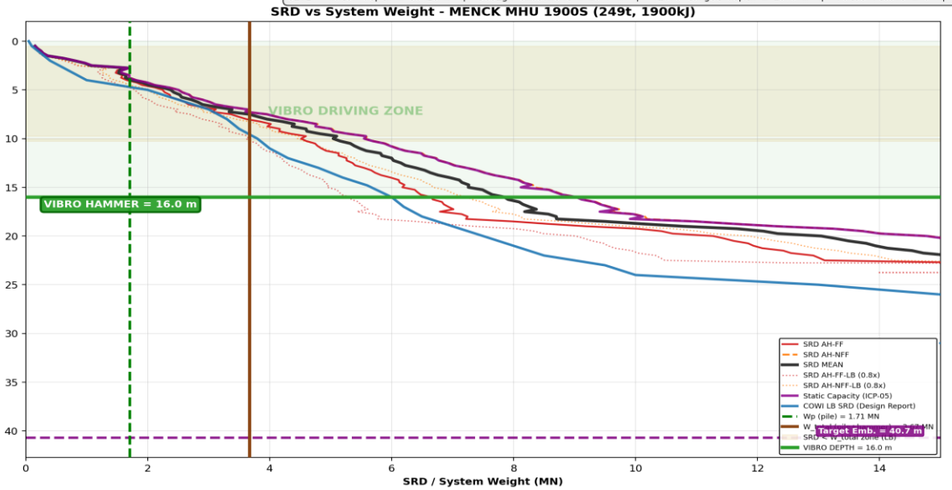
PILE RUN ASSESSMENT - WTG-20

PILE RUN RISK ASSESSMENT - WTG-20 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 42.2 m  |  Wp = 1.71 MN (1710 kN, 174.3 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W_hammer(sub) = 1962 kN  |  W_total = 3672 kN (3.67 MN)
SITE:  Water depth = 30.26 m  |  Design embedment = 40.7 m  |  Vibro target depth = 16.0 m  |  False floors = 6  |  True arrest = 35.6 m
```

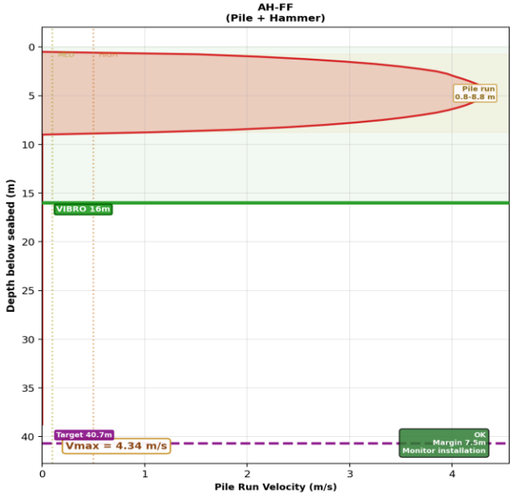


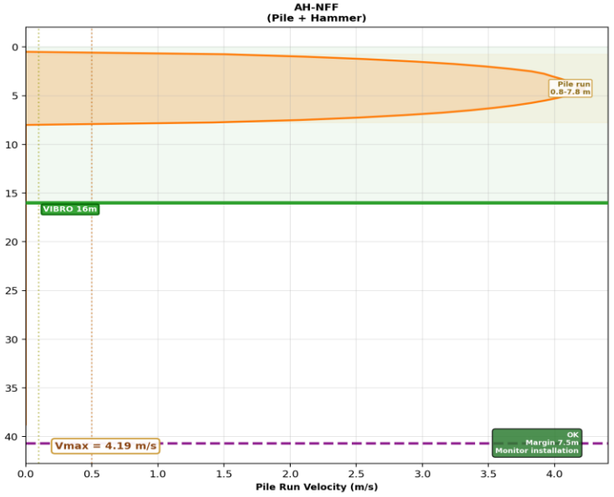


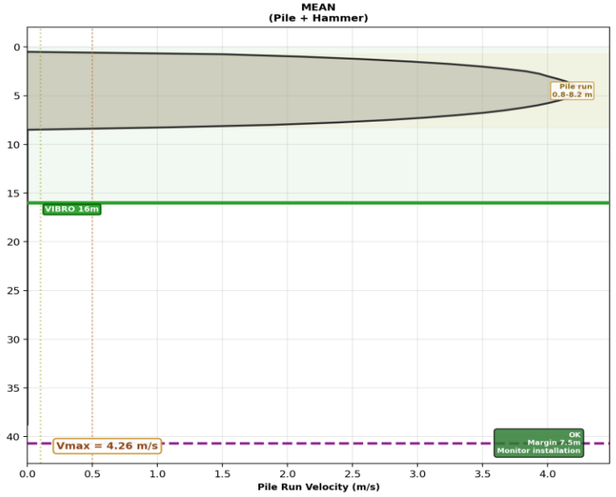


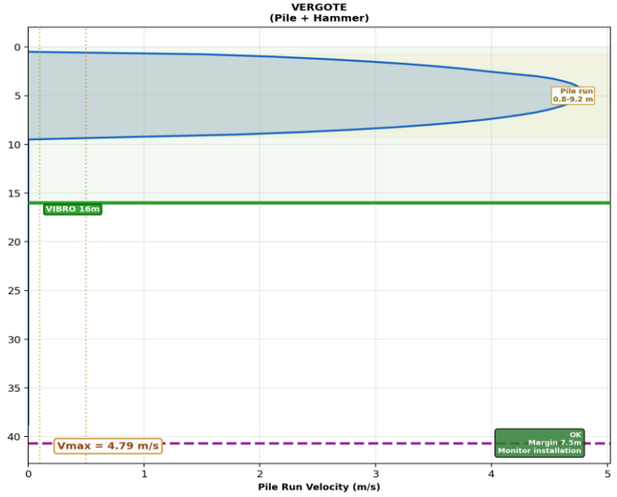
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	8.2	0.8 - 9.0	4.34	OK
AH-NFF	7.5	0.8 - 8.0	4.19	OK
MEAN	**7.8**	**0.8 - 8.5**	**4.26**	**OK**
VERGOTE	**8.2**	**0.8 - 9.5**	**4.79**	**OK**





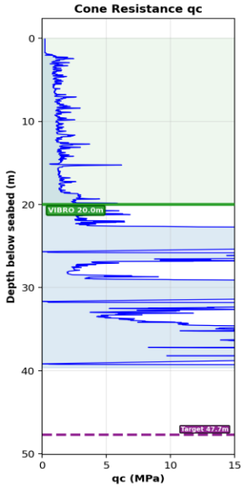


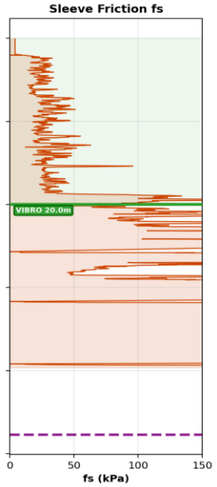


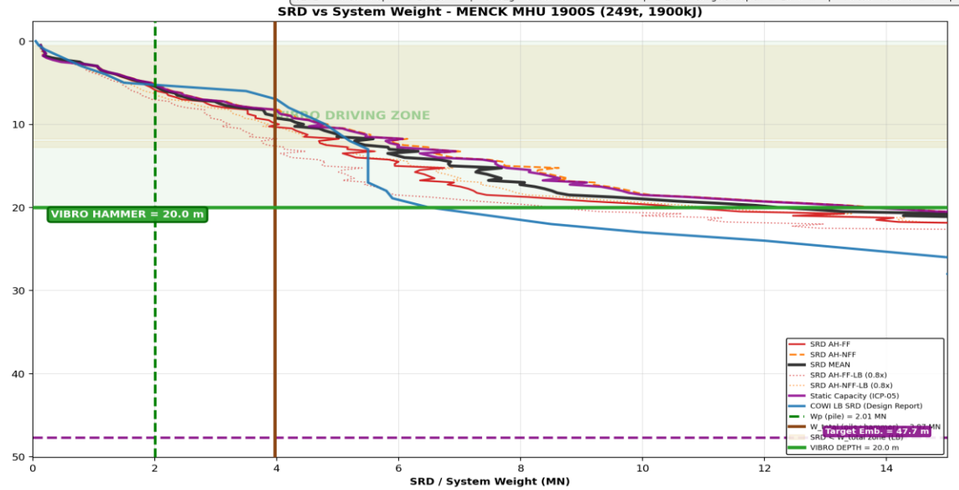
PILE RUN ASSESSMENT - WTG-21

PILE RUN RISK ASSESSMENT - WTG-21 (IP) | Design Report Category: Cat 2
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 49.2 m | Wp = 2.01 MN (2010 kN, 204.9 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 3972 kN (3.97 MN)
SITE: Water depth = 29.18 m | Design embedment = 47.7 m | Vibro target depth = 20.0 m | False floors = 9 | True arrest = 39.2 m

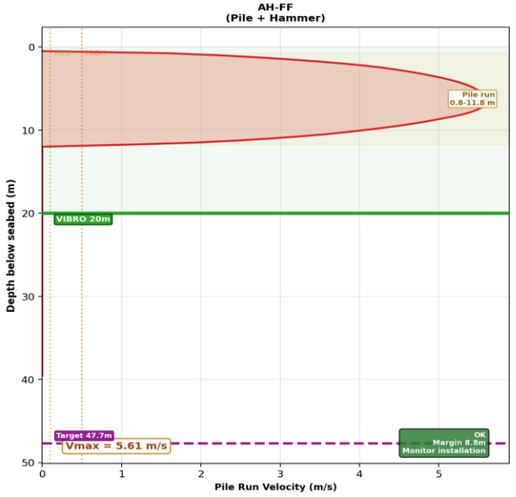


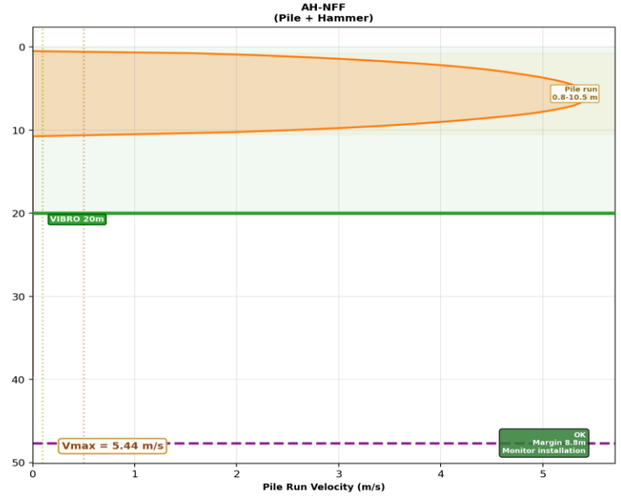


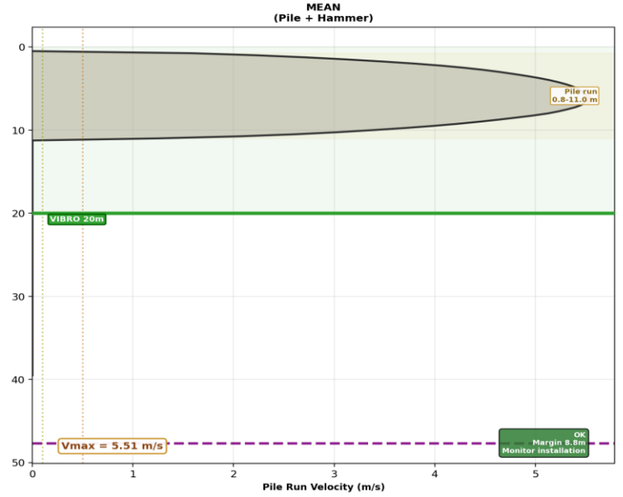


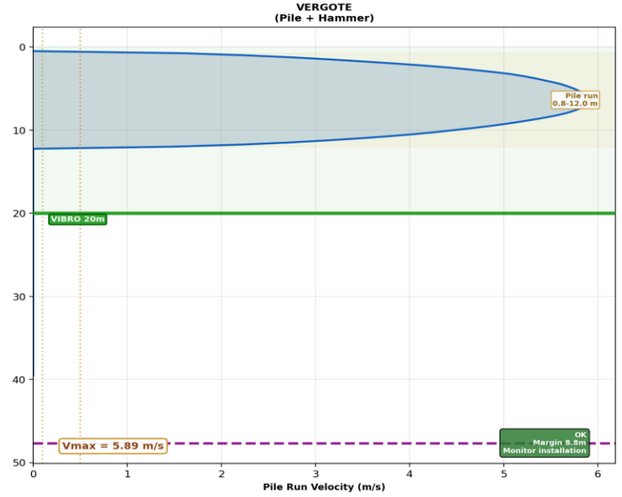
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	10.0	0.8 - 12.0	5.61	OK
AH-NFF	8.2	0.8 - 10.8	5.44	OK
MEAN	**9.0**	**0.8 - 11.2**	**5.51**	OK
VERGOTE	**10.0**	**0.8 - 12.2**	**5.89**	OK





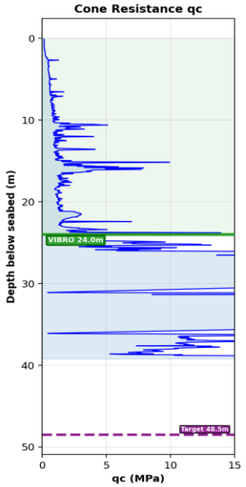


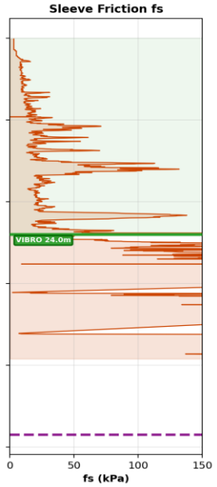


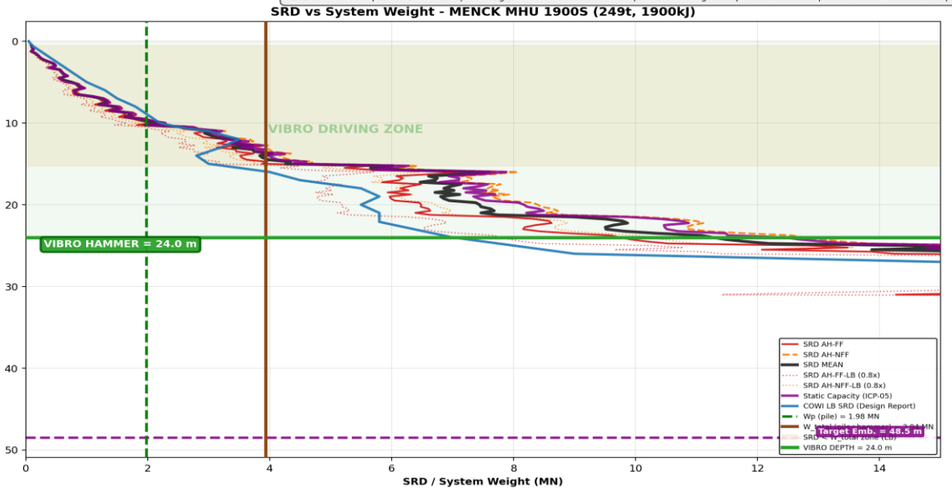
PILE RUN ASSESSMENT - WTG-22

PILE RUN RISK ASSESSMENT - WTG-22 (DP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 51.9 m  |  Wp = 1.98 MN (1980 kN, 201.8 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 3942 kN (3.94 MN)
SITE:  Water depth = 26.04 m  |  Design embedment = 48.5 m  |  Vibro target depth = 24.0 m  |  False floors = 11  |  True arrest = 24.5 m
```

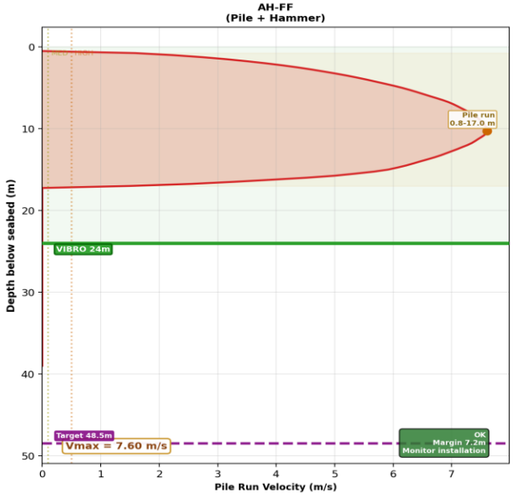


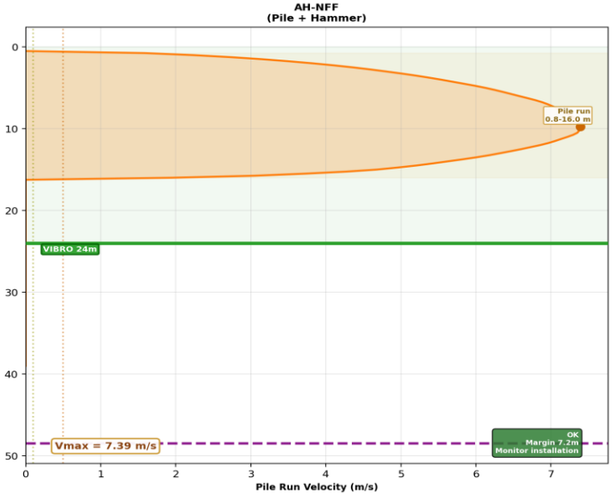


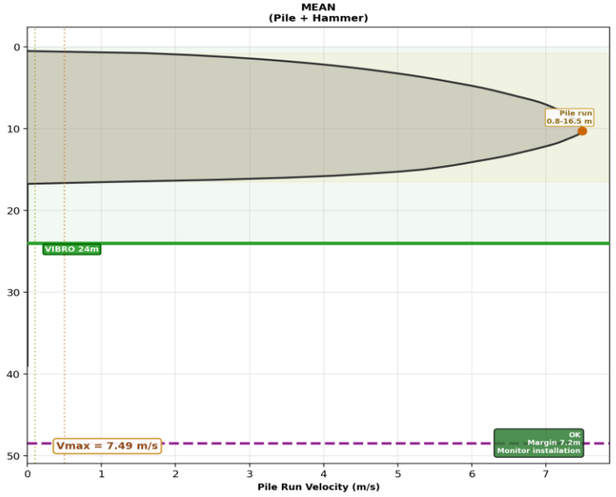


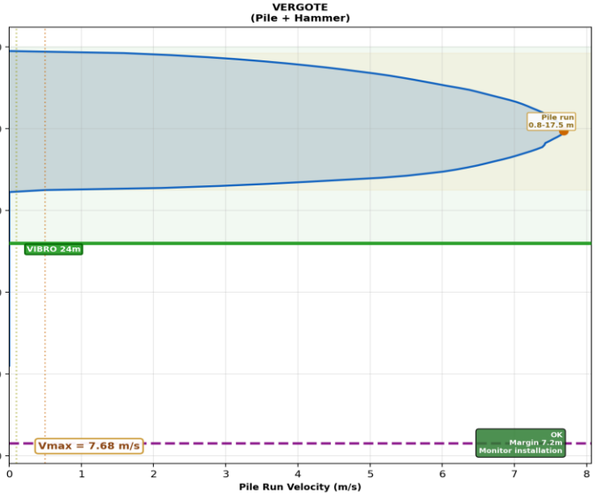
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	14.8	0.8 - 17.2	7.60	OK
AH-NFF	12.8	0.8 - 16.2	7.39	OK
MEAN	**13.8**	**0.8 - 16.8**	**7.49**	OK
VERGOTE	**14.8**	**0.8 - 17.8**	**7.68**	OK





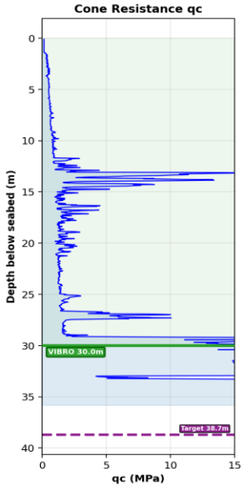


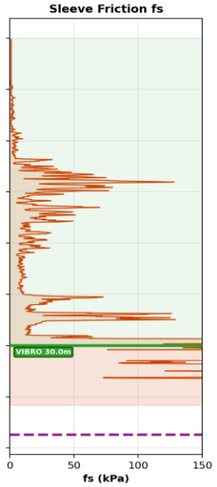


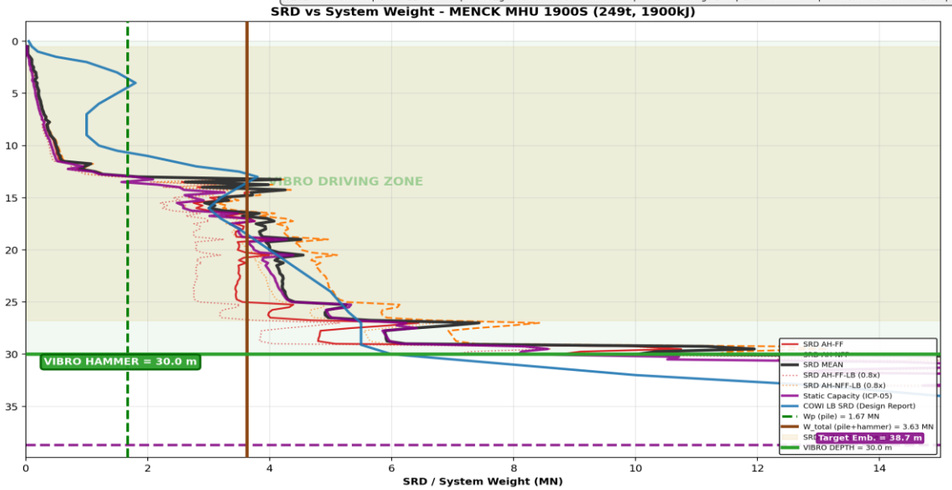
PILE RUN ASSESSMENT - WTG-23

PILE RUN RISK ASSESSMENT - WTG-23 (IP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 40.2 m  |  Wp = 1.67 MN (1670 kN, 170.2 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 3632 kN (3.63 MN)
SITE:  Water depth = 22.00 m  |  Design embedment = 38.7 m  |  Vibro target depth = 30.0 m  |  False floors = 15  |  True arrest = 28.9 m
```

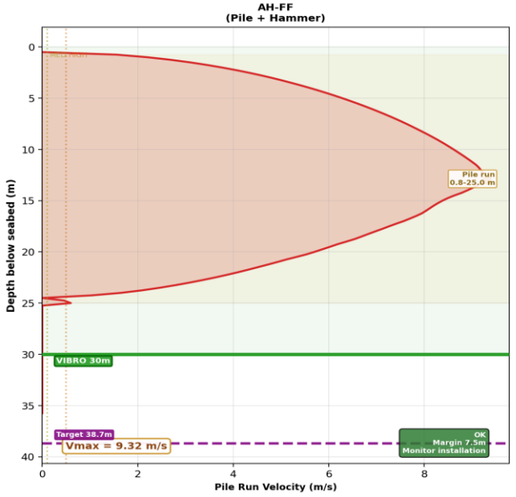


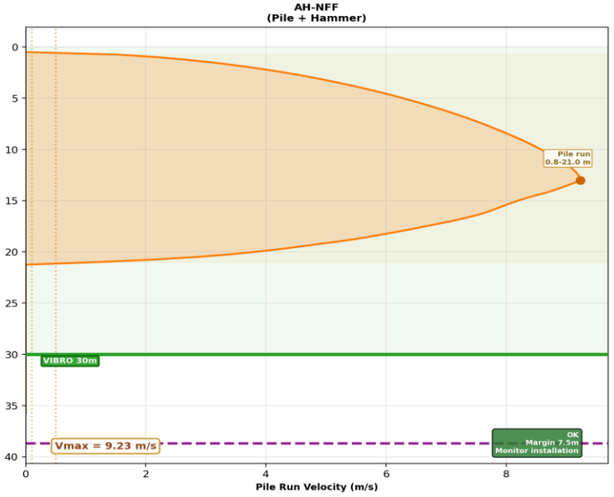


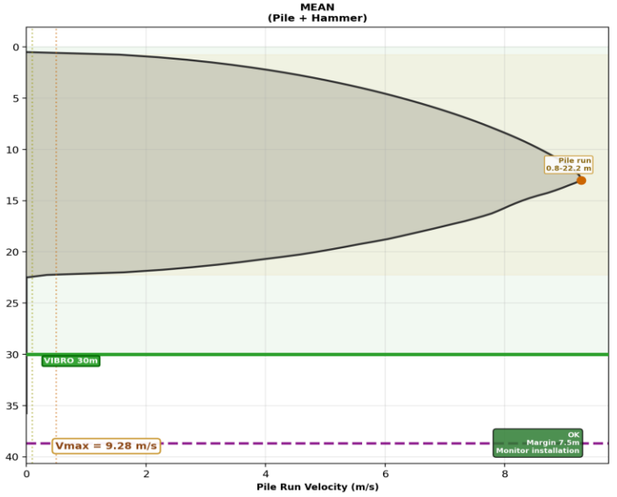


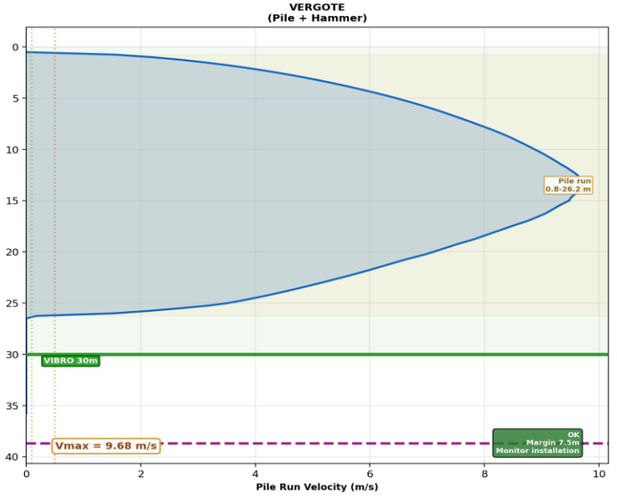
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	13.2	0.8 - 24.5	9.32	OK
AH-NFF	13.2	0.8 - 21.2	9.23	OK
MEAN	**13.2**	**0.8 - 22.5**	**9.28**	OK
VERGOTE	**13.2**	**0.8 - 26.5**	**9.68**	CAUTION





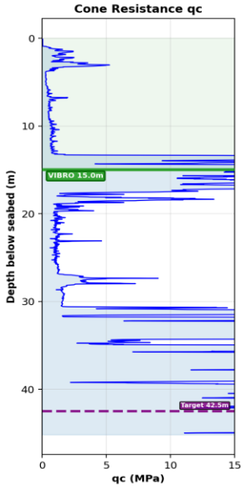


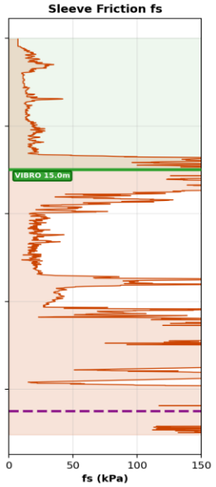


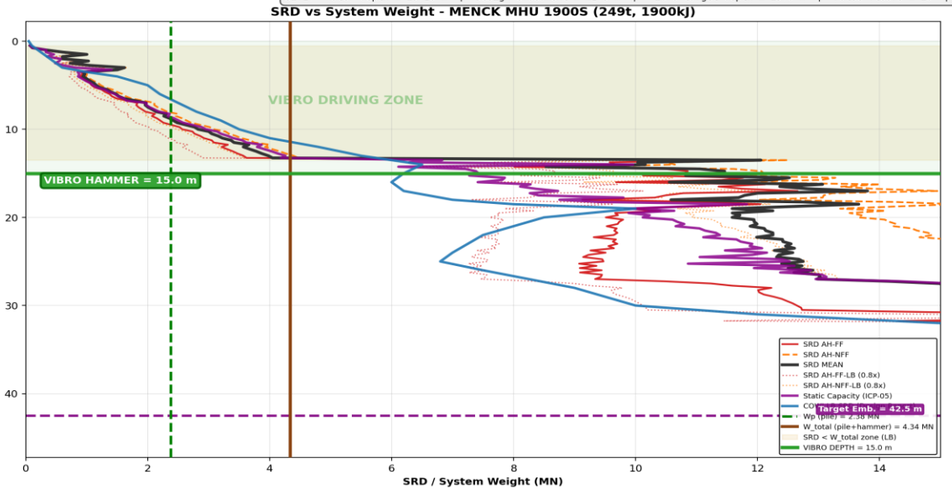
PILE RUN ASSESSMENT - WTG-24

PILE RUN RISK ASSESSMENT - WTG-24 (DP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 44.4 m  |  Wp = 2.38 MN (2380 kN, 242.6 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 4342 kN (4.34 MN)
SITE:  Water depth = 19.26 m  |  Design embedment = 42.5 m  |  Vibro target depth = 15.0 m  |  False floors = 10  |  True arrest = 31.7 m
```

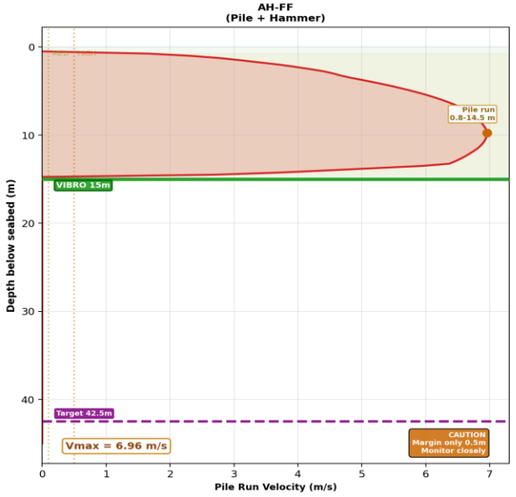


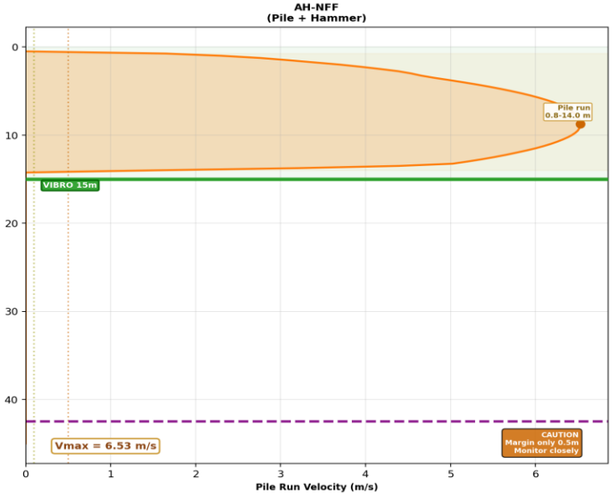


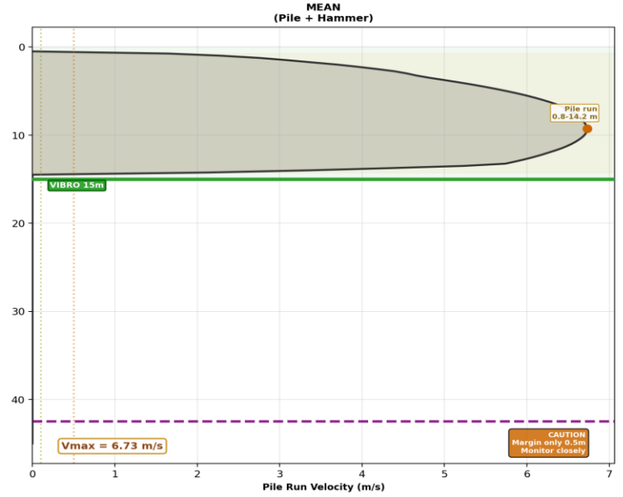


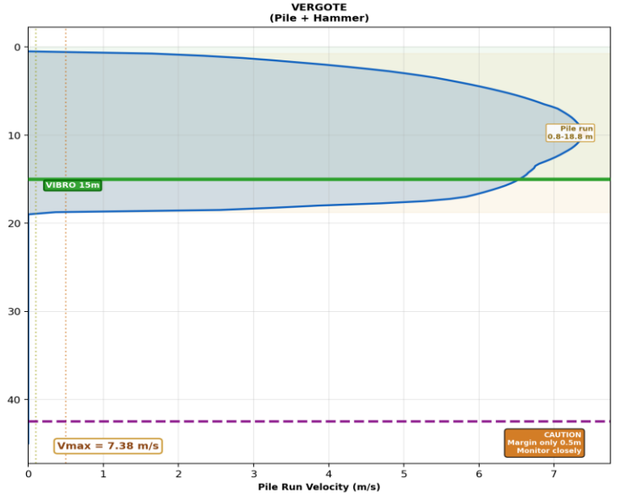
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	13.5	0.8 - 14.8	6.96	CAUTION
AH-NFF	13.0	0.8 - 14.2	6.53	CAUTION
MEAN	**13.5**	**0.8 - 14.5**	**6.73**	CAUTION
VERGOTE	**13.5**	**0.8 - 19.0**	**7.38**	ATTENTION





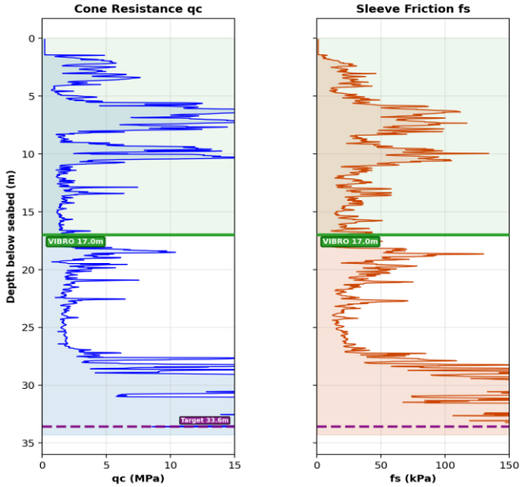


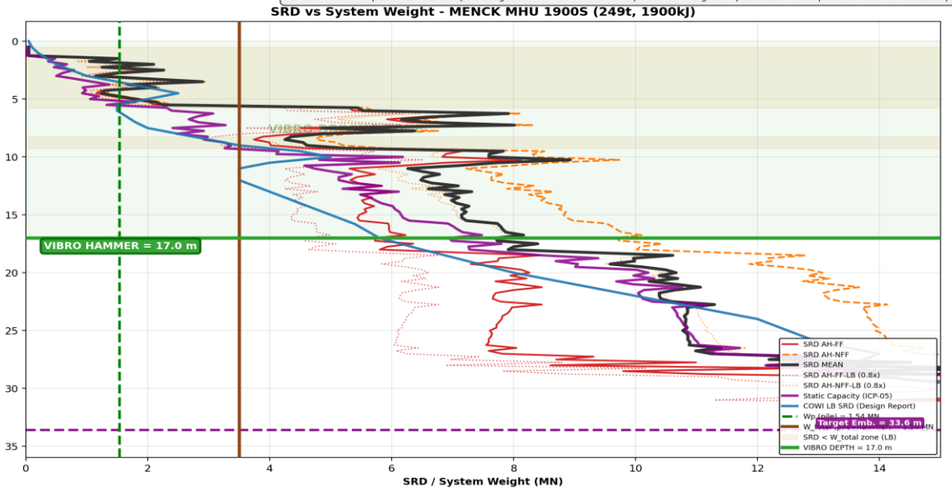


PILE RUN ASSESSMENT - WTG-25

PILE RUN RISK ASSESSMENT - WTG-25 (IP) | Design Report Category: Cat 1
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

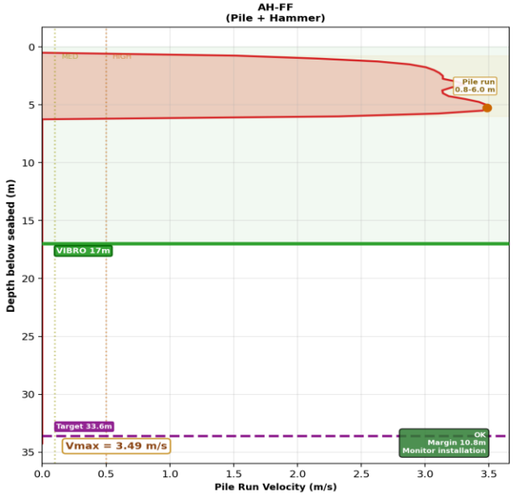
```
PILE:  OD = 3.5 m  |  WT = 70 mm  |  Length = 35.1 m  |  Wp = 1.54 MN (1540 kN, 157.0 t)  [from Design Report AppB]
HAMMER:  MENCK MHU 1900S  |  Energy = 1900 kJ  |  Weight(air) = 249 t  |  W hammer(sub) = 1962 kN  |  W total = 3502 kN (3.50 MN)
SITE:  Water depth = 17.72 m  |  Design embedment = 33.6 m  |  Vibro target depth = 17.0 m  |  False floors = 23  |  True arrest = 26.7 m
```

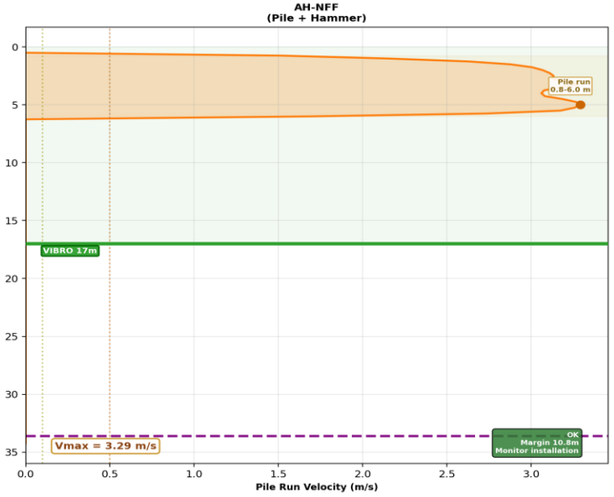


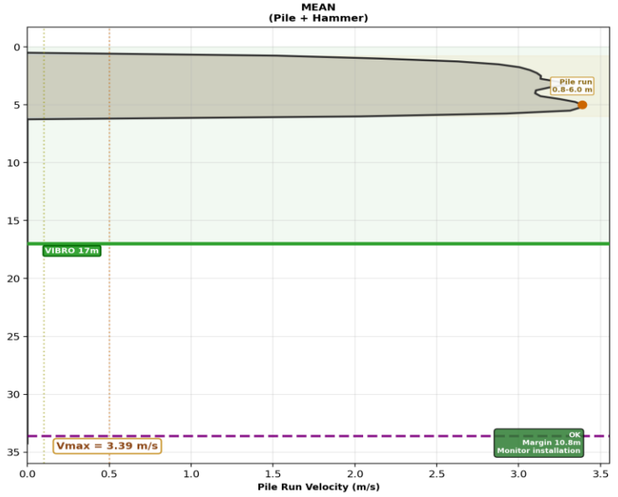


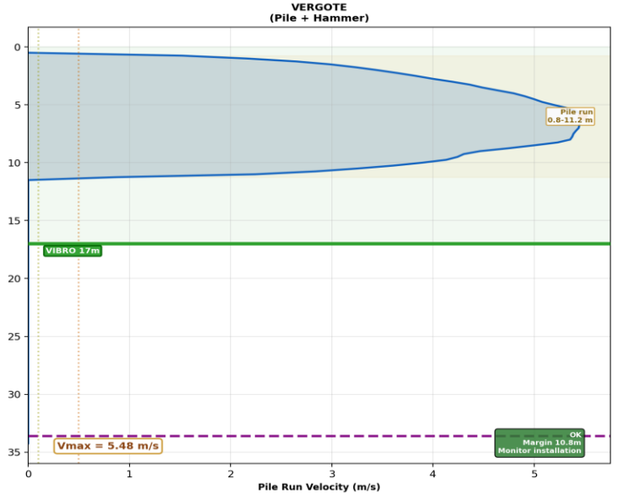
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	5.8	0.8 - 6.2	3.49	OK
AH-NFF	5.8	0.8 - 6.2	3.29	OK
MEAN	**5.8**	**0.8 - 6.2**	**3.39**	OK
VERGOTE	**5.8**	**0.8 - 11.5**	**5.48**	OK





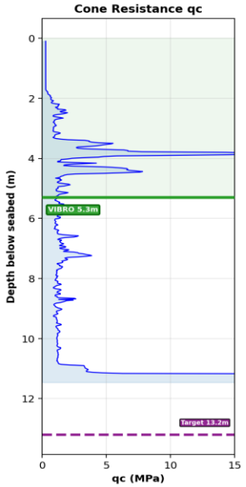


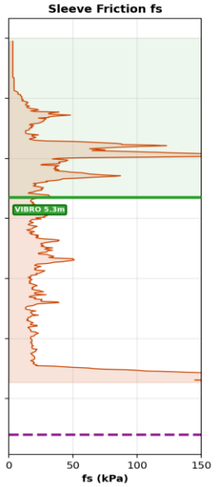


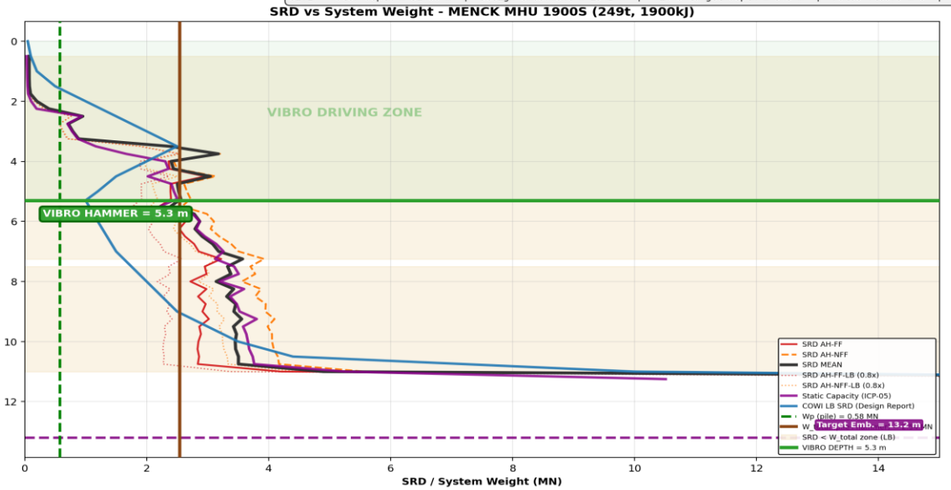
PILE RUN ASSESSMENT - WTG-26

PILE RUN RISK ASSESSMENT - WTG-26 (IP) | Design Report Category: Cat 3
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 14.7 m | Wp = 0.58 MN (580 kN, 59.1 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W_hammer(sub) = 1962 kN | W_total = 2542 kN (2.54 MN)
SITE: Water depth = 31.00 m | Design embedment = 13.2 m | Vibro target depth = 5.3 m | False floors = 6 | True arrest = 10.9 m

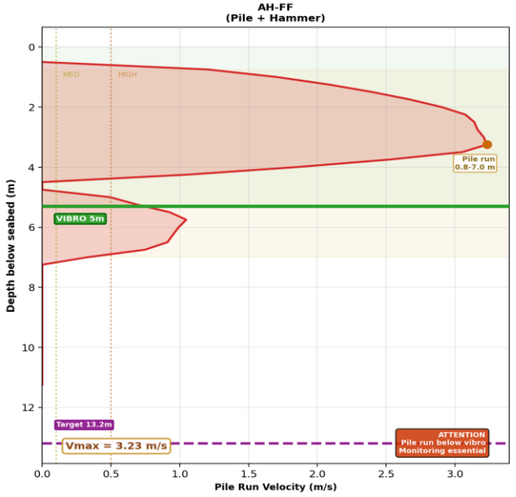


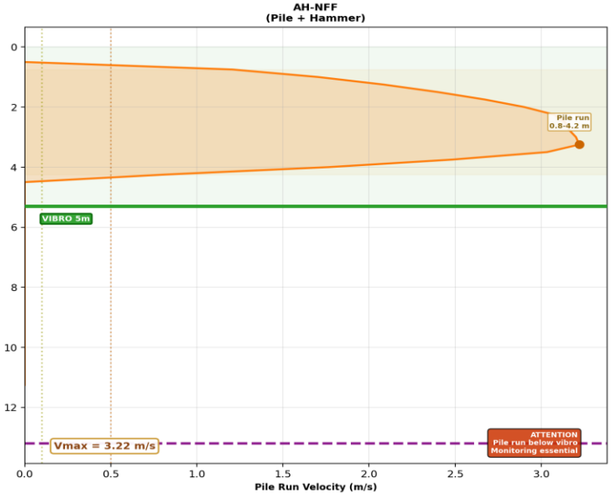


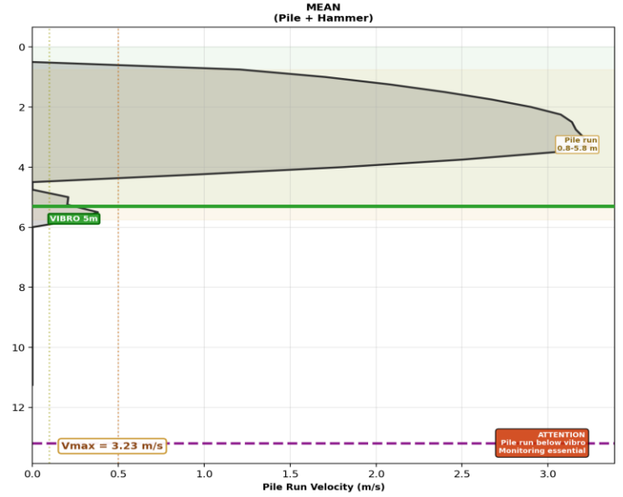


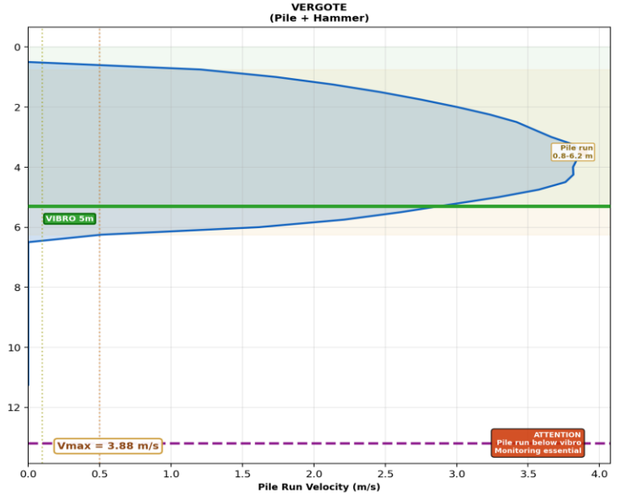
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	3.8	0.8 - 4.5	3.23	ATTENTION
AH-NFF	3.8	0.8 - 4.5	3.22	CAUTION
MEAN	**3.8**	**0.8 - 4.5**	**3.23**	**ATTENTION**
VERGOTE	**3.8**	**0.8 - 6.5**	**3.88**	**ATTENTION**





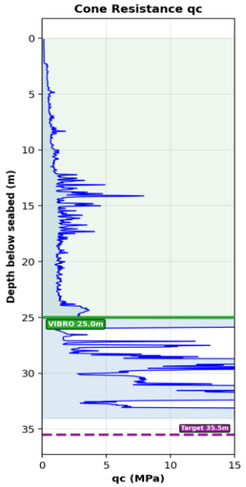


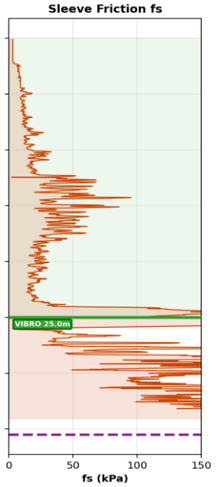


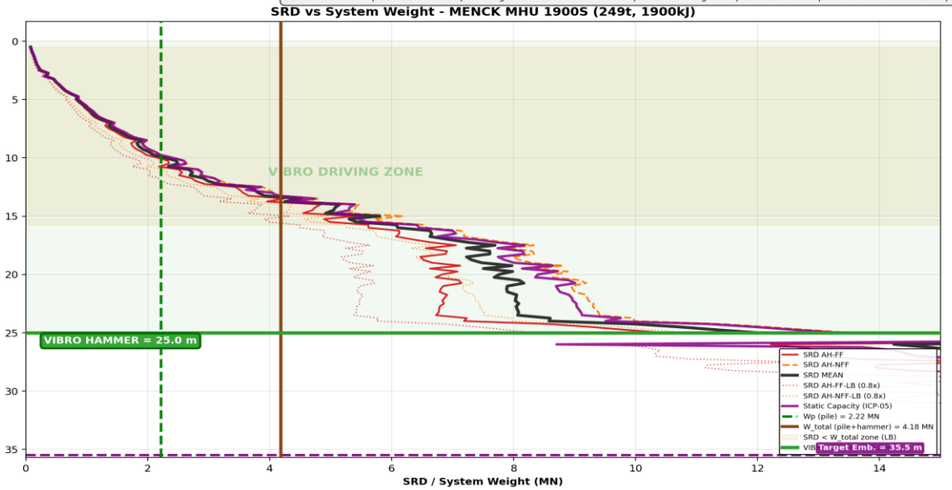
PILE RUN ASSESSMENT - OSS

PILE RUN RISK ASSESSMENT - OSS (OSS) | Design Report Category: N/A
ISFOG2025-516 | Hammer: MENCK MHU 1900S (249t, 1900kJ)

PILE: OD = 3.5 m | WT = 70 mm | Length = 37.5 m | Wp = 2.22 MN (2220 kN, 226.3 t) [from Design Report AppB]
HAMMER: MENCK MHU 1900S | Energy = 1900 kJ | Weight(air) = 249 t | W hammer(sub) = 1962 kN | W total = 4182 kN (4.18 MN)
SITE: Water depth = 26.50 m | Design embedment = 35.5 m | Vibro target depth = 25.0 m | False floors = 16 | True arrest = 27.4 m

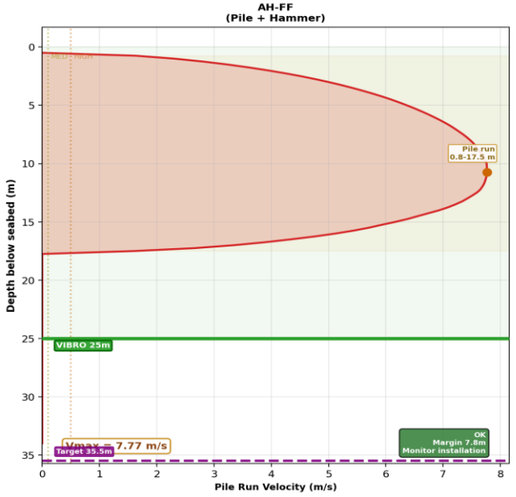


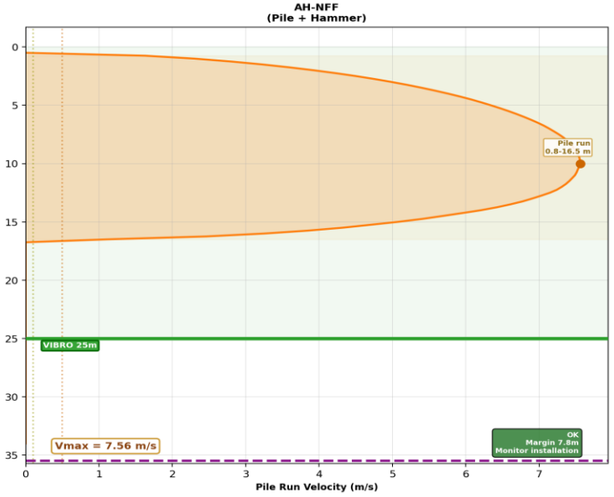


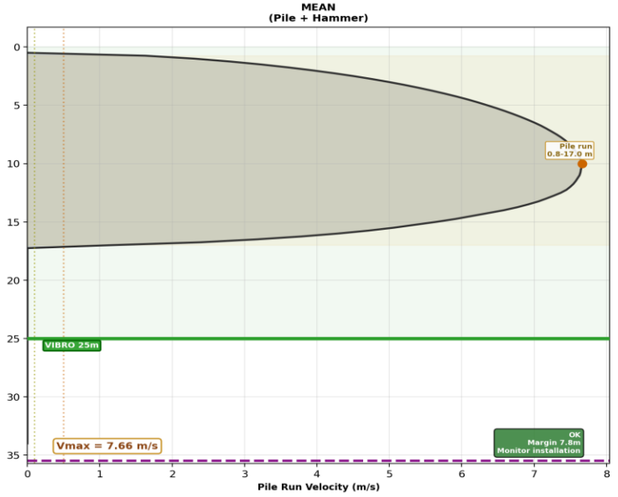


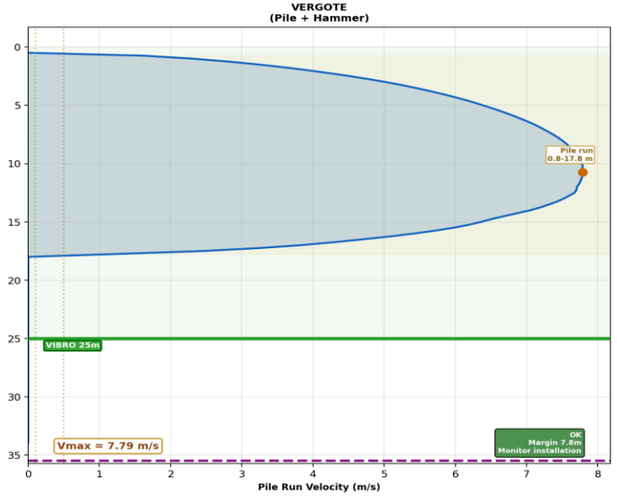
RESULTS SUMMARY

SRD Method	SWP (m)	Pile Run Start-End (m)	Max Vel. (m/s)	Risk
AH-FF	13.5	0.8 - 17.8	7.77	OK
AH-NFF	13.5	0.8 - 16.8	7.56	OK
MEAN	**13.5**	**0.8 - 17.2**	**7.66**	OK
VERGOTE	**13.5**	**0.8 - 18.0**	**7.79**	OK









CONCLUSIONS

Pile run risk has been assessed at all 26 WTG and 1 OSS locations using multiple CPT-based SRD methods (Alm & Hamre 2001) and energy-based pile run dynamics (Sun et al. 2022)

The primary mitigation measure is the use of a vibratory hammer (Cape Holland CV-320-5) to pre-install piles through the soft upper layers to a target depth where soil resistance exceeds the combined pile and impact hammer weight. This mitigation is effective at the majority of locations.

Risk classification based on MEAN SRD (vibro depth margin vs pile run end):

21 locations OK | 5 locations CAUTION (WTG-02, -04, -15, -24, -26) | 1 location ATTENTION (WTG-19)

An additional sensitivity analysis using the Vergote et al. (2025) rate-dependent SRD method confirms that pile run distances could extend 2-5m further in contractive soils due to transition from drained to undrained conditions at high velocities. This supports the use of conservative vibro target depths as specified in the Design Report.

Monitoring of penetration rates during installation is recommended at all locations, with enhanced monitoring and geotechnical supervision at CAUTION and ATTENTION locations (compared to the COWI suggest penetration when possible deeper penetration using vibro hammer is suggested as the deeper penetration would increase any residual risk against pile run)