BMVIT-327.120/0012-IV/IVVS2/2016

# Specification sheet for approval

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|---|---|
| Object of approval: | **ANP – SHS micropile**<br>**Typ H 0420-38, H 0500-38, H 0630-51, H 0800-51**<br>**Typ H 1000-64, H 1200-64, H 1400-76, H 1600-76**<br>**Typ H 1800-76, H 2400-108**<br>**for temporary use and as permanent micropile** |
| Approval holder: | ANP – SYSTEMS GMBH<br>Christophorusstraße 12<br>5061 Elsbethen / Austria |
| Micropile manufacturer: | ANP - SYSTEMS GMBH<br>Christophorusstraße 12<br>5061 Elsbethen / Austria |
| Manufacturer of components: | The individual manufacturers of the components of the micropile system are listed in the supervision contract |
| External control: | bvfs - Bautechnische Versuchs- und Forschungsanstalt Salzburg (research center) |
| Area of validity: | Austrian Republic<br>Federal roads |
| Reference: | ÖNORM EN 14199: 2016<br>Execution of special geotechnical construction work (special civil engineering)-piles with small diameters (micropiles)<br>ÖNORM B 1997-1-1: 2013<br>Eurocode 7- Design, calculation and dimensioning in geotechnics-Part 1-1: General rules, national specifications for ÖNORM EN 1997-1 and national supplements<br>ÖNORM B 1997-1-3: 2015<br>Eurocode 7: Design, calculation and dimensioning in geotechnics-Part 1-3: Foundations construction, pile foundations |

The approval comprises 15 pages and 8 annexes.

The translation from the German original has not been certified by any authorities. The translator is not responsible for any misunderstandings or damages.

# I General terms/regulations

1. The proof of the usability of the object of approval is established by the BMVIT (Federal Ministry of Transport, Innovation and Technology). The approval is granted on the basis of non-harmonized technical specifications and without prejudice to third-party rights.

2. The usability of the object of approval is assessed by the submission of the respective test results and reports in accordance with the respective Eurocodes, norms and guidelines as to the applicable properties and application range.

3. If technical specifications or norms and guidelines are given without issue date in the specification sheet, the current version is decisive.

4. The approval holder is responsible for the building product's conformity with the approval and guarantees all the assured properties.

5. The approval refers only to the building product of the named manufacturer.

6. The BMVIT (Federal Ministry for Transport, Innovation and Technology) is authorized to check at the approval holder´s expense whether the provisions of this approval and the specification sheet are complied with.

7. The approval is not granted irrevocably. Provisions may be amended due to new technical findings and standards.

8. The approval certificate and specification sheet may only be copied in its entirety. Texts and drawings in advertising brochures must not contradict the approval certificate.

# II Special terms/regulations

## Index

## 1 General

The planning, dimensioning, execution, testing and control of hollow bars must be carried out by companies and skilled staff with adequate expert knowledge and experience without exception.

The responsibilities for the planning, dimensioning, execution, testing and control must be agreed by contract for the implementation of a building project. Appropriate records and documentation shall be kept about the micropile system, the micropile production and the installation.

The micropiles at hand are a system approval consisting out of a SHS-hollow bar with a left-handed/ right-handed, cold-rolled thread, a threaded sleeve joint and a threaded end anchorage.

## 2 Reference standards

| | |
|---|---|
| ÖNORM EN 14199: 2016 | Execution of special geotechnical works-micropiles |
| ÖNORM EN 1990: 2013 | Eurocode – Basis of structural design |
| ÖNORM EN 1992-1-1: 2015 | Eurocode 2 – Dimensioning and design of reinforced concrete and prestressed concrete structures – Part 1-1:<br>Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings |
| ÖNORM EN 1993-5: 2012 | Eurocode 3 – Dimensioning and design/construction of steel structures - Part 5: Piles and piling walls |
| ÖNORM EN 1997-1: 2014 | Eurocode 7 – Design, calculation and dimensioning in geotechnics – Part 1: General rules<br>Eurocode 7: Geotechnical design - Part 1: General rules |
| ÖNORM B 1997-1-1: 2013 | Eurocode 7 – Design, calculation and dimensioning in geotechnics – Part 1: General rules – national specifications for ÖNORM EN 1997-1 und national supplements |
| ÖNORM B 1997-1-3: 2015 | Eurocode 7 – Design, calculation and dimensioning in geotechnics – Part 1-3: pile foundations |
| ÖNORM EN 10025: 2005 | Hot rolled products of structural steels - Technical delivery conditions for non-alloy structural steels |
| ÖNORM EN 10080: 2005 | Steel for the reinforcement of concrete - Weldable reinforcing steel - General |
| ÖNORM EN 10083-2, 3: 2006 | Steels for quenching and tempering - Part 2: Technical delivery conditions for non alloy steels; Part 3: Technical delivery conditions for alloy steel |
| ÖNORM EN 10210-1, 2: 2006 | Hot finished structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery<br>Hot finished structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties |
| ÖNORM EN 10293: 2012 | Steel castings for general engineering uses |

| | |
|---|---|
| ÖNORM EN 10297-1: 2003 | Seamless circular steel tubes for mechanical and general enginering purposes - Technical delivery conditions - Part 1: Non-alloy and alloy steel tubes |
| ÖNORM EN 12699: 2013 | Execution of special geotechnical works – displacement piles |
| ÖNORM EN 12501-1, 2:2003 | Protection of metallic materials against corrosion - Corrosion likelihood in soil - Part 1: Protection of metallic materials against corrosion - Corrosion likelihood in soil - Part 2: Low alloyed and non-alloyed ferrous |
| ÖNORM EN ISO 1461: 2009 | Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods |
| ÖNORM EN ISO 15630-1: 2011 | Steel for the reinforcement and pre-stressing of concrete - Test methods - Part 1: Reinforcing bars, wire rod and wire |
| ÖNORM EN ISO 1872-1: 1999 | Plastics- Polyethylene (PE) – molding materials–Part 1: Designation system and basis for specifications |
| ÖNORM EN ISO 1872-2: 2007 | Plastics – Polyethylene (PE) - molding/extrusion materials– Part 2-Preparation of test specimens and determination of properties |
| ISO 1720: 1974 | Rock drilling – Extension rod for percussive long-hole drilling -- Rope-threaded equipments 1 1/2 to 2 in (38 to 51 mm) |
| ISO 10208: 1991 | Rock drilling equipment-left hand rope threads |
| DIN 8061: 2009 | Unplasticized polyvinyl chloride (PVC-U) pipes - General quality requirements and testing |
| DIN 8062: 2009 | Unplasticized polyvinyl chloride (PVC-U) pipes - Dimensions |
| ÖNORM EN 445: 2008 | Grout for prestressing tendons - Test methods |
| ÖNORM EN 446: 2008 | Grout for prestressing tendons - Grouting procedures |
| ÖNORM EN 447: 2008 | Grout for prestressing tendons - Basic requirements |
| ÖNORM EN 206: 2014 | Specification performance, production and conformity |
| ÖNORM EN ISO 9001: 2009 | Quality management systems-Requirements |
| ETAG 013: 2002 | Guideline for European technical approval of post-tensioning kits for prestressing of structures |
| RVS 08.22.01: 2013 | Grouted anchors, tensioned grouted piles and nails /pressure-grouted anchors, piles and nails |

## 3 Description of the ANP - SHS micropile system

The ANP – SHS micropile (self-drilling hollow bar) uses as a load bearing element an entirely screwable hollow bar with cold-rolled left-handed circular thread (type R) and a right-handed and a double-threaded round thread (type RR) for the special use in geotechnics.

The ANP - SHS micropile system comprises the following types:

- H 0420-38, H 0500-38
- H 0630-51, H 0800-51
- H 1000-64, H 1200-64
- H 1400-76, H 1600-76, H 1800-76
- H 2400-108

Explanation:

H means– hollow bar with cold-rolled thread
Number 420 to 2400 – nominal value of maximum load in KN
Number 38, 51, 64, 76 and 108 - Ø nominal diameter of hollow bar in mm

The pile head consists of a square pile plate which is locked - hand-tightened - with nuts (hex nuts and lock nuts).

An extension of the load bearing element is achieved with a threaded sleeve which is locked via the drill's percussion drill device.

The ANP-SHS micropile is a hollow bar made of quenched and tempered steel with a rolled round thread on its entire length. The pile is drilled in with a lost drill bit by percussive rotary drilling. The hollow bar is used for flushing with water, air, anchor mortar or cement grout during the drilling procedure.

The hollow bar and the drill bit are also used to fill the annulus or flushing canal with anchor mortar or cement grout. The filling of the annulus can be done simultaneously with the drilling of the pile with a rotary injection adapter or later – only when the borehole is stable – with an injection adapter that is screwed on the hollow bar. The grout body that is formed after reaching the set depth serves for load transmission to the borehole wall. The pile can also be driven with an appropriate pile shoe and can be grouted at the same time.

Types of pile systems:

- Temporary micropiles (short-time use) with service life up to 2 years
- Permanent micropiles with a planned service life up to 50 years depending on soil conditions and corrosion

In case of more stringent requirements with regard to the longer service life, also hot-dip galvanized micropiles can be delivered. Exposed component parts are galvanized as well.

The information about service life cannot be interpreted as a guarantee furnished by the manufacturer or approval authority. The information should merely be seen as a resource to choose the right product in view of the expected, economically adequate service life of the bearing structure.

The specification sheet's area of application is Austria. If used for building purposes anywhere else the local construction standards and regulations have to be complied with.

The following annexes include details about the ANP-SHS micropile system:

| | |
|---|---|
| Annex 1: | Drawing of the micropile system with pile head alternatives, pile neck reinforcement and center distance and edge distance |
| Annex 2: | Specifications, geometry, nominal dimensions, nominal weights and strength properties of the ANP - SHS bar type R |
| Annex 3: | Specifications, geometry, nominal dimensions, nominal weights and strength properties of the ANP - SHS bar type RR |
| Annex 4: | Design values for ultimate limit state with respect to different consequences classes and admissible test loads according to ÖNORM B 1997-1-1 as well as loss of load capacity due to of corrosion |
| Annex 5 - 7: | Accessories and components of the corrosion protection system with dimensions and material information |
| Annex 8: | Installation guide for the ANP – SHS micropile |

## 4 Field of application

The purpose of pile foundations is to transmit structural loads to deeper ground layers and/or to limit deformation according to the principles about the execution of geotechnical works. The piles may be used for axial tension, compression and alternating load.

The micropile's application areas are:

- Foundation of structures
- Reinforcement/strengthening of existing structures
- Production of retaining walls out of micropiles
- Ground reinforcement for creation of supporting and retaining bodies
- Uplift piles to avoid floating

The micropile system can be used in cohesive and non-cohesive soils, and in weathered or solid rock. The execution of micropiles is described in ÖNORM EN 14199.

In the drilling and grouting procedure the self-drilling pile is drilled in with a lost drill bit by rotary percussive drilling and grouted. In solid rock the borehole can be made without the SHS – bar. In this case the pile is placed after drilling and grouted subsequently.

ÖNORM EN 12699 regulates the driving procedure. Installation via driving is only possible in defined foundation/soil when a pile shoe is used. After the driving procedure the pile is grouted with anchor mortar or cement grout.

The principles for the execution of micropiles are specified in ÖNORM EN 14199 and include details about the execution of pile foundations, foundation soil analysis, construction materials and products, dimensioning aspects, installation of micropiles as well as testing and control. In the annexes of this norm the execution of micropiles is described in detail.

The principles and requirements for planning of structures are stipulated in ÖNORM EN 1990. The principles for dimensioning in geotechnics are specified in ÖNORM EN 1997-1, and rules for the determination of a micropile's external load capacity referring to soil influences are stated. The standard parameters that have to be used for tension piles are specified in ÖNORM B 1997-1-1 and for the pressure piles in ÖNORM B 1997-1-3.

The design parameters of the micropile system for the internal ultimate limit state are defined in ÖNORM B 1997-1-1- and their load capacity is specified with respect to different consequences categories for grouted micropiles under tension in accordance with ÖNORM EN 14199.

ÖNORM B1997-1-3 determines national parameters for the design of piles in terms of their external load capacity and has to be used when piles are used under compression load. Additionally, the norm requires verification by calculation against the uplift of a structure that is attached to a tension pile.

The following principles should be complied with:

- The micropile should be designed in a way to guarantee the load capacity in its effectiveness as a single element. The micropile shall only be used for axial load under tension, compression or alternating load.
- Despite the micropile's effectiveness as a single load bearing element, a redundant construction shall be the objective of a pile foundation.
- In soils that allow a lateral deflection the matter of buckling has to be clarified by way of calculation in which the grout body is not taken into account, or a static test load.
- The foundation structure has to be designed in relation to the load direction into the pile head (additional reinforcement, punching).

# 5 Construction materials and construction products

## 5.1 Load bearing element – SHS bar

As load bearing element for the types R (H0420-38 to H0800-51) a HF longitudinally welded and hot-stretch reduced steel tube with removed burr made of quenched and tempered steel 28Mn6 according to ÖNORM EN 10083-2 is used. The longitudinally welded steel tube complies with the product standards ÖNORM EN 10210-1 and meets the demands of ÖNORM EN 14199.

For the types RR (H1000-64 to H2400-108) a seamless hot-rolled precision steel tube made of quenched and tempered steel 36Mn5 is used. The seamless drawn steel tube complies with the product standards ÖNORM EN 10210-1 and ÖNORM EN 10297-1 and meets the demands of ÖNORM EN 14199.

The self-drilling hollow bar (SHS) type R has a cold-rolled left-handed round thread on its entire length according to ISO 1720 and ISO 10208 respectively.

The thread height is 1.5 mm for types Ø 38 and 1.7 mm for types Ø 51. The thread pitch is 12.7 mm for all dimensions.

The self-drilling hollow bar (SHS) type RR with diameters 64, 76 and 108 has a cold-rolled right-handed and double-threaded round thread on its entire length. The thread for diameters 64, 76 und 108 complies with an internal company standard and has a thread height of 2.1 mm for types Ø 64 and 2.2 mm for types Ø 76 and Ø 108. The pitch is 16.3 mm for all dimensions.

***Annexes 2 and 3*** include a drawing of the thread profile and the main dimensions as well as the strength parameters of the hollow bar. The parameters have been determined according to the requirements for reinforcing steel and comply with EN 10080. The tests have been carried out in accordance with EN ISO 15630-1. When corrosion rates are considered a percentage-wise loss of cross section has to be taken into account in accordance with **Annex 4** and then the design value of the material resistance has to be determined.

The standard length of SHS – bars is 1, 2, 3, 4 or 6 m. For types Ø 76 and Ø 108 maximum delivery length is 4 m. Other lengths are available on request.

In case of more stringent requirements with regard to the service life the SHS-bar is surface-coated by hot-dip galvanization in accordance with ÖNORM EN ISO 1461. The minimum average zinc layer thickness is 85 µm.

### 5.2 Coupling of SHS - bars

The SHS – bars can be coupled by means of threaded sleeves to reach the intended length. The sleeves are made of seamless 42CrMo4 pipes in accordance with ÖNORM EN 10083-3 and they have a center stop. The sleeves are designed in the same way for every nominal diameter of the SHS – bar and designed for the maximum tensile load capacity. ***Annex 6*** includes the relevant sleeve parameters.

### 5.3 Spacers

Spacers made of cast steel C45 according to ÖNORM EN 10083-3 are used to guarantee the required thickness of the anchor mortar/cement grout cover. The minimum cover with anchor mortar or cement grout is 15 mm.

When SHS bars with a length of 3 m are used the spacer is placed at the lower end of the sleeve. With longer SHS bars the spacer is locked with lock nuts every 3m.

### 5.4 Pile head design

The pile head consists of a square pile plate that is fixed between hand-tightened nuts (hex nut and lock nut) and then set in concrete, without and with additional reinforcement.

As material for the pile plate S355J2 according to ÖNORM EN 10025-2 is used. For the Hex nuts C45 steel according to ÖNORM EN 10083-2 is used. The cast iron nuts are made of cast steel C45+QT according to ÖNORM EN 10083-2.

The nuts have the same design for every nominal diameter of the hollow bar and are designed each for the highest tensile load capacity. Suitable pile plates have to be arranged perpendicular to the SHS-bar’s center line.

***Annex 1*** shows the pile head details, ***Annexes 5-7*** include system drawings for the components of the pile head.

The pile connection to the foundation body requires a pile neck reinforcement that is made of a plastic or steel tube to seal a possible construction joint with regard to corrosion protection and to sustain lateral pressure respectively.

| Kind of micropile load [1] | Kind of joint | | | |
|---|---|---|---|---|
| | connection without solid fit | | connection with solid fit [2] | |
| | Temporary micropile | Permanent micropile | Temporary micropile | Permanent micropile |
| Tensile | Plastic tube [3] | Plastic tube [3] | - | Plastic tube [3] |
| Compression | Steel tube [3] | Steel tube [3] | - | Plastic tube [3] |
| Alternating | Steel tube [3] | Steel tube[3] | - | Plastic tube [3] |

1) When piles are used as working piles after a compression load test a steel pile neck casing has to be installed.
2) Solid fit connection joint between grout body and construction concrete. Before concreting dirt/impurities, laitance and loose cement mortar have to be removed and the top surface of the grout body has to be wetted.
3) Embedment of pile neck reinforcement with 100 mm into foundation body.

## 5.5 Anchor mortar/cement grout

Conditional upon the installation process the micropile has a cement grout or anchor mortar cover to the borehole wall. The required minimum cover has to be determined in consideration of aggressiveness classes according to ÖNORM EN 206. Usually the minimum cover is 15mm.

Anchor mortar that complies with ÖNORM EN 14199 is used to form the grout body. The water-cement ratio has to be adjusted to site conditions. Alternatively anchor mortar or cement grout according to ÖNORM EN 445, ÖNORM EN 446 and ÖNORM EN 447 can be used.

## 5.6 Drill bit/pile shoe

The choice of the drill bit and the pile shoe is influenced by following factors:

- SHS-type chosen (bar diameter)
- Length of micropile
- Required cement grout or anchor mortar cover
- Geology

If necessary an authorised expert with relevant specialist knowledge and experience shall be consulted.

The ANP-SHS micropile system works with a lost drill bit. The drill bit which is screwed on the SHS-bar is used to produce the borehole, to form the grout body with anchor mortar or cement mortar and eventually remains in the ground. The SHS-bar serves as drill rod.

For driving, a pile shoe that matches the external diameter of the grout body is used instead of the drill bit. During the driving procedure the pile is injection-grouted via the pile shoe.

Drill bit and pile shoe have no influence on the bearing capacity of the micropile system.

### 5.7 Requirements concerning the load capacity of the micropile system

Following points have to be observed:

- The construction and dimensioning of the ANP-SHS micropile system have to be carried out in accordance with ÖNORM EN 14199 as well as the corresponding Eurocodes and their national annexes.
- The micropile's tension capacity - the system consists of the components hollow bar, pile head and threaded sleeve - shows 100% efficiency with reference to the characteristic breaking load of the hollow bar. Please see ***Annexes 2, 3 and 4*** for relevant characteristic breaking load.
- In case of a failure the system shows ductile forming. It may be induced by a component break or pulling the SHS-bar out of nut or sleeve.
- According to ÖNORM EN 1992-1-1 the rated value of the pile's internal ultimate limit state has to be set with an additional factor for partial safety of 1.15 on to the 0.2% yield strength. That applies to tension and compression piles. Furthermore the national specifications in ÖNORM B 1997-1-1 for tension piles and ÖNORM B 1997-1-3 for compression piles have to be complied with.
- ÖNORM EN 1990 shall be used to determine the ultimate limit state of the piles external load capacity. Soil properties are identified in accordance with ÖNORM EN 1997-1.
- The rated values of the pile system's internal load capacity as tension pile are compiled in Annex 4 for the different consequences categories CC1, CC2 and CC3 in accordance with ÖNORM B 197-1-1.
- At 65% of the yield strength's nominal value, which nearly equals the rated design value range, following displacement values were verified:

  Type R:

  - Slip at sleeve: 0,4 to 0,8 mm
  - Slip at anchorage (tightened by hand): 0,5 to 1,0 mm

  Type RR:

  - Slip at sleeve: 0,4 to 0,5 mm
  - Slip at anchorage (tightened by hand): 0,4 to 0,5 mm

  Values have to be doubled for micropiles under alternating load.

  The tests on the micropile system have been carried out in accordance with ETAG 013, ISO 15835-1, 2 respectively.

- The fatigue strength of the pile for $2x10^6$ load changes can be derived from ÖNORM EN1992-1-1 for coupled reinforcing steel with a stress variation of 60 $N/mm^2$ at a maximum force of 60% of the nominal value of the yield force.
- The behaviour under earthquake loads has not been proven.
- The minimum values for the pile's center and edge distances are specified in ***annex 1*** without and with additional reinforcement.

The specified center and edge distances were calculated with consideration of the ETAG 013 requirements for a minimum concrete quality of the foundation structure ≥ C 20/25 according to ÖNORM EN 206-1 and a concrete compressive strength ≥ 25 N/mm² at the time of load transmission.

-For a system with additional reinforcement with an efficiency of 110 % with reference to the nominal value of the hollow bar's ultimate load. The additional reinforcement is also specified in ***Annex 1***.
-For a system without additional reinforcement with an efficiency factor of 130 % with reference to the nominal value of hollow bar's ultimate load.

- The connection of the micropile to the bearing structure has to be designed with reference to the load transmission into the micropile head and load capacity of micropiles according to ÖNORM EN 1992 - 1-1.
- For grout with a prism strength ≥ 50N/mm² a characteristic bond stress of 6 N/mm² has to be set.
- When corrosion rates are considered a percentage-wise cross-section loss has to be taken into account for the proof of load capacity and then the design value of the material resistance has to be determined. ***Annex 4*** includes the relevant values.
- Testing of micropiles has to be carried out with a static load test. Thereby the maximum test loads which are stated in **Annex 4** in accordance with ÖNORM B1997-1-1 must not be exceeded.

  In case of tension piles, 3% of the total number of piles have to be tested, at least a minimum of 3 piles. The test load results from the rated value of the pile's external tensile load capacity and the additional factor for partial safety for the resistance against pulling out according to the consequences categories CC1, CC2 and CC3 as well as allowing for variance for all design situations according to ÖNORM B1997-1-1.

  The external bearing capacity of compression piles has to be determined from the characteristic bearing resistance values and the skin friction values in accordance with ÖNORM B 1997-1-3. The variance factors in ÖNORM B1997-1-1 have to be considered.
- If piles are only used as compression piles the load test should preferably be a static compression test.

# 6 Service life/durability of the micropile system

## 6.1 Corrosion protection

The ANP - SHS micropile system applies the following methods to achieve the desired service life:

Service life up to 2 years for temporary use:

- No further corrosion protection required

Service life up to 50 years for permanent use:

- Allowance for a corrosion rate. Additionally and due to the installation method an encapsulation takes place by forming a grout body with a thickness of at least 15 mm.
- Surface coating by hot dip galvanizing with an allowance for a corrosion rate for corrosion. Additionally and due to the installation method an encapsulation takes place by forming a grout body with a thickness of at least 15 mm

Further corrosion protection requirements have to be derived from a critical evaluation of the structure and ambient conditions.

The slowing down influence of the grout body on the corrosion speed is disregarded. So the inevitably high variance as a result of corrosion can be limited.

Even with an early failure of single elements the bearing capacity of the pile foundation has to be assured.

Consideration of a corrosion rate may only be used with a statistically secured number of piles (redundant system to increase the reliability).

## 6.2 Exposure to corrosion

To assess exposure to corrosion of metallic materials in soils ÖNORM EN 12501 - 1 and ÖNORM EN 12501 – 2 shall be used.

Exposure to corrosion is classified either as

- low
- medium or
- high.

The most important physical and chemical parameters of soils and beding materials are dealt with in ÖNORM EN 12501-2. Annex B of this norm contains detailed information for data collection to classify soils.

Different exposures to corrosion can be evaluated by an informative soil parameter table which deals with the essential soil parameters. These parameters are the basis for a micropile's respective corrosion rate value.

Assessment criteria for exposure to corrosion in soils:

| Soil parameters | Exposure to corrosion in soil | | |
|---|---|---|---|
| | low | medium | high |
| Aeration/ventilation | Moderate to very good | Bad to moderate | Very bad to bad |
| Soil composition | Predominantly sand, gravel, weathered rock (coarse to medium particle ) | High proportion of silt and fine sand, (medium to fine particle) | In certain cases proportions of organic matters; high proportions of clay (fine particle), industrial waste, de-icing salt |
| moisture | low (drainageable) | Generally medium (moist) | Generally high, range between and low and high water level |
| Neutral salinity | low | Possibly above value | Possibly high |
| pH-value | 5 to 8 | 5 to 8 | 5 to 8 |
| Specific resistance in Ωm | > 70 | 10 to 70 | < 10 |

For pH-values < 5 for blank and zinc coated steel and for pH-values > 8 for zinc coated steel there is an uprating to the next exposure category. That means:

low → medium

medium → high

high → limited service life

### 6.3 Surface coating with galvanizing

According to ÖNORM EN 14199 surface coating by hot-dipped galvanizing of the micropile (SHS-bar) to extend service life is provided for. Accessory components are zinc plated.

The hot-dipped galvanized pile starts to corrode only after the zinc layer is gone, and herewith the start of the corrsion process of the underlying bar is delayed so the service life is extended.

ANP-SHS bars are hot-dipped in accordance with ÖNORM EN ISO 1461. Normally the zinc layer coating thickness is ≥ 85 µm.

### 6.4 Corrosion rate

The reference values for the corrosion rate of blank and hot-dipped piles in soils are derived from the results of long-term exposure (see below). Corrosion (in mm) is given for a low, medium and high exposure to corrosion and a service life of 2, 7, 30 and 50 years. There is a rounding of about 0.1 mm. The admissible corrosion of a pile is limited to 1.0mm.

Reference values for corrosion

| Service life in years | **Pile type** | Corrosion in mm when exposed to corrosion | | |
|---|---|---|---|---|
| | | low | medium | high |
| 2 | A | 0 | 0 | 0,2 |
| | B | 0 | 0 | 0,1 |
| 7 | A | 0,2 | 0,2 | 0,5 |
| | B | 0 | 0,1 | 0,4 |
| 30 | A | 0,3 | 0,6 | -- |
| | B | 0,1 | 0,4 | -- |
| 50 | A | 0,5 | 1,0 | -- |
| | B | 0,3 | 0,7 | -- |

Pile type A……blank pile/steel

Pile type B……hot-dipped galvanised pile, zinc coating thickness ≥ 85 µm

ÖNORM EN 1993-5 summarizes details about corrosivity assessment and evaluation of pile corrosion in table 4-1.

The details about thickness loss due to corrosion given in this norm generally agree with the stated values. Micropile norm ÖNORM EN 14199 refers to table 4-1.

***Annex 4*** includes data on the pile's percentage-wise cross-section loss due to pile corrosion. A separate proof for corrosion at the coupler is not required.

# 7 Manufacturing and installation

For the installation of the micropile the RVS 08.22.01 regulations shall be complied with. RVS 08.22.01 points out that it is a prerequisite for the execution of a pile foundation to proof the micropile system's aptitude in time. The execution of works, record keeping and testings must be done according the respective embodiments and test standards.

With reference to ÖNORM EN 1997-1-1 the micropile system's aptitude is proven for federal roads by a BMVIT approval.

**Annex 8** includes an installation guide.

The assembly and installation of the ANP – SHS micropile system has to comply with the approval holder's installation guide and must be executed by skilled staff and technical supervision

# 8 Tests

## 8.1 Material tests and conformity proof

The manufacturer of the micropile parts as well as the completed system kit has to carry out an internal production control according to ÖNORM EN ISO 9001.

The inspection which is based on a supervision contract has to be carried out by an accredited inspection and supervision authority. In this supervision contract also the scope of the company's internal quality control is defined. The inspection comprises a check of the internal production control and a sampling test.

The supervision contract has to be closed between the approval holder and the external control body and has to deal with the manufacturing plants of the individual components of the ANP-SHS micropile system.

An initial inspection has to be carried out in each manufacturing plant. Further inspections have to be carried out at the approval holder's at least once a year. The results have to be documented in a report.

## 8.2 Static pile load tests

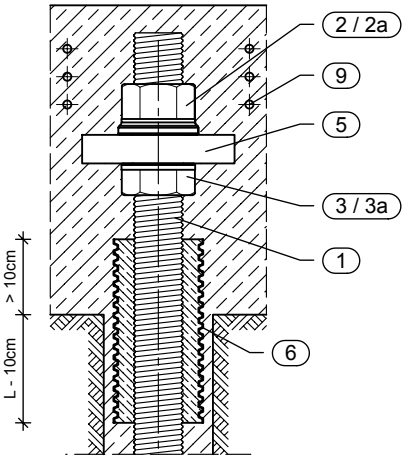
Static pile load tests have to be carried out and documented at the building site according to ÖNORM EN 14199. ÖNORM B 1997-1-1 defines the static test load of micropiles under tension load as suitability test.

The tests have to be executed in accordance with ÖNORM EN ISO 22477-5 (draft). Mere pressure piles have to undergo a static load test under compression if possible.

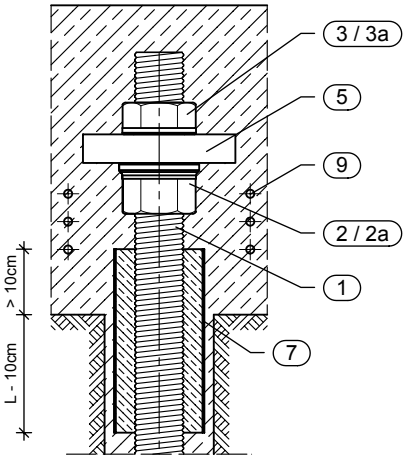
| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 to H 2400-108<br>System drawing: temporary pile und permanent pile<br>pile head variants, center- and edge distance | Annex 1 |
|---|---|---|

## Head detail:

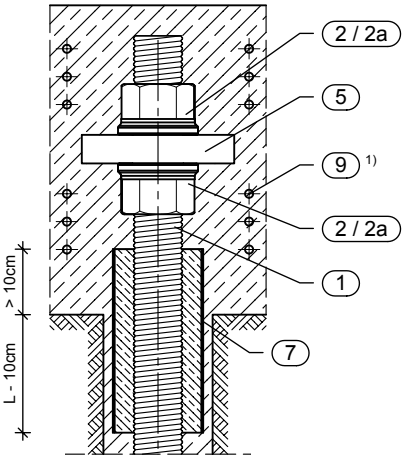
### Tension load



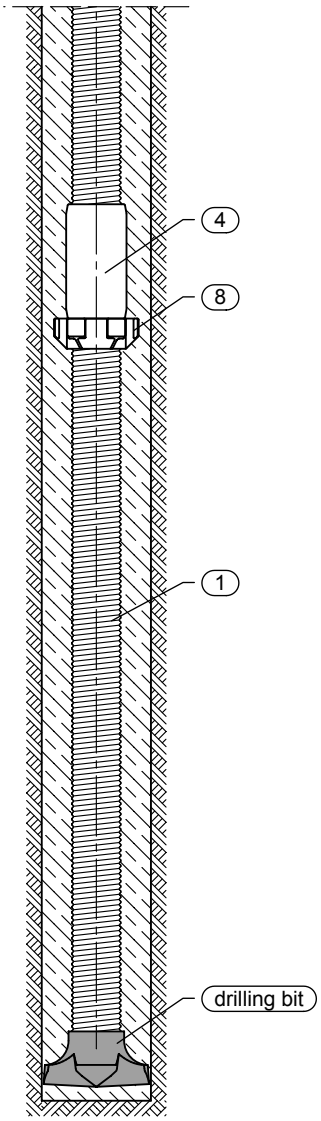

### Compression load




### Alternating load




## Micropile:



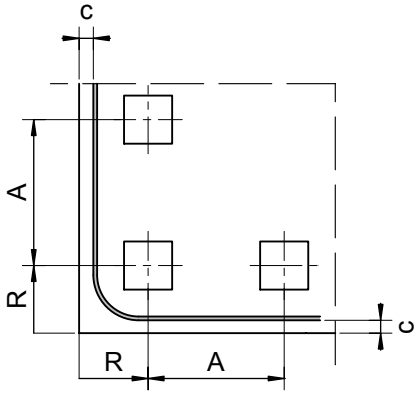

## Center- and edge distances:

Min. concrete quality ≥ C20/25,
Concrete compression strength at the time of load transmission ≥ 25 N/mm²

| type | without additional reinforcement | | with additional reinforcement | | |
|---|---|---|---|---|---|
| | center-distance A mm | edge-distance R mm | center-distance A mm | edge-distance R mm | additional-reinforcement [1] n x Ø / L / a mm |
| H 0420-38 | 220 | 100 + c | 180 | 80 + c | 1 × 8 / 160 / - |
| H 0500-38 | 250 | 115 + c | 220 | 100 + c | 2 × 8 / 200 / 45 |
| H 0630-51 | 290 | 135 + c | 240 | 110 + c | 2 × 8 / 220 / 45 |
| H 0800-51 | 310 | 145 + c | 270 | 125 + c | 3 × 8 / 250 / 45 |
| H 1000-64 | 380 | 180 + c | 310 | 145 + c | 3 × 8 / 290 / 45 |
| H 1200-64 | 430 | 205 + c | 370 | 175 + c | 3 × 10 / 350 / 50 |
| H 1400-76 | 490 | 235 + c | 440 | 210 + c | 5 × 10 / 420 / 50 |
| H 1600-76 | 520 | 250 + c | 450 | 215 + c | 5 × 10 / 430 / 50 |
| H 1800-76 | 550 | 265 + c | 460 | 220 + c | 4 × 12 / 440 / 55 |
| H 2400-108 | 680 | 330 + c | 560 | 270 + c | 5 × 12 / 540 / 55 |

[1] n - number of stirrups, Ø - rod diameter of the stirrup, L - side length of the stirrup, a - distance of the stirrups,
In case of alternating load the stirrups have to be arranged above and underneath the flat pile plate

| | |
|---|---|
| 1 | SHS- bar |
| 2 | Hexagonal nut |
| 2a | Hexagonal nut cast |
| 3 | Lock nut |
| 3a | Lock nut cast |
| 4 | Coupler |
| 5 | Flat pile plate |
| 6 | Plastic tube |
| 7 | Steel pipe |
| 8 | Spacer steel/plastic |
| 9 | Additional reinforcement |



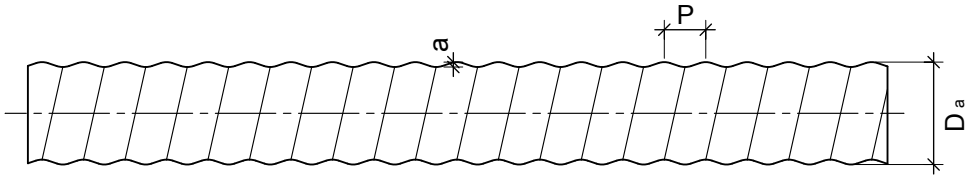
| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 bis H 2400-108<br>Specification, geometry, nominal size, nominal weight<br>strength properties of the ANP - SHS bar type R | Annex 2 |
|---|---|---|

## (1) ANP - SHS bar (hollow bar) type R

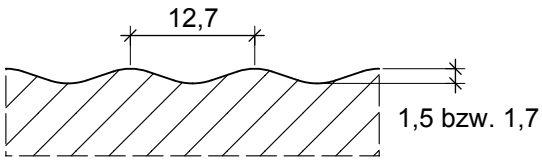
Thread: left-handed, single thread

Material: 28Mn6 acc. to ÖNORM EN 10083-2

Geometry:




Thread shape:




## Specifications of the SHS-bar, nominal size, nominal weight and strength properties

| Nr. | Kennwert / Typ | | | H 0420-38 | H 0500-38 | H 0630-51 | H 0800-51 |
|---|---|---|---|---|---|---|---|
| 1 | nominal external diameter | $D_{a,\,nenn}$ | mm | 38 | | 51 | |
| 2 | external diameter (nominal value) | $D_a$ | mm | 37,99 | | 49,99 | |
| 3 | inner diameter [1] | $D_i$ | mm | 21,0 | 18,5 | 33,0 | 29,0 |
| 4 | thread height | a | mm | 1,5 | 1,5 | 1,7 | 1,7 |
| 5 | Pitch | p | mm | 12,7 | | | |
| 6 | nominal cross sectional area [2] | $S_0$ | mm² | 640 | 740 | 930 | 1145 |
| 7 | nominal mass [3] | m | kg/m | 5,0 | 5,8 | 7,3 | 9,0 |
| 8 | load at 0,2% yield strength [4] | $F_{p0.2.nom}$ | kN | 350 | 400 | 530 | 630 |
| 9 | ultimate load [4] | $F_{m.nom}$ | kN | 420 | 500 | 630 | 800 |
| 10 | yield strength [5] | $R_{p0.2}$ | N/mm² | 550 | 550 | 570 | 550 |
| 11 | tensile strength [6] | $R_m$ | N/mm² | 660 | 680 | 680 | 700 |
| 12 | $R_m$ / $R_{p0.2}$ [6] | ---- | ---- | ≥ 1,15 | | | |
| 13 | elongation at ultimate load [6] | $A_{gt}$ | % | ≥ 5,0 | | | |
| 14 | related rib area | $f_R$ | ---- | 0,12 | | 0,13 | |
| 15 | thread standard | ---- | ---- | ISO 10208 | | ISO 1720 | |

[1] Inside diameter Di - average value

[2] Calculated with the nominal size $s_0 = m \times 10^3 / 7,85$

[3] Admissible deviation of nominal mass ± 4,5%

[4] Charateristic value as 5% fractile

[5] Calculated with the nominal force and the nominal cross-sectional area, rounded off

[6] Characteristic value as 10% fractile

E - modulus: 205.000 [N/mm²]

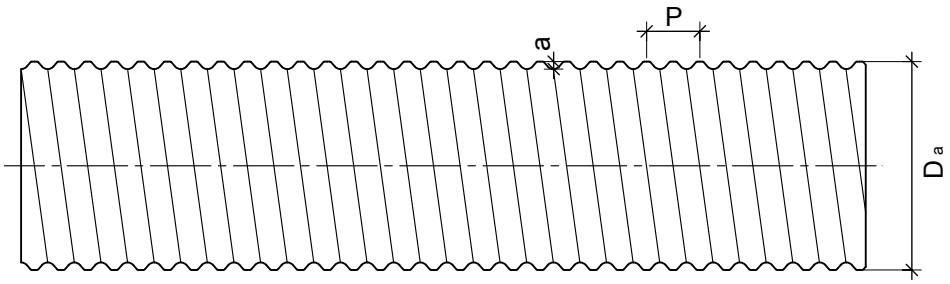
| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 bis H 2400-108<br>Specification, geometry, nominal size, nominal weight<br>strength properties of the ANP - SHS bar type RR | Annex 3 |
|---|---|---|

## (1) ANP - SHS bar (hollow bar) type RR

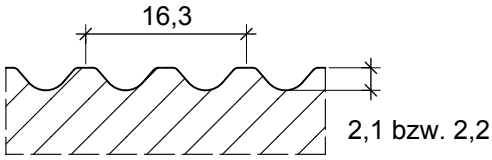
Thread: right-handed, double thread

Material: 36Mn5 acc. to ÖNORM EN 10210-1, ÖNORM EN 10297-1

Geometry:




Thread shape:




Specifications of the SHS-bar, nominal size, nominal weight and strength properties

| Nr. | Characteristic value / type | | | H 1000-64 | H 1200-64 | H 1400-76 | H 1600-76 | H 1800-76 | H 2400-108 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Nominal external diameter | $D_{a,\,nom}$ | mm | 64 | | 76 | | | 108 |
| 2 | External diameter (nominal value) | $D_a$ | mm | 63,80 | | 76,90 | | | 108,1 |
| 3 | Inner diameter [1] | $D_i$ | mm | 42,0 | 38,5 | 54,0 | 51,5 | 47,5 | 82,0 |
| 4 | Thread height | a | mm | 2,1 | | 2,2 | | | |
| 5 | Pitch | p | mm | 16,3 | | | | | |
| 6 | Nominal cross sectional area [2] | $S_0$ | mm² | 1470 | 1720 | 2020 | 2270 | 2510 | 3550 |
| 7 | Nominal mass [3] | m | kg/m | 11,5 | 13,5 | 15,8 | 17,8 | 19,7 | 27,8 |
| 8 | Load at 0,2% yield strength [4] | $F_{p0.2.nom}$ | kN | 800 | 950 | 1080 | 1200 | 1400 | 1780 |
| 9 | Ultimate load [4] | $F_{m.nom}$ | kN | 1000 | 1200 | 1400 | 1600 | 1800 | 2400 |
| 10 | Yield strength [5] | $R_{p0.2}$ | N/mm² | 550 | 560 | 540 | 530 | 560 | 510 |
| 11 | Tensile strength [6] | $R_m$ | N/mm² | 690 | 700 | 700 | 710 | 720 | 680 |
| 12 | $R_m$ / $R_{p0.2}$ [6] | ---- | ---- | ≥ 1,15 | | | | | |
| 13 | Elongation at ultimate load [6] | $A_{gt}$ | % | ≥ 5,0 | | | | | |
| 14 | Related rib area | $f_R$ | ---- | 0,26 | | 0,27 | | | |
| 15 | Thread standard | ---- | ---- | ANP in-house standard | | | | | |

[1] Inside diameter Di - average value

[2] Calculated with the nominal mass $s_0 = m \times 10^3 / 7,85$

[3] Admissible deviation from of mass ± 4,5%

[4] Charateristic value as 5% fractile

[5] Calculated with the nominal force and the nominal cross-sectional area, rounded off

[6] Characteristic value as 10% fractile

E - modulus: 205.000 [N/mm²]

| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 bis H 2400-108<br>Rated value of the ultimate limit state and the permissible test force acc. to ÖNORM B 1997-1-1 and loss of braking strength because of corrosion | Annex 4 |
|---|---|---|

## Rated value of material resistance for ANP - SHS micropile acc. to consequence category acc. to ÖNORM B 1997-1-1

| Type | Load at 0,2% yield strength | Characteristic ultimate load | Rated value of ultimate limit state | | | Max. test load $P_P$ [3] for proficiency- and acceptance test | |
|---|---|---|---|---|---|---|---|
| | | | of load bearing capacity of the pile | of load bearing capacity acc. to consequence category $R_{t,d} = F_{p0,2} / 1,15$ [2] / η | | | |
| Ø | $F_{p0,2}$ | $F_{pk}$ | $F_{p0,2} / 1,15$ [1] | CC 1, CC 2, η=1,3 | CC 3, η=1,5 | $P_P < 0,90*F_{p0,2}$ | $P_P < 0,80*F_{pk}$ |
| mm | kN | kN | kN | kN | kN | | kN |
| H 0420-38 | 350 | 420 | 304 | 234 | 203 | 315 | 336 |
| H 0500-38 | 400 | 500 | 348 | 268 | 232 | 360 | 400 |
| H 0630-51 | 530 | 630 | 461 | 355 | 307 | 477 | 504 |
| H 0800-51 | 630 | 800 | 548 | 421 | 365 | 567 | 640 |
| H 1000-64 | 800 | 1000 | 696 | 535 | 464 | 720 | 800 |
| H 1200-64 | 950 | 1200 | 826 | 635 | 551 | 855 | 960 |
| H 1400-76 | 1080 | 1400 | 939 | 722 | 626 | 972 | 1120 |
| H 1600-76 | 1200 | 1600 | 1043 | 803 | 696 | 1080 | 1280 |
| H 1800-76 | 1400 | 1800 | 1217 | 936 | 812 | 1260 | 1440 |
| H 2400-108 | 1780 | 2400 | 1548 | 1191 | 1032 | 1602 | 1920 |

[1] Partial safety factor $\gamma_S$=1,15 for steel acc. to ÖNORM EN 1992-1-1, table 2.1N
The load bearing capacity applies for tension and compression pile.
[2] The load bearing capacity acc. to consequence category apply for tension pile.
[3] The smaller value is decisive.

## loss in breaking strength because of corrosion

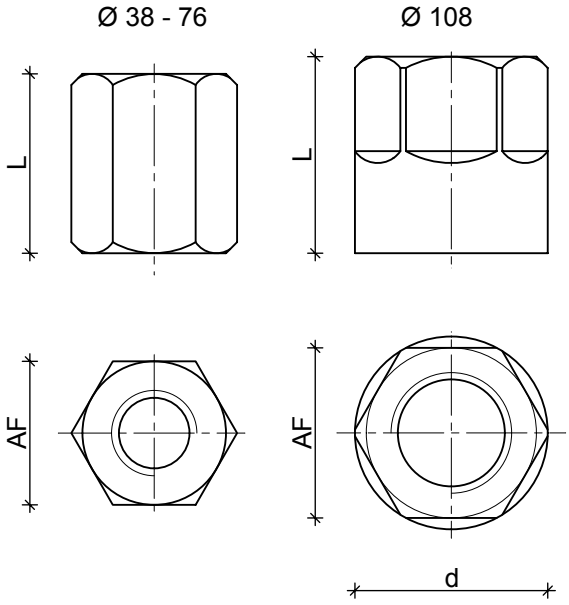
| Type | Load at the 0,2% yield strength | Characteristic ultimate load | Cross section area | Loss of cross section in % under exposure of corrosion [1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_{p0,2,k}$ | $F_{p,k}$ | A | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 1,0 |
| | kN | kN | mm² | mm | mm | mm | mm | mm | mm | mm | mm |
| H 0420-38 | 350 | 420 | 640 | 1,9 | 3,7 | 5,6 | 7,4 | 9,2 | 11,0 | 12,8 | 18,2 |
| H 0500-38 | 400 | 500 | 740 | 1,6 | 3,2 | 4,8 | 6,4 | 8,0 | 9,5 | 11,1 | 15,7 |
| H 0630-51 | 530 | 630 | 930 | 1,7 | 3,4 | 5,1 | 6,8 | 8,5 | 10,2 | 11,9 | 16,9 |
| H 0800-51 | 630 | 800 | 1150 | 1,4 | 2,8 | 4,2 | 5,6 | 6,9 | 8,3 | 9,7 | 13,7 |
| H 1000-64 | 800 | 1000 | 1470 | 1,4 | 2,7 | 4,1 | 5,4 | 6,8 | 8,1 | 9,5 | 13,5 |
| H 1200-64 | 950 | 1200 | 1720 | 1,2 | 2,3 | 3,5 | 4,6 | 5,8 | 6,9 | 8,1 | 11,5 |
| H 1400-76 | 1080 | 1400 | 2020 | 1,2 | 2,4 | 3,5 | 4,7 | 5,9 | 7,0 | 8,2 | 11,7 |
| H 1600-76 | 1200 | 1600 | 2270 | 1,1 | 2,1 | 3,1 | 4,2 | 5,2 | 6,3 | 7,3 | 10,4 |
| H 1800-76 | 1400 | 1800 | 2510 | 0,9 | 1,9 | 2,8 | 3,8 | 4,7 | 5,7 | 6,6 | 9,4 |
| H 2400-108 | 1780 | 2400 | 3550 | 1,0 | 1,9 | 2,9 | 3,8 | 4,8 | 5,7 | 6,6 | 9,5 |

[1] The loss of load capacity considering corrosion based on nominal diameter and nominal cross section.
The design resistance of the pile bearing capacity depends on the useful life and the ground aggresivity to reduce the loss of breaking strength because of corrosion.

| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 bis H 2400-108<br>Accessories : hexagon nut flat, hexagon nut cast and lock nut | Annex 5 |
|---|---|---|

## (2) Hexagon nut H 2002 - Ø

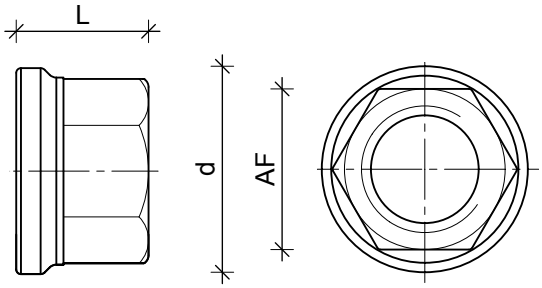
Material: C45, C45E and C45R acc. to ÖNORM EN 10083-2




| Type | AF mm | L mm | d mm |
|---|---|---|---|
| H 2002-38 | 55 | 55 | - |
| H 2002-51 | 75 | 70 | - |
| H 2002-64 | 85 | 70 | - |
| H 2002-76 | 100 | 80 | - |
| H 2002-108 | 130 | 100 | 100 |

## (2a) Hexagon nut - cast steel, H 2163 - Ø

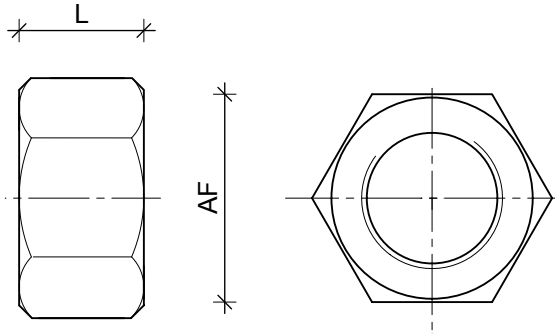
Material: cast steel C45 acc. to ÖNORM EN 10083-2




| Type | AF mm | L mm | d mm |
|---|---|---|---|
| H 2163-38 | 55 | 55 | 76 |
| H 2163-51 | 75 | 70 | 99 |
| H 2163-64 | 85 | 70 | 109 |
| H 2163-76 | 100 | 80 | 126 |
| H 2163-108 | 130 | 100 | 148 |

## (3) Lock nut, H 2040 - Ø

Material: C45, C45E and C45R acc. to ÖNORM EN 10083-2

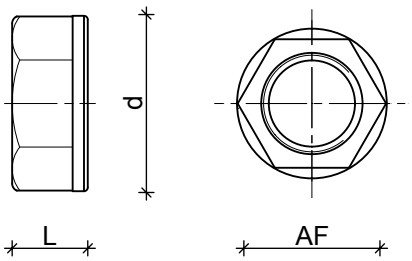



| Type | AF mm | L mm |
|---|---|---|
| H 2040-38 | 55 | 35 |
| H 2040-51 | 75 | 45 |
| H 2040-64 | 85 | 45 |
| H 2040-76 | 100 | 50 |
| H 2040-108 | 130 | 60 |

| ANP - SYSTEMS GmbH | ANP - SHS micropile<br>H 0420-38 bis H 2400-108<br>Accessories : lock nut cast, coupler and pile plate, flat | Annex 6 |
|---|---|---|

## 3a Lock nut cast, H 2040C - Ø

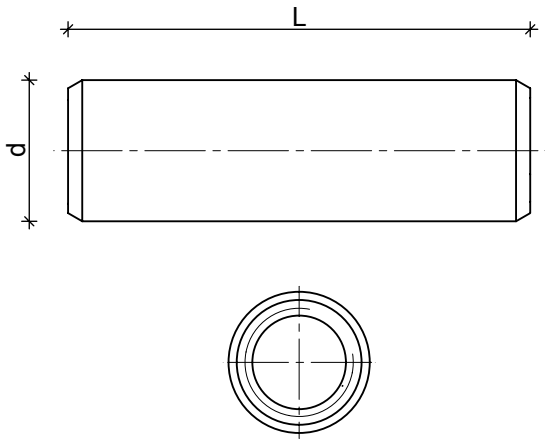
Material: cast steel C45 acc. to ÖNORM EN 10083-2




| Type | AF mm | L mm | d mm |
|---|---|---|---|
| H 2040C-38 | 55 | 35 | 66 |
| H 2040C-51 | 75 | 45 | 89 |
| H 2040C-64 | 85 | 45 | 99 |
| H 2040C-76 | 100 | 50 | 116 |
| H 2040C-108 | 130 | 60 | 140 |

## 4 Coupler, H 3003 - Ø with middle stop

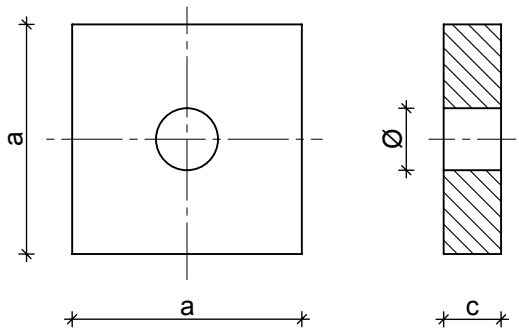
Material: 42CrMo4 acc. to ÖNORM 10083-3




| Type | L mm | d mm |
|---|---|---|
| H 3003-38 | 163 | 51 |
| H 3003-51 | 180 | 64 |
| H 3003-64 | 160 | 76 |
| H 3003-76 | 180 | 95 |
| H 3003-108 | 220 | 127 |

## 5 Pile plate, flat

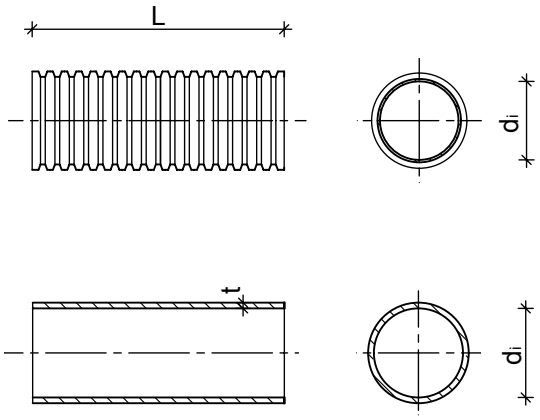
Material: S355J2 acc. to ÖNORM EN 10025-2




| Type pile plate | Type SHS - bar | a mm | c mm | Ø mm |
|---|---|---|---|---|
| H 14025-38 | H 0420-38 | 140 | 25 | 41 |
| H 14025-38 | H 0500-38 | 140 | 25 | 41 |
| H 16025-51 | H 0630-51 | 160 | 25 | 53 |
| H 18030-51 | H 0800-51 | 180 | 30 | 53 |
| H 20030-64 | H 1000-64 | 200 | 30 | 67 |
| H 20035-64 | H 1200-64 | 200 | 35 | 67 |
| H 20040-76 | H 1400-76 | 200 | 40 | 80 |
| H 22045-76 | H 1600-76 | 220 | 45 | 80 |
| H 24045-76 | H 1800-76 | 240 | 45 | 80 |
| H 28050-108 | H 2400-108 | 280 | 50 | 112 |

## 6 Plastic tube, H 5080 - Ø, plain or ripped

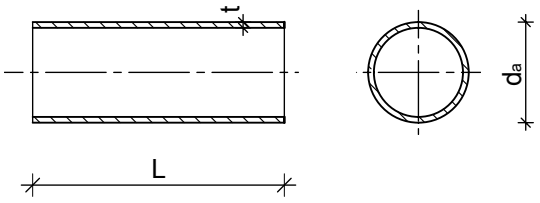
Material: PE-HD acc. to ÖNORM EN ISO 1872-1;2
PVC-U acc. to DIN 8061 and DIN 8062




| Type | L mm | t mm | $d_i$ mm |
|---|---|---|---|
| H 5080-38 | ≥ 300 | ≥ 1,0 | ≥ 68 |
| H 5080-51 | | ≥ 1,0 | ≥ 80 |
| H 5080-64 | | ≥ 1,0 | ≥ 94 |
| H 5080-76 | | ≥ 1,0 | ≥ 106 |
| H 5080-108 | | ≥ 1,0 | ≥ 138 |

## 7 Steel pipe, H 5090 - Ø

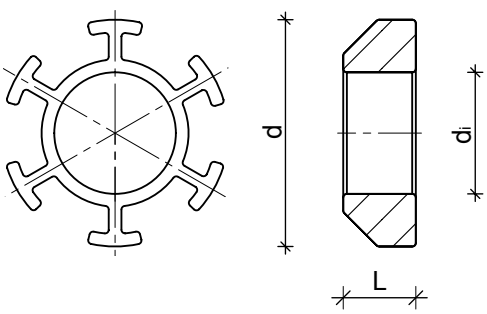
Material: P235TR1/2 acc. to ÖNORM EN 10216-1 / ÖNORM EN 10217-1




| Type | L mm | t mm | $d_a$ mm |
|---|---|---|---|
| H 5090-38 | 450 | 2,9 | 76,1 |
| H 5090-51 | 450 | 2,9 | 88,9 |
| H 5090-64 | 450 | 2,9 | 108,0 |
| H 5090-76 | 550 | 3,2 | 114,3 |
| H 5090-108 | 600 | 4,0 | 159,0 |

## 8 Spacer, H 5086 - Ø

Material: cast steel C45 acc. to ÖNORM EN 10083-2




| Type | L mm | $d_a$ mm | $d_i$ mm |
|---|---|---|---|
| H 5086-38/70 | 35 | 70 | 40 |
| H 5086-51/85 | 40 | 85 | 52 |
| H 5086-64/95 | 40 | 95 | 67 |
| H 5086-64/125 | 40 | 125 | 67 |
| H 5086-76/110 | 50 | 110 | 80 |
| H 5086-76/140 | 50 | 140 | 80 |
| H 5086-108/145 | 60 | 145 | 111 |
| H 5086-108/170 | 60 | 170 | 111 |

# Installation guide for the ANP - SHS micropile

## System components:

- Drill bits with different diameters and types to match the particular ground condition and the required minimum cover
- ANP - SHS bars with different nominal diameters and load bearing capacities with a rolled on full-length thread and 1, 2, 3, 4, or 6 m length.
- Coupling sleeves for connection and extension of ANP - SHS bars
- Flat pile plates
- Hex nuts and lock nuts
- Special anchor mortar or cement grout

## Installation of ANP - SHS micropiles

A suitable drill bit type has to be chosen depending on the intended pile length, expected geology and the required minimum cover. The aggressiveness of soil has to be checked and special provisions have to be made if necessary. In case of insufficient experience with the given conditions an expert who is familiar with the properties of the ANP - SHS micropile has to determine the suitable drill bits and ANP - SHS bar types and, if necessary, confirm the pile capacity with a static load test.

The chosen drill bit is screwed on the ANP - SHS bar and then ANP - SHS the bar is inserted into the transition sleeve of the shank or the casing of the rotary injection adapter respectively.
The ANP - SHS bar is installed by rotary percussive drilling or driven with a suitable pile shoe.
The ANP - SHS can be extended with a hand-screwed coupler sleeve with center stop.
The required torque is applied by the drilling procedure.
The filling of the flushing channel with anchor mortar or cement grout can be done simultaneously with the drilling of the pile using a rotary injection adapter or later with an injection adapter that is screwed on the ANP - SHS bar. A stable borehole is the precondition for a later injection.

The pile neck reinforcement has to be installed after drilling and the grouting of the annulus/annular space in compliance with the minimum embedment length depending on load direction and construction joint condition and the annulus/annular space between the ANP - SHS bar and the pile neck reinforcement has to be filled with anchor mortar or cement grout.

After the hardening of the cement grout or anchor mortar the appropriate pile head components have to be installed on the ANP - SHS bar. The pile plate has to be locked with the designated hex or lock nut depending on load direction in accordance with Annex 1. The nuts have to be tightened by hand. As the pile head is set in concrete afterwards, no additional corrosion protection is needed.