KWT Waterbeheersing

Technical Installation & Operation Manual

KWT Penstock

Type KSA

Supplied by:

AQUATIC
CONTROL
ENGINEERING LTD

Phone 01777 249080 info@aquaticcontrol.co.uk

Foreword:

All products are designed and constructed according to the specifications as written in the quotation and order confirmation.
Never use the product for any other means or applications than stated. This could result in premature failure of the product, flooding or risk the safety of personnel. Without exception, the products are not designed to bear or carry any loads of the civil construction.

KWT products will be virtually drop-tight at their working pressure if installation has been carried out correctly. Better sealing can be expected at applications with on seated pressure.
The responsibility of drop-tight installation lies primarily with the installing contractor.

Phrases in this manual which need special attention are marked as follow:

☞ ☐ Gives the user suggestions and tips to carry out instructions more easily.
☐ Remarks, with additional information.
☐ Informs user for possible problems

☝ ☐ The user can cause serious injury to himself or others or can damage the product.

CE When the KSA is supplied with or retrofitted with an actuator, the complete system must meet the machinery guide lines.

Contents

1. Introduction:

1.1 Product

The penstock type KSA-HDPE is constructed using HDPE and Stainless Steel 316, comprising a vertically moving door manufactured in HDPE with stainless steel stiffeners. This incorporates an EPDM rubber lip seal, to provide a seal between the back plate and is guided within a stainless steel frame with HDPE guides. An EPDM sponge seal is used between the frame and concrete wall, which is compressed to provide a good seal. The design is such that the penstock can withstand both on and off seating heads, and although non-rising spindles are fitted as standard, the KSA can be easily fitted with a rising spindle.

Purpose of usage & Principle of functioning

By moving the sliding plate up or down, the water flow is allowed to be discharged or isolated. The flow can be controlled proportionally to the level of the sliding plate.
Never exceed the designed water pressure on the KSA. Use the KSA only in a free flow application at ambient conditions – 20 up to 40 degrees Celsius. The KSA is well suited for applications involving Waste Water plants, pumping stations, sewage systems etc. Sudden impact as result of waves, water hammer should be avoided at all times.

Installation & operation stipulations:

Read this instruction manual carefully before installing the KSA.
Make sure you have taken all the right safety precautions into account before starting. All legal and local regulations have to be followed precisely.
Installation of the KSA should be only be carried out by skilled and therefore qualified personnel only. In case of any doubt, please contact the supplier immediately.

1.2 Technical specifications:

Materials of construction	
Weir plate	HDPE
Spindle	AISI 316 L
Frame	AISI 316 L
Sealing	EPDM
Spindle Block	POM(Polyacetol)/ Phosphor Bronze
Duty	On and off seated pressure
Max. Allowable water pressure	5 mwc (Standard design)

Table 1: Technical specifications.

2. Safety

2.1 General

In this chapter all safety precautions of the KSA are discussed. All personnel operating or installing the KSA must have read and fully understood all elements of this manual.

2.2. Safety, Health and Environmental Risks

The following risks should be regarded:
☐ Danger of trapping of body parts/clothing when mounting or operating.
☐ Electrical dangers during mounting or maintenance
☐ Falling during hoisting.

2.3 Safety precautions if applicable.

☐ Unsafe situations or defects must be reported on discovery to the responsible person.
☐ Make sure that the power supply to the actuator has been isolated during installation or maintenance.
☐ Qualified personnel only may carry out Electrical and mechanical work.
☐ Wear all necessary P.P.E. Secure all loose hair/clothing to prevent entanglement.

3. Transport and storage

3.1 Transport:

The KSA has to be moved horizontally with the Weir plate facing up on a matching pallet size. The KSA can be lifted by means of suitable lifting slings and a lifting bar matching the width of the KSA. The slings should be placed on the hoisting eyes on the sides of the top bridge

☞ Fully trained personnel should carry out all necessary lifting.

☝ Only lift the KSA by means of lifting slings and a lifting bar, using supplied lifting points.

3.2 Storage:

It is recommended to store the KSA horizontally, free of dust, dirt and moisture.

4. Installation & Erection.

4.1 introduction

In this chapter it is discussed how the KSA should be installed.
In paragraph 4.3 and 4.5 is the installation explained step by step. In paragraph 4.7 the required actions prior to operation are described.

Warranty
It is the responsibility of the purchaser to inspect the supplied KWT products for possible defects and that all ordered items are present at arrival. Missing parts or defects should be reported to KWT immediately and the installation must not be carried out until these are rectified. The warranty will be deemed void if:

- The items supplied are not installed in the manner set out in this manual
- The products are modified in any way without the prior approval of the supplier/manufacturer
- The items are damaged due to mis-use, vandalism or overload.

All claims for warranty are subject to a full inspection by the supplier/manufacturer. KWT/ACE maintain the right to refuse claims for warranty where the inspection proves the damage to be the fault of another party.

Safety Aspects:
The installing contractor is considered to be acquainted with the safety procedures as mentioned in chapter 2.

4.2 Preparation prior mounting:

Check the mounting supplies

1) EPDM sealing (15mm thick)
2) EPDM glue (in a small canister)
3) A white pencil
4) Tube of copper grease
5) A drill can
6) Chemical anchor capsules and accessories

Check the concrete wall

1) The KSA should be adjusted to ensure access to invert of channel.
2) Check the concrete wall for alignment with respect to the standard NEN 6722 March 1998 article 8.6.
3) Check the wall area above the KSA if applicable also for alignment. Spindle extension should be mounted vertically.
4) Check the concrete wall for local holes or eruptions on the mounting area. Irregularities in the wall may affect the EPDM sealing between KSA and wall.
5) Correct any deviation. Any possible gravel pockets must be filled out and concrete remains must be removed.

Tolerance difference is Max. 2mm per metre length

4.3 Mounting with chemical anchor bolts

When all points in 4.2 are addressed then continue with following installation procedure:

1) With suitable lifting slings, lift KSA up and adjust to ensure KSA is vertical and level (use lifting eye's)
2) Lower the KSA into required aperture.
3) Check and adjust the KSA into correct position, ensure invert of the pipe is flush with invert of the frame.
4) Mark all the mounting holes.

NOTE: On penstocks over 500mm diameter, there are also holes above the penstock opening. These are accessed by fully closing the penstock

5) Remove the KSA and attach EPDM seal

Placing the EPDM seal

1) Before placing the EPDM compound, ensure that the mounting face is clean and smooth.
2) Mark the mounting holes onto the seal with the white pencil, so you will be able to drill a hole in the compound, which now correspond with the existing holes in the frame
3) The compound is self adhesive on one side. Cut the compound oversized then remove the protection slip and fit the compound to the frame
4) The compound now should be cut to length and squared so that the corners connect properly.
5) Glue the corners together by using the provided EPDM glue. When not glued properly it can lead to leakage between the sealing face and the concrete wall
6) Grease the drill can on the outside with the copper grease to prevent ripping of the compound. Now drill the previously marked holes in the compound

☞ **Follow the instructions supplied by the manufacturer of the chemical anchors. (See appendix B and the anchor manufacturer's guidelines supplied) Ensure the holes are drilled to the correct depth and that the holes are fully cleaned out and dust free. The curing time should be considered precisely.**

☝ **USE THE MOUNTING ACCESORIES SUPPLIED WITH THE KSA!**

NOTE 1: On penstocks over 500mm diameter, there are holes above the penstock opening, the sockets for the countersunk anchors need to be installed before re-positioning the penstock.

NOTE 2: On penstocks with a flush invert, the sockets for the countersunk anchors need to be installed before re-positioning the penstock.

1) Replace the KSA into position, ensuring not to damage the EPDM sponge seal
2) Re-position the KSA, checking all levels and that the inverts are aligned.
3) Follow the applicable instructions for the chemical anchors to install the KSA (see appendix B)
4) Once the curing time has elapsed, place the countersunk bolts into the sockets and tighten by hand(if applicable)
5) Install standard chemical anchors (appendix b), place a washer, spring washer and nut onto each chemical anchor, and tighten by hand
6) Working around the frame, tighten the bolts and nuts, ensuring that the EPDM sponge seal is compressed evenly, and tighten to full recommended torque supplied with the anchors.
7) On larger penstocks, adjust side frame jacking bolts to brace the frame, then lock into position with locking nut.

NOTE: If any of the threaded rods turn, leave further to cure.

☞ Make sure any Countersunk Screws in the horizontal plate above the opening are not sticking out too far as these will obstruct the slide plate when operated and could damage the seal of the weir plate. If necessary shorten the bolts.

4.4 Installation of Spindle extension:

1) Place the spindle extension with the support(s) on top of the top bridge.
2) Place the upper support 150 mm below the deck or top of the spindle extension. Divide the other supports over the length of the spindle extension.
3) Mark the anchor holes of the supports in such way that the spindle extension is perpendicular to the KSA and vertical..
4) Remove the spindle extension.
5) Follow instructions for mounting of chemical anchors (see appendix B)
6) Replace the spindle extension and the brackets and fix these to the wall (place locking ring onto extension before placing uppermost bracket)
7) Adjust the position of the brackets to ensure a proper alignment of the spindle extension.
8) Locate the spindle extension under uppermost bracket and lock into position (non rising spindles, for rising spindles, this is done during commissioning)

4.5 Operation accessories

Pedestals

1) Remove the side plates from the pedestal and attach the pedestal to the penstock using the supplied bolts.
2) Place extension shaft into the operation point and align with the top hole of the pedestal. Tighten all grub screws.
3) Place gearbox/ Handwheel / protection hood/ actuator into place on pedestal and attach using suitable screws.
4) Replace pedestal side plates.

Rising Spindle Attachments

Manual:

1) Attach gearbox using supplied bolts.
2) Push Handwheel onto gearbox shaft and secure in place using supplied bolt.
3) Screw spindle protection tube into gearbox until secure.

Electrical:

1) Attach actuator using supplied bolts.
2) Screw spindle protection tube into actuator until secure.

4.6 Dry Commissioning

Manual Penstocks:

1) Operate the penstock to it's fully closed position.
2) Operate the penstock to it's open position, in the case of a rising spindle, locate lower locking ring under the penstock cross beam and lock into place using supplied grub screw.
3) Expose the penstock to water and operate through it's full cycle.

Electrical Penstocks:

1) Operate the penstock to it's fully closed position, set the closed actuator limit.
2) Operate the penstock to it's fully open position, set the open actuator limit. Locate the locking ring under the top spindle support bracket and lock into place using supplied grub screw.
3) Set the actuator torque limits for open and close, according to the order acknowledgement.

Greasing:

In most cases greasing is not required, however when using a phosphor bronze spindle bush or nut, the KSA must be operated through it's full cycle and a suitable water-resistant grease is to be applied to the spindle bush/nut at stages through the cycle.

4.7 Inspection prior to operation:

1) Clean the KSA thoroughly after installation.
2) Check the proper functioning of the KSA by closing and opening the KSA.

☝ **If in any doubt always contact the supplier.**

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5. Operation:

5.1 General

The operation of the KSA is discussed in paragraph 5.2. In paragraph 5.3 possible failures, the causes and methods for solving.

Safety issues:
The installing contractor is considered to be acquainted with the safety procedures as mentioned in chapter 2.

5.2.1. Specifications:

The KWT Penstock, type KSA™ is standard supplied with:

- AISI 316L non-rising spindle
- POM Spindle Block

The KSA is clock-wise closing.

5.2.2. Opening and closing:

Using a T Crank

1) Insert the T Crank into the operation point of the KSA Penstock
2) Turn the T-crank counter clockwise for opening, clockwise for closing..
3) If a high operation torque is noticed, the KSA must not be operated until a cause has been found and rectified.

Using a Handwheel

1) Turn the Handwheel counter clockwise to open, clockwise to close.
2) If a high operation torque is noticed, the KSA must not be operated until a cause has been found and rectified.

Using an Actuator

Before operating the actuator, it must be fully commissioned to ensure that it will not overload the KSA or work past it's limits. For instructions on setting/operating the actuator, please refer to the manufacturer's instructions, following this procedure:

1) Operate the penstock to it's fully open position, then reverse slightly before setting the open limit on the actuator.
2) Operate the penstock to it's fully closed position, then reverse slightly before setting the closed limit on the actuator.
3) With reference to the data supplied with the KSA, set the torque limits for open and close on the actuator.
4) Operate the KSA through a full open and close cycle, in dry conditions, then with the design head of water, to check the torque levels are suitable and the gate operates correctly.

Electrical Mode:
For details on the operation in this mode, please refer to the manufacturer's instructions. This must only be carried out by competent personnel.

Manual Operation:
For full details on this mode, please refer to manufacturer's instructions.
Basic Details:

1) To engage the Handwheel, operate the Handwheel clutch lever then turn the Handwheel until it is engaged.
2) Turn the Handwheel counter-clockwise to open, or clockwise to close.
3) Once electricity is restored, or the actuator is operated electrically, the Handwheel clutch will automatically disengage.

For the number of cycles to operate the KSA please refer to the order confirmation. The operation torque should be less or equal to the value stated in the acknowledgement.

☝ Never increase the operating torque by using transmission, spindle driver, enlarged lever i.e. whilst the maximum allowable torque will be exceeded and may lead to damage of the components.

☝ Great care must be taken to ensure that the KSA is not operated past it's limits, or operated when obstructed by debris etc.

5.3 Failure

Failure	Possible cause	Suggestion
KSA is leaking between frame and wall	Wall not flat	Wall need to flattened according NEN 6722 march 1998, article 8.6
	Sealing not glued correctly	Sealing has to be renewed and installed according the installation instructions.
KSA is leaking between weir plate and frame	Seal damaged	Replace seal
	Application specifications are exceeded.	Please contact supplier.
	Dirt between seal and seal face area	Remove present obstacles
	Seal does not contact seal area. ☝ Check if the frame has not been deformed due to a non-flat wall.	Adjust screws on front to obtain a better sealing.
Operation torque is significant higher.	Wall not flat	Wall need to flattened according NEN 6722 march 1998, article 8.6
	Spindle polluted or damaged	Clean or replace spindle
	Application specifications are exceeded.	Please contact supplier.
	Dirt between seal and seal face area	Remove present obstacles
Seal damaged	The attachments in the horizontal bar are sticking out too far.	Shorten these rods.

6. Cleaning and maintenance:

6.1 General

The KSA is constructed in a way that minimal maintenance is required. Paragraph 6.2 describes the requirements for maintenance of the KSA

6.2 Maintenance & Inspection:

For a correct functioning of the KSA it is recommended to operate the KSA annually to fully open and closed position. The following parts require attention in particular and need to be cleaned if necessary

1) Spindle block (dirt and wear)
2) Spindle (dirt and wear)
3) Spindle stop (present)
4) Sealing (dirt and wear)

For heavy duty penstocks, or any other penstock fitted with Phosphor Bronze Spindle Blocks/Bushes, occasional greasing is required. We recommend the use of any suitable water-resistant grease. Penstocks fitted with POM (Polyacetol) spindle blocks should not be greased.

NOTE Do not grease any part of the penstock unless otherwise instructed.

In an aggressive environment or in locations with large amounts of silt or debris, it is strongly recommended to increase the inspection/maintenance interval.

7. Disposal

7.1 General:

Paragraph 7.2 describes the procedure how the KSA at the end of its life cycle can removed safely and on an environmental responsible way.

7.2 Removal

Dismantle the KSA as follows:

1) Ensure that the KSA is sufficiently supported before removing fixings
2) Remove all the mounting material from the KSA.

Ensure that suitable precautions are in place to prevent injury whilst the KSA is not held in place by the mounting attachments.

3) Remove the KSA from the wall.
4) Remove the fixing materials from the wall.
5) Dismantle the KSA and separate materials into suitable classifications.

Dispose of the different materials via recognised methods, and in an environmentally responsible way

Appendix A Drawings

Appendix B Instructions Chemical anchor bolts

Procedure for installing Chemical Anchor Attachments

Please note that chemical anchor attachments in two forms are used for installing various elements of the KKS tilting weir. The following procedure must be referred to for details of this:

Standard Chemical Anchors

Comprising of:

Stainless Steel Threaded Studding
Chemical Anchor Capsules
Drill Adaptor
Stainless Steel Nuts, Washers and Spring Washers

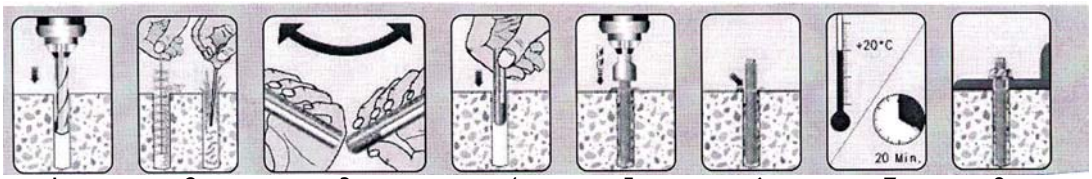
1. Drill Mounting hole in required position to the correct depth and diameter (please refer to details supplied with chemical anchors)
2. Blow out drilled hole using compressed air. (Warning, suitable eye protection to be worn)
3. Insert a chemical anchor capsule into each hole.
4. Attach a length of studding to the drill adaptor, then attach the adaptor to a rotary drill (NOTE: Do not use a hammer-action drill, as this will cause resin to escape from the hole)
5. Place the end of the threaded stud into the hole, then in one motion operate the drill at high speed, while pushing the stud through the anchor to the back of the hole. Once the back of the hole is reached, stop the drill to prevent resin escape.
6. Carefully remove the drill adaptor from the drill chuck, taking care not to move the stud.
7. Once the resin has sufficiently cured, remove the drill adaptor from the stud, however if the stud turns, leave the resin to cure further.
8. Replace the item to be mounted, then place a washer, a spring washer and a nut onto the stud and tighten by hand.
9. Once all required anchors have been installed and are fully cured, proceed to tighten the nuts evenly to the recommended torque. Where EPDM seal is used, this must be compressed evenly to ensure a good seal, however the frame must not be allowed to deform. For torque moment data, please refer to the anchor manufacturer's guidelines supplied with the anchors.

Special Countersunk Socket Anchors

Comprising of:

Threaded sockets with internal thread
Countersunk Bolts
Chemical Anchors
Special Drill Adaptor

1. Drill Mounting hole in required position to the correct depth and diameter for the threaded socket (please refer to details supplied with chemical anchors)
2. Blow out drilled hole using compressed air. (Warning, suitable eye protection to be worn)
3. Insert a chemical anchor capsule into each hole.
4. Attach the special drill adaptor to a threaded socket, then attach the adaptor to a rotary drill (NOTE: Do not use a hammer-action drill, as this will cause resin to escape from the hole)
5. Place the end of the threaded socket into the hole, then in one motion operate the drill at high speed, while pushing the socket through the anchor to the back of the hole. Once the back of the hole is reached, stop the drill to prevent resin escape.
6. Carefully remove the drill adaptor from the drill chuck, taking care not to move the socket.
7. Once the resin has sufficiently cured, remove the drill adaptor from the socket, however if the socket turns, leave the resin to cure further.
8. Replace the item to be mounted, then insert a countersunk bolt into the threaded socket.
9. Once all required anchors have been installed and are fully cured, proceed to tighten the bolts evenly to the recommended torque. Where EPDM seal is used, this must be compressed evenly to ensure a good seal, however the frame must not be allowed to deform. For torque moment data, please refer to the anchor manufacturer's guidelines supplied with the anchors.



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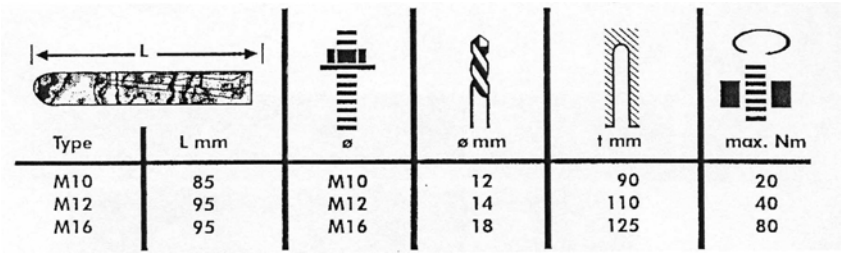

Type	L mm	ø	ø mm	t mm	max. Nm
M10	85	M10	12	90	20
M12	95	M12	14	110	40
M16	95	M16	18	125	80

Table 1 requisite dimensions and turn moments

Temperature in °C	Mins.	Hours
The bore hole		
above 20	10	-
10-20	20	-
0-10	-	1
-5- 0	-	5

Table 2 Stated Curing Times

Appendix C High Density Polyethylene Properties

High Density Polyethylene (HDPE)

SIMONA
plastics

CEE- Safety Data Sheet according to 91/155 EWG Trade name: SIMONA PE-HWU-B / SIMONA PE-HWU / SIMONA PE-HD-pipe	
1. Indications to the manufacturer	SIMONAAG Tel: 06752 / 14-0 Teichweg 6 Fax: 06752 / 14-211 D-55606 Km
2. Composition / Indications to components	
Chemical characteristics	Polymer of ethylene
CAS-number	Not necessary
3. Possible dangers	Un-Known
4. First aid measures	
General comment	Medical aid is not necessary
5. Fire-fighting measures	
Suitable fire-fighting appliance	Water fog, foam, fire fighting powder, carbon dioxide
6. Measures in case of unintended release	Not applicable
7. Handling and storage	
Handling	No special regulations must be observed
Storage	Unlimited good storage property
8. Limitation of exposition	
Personal protective equipment	Not necessary

Continue Appendix C

9. Physical and chemical characteristics.

Phenoype:

Form:	Semi- finished product
Colour:	Black
Smell:	Not distinguishable

Change of state

Crystallite melting point	126-130 °C
Fire point	Not applicable
Inflammation temperature	Approx. 350 °C
Density	0.95 g/cm^3

10. Stability and reactivity

Thermal decomposition	Above approx. 300 °C
Dangerous decomposition products	None

Besides carbon black also carbon dioxide and water as well al low molecular parts of PE will develop during the burning process. In case of incomplete burning also carbon monoxide may arise

11. Toxic indications

During several years of usage no effects being harmful for the health were observed

12. Ecological indications

No biodegradation, no solubility in water, no effects being harmful to the Environment must be expected.

13. Waste-disposal indications

Can be recycled or can be disposed of together with household rubbish (acc. To Local Regulations)

Waste key for the unused product	57128
Waste name	Waste of polyoefine

14. Transport indications

No dangerous product in respect to / according to transport regulations.

15. Instructions.

Marking according to GefStoff V/EG	No obligation for marking
Water danger class	Class 0 (self classification)

16. Futher indications

The indications are based on your to-days knowledge. They are menat to describe our Products in respect to safety requirements. They do not represent any guarantee of The described product in the sense of the legal guarantee regulations.

Appendix D Characteristic values of Material

Simona
Technical information for HDPE

	Test method DIN	Dimension	SIMONA PE-HWU
Density, method C	53479	G/cm^3	0.950
Yield stress, Test piece 3	53455	N/ mm^2	22
Elongation at yield stress	53455	%	9
Elongation at tear	53455	%	300
Tensile-E-Module	53457	N/ mm^2	800
Impact strength (std. Small bar)	53453	KJ / mm^2	Without break
Impact strength when notched (U-notch)	53453	KJ / mm^2	12
Indentation hardness H 132 / 30	53456	N/ mm^2	40
Shore hardness D	53505	N/ mm^2	63
Crystalline melting range calorimetric	52328	K	399 – 403
Mean coefficient of thermal expansion	53752	k	1.8 .10
Heat conductivity	52612	W /mk	0.38
Behaviour in fire	4102		82
Dielectric strength. Methode K 20 / 5D	53481	KV / mm	47
Volume resistance Annular electrode	53482	Ohm .com	>10
Surface resistance. Electrode A	53482	Ohm	10
Creep resistance	53480	V	600

Method KC			
Dielectric constant; At 300-1000 Hz. At 3 .10 Hz.	53483		 2.3 2.3
Dielectric loss factor. At 300 Hz. At 1000 Hz. At 3.10 Hz.	53483		 < 3.10 5.10 < 3.10
Physiological safety	BGA		JA

The data specified here are guide values and may vary depending on the processing method and the production of test pieces. Unless specified otherwise, these are average values taken from measurements on extruded sheets 4 mm thick. This information cannot be automatically transferred to finished components. The manufacturer or user must check the suitability of our materials for a specific application.

Standard Cr-Ni-Mo Stainless Steels

STEEL GRADES

AvestaPolarit	EN	ASTM
4404	1.4404	316L
4401	1.4401	316
4406	1.4406	316LN
4571	1.4571	316Ti
4432	1.4432	316L
4436	1.4436	316
4435	1.4435	316L
4429	1.4429	316LN

CHARACTERISTIC PROPERTIES

- All-purpose grades
- Enhanced corrosion resistance compared to standard Cr-Ni grades
- Excellent formability
- Excellent weldability
- Excellent impact strength

GENERAL CHARACTERISTICS

These grades are molybdenum-containing austenitic stainless steels intended to provide improved corrosion resistance relative to the standard Cr-Ni steel grades used in corrosive process environments.

The addition of molybdenum provides improved resistance to pitting and crevice corrosion in environments containing chlorides or other halides.

These grades are used in applications for handling the wide range of chemicals used by process industries, e.g. pulp and paper, textile, food and beverages, pharmaceutical, medical, and in the manufacture of other chemical processing equipment. These grades are supplied with a wide range of functional and aesthetic surfaces. Non-titanium-stabilised grades generally have a better surface finish than titanium-stabilised grades.

Given their fully austenitic structure, these grades are non-magnetic in the annealed condition but may become slightly magnetic as a result of cold working or welding.

CHEMICAL COMPOSITION

The chemical composition of specific steel grades may vary slightly between different national standards.

The required standard will be fully met as specified on the order.

CHEMICAL COMPOSITION

AvestaPolarit steel name	International steel no.		Typical composition, %						National steel designations, superseded by EN			
	EN	ASTM	C	N	Cr	Ni	Mo	Other	BS	DIN	NF	SS
4404	**1.4404**	**316L**	**0.02**	**0.04**	**17.2**	**10.2**	**2.1**	**–**	**316S11**	**1.4404**	**Z3 CND 17-11-02**	**2348**
4401	**1.4401**	**316**	**0.02**	**0.04**	**17.2**	**10.2**	**2.1**	**–**	**316S31**	**1.4401**	**Z7 CND 17-11-02**	**2347**
4406	**1.4406**	**316LN**	**0.02**	**0.14**	**17.2**	**10.3**	**2.1**	**–**	**316S61**	**1.4406**	**Z3 CND 17-11 Az**	**–**
4571	**1.4571**	**316Ti**	**0.04**	**0.01**	**16.8**	**10.9**	**2.1**	**Ti**	**320S31**	**1.4571**	**Z6 CNDT 17-12**	**2350**
4432	**1.4432**	**316L**	**0.02**	**0.05**	**16.9**	**10.7**	**2.6**	**–**	**316S13**	**–**	**Z3 CND 17-12-03**	**2353**
4436	**1.4436**	**316**	**0.02**	**0.05**	**16.9**	**10.7**	**2.6**	**–**	**316S33**	**1.4436**	**Z7 CND 18-12-03**	**2343**
4435	**1.4435**	**316L**	**0.02**	**0.06**	**17.3**	**12.6**	**2.6**	**–**	**316S13**	**1.4435**	**Z3 CND 18-14-03**	**2353**
4429	**1.4429**	**316LN**	**0.02**	**0.14**	**17.3**	**12.5**	**2.6**	**–**	**316S63**	**1.4429**	**Z3 CND 17-12 Az**	**2375**
4301	1.4301	304	0.04	0.05	18.1	8.3	–	–	304S31	1.4301	Z7 CN 18-09	2333
904L	1.4539	904L	001	0.06	20	25	4.3	1.5 Cu	904S13	1.4539	Z2 NCDU 25-20	2562
254 SMO®	1.4547	S31254	0.01	0.20	20	18	6.1	Cu	–	1.4547	–	2378
SAF 2304®	1.4362	S32304	0.02	0.10	23	4.8	0.3	–	–	1.4362	Z3 CN 23-04 Az	2327
2205	1.4462	S32205*	0.02	0.17	22	5.7	3.1	–	318S13	1.4462	Z3 CND 22-05 Az	2377

*also available as S31803

SAF 2304® is produced under licence from AB Sandvik Steel

MECHANICAL PROPERTIES

AvestaPolarit has used the European Standard EN 10088 where applicable. The permitted design values may vary between product forms, see the specification in question for the correct value.

The values in Table 2 refer to hot rolled plate/cold rolled strip and sheet. For hot rolled strip, the proof strength corresponds to that of hot rolled plate, and the tensile strength and elongation to that of cold rolled strip.

Mechanical Properties

Table 2. Hot rolled plate/cold rolled strip and sheet, minimum values at 20°C

Steel grade	Proof strength $R_{p0.2}$ MPa	Proof strength $R_{p1.0}$ MPa	Tensile strength R_m MPa	Elongation A_5 %	Hardness HB (typical)	Impact value KV J
4404	220/240	260/270	520/530	45/40	165	60
4401	220/240	260/270	520/530	45/40	160	60
4406	280/300	320/330	580/580	40/40	–	60
4571	220/240	260/270	520/540	40/40	165	60
4432	220/240	260/270	520/550	45/40	165	60
4436	220/240	260/270	530/550	40/40	165	60
4435	220/240	260/270	520/550	45/40	165	60
4429	280/300	320/330	580/580	40/35	–	60

Tensile properties at elevated temperatures

Table 3a. Proof strength $R_{p0.2}$, MPa, minimum values

Steel grade	Temperature, °C 100	200	300	400	500
4404	177	147	127	115	110
4401	166	137	118	108	100
4406	211	167	145	135	128
4571	185	167	145	135	129
4432	177	147	127	115	110
4436	166	137	118	108	100
4435	165	137	119	108	100
4429	211	167	145	135	129

Table 3b. Proof strength $R_{p1.0}$, MPa, minimum values

Steel grade	Temperature, °C 100	200	300	400	500
4404	211	177	156	144	139
4401	199	167	145	135	128
4406	246	198	175	164	158
4571	218	196	175	164	158
4432	211	177	156	144	139
4436	199	167	145	135	128
4435	200	165	145	135	128
4429	246	198	175	164	158

Table 3c. Tensile strength R_m, MPa, minimum values

Steel grade	Temperature, °C				
	100	200	300	400	500
4404	430	390	380	–	–
4401	430	390	380	380	360
4406	520	460	440	–	–
4571	440	390	375	375	360
4432	460	420	410	410	390
4436	430	390	380	380	360
4435	420	380	370	–	–
4429	520	460	440	435	430

Mechanical properties at low temperatures

Table 4. Minimum values

Steel grade	Temp. °C	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa	R_m MPa	A_5 %
4404*	–80	275	355	840	40
4404*	–196	350	450	1200	35
4406**	–80	380	450	800	35
4406**	–196	600	700	1150	30

Values from EN 10028-7
* 4401, 4571, 4432, 4436 and 4435 have approximately the same values as 4404
** 4429 has approximately the same values as 4406.

PHYSICAL PROPERTIES

The physical properties are the same for all steel grades in this group.
Data according to EN 10088.

Table 5. Physical properties, typical values at 20°C

Density	kg/dm³	8.0
Modulus of elasticity	GPa	200
Poissons ratio		0.3
Thermal conductivity	W/m°C	15
Heat capacity	J/kg°C	500
Electrical resistivity	µΩm	0.75

Physical properties at elevated temperatures

Table 6a. Linear expansion (RT⟶T) x 10^{-6}/°C

Steel grade	Temperature, °C				
	100	200	300	400	500
4571	16.5	17.5	18.0	18.5	19.0
Non-Ti-stabilised grades	16.0	16.5	17.0	17.5	18.0

Table 6b. Modulus of elasticity, GPa

Steel grade	Temperature, °C				
	100	200	300	400	500
All grades	194	186	179	172	165

CORROSION RESISTANCE

The Cr-Ni-Mo standard stainless steels have a versatile corrosion resistance and are suitable for a wide range of applications. The grades with molybdenum content of 2.6 per cent (4432, 4436, 4435, 4429) have somewhat enhanced corrosion resistance compared to the grades with molybdenum content of 2.1 per cent (4404, 4401, 4406, 4571). A brief description of their resistance to different types of corrosion follows below. For a more detailed description of their corrosion resistance properties in different environments, please refer to the AvestaPolarit Corrosion Handbook.

Uniform corrosion

Uniform corrosion is characterised by a uniform attack on the steel surface that has come into contact with a corrosive medium. The corrosion resistance is generally considered good if the corrosion rate is less than 0.1 mm/year.

This group of Cr-Ni-Mo grades have a good resistance in many organic and inorganic chemicals. An example of an isocorrosion diagram is shown in figure 1.

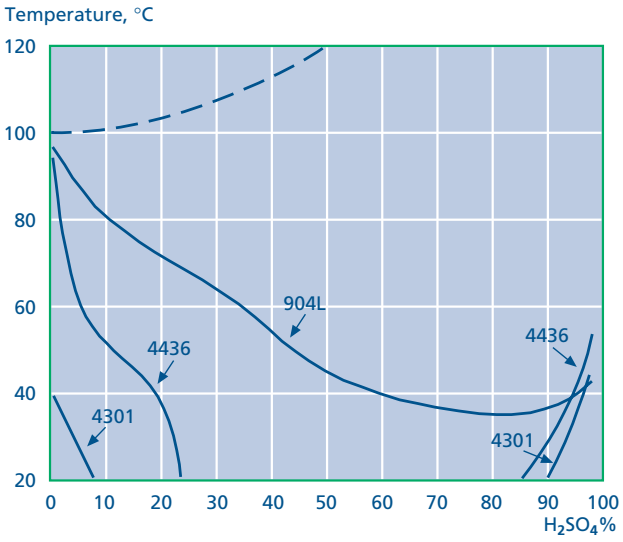

Fig. 1. Isocorrosion diagram for 4301, 4436 and 904L in stagnant sulphuric acid. The curves represent a corrosion rate of 0.1 mm/y. The dashed line represents the boiling point.

Pitting and crevice corrosion

The resistance to pitting and crevice corrosion can be enhanced by increasing the content of chromium, molybdenum and nitrogen. These grades have a significantly better resistance to these types of localised corrosion than the standard Cr-Ni grades.

For better resistance, higher alloyed grades such as 2205 and 254 SMO® are recommended (see Figure 2).

Figure 3 shows up to which approximate temperatures stainless steel can be used in oxygen-saturated solutions of varying chloride content. There is an additional risk for stress corrosion cracking at temperatures above 50°C.

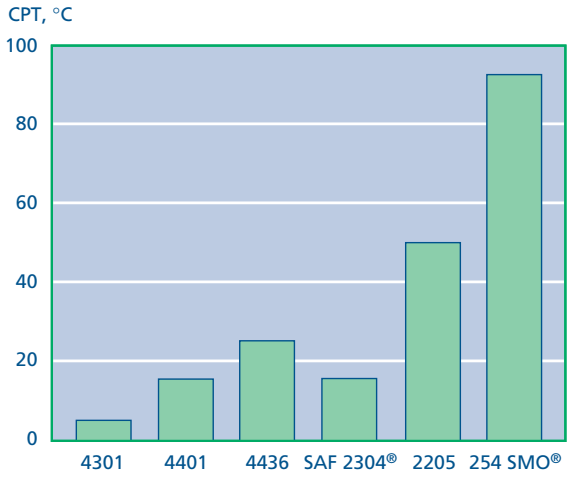

Fig. 2. Critical pitting temperatures (CPT) in 1M NaCl according to ASTM G150 using the Avesta Cell. Typical values.

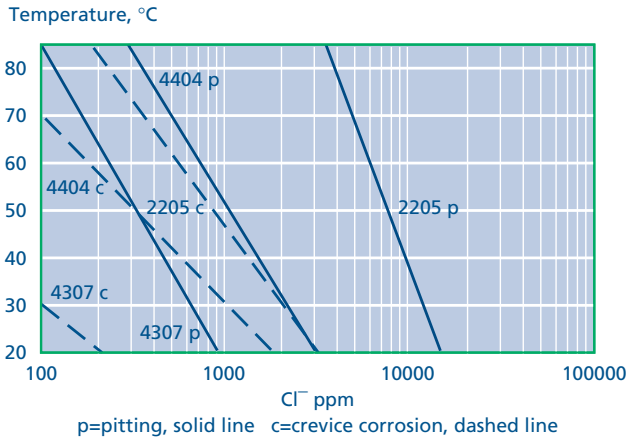

Fig. 3. Risk of pitting and crevice corrosion on conventional stainless steel in water of different chloride content or temperature.

Stress corrosion cracking

These austenitic grades – like the standard Cr-Ni steels – are susceptible to stress corrosion cracking (SCC). Critical service conditions, i.e. applications subjected to combinations of tensile stresses, temperatures above about 50°C and certain solutions, especially those containing chlorides, should be avoided.

For applications demanding high resistance to SCC, the duplex grades 2205 and SAF 2304® are more suitable.

Stress corrosion cracking may also occur in hot alkaline solutions (above 110°C).

Intergranular corrosion

Intergranular corrosion is not a common problem for modern stainless steels since the carbon content is generally kept at a low level.

Operations that increase the risk for intergranular corrosion are welding of heavy gauges, heat treatment operations within the critical temperature interval (550 – 850°C) and slow cooling after heat treatment or hot forming. Ti-stabilised steels and steels with low carbon content (0.02%) have better resistance towards intergranular corrosion after such operation conditions.

FABRICATION

Hot forming

Hot working can be carried out in the 850 – 1150°C range. For maximum corrosion resistance, forgings should be annealed at 1070°C and rapidly cooled in air or water after hot working operations.

Cold forming

These grades can be readily formed and fabricated by a full range of cold working operations. They can be used in heading, drawing and bending. Any cold working operations will increase the strength and hardness of the material (see Figure 4). For more information on deep drawing, see "Guide for deep drawing stainless steel".

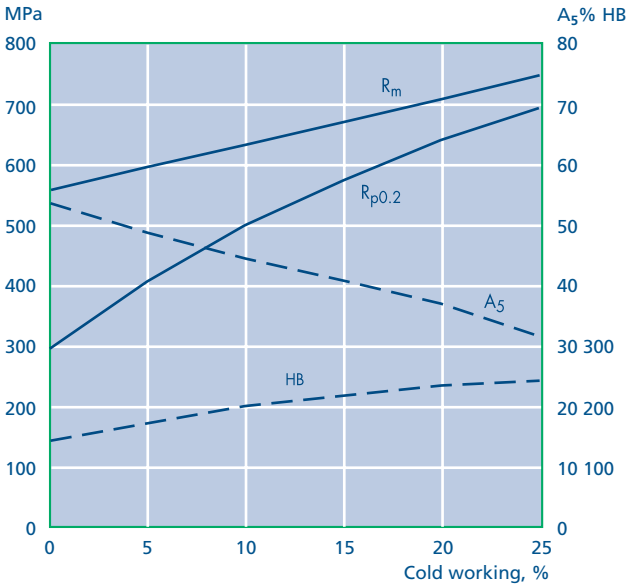

Fig. 4. 4301 work-hardening at cold working

Heat treatment

Annealing

Quench annealing should be performed at 1030 – 1110°C and followed by rapid cooling in water or air. For Ti-stabilised grades, annealing temperatures above 1070°C may impair the resistance to intergranular corrosion.

Ti-stabilised grades may also be given a stabilising treatment at lower temperatures. However, temperatures below 980°C should only be used after due consideration of the intended service environment.

In applications where high residual stresses cannot be accepted, stress relief treatment may be necessary. This can be performed by annealing as outlined above, but may also be performed at lower temperatures. Please contact AvestaPolarit for further information.

Hardening

These grades cannot be hardened by heat treatment. However, they can be hardened by cold working.

Machining

These austenitic grades are more difficult to machine than ordinary carbon steels but are still comparatively easy to machine compared to more highly alloyed stainless grades. Unless modified for improved machinability, they require higher cutting forces than carbon steels, show resistance to chip breaking and a high tendency to built-up edge formation. The best machining results are obtained by using high-power equipment, sharp tooling and a rigid set-up.

The machinability of these grades in relation to other stainless steels is indicated by the machinability index in Figure 5. This index, which rises with increased machinability, is based on a compounded evaluation of test data from several different machining operations. It gives an indication of the machinability of different stainless steel grades in relation to that of grade 4436. It should be noted that it does not describe the relative difficulty of machining with cemented carbide and high speed steel tools. Nitrogen alloyed stainless steels are more difficult to machine.

Better machinability performance is given by PRODEC® versions, which have been modified for improved machinability. PRODEC® is available as hot rolled plate and bar in 4401, 4404, 4436 and 4432.

For more information, see "Machining Guidelines", available from AvestaPolarit on request.

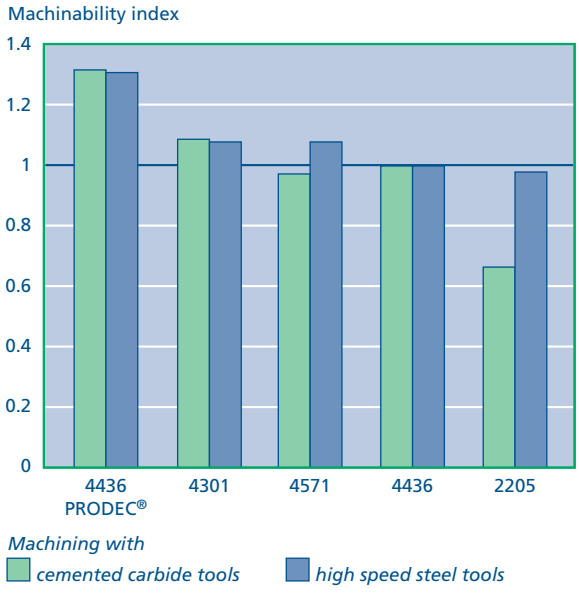

Fig. 5. Relative machinability for some stainless steel grades.

Welding

These grades can be readily welded by a full range of conventional welding methods such as:

- Shielded metal arc welding (SMAW)
- Gas tungsten arc welding, TIG (GTAW)
- Gas metal arc welding, MIG (GMAW)
- Flux-cored arc welding (FCW)
- Plasma arc welding (PAW)
- Submerged arc welding (SAW)

The following welding filler metals from AvestaPolarit Welding are recommended:

4404	316L/SKR
4401	316L/SKR
4406	316L/SKR
4571	318/SKNb, 316L/SKR
4432	316L/SKR
4436	316L/SKR
4435	316L/SKR
4429	316L/SKR

Other filler metals with a molybdenum content higher than that of the base metal may also be used. For further information, see the brochures "STAINLESS STEELS – Their properties and their suitability for welding", Info. No. 9473, and "HANDBOOK for the pickling and cleaning of stainless steel", Info. No. 270101GB.

PRODUCTS

- Hot rolled plate, sheets and strip
- Cold rolled plate, sheet and coil
- Cold rolled narrow strip
- Welded tube and pipe
- Bar
- Rod
- Billet
- Welding consumables

MATERIAL STANDARDS

EN 10088-1	Stainless steels – List of stainless steels (Not for ordering)
EN 10088-2	Stainless steels – Sheet/plate and strip for general purposes
EN 10088-3	Stainless steels – Semi-finished products, bars, rods, sections for general purposes
EN 10028-7	Flat products for pressure purposes – Stainless steels
EN 10272	Stainless steel bars for pressure purposes
ASTM A240/ASME SA-240	Heat-resisting Cr and Cr-Ni stainless steel plate, sheet and strip for pressure vessels
ASTM A479/ASME SA-479	Stainless steel bars for boilers/pressure vessels
ASTM A666/ASME SA-666	Austenitic stainless steel sheet, strip, plate, bar for structural and architectural applications

AvestaPolarit has sales companies and agents throughout the world. For contact details please consult the company website:

www.avestapolarit.com

AvestaPolarit STAINLESS

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