

# **KWT** Waterbeheersing

## *Technical Installation & Operation Manual*

### *KWT Tilting gate*

#### *Type KKS*



2004 KWT® Waterbeheersing BV

**Supplied by:**

**ACE** AQUATIC  
CONTROL  
ENGINEERING LTD

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## Foreword:

All products are designed and constructed according to the specifications as written in the order confirmation. Never use the product for any other means or applications than stated. This could result in premature failure of the product or risk the safety of personnel. Without any 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. A better seal 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 of possible problems.



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

**CE** When the KKS is supplied with, or retrofitted with an actuator, the complete system should meet the machinery guidelines.

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## I. Introduction

### I.1 Product

#### **General**

The KKS is completely constructed in Stainless steel and HDPE parts (High Density Polyethylene) The KKS is driven by two quadrant shaped rack and pinion drives, coupled by a common shaft.

#### **Purpose of usage & Principle of functioning**

The KKS can be used for maintaining a required water level upstream, or for raising levels for irrigation. The primary drive of the KKS is a Rotork electric actuator, however this can be operated by hand or with a portable spindle driver in case of power failure. Due to the design of the drive system, the gate should be able to travel through its full arc and should be free from obstruction, which enables the water level to be infinitely controlled between upper and lower limits of the KKS, and maintenance requirements are minimal.

#### **Installation & operation stipulations**

All installation/ operation personnel must read this instruction guideline carefully before installing/operating the KKS.

Make sure you have taken all the correct safety precautions into account before starting. All legal and local regulations have to be followed precisely.

Installation of the KKS should only be carried out by fully competent personnel. In case of any doubt, please contact the supplier immediately

### I.2 Technical specifications

<b>Materials of Construction</b>	
Weir Plate	AISI 316 L
Frame	AISI 316 L
Sealing	EPDM Seal compound
Gear rack	AISI 316L

Table 1: Technical specifications

## 2. Safety

### 2.1 General

In this chapter all safety precautions of the KKS are discussed. It is most important that everybody who operates the KKS is familiar with the contents of this chapter.

### 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 should reported to the responsible person.
- Make sure that the power supply to the actuator has been isolated during installation or maintenance.
- Qualified personnel should only carry out Electrical and mechanical work
- Wear all necessary P.P.E. Secure all loose clothing/hair before operation.

## 3. Transport and storage

### 3.1 Transport:

The KKS must be transported in such a way that it is fully secured, so that it cannot overturn or move. This must also be considered during loading and lifting of the KKS.

The KKS can be lifted with 'soft' suitable slings, or with suitable shackles and chains. The slings should only be placed on the lifting points provided to prevent damage to the KKS.

-  All necessary lifting should be carried out by fully trained personnel
-  Only lift the KKS by means of lifting slings and a lifting bar.

### 3.2 Offloading

Before offloading, check the KKS for signs of damage and ensure all parts are according to the consignment note. Using suitable lifting slings, lift as follows, referring to lifting drawings for instructions:

- Place the lifting slings in the lifting points.
- Ensure that when lowering the gate the load is guided into position over packers to support the gate away from the floor.
- Ensure that when positioning the gate, there is sufficient space for storage.

### 3.3 Storage

It is recommended to store the KKS upright, free of dust, dirt and moisture. The gate must also remain supported on timbers to keep it off the ground and to prevent damage to parts of the gate.

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## 4. Installation & Erection

### 4.1 General

In this chapter it is discussed how the KKS should be taken into operation. In this manual, the installation with chemical anchor bolts is discussed.

In the paragraph 4.3 the installation is explained step by step. In paragraph 4.5 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 product can not be installed 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 to mounting

#### **Check the mounting supplies**

- 1) EPDM compound (15mm thick)
- 2) EPDM glue (in a small canister)
- 3) A white pencil
- 4) A drill can
- 5) Copaslip
- 6) Resin anchors and installation accessories
- 7) Stainless steel bolts, washers, spring washers and nuts
- 8) Jacking screws (where applicable)
- 9) Actuator Protection Hoods (where applicable)

#### **Check the concrete wall**

- 1) Check the concrete wall before installing the KKS, to ensure the wall is smooth. The wall must be within a tolerance of 2-3 mm per metre to ensure that the gate can be fitted to achieve optimum sealing. For this application, it is necessary to remove concrete from the bottom corners of the channel, to ensure that the corners are square.
- 2) Correct any deviation. Any possible gravel pockets must be filled out and concrete remains must be removed.

### 4.3 KKS Installation

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

- 1) Referring to the drawings, place the slings in the correct position for installation of the gate. When lifted, the frame should be close to vertical, therefore using the spindle driver adjust the frame to the vertical position.
- 2) Also check that the weir plate and frame are vertical in a horizontal plane to ensure that the gate can be placed smoothly into position.
- 3) Lift and lower the gate into position and check all planes for level, adjusting as necessary. **NOTE- SEE OPERATION, SECTION 5 REGARDING POSITIONING OF THE GATE.**
- 4) Mark all mounting holes.
- 5) Remove the KKS to a safe location, and proceed to mount EPDM seal as follows.

### Applying the EPDM compound

The EPDM compound is attached on the back of the frame, to be between the frame and the concrete wall.

1. Before applying the EPDM compound to the gate, ensure the frame is clean and smooth.
2. Starting with the bottom edge, cut a suitable length of seal, and mark the holes onto the seal with the white pencil. Remove the protection cover from the seal, then press into place on the frame. Repeat this process with the side frames.
3. Remove excess seal then glue the corners of the seal together using the provided EPDM glue. When not glued properly, this can lead to leakage between the back-plate of the KKS and the concrete wall.
4. Grease the drill can on the outside with the copper grease to prevent ripping of the compound, then attach to a suitable drill.
5. Now drill the previously marked holes in the compound, ensuring the hole in the seal is central to the hole in the frame.

**SAFETY WARNING- Make sure that contact with the EPDM glue to your skin and eyes is prevented. If this does occur, contact your doctor immediately.**

1. Re-position the KKS to previous position, adjust as necessary.
2. Install the chemical anchor fixings as described in appendix B.

**The curing time must be fully observed.**

**On larger versions of the KKS Tilting Weir, jacking bolts may be fitted to the base of the frame. Once the installation procedure above is carried out, these bolts are used to brace between the bottom frame and the concrete floor.**

1. Extend the jacking bolts and tighten to brace the gap between the bottom frame and concrete base.
2. Lock in position using locking nut.
3. During commissioning, the jacking bolts may require adjustment to improve the seal along the bottom of the tilting weir.

#### 4.4 Actuator Installation

Please note that the actuator can be fitted with or without a protection hood.

1. Remove the side plates from the pedestal, and ensure all Allen bolts are tight on the couplings.
2. Remove thrust base from the actuator.
3. Place the protection hood onto the pedestal (if supplied), and position the thrust plate on the end of the shaft.
4. Using the bolts supplied, attach the thrust plate to the protection hood and pedestal.
5. Carefully lift the actuator back onto the thrust plate and tighten mounting screws.
6. Refit the side plates to the pedestal, and check the gate operates correctly.

NOTE: The actuator must only be operated by fully competent personnel and all operators must have read the actuator manufacturer's instructions before use.

IMPORTANT- Do not lubricate any part of the KKS with grease or oil, unless otherwise instructed.

#### 4.5 Inspection prior to operation

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

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

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## 5. Operation

### 5.1 General

The operation of the KKS is discussed in paragraph 5.2. In paragraph 5.3 possible failures, causes and solutions are provided.

#### Safety issues

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

#### **PRE-START CHECKS:**

- **The gate must be checked for obstruction, damage or vandalism, all of which must be rectified before operation.**
- **Under no circumstances may the gate be operated with the locking pins in place- before use, the locking pins must be removed and locked in their storage positions. Failure to do this may cause damage to the pinions/gate.**

Operation of the locking pins:

To insert the locking pins, the gate needs to be moved to the closed position. When in the correct position, the locking pin handles can be unlocked and pushed down to engage the locking pins. Once in position these must be locked off using a suitable padlock.

To remove the locking pins, unlock the handles and pull upwards. Once in position, these must be locked off using a suitable padlock.

NOTE: The physical stops on each end of the quadrant are for fail-safe only, and should not be used as an indicator that the gate is at it's end of travel. The gate should only be operated so that the physical stops just enter the cross beam to prevent damage to the gate.

#### 5.2.1. Specifications

The KWT KKS, type KKS is provided as standard with:

- Reduction gear units
- Two sided rack driving,
- Clockwise closing operation.

#### 5.2.2. Opening and closing:

NOTE: The gate should only be operated so that the physical stops on the ends of the rack quadrants just enter the cross beam (see fig. 1 below). The stops are for fail-safe only, and should not be used as an indication that the limits are reached. If excessive force is applied to these, this could result in premature failure and/or damage to the gate.

NOTE-GATE POSITIONING: When installing, the gate frame must be installed at such a height so that when the gate is fully closed, the side cheeks (1) are approx. 10mm above the upstream slab to prevent fouling the sill. Also ensure that the civil structure is designed to provide enough clearance for the physical end stops on the upstream side, e.g. make pockets (2) or a step (3) as highlighted.



Fig. 1

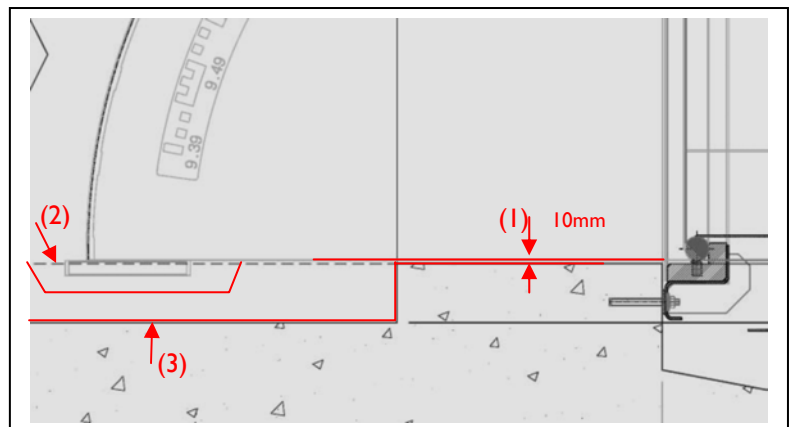


Fig. 2



#### **Using a T Crank**

- 1) Insert the T Crank into the operation point of the KKS.
- 2) Turn the T-crank counter clockwise to open, clockwise to close.
- 3) If a high operation torque is noticed, the KKS 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 KKS 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 KKS or work past it's limits. For instructions on setting the actuator, please refer to the manufacturer's instructions, following this procedure:

- 1) Operate the tilting weir to it's fully open position, then reverse slightly before setting the open limit on the actuator.
- 2) Operate the tilting weir 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 KKS, set the torque limits for open and close on the actuator.
- 4) Operate the KKS 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 penstock please consult the order acknowledgement. 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 weir is not operated past it's limits, or operated when obstructed by debris etc.

### 5.3 Failure

Failure	Possible cause	Suggestion
The KKS 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
Operation torque is significantly higher than expected (see order confirmation).	Reduction gear units are Dirty or damaged	Clean Reduction gear units or replace then (Please contact supplier).
	Application specifications are exceeded.	Please contact supplier.
	Dirt between seal and seal face area	Remove present obstacles
	Locking pins in locked position	Remove locking pins and lock off- Please contact supplier if the gate has been operated with pins in position.

Table 2 Failure

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## 6. Cleaning & maintenance:

### 6.1 General

The KKS is constructed in a way that a minimum of maintenance is required. Paragraph 6.2 describes the regulations involving regular maintenance.

### 6.2 Maintenance & Inspection

#### *Minimum Requirements*

For correct functioning of the KKS Tilting Weir, it is recommended to operate the KKS fully through its cycle annually, and inspected for damage or obstruction monthly. The weir must also be visually inspected before each use.

The following parts require attention in particular and need to be cleaned if necessary

- 1 Cross Beam and Reduction gear units
- 2 Rack and Pinion
- 3 Sealing rubber

### **Warning**

Before working on any part of the gate ensure that all power sources are locked off and safety precautions have been implemented. Where gates are fitted with locking pins, these must be inserted before entering the channel, or carrying out any maintenance on the gate.

Report immediately any loose or damaged parts that may cause injury to personnel, damage the gate or affect the efficiency of its operation. Check for any damage to actuator cables, protection hood or padlock.

## 7.0 Disposal

### 7.1 General

Paragraph 7.2 describes the procedure that a KKS at the end of its life cycle can be removed safely and in an environmentally responsible way.

### 7.2 Removal

Dismantle the KKS as follows:

- 1) Support the KKS using suitable lifting equipment.
- 2) Remove all the mounting material from the KKS.

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

- 3) Remove the KKS from the wall.
- 4) Remove the fixing materials from the wall.
- 5) Dismantle the KKS and separate materials into suitable classifications.
- 6) 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

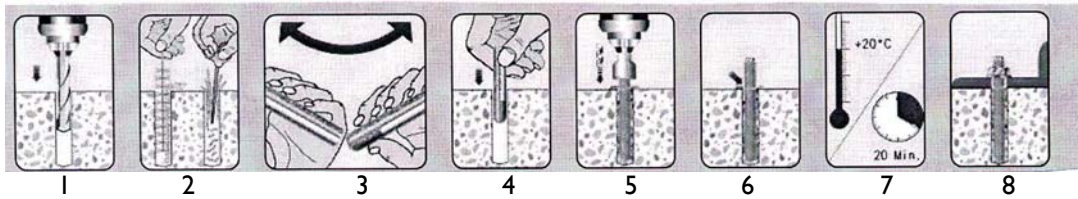
1. Drill Mounting hole in required position to the correct depth and diameter (please refer to details supplied with chemical anchors)
2. Blow out drilled hole using compressed air. (Warning, suitable eye protection to be worn)
3. Insert a chemical anchor capsule into each hole.
4. Attach a length of 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.



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

Please note that these are guide values, therefore reference should be made to the anchor manufacturer's instructions supplied with the products.

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	Unknown
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.	
Phenotype:	
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 <sup>3</sup>
10. Stability and reactivity	
Thermal decomposition	Above approx. 300 °C
Dangerous decomposition products	None
Besides carbon black also carbon dioxide and water as well as 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. Further indications	
The indications are based on your to-days knowledge. They are meant 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 <sup>3</sup>	0.950
Yield stress, Test piece 3	53455	N/ mm <sup>2</sup>	22
Elongation at yield stress	53455	%	9
Elongation at tear	53455	%	300
Tensile-E-Module	53457	N/ mm <sup>2</sup>	800
Impact strength ( std. Small bar)	53453	KJ / mm <sup>2</sup>	Without break
Impact strength when notched ( U-notch)	53453	KJ / mm <sup>2</sup>	12
Indentation hardness H I32 / 30	53456	N/ mm <sup>2</sup>	40
Shore hardness D	53505	N/ mm <sup>2</sup>	63
Crystalline melting range calorimetric	52328	K	126
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	>10
Surface resistance. Electrode A	53482	Ohm	10
Creep resistance Method KC	53480	V	600
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

## 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	0.01	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

## 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.

### 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		Tensile strength $R_m$ MPa	Elongation $A_5$ %	Hardness HB (typical)	Impact value KV J
	$R_{p0.2}$ MPa	$R_{p1.0}$ MPa				
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/dm <sup>3</sup>	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	$\mu\Omega\text{m}$	0.75

**Physical properties at elevated temperatures**

**Table 6a. Linear expansion ( $RT \rightarrow T$ )  $\times 10^{-6}/^\circ\text{C}$**

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.

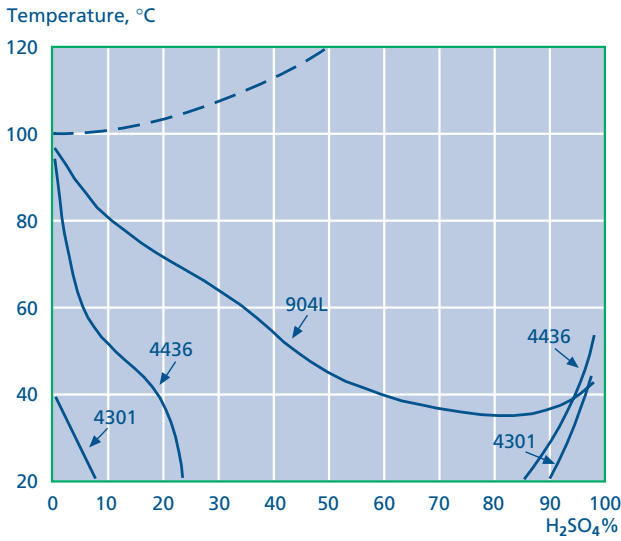


Fig. 1. Isocorrosion diagram for 4301, 4436 and 904L in stagnant sulphuric acid. The curves represent a corrosion rate of 0.1 mm/y. The dashed line represents the boiling point.

**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.

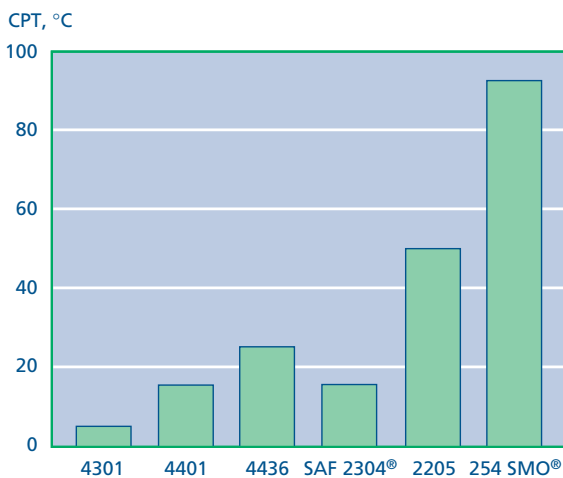


Fig. 2. Critical pitting temperatures (CPT) in 1M NaCl according to ASTM G150 using the Avesta Cell. Typical values.

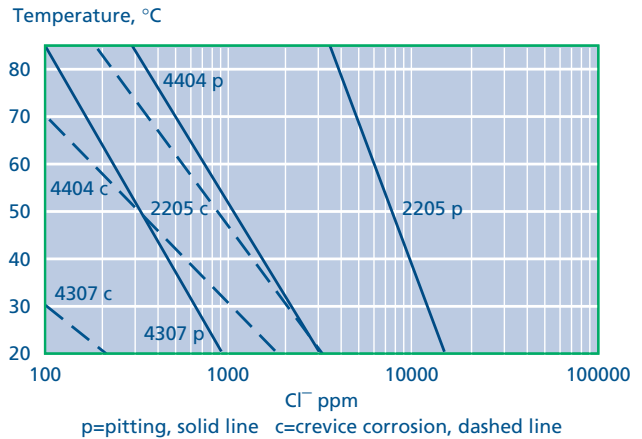


Fig. 3. Risk of pitting and crevice corrosion on conventional stainless steel in water of different chloride content or temperature.

**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".

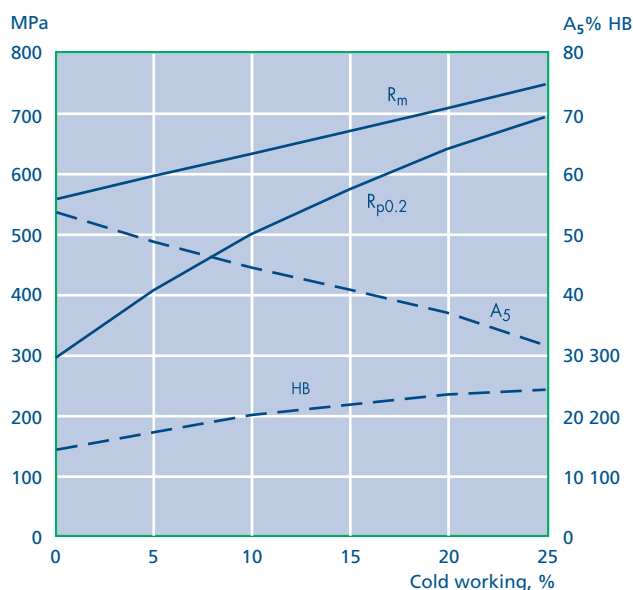


Fig. 4. 4301 work-hardening at cold working

### 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.

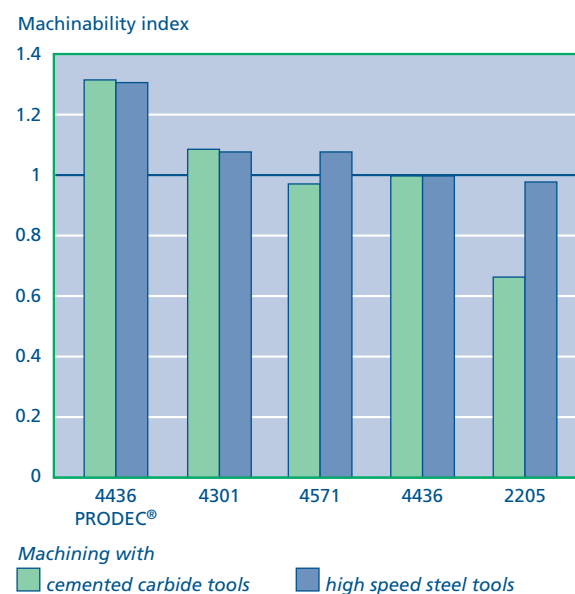


Fig. 5. Relative machinability for some stainless steel grades.

### 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/SKINb, 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

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