krah community - innovative pipe solutions

IMPROFIL

Storage tanks and special apparatus

Pipe Application / Egypt - „Primary care families"

Krah pipes goes crazy - apps beside the applications

See also: ImProfil of: Sandra Perez / Krah América Latina, Buenos Aires

ATV A127 Standard VS. AWWA M55 manual - Main Differences in the Static Calculation Methodology for Flexible Pipes

Welcome to the 4th issue of ImProfil

Dear Members of the Krah Community and friends and interested people,

The year 2011 has gone so fast again and we are now publishing already the 4. Issue of our "ImProfil", which according to your feedback has been quite well-received and we are looking forward to improving ourselves with the help of your interesting articles and news related to pipe products in 2012!

Besides several technically interesting articles you will find some motivating pictures which show what else can be done with and from Krah pipes – maybe you can build your children a Christmas present yourself this year ;)

Very soon, in the beginning of 2012 we will offer a print version „BestOf" of all Improfil Issues 2011, which can be ordered for free! Don´t miss this offer and send your email with the reference: „BestOf" to **info@krahcom.net.**
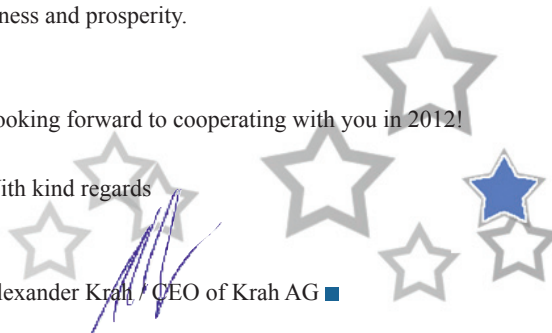Furthermore we have just produced our 750. mandrel which combines the latest innovations and best quality with the lowest price. For further information on our promotion please refer to http://www.krah.net/en/home/news-archive.html

Finally, there is no time more fitting to say „Thank You" and to wish you a Happy Holiday Season and a New Year of health, happiness and prosperity.

Looking forward to cooperating with you in 2012!

With kind regards

Alexander Krah / CEO of Krah AG ∎

Storage tanks and special apparatus

Tanks for storage of liquids are required in all areas of public life. Constructions made of thermoplastic plastics are playing a decisive role on this. Beginning with the traditional bucket, which are belonging to our lives since the earliest initiations of plastics technology, up to the 100 m³ storage tank for chemicals and hazardous liquids – there is no way of avoiding constructions made of polyethylene and polypropylene today. Particularly if the cylinder barrel is made of helical extruded pipes, the flexible wall construction (profiled wall structure, multi layer, etc), which comes along with the manufacturing method, in connection with new generations of raw material, continuously opens up new possibilities of solution for the construction of tanks. Thereby new possibilities to connect stability, resistance, long-life cycle and chemical resistivity as well as cost-effectiveness are established. This makes it possible to incorporate them suggestively into construction.

A multitude of tanks is engineered in vertical form. The bottom construction is carried out as flat, beveled or conical bottom. The roof construction in turn can be engineered open – with or without reinforced edges, with cone-type roof or with flat roof.

Horizontal tank constructions are also applied, whereas the calculation and especially the construction can be much more complex. Horizontal tanks are:
- aboveground with supports
- aboveground in shells
- in some extent carved in the ground (supporting angle mostly 90°-120°)
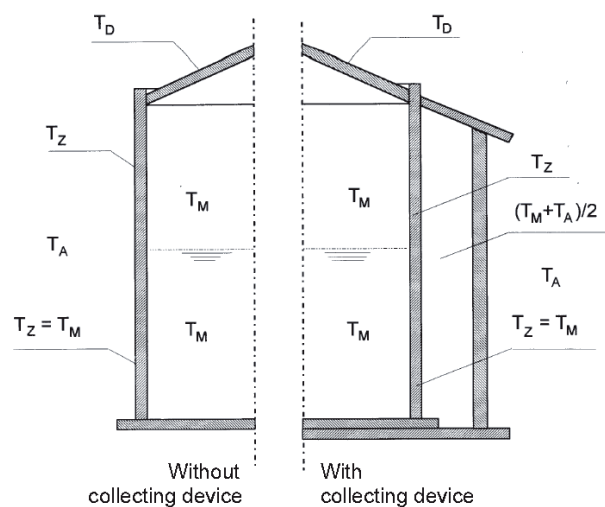or subsurfacely installed.

The most common mounting form is for sure the vertical, cylindrical tank with a flat top, which cylinder is made of helical extruded pipes. The applied load on the tank constructions can normally be derived from the operating conditions.

Attention should be paid to the fact that the tank often is part of a complex construction, which means, it may need suitable additionally installed equipment. Tanks which are for example used in chemical engineering, in filling or decanting stations or as process containers, are often additionally equipped with stirring devices, pumps, metering or tempering devices. The resulting static and dynamic loads have to be considered just as these following general points:

Typical storage tank for hazardous liquids:

Storage tanks 68 m³, manufactured by PCT, Belgium design acc. DVS 2205

manufactured by PCT, Belgium
temperature design: TA: environmental temperature
TZ: temperature cylindric wall
TD: temperature roof
TM: temperature liquid

...

Hydrostatics and operating pressures

Hydrostatic conditions result from the kind of medium (density, viscosity) and the conditions of filling (filling cycle, filling level, duration of filling).The resulting operating pressures are decisive for the dimensioning of the cylinder wall, cylinder bottom and roof, as well as for additionally installed equipment. Additional pressures (negative or positive pressure) can be produced by the action of emptying and filling or by external influences like changing weather conditions or wind load.

Chemical resistance

The medium which is filled in can influence the stability and strength durability of the chosen material of the tank. Although Polyethylene and Polypropylene generally have got a very good resistance to a multitude of acids and bases, there are limitations and boundaries of resistance. These boundaries can furthermore be changed by the influence of temperature and reaction time. In many cases the reduction ratio for the used medium is to be found in literature and standards, which make dimensioning easier.

Temperature

The behavior of Thermoplastics is depending on temperature, with increasing temperature tolerable stability and stiffness decrease. This behavior has been adequately proven and follows principles, which allows an exact calculation. The required material data is provided by manufacturers of raw materials and is the base for the dimensioning of pressure pipe systems, sewers etc. The temperature of the cylinder wall is influenced by the temperature of the medium on the one hand and by the ambient temperature on the other. Normally the average temperature is used for the dimensioning. This procedural method, in which the aspect of time also has to be taken into account, works best if there are only minor or median differences in temperatures. A detailed observation of material property is useful if there are big differences in temperature.

Influence of weather

According to the installation site different climatic conditions can occur. If it is installed inside a building there has to be paid attention only to the ambient air temperature, other climatic conditions can normally be excluded or have just an extremely alleviated effect. But outside buildings wind, sun, precipitation and ambient temperature have to be considered. The load by weather is naturally dependent on season; furthermore different regions have to be considered differently. Regions are often divided into different areas of weather, for which the frequency and intensity of weather conditions have been empirically defined. A change of weather conditions caused by climate change should be noted if a long term dimensioning is carried out.

Potential danger

Consideration of danger is the central point of all considerations concerning safety, especially if handling with chemicals or other hazardous substances. Here we differentiate between dangers for: persons, subjects and environment. Regulatory requirements differ a lot in the countries of the world, which has to be paid attention to when defining values and rules for safety. That is why there are no readable universal laws for safety.

Operating conditions are also very important because it is a difference if the load is static or varying a lot. Protections like overflow protection, devices for detecting leakages and alarms, as well as the possibility of remote supervision have to be clarified from case to case, but are in any case good instruments to reduce the potential danger. Normally a collecting device or tank is prescribed for dangerous substances, which influences the static load of wind, precipitation and solar radiation in addition to security.

Dimensioning of tanks

Dimensioning of tanks takes place by using principles of strength of materials and plastics technology. Thereby we can fall back on the experience of more than fifty years. For modern pipe material normally corresponding curves and tables are provided by the manufacturers when launching a product, from which you can read necessary figures for short- and long-term usage. In terms of static calculation and temporal scale, you often differentiated between applications. Calculation therefore normally is scheduled to run for 10 or 25 years, in individual cases for 50 years.

In order to be able to get needed material characteristics for the respective time of calculation, you can, concerning to the consideration of load, fall back on hydrostatic strength diagram, which have been determined exemplarily on an axial extruded pipe. The calculation of stability is carried out with material properties, which are based on creep modules, which can be extrapolated from measurement data form up to 10000h. Security of such extrapolations for pipe material made of polyethylene is given by continuing experience for many decades.

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For raw materials with laboratory confirmed long term behaviour (hydrostatic strenght curves acc. international standards ISO 1167), a sufficient accuracy of extrapolation to 50 Jahre from 2000 h datas is approved. This means a extrapolation for 2,5 decade.

The first storage tanks made of polyethylene were produced in 1950s. Since this time computer programs for static calculation have gained credibility on the market, which can limit calculation costs. Standards and guidelines ensure the required standardization for this important market segment of plastics industry. Calculation rules are, inter alia, described in detail in standard EN 12573 or DVS 2205 part 2.
A simple wall dimensioning can often be estimated with sufficient accuracy by carrying out a calculation of stability to internal pressure on the one hand and to vacuum on the other.

Firstly must calculated with the traditional equation for inner pressure (acc. Peter Barlow) the required cylinder wall. The inner pressure depends from filling height, density of the liquid and permitted load. This can be conducted in different heights of the cylinder to get a staged and with it cost-efficient wall structure.

The permitted stress is the result of typical creep rupture curves (hydrostatic stenghts diagram) for the raw material, in consideration of the safety factor and the reduction coefficient for the specific ductility (depending on the temperature), the joint factor (depending on the kind of welding) and the chemical loading by the liquid (tables of operating experience, inter alia DVS and DIBt, Germany). For the consideration of the bending moment you have to choose an additional factor, which takes the constraint of elongation of the cylinder in the area of joint between cylinder and bottom plate into account. The constraint of elongation respectively the stiffness depends by the thickness of the bottom plate. In practice this factor is between 1 (membrane bottom plate) and 1,82 (fixed bottom plate).

$$p = \rho \cdot g \cdot h_f$$

$$s_{ZS} = C \cdot \frac{S \cdot p \cdot d_i}{2 \cdot \left(\dfrac{\sigma \cdot f_S}{A_1 \cdot A_2} \right) - p}$$

p: hydrostatic pressure[N/mm²]
g: acceleration of gravity [m/s²]For
ρ: density of the medium [kg/cm³]
sZS: minimum wall thickness for the consideration
        of loads [mm]
C: factor for bending moment [-]
di: inside diameter [mm]

S: safety factor [-]
σ: load from hydrostatic strength diagram for the
        present temperature [N/mm²]
A1:   reduction coefficient specific ductility [-]
A2:   reduction coefficient ambient medium [-]
fs: long duration welding factor for homogenously
        manufactured helical extruded pipes = 1

Table for specific ductility following DVS 2205 (dated 2010):

Material	Operating temperature			
	-10 ℃	20 ℃	40 ℃	60 ℃
Polyethylene	1,2	1	1	1
Polypropylene Homopolymer PP-H	1,8	1,3	1	1
Polypropylene Copolymer PP-R	1,5	1,1	1	1

...

Including the calculation of stability against vacuum, which can for example arise during emptying the tank or be caused by increasing wind suction, a good approach towards the statically required wall thicknesses can be reached. The minimum value for this vacuum, which could arise, has been set at 0,0003N/mm² by guideline DVS 2205.

Equation for buckling of cylinders:

$$s_{ZB} = 0,9 \cdot \left(S \cdot A_{2I} \cdot \frac{h_z \cdot \sum p_u}{E_K^{T°C} \cdot d_i} \right)^{0,4} \cdot d_i$$

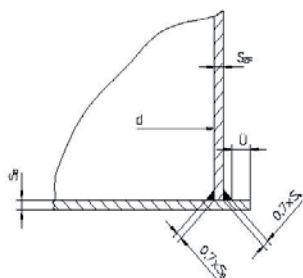|	
sZB:	minimum wall thickness for buckling load [mm]
S:	safety factor [-]
A2I:	reduction coefficient ambient medium for consideration of stability [-]
hZ:	high of cylinder [mm]
Σpu:	^total vacuum loads [N/mm²]
EK:	creep modulus for period under consideration and temperature [N/mm²]
di:	inside diameter [mm]

A concluding calculation can not be replaced by such a first consideration, as described before. However, it provides a good and quick indication to the required construction.

At Krah Community (www.krah.net) an Excel spread sheet can be downloaded by members for calculation of vertically tanks!
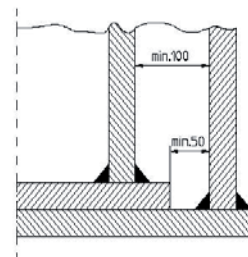
Design details for production of tanks

Normally, cylinder are fastened onto the bottom plate with double fillet weld, whereas a ≥ 0,7 x sB . The bottom thickness sB should always be less than the thickness oft he cylinder sZ.

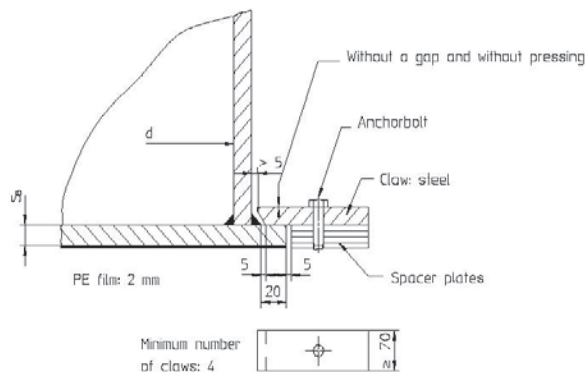A rule of thumb for bottom plate dimensioning is sB = 0,8 x sZ.

Simple tank

tank in tank systen

To give tanks the required stability, especially for use outdoors, the bottom plate often is anchored in the foundations. The ancors must be designed against the worst case of load. This concerns primarily dimensioning against wind and the resulting bending moment but also increasing pressure fluctuations can affect the load conditions. If anchors are necessary, at least four fastening anchors are needed to ensure a steady load bearing. The anchoring logically is to be carried out with help of separate fastening anchors so that the tank can move/slide sideward and relax. To ensure that be bottom plate of the tank can slide, an additional plastic plate with a thickness of app. 2 mm below the base is recommended. In this way no elongation under the influence of temperature or change of load can result in avoidable additional loads.
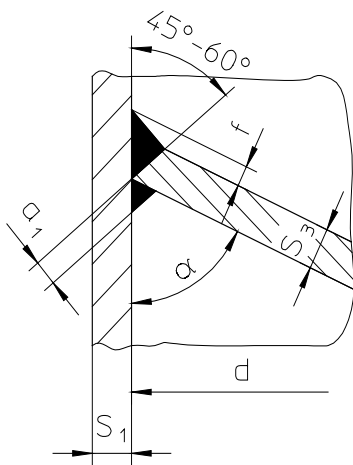
Anchoring of the bottom

For fluidic and procedural reasons, the usage of tanks often leads to different bottom constructions than the typical flat-bottom (beveled or conical bottom,...). These geometries have to be
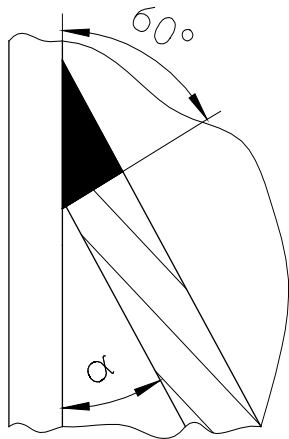
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statically calculated and professionally integrated into the overall construction by welding just as a flat-bottom. The accessibility of the welding zone is partly complicated and places special demands on welder and welding apparatus.

$a = 0,7 \times s3$
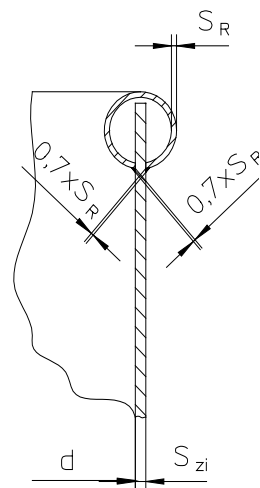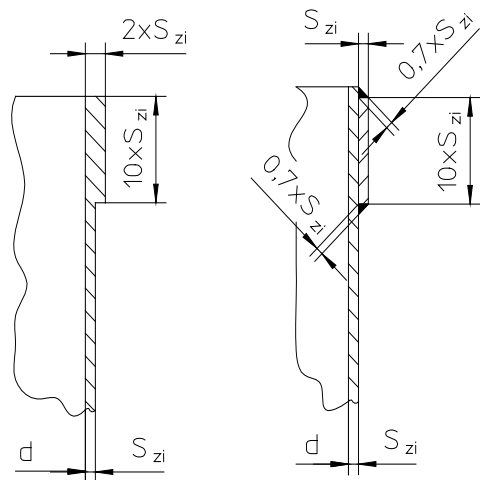$a \geq 60°$
$f = 0,5 \times s3$

$a < 60°$

Reinforcement of the rim

Tanks, which are open to the top, need to have a reinforced rim. The minimum wall thickness, which is the result of the hydrostatic, does not lead to a sufficient stiffness, especially when talking about partial filling. There are several solutions to avoid this. The most useful variation is to use the flexibility in manufacturing of helical extruded pipes and to thicken the wall thickness during production at the rim of the container. A retrofitting solution is the welding of a separate stripe or the attachment and welding of an axial extruded pipe, which has been slotted before.

Roof constructions

If containers, made of thermoplastics, are designed with a roof, normally conical roofs with a roof inclination of 15° or ripped flat roofs are used. A stability check is to be carried out for the deadum.
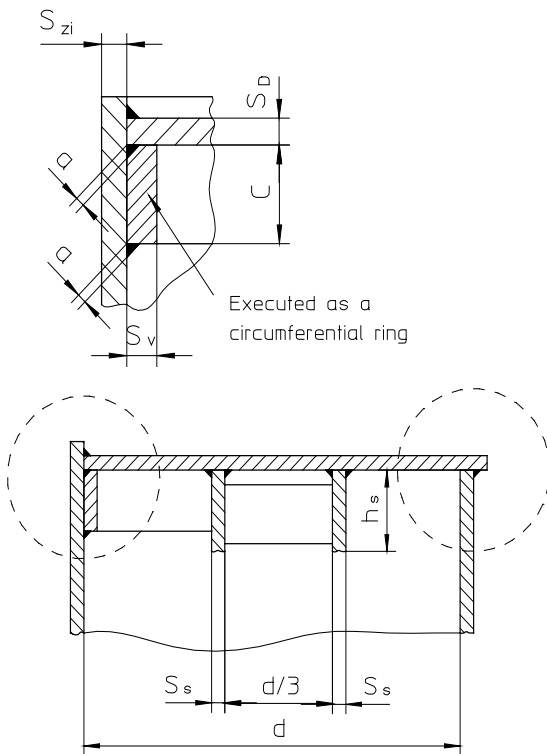
Special attention has to be paid to arising operating- and ambient temperatures. An accessibility of thermoplastic roofs is usually not intended, according to the safety regulations, but is still guaranteed by grates on separate platforms or by suitable ladders. When used in connection with platforms and ladders you have to take the different elongation by temperature of steel and thermoplastics into account. In either case, suitable slide bearings in the construction are needed to avoid loads.
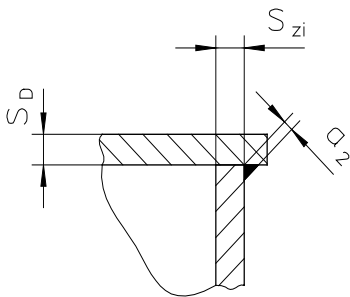
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Section through flat roof with two stiffeners and bulkheads, with two variants for bearing flat roof on the cylinder:
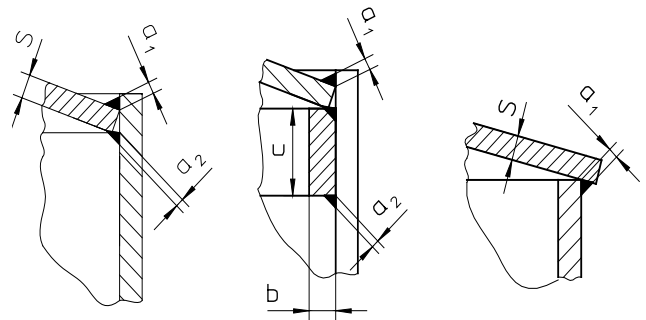
Variante 1:

Executed as a circumferential ring

$SV \geq SD$ and $SV \geq 10$ mm
$C \geq 5$ x SD and $C \geq 80$ mm
$a1 \geq 0,5$ x min (SD, Szi)
$a2 \geq 0,5$ x Szi

Variante 2:

$a2 \geq 0,5$ x Szmin
$Smin \geq$ min (Szi, SD)

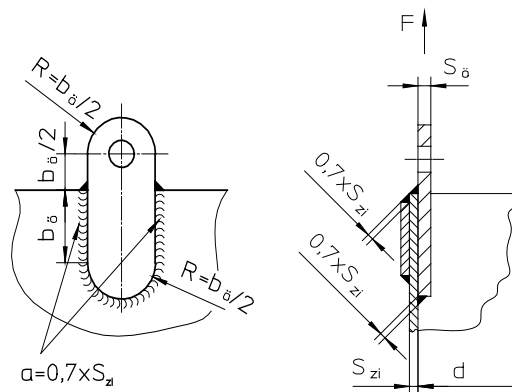Conical roof - Different variants for bearing roof on cylinder

Lifting lugs

To make the lifting of a tank easier, two lifting lugs are welded on it. The dimensioning and the choice of the safety factor have to take account of possible dangers of floating loads. Account should be taken to the weight of the tank plus mounting parts. The required thickness of the lifting lug is situated within following limits: $bÖ > sz$ and $bÖ < 3$ x sZ

The use of traverses protect the rim of the tank against avoidable deformations and it guaranty a vertical lifting without additional loads. It is important to note that in setting up a tank, which was transported in a laying position, the lifting lug is temporary loaded by thrust, torsion and bending. Furthermore, the hole diameter hast to be coordinated to the diameter of the shackle, to avoid inadmissible bearing stresses.
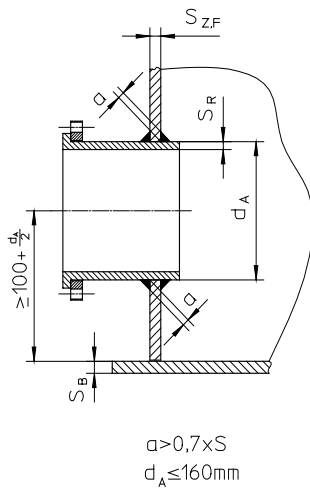
Design of lifting lugs:

$a = 0,7 \times S_{zi}$
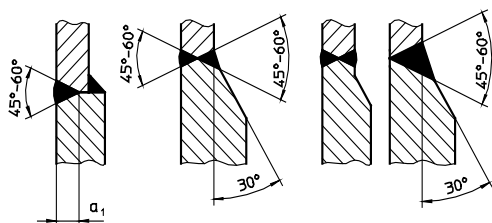
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Nozzles

Number and suitable dimension of nozzles is important for the dimensioning of the wall thickness, because every cutout can present a weakening. As smaller the nozzle, as smaller the weakening. By the use of DVS 2205 for dimensioning, nozzles in the cylinder wall are just permitted up to a diameter of 160 mm. Especially the lower section near to the bottom should be avoided if possible, because of the stress and the disability of elongation. If using storage tanks, the nozzles should be integrated into the roof, which requires no special calculative proof. This applies in particular to manways and nozzles with large diameter. The weld has to be made with fillet welds on both sides, which requires a minimum distance to the basement or installed equipment.

Nozzle in the cylinder shell:

$$a > 0,7 \times S$$
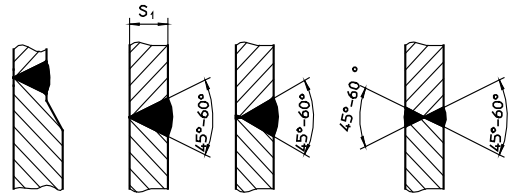$$d_A \leq 160mm$$

Welding in cylinder walls

If cylinder walls are extended (helical extruded pipes can be manufactured in homogenous units up to a length of 6 m), following joints made by welding can be chosen dependent to the wall thickness constellation.
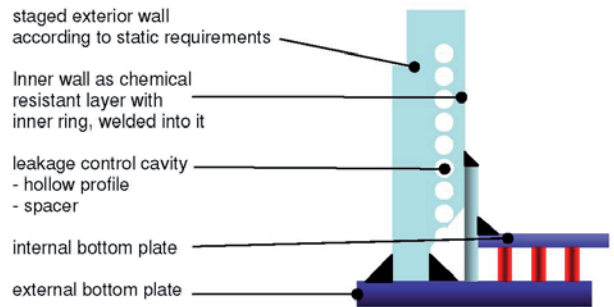

Staged walls: with a1 = 0,7 x s

same wall thickness

Double wall tanks for hazardous liquids

As already mentioned, you need to make special arrangements for dangerous liquids where regulatory requirements differ in the countries. Widely similar is the requirement for a safety tank or a collection container, in which liquids can safely escape if there is a leakage. Tanks fabricated out of helical extruded pipes are available as "tank in tank" solution. For this purpose you integrate a hollow profile into the cylinder wall, which separates the inner wall from the outer wall on the one hand, which gives them different functions and serve as a leakage warning cavity on the other. A leakage sensor can be arranged in a way that it gives alarm when there is only a minimal leakage, which ensures best reaction time!

staged exterior wall according to static requirements

Inner wall as chemical resistant layer with inner ring, welded into it

leakage control cavity
- hollow profile
- spacer

internal bottom plate

external bottom plate

The inner wall performs a protective function and has to be statically designed in a way that it – supported by profile and outer wall – can cope with hydrostatic pressure. It also needs to have a suitable wall thickness to guarantee a proper welded joint to the double bottom. The outer wall has to carry the total static load, which is transmitted from the inner wall over the profile outwards, which is why it is normally dimensioned in these premises. The outer wall normally is not exposed to long time affect by chemicals or hazardous liquids, which can be taken into account when calculating, what permits significant savings in the wall thickness. Moreover, the advantage is space-saving and the cheaper manufacturing.

Dipl.-Ing. Stephan Füllgrabe
Managing Director / Plaspitec GmbH

IM *PROFIL of*

SANDRA PEREZ /
Krah América Latina, Buenos Aires

1. Since when do you work for Krah América Latina S.A.?

I'm at the company since it started in Argentina, in August 2004.

2. What is your position in the company?

I'm a Civil Engineer and my business card says: "Development, Technology & Marketing Manager". I'm responsible for many different things, such as technical developments (manuals, technical reports, catalogues, technical articles, etc), new products design, technical support (for customers, for the sales department and for production department), project analysis, quality control procedures, and marketing.
I also follow the development of local standards at the Argentinean Standardization and Certification Institute (IRAM), as a member of different committees, and I dictate curses and/or conferences to different groups of interest regarding our technology.

3. What exactly is Krah América Latina S.A. doing?

Up until now, we've been exclusively producing Krah profiled pipes and accessories, mainly providing for the sewerage and drainage markets in Argentina. However, we're currently working on developing new products in order to expand to other markets.

4. What are the characteristics of the company compared to the competition?

We're a small company compared to our main competitors. However, we offer much more than just a standard product as we have a strong technical support and the possibility of a great flexibility in production. This lets us provide a unique service, offering our clients the study of their projects in order to optimize them with our products.

5. Since when Krah America Latina S.A. is working with the Krah technology?

Krah America Latina S.A. was originally created for the distribution of Krah products in Latin-America, so it's working with Krah technology since its beginning, 7 years ago.

6. How did you learn about this?

I was invited to join the company by its Argentinean owners, Daniel and Gustavo, before the company was formally created. I had known them, especially Daniel, for a long time and had worked for them in some projects as a freelance engineer. At that moment, I knew very little about Krah AG and its technology (they were not known yet in the Argentinean market), but I did know about pipes and I remember being really impressed by Krah profiled wall pipes and their possibilities for the Latin market.

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7. Which Krah machines does Krah America Latina S.A. own until now?

We own one machine KR700.

8. What do you call your „Krah pipes"? (brand name)

We call the profiled wall line as "Krah Profil" pipes. The idea was to maintain a clear reference to Krah in the product name, being ourselves a Krah company.

9. How many projects you have been realized with these so far?

Our products have been installed in over 90 projects now, totalizing more than 140 km of installed pipes, including the first 2 experiences with HDPE outfalls in Argentina.

10. What is your experience retrospectively?

My experience with Krah technology, as I already said, comes from its beginnings in Argentina, so I lived all the process, since the KR700 installation, through the study of the product, it's presentation for the Argentinean market, the first projects, etc, etc. So far, it's been a great experience that made me grow up both professionally and personally. With regard specifically to Krah's technology, I think the flexibility given by the production system and its continuous upgrades are the mayor advantages, as they let us be constantly optimizing our products or creating new ones, offering the client always the best possible choice.

Sandra personal

Family:
I'm married with Pablo (another engineer like me) and we have two daughters: Lucia (4 years old) and Victoria (1 year old)

In my spare time…
Unfortunately, I do not have much spare time at the moment as my kids are too young. However, when I can, I like to go to the movies, spend time with friends or travel. I also like sports a lot, like skating or skiing.

I am just reading …
Dan Brown's "The Lost Symbol". But I'm reading it very slowly, as it's hard for me to find the time these days.

I can laugh about:
Many things: a funny movie, a funny TV show and, mostly, my kids' ideas and jokes.

krah community - innovative pipe solutions

Pipe Application / Egypt - „Primary care families"

With approximately 8 million people Cairo (Egypt) is the most populous city in the Arab world. Today the metropolitan area of Cairo is even home to around 25 million people, which means that the provision of clean drinking water and disposal of wastewater is one of the biggest challenges of this region. To address this problem the government has embarked on the project „Primary care families", some time ago. This project aimed to support people, „who had lost their homes in catastrophes or who lives in very bad conditions."

As part of this project a sub-project for 12,500 residential units and 60,000 residents was planned and completed successfully 30 km south from the city center. This could be realized in collaboration with project partners as follows

• **EGEC** (engineering consultancy) - *www.egec-xprt.com*
• **Arab Contractor** (Contractor) - *www.arabcont.com*
• **Krah New Mena Plast** (pipe manufacturer)
  www.krahmisr.com

To offer help to the people as quickly as possible, the entire project was under a very high time pressure. That's why the estimated construction period had been one of the most important selection criteria for products and companies.

The company New Mena Plast / Cairo could meet all necessary demands of the project. It was advantageous that the selected and used profiled Krah pipes (made of polyethylene) could be produced directly at Mena New Plast / Cairo, thus the delivery time could be kept very low. The lightweight but very stable PE-profile pipes - with a weight of well under 50 kg per meter - could be handled on the construction site without the use of special equipment.

The complete pipeline of length: 3 Km divided between 500, 800 and 1000 mm pipe diameters. The durable welded joint was made by Krah welding equipment simultaneously with the pipe installation in less than half an hour. Thus the construction process was not disturbed and the installation time could be reduced to a minimum. Per day and welding machine more than 60 meters were installed.

The pipes have been statically calculated according to the standard ATV 127. Therefore, the occurring loads as well as the soil and installation conditions were considered. The pipes were laid in a trench 1.2 to 2.5 m width up to 8 meters depth. Since polyethylene is a flexible pipe material which adopts to stress, we can by now expect a lifetime of more than 100 years. The homogeneous welded joints are very beneficial to lifetime of the pipes, as no additional seals must be used and the entire piping system is

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completely homogeneous and dense. The tightness is especially important to protect groundwater from contamination and thus prevent disease. So it was checked and verified successfully in 50 meter intervals. With the help of static analysis a solution to short term changes in environmental conditions can be found.

Because the pipeline route had to be rescheduled, very high traffic loads had to be considered for a subsection below a highway. Sin-

ce flexible pipe systems create a synergistic association with soil, the installation conditions have been optimized so that even here an optimal load distribution could be ensured.

More information:
Krah New Mena Plast / Peter Youssef

www.krahmisr.com

ATV A127 Standard VS. AWWA M55 manual
Main Differences in the Static Calculation Methodology for Flexible Pipes

Introduction

The purpose of this article is to set up the main differences between two popular methods worldwide for performing static verifications of HDPE flexible pipes, i.e. between the method given by the ATV A127 standard („Guidelines for Static Calculations on Drainage Conduits and Pipelines") and the method established by the American Water Works Association (AWWA) more specifically in its manual M55 („PE Pipe Design and Installation").

Brief review about the related methodologies

The ATV A127 is a standard of German origin and its latest version dates from the year 2000. It is widely used in Europe and its content exclusively covers the methodology for calculations of all kinds of pipes.

AWWA M55 is not a standard, but rather a design manual according to the recommendations of the American Water Works Association (AWWA) covering all relevant aspects of the design and installation of HDPE pipes. The recommended methodology of structural calculation is one of the ten chapters that the manual contains and is exclusive for HDPE pipes (although the guidelines are common to the AWWA manuals of other types of pipes). The methodology basis used in this manual is the most used, almost exclusively, in the Americas.
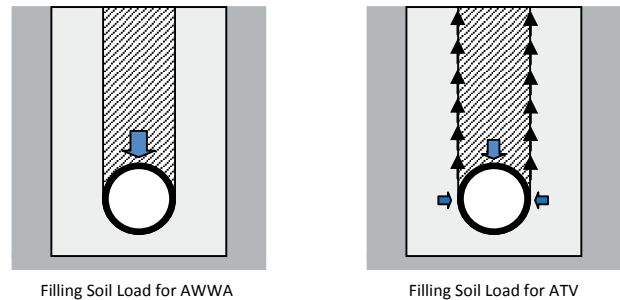
COMPARISON

Basic Ddifferences in the methodology of calculation

For the main basic differences between both documents, it can be mentioned:

I.   The ATV A127 methodology aims to be universal, i.e. for any kind of pipe, regardless of the material or its status as „rigid" or „flexible". The AWWA M55 methodology, on the other hand, stands exclusively for the case of flexible pipes.
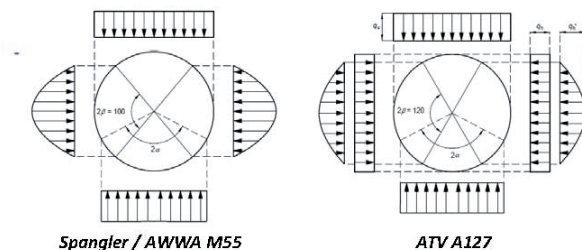
II.   Soil load calculation is more conservative in AWWA, due to the fact that this manual does not consider, as ATV does, the "arc" effect that usually takes place for flexible pipes (reducing the weight of the soil prism right above the pipe).

Filling Soil Load for AWWA   Filling Soil Load for ATV

III. Another important difference is the way in which each methodology analyses the distribution of the filling soil load around the pipe. Both methodologies are based on the theory of M.G. Spangler. However, while the M55 AWWA manual takes this theory without modification assuming, as Spangler, that no horizontal active pressure will develop on the pipe, the A127 ATV standard does take into account the influence of this horizontal active pressure.

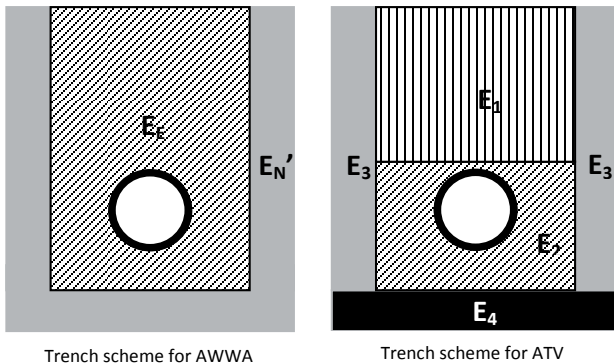*Spangler / AWWA M55*   *ATV A127*

IV.   The ATV methodology is much more detailed regarding trench-pipe interaction and does a deeper analysis about the intervention of each of the variables. The main difference in the trench scheme that analyzes each methodology is based on the consideration of the different zones of ground: while AWWA only differences between natural and filling soil (assigning different modules of soil reaction EN' and EE' respectively), ATV divides the trench in four areas:

- Zone 1: filling soil above the pipe (E1)
- Zone 2: filling soil below and to the sides of the pipe (E2)
- Zone 3: natural soil on the trench sides (E3)
- Zone 4: natural soil below the trench (E4)

In both cases an influence of the native soil in the global pipe-trench structural package is considered, but the way of analysis for each methodology is different.

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Trench scheme for AWWA

Trench scheme for ATV

V.   While AWWA methodology does not distinguish between vertical or sloping trench walls, in the ATV methodology the inclination angle of the walls of the trench is an important variable.

VI.   In the ATV the use of sheet piling or coatings to contain the walls of the trench, and its removal methodology once installed the trench fill, acquires importance. However, these considerations are not taken into account by AWWA at any time.

VII.   The ATV A127 methodology is more conservative when coming to the treatment of the „long term" analysis, especially in the case of thermoplastic materials, as it considers that the pipe will be permanently loaded in time and, therefore, it has to be always verified for every long term load using the materials long term properties (creep module, ultimate stresses).

The methodology of the AWWA M55 manual, on the other hand, considers that, against the external vertical loads, the pipe will not always be requested in the long term, but only when the stiffness of the pipe exceeds 25% of the rigidity of the filling soil of the trench. This is based on the theory that, if the pipe behaves like flexible and it is well installed (i.e. has a good soil filling around, compacted to an adequate density) it shall transmit the vertical loads to the lateral filling soil and will therefore not be requested permanently, but rather by „discrete" load pulses, against which, the material of the pipe will always respond with its short term resistance. However, if the stiffness of the pipe is close to the rigidity of the filling soil, it will behave more like a rigid pipe and will have to withstand the burdens in its own structure on an ongoing basis, responding, as a result, with material's long term parameters.

VIII.   ATV's treatment of buckling verification is more conservative, especially in the case of existing groundwater, as it adopts the criteria that the pipe's confinement due to the filling soil will never have any influence in the pipe's resistance. On the other hand, AWWA only considers that the pipe's confinement does not fully act when the cover depth is low, because it cannot develop properly, but it's help on pipe's buckling resistance is always considered for cover depths equal or greater than 1.20 meters.

Differences in the application of each method

When applying each method in performing static calculations of pipes, the following differences can be observed:

I.   The ATV requires a prior knowledge and/or definition of a large number of installation parameters (many of them of difficult definition in advance). On the other hand, AWWA requires less and easier to estimate data.

II.   The ATV methodology is more complex to understand and to apply than the AWWA methodology.

III.   The ATV methodology presents a strong dependence of the results with some variables (such as the methodology of installation of the filling soil and/or the slope angle of the trench walls) that the AWWA methodology has directly no consideration of.

IV.   In the ATV methodology there's a great variation in the results when varying the pipe's bedding angle. This does not happen in AWWA, where, despite the fact that the bedding angle is actually considered, its real influence on the final results is very low.

V.   In all cases, especially in the cases where there´s groundwater above the pipe, ATV's required ring stiffness is far superior to the one required by AWWA. Generally this is because of the differences in the treatment of buckling verification between both methodologies.

Example analysis

A priori, given the great variability existing between the parameters considered by each methodology, it's virtually impossible to make a detailed theoretical comparison between the two.
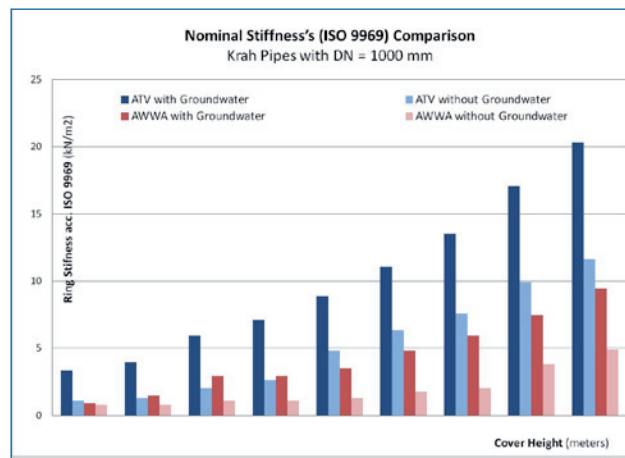
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However, what can be analyzed are the results that occur in one or another case.

For this, a brief analysis was performed based on Krah's profiled wall pipes offer, making structural verification of buried pipelines using both methodologies, for pipe's diameters from 400 to 1600 mm, varying the cover height between 1 and 9 meters and in the 2 following conditions: a) without groundwater and b) with a groundwater level at a 0.5 meters depth below ground surface. In both cases, a native cohesive soil (with medium to low stiffness), a granular filling soil compacted up to 90% of normal Proctor Density and the heavier vehicular traffic considered by each methodology (AASHTO H20 truck for AWWA and HGL60 truck for ATV) with rigid pavement were adopted. In each case the most appropriate Krah pipe (the one that verified all conditions) was selected and its ring stiffness was registered, observing the following:

a)   The pipes that verified ATV's conditions required a much higher ring stiffness (in the order of 40 to 260 % higher) than the pipes that verified AWWA's conditions.

b)   The influence of groundwater, especially for long term buckling verification, probed to be very important in the ATV, resulting pipes of a very high ring stiffness for big cover depths in the presence of groundwater pressures. AWWA methodology verification for long term buckling in the presence of groundwater was also defining in most cases, but without reaching the magnitudes of ring stiffness of ATV.

In the figure below an example can be seen of the obtained results (i.e. the required nominal stiffness according to ISO 9969) for DN = 1000 mm pipes, with the following color references:

-        Light blue: ATV's verifications without groundwater
-        Dark blue: ATV's verifications with groundwater
-        Light red: AWWA's verifications without groundwater
-        Dark red: AWWA's verifications with groundwater

Final conclusions

The ATV presents as a more complete and detailed calculation methodology, but is also more conservative, it's difficult to get all the required data for its implementation and the results penalize the pipe much more than AWWA. Therefore, from the point of view of the economy of a project, the choice of AWWA's methodology seems more appropriate.

However, what should be the choice of one or another methodology for calculating is the accuracy of each in terms of its correlation with reality. And that's the big question that is still matter of vigorous discussions up to this date, without a clear or definitive conclusion, because pipes being calculated by one or the other method had presented in both cases very good field performances over the last decades. So nowadays, unless there's an obligation to attend to a specific standard, the election is at the discretion of the professional in charge of each project in particular.

Krah sewage line for water treatment plant - obregon sonora / mexico

December 1st, 2011.
Ciudad Obregón, Sonora, una ciudad de 475,000 habitantes ubicada en el Noroeste de México, es una de las ciudades con mayor porcentaje de agua de drenaje tratada en el país, llegando a 95% , ahora la tecnología Krah ha entrado a este mercado exitosamente.

Ciudad Obregon, Sonora a city of 475,000 people in the Northwestern part of Mexico is one of the cities, that has the highest percentage of treated water in the country, treating around 95% of its sewage water, and now Krah technology has entered this market successfully.

OOMAPAS DE CAJEME, the water organism in Obregon, wanted to replace several sewage lines that converged in the South Water Treatment Plant of the city, which has a capacity of 735 liters per second and started its operation in August 1997.

The installation conditions were 5 meter in depth, clay soil, and high phreatic (groundwater) surface at 20 cm from the ground soil. Also the lines were to be installed near agricultural fields so this created more water in the soil because of irrigation.

OOMAPAS had already tested a 60 inch corrugated pipe from the brand ADS, which had problems and collapsed in some sections, and Krah Mexico proposed a 60 inch pipe with an SN 3, which performed very well and also reduced the size of the trench they needed to open having savings in their installation costs.

The line was installed by the company Construmaq SA de CV with the help of one of our technicians, Antonio Jaramillo better known as Toñito, doing the electrofusion process. Pipes were pre-joined in our plant or at the field so they were always installed in segments of 12 or 18 meters accelerating installation by doing so.

Project Data	
City	Obregon, Sonora
Type	Sewage Line for Water Treatment Plant
Phase I	60" inch diameter – 1312 meter length PR pipe Electrofusion Joint 36" inch diameter – 367 meter length PR pipe Electrofusion Joint
Phase II	60" – 1556 meter length PR pipe Electrofusion Joint 36" – 638 meter length PR pipe Electrofusion Joint 24" – 150 meter length PR pipe Double Rubber Gasket Joint

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All the deliveries were made by telescoping pipe and arranging the 60 inch pipe in diagonal so it complied with transport regulations.

The length of the pipe installed was in segments of 120 meters where a manhole was placed. Once the line was installed every 120 meter segment was tested at 0.5 kg/cm2 with rubber plugs at each end to prove that it was tight. Every segment passed successfully.

The majority of the joints were done by the patented Krah process of electrofusion. However in the 24 inch line, the water organism wanted to replace a live line, in which Krah pipes with double rubber gasket joint was more convenient and was installed that way.

Deliveries

Pipe Installation

South Water Treatment Plant in Obregon Sonora

Krah pipes go CRAZY

apps beside the applications....

All pictures by courtesy of
Krah Pipes OÜ - www.krah-pipes.ee