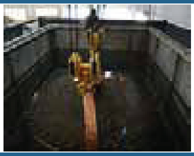
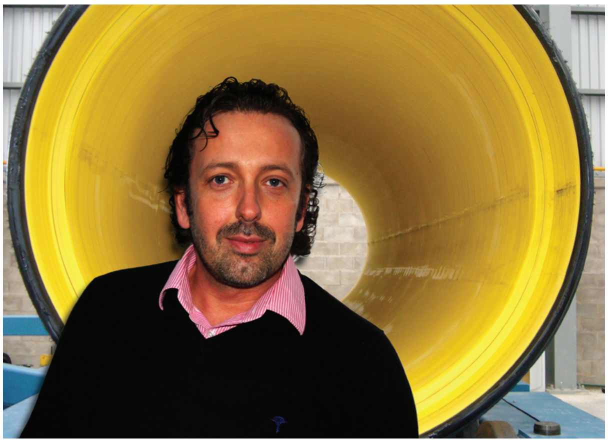
IMPROFIL

30% less Energy Consumption...

Krah - Large Pipe Technology
Outfall DN/ID 3000 mm in La Taboada, Lima, Peru



Helical Extruded Polyethylene Pipes for Pressure Application
Pressure Test DN/ID 1700, SDR 26, Design pressure PN 6



The new year „2014“ has already started and the trend for large pipe system continues. Krah AG is fully booked for the year 2014, so we are looking forward to a good year! This good prospects are mainly due to the K2013. The big trade fair with its high quality of visitors was a full success. Kalli, our new explanation movie, is now available in the following languages: English, German, Russian and Spanish. We will extend our Youtube Channel even more, just search for “Krah AG” – or better subscribe the channel. We plan to make more of these informative videos of Kalli. Should anybody have a special request, please let us know and we will try to realize this. (info@krah.net)
Finally the special topic: Poland!
My personally longest sales activity – 8 years – has finally end up in big success - December 2013.in the near future a Krah-pipe production plant will be established in Poland – very closeto the German border. My friends, 2013 was exciting, but 2014 promises to be even more exciting. We´ll start some very interesting development projects, for piping systems, for machine improvements and for complete new machines. And a highlight will definitely be our Community Meeting, no question about this ;) This year its gonna take part in TALLIN / ESTONIA, 3-6 June. The invitations will follow very soon and I hope we all meet up there. Looking forward to the joint development, take care

Yours Alexander

30 % less Energy Consumption...

... was not the only reason for the English Polypipe Group to purchase the Krah Compounder Concept.

Krah Comtruder® for improving competitiveness by Saving Energy and Optimization the mechanical, physical and chemical properties of raw materials!

Since many years Krah is with the ComTruder® involved in the inline compounding technology. Until today the system was used to produce and to extrude a compound based on PE/PP with glassfiber or Calcium Carbonate as a part of the spiral pipe production machines KDR700 and DR700.

For Polypipe now Krah developed a standalone compounder to produce Polyethylene Pellets, filled with Calcium carbonate (30%). The standalone compounder, called Comtruder®, has an output of 700 kg/hr. The pellets are produced by an underwater pelletizer, what is flanged directly to the comtruder.

The energy consumption of the new Comtruder® compared to normal Compounder is 30% less, due the unique Krah-compounding-system.

The new material is used in the existing two KR-production lines at Polypipes plant.If needed the complete system can be used for Direct Extrusion also.

The Krah Comtruder® is also equipped with

- Gravimetric dosing system forraw materials and all additives,
- Sidefeeders for CaCO3 and other additives
- Screen changer and metal separator
- Vacuum pump system
- Electrical control cabinet
- Control system with touch-screen for operation and process control

Outfall DN/ID 3000 mm in La Taboada, Lima, Peru

In this year 2013 a new record was made in Lima, Peru. Polyethylene pipes DN/ID 3000 were used for a deep water outfall pipeline. The polyethylene pipes were produced according to the Krah-Technology in Spain by PPA&Krah, Vitoria. PPA&Krah had already a lot of successful installed large outfall pipelines in the Mediterranean Sea and Atlantic Ocean. One of the challenges in this Project was to open a new site for the Krah Large Pipe Technology – The Pacific Ocean.

The “Taboada” Wastewater Treatment Plant is one of the biggest constructions for sewage treatment all around the World.

The aim of the Project was to increase significantly the amount of treated water in the city of Lima, thus reducing ocean pollution and improving the health conditions in the area.

Main Project features:

- Project Location: City of Lima (Peru).
- Average treatment capacity: 14m3/s.
- Maximum treatment capacity: 20m3/s.
- Population Served: 4 million people.

A Mega Waste Water Treatment Plant normally needs a large outfall to comply with the Project requirements. The dilution and hydraulic calculations were made and a pipe with an Internal Diameter of 3.000 mm was selected.

The Outfall is located in a seismic-sensitive region and it must be corrosion free.

It was decided by the end-user and main contractor to consider the Large Diameter helical structured polyethylene pipes (according to DIN16961) fabricated with Krah Technology and jointed by Electro fusion technology to meet the Project requirements.

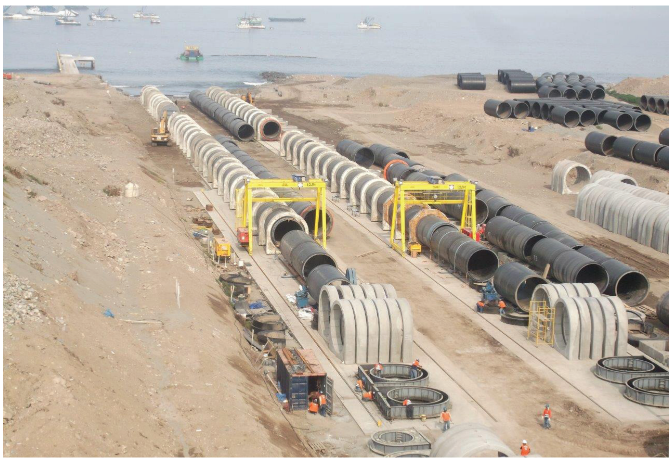
Main Outfall features:

- Total length of the outfall: 3900 m
- Deepest point of installation is – 20 m
- Sea outfall DN/ID: 3000 mm
- Diffuser segment length: 1000 m
- Diffuser section DN/ID: 3000 mm / 2400 mm / 1800 mm
- Helical structured polyethylene pipes, fabricated with Krah Technology.
- Total Pipe weight of the project = 3.500 tons
- Jointed Electro-Fusion Technology
- Expected Service Life Time = 100 years

Outfall DN/ID 3000 mm in La Taboada, Lima, Peru

The pipes and fittings were manufactured and fabricated by PPA&Krah in Spain from where they were sent to Lima in 4 different shipments. Each pipe had a length of 6 m and the wall construction was not solid – it was a structured wall design, with the same or better characteristics than a solid wall pipe. Due the unique production process the pipes have no frozen stresses in the pipe wall and the profiled wall structure can be designed tailor made for the application requirements.

The helically wound pipes and fitting were welded by a patented Electro-Fusion welding procedure and they were ballasted on site before the launching of the sinking strings to the sea from the working ramp made onshore. All ballast blocks had no screws and bolts, by fixing them on special points of the special made pipes. So a later unwanted sliding of the blocks was impossible. And beside the technical aspects the costs compared to other solution was very low. (See foto TABOADA 4.JPG)



The construction of the sea outfall La Taboada was an amazing challenge for the PPA Group. Up to 19 sinking strings were sunk and connected Off-shore. deepest point of the installation was -20 m in the Pacific Ocean. Every string was joined by integrated flanges.

This challenge has been accomplished perfectly but now already several new ones in sight.

Pipe Producer: PPA&Krah, (www.ppakrah.com)

Installation was done by: PPA Peru (www.ppaperu.com)

Production Technology: Krah AG, Betzdorfer Str. 1, 57520 Schutzbach Germany, www.krah.net

Helical Extruded Polyethylene Pipes for pressure application

Pressure Test DN/ID 1700, SDR 26, Design pressure PN 6

UGPM helical extruded Pressure Pipe PE100, ID 1700, PN6 – 6 m length, elongated to 12 m length

General:

Pressure pipes made of Polyethylene are successfully used since the 50ths of the last century. In more than 60 years the material has developed significantly in mechanical, thermal and physical characteristics. Mostly used in the pressure market is the pipe grade PE100 with a long term strength of 10 MPa (MRS 10). Furthermore you find in the market PE-types with optimized properties for example with a better resistance against slow crack growth, called PE 100 RC (crack resistance) or fiber reinforced polyethylene pipes (e.g. Krah PE-GF 200) with very high strength and stability (MRS 20).

The international mostly used standard for polyethylene pressure pipes is the ISO 4427. Even if this standard has some limitations in tolerances and dimensions, it is always a good basement for more detailed specifications.

The requirements of ISO 4427 are original made for external calibrated pipes (direct/axial-extruded) and the standard is limited until pipe diameter OD 2000 only. Nevertheless the physical and mechanical requirements can be adopted for larger dimensions easily.

ISO 4427 does not consider that more and more pressure pipes in large dimensions are produced in helical extrusion process with internal calibration. For helical extrusion the pipe tolerances must be verified, the wall thickness can be produced much more accurate because no sagging-effect happens during production. Additionally it would make sense for helical extruded pipes to specify the tolerances for inner diameter. Also the pressure classes should be defined more flexible, because for these pipes there is almost no limitation in wall thickness and every pressure class can be manufactured.

Also low quantity of pipes can be produced very economically with the helical extrusion process.

This kind of helical extruded pressure pipes are already used worldwide. The company UGPM from the Sultanate of Oman for example is using the newest pressure pipe production technology for direct extrusion and helical extrusion (Krah-pipes). For large dimensions UGPM installed a special isolated test basin with all equipment for testing pressure pipes and fittings until DN 3000 mm.

In the following, the test procedure for a helical extruded Krah pipe in dimension DN/ID 1700 is documented. These pipes are part of the big pressure pipe project “Ghubra Desalination plant”, where the pipe dimensions ID1700 and ID 1900 are required in SDR 26 (PN6). All pipes and necessary bends, T-branches, stub-ends and flanges are produced and manufactured by UGPM Oman and will be tested acc. ISO 4427.

Scope:

For the helical extruded PE100 pipes, the resistance against constant internal water pressure has to be determined at constant temperature bath and at prescribed duration and conditions according ISO 4427.

The Product:

- Helical extruded pipe (Krah-pipe), solid pipe wall
- Raw material = PE 100 (Borouge HE3490LS)
- Internal diameter = 1700 mm
- External diameter = 1842 mm
- SDR class = SDR 26
- Design pressure PN class = PN 6
- Date of production = 05. August 2013.

Helical Extruded Polyethylene Pipes for pressure application

Pressure Test DN/ID 1700, SDR 26, Design pressure PN 6

Laboratory Equipment:

- UGPM - United Gulf Pipe Manufacturing, Sultanate Oman
- Hydrostatic pressure testing machine UGPM, plant 2 (2013)

Quality Inspector:
K.Subramanyam, QA/QC Manager UGPM

Date of Testing:
08 until 24. October 2013

Test conditions:
According to ISO 4427 and in agreement with the third party, UGPM has tested the pipes under
two different load conditions:

a) Temperature = 20°C
Duration = 100 h
Test Pressure = 9 Bar
Stress = 12,4 MPa
Samples = 3

b) Temperature = 80°C
Duration = 165 h
Test Pressure = 4,4 Bar
Stress = 5,4 MPa
Samples = 3

Specimen preparation:

- The test specimens are taken from running production for current project, date of production 05/08/2013.
- Each specimen is joint by Butt fusion with two stub ends, made from same raw material and also helical extruded (PE 100 stub ends also manufactured by UGPM, Oman)
- Closing both stub end with Steel blind flanges and GRP backing rings, with help of Bolts & Nuts.
- Pre conditioning = 24 h in test bath

Specimen before, during and after testing

Helical Extruded Polyethylene Pipes for pressure application

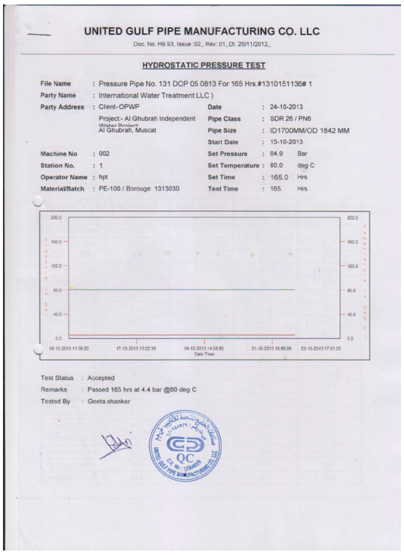
Pressure Test DN/ID 1700, SDR 26, Design pressure PN 6

Test results:

The helical extruded pipes DN/ID 1700, PN6 fulfills the requirements of ISO 4427 regarding hydrostatic pressure load at 20°C and at 80°C.

The pipe-specimens have not shown any damage during or after testing.

UGPM Test documents



UNITED GULF PIPE MANUFACTURING CO. LLC

Doc. No. H9.93, Issue :02,, Rev: 01,,Dt. 25/11/2012,,

HYDROSTATIC PRESSURE TEST

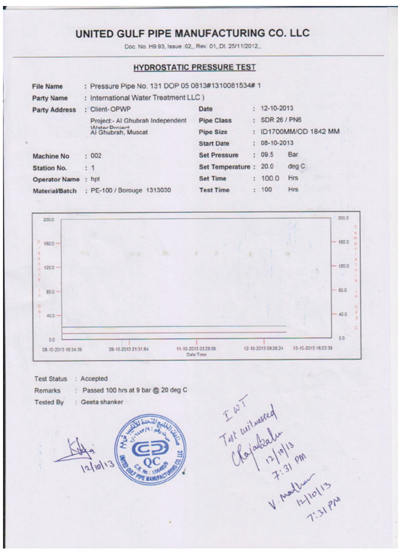
File Name : Pressure Pipe No. 131 DOP 05 0813 For 165 Hrs.#1310151136# 1
Party Name : International Water Treatment LLC)
Party Address : Client- OPWP
Project:- Al Ghubrah Independent Water Project
Al Ghubrah, Muscat

Date : 24-10-2013
Pipe Class : SDR 26 / PN6
Pipe Size : ID1700MM/OD 1842 MM
Start Date : 15-10-2013

Machine No : 002
Station No. : 1
Operator Name : hpt
Material/Batch : PE-100 / Borouge 1313030

Set Pressure : 04.9 Bar
Set Temperature : 80.0 deg C
Set Time : 165.0 Hrs
Test Time : 165 Hrs

Test Status : Accepted
Remarks : Passed 165 hrs at 4.4 bar @80 deg C
Tested By : Geeta shanker



UNITED GULF PIPE MANUFACTURING CO. LLC

Doc. No. H9.93, Issue :02,, Rev: 01,,Dt. 25/11/2012,,

HYDROSTATIC PRESSURE TEST

File Name : Pressure Pipe No. 131 DOP 05 0813#1310081534# 1
Party Name : International Water Treatment LLC)
Party Address : Client- OPWP
Project:- Al Ghubrah Independent Water Project
Al Ghubrah, Muscat

Date : 12-10-2013
Pipe Class : SDR 26 / PN6
Pipe Size : ID1700MM/OD 1842 MM
Start Date : 08-10-2013

Machine No : 002
Station No. : 1
Operator Name : hpt
Material/Batch : PE-100 / Borouge 1313030

Set Pressure : 09.5 Bar
Set Temperature : 20.0 deg C
Set Time : 100.0 Hrs
Test Time : 100 Hrs

Test Status : Accepted
Remarks : Passed 100 hrs at 9 bar @ 20 deg C
Tested By : Geeta shanker

12/10/13

IWT
Test witnessed
12/10/13
7:31 PM
V. madhav
12/10/13
7:31 PM

Conclusion:

The helical extruded pipes are technical equal to axial extruded pipes. The pressure load capacity of helical extruded pipes is minimum the same like for axial extruded pipes. The tolerances for wall thickness of helical extruded pipes are less because of no-sagging-effect and rotating production procedure. Tolerances for ovality are more or less the same.
The difference in calibration should be considered for joining pipes and fittings.

An additional specification for helical extruded pressure pipes, concerted to requirements of ISO 4427, is available in the Download-section of Krah Community soon.

Eng. Mohammed Al Hashani

Managing Director of United Gulf Pipe Manufacturing Co.LLC
Sultanate of Oman

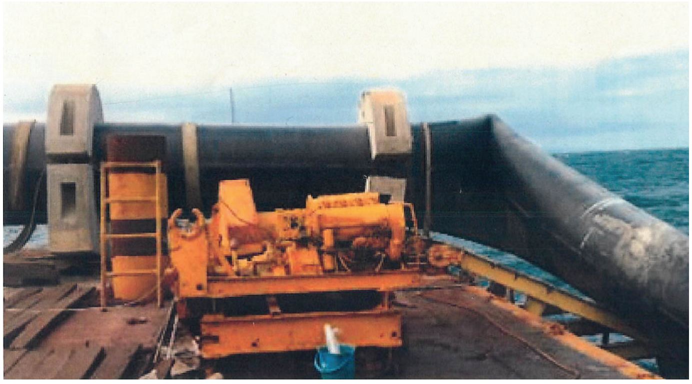
UGPM is one of the leading producer of thermoplastic pipe systems in Middle East Diameter range: 40 mm until 4000 mm

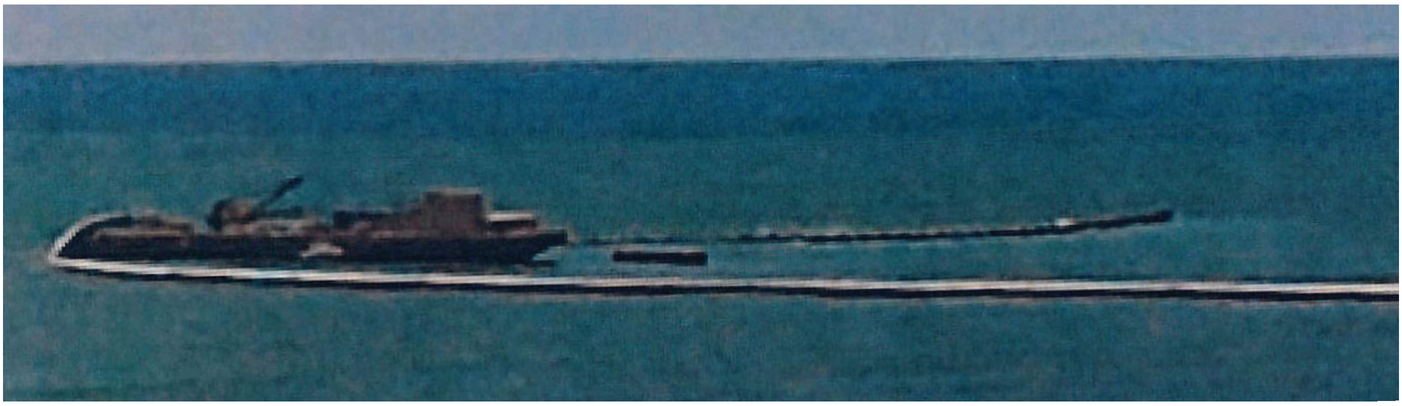
Dipl.-Ing. Stephan Füllgrabe

Managing Director of
Plaspitec GmbH / Cologne, Germany

Plaspitec is an international operating Consulting and Engineering Company forLarge Diameter Plastic Pipe Systems

A solution of Krah Technology to repair a direct extruded outfall pipeline





During installation of an outfall pipeline supplied from north of Europe to Latin America, a pipe has broken.

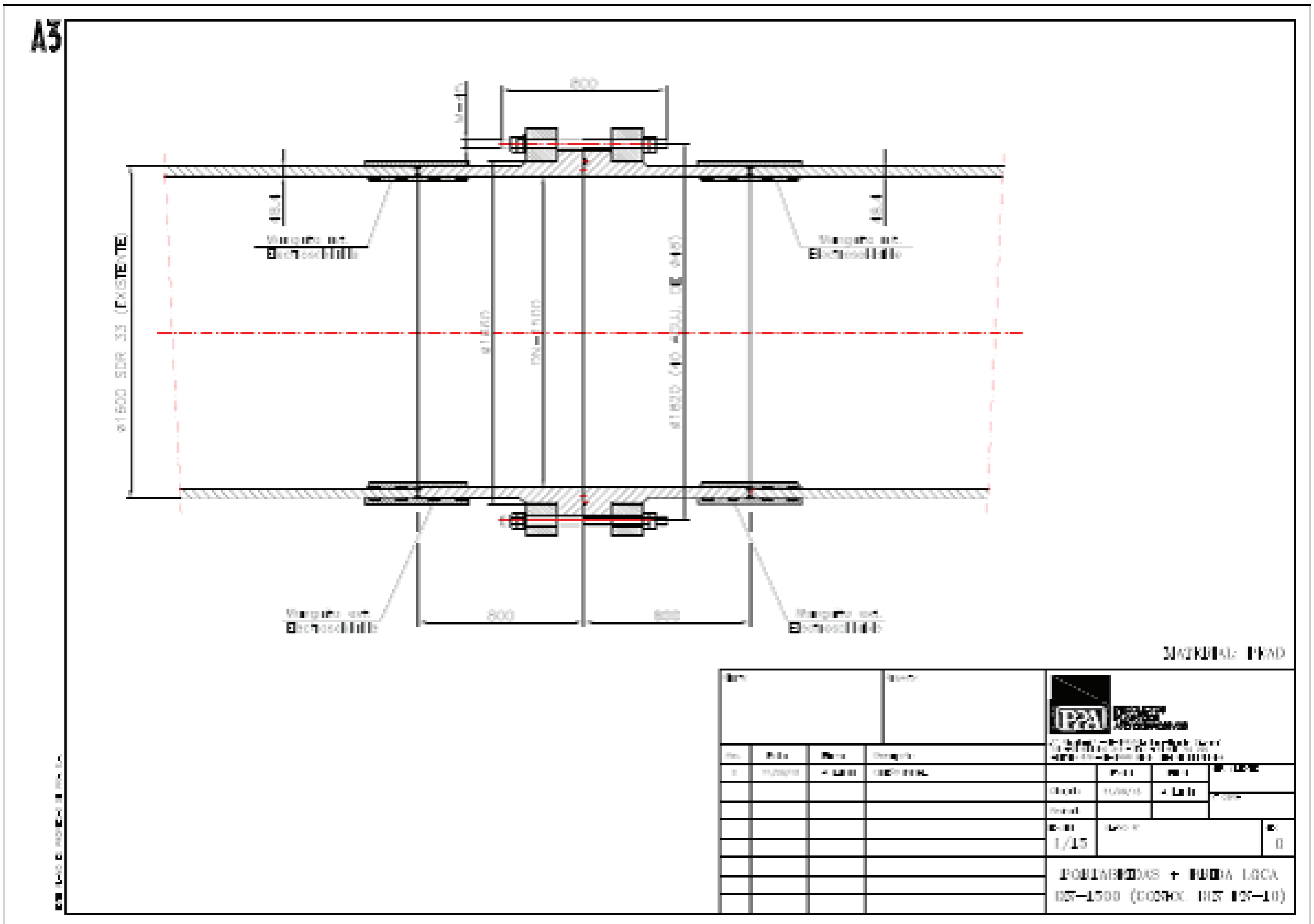
The pipe was DN/OD1600x49 (PN5, C=1,25), PE100 and was shipped to Latin America in long length over the ocean. It seems that something during installation went wrong and the pipes could not resist breaking.
The Break in detail:

It seems that pipe broke because of frozen internal stresses in the pipe wall or maybe due to inhomogeneity, which could occur due to the fast cooling of direct extrusion of pipelines in large diameter.
So, what to do???
A butt welding machine DN1600 to repair the fault of the pipe wasn´t available and in case of availability it would be too heavy to place on a barge. The customer asked the specialist in large outfall pipeline PPA&Krah in Spain for help. A technically perfect and quick solution was made. Overnight the company produced two couplings for the existing pipe, with a DN/ID1500. The parts and the electro fusion equipment were sent by plane and were installed directly after arriving. The special couplings were based on Krah E-Fusion Technology on one side and on the other side with a flange.

A solution of Krah Technology to repair a direct extruded outfall pipeline

The couplings were welded by Krah-Electro-Fusion Technology to the existing pipe and to the flanges made by Krah Technology. In a record time the pipeline was working again.

And once again it shows that the Krah Technology is very suitable for outfall pipelines, even for repairing of conventional (direct extruded) pipelines made by competitors.



Principal Groundwater Discharge for Codelco / Ministro Hales Mine




After installation a pressure test is done to warranty that every welding fulfill the requirements. The Pressure Test is done at the whole pipeline with 1,3 time nominal pressure, that means with 20,8 Bar.

Krah Chile is using Krah PE-GF Pressure Pipe Technology since 2009. The installed Krah KDR 700 is able to produce pressure pipes with standard PE100 or with PE-GF200. Since beginning Krah Chile delivered their pressure pipes for many applications. One examplary project is described below:

Krah Chile produced more than 1300 meter PE-GF-pressure pipes in dimension DN 300 and for pressure class PN 16. The pipes are designed with a safety factor of 1,25, that means the total wall thickness is 15,8 mm (SIDR 19)

The pipes were supplied for Ministro Hales Mine owned by Codelco, the largest company of the state of Chile. The mine is located in the Atacama Desert, near the city of Calama, 1570 km north of Santiago de Chile. In this area the outside temperature reach in summer more than 40 °C and in winter temperature drop down to -10 °C. The pipeline is necessary to supply fossil water from the original accumulation pool to the project reservoir for usage in the mine.

After production and quality testing the pipes are welded in the Krah-factory from original 6 meter length to a total length of 18 meter. The 18 meter long pipes are delivered to the construction site for final installation. The installation and welding is done by company MONTEC S.A. and took around 2 month for the complete 1300 meters. The pipes are installed in silty sand by embankment.

For the butt-fusion process the DVS 2207, part 1 are observed. According to the Krah Specification the temperature of the heated tool is adjusted to 235 °C (that is ca. 20°C more than for standard PE 100). Furthermore the aligment pressure and the joining pressure is adjusted to 0,3 N/mm² instead of 0,15 N/mm²

KRAH Piping Solutions

Krah Chile / Mauricio Sarasúa

Chorrillo Uno, Km. 0.55 - Lampa Santiago - Chile

Planta Productiva

Fono (56 2)271 30 400 / Fax (56 2) 271 30 401

Ventas@krah.cl / www.krah.cl

RALF SCHNITZLER

starts working at Krah AG March 2014

1. **In March 2014 you will start working for Krah AG, what is your new position in the company?**
I am looking forward to be the new Business Development Director at Krah AG.

2. **What did you do before? Do you have experience in large pipes?**
After my graduation as an civil engineer specialized in water technology I have started working at a construction company to gain the first professional experience. After this I have moved on to a large plastic pipe manufacturer in Germany. In a sales and marketing role I managed the pipe business on the German and European market. Before I joined Krah AG I worked for one of 100 largest enterprises in the world in order to upgrade my sales and general management profile.

3. **You have gained experience in a big corporation, is it not difficult to change to a medium sized company now?**
At first let me point out that in my professional career I got to know the big cooperation world as well as the small and medium enterprise. At the medium sized company it´s only different but not difficult. Negotiations and decisions are faster and you see very soon success of your daily work.

4. **You are original Civil-Engineer, so you are experienced in technical things.**
What does enthuse you in Sales and Marketing of machines?

Ralf personal

Family:

Yes, but divorced. I have one son at the age of 10 and one stepdaughter at the “nice” age of 16.

In my spare time…

I do a lot of sports in my spare time and motorcycling is my new hobby.

I am just reading …

Everything about motorbikes, technics and routes.

I can laugh about:

Good jokes, comedy appearance and all my sons´ tries to avoid the parents’ order.

The one thing I would never do again is:

From the professional view: to go back to a big group and considered in a personal way: to do nothing I´m not 100 percent convinced of.

My knowledge of the large pipe plastic systems in the past as well as the civil engineer market nationwide are the fundament of my sales profile. The machine technology will start often with one special project spotted in the different countries. Select a machine technology solution for this installation issues will be my key task.

5. **What are in your opinion the most important advantages of Krah machines and Krah itself?**
   I think that the specialization of Krah and their highly sophisticated machines in the large plastic pipes market are the biggest advantage. The longtime and practical experience as well as the international partner community make Krah the leading technology company in this business sector.

6. **The development in large diameter pipe market was rapid in the last years – how do you estimate the future prospects for helical extruded pipes (Krah Pipes) worldwide?**
   Compared to other materials the large plastic pipes are underrepresented worldwide. We are able to increase the plastic pipes proportion in the large pipe business over one double-digit percentage. The pipes and system advantages are raged over but not well known worldwide.

7. **What do you miss in the product range of Krah AG**
   On the first glance: Nothing! From the long-term view possibly the R&D department would make sense in the company.

8. **What are your targets in 2014 as a part of the Krah Team?**
   My target will be to start quickly in the international market with selling machines and help my company to increase the underrepresented percentage in a significant degree as soon as possible.

9. **Krah AG is an international operating company, which countries would you like to visit most?**
   In coordination with the sales team and the board of Krah we will find soon the primary target countries or markets. At first I will focus on the Asian continent and North – and South America as I consider this market not being developed that well currently.

10. **What are your personal targets?**
    Health at first and an interesting challenge at Krah. That is fairly enough to make me happy at Krah.

Butt-Fusion of Glass-Fiber Reinforced Polyethylen Pipes (PE-GF)

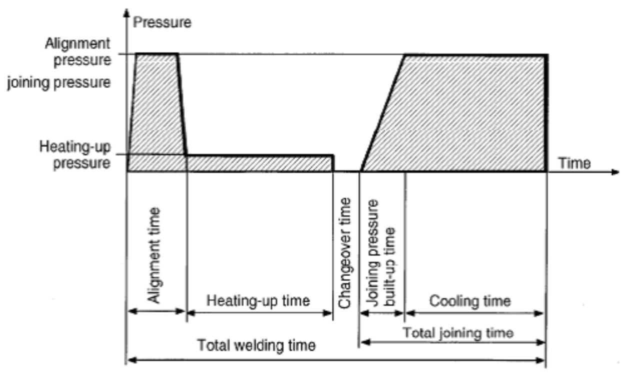
General

Since some years helical extruded pipes made of PE-GF are used in the market for pressure application. Worldwide many projects have been realized in various diameters and for pressure applications up to 16 bar. The pipes are produced by the Krah Comtruder®-Technology, what guarantees a homogenously distribution of the chopped glass-fibers and the coupling-agent in the polyethylene-matrix. The international available standards for pipes DN/ID 400 until DN/ID 4000 are ASTM F 2720/ASTM 2720M, DIN SPEC 19674 and ISO/CD 29561 is still in process. Mostly used in the market is the PE-GF 200 with a MRS-class 20 MPa, based on 20 % Glass Fibers, 2 % Coupling agent and 78 % polyethylene matrix of PE 100. Joining of this kind of pipes is done either by the typical Krah-Electrofusion-Technology or by Butt-Fusion.

The Butt-Fusion-process

For standard Polyethylene Pipes the Butt-Fusion process is standardized in DVS 2207. Also the Butt-Fusion process for helical extruded PE-GF-pipes is following the rules of DVS2207 in general issues, especially regarding preparation of welding, quality control and general requirements for training and equipment.

The welding parameters itself, must be adapted regarding temperature-and pressure profile:



Process stages of heated tool butt welding

Welding factor

BECETEL, the international well-respected institute in Belgium was instructed and authorized to verify the short- and long-term behavior of the butt-fusion-joints.

- Test Product is a helical extruded pipe (Krah-pipe) with solid pipe wall.
- The used Polyethylene Raw Material is PE 100 (Hostalen CRP 100, Lyondell-Basell)
- Internal Diameter / Nominal Diameter = 500 mm
- Wall thickness = 33 mm
- Pipe Producer = Krah AG
- Place and Date of Production = Schutzbach, Germany, 2013
- Butt-Fusion = Henze GmbH, Germany, 2013

The measured welding factors by BECETEL are:
Short term fz = 0,83
Long term fs = 0,79

Conclusion

The butt-fusion process is proper for welding of PE-GF pipes. The Butt-Fusion process fulfills the requirement to take the load of pipe under internal pressure.

The axial stress in pipes because of inner pressure is 50% of the circumferential stress.

PE-GF (MRS 20) pipes acc. DIN SPEC 19674 are designed with a safety factor of 1,6 for inner pressure.

- The circumferential stress in PE-GF pipes by inner pressure is 12.5 N/mm²
- The axial stress in PE-GF pipes by inner pressure is 6.25 N/mm²
- The axial strength in butt-fused joints of PE-GF pipes is more than 22 N/mm² and provide a lot of safety!

Butt-Fusion of Glass-Fiber Reinforced Polyethylen Pipes (PE-GF)

The members of the committee for DIN SPEC 19674 have already signalized to integrate the mentioned welding parameters to the new and updated DIN SPEC 19674.

Furthermore you will find the detailed test report soon in the News of the Krah Community.

Author:
Dipl.-Ing. Stephan Füllgrabe
Managing Director of
Plaspitec GmbH, Cologne, Germany
Plaspitec is an international operating
Consulting and Engineering Company for
Large Diameter Plastic Pipe Systems

Damage and vulnerability of materials in sewage systems

This essay focuses on three central questions:

- What are the most common damages happening to pipes in waste water systems?
- By which factors are such damages caused?
- Which material is especially weak or strong in resistance against certain damages?

The advantages of pipe-materials and the needs of a proper sewage system are well known. Less highlighted are usually the disadvantages of materials or the most frequent damages occurring. This overview shall present these in three pinpointed questions and answers.

I. Most common damages:

Corrosion

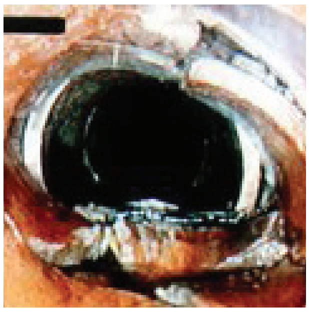
Corrosion counts to the most frequent damages happening in drainage systems. Corrosion is the gradual destruction of materials by chemical reaction with its environment. It can occur from in- or outside the pipe and with various consequences. According to the norm DIN EN ISO 8044 there are 37 different appearances. Most common one is rust corrosion but contact -, pitting -, erosion-, stress- or crevice corrosions are also pervasive. Also material incompatibility can cause corrosion. Results are for example instability or contaminations.

Sealings

Sealings are rarely taken into consideration when talking about damage potentials. Thus they are lacking of quality checks on the construction side although sealings are often the basic problem when others follow. Pipe joints can be mechanical and made from another/third material or they are homogenously wealded. In concrete pipes rubber seals are often used, steel and plastics can be wealded and other materials might be glued. Whatever sealing method/material is being used, it must be double checked for pressure, tightness and stability as the mecanical loading capacity is less. A common problem is additionally the durability of a sealing which is mostly shorter than the pipe itself. Many of the damages described in the following are a cause of deffected sealings.

Pipe burst

Pipe burst mostly occurs because of constant pressure such as traffic load and ground displacements but also because of strong corrosion, frost, fabrication defect or construction faults. Pipe bursts are rarely repairable but immediately in need of replacement. In case of waste water systems bursts are very dangerous because of environmental burden through its gens and pollutants.



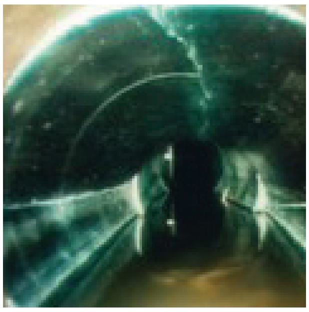
Aggradations

Aggradations can cause astringencies which can cause burst or cracking. A few aggradations/incrustations are normal over the years but danger depends on which substance is alluvial and to what extent. Uric stone e.g. is often found in domestic waste water pipe systems and needs a special purification.

Damage and vulnerability of materials in sewage systems

Flaws

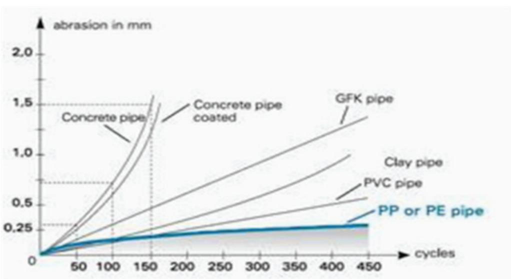
Flaws are often difficult to recognize (craze) until they slowly become longer and more obvious. Usually a flaw is found when there are brownish spots or tiny bubbles visible at the pipe. Flaws are the precursor of cracks and bursts. One distinguishes between transverse - and longitudinal flaws. Most appear while transport and installation. Depth and pathway of the flaw are important for inspectors to decide for the correct repair method.



Cracks

Cracks are caused by transport, implementation, frost or simply obsolescence. However most frequent reason is traffic and other external load, impact or ground displacements which strain the sealing. Cracks are dangerous when exfiltration and infiltration is happening. The transported liquid from inside the pipe (possibly toxic) can leak and cause environmental load. Other way round fluids and bacteria from outside can get in and cause aggradations or corrosion, which plays a greater role in drinking water systems. Therefore material consistency is a crucial factor.

Abrasion



Abrasion is the progressive loss of material. In case of sewage systems, wear occurs on the moist inside wall. Higher roughness of the walls is a consequence and can be measured in variables. A cause is less hydraulic conductivity and reduction of wall thickness. Wear emerges by impacts, running liquids or droplet impingement.

Deformation

Deformation of pipes do exclusivley occur in flexible thermoplastic material. Reasons for deformation are usually elevation of the ground, earthquacks, bad compaction or external pressure such as impact, soil conditions or traffic load. The water flow will change in speed and additionally maintenance might be limited as the passways are being blocked. Deformation is not exclusivly a damage but on the contrary an advantage sometimes. It is questionable to what extend joints stand these deformations.

Purification

Purification inside the pipes is an indispensable service for the maintenance. It is done to clear the pipes from aggradations, pluming and/or prepare it for inspection. Residues in sewage systems are containing mineral (sand/stone), organic (food, paper, plastic) and other components. Next to normal scavenging and mechanical cleansing there is high pressure purification (GER: 120bar).

Damage and vulnerability of materials in sewage systems

This method is usually used in sewage systems but can lead to considerable damage too (→GRP).

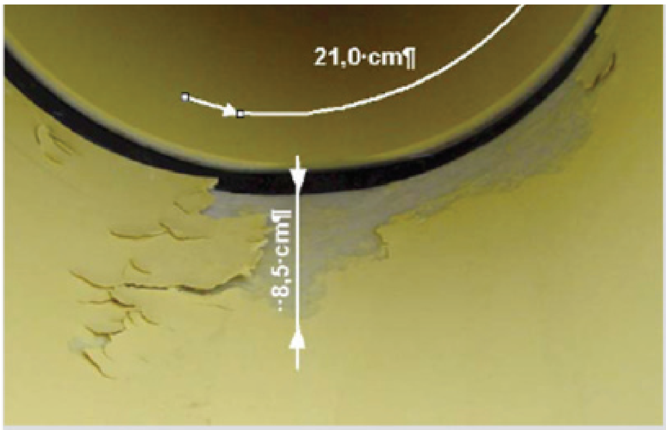


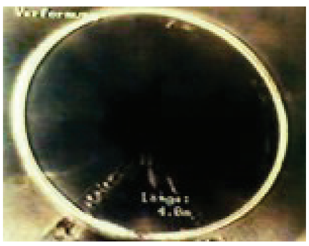
Bild 197: **Belastung:** 50 Zyklen-ohne Splitt- D2 (5x20°, 5x30°)

Root penetration

Root penetration has always been a problem towards pipe systems. During the planning process architects and engineers must cooperate with the town and country planner. When the system is running, roots can still grow into the pipe/fittings or cause deformation and cracks. There are a range of methods how tree roots can be secured and pipe systems can be built without interference such as partitions or protective tubes.

Shifted pipes

Shifted pipes are pipes which drifted out of their original position as a cause of erosion, earth quarks, root penetration or other in- or external pressure. Pipes can shift up to an extent that they narrow or burst (Pipe burst). Some materials are massive and heavy that rarely anything could shift them during installation but when implemented, soil or traffic pressure will affect them too. Others are designed deliberately in a way that they deform and suit the surrounding soil and incidents (Deformation). For this distinction not only the material matters but the joint method as well. Homogenous welded joints will not break but deform, while pipes with a mechanical sealing would shift.



II. Factors causing damage:

Physical (frost, heat, UV, butt, pressure, earthquakes …)

EXMP 1: When water is freezing during very low temperatures, it expands. When the pressure cannot lighten, the pipe containing the frozen water might burst. Trouble is to detect those flaws and cracks caused by frost in time. Wet walls in domestic pipes or great amount of water loss in outside pipelines can be implications.

Chemical (substance of liquid, soil composition, pH value, oxygen concentration…)

EXMP 1: Especially industrial- or sewage pipe systems contain crucial chemical impact. Factors which can cause corrosion, aggregation or abrasion are among others: fats, oils, acids, lyes, alcoholics, coolant, ketone or ester.

Biochemical (biological molecules, decomposition…)

EXMP 1: The biogenic sulfuric acid corrosion is well known in sewage/drainage systems. Constant maintenance and the removal of aggradations are indispensable processes. The warm temperature of waste water may sustain such corrosion because bacteria can receive energy.

Damage and vulnerability of materials in sewage systems

Biological (animals, roots, biological waste in liquid …)

EXMP 1: As mentioned above, tree roots can destroy pipe systems completely when they find spots to grow into or when they deform and shift the pipes. Animals such as rodents below ground level may also be a serious thread.

Mechanical (density, traffic-/soil-pressure, impact, concentrated load …)

EXMP 1: Plugging can be a cause from mechanical wear and end in deformation or burst. Outside pressure such as traffic load or concentrated/punctual load may force a pipe into deformation or even break. Impact, especially at the sealing, results often in cracks or flaws. Internal pressure can cause damage when it is too high but in sewage systems it is rarely the case. In summary, the density of a pipe plays a major role when the mechanical strength is measured.

Logical (defective planning, defective building construction, transport…)

Damages do certainly not only happen underground when the system is installed. Some failures are already being done while the process of planning, choosing the correct material, the transport or on the construction side. Every single material may it be fitting, application or pipe must be checked for the requirements and density. Technical test reports help to choose correctly and stay informed about new developments. An installation guide is advisable.

III. Characteristics of Materials mattering for sewage systems

Concrete/ Ferroconcrete is used since ages for sewage systems and thus profits from long experiences. Concrete is utterly solid, stable and resistant against shifting while installation. Later on, pipes might definitely shift because of different pressures. Furthermore it is high temperature resistant and inflammable. On the other hand concrete has a high mass density, which makes the transport and implementing more difficult. Besides that, concrete is vulnerable towards crack initiation, aversion and thus to in- and exfiltration. Last but not least the usually very efficient and high quality surface structure is soon worn out. Cementitious materials are in sewage systems more vulnerable towards corrosion than others.

Steel has a high strength and can be welded. It was quite often used for coverings in sewage systems. Tremor and butt are not as harmful towards steel pipes as to other materials but still it can more easily harmed during transport than plastic for example. Steel has a low corrosion resistance and is thus laminated from inside with an additional corrosion protection.

Thermoplastic (PP/PE) are flexible in their structure and deform in case of pressure. These deformations happen without crack formation and are especially positive in regions of temperature variations or earthquakes. Thermoplastics have a very high corrosion resistance such as against chemical and physical factors of damage. They are easily weldable and have afterwards a high material density. On the other hand they are flammable and sensible towards oils and fats. Their light weight may, next to numerous advantages, be problematic in terms of shifting. An unchallenged advantage of thermoplastics is the durability of 100 and more years.

GRP is composed of strands of glass, lightweight and has good thermal insulation properties. Additionally glass fiber reinforced plastics have the ability to contain liquids with very high temperature. Their light weight is, just as for thermoplastics, a plus and a minus same time. GRP pipes have a higher impact sensibility and thus a rela-

Damage and vulnerability of materials in sewage systems

tively higher crack initiation. GRP pipes are very sensitive against high pressure purification.

Cast-iron is known for its robust chemical composition. A rust layer offers resistance against material destruction and is additionally secure because of its thick walls. Next to its weather-reliability (especially UV), it has a low electronic conduction and a good breaking stress. Problematic is, that it is only partly weldable and difficult to cut. The material is quickly destructed with aggressive waters or vagrant streams which makes them corrosion vulnerable in sewage systems. Finally cast-iron is heavy and hard to handle.

Water categories:

category	Description
I	hazardous to water, requiring treatment
II	industrial sewage
III	domestic sewage
IV	Rainwater

When evaluating damages at sewage systems, it has to be taken into consideration that one is dealing with different waste water categories. One might think at first that category 4, containing rainwater, does not harm the environment in a leaking pipe and thus will not need to be considered that much. Actually that is not wise because also rainwater can accidentally contain chemical liquids. Next to poisoning, massive water loss might cause undercutting followed by traffic accidents or the collapsing of a building.

In conclusion, the water category must also be taken into consideration, when talking about sewage system damages.

Most frequent damages at sewage systems have been illustrated from the cause until the consequence. It became obvious that initially small damages can lead to dangerous results without exact planning, secure installation and constant maintenance. Some materials are nowadays optimized and developed that they are only vulnerable to very few aspects. It is highly advisable to spend more attention to currently less prominent topics such as a well functioning sealing or material durability in order to achieve a long-time satisfying result

Paulina Fröhlich, Krah AG

Sources:

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Pictures:

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