

IMPROFIL

ECOLINE

BY KRAH PIPING & FITTING

URBAN CHALLENGES

FACED WITH GREEN SOLUTIONS

FLUSH RAIN WATER SYSTEMS

FIRST EXPERIENCES BY CENTRALTUBI



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Dear Reader

This issue is a very special one, which we have not had in recent years, partly due to the Covid pandemic. But now it was finally time again, a few days ago we met with our customers in Malaysia for our regularly scheduled community meeting. Over the 5 days, we did a lot of sightseeing and excursions and had a very eventful, fun time together with customers and friends. We also listened to many presentations ranging from project reports to technical news and new products that we would like to share with you in this issue. The presentations are mostly about our pipes or pipe applications, just as our ImProfil mostly reports about pipe projects. Since we as Krah GmbH are a mechanical engineering company



that develops and produces the machines for pipe production, it is surprising for many why we focus so much on the pipes, although we do not produce them ourselves.

In order to answer this question, I would like to introduce the System Krah company concept in detail. For the sake of understanding, let's start at the beginning. Since 1968, the medium-sized mechanical engineering company Krah has been one of the world's technology leaders in the field of large-diameter pipes. In this industry, everyone knows the mostly black and yellow Krah pipes, which have a diameter of up to 5000mm. However, almost nobody knows the Krah machine that produces these pipes. In this case, the awareness of the Krah pipes and the Krah brand are used to sell the machines through them. We as Krah GmbH do not earn a cent on the actual pipe as the end product, but only on the pipe producing machine and the technology. Although we only build, develop and sell the machines, the end product pipe is still an indispensable part of the company concept.

Company qualities

Since we have excellent capabilities in the areas of development and design, almost the entire value chain can be represented within the company. We assume a social responsibility for the region and for the country in which our company is located - for the Westerwald, for Germany, and for Europe. With an average training quota of 10%, young people are trained here in more than 10 trades.

The numerous trainees are offered a wide range of work areas, thus generating extensive knowledge within the company.

Even in difficult times, our main

goal is to retain and fairly compensate all employees. This is rewarded with a very low turnover of employees. Our employees are all part of the company family and the most important element for the sustainable success of our company. There is also a great responsibility for the production facilities and therefore for the customers. Nowadays, the word responsibility is a very rarely seen word in most established company goals. Rather, only values such as growth, climate targets, ESG, and the like appear there. Yet the value of responsibility replaces almost all other values and is the most significant value of Krah GmbH. We are active in some international standardization committees and thus ensure through its influence that the standards and the produced pipe system harmonize.

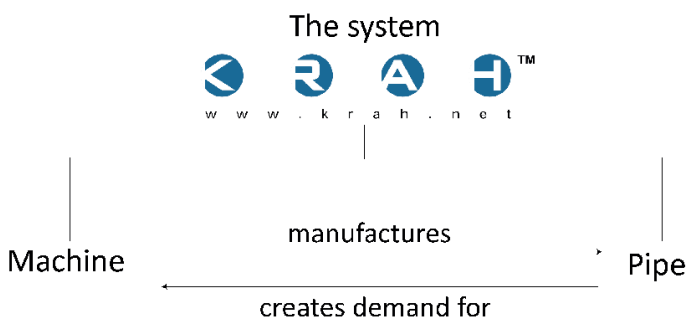
The Krah machine is a capital asset that can be used to produce an entire system. This includes, among others, pipes, fittings, and manholes. The pipe systems are mostly used in public infrastructure projects.

Unique selling points

Crucial to the success of our Krah system are the following sales requirements, which must be in place:

- Branding
- Quality
- Customer loyalty
- Krah community
- Magazine

For decades, Krah stands for quality “Made in Germany” and thus for high-quality products. Krah pipes are a term in the infrastructure sector that stands for quality and durability. Therefore, it is often the case that many of the customers integrate the name Krah into their company and/or call their pipes Krah pipes. The resulting awareness, as well as the branding of the Krah brand, greatly improves sales opportunities. However, not only the quality of the products is crucial, but also the intangible value is important to build trust and strong customer loyalty. To this end, we invite our customers to a community meeting every one to two years, where many of them come together in different countries - always at the location of a Krah pipe producer - to give technical presentations, exchange ideas and make contacts.



The marketing of the pipes for the customers of Krah GmbH creates the demand for the production plant.

For us, the social interaction and sense of community at numerous events, in addition to the transfer of knowledge, is a big part of why customers enjoy being part of the community. Ideally, this takes over the marketing of the products by passing on positive testimonials and recommendations among themselves,

as well as to potential new customers. Our team can use these meetings and the resulting discussions and presentations to optimize its research and development by taking problems, new ideas and improvements from the customers and then processing them within the company. The community meetings, along with trade show events and company open days, are a big part of the corporate identity that makes our company special.

For technical details and other important tools that potential customers need, an in-house magazine is published at regular intervals. This offers our customers the opportunity to satisfy their own customers with regard to corresponding needs. By providing their own magazine, customers, consultants and designers are targeted. Direct customers are thus provided with a convenient way of passing on the information they require about Krah GmbH. They benefit from this by, at best, gaining a new customer without having to become active themselves. Consequently, this results in a win-win situation for the customers and for our company itself. It is also important for sales success that the Krah machine is understood as a production product. Because ultimately it is the production technology alone that is sold, and not the end product pipe.

How does Krah sell the production technology?

Since the machine is the only product that is actually sold on paper, all sales are focused on maximizing machine sales. While you may hear a lot about Krah pipes, this only serves to help customers sell the pipes and thus increase their attractiveness as a machine supplier. Expansion investments, spare parts, etc., are also sold this way. The purchase must therefore pay off for the customer in the end. By means of the profitability calculation for the end product included in the business plan, the customer checks the profitability of the machine investment. In this process, we support him with our many years of experience and expertise in order to realize the machine purchase. In this area, we also cooperate with consulting companies and local representatives to obtain information.

Sales are to be optimized via as many profitable sales channels as possible. However, due to the complexity of the machine acquisition and the resulting need for explanation to interested



potential buyers, there is currently no serious alternative to personal direct sales. To supplement this, social media platforms are available as communication channels, but for the most part these also focus on pipes for customer support. In order to realize the sale of a machine, in addition to delivering a profitable machine, the essential task for us is to allay any fears our customers may have regarding a possible bad investment. A so-called "technical fear" is especially prevalent in developing countries. It describes the fear that the machine could not be used and operated properly, due to a lack of skilled personnel, because of local (education) deficiencies. In order to overcome this fear, we like to invest in companies for a limited period of time or establish new joint ventures in order to be able to ensure the proper operation of the machine through local expertise. These participations are expressly not intended to generate profit or other financial opportunities, but are exclusively confidence-building measures to eliminate technical and commercial fears. Another fear that drives potential customers is fear of the market. Here, too, we can counteract through participations. The decisive profitable competence of Krah GmbH consists above all

in the worldwide excellent contacts to customers, designers and consultants in the pipe industry. In order to take the fear of the market away from the customers, they are given an exclusivity for the production for a geographically and temporally limited market. As a rule, this is done free of charge and serves primarily to retain and support customers.

After-Sales = Pre-Sales

The last important point of a company concept is the after-sales issue. In our company, this does not exist, because here after-sales is synonymous with pre-sales and can therefore be understood as sales. Acquired customers are connected with existing customers through their inclusion in our Krah community. Together with these, a real multiplier effect is created when contact is made with potential new customers. New prospects are brought to existing customers to get first-hand information about production. After all, there is hardly any better advertising than an honest recommendation from convinced customers. Optimally, direct customers thus sell the machine to further potential customers.

In addition to the fears already mentioned and the membership in the Krah community, the close connection with the Krah Group also simplifies the spare parts business, making the purchase of a Krah machine more attractive. Through a minority shareholding in the customer's company, we gain an insight into the economic figures and can thus better verify business plans in the future and thus learn through best practice.

Since many customers voluntarily use the name Krah for the pipe system or even for the company itself, thereby massively increasing the level of awareness, the company can market itself much better without having to become active for it itself. The added value of strong branding is particularly evident here. In summary, it can be said that our company clearly focuses on the customer and the product. To remain successful, creative sales systems must be applied that set the company apart from others. These are not always immediately understood because they are a somewhat unconventional, but that is our unique selling point. After all, a mechanical engineering company producing in Germany is now no longer able to survive on the basis of a good product alone and has to find other ways of doing things.

It is to be hoped that Germany will continue to be a location for industry and that the country will take responsibility and establish the framework conditions for companies like us.

With this corporate concept, it will hopefully now be clear to everyone how the Krah company sells its machines via the end product pipe. Even though it is a special concept, it seems to work very well and we are happy about every single person in our Krah community who goes this way with us. We would like to thank everyone who attended the community meeting in Malaysia for a great, fun and educational time and hope you have fond memories of this time. For us, this community is one of the most important points of our corporate concept to make our concept work and be accepted. We are therefore all the more pleased to have such a great community and cordially invite all interested members to become a part of it. For those who were not there, and for those who would like to look back at them, we have published all the presentations in this issue.

We are a strong community, so be a part of it, preferably an active one! *Enjoy reading!*



The Krah Community at the KCM 2023 in Malaysia



Krah Community Meeting 2023

A resounding success in Malaysia

The annual customer event hosted by Krah Grande Borneo, the „Krah Community Meeting,“ reached impressive heights this year. From September 17th to 23rd 2023, customers from over 18 countries gathered in Malaysia to participate in this unique event.

Malaysia, a country of breathtaking beauty and captivating culture, provided the ideal backdrop for this significant gathering. Participants not only had the opportunity to explore Malaysian culture and attractions but also to engage in a variety of professional events.

The centerpiece of the event was the numerous presentations on Krah technology. These sessions offered insights into new projects, past successful endeavors, and discussions about the future of plastics and plastic pipes. The presentations provided attendees with the

opportunity to deepen their knowledge and stay informed about the latest developments in the industry.

The planning and organization of this event spanned many weeks and required close collaboration between the employees of Krah GmbH and Krah Grande Borneo. The effort and dedication invested in the preparations undeniably paid off, as the event ran smoothly and garnered great enthusiasm from the participants. Alexander Krah, CEO of Krah GmbH, stated:

“We are thrilled with the positive feedback and success of this year's Krah Community Meeting. It was a fantastic opportunity to meet our customers from around the world and collectively shape the future of our industry. We are proud to have such dedicated partners and look forward to continuing our collaboration.”

The „Krah Community Meeting“ 2023 was not only a forum for professional exchange but also an opportunity to deepen relationships, explore new business opportunities, and strengthen the global Krah community. The event concluded with a festive gala dinner where participants had the opportunity to reflect on the week's experiences and forge new plans for the future. One of the highlights of the event was the visit to the Batu Caves, a renowned Malaysian attraction. Participants were also treated to a visit to the Handicraft Market, immersing themselves in the local culture. The SkyBar, offering drinks with a stunning view of Kuala Lumpur's skyline, provided a perfect setting for networking and relaxation.

Furthermore, as Krah GmbH, we are extremely grateful for the hospitality and warm welcome provided by Krah Grande Borneo. We felt very comfortable and

are proud to have such a professional and new partner at our side. Overall, the „Krah Community Meeting“ 2023 was a resounding success, leaving indelible impressions on all participants. It underscored the importance of collaboration and innovation in the plastic industry and will undoubtedly be remembered as a milestone in the history of Krah GmbH and its valued customers.

Krah GmbH





First Flush Rain Water Systems

Centraltubi solutions

Centraltubi S.p.A. (Italy) has shared with all Krah Community Members its experiences about the accumulation and treatment systems developed and installed for the 1st flush of rain waters.

Considering the European regulations for environmental protection (in these days under review), the definition of "1st flush of rain water" was passed as follow: "the amount of rainwater precipitated in the first 15 minutes of the meteor event". Thus, two different systems widespread in Italy were shown: system 1 operating by water accumulation, and system 2 operating continuously.

System "1" consists in an accumulation volume, sized for storage the quantity of water calculated on project (minimum: 15 min. of rainfall x 5 mm thickness x drainage surface considered). The rain falling on waterproof surfaces (roads, parking, airport runways, harbours, logistic platforms etc.), washes the surfaces and thus transports very aggressive polluting materials. After the rainfall these surfaces are considered "clean"; they will be considered "dirty" again after 48 h. So, the water collected

must stay into the accumulation volume for at last 48 h. During this period, the water is sent by a pump to an external system dedicated to oil and sand separation or, when available, in a waste water treatment plant. Water depuration level is depending on the efficiency of oil and sand separators elements. The accumulation volumes (tanks) are realized with HDPE Spiral pipes made with KRAH technology, where modularity allows to size any volume desired, thanks to the electrofusion socket system that allows a 100% water tightness.

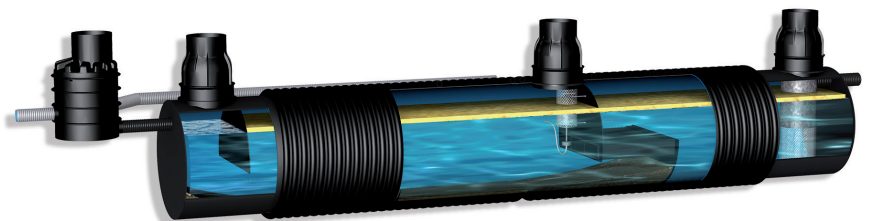
Completion and management of the system

Some components are necessary to complete and manage the system: manholes for inspection and cleaning + the first manhole behind the tank must be equipped with a by-pass system; closing valve and pump with electrical cabinet.

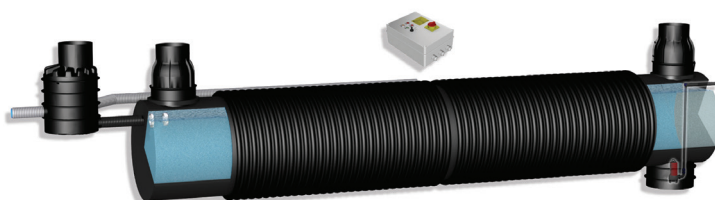
There are some waterproof surfaces that must be considered always "dirty" (polluted) also after 15 min. of rainfall, like car demolition areas, gas stations etc. so, in this case, it's necessary to treat all waters drained.

PE plate stops the water turbulence

System 2 provides to treat a flow rate (litres/second instead a volume) into a tank, where water passes through and the separation of pollution materials happen through floating (light liquids, leaves, papers, woods ...) and for sinking (sands, stones, metals). The tank is inside equipped with a PE plate to stop the water turbulence immediately after the inlet. In this surface will be accumulated all floating wastes: papers, leaves, plastics etc. that can be extracted from the manhole above. The water flow slows down into the big volume of the tank, so light liquids will float on the surface and the heavy materials settle at the bottom. To have the best separation efficiency it's necessary to minimize the turbulence of the water, so it's preferred to use the biggest diameter possible, to reduce the speed of the water flowing; small diameter pipes need to make longer tanks. Lamellar



Continuous system (System 2)



Accumulation system (System 1)



Accumulation system



Continuous system

packs and/or coalescence filters can be installed into the tank, to have a better filtration of smallest parts which failed to float in surface, or settle to the bottom of the tank. To go out of the tank, water must flow into an apparatus equipped with a special floating valve, set-to float in the water, but not in light liquids. In case of too much accumulation of light liquids, this layer grows from the surface towards the bottom, so the water floating valve

gradually descends, until it closes the tank outlet at the established level, so as not to let the oils escape too.

If water continues to flow inside, its level grows into the tank and will go out from the by-pass of the manhole installed before the water entrance in the tank. An automatic gravity system to extract continuously the light liquids from the tank has been shown.

Oil and sand separation systems installations are significantly advantageous for installer when made with spiral pipes. Their main advantages are:

- Handling and installation (facilitated by the lightness)
- Faster installation time
- More working site safety
- Ready to install (tanks arrive already complete of everything inside)

- Modular system (= no volume limits) easy and fast to connect
- Affordable watertight connections thanks to the electrofusion socket system
- Technical and design support
- Less workers operations in the working site
- Safety
- HDPE durability and tolerance of the pipe settlements
- Gravity system (> sustainability)
- Little working time thanks to the easy system and supporting given from producer
- Possibility to use recycled materials (standard EN 858 don't regulate it), so "green" certifications can be provided



Coalescence filter

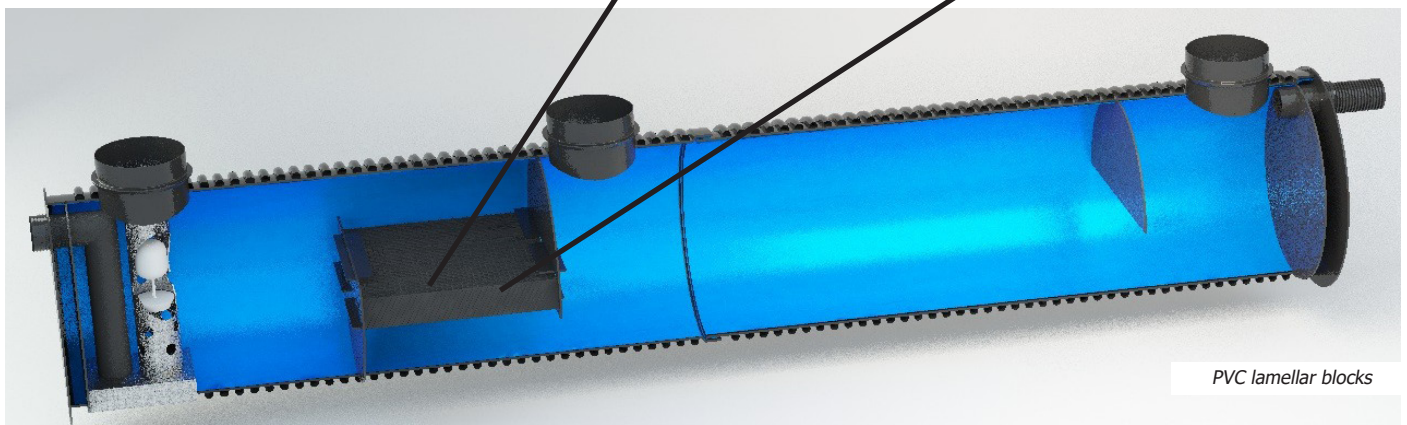
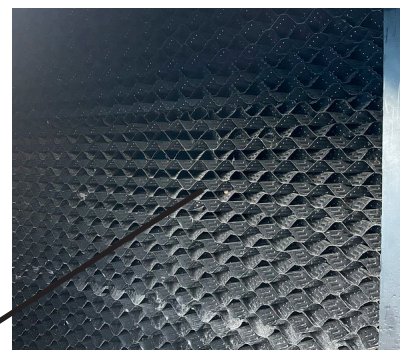
Maintenance plan of the network operator required

All systems separate water from pollution materials, so these materials will be accumulated. A maintenance plan from the network operator is therefore necessary to check and clean the system. Frequency of controls are depending mainly on the number of rainfall and the cleaning status of surfaces. At the beginning, we suggest

everyone carries out the first checks every 6 months (more frequently is better), in order to form an idea of the seasonal situation to draw up a correct final

maintenance plan.

*Marco Maroncelli
R&D Team of System Group*



PVC lamellar blocks

Discharged Large Diameter Pipeline

for coal fired generation plant by PE-sGF in Japan

In 2020, a PE-sGF discharged pipeline with a diameter of DN/ID1800mm and approximately 2 km length was completely installed for a coal fired power plant in Japan. In this paper, the characteristics, designation and construction of large diameter PS-sGF pipelines are presented.

Plastic pipes must be designated in two directions - circumferential and longitudinal - when laid on construction site. Basically, thermoplastic pipes have been designed with the same values, yet PE-sGF pipes with different properties can be specified for these directions. PE-sGF pipes provided with a spiral cross-wound method of PE100, short glass fibers and a coupling agent have two times tensile strength in the circumferential direction than PE100, but the same strength in



Electrofusion jointing

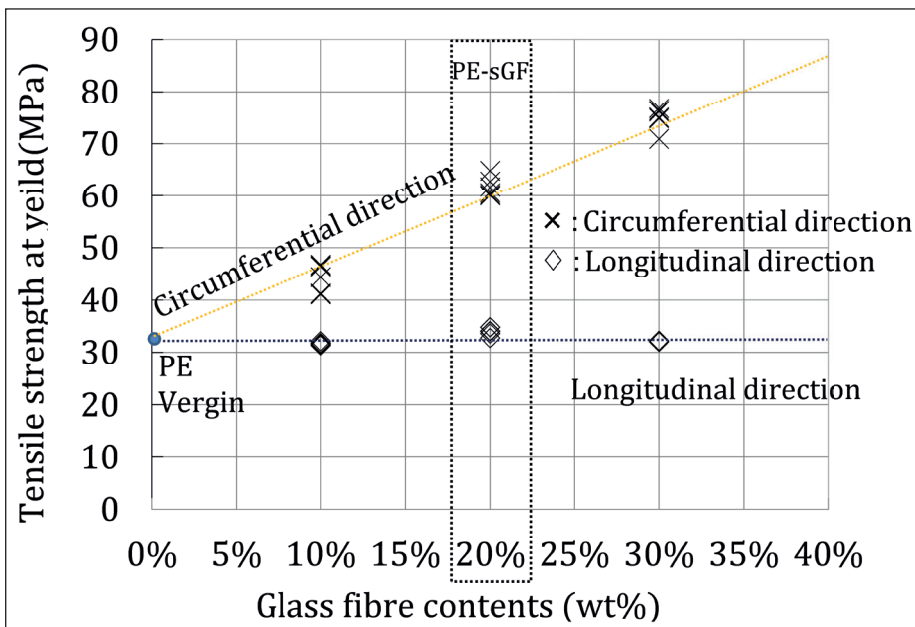
the longitudinal direction as the flexibility of the axes. According to the statistics of the Ministry of Economy, Trade and Industry, there are 142 thermal power plants in Japan in June 2020, and taking

into account the energy supply and demand as well as the environmental assessment, 17 thermal power plants are planned to be newly built or renovated. In thermal power generation, a large amount of water is required to cool the steam with the condenser and ascites treatment system, so it is still common to use seawater as cooling water. Previously, iron pipes were mainly used for pipelines to pull up seawater, but there were problems such as corrosion due to salt damage and blockage due to biofouling.

Corrosion resistant and resistant to biofouling

Therefore, the use of plastic pipes that are corrosion resistant and resistant to biofouling is being investigated for seawater use worldwide. Andrew Wedgner et al.

Fig. 1: Tensile strength characteristics



(2016) summarized the results of laying a PE100 pipeline for geothermal power generation facilities in Java, Indonesia, in 2012 to deal with the problem of corrosion of existing iron pipes (PPXVIII 18th Plastic Pipes Conference 2016, Berlin).

Oka et al. (2020) installed for the first time a PE80 pipeline with a very large diameter of DN/ID3000mm manufactured by the spiral winding method in Japan in the construction of water intake and discharge pipelines for a thermal power plant, and clarified the validity of its design and biofouling characteristics (Electric Power Civil Engineering, 2020 No.407 pp 60-76). Furthermore, Tokiyoshi et al. (2018) laid PE-sGF pipes on soft ground and conducted an analysis of long-term burial behavior in terms of circumferential stiffness and longitudinal flexibility to verify the circumferential pressure tolerance and the longitudinal tracking capability (PPXVIII 18th Plastic Pipes Conference 2018, Las Vegas Nevada USA).

This paper shows an example of the design, demonstrating testing, and installation of

Fig.2: Properties of different materials with regard to flexibility

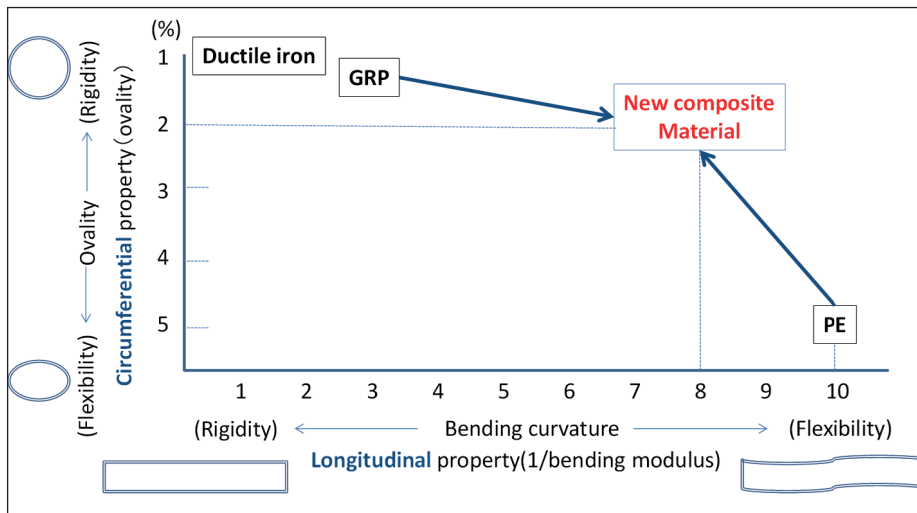
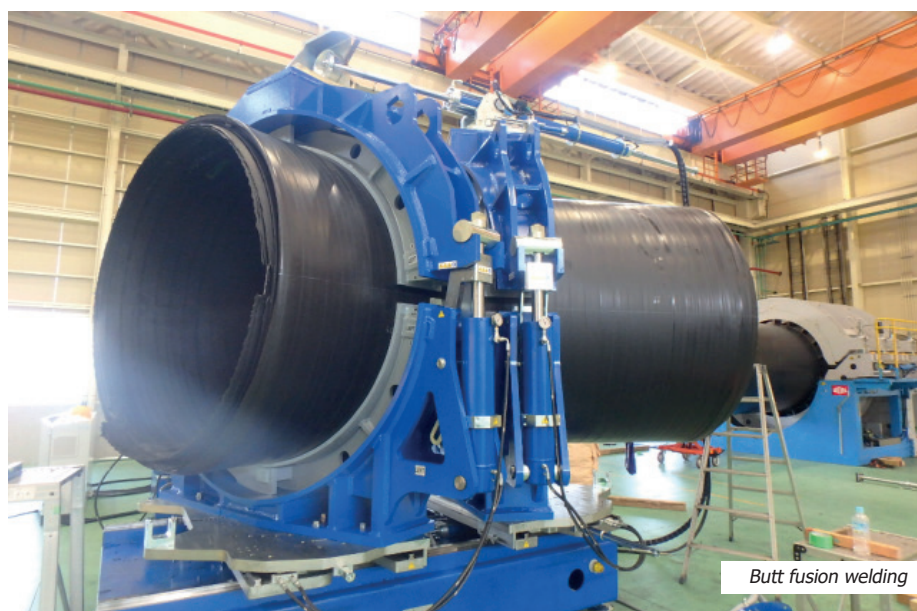


Fig.3: Properties of PE-sGF and PE100 under the same conditions

Item	PE-sGF	PE100
Circumferential thickness (mm)	51	70
Longitudinal thickness (mm)	51	116
Finalized minimum thickness (mm)	51	116
Weight (kg/m)	330	690
EI (kNm ² /m)	27,6	28,0



Butt fusion welding

a discharge pipeline for a thermal power plant using similar pipe and joint types as above. Based on an example of the design, construction and demonstration tests of a discharge pipeline using PE-sGF pipes and joints for a thermal power plant, the following findings were obtained:

1. Using PE-sGF pipes and joints manufactured by the spiral-wound method, a discharge pipeline with an DN/ID1825 mm, a pipe wall thickness of 51 mm, and an expansion distance of 1844 m was laid for a thermal power plant.



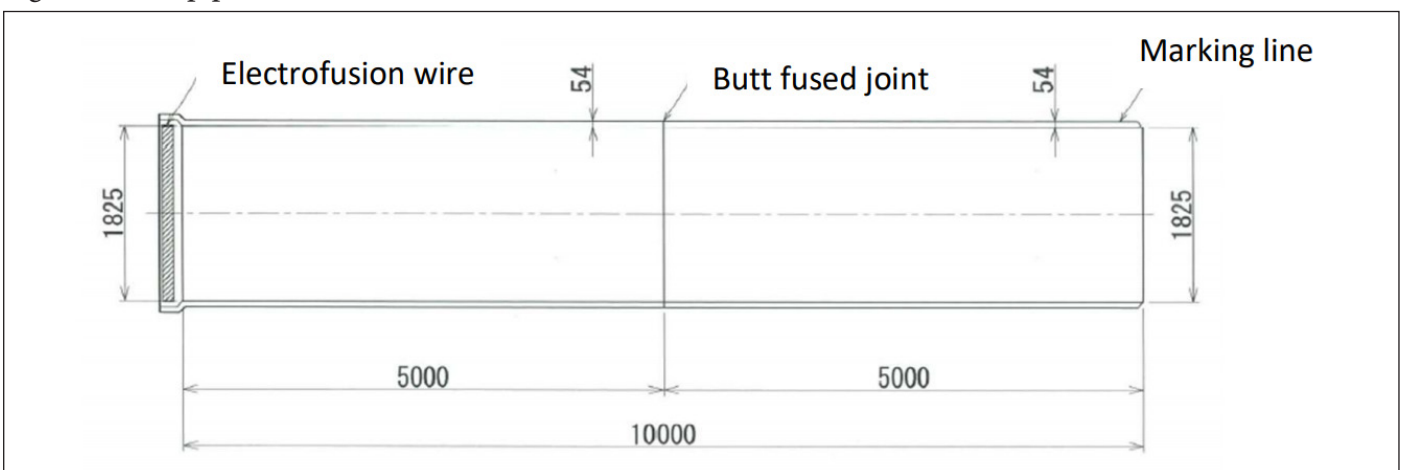
2. An electrofusion joint and a butt fusion joint were selected, and their safety was confirmed at actual scale.
3. It was found that the stresses in the electrofusion joints were about 40% lower than in straight pipes, with no local stress concentration.
4. Under the same conditions, the circumferential thickness for PE pipe is 70 mm.
5. A stress of 5,645 kN/m² is generated

in the PE pipe, depending on the range of operating temperature change of the liquid in the pipe. The permissible change due to the Poisson effect resulting from the permissible longitudinal stress limit (5,920 kN/m²) shall not exceed 275 kN/m². When used under conditions where both ends are restrained, a thickness of 116 mm is required, considering the Poisson effect resulting from the pipe wall thickness. On the other hand, PE-sGF

pipes have been shown to have a lower coefficient of linear expansion, which is about 40% of that of PE pipes, so that the pipe wall thickness of 51 mm achieved in the circumferential direction is sufficient to show good behavior in the longitudinal direction as well.

Mitsuaki Tokiyoshi
C.I. Takiron Corporation

Fig.4: PE-sGF pipe unit



Turning Urban Challenges into Green Solutions

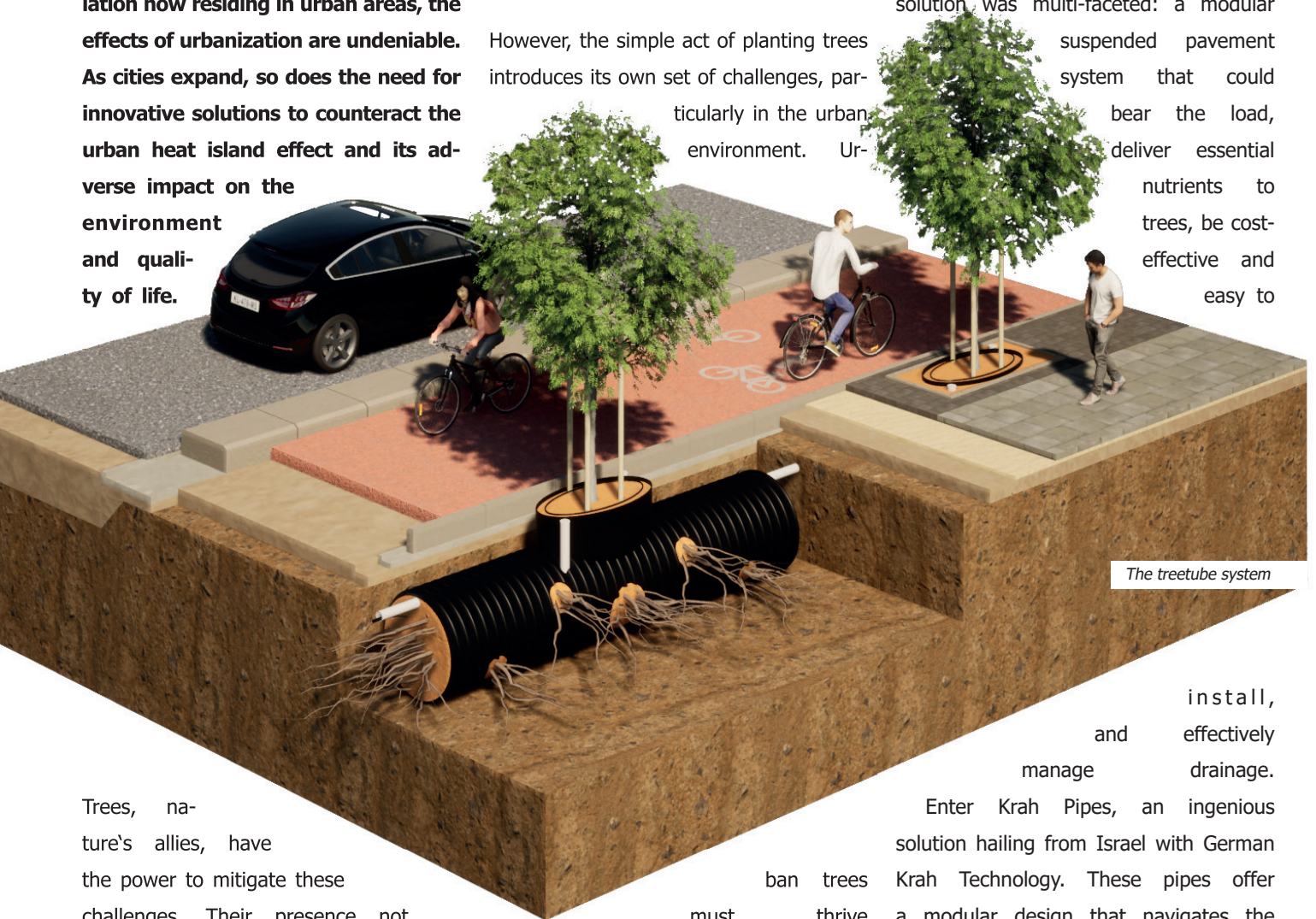
Introducing Krah pipes and Treetube for sustainable cities

Climate change is rapidly reshaping our world, and nowhere is this transformation more evident than in our cities. With over half of the global population now residing in urban areas, the effects of urbanization are undeniable. As cities expand, so does the need for innovative solutions to counteract the urban heat island effect and its adverse impact on the environment and quality of life.

that tree planting initiatives are gaining momentum across cities worldwide, as they offer a powerful means of combatting the effects of climate change.

However, the simple act of planting trees introduces its own set of challenges, particularly in the urban environment. Ur-

Antebi and Mr. Roni Cohen recognized. Their analysis led to the identification of crucial parameters for promoting healthy tree growth in urban areas. The solution was multi-faceted: a modular suspended pavement system that could bear the load, deliver essential nutrients to trees, be cost-effective and easy to



The treetube system

Trees, nature's allies, have the power to mitigate these challenges. Their presence not only adds beauty to our concrete jungles but also serves as a natural cooling mechanism for the streets. By absorbing carbon dioxide and producing oxygen, trees play a pivotal role in urban ecosystems. Moreover, they act as windbreaks, cleanse the air, retain water, and stabilize soil in urban landscapes. It's no wonder

urban trees must thrive amidst challenging conditions, often constrained by limited space and compromised soil quality. Uncontrolled root growth can lead to conflicts with infrastructure, causing damage that's both costly and disruptive. Addressing this issue requires innovation, and that's precisely what Mr. Jonathan

install, and effectively manage drainage.

Enter Krah Pipes, an ingenious solution hailing from Israel with German Krah Technology. These pipes offer a modular design that navigates the complexities of urban infrastructure, creating the ideal conditions for trees to flourish beneath pavements. The advantages are manifold:
1. Meeting Standards: Krah Pipes conform to all relevant loading and drainage standards, ensuring that trees thrive without



- jeopardizing city infrastructure.
2. **Damage Prevention:** By providing a controlled growth environment, KraH Pipes prevent trees from damaging urban structures.
 3. **Effective Drainage:** With integrated drainage systems, KraH Pipes guarantee proper water management, promoting healthy tree growth.
 4. **Strength and Lightness:** These pipes are both lightweight and remarkably strong, offering a resilient solution.
 5. **Optimal Substrate:** They provide up to 95% available substrate for trees to establish strong root systems.
 6. **Irrigation and Aeration:** KraH Pipes facilitate efficient irrigation and aeration, key to a tree's health.
 7. **Thermal Management:** Trees benefit from a stable thermal environment, even in the concrete heart of the city.

8. **Ease of Handling:** Easy installation and management make KraH Pipes a practical choice for urban planners and landscape engineers.

Cost-effective, sustainable solution

In parallel, the Treetube system has been gaining traction as a cost-effective, sustainable solution for urban infrastructure. Its benefits include:

- **Cost Efficiency:** The Treetube system offers a cost-effective solution for cities looking to improve their infrastructure.
- **Enhanced Urban Life:** Healthy trees not only beautify the city but also contribute to improved population health and energy savings.
- **Maintenance Savings:** By managing root growth, the Treetube sys-

tem reduces the need for pavement repairs, saving maintenance costs.

- **Rapid Installation:** Quick and straightforward installation means cities can see positive impacts sooner.

In a world grappling with climate change, our cities face a critical challenge: to remain livable, safe, healthy, green, and attractive. KraH Pipes with its Treetube system have emerged as powerful tools, enabling cities to transform these challenges into sustainable solutions. By embracing these innovations, urban areas can continue to thrive while actively combatting the effects of climate change. It's time to build a greener future for our cities with innovative solutions by using KraH Pipes.

*Bülent Kuzkaya,
KraH GmbH*





Installation of the treetube system with multiple openings for trees



15 Years of Success

with KRAH technology under CORSYS PLUS brand

Since 2005, POLYPLASTIC Group has been producing non-pressure pipes with a structured wall for drainage systems. Initially limited to a diameter of 1200 mm, quite soon it became clear that larger diameters were also needed.

The ability to manufacture a variety of pipes with different profile types, including pressure ones, makes KRAH equipment for the production of polymer pipes the most versatile and multifunctional on the world market both at that time and now. And in 2007, POLYPLASTIC Group signed a contract for the purchase of a complete KRAH line for pipes of large diameters using the profile winding technology. The line was installed at the Group's largest plant, Klimovsk Pipe Plant, which already at that time had a capacity of more than 50,000 tons. CORSYS brand name (originated

from CORrugated SYStems) had already been registered by POLYPLASTIC for smaller diameter twin-wall corrugated pipes, so large sizes received the brand name CORSYS PLUS. The commissioning of the line took place in close cooperation with KRAH, in addition to experienced commissioning personnel, all necessary auxiliary equipment and components were provided, as well as detailed instructions for the production and welding of CORSYS PLUS pipes. The implementation progressed very intensively and the first projects were not long in coming. The first large facility appeared already in 2008 - a 9000 meters long DN/ID1400mm public sewer collector in the resort area of Caucasian Mineralnye Vody. Giving up traditional reinforced concrete was due to its obvious flaws, which do not allow to talk about the stability and durability of the sewer system to preserve the unique environment of the area.





Installation of Krah pipes on a construction site

Thanks to the variety of profile types, KRAH pipe system is highly competitive. Flexible and lightweight pipes withstand high static loads. The unique process of conjugated coextrusion makes it possible to produce pipes with a special inner layer, for example, light-colored - convenient for teleinspection, colored for identification of applications or technical characteristics, light-resistant and non-flammable - for culverts, etc. The main method used for connecting CORSYS PLUS pipes is electrofusion connection which provides a high quality welding, giving the pipeline homogeneous properties and flexibility.

Advantages of the CORSYS PLUS system

It is the electrofusion connection, coupled with the wide possibilities for the strength characteristics of the pipe wall, that provides the advantages of CORSYS PLUS system over SPIROLINE pipe made of spirally wound profile and CORSYS ARM pipe reinforced with steel tape, of the same pipe sizes. The main areas of



Transport of Corsys Plus pipes

application for KRAH pipes are non-pressure and low-pressure water disposal, drainage, and irrigation systems. In addition, several marine outfalls have been commissioned recently. These pipelines are also widely used in the construction of airfields, where reliability issue comes first.

A large number of sudden and non-standard tasks arise at construction sites. For instance, at the "Technopark Grabtsevo" facility, it was necessary to weld in a

manhole into the existing pipeline made of CORSYS PLUS pipes with a diameter of DN/ID2000 mm. For this, repair electrofusion liners were manufactured and tested, which allow not only to repair CORSYS PLUS pipeline by connecting the ends of the pipes without a socket, but also to make cut-ins into the pipe, which was required at the aforementioned facility. The branch pipes of the tangential manhole, which was also made of CORSYS PLUS pipe, were welded with two liners. The experiment on insertion into the existing CORSYS PLUS collector, of course, should be considered successful. The proposed technology has proven itself in the field both in terms of connection reliability and installation speed. And since inserting a manhole into a large-diameter CORSYS PLUS pipe in principle is no different from inserting a pipe segment, this experiment is a brilliant proof of the promise of CORSYS PLUS pipeline repair technology using electrofusion sleeves-liners.

In 2011, in cooperation with KRAH specialists, the line underwent a total mod-



Electrofusion of Corsys Plus pipes

ernization. As a part of this modernization, the range of pipe sizes was significantly expanded with the possibility of using DN/ID90mm and DN/ID110mm PE coated PP corrugated pipes, which increased the efficiency of the structure to achieve maximum ring stiffness of the pipe.

Capabilities for pressure applications

Increasingly, the question arose about the capabilities of CORSYS PLUS pipes for pressure applications. Work experience was proving that a standard socket and one welding spiral cannot withstand a high working pressure, especially with an increase in diameter. As a result, a solution was worked out

to extend the socket and install a double spiral welding. Such a solution was implemented for the public sewer in Cheboksary, where the normalized working pressure of the pipeline is declared up to 0.6 MPa for diameters up to 2000 mm. In order to test pressure pipes and fittings for a constant internal pressure at a temperature of 80°C, a unique test equipment for pipes with a diameter of up to DN/ID2200 mm was developed and installed - equipment which, according to our data, is still the only one in the world.

Despite the fact that in Europe the standard classes for structured wall pipes are usually SN2 or SN4 ring stiffness, in the realities of the Russian market, especially for megapolis cities, a pipe with greater ring stiffness turned out to be in demand. Thus, in Moscow there is a technical regulation that defines the requirements for pipes for various laying methods, so CORSYS PLUS pipes up to DN/ID2200mm

included standard elbows and stub flanges, as well as pressure reducers, including eccentric ones, and tees.

More than 15 years of successful Krah technology

The products of POLYPLASTIC Group based on KRAH technology have been successfully used throughout the country for more than

15 years. One of the recent projects (2022) was the use of CORSYS PLUS pipes with a DN/ID3500 mm in the project for the reconstruction of the Akulovsky water channel in the Moscow region. The total length of the pipeline from CORSYS PLUS pipes was 1.2 km.



Storage of Corsys Plus pipes

with ring stiffness up to SN16 appeared in the production range.

Wastewater treatment plant with various CORSYS PLUS pressure pipes

In 2021-2022, a wide range of pressure CORSYS PLUS with diameters of DN/ID1200-2200 mm was used at the Schelkovo wastewater treatment plant, and a variety of fittings were also used, most of which were produced for the first time specifically for this project. Those

The project was the first application of CORSYS PLUS pipes with a diameter of 3.5 meters in the construction of water conduits. The experience will be scaled up during the implementation of similar projects and the reconstruction of reclamation canals - by replacing them with pipelines based on CORSYS PLUS.

Polyplastic

The Ecoline by Krah Piping and Fittings System in the rice planting industry in Argentina

In search of new market developments, our company constantly explores the possibilities offered by industries that require massive movement of liquid flows. The technological capacity of Krah pipes allows to handle large diameters with low pressures, which positions the technology against usual competences. In this context, rice planting industry introduce a very suitable market for this type of profiled pipes, which Krah America Latina SA has ventured into in recent years, with great success.

This document includes relevant aspects of use of the Ecoline by Krah Piping and Fittings System in the rice planting industry in Argentine.

The rice planting market

Traditional method for cultivating rice is flooding fields while, or after, setting young seedlings. This simple method requires a sound irrigation planning, but it reduces the growth of less robust weed and pest plants that have no submerged growth state and deters vermin. While flooding is not mandatory for cultivation of rice, all other methods of irrigation require higher effort in weed and pest control during growth periods and a different approach for fertilizing the soil. Rice requires slightly more water to produce than other grains. It's production uses almost a third of Earth's fresh water. Water outflows from rice fields through transpiration, evaporation, seepage and percolation.

It is estimated that it takes about 2.500 litres (660 US gal) of water need to be supplied to account for all these outflows and produce 1 kg (2 lb 3 oz) of rice.

Rice cultivation requires flooding during plant development. If we consider that 290,000 ha are planted in Argentina and during the entire rice crop cycle approximately 1.0 m³ of water is needed for each m² of land, each season 2,200 million m³ of water are flowed. The water required in each field is usually pumped from a reservoir or river to a certain height and then distributed through canals by gravity. Throughout production cycle we can define two points in water path where pipes are used: pumping and distribution. Consider the amount of hydraulic capacity needed to mobilize this volume of water at different levels of height and we will have a great business in hand.

What is Rice?

Rice is a monocot belonging to the family Poaceae (grasses). The roots are thin, fibrous and fasciculate. Rice is a seed of grass species *Oryza sativa* (Asian rice) or, less commonly, *Oryza glaberrima* (African rice). The name wild rice is usually used for species of genera *Zizania* and *Porteresia*, both wild and domesticated, although the term may also be used for primitive or uncultivated varieties of *Oryza*. As a cereal grain, domesticated rice is the most widely consumed staple food for over half of world's human

population, particularly in Asia and Africa. It is an agricultural commodity with the third-highest worldwide production, after sugarcane and maize. Since sizable portions of sugarcane and maize crops are used for purposes other than human consumption, rice is the most important food crop regarding human nutrition and caloric intake, providing more than one-fifth of worldwide consumed calories by humans. There are many varieties of rice, and culinary preferences tend to vary regionally.

Rice is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years. Rice cultivation



Rice on terraces

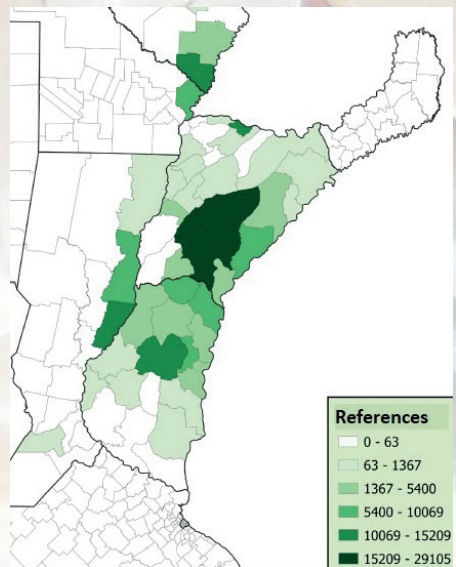
is well-suited to countries and regions with low labour costs and high rainfall, as it is labour-intensive to cultivate and requires ample water. However, rice can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide. Production and consumption of rice is estimated to have been responsible for 4% of global greenhouse gas emissions in 2010.

Rice production in the world & Argentina

Rice is second most produced cereal in the world behind maize (1 billion tonnes) and ahead of wheat (713 million tonnes). Many hectares are dedicated to rice cultivation in the world. It is known that 95% of this crop extends between parallels 53° north latitude, and 35° south latitude. In

Indonesia, and Vietnam. The five major producers accounted for 72% of total production, while top fifteen producers accounted for 91% of total world production in 2017. Developing countries account for 95% of total production.

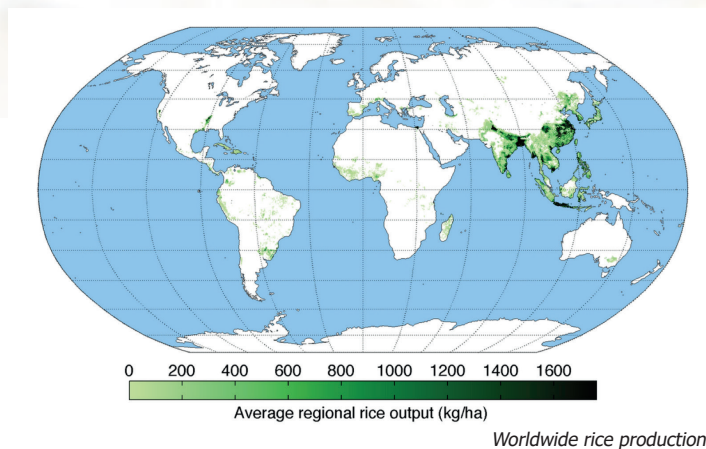
Argentina produces 1.6 million tons per year. In last 10 years production increased by 121%, accompanied by a 16%



Rice production in Argentina

increase in yields. Argentina currently

exports around 640 thousand tons of rice, of which 55% of shipments are concentrated in semi-milled rice, about 30% in husked rice, 12% in broken rice and rest in paddy rice and rice for planting. In the



Worldwide rice production

2020, world production of paddy rice was 756.7 million metric tons, led by China and India with a combined 52% of this total. Other major producers were Bangladesh,

in the nineties there was a boom in expansion of planted area reaching a record of 290,850 hectares and a production of 1.66 million tons representing 0.22% of

world production.

Analysing geographical location of places where planting is recorded, it is observed that Corrientes is the province where farmers declared the largest area planted for rice 2021/2022, representing 48.78%. In second and third place are provinces of Entre Ríos and Santa Fe with 26.44% and 12.33%, respectively. Between three provinces they represent 87.55% of total planted area.

Rice cultivation and materials used

Most rice is grown in flooded fields. The success of production is based on water management for adequate irrigation, which involves construction of walls and use of waterwheels, as well as ensuring that water penetrates more than five centimetres into the soil. For this reason, it is convenient that fields to be flooded are relatively close to lagoons that provide necessary water.

First, property margins and walls for delimitation are built on bottom of the land. Soil is provided from some shallow place of lake, for which a dredge is used until sides reach a height of half a meter above lagoon water level, forming the cerrado. Then the cerrado itself is filled with earth until it reaches neighbouring fields level. In case of rice fields located on flat lands, where fields level and lagoon level are the same, pumps are used to extract water from fields to ditches. To flood fields, it is enough to open the floodgate. In case of land located at higher altitudes, as is more common, fields form terraces. Water passes through pipes driven by pumps



that take water and raise it to closed ones that must be flooded. Therefore, as we said previously that throughout production cycle two points are defined in path of water where pipes are used: pumping and distribution; Let's analyse each one.

Pumping phase

There are different variants of pumping. Broadly speaking, and following path that water travels, installation begins with a



suction section of little or no length, the pump, a short segment where diameters are adapted and valves and chimneys are placed, and finally a counter-slope discharge line that usually is at least 200 meters long. Nowadays these facilities are made of rolled sheet metal and welded from start to finish. Except for smaller

diameter pumps (up to DN600) where in several cases discharge lines are made of solid PVC. Sheet metal installations have several drawbacks. The first and main one is that sheet rusts and even more so in operational context of this type of installation. Carbon steel is in constant contact with water while it is being watered (6 months); The steel pipe is filled with water and the rest of the year it contains water partially since installation is never completely emptied. The second scenario is even more unfavourable because of having humid areas in contact with oxygen. Pipe cannot be buried and must be installed above ground since installation service life is a few years and soil movement are not justified. In addition, if buried, corrosion phenomenon would be aggravated by moisture and galvanic corrosion. Even leaving laying on ground, these corrosion phenomena would appear throughout lower part where soil and pipe come into contact. For this reason, lines are usually placed on tries to keep them separate from ground (remember that the lines have a length of 200 meters on average).

Because pressures are low, pipes are

made by rolling 1/8" or 3/16" sheets and welding them. This construction method results in a pipe of a nominal pressure suitable for the project, but with a very poor annular stiffness in large diameters. This lack of stiffness causes two types of very recurrent failures in this type of installations:

- First, in transient vacuum phenomena pipe buckles and collapses leaving installation out of operation.
- Additionally, the pipe constantly undergoes an "oscillating deflection", with is the deflection and return to its original shape cyclically both in transient phenomena, where amplitude is greater, and in permanent regime where fluid turbulence generates deflections of lower amplitude, but higher frequency. This oscillating deflection fatigues material and longitudinal cracks occur.

Distribution phase

It is evident that channels used to transport such a volume of water in such large areas of soil must be piped in s that it can be passed overhead, to be able

to pass under embankments, or even so that one channel passes under another. In cases of larger producers, where field surfaces are larger, the need for gravity pipes increases.

Let us consider the case of largest rice producer in Argentina with approximately 60,000 hectares under cultivation. This customer differs from rest of producers by its cultivation system of zero level or controlled slope. Here we are not going to delve into details of this methodology, we will focus on what is relevant in terms of pipes.

The system requires dividing land into rectangular portions of between 20 ha and 25 ha each. Each rectangle has a pipa. It is called pipa a set of water gate plus pipe segment of 3 m to 9 m; the reason of that is to regulate water level in each portion of land, while pipe makes a crossing so that vehicles and machinery can access said rectangle.

**The Ecoline system -
A superior alternative**

Throughout northeastern region of Argentina, western Uruguay and southern Brazil and Paraguay, this market has great potential for us, where our technology stands out. It is clearly a niche market that is technologically behind when it comes to driving systems.

Obviously when working with polymers the oxidation problem is eradicated, but our differentiation regarding to other suppliers of plastic pipes is the profile design and electrofusion. With working on profiles, we achieve pipes with nominal pressure and accurate stiffness as installation

requires, even in some of the executed lines we have designed pipes of different nominal pressures at different line points in order to optimize costs. Additionally, electrofusion reduces significantly working costs since it would be totally impractical to mobilize butt fusion equipment for

not withstand the working pressures of this type of installation, while solid profile pipes (HDPE or GRP) should be thicker than that required by working pressure to have a stiffness that can withstand transient phenomena.

This results in a significant impact on



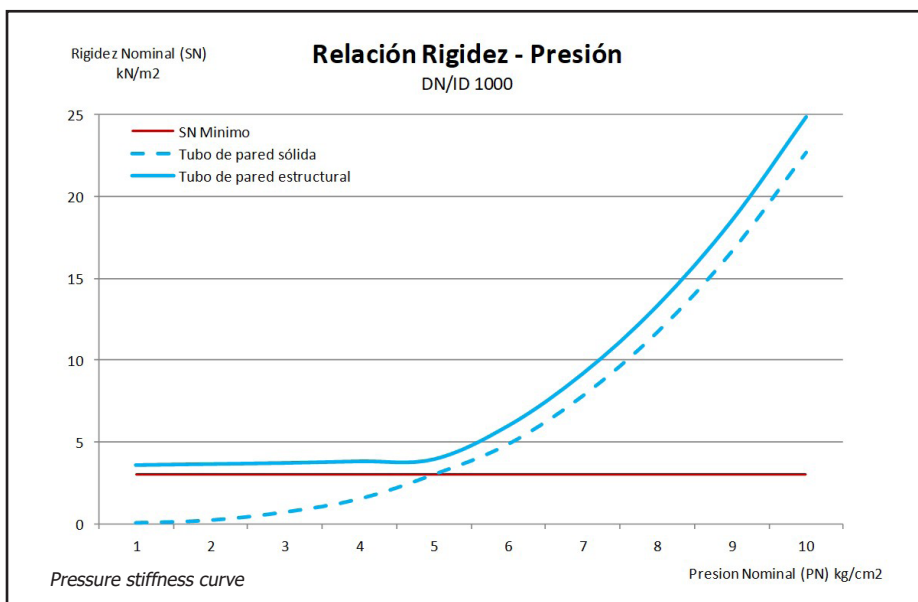
lengths of this type of installations.

We are the only ones in the region with the ability to offer this combined solution. Corrugated plastic pipes on the market do

costs. Working smart, we can have this market captive to Kraih technology.

In pumping section, what interests us is the discharge line; all above has large

Fig.1: Pressure stiffness curve of DN/ID 1000



diameter variations, low radius curves, derivations, etc. that are very complex to do in HDPE. The diameter range of these installations is from DN/ID400 mm to DN/ID1200 mm. In working regime, discharge line works with relatively low pressures, between 1 and 4 kg/cm²; However, transient phenomena in pumping with internal combustion engines are much more recurrent than in other types of facilities due to pumps stops and start-up due to power cuts in electrical installations or lack of diesel, mechanical damage, etc. In these transient phenomena installations experience water hammer (overpressure) as well as phenomena of separation of fluid column (depressions and / or voids).

Case Pumping station – Aguaceros Dam 2

For hydraulic analysis and preparation of the design report, consultant used following basic information:

- Estimated altimetric pipeline profile
- Permanence curve of levels in Aguaceros 2 dam, estimated from water balance considering recharges and extractions for irrigation.
- Brand and model of the pump to be used.
- Information from pipe suppliers, profiled polyethylene pipes from the supplier Krah

The estimated longitudinal profile considered for pumping analysis consisted of a uniform slope ramp from a point at elevation +74.00 m where manifold and protection mechanism against water hammer were installed, to discharge in cylinder head at height +86.0 m, whose

beginning is at a point 366 m away. For the dam to be built, water inside reservoir will present variations in water height between +74.0 (full reservoir) and +70.0 m height. Based on an analysis of permanence of levels through water balance of reservoir that considers contributions and extractions, 65% of time was determined during harvests, reservoir will find water at elevation +73.0 m or higher, so this lake level is considered as a reasonable value for dimensioning of pumping in condition of maximum instantaneous flows, that occurs at the beginning of harvest. To avoid negative pressures below cavitation line, 4 air valves were placed along rigid pipe, in progressive 80 m, 170 m, 260 m and 450 m. Based on these results, it is observed that the maximum internal pressure in the pipes is around 24 mca, which occurs in the initial section. Therefore, pipes were required to work above the following nominal pressures:

1. Progressive 0 m to 84 m: 2.6 kg/cm²
2. Progressive 84 m to 160 m: 2.2 kg/cm²
3. Progressive 160 m to 240 m: 1.7 kg/cm²
4. Progressive 240 m to 360 m: 1.4 kg/cm²

With respect to balance chimney, it must have a height equal or greater than 16,0 m, to avoid water loss during on-regime operation and greater than 25,0 m to avoid water loss in transient scenarios. Observing results, it is concluded that it is viable to pump target flow working with two IMBIL pumps at 440 RPM, complying with engines indicated power. Operating points closest to target, using DN/ID900 mm pipes, are as follows, all with a nominal rotational speed of 440 RPM:

- 1.55 m³/s flow rate, 900 mm pipe, power 310 kW (412 HP)
- flow rate of 1.65 m³/s, pipe of 1,000 mm, power of 321 kW
- flow rate of 1.70 m³/s for 1,100 mm pipe, power of 325 kW

To DN/ID900 mm pipe, a maximum flow of 1.8 m³/s could be obtained working at 450 RPM and using a power of 340 kW, although we understand that engine would work very close to or above its recommended limit. It was finally determined to use DN/ID1000 mm pipes according to the following detail.

Merceditas Line:

- Required flow: 1.6 / 2.0 m³/s
- Pump: IMBIL 750-860 pump
- Stub-end DN1000
- Pipes:

DN	Perfil	PN	Longitud
1000	PR-34-002.67	2,9	60
1000	PR-42-002.52	2	12

San Lorenzo Line:

- Required flow: 1.6 / 1.8 m³/s
- Pump: Worthington 750 Ingersoll-Dresser Pumps, 30 MNI 33 rotor A
- Electric Motor: WEG 480 HP 1000 rpm
- Stub-end DN1000
- Pipes:

DN	Perfil	PN	Longitud
1000	PR-34-002.22	2,5	42
1000	PR-42-002.27	1,6	60

To connect with master irrigation channel, use of a culvert composed of two Krah

Profil pipes of DN/ID1600 mm internal diameter was determined. Depending on working flow, pipes speed can exceed 1.2 m/s, and therefore there is a possibility of soil erosion at entrance and discharge of pipes, so protection measures were defined to prevent erosion at these points.

*Gustavo Mastelono,
Krah America Latina*





Haplast Unique Product Innovations from Krah Pipes

On the Lyngen peninsula, located at 69° north in the arctic region of Northern Norway, you find the small village Furufalten. Here, tucked between the Lyngen Alps, Lyngsdalen Valley and the Lyngen Fjord, you find the worlds northernmost Krah Pipes manufacturer - Haplast AS.

While the Lyngen alps are world famous for spectacular alpine skiing, glaciers, and clear blue lakes, Furufalten is well known as home to the region's largest industry hub. Since the late 1940's, Furufalten has manufactured many different commodities such as waterpipes of wood, garments, lumber, steel constructions, mechanical products, aluminum and plastic products, building elements, incineration toilets and marine waste products. In fact, today the village has only 280 permanent residents while the industry hub employs 130 people

in total - and have a total turnover of NOK 300 million (approx. USD 33 million). Haplast alone employs 44 people and reached a turnover of NOK 135 million (approx. USD 12,5 million) in 2022. Since the Haplast factory was opened in 1961, one of our strengths has been to learn and adapt. Learn from the market needs and adapt our products accordingly. Throughout six decades, the company has accumulated a huge amount of industry know how. Our dedicated staff have seen the possibilities and advantages that lies in Krah Pipes, and we have invested in product development.

Based on this we have developed a quite unique range of innovative products. Today Haplast manufactures PE based products within four main categories: Water and wastewater, transportation infrastructure, fish farming and ventilation. The Krah pipes serves as main component for





products in all these categories. Yes, Haplast manufactures Krah Pipes as just that, pipes. But we make our turnover by selling more than pipes. Haplast creates durable solutions to our customers in the form of water and wastewater basins, chemical, sedimentation and silage tanks, culverts,

tation, something that our customers are increasingly demanding. And of course, the Krah pipes allow us to manufacture lasting, leakage free solutions. In our experience, there are many good solutions for containing and transporting water in leakage free pipes or containers. However,

is to install the Haplast products compared to for instance concrete based solutions.

Haplast water basin

The Øvre Russvik basin and extension tower was delivered to a Nordkraft Hydroelectric plant. The Haplast water basin delivered for this project is 3 meters in height, DN/ID2500 mm in diameter. Because of the snow conditions during winter, the exposed environment and risk of avalanches, the contractor had to install an extension tower to safely access the water basin during winter. Due to the inaccessible location at 610 msl, the basin and extension tower had to be flown in by helicopter. The extension tower is 5 meters tall, DN/ID2500mm in diameter and weighs in at 1280 kg. The KRAH profile for this product is CPR 4/4/4 CC110 75PP and has a ring stiffness of SN 2.



The Haplast factory has a total size of 4400m²

bridges, road pipes and ventilation pipes to name some of our main products. We have delivered infrastructure solutions to hospitals, schools, road projects, fish processing factories, public water and sewage systems and many more private and public projects. We manufacture all our products from plastic granules to finished plug-and-play solutions.

The Krah technology allows us to manufacture double-walled pipes, and thus meet both industry standards and public requirements. In addition, our products can be both reused and recycled. Once redundant the product can be reused in another project. The PE can be recycled with full traceability and history documen-

not as many solutions ensure no leakage into the contained water. We have seen many basin and tank products that contain water, but where both dirt and chemicals from the surroundings find their way into the water. The Krah Pipes however are 100% leakage free and successfully keeps clean water crystal clear. This property, together with the strength, durability and adaptability of the Krah Pipes and our accumulated know-how has prompted us to develop a few innovations from Krah Pipes.

We deliver our products as plug-and-play solutions - ready to be connected to other piping infrastructure. One of the key take-aways from our customers is how easy it

We manufacture the Haplast water basin with a cast anchoring plate in concrete to counteract buoyancy and a bespoke system for anchoring valve connections and other fittings. The basins are fully assembled in our factory and all pipe entrances are fully welded. We ensure safety requirements are met for necessary access point such as manholes and ladders. The basins are tested for leakage before they leave the factory.

Haplast wastewater basin

The Stormoen wastewater basin was delivered to Perpetuum Landfill. The landfill facility is required to monitor the wastewater in the landfill ground. Our solution helps them contain, measure and monitor



Haplast water basin extension tower

pollution in the ground water. We assemble our basins in our factory and deliver them ready to install on site as a plug and play solution. In fact, it only took two men 15 minutes to install and adjust the wastewater basin. Because of the integrated pipes welded into the basin, it's easy to connect the basin to other piping infrastructure on site. This Haplast wastewater basin is 7 meters tall and has a diameter of DN/ID1600 mm. The KRAH profile used is SQ1 and the ring stiffness is SN 2. Due to the height, this product has two internal welded PE decks and three ladders for safe access. To counteract buoyancy the basin has a molded sandwich PE base. Customized water flow solution based on

project specifications is fully welded.

Haplast sludge separator/ sedimentation tank

The Stette sludge separator was delivered to Ålesund Municipality on the west coast of Norway. The tank is a sedimentation tank, which separates sludge from gray water. The sludge remains in the tank and the municipality can extract the sludge a few times a year, while gray water flows through to the deep sea or to a water treatment plant. It measures DN/ID3000mm in diameter and has a length of 27,5 meters. Because of its size, the Stette tank was too long for road trans-

portation and was shipped to Ålesund by boat. Our factory lays by the banks of the Lyngen fjord and close to a deepwater dock. Hence, we can deliver large products efficiently to our customers even by boat or tow. The Stette sludge separator has three separate chamber compartments with fully welded inner walls and 6 manholes. It is manufactured as KRAH profile CPR 8/4/8 and ring stiffness SN 2. The double walls fulfil public and industry standards for leakage protection and



Haplast wastewater basin



Haplast sludge separator

isolates for the Perma frost – a necessity in the Nordic countries. The Haplast sedimentation solutions works with hydraulic drop throughout the system. We deliver sedimentation tanks, valve housing tanks with control valves and sludge storage tanks for cleansing of solid particles from sewage systems. The tanks can be made in custom lengths with bespoke chamber and water flow solutions.

Haplast road culvert

The Kvæangsfjellet road culvert is 64 meters long and has a diameter of 2500 mm. We delivered this project in sections of 6 meters and the structure was assembled on site with socket and tip – in this case fully welded on site. The Krah profile is PR+PR 75 PP 5/6/5/6 CC120. The ring stiffness is SN8, which is approved by the Norwegian Directorate of Public Roads. The culvert was manufactured with solid ends and oblique cuts for a mor seamless result. This is highly appreciated by the contractor because the culverts will integrate better into the surroundings. Haplast has manufactured culverts for small bridges, road underpasses for animals and people, as transfer culverts for water or as

infrastructure culverts. End arrangements, external washout stoppers, sand stoppers for fish and other arrangements can be made according to the customers specifications.

Haplast ventilation system

Haplast has delivered KRAH pipes for underground ventilation to many projects in Norway, a market segment which has been a good business over the last ten years. Hjelset Hospital and Stavan-

ger Hospital, and the largest public bath, Tøyenbadet, in Oslo - the capitol of Norway, are some examples. Ventilation towers and pipes was manufactured based on the contractors' specifications within the limitations of the KRAH pipe technology, and usually with a ring stiffness of 2-4. As always with Haplast products, the sections are delivered as plug and play modules, with socket and tip and can if necessary be welded in house or on site.

*Lena Steffensen,
Haplast AS*



Kvæangsfjellet road culvert



Haplast ventilation is installed at Drammen Hospital

Milling Station – MF-400 CNC

for post-processing Krah products

Many customers of the Krah GmbH have a demand for post-processing of their produced pipes, for example to build manholes, tanks, branches or house connections. The existing milling station MF-200 provides an inexpensive possibility to this issue but is restricted in terms of flexibility and efficiency.

This leads to a novel development of the Krah GmbH, the new MF-400 CNC, which represents a fully automated and numerically controlled milling station for large dimensional pipes made of plastic.



Objectives

Within the development process of the new milling station the following issues were considered:

- High flexibility
- Fully automated milling process
- Easy handling
- High efficiency

- Reduced demand on production space
- High cost-effectiveness

Realization

In this section, we demonstrate the realization of the goals defined before in the objectives.

Cut outs and possibilities

In a first version, a selection of three object types shown in Figure 1 is implemented. These objects are circular holes as standard for conventional machines, rectangular holes which are pertinent for some special applications and straight cuts used for numerous important applications. All object types can be processed in a centric as well as an eccentric position on the pipe up to a height of 3,500mm. Moreover, support structures can be created to prevent damage on the machine due to extracted cut outs and to preserve the stability of the pipe during the milling process. Note that many object types for new applications can be implemented flexibly without changing any components of the hardware.

Multi object mode

A fully numerically controlled and

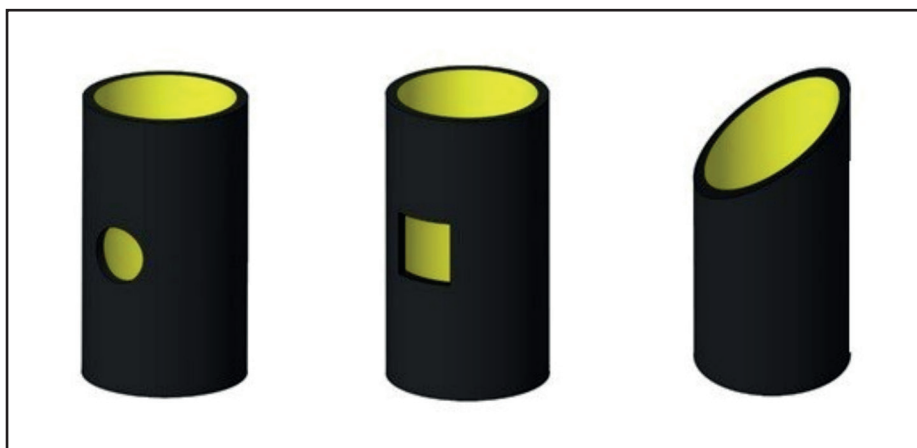


Figure 1: Principal object types. Circular hole (left), rectangular hole (middle) and straight cut (right).



Figure 2: Multi object mode. Object definition on machine panel (left) and processed pipe (right).

automated production scheme including six axes along with intelligent milling software allows for an efficient processing of an arbitrary number of objects within the multi object mode and without the need of any human support. Figure 2 shows the definition of objects on the

machine panel and the processed pipe.

Intuitive user interface

A very important issue within the development process represents the design of the user interface to make the handling of the milling station as easy as possible

for the operator. To achieve this goal several smart features are implemented like an automatic determination of the pipe diameter and the object position, a copy to backside option and a preview option for objects or an automatic calculation of the optimal milling tool and optimal trolley position. In Figure 3, corresponding pages of the machine panel are shown to define and check parameters of the pipe and related objects, respectively. Moreover, two configuration pages are shown which provide intelligent support for setting up the machine. This intuitive implementation of the user interface allows for the usage of low-skilled and non-technical staff on the machine.

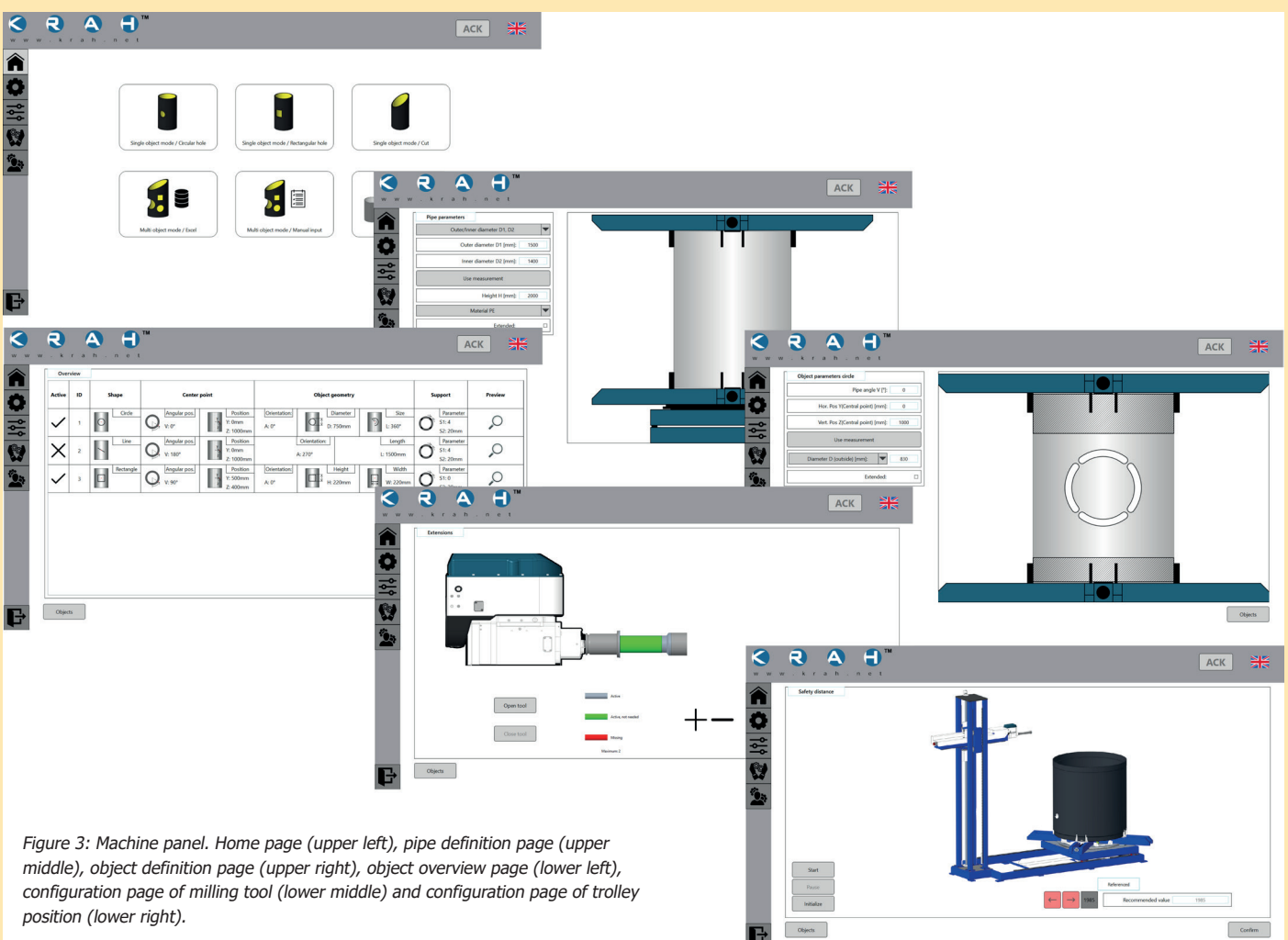


Figure 3: Machine panel. Home page (upper left), pipe definition page (upper middle), object definition page (upper right), object overview page (lower left), configuration page of milling tool (lower middle) and configuration page of trolley position (lower right).

Machine concept

The concept of conventional machines is based on a translational movement of the pipe which leads to a production space with a width higher than twice the pipe diameter, see Figure 4 (left). In contrast, the concept of the new MF-400 CNC milling station is based on a rotational movement such that the production space can be halved, see Figure 4 (right).

To be specific, the production space required for pipes with different diameters is given as follows:

- from DN/ID 600mm up to DN/ID 3000mm: **7900mm x 3800mm**
- from DN/ID 3,000mm up to DN/ID 4000mm: **8600mm x 5200mm**

This reduced demand for production space represents a further great benefit of the new milling station.

The MF-400 CNC milling station provides a combination of functionality of a conventional milling station like the MF-200 or any similar machine and a saw as shown for example in Figure 5 (middle).

This allows us not only to considerably reduce acquisition costs, but also the production space as well as the production time, since it is not necessary to set up a further machine.

Within the development process all defined goals were successfully implemented. That has resulted into a novel and superior milling station for the processing of large dimensional pipes made of plastic.

*Dr.-Ing. Maik Dittmann,
Krah GmbH*

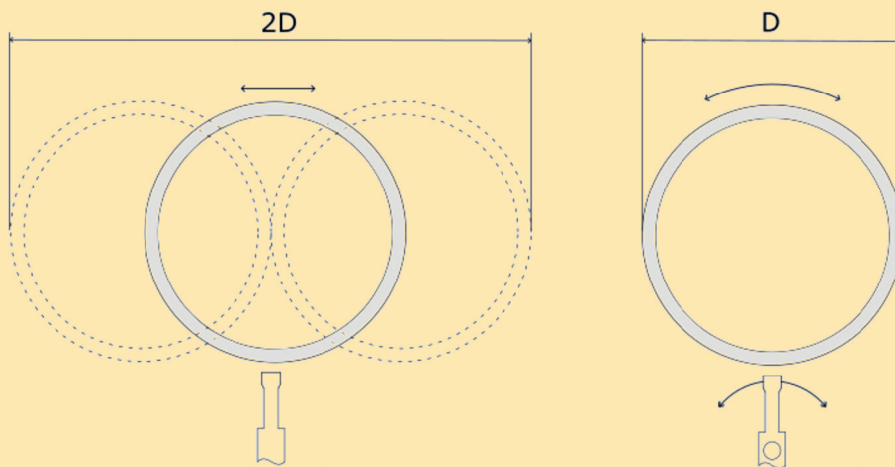


Figure 4: Top view of the machine concept. Standard concept of conventional machines (left) and novel concept of the MF-400 CNC (right).



Figure 5: Comparison of functionality. Conventional milling station MF-200 (left), saw machine from Eugen Riexinger GmbH & Co. KG* (middle) and new MF-400 CNC milling station (right).

*Source: <https://riex.de/produkte/saegemaschinen-fuer-kunststoff/>

The Bahr El-Baqar Treatment Plant

A cornerstone of African water management

The Bahr El-Baqar Treatment Plant stands tall as the largest water treatment facility on the continent Africa, boasting an impressive capacity of 64.8 cubic meters per second.

This facility not only show the brilliance of the engineers participating, but also is a critical driver of development in the Sinai Peninsula. The plant's primary function is to treat wastewater, but its impact reaches far beyond purification. Bahr El-Baqar's treated water nourishes an expansive 400,000 feddans (equivalent to 168,000 hectares) of cropland, breathing life into the region's agriculture. This infusion of treated water has transformed the landscape, elevating land productivity and ensuring long-term agricultural sustainability. In doing so, it plays a huge role in optimizing the utilization of Sinai's natural resources. However, this project has not been without its challenges. Throughout the planning and implementation phases, several hurdles emerged. The site's soil, a byproduct of the Suez Canal excavation, meant quite a few challenges. With an E modulus of 2 MPA, it was considerably loose, leading to significant settlement concerns. The initial time frame of 18 months was later compressed to only 8 months due to customer demands, intensifying the project's demands.

The welding process for High-Density Polyethylene (HDPE) pipes presented a significant learning curve. The project required the training of technicians in HDPE

welding techniques, a skill not readily available on the Egyptian market.

Testing under these conditions was not easy. The team had to navigate the complexities of joint testing, often requiring specialized equipment for large-diameter pipes.

The soil's loose nature resulted in considerable settlement, requesting innovative solutions. To address this challenge, flexible and welded pipes were used. Moreover, connecting pipes to concrete structures demanded careful joint design, with external couplers and hand welding being implemented to ensure stability. To ensure the structural integrity of the pipeline under the influence of settlement, loose soil, groundwater, and internal pressure, a finite element study was conducted. In accordance with DIN 16961 ISO 1167-1 standards, a rigorous 100-hour test was performed in a temperature-controlled environment. Differential settlement posed a

unique problem, generating shear forces on the pipes. Two solutions were considered: flexible joints, with protection for underground placement, or concrete chambers designed to allow movement and equipped with HDPE sheets to prevent soil ingress. The project scope included 1600 meters of DN/ID1600 mm pipes with a 2.2 bar working pressure and 1200 meters of DN/ID2500 mm pipes with a 1 bar working pressure, requiring a total of 260 and 200 welding points, respectively. One standout feature of this project was the seamless collaboration between Krah Misr, Krah Estonia, and Frank-Germany, which enabled the timely delivery of pipes and fittings. The decision to work with Krah was instrumental in the project's success. Krah's expertise in pipe design allowed for cost-effective solutions tailored to specific requirements.

*Peter Youssef,
Krah Misr*



Bahr El-Baqar treatment plant with Krah pipes

How to Handle First Marine Project

Experience and advice for marine projects

Krah MISR has been producing Krah pipes in Egypt for decades, mainly for water and wastewater pipelines. Krah MISR reports on his first marine project experiences and gives advice on what needs to be considered in advance.

First of all, there is basic marine survey information that needs to be considered in order to make the ideal pipes with their connections for these conditions. To begin with, a bathymetric survey is carried out. Bathymetric data is used to create models that can calculate currents, tides, water temperature and salinity in an area, and what forces will act on the pipes. Then a soil survey is done for the seabed. It is important to know how loose or firm the seabed is in order to find out what subsidence will occur along the pipeline and

what forces will act on the joints and the pipe body. The installation method also plays an important role. Here we look at whether the pipes will be laid in S-curves or whether the lowering of the pipes will be carried out using concrete, or whether other laying methods are more suitable. Again, this must be considered as it will affect the forces that will be applied to the pipe and joints. Finally, the pipe profile must be considered. The pipe profile must be adapted to the depth of the water, because the depth is an important factor with regard to the load-bearing capacity of the pipe. The deeper the pipes are laid, the more stable the profile of the pipe must be to withstand the increasing pressure.

After these points had been worked through, there were other things that had to be considered in advance. The first

question was how to transport the pipes from the welding point to the sea. Then it was necessary to find out how to best build the inlet and outlet chambers. Fixing the pipes to concrete ballast bases and fixing two adjacent pipelines were also issues that Krah MISR had to address in advance before the project started.

Connection of the pipes is particularly important

The connection of the pipes is one of the most important points to be examined in the marine application, as the forces usually affect the weakest point of the pipeline, which is always the connection. The pipe joint in the marine application is subject to strong tensile and compressive loads, and a special construction must be built for the installation period. The finite element method is the best way to find out whether the joint can withstand the load or not. The finite element method is a simulation method that uses small areas of a component or calculation area - the finite elements - to predict the physical behaviour of the component. Other points to be considered are the length of the pipeline section, the distance between 2 concrete ballastings, the swell, the water depth, and much more.

A lot of calculations had to be done, among others:

- Profile of the main pipeline
- Cross-section of the connection
- Recommendation for the length of the pipeline sections
- Recommendation for spacing be-



Installation of the pipes in the sea



Lowering the pipes into the more with the help of concrete ballast

tween concrete ballast

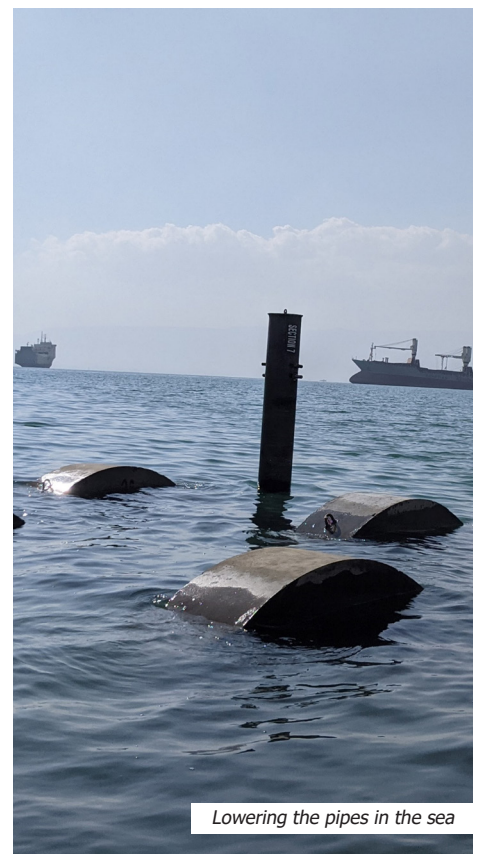
- Design of the butt end
- Flange material and dimensions
- Load cases and safety considered therein
- Verification of the installation method

What also needs to be considered for marine applications is the material of the pipes. A material must be found that does not interact with the seawater. GRE material is often used for this purpose. GRE is a mixture of high-strength glass fibres and epoxy resin as a base material. Due to its chemical and corrosion resistance, it is often used as a lining material in the marine industry. A combination of HDPE spigots and GRE flanges was chosen to connect the pipes together, which is reliable due to its long service life and low maintenance requirements. The bolts, nuts and wash-

ers are also made of the same material and can therefore maintain the high pressure. To be on the safe side, the GRE material was tested at 1.5 times the working pressure required by the customer (there is NO PRESSURE in shipping as the pipeline is open at its end), but to meet the customer's requirements, it was tested.

After everything was calculated and the perfect materials and connections were found and all tests were passed, nothing stood in the way of the first marine application. The pictures speak for themselves, the project worked perfectly and left happy customers and suppliers.

*Peter Youssef,
Krah MISR*



Lowering the pipes in the sea

Krah Pipes in New Zealand -

Unique geography and landscape determine how the Krah system is used

Infrapipe is a leading New Zealand manufacturer and supplier of PE 100 profile pipe technology throughout New Zealand. Using the latest European technology from Krah, Infrapipe manufactures the largest size range in New Zealand of up to DN/ID 3200mm.

Infrapipe continuously grows and enhances its market presence as a manufacturer and supplier for various applications. Examples of applications include sewer, stormwater, and low pressure. Our ability to create manholes and tanks from any Infrapipe PE pipe is in continual high demand.

In the New Zealand marketplace, we are one of the only companies in the indus-

try that manufacture culverts for forestry and rural use. We guarantee our products are one of the strongest engineered culvert pipes on the market, with the bonus of using recycled materials in our manufacturing process to promote closed-loop cycles. Infrapipe continuously increases its presence at the forefront of any industry space it operates in.

Guarantee of reliability and durability

As a business, we continuously gain certifications and approvals to guarantee our products' reliability, durability, and industry-leading standards. Infrapipe Spiral and Ecopipe are manufactured to the highest quality and comply with all the terms

and conditions stipulated by the governance of the ISO Type 5 Scheme's operating rules that meet or exceed standards requirements AS/NZS 5065:2005.

Our knowledgeable sales team is continuously increasing our market presence with councils, merchants, and engineering consultants, to name a few. As a company, we promote transparency and regularly provide factory tours to engage more with our market and clients and demonstrate our expertise. As a cohesive sales team, they provide hands-on knowledge with the technical assistance of our engineering team to meet any project's exact specifications and requirements.

Picture 1 demonstrates a project recently completed in September 2023 in Hawkes Bay, highlighting the impressive magnitude of Infrapipe's operations. This project required multiple HDPE DN3200 SN8 spiral wound culvert pipes. Using our latest technology, we supplied the necessary lightweight PE pipes while performing static calculations to determine the appropriate SN rating. Picture 2 illustrates our second large-scale project completed in September in Hawkes Bay. Infrapipe manufactured large DN/ID3200mm SN7.57 culverts for a forestry application. The culverts were PE100 spiral wound CPR pipes.



Picture 1: HDPE DN/ID3200 SN8 spiral wound culvert pipes

Fynn McDonough,
Infrapipes



Picture 2: DN3200 SN7.57 culverts for a forestry application

Deep Changes for Storm Water Pipes in Joliette

What does the need to change a storm sewer in the city of Joliette, Quebec have in common with an innovative European HDPE pipe design and manufacturing process? Soleno's expertise in meeting a major engineering challenge by reaching overseas for technologically advanced product to solve a complex situation.

At a time when a marked increase in the frequency and intensity of rainfall events

has prompted various levels of government to impose more restrictive regulations to avoid the risk of sewer overflows that could have consequences in terms of human health, as well as the health of flora and fauna, the City of Joliette needed to repair and bring into compliance a portion of its stormwater drainage infrastructure that would be called upon to carry a greater volume of water caused by new residential developments. To fulfill this contract, the construction firm Sintra

Inc., along with the engineering firm Parallèle 54, needed a versatile pipe capable of meeting the specifications required by the circumstances. They called on Soleno to provide them with a HDPE product that would meet their particularly high expectations.

The City of Joliette, Sintra Inc. and Parallèle 54 chose to trust Soleno to supply the products needed to upgrade the storm sewer system under Saint-Pierre Street



South. The work site, active from June 2019 to November 2019, offered limited space between neighbouring homes to carry out the work, which involved replacing 350 metres of pipe at the bottom of a 7 metres deep trench. The pipe had to be able to carry a significant flow of water, while withstanding the combined pressures of the weight of the overlying fill and the water table.

In order to meet the requirements of the engineers' specifications, Soleno's technical team proposed the use of DN/ID2200 mm and DN/ID2400 mm HDPE pipes manufactured by the German company Krah

in its factory in Estonia, a North American first for these products, which have been renowned in Europe for over 40 years.

350 Meters of DN/ID2200 mm and DN/ID2400 mm HDPE Krah pipes

Indeed, Krah's HDPE pipes were perfect for the particularly complex specifications of the project. Their light weight made them easy to install, as they did not require a crane, as would be the case with a concrete pipe of similar diameter. A simple excavator was all that was needed, greatly speeding up the operation, therefore cut-

ting down cost drastically. Also, the high compressive strength of the pipes made it possible to withstand the high pressures that would be exerted on their external surface. Their large diameter and excellent roughness coefficient allowed them to easily accommodate the high water flow that would be required to pass through the storm sewer system. Krah's HDPE manhole had the same advantages as the pipes themselves. In addition, an HDPE manhole does not need to be oversized for the diameter of the pipes, unlike an equivalent concrete product.

Once the proposal was approved, Soleno took charge of all the logistics and tech-



Construction site with Krah pipes



Storage of Krah pipes

nical support required for the project to proceed smoothly. Soleno's Quebec ingenuity and international vision enabled it to provide an affordable and sustainable solution to a local municipality's problem. Thanks to Soleno's proposal, the City of Joliette was able to complete the work within its budget and schedule. HDPE

structures and pipes are much lighter than comparable concrete products, making their installation quicker and more affordable. In this project, Krah's DN/ID2200 mm and DN/ID2400 mm pipes were on average 15 times lighter than the outdated concrete products being replaced. A unique feature of Krah's technology is its method of man-

ufacture, which allows the product design to be tailored to the unique specifications of a project. The range of possibilities is vast in terms of diameter, product size, durability and hydraulic properties. Krah's DN/ID2200 mm and DN/ID2400 mm diameter pipes were smaller than their predecessors but could handle the same amount of water flow. Capable of withstanding the pressure of the overfill, the water table and the frequent passage of cars on the roadway above, as well as corrosion, abrasion and the effects of de-icing salts, Krah's products will ensure the durability of the storm sewer system on Saint-Pierre Street South. Soleno supported its clients in the design, procurement, delivery and implementation of this project with a dedicated technical team and a constant presence on the site.



Post processing of Krah pipes

Soleno

What is the Purpose of a Pipe Stiffness Test?

Why should you do a pipe stiffness test, regardless according to which standard, constant speed (ISO9969) or constant load (DIN16961)? As a part of a paper related to stiffness testing this little article will answer the upper mentioned question.

The pipe stiffness or a stiffness class will not give any confirmation for a pipe that it is suitable for a specific pipe project.

The only proof that a pipe is suitable for a specific project is a structural calculation (or in some cases experience).

The stiffness test will only prove that the produced pipes are correct according to given specifications. To be specific, the proposed specific bending stiffness is proven as the product of the short-term Modulus of Elasticity E for the used material and the specific area moment of inertia I with dimension mm^4/mm . It is an integrated part of the production quality!

To explain it on a short example:

- A given project (gravity pipeline for drainage, DN/ID1600mm installed under a hard shoulder of a highway, with certain installation conditions, short term ground water, traffic load, etc.) required a structural calculation regarding the American AWWA M55 standard. The idea of this calculation is to be sure that the proposed pipes-material combination will take all load of the project. A structural calculation will always check and proof multiple load-cases and not

only deflection/stiffness.

- The result of the calculation (considering all site conditions and installation conditions) is a profile type in combination with a raw material, in our example it should be Profile No. PR75-011.95 (profile distance 140mm, waterway wall thickness 6mm and profile height 83mm, etc.) with a theoretical area moment of inertia of $11.95\text{mm}^4/\text{mm}$ and a raw material PE100 with a short-term E-Modulus of $1.100\text{N}/\text{mm}^2$ – for a pipe diameter of DN/ID1600. So, the manufacturing company knows exactly what to produce.
- The product EI is called specific bending stiffness of the profile, where the area moment of inertia is normalized with respect to the profile width.
- The corresponding stiffness (according to ISO9969) is given by the specific bending stiffness divided by the

third power to the mean diameter of the pipe. So that the testing machine can do a proper quality control test.

- The theoretical pipe stiffness for this combination of profile, material and diameter should be approximated.

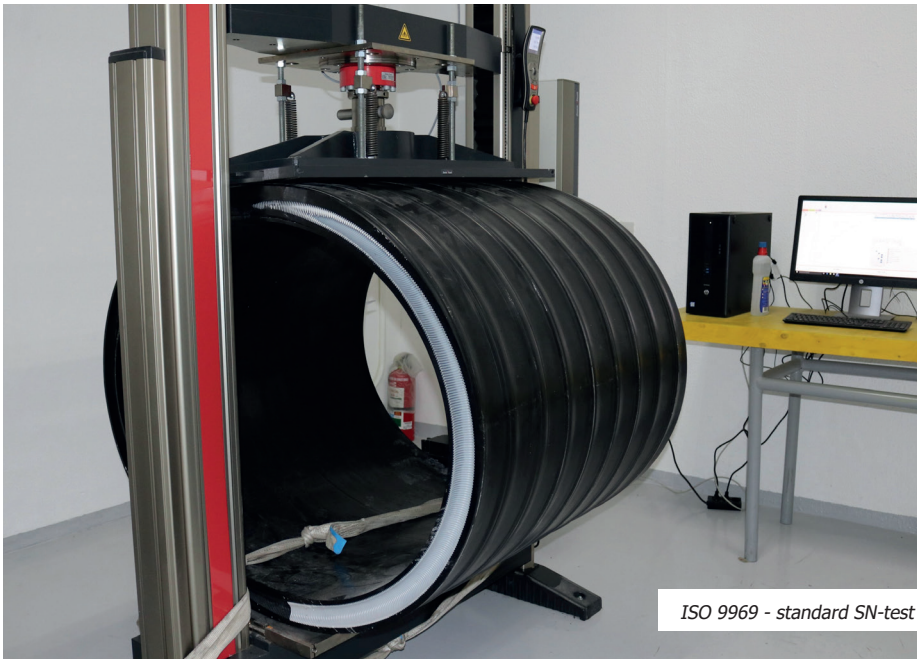
SN 2.8 (rounded)

Remark: A SN2 lass pipe would be too weak, whereas a SN4 class pipe would be over-designed.

- Now, this theoretical approach should be “re-checked” by a physical stiffness test according to ISO9969. Following the test procedure of ISO9969 three pipe samples should be checked by the constant speed method, where the average value should be taken as result. Note that the pipe need to be exposed to a proper temperature within the test as well as before the test. Moreover, a correct storing



Constant load testing



ISO 9969 - standard SN-test

of the pipe is of most importance to avoid ovality.

- The actual testing result (SN-value), according ISO9969, will be compared with the theoretical value.
- If the measured SN-value is greater or equal to the theoretical value – the real pipe fulfilled the theoretical approach (in this specific case it was 3.1 and all was more than ok).
- If not, problems could be:
 - usage of unsuitable material
 - improper temperature conditions within the last 24 hours
 - deviating dimensions of the pipe
 - improper storage of the pipe
 - incorrect cutting of the pipe sample
 - incorrect placing and testing of the pipe
- The problem needs to be analysed using another raw material test as well as a detailed measurement and check of the profile geometry.
- Checking the production settings to

exclude e.g., an overheating of the material.

- Depending on above mentioned issues, for spiral wound pipes like Krah-Pipes especially the cutting and positioning of the pipe sample allows a variation of -5% which can appear and is not critical. Note that due to the profile structure of standard double wall corrugated pipes which are

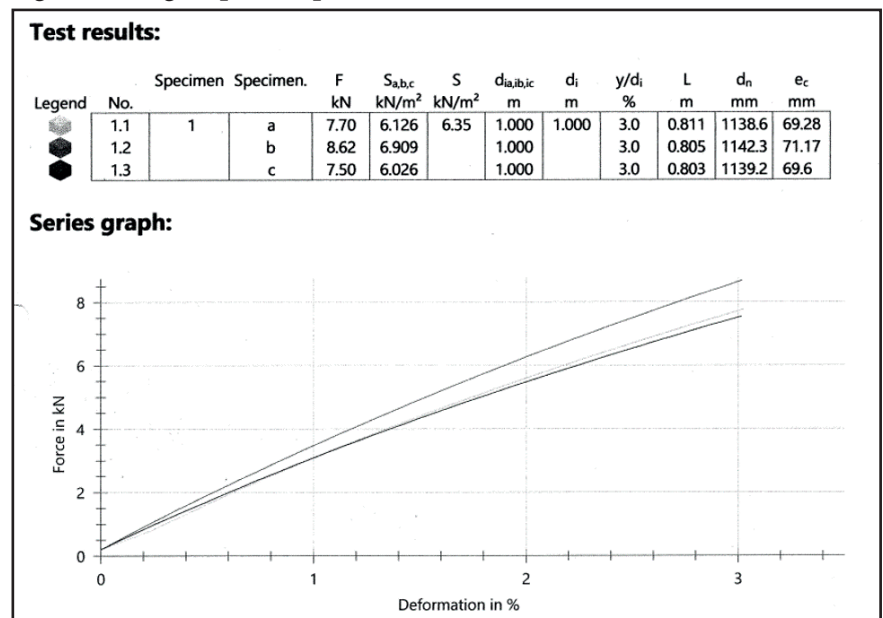
not spiral produced, these tolerances do not appear.

- Other solutions and problem finding methods are available. One is sending a thin cut of the profile to Krah Germany making a real analysis of the actual profile to certify the actual area moment of inertia.

Conclusion: The basis of the decision which pipe can fulfil the requirements on a real project, is never a stiffness test, or even a stiffness class, it is always a structural calculation (e.g. AWWA M55 or ATV A127). A stiffness test only confirms that the theoretical values of material properties in terms of E and the profile geometry in terms I are reached. A stiffness test is only a quality control test for the production, additional tests according to the standards should be checked, too. In our example the theoretical approach was approved by the physical deflection/stiffness – test.

Alexander Krah,
Krah GmbH

Fig.1: Testing steps (simplified)





Flood Mitigation Using Large Diameter Krah Pipes in the Philippines

Philippines is indeed blessed with abundant resources. We are first in terms of marine biodiversity which comprises of more than 2,500 underwater species, we are third in geothermal energy coming next to US and Indonesia and third in terms of having the longest coastlines. And yet, on the other side, we are also bombarded by an average of 20 typhoons per year, five of which are fatally destructive. The geographical location of the Philippines is one of the major factors that causes flooding in its cities and communities, but it is not the only.

It is a common knowledge that there's always two sides in every coin. Yes, climate change is something that we all have been hearing for many years now, and its publication makes it all the more

real. But have we considered that on the other side, these effects are also brought to us by our own making? Architect Felino Palafox, Jr., a renowned Filipino-Catalan urban planner, opened an unresolved issue in one of his books regarding his observation on "acts of man and man's acts of omission" that causes fatal flooding in the Philippines—the failure to plan and execute preparations for such expected hazards like typhoons.

Here's a timeline of the most devastating typhoons in the recent history of the Philippines. I specifically, wanted to highlight a perfect example of what Ar. Palafox have mentioned about failing to plan. The first entry, Ondoy in 2009 and Ulysses in 2020 both infiltrated Manila area, particularly, Marikina City. It is a valley next to Luzon's natural typhoon shield, the mountain ranges of Sierra Madre where in the old days, it is a lush ground for farming and

marshlands. But in time, its population rises which greatly influenced the need for urbanization and suburbanization. Meaning, the old areas of natural soil are now being converted to concrete paved areas, communities and structures. In spite of Marikina's knowledge of their topographic situation and history of typhoons, they were still unprepared when another big typhoon hit them in 2020.

Full water cycle and half water cycle

An ideal rainfall cycle could be described as a full water cycle where the rain from the clouds will be absorbed by the soil and will be lagged as it seeps through underground back to the rivers, lakes and sea; and then up again to the clouds; but instead, we are now experiencing a half water cycle. In a half cycle, we skip the



seepage through the natural soil due to concrete pavements and structures that covers the natural soil, and the water goes directly into the drainage and to the bodies of water. This phenomenon shortens the cycle of rainfall which contributed to the drastic increase of rainfall volume recorded since then up to now. According to data from Worldbank, the annual average precipitation in the Philippines has increased to 2826.17 mm in 2021 from 2529.66 mm in 2020.

Yes, there are hazards and natural risks and disasters like hurricanes from the north, typhoons from the east, earthquakes and tsunamis, and we can name more, but there are necessary preparations and risk mitigating solutions that we can do. Some countries have already been successful and now, it is our turn to follow suit.

Thus, major flood mitigation measures were established last 2021 to cater the

excess runoff of heavy rains in the main cities of the Philippines. Spearheaded by the government agencies such as Department of Public Works and Highways in the National Capital Region and Region XI and together with their respective local government units, a stormwater retention tank using Krah pipes of diameters DN/ID 3000mm by 300m and DN/ID 3500mm by 2.4km length, respectively were designed to resolve flooding.

300 linear meter in 2 weeks

Last December 2022, we have completed the installation of DN/ID 3000mm pipeline along the main road of Tagum Davao Del Norte in Mindanao. The laying of the pipeline of 300 linear meter was done in a span of 2 weeks which drastically improved the duration of construction comparing to the conventional way of using concrete box culverts.

As for the Marikina city stormwater retention project, a DN/ID 3500mm pipeline is to be used at 2.4 km length from an original design of a 4m by 4m box culvert. According to the lead engineer designer of the project, the decision to shift from reinforced concrete box culvert (RCBC) to a Krah pipe is due to the significant difference of construction speed. Based on their recorded history of constructing RCBC along Boni Avenue, a 500m length of 4m x 4m took them 2.5 years to finish due to the laborious process and existing heavy traffic in city areas.

But with the Krah pipe system, and they have high hopes that the construction time would be 6 months for the first phase of 600 linear meter.

Further projects with large diameters

After the success of the DN/ID 3000mm Krah pipe installation, we are now expecting similar projects that will be using large diameters such as what Marikina City has adopted since flooding problem is shared by most of the big provinces in the north and central of Luzon such as Pampanga, Nueva Ecija, Bulacan, Pangasinan and Tarlac.

Meanwhile, Cebu City in Visayas have already been planning their city's master drainage design together with Zamboanga City in Mindanao.

*Jen Lansangan,
Krah Asia, Inc.*

Last Words

The last few months have been very exciting and our Krah community meeting in Malaysia was a great success. We would like to thank all those who participated in this meeting and made it an unforgettable experience for all of us.

This again shows how strong our Krah community is, which gives us a very good feeling and makes us very happy. The next community meeting is already planned for the end of 2024, and the main theme has already been decided. At this meeting we will focus on the question of what we have learned. In addition to introducing the companies and our new clients and projects, a big topic in Malaysia was what we have learned in the past and how we can pass on and use this knowledge. Because through these experiences and the knowledge that is passed on, we achieve a so-called swarm intelligence that benefits the community. In order not to make this issue too thick, some existing reports have not been printed here but will be included in the year-end issue of this magazine. The photoshoots for the new Krah calendar 2024 are currently underway again (one at the KPMI factory, one in the Philippines and one at Frank GmbH in Germany) - it will be sent to Krah customers in December.

Should you require more information on the Krah Community, or would like to become a member, please contact marketing@krah.net

Alexander Krah



IMPROFIL