

GRP pipes are designed for generations. Here's the proof.

A generations-long, low-maintenance service life: It's a promising claim that Amiblu makes about their GRP products. A promise that is not just based on the company's 60 years of age and experience – there's quite a bit of meticulous scientific research involved. We talked to former Amiblu Product Development Manager Högni Jónsson who told us why we can confidently stand by our claim.

Amiblu promises an operational lifetime of many generations for their GRP products. Where's the proof?

Jónsson: To answer this question, we first need to look at the reasons why most pipes do *not* reach such a mature age. These reasons carry names such as thiobacillus concretivorus and thiobacillus ferrooxidans – tiny bacteria that decompose sewage and form hydrogen sulphide gas (H_2S). When combined with moist air, the gas forms sulphuric acid (H_2SO_4), which is highly corrosive to materials like concrete, steel, and cast iron. This “microbially induced corrosion” can cause significant damage over time. Corrosion is also a major problem in seawater applications, where the contained sodium chloride eats away at e.g. metals and causes them to fall apart. With GRP products, the situation is quite different.

You're saying that GRP pipes are not affected by corrosion?

Jónsson: Exactly. Plastics are inherently more robust than both concrete and metals in acidic environments. To prove this, we literally put our pipes to the acid test: Several pipe samples are exposed to sulphuric acid (H_2SO_4) for a considerable time, while being subjected to artificially high tensile strains (see Fig. 4). The idea is to simulate the chemical conditions in aggressive sewage, but under an excessive strain in order to cause failure within a reasonable time frame. →

Fig. 1: Pipelines made of concrete or metals corrode in low-pH sewer environments under the influence of sulphuric acid.



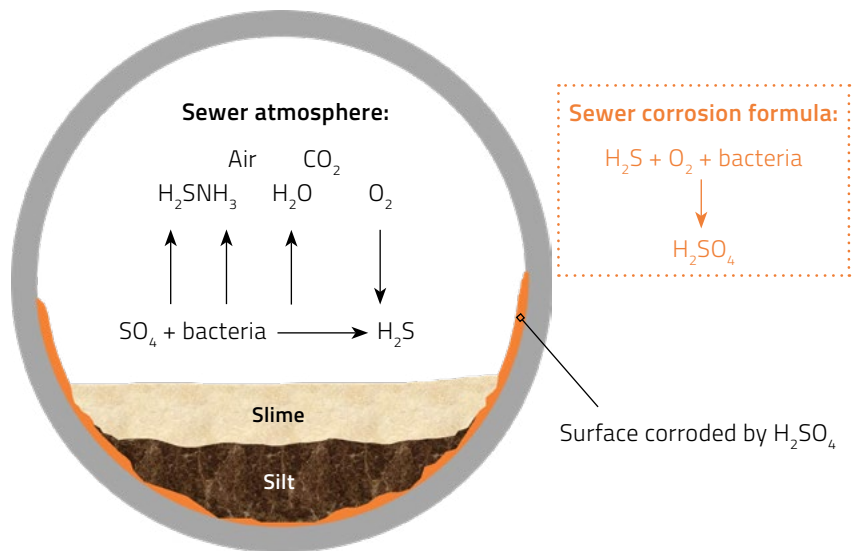
The test results demonstrate the product performance and reveal a product service life of many generations, including a remarkably high safety margin.

– Högni Jónsson
Former Head of Product Development and Support, Amiblu Group

Fig. 2: GRP pipes are inherently corrosion-resistant and feature a long, low-maintenance lifetime also in harsh sewer environments.



Fig. 3: The process of microbially induced corrosion. Slime and silt contain bacteria which break down organic and inorganic sulphur compounds, thereby producing hydrogen sulphide (H_2S). When the H_2S gas comes into contact with the moist surfaces above the water line in the sewer, it can combine with dissolved oxygen (O_2) to directly form sulfuric acid (H_2SO_4). However, most of the H_2S is decomposed into elemental sulfur S , which is a source of energy for the *Thiobacillus* bacteria family; they are oxidizing the elemental sulfur and their metabolic waste is H_2SO_4 . This sulfuric acid lowers the biofilm pH and corrodes concrete, steel, and cast iron.



To determine the pipes' long-term properties, the measured data is analysed statistically and extrapolated into the unknown to predict a limiting strain for use in pipe design.

Did Amiblu invent this test method?

Jónsson: No. The acid test for GRP pipes was first standardized by the American Society for Testing and Materials in 1978 (test method ASTM D3681) and has been in use ever since. The same procedure is also specified in EN 1120 and ISO 10952. The test method calls for minimum 10,000 hours of testing with at least 18 samples. However, since the test is relatively simple to conduct and does not require much space, a great number of samples have been left exposed to acid for much longer time periods. We studied the results from over 40 years of continuous testing of Flowtite and Hobas GRP pipes, involving more than 1800 test samples.

This sounds very comprehensive. Please tell us a little more about these samples and the test setting.

Jónsson: Our tests cover a variety of pipe designs which have been in continuous use. The samples, most of them DN 600, were taken from a number of Flowtite and Hobas manufacturing plants. According to ASTM D3681, we subjected each 300 mm long pipe sample to a vertical force causing tensile bending strain in the pipe invert, while exposing it to a 5% concentration of sulphuric acid.

A typical test series consists of 18-25 samples, usually from a single production batch, at various strain levels.



Fig. 4: Strain corrosion tests according to ASTM D3681 in the Amiblu R&D center in Norway.

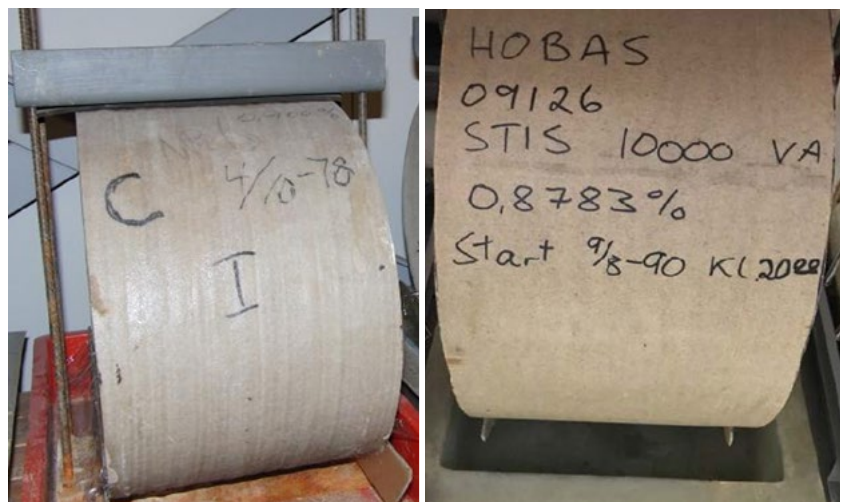


Fig. 5/6: Flowtite sample from 1978 (left) and Hobas sample from 1990 (right).

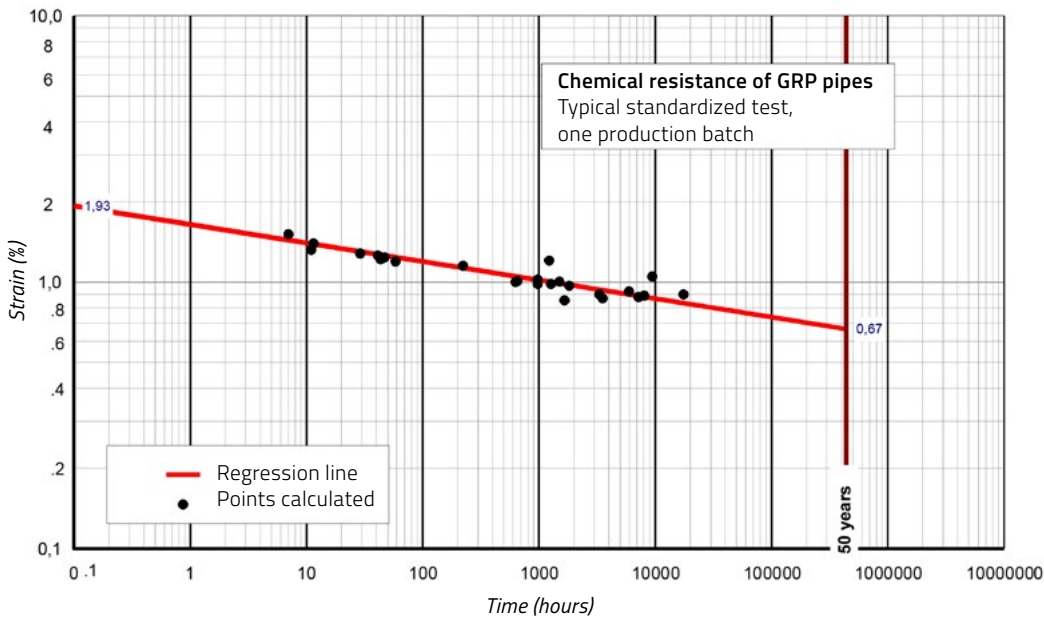


Fig. 7: A typical test series with 25 Flowtite pipe samples. The horizontal axis is the time-to-failure, the vertical axis shows the bending strain at the pipe invert, both on a logarithm scale. Each point on the graph represents a pipe sample that has been subjected to the recorded strain until failure occurred. Having fulfilled the statistical requirements, a straight line that fits the data is computed, using covariance regression analysis. In this case, the extrapolated strain value at 438,000 hours (i.e. 50 years) is 0.67%. With typical long-term deflection of 3% (yielding a strain of 0.27% for current pipe designs), the calculated safety margin is approximately 2.5.

The strain is measured after the load has been applied and then the sample is stored under controlled conditions until failure occurs, detectable as leakage through the pipe wall.

With at least one data point exceeding 10,000 hours and the rest relatively evenly spread over the time range, and with an appropriate coefficient of correlation, the data can be safely used and extrapolated with classic statistical methods.

How about the results?

Jónsson: The shortest measured time to failure is 0.3 hours at 1.35% strain; the longest is 28 years and 78 days at 1.05% strain. The longest, still running test was set up on October 4th 1978. The sample has now been exposed to the acid test for

almost 45 years at 0.91% strain. What's really interesting here is the bilinear behavior: up to strains of about 1.6%, most samples fail within relatively short time periods. At strains between 0.9% and 1.3%, the time to failure is much longer.

Only a handful of data points fall below this range, meaning that below a certain "threshold strain", the samples simply do not fail. For this set of data, the threshold appears to be around 0.9% strain. A classic regression analysis of the data points up to 1000 hours results in a line with a mild slope. →

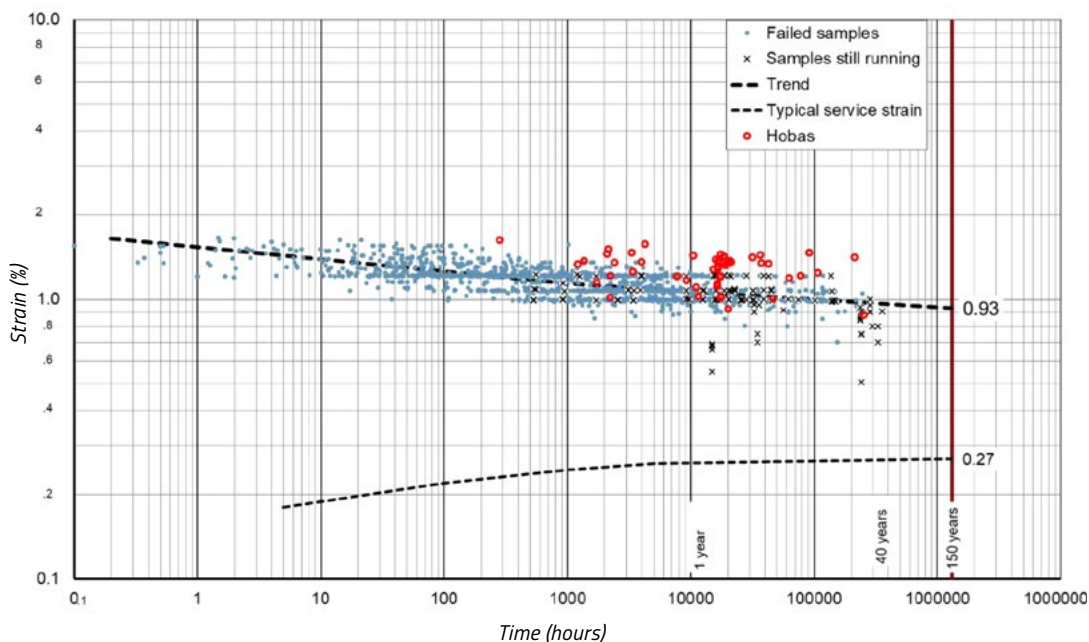


Fig. 8: The complete data of tested Hobas and Flowtite pipe samples over the past 40 years on a log-log scale. The dots on the chart represent failed samples, while the crosses represent samples that are still running. The failed samples are distributed along the whole time scale, clustering together on a relatively narrow strain-band. There are 40 samples that have lasted more than 12 years, with strains ranging from 0.5% to 1.1%. Of these, 16 have failed, while 24 are still running.

On the other hand, regression analysis of data points after 1000 hours through to over 350,000 hours show an almost horizontal line. By extrapolating this line by only ½ of a decade, which is less than one third of what classical statistics allows, we reached a long-term strain value of 0.93%.

Is this a typical strain in sewer or similar applications?

Jónsson: No, and that’s the fantastic conclusion: The typical long-term operating strain of such a pipe is merely 0.27%. This means that, in real-life applications, we even reach an excellent safety margin of 3.4.

This sounds really impressive! Any project examples that prove this durability?

Jónsson: In 2004, a pipe DN 1800 that had been in continuous use in aggressive environment since 1980 was unearthed and inspected (Fig. 9-10). The pipe came from the sewage treatment plant belonging to the Water and Sewerage Department in Riyadh. After almost 25 years in service, the pipe showed no signs of degradation or deterioration, only a slight change in stiffness. Another sample taken from a pipe in Norway that had been submerged in sea water for more than 33 years showed no signs of corrosion or visible aging either. The mechanical properties were also well within the initial design requirements (Fig. 11-13).

Bottom line: The extraordinary lifetime of Amiblu GRP pipes is a matter of fact!

Jónsson: Indeed. The data shows that, if the strain is below a certain threshold level, the pipes will serve several future generations.

Högni Jónsson was the Head of Product Development and Support of the Amiblu Group until 2022. He can draw on over 30 years’ experience with composite materials and is chairman of CEN and ISO standardisation committees for glass fiber reinforced plastic pipes.



Fig. 9-10: A Flowtite GRP sewer pipe DN 1800 was unearthed and inspected after almost 25 years in service at a sewage treatment plant in Riyadh, SA. The pipe showed no signs of deterioration.



Fig. 11-13: In 2008, after 33 years exposure to treated sewer and seawater, a section of a Flowtite GRP DN 500 pipe was brought ashore for analysis of its condition and mechanical properties. After cleaning parts of it, the pipe looked almost brand-new. The pipe showed no visible signs of ageing and its mechanical properties were basically unchanged.