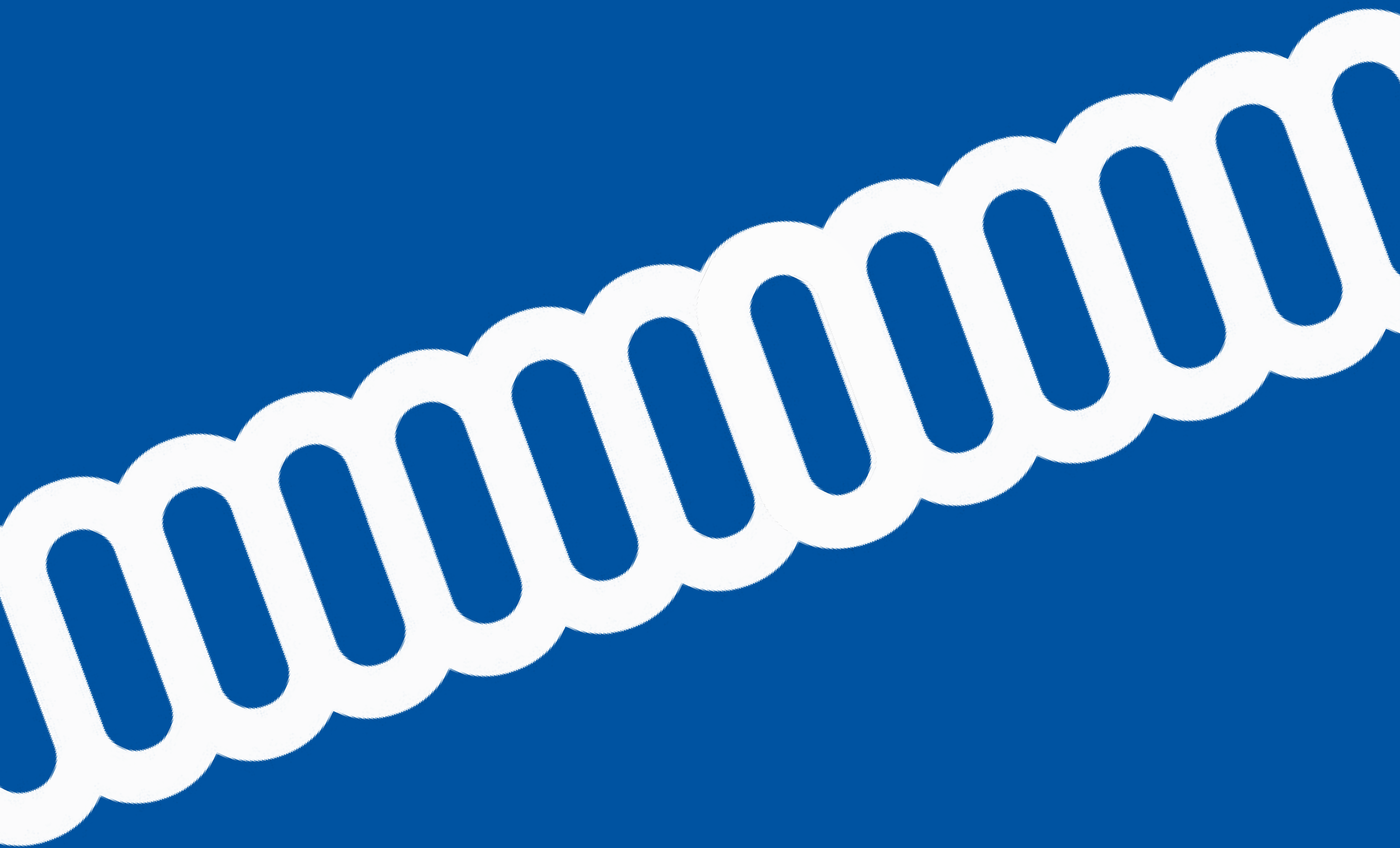
MASTERFLEX
Connecting Values

WHITEPAPER

Cost-efficient maintenance is not a matter of luck

How intelligent sensor technology minimises production downtime in industrial environments



A VALUABLE PART OF THE
MASTERFLEX GROUP

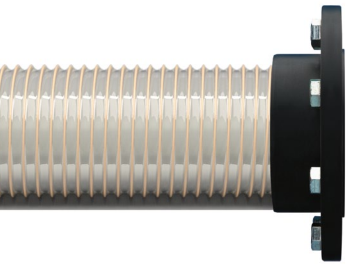
Cost-efficient maintenance is not a matter of luck

How intelligent sensor technology minimises production downtime in industrial environments

Customers often ask about the service life of our hoses and hose assemblies. There is no general answer to this question. Wear depends on many factors. These include, for example, the flow rate, flow speeds, temperature or the specific installation situation. Intelligent sensor technology is increasingly being used so that wear can be detected in time and production downtimes can be avoided.

Colloquially, wear in connection with hoses often refers to abrasion, i.e. the removal of material. The weakening of cross-sections or the alteration of functional surfaces affects the functionality of components, parts or even complete systems. However, the term wear goes much further.

In addition to mechanical wear, for example through friction, grinding or cutting, there are other influencing factors. In the case of rolling, for example, depending on the material combination of the components, adhesion occurs, i.e. two materials stick together. Piece by piece, the components are thus worn out. A handy example of this is the abrasion of car tyres on asphalt. The asphalt is also gradually worn down by the tyre - but to a much lesser extent due to its hardness. So both friction partners in a tribological system always wear out.



Tribological system

Tribology (friction science) scientifically describes the system of friction, wear and lubrication, where components act on each other under force in relative motion. The goal is to develop technologies that optimise friction processes.

Thermal, chemical or biological wear phenomena are also based on the decomposition of intact material structures by external influencing factors. The latter includes the decomposition of plastics or other materials through the infestation of microbes, which are ubiquitous.

Hydrolysis, i.e. the decomposition of materials through chemical reaction with water or humidity, also influences products and processes.
The removal of material creates several difficulties at once. On the one hand, as mentioned at the beginning, the material cross-section is weakened. At a certain point, the stability, integrity or tightness of the component can no longer be guaranteed.

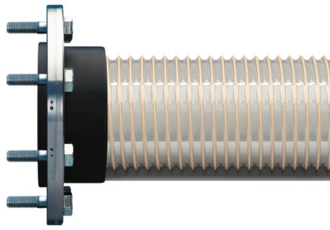
On the other hand, in many cases the abrasion itself produces further impairments in the case of abrasive wear. The abrasion of car tyres, for example, is found in the environment as micro-rubber.

If sensitive media are conveyed through hoses with low abrasion resistance, the abrasion can contaminate the conveyed medium and even influence the mixing ratio of formulations. The use of hoses made of abrasion-resistant materials such as polyurethane makes this problem much smaller, but even these products wear out over time due to single or multiple influencing factors.

The most common causes of wear on hoses in systems/plants are

- Media causing abrasion (corundum, quartz sand, metal chips, GRP granules, etc.))
- Ageing of the materials (curing)
- Chemical stress
- Continuous movements and -vibrations
- Temperatures too high
- Excessive overpressure or underpressure

Source: Masterflex Group



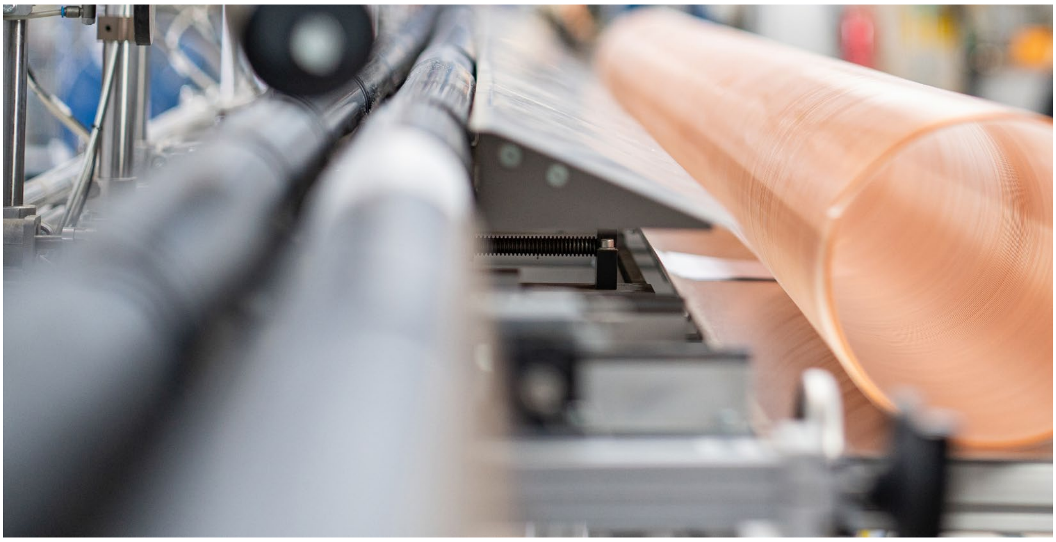
What influences the wear?

The manifestation and effects of wear are influenced by a variety of factors. The mere existence of wear due to friction, for example, is not the sole reason for component failure. If an abrasive medium is conveyed through a hose, the other application conditions also affect the severity .eg conveying pressures, media compositions and geometries, operating temperatures, vibrations - the list of complementary influencing factors is almost endless.

The condition of the abrasion partners is also decisive. Is the surface of the granulate to be conveyed very rough? Does the inner layer of a conveying pipe tend to be wavy or does it even have edges? Due to the multitude of parameters and combining influencing factors, an exact assessment of the wear behaviour is often only possible by means of elaborate tests or tests close to the application.

If a highly abrasive medium is conveyed through a hose made of thermoplastic, the temperature, for example, has a very significant influence on the performance of the hose component. Thermoplastic materials soften under pressure and temperature. It is therefore logical that the abrasion resistance of such a hose is significantly lower at +90°C than it would be at +20°C.

Volume and pressure also determine longevity, as they define how many abrasion-producing particles affect the hose wall and with what force this happens.



Unfortunately, the factor of the installation position of a hose is also very often underestimated. A uniform flow in a U-shape is equally gentler for the medium and the hose than transport through a hose in multiple S-positions or in loops. For this reason, hose manufacturers often provide information on the optimal installation position of hoses in the appendix of their catalogues. The correct installation position is an important way to reduce wear.

Likewise, to avoid excessive wear, the maximum operating parameters (especially pressures and temperatures) specified by the manufacturer should always be observed.

Occasional driver or commuter?

Customers often ask how long products such as hose assemblies withstand wear and how long their service life is. However, due to the very diverse application conditions mentioned above, it is not possible to make a blanket statement on this, just as in the example of car tyres already mentioned.

The question is rather: Am I an occasional driver or a commuter? Does my route take me along the motorway or through dense city traffic? Do I drive sportily or in a resource-conserving manner? In this respect, wear and tear or its effects on the service life of components can usually only be roughly estimated on the basis of experience. A prediction is rarely based on empirical data, but often on a gut feeling. In order to at least classify materials against each other and to back up the gut feeling with measurement data, there are standardised tests. Although these usually do not refer to the exact later application, they give an idea of how much materials differ in their abrasion resistance.

For thermoplastic hoses, DIN ISO 4649 (for determining abrasion resistance) is used here. Here, test specimens made of a test material are pushed over a rotating cylinder drum. Taking into account a standardised reference material, the volume removed is determined, which ultimately serves as a comparative value to other test materials.

From Preventive Monitoring to Predictive Maintenance

In the worst case, wear becomes noticeable through a drop in process performance, which can go as far as the failure of the worn component. This has particularly serious consequences when it comes to expensive pumped media, tightly timed or cost-sensitive processes.

Regular performance tests or visual inspections of components as part of preventive maintenance can greatly minimise risks. Without appropriate measures, even a product such as a hose, which is rather inexpensive compared to peripheral components, can cause downtime and thus high costs. In this sense, it is a „small“ component, but its failure can have a very large impact.

But regular, preventive maintenance should be seen more as a stopgap measure.

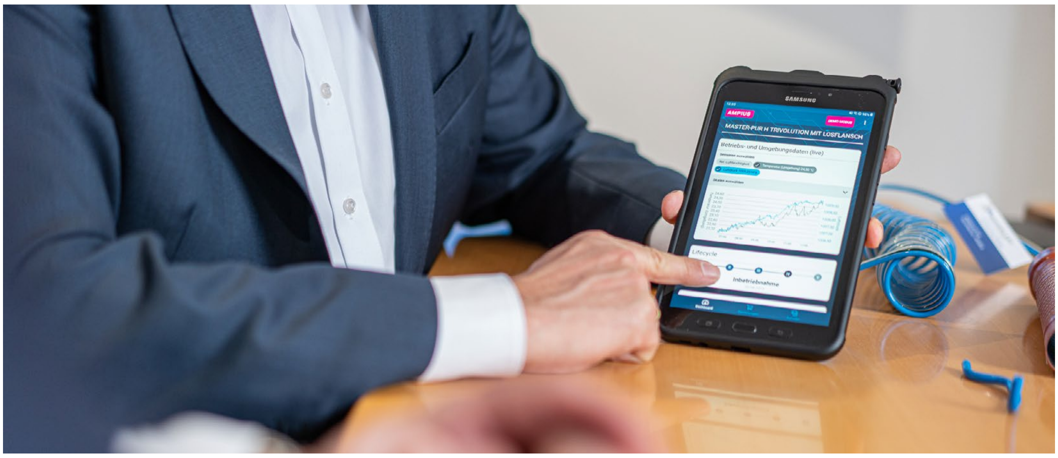
> *The gut feeling or the look into the crystal ball becomes measurable and provable thanks to valid data.*

Dipl.-Ing. (FH) Stefan Nüßen, Development Engineer Spiral Hoses and Connecting systems at Masterflex in Gelsenkirchen

Analogue components, regardless of their condition, must be taken out of service, checked, replaced if necessary, and then put back into service. In many cases, these components are also replaced as a precautionary measure for safety reasons, regardless of their condition and service life. This equates to a double cost, as the system would possibly continue to function for a certain time with the previous component.

Digital products with intelligent sensors offer the possibility of condition monitoring. The maintenance department can view the condition of the component „live“ at any time and, based on their experience, estimate how long the functionality will still be available. This enables initial findings and analyses on factors influencing the service life, as the data stock enables an immediate comparison of application scenarios.

Predictive maintenance goes one step further. With condition monitoring as a basis, a multitude of data and processes are recorded in a database. In the context of Industry 4.0, the term „data lake“ is often used, i.e. a database that contains a huge amount of data from a wide range of areas. With a sufficiently large database, correlations can be discovered that serve as the basis for algorithms.



The following scenario could be an example:

> *In a plastics processing company, production runs mostly stable over the course of a year. Minor fluctuations are cushioned by defined tolerance limits. From mid-July to mid-August, however, the quality of the produced parts regularly drops, sometimes significantly. While the inspection of all plant parameters remains inconclusive, as all parameters are within the target, the investigation of the cause begins with the material supplier. Are there fluctuations at the supplier? Is the material being sourced from another plant during this period? By linking all the available data, it becomes apparent that climate data loggers installed on the production line detect increased humidity precisely during the problem period. The periods with measurement peaks of the loggers and quality losses of the products coincide practically 100 per cent. This correlation leads to the conclusion that on days with high humidity, the material reacts with it and this causes problems. Henceforth, the monitoring of climatic conditions is also part of the spectrum of parameters to be monitored.*

This simple example shows how a rather secondary parameter (climate) correlates with a primary parameter (e.g. surface quality). In reality, however, correlations are usually much more complex and can only be determined through in-depth expert knowledge or correlation analyses. The resulting findings lead to algorithms that serve as the basis for artificial intelligence.

Individual raw data may be difficult for the user to interpret. Thanks to our decades of experience in hose technology, we know the effects of a wide variety of influencing factors. We see the big picture and can provide our customers with optimal advice based on experience from countless different application scenarios combined with live data from production.

Dipl.-Ing. (FH) Stefan Nüßen, Development Engineer Spiral Hoses and Connecting systems at Masterflex in Gelsenkirchen

The extent to which the use of algorithms can actually be described as intelligence is debated among experts. What is certain, however, is that the accuracy of statements about future developments increases as the size of the data pool of various influencing factors increases.

In our example, the sensor technology detects the increase in humidity within the production environment. A warning is issued in time and an air dryer is automatically activated. The humidity drops and the quality remains stable.

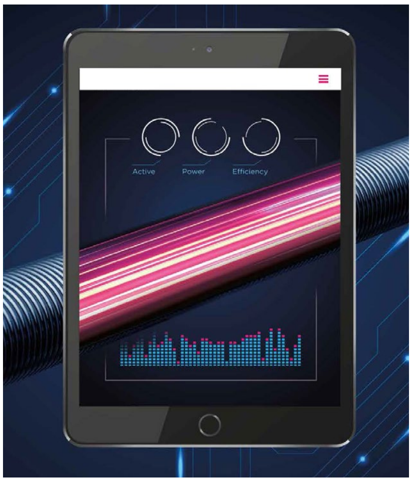
The avoidance of rejects in this example and the generally longer operation of still intact hose systems provides, as mentioned before, significant cost savings. But even beyond economic interests, digitalisation makes a tangible ecological contribution here. The unnecessary use of material and energy that occurs in the production of rejects or the waste of material due to hose systems that are replaced too early is avoided through digital solutions. The result is a contribution to more sustainable production through the reduced use of resources.

Another example illustrates the connection between algorithms and predictive maintenance:

> *A product has sensors for a wide range of operating parameters such as temperature, delivery pressure, vibration and component elongation. Based on the extensive database, the connected IT system knows several thousand constellations of these parameters. It is also known how long a wear component withstands the respective parameter constellation. With this knowledge and the knowledge of which constellations the installed component was previously exposed to, it is possible to estimate when a specific parameter constellation will lead to component failure in the given case.*

The world of hoses and hose assemblies is complex

Since environmental and operating conditions differ from case to case, there is no „one hose for all cases". In the case of intelligent products, this is further reinforced by the requirements imposed by digitalisation. Accordingly, intelligent hose lines are always adapted to the specific conditions of the respective customer application. Which sensor technology has to be installed in which product and how the sensor data is made available to the customer is worked out together.



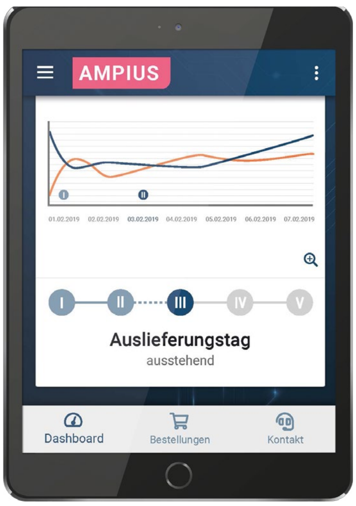
The areas of sensor technology and data transmission in particular are developing so rapidly that new possibilities are constantly emerging that were previously considered impossible, very costly or uneconomical. It is already possible today to read out product-specific data by simply contacting a smartphone with a hose line and thus determine the order number, production data or the time of commissioning. This information ensures optimised traceability of individual products as part of lifecycle tracking. Especially in sensitive production environments that are strictly monitored and audited, proof of product traceability is a decisive advantage. Likewise, this technology provides direct insight into product specifications at the point of use, such as maximum operating pressures or operating temperatures. Searching for information or data sheets is thus no longer necessary and ensures time and cost savings. In combination with wear, temperature, pressure or other sensors, it is also possible to quickly and easily determine whether the current operating conditions correspond to the limits defined by the manufacturer. The combination of sensor technology, unique product ID and digital platform will enable many more possibilities in the future, such as automated ordering processes, the storage of test certificates on the product itself or feedback that the right hose is attached to the right connection.

These processes generate data, which in turn form the basis for new knowledge and know-how. The use of new, previously unavailable data offers completely new insights into one's own processes. Understanding why a component behaves in a certain way under certain influencing factors is the basis for improvements. Using intelligent and sophisticated simulation models, precise statements can be made about the expected remaining service life under defined influencing parameters.

Author/Editor: Stefan Nüßen / Heike Friedrichsen (Masterflex Group)

AMPIUS® - Intelligent products that protect themselves from failure

Our aim is to constantly improve our products and to use new technologies economically. This is how the idea of an „intelligent hose" came about, with which we enable our customers to view the exact condition of our products at any time without having to interrupt their use. Under the name AMPIUS® , the Masterflex Group has developed hose systems that are equipped with a digital interface as standard. Via an app, it is also possible to call up data on wear, pressure, internal and external temperature and other parameters of appropriately equipped hoses. The possible uses of AMPIUS® are as diverse as the applications of our customers.



Contact us - together we will find the best solution for the specific requirements of your industry.

Your **AMPIUS®** contact persons:

For the technical area:

Stefan Nüßen +49 (0)209 / 97077 – 43

For the distribution:

Christian Gemsa +49 (0)209 / 97077 - 211

Email: AMPIUS@masterflexgroup.com