



# AGRITECHNICA Highlights

November 2015

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## COMPANY HIGHLIGHTS

**ARGO-HYTOS Is Expanding Its Presence in France**

On Friday, July 10, 2015, in a fantastic summer weather, the new building of ARGO-HYTOS France in Forbach, in a beautiful situated location, was officially opened in the presence of customers, colleagues and family members.

Didier Ledig, CEO of ARGO-HYTOS France, opened the festivities and presented the necessity of the decision to move from Sarreguemines to Forbach and erect an own building.

Christian H. Kienzle, CEO of the ARGO-HYTOS Group, explained the history of ARGO-HYTOS France, which began in Paris in 1983 and now celebrates a grandiose climax with the new building in Forbach. In a record time of 7.5 months, the new building was erected. Mr. Kienzle once again placed his confidence in the French site and emphasized the importance of the French market for the ARGO-HYTOS Group.



With an office area of 550 square meters and a production area of 1,200 square meters, the new building now provides the appropriate place in order to optimally serve the customers of ARGO-HYTOS especially in France.

Currently 13 colleagues are employed at ARGO-HYTOS France. However, it is planned to hire 8 – 10 more employees within the next 5 years.

Paul Fellingner, president of the municipality Forbach and Laurent Kalinowski, Member of Parliament and mayor thanked for erecting the new building in Forbach and look forward to the creation of employment in the coming years.

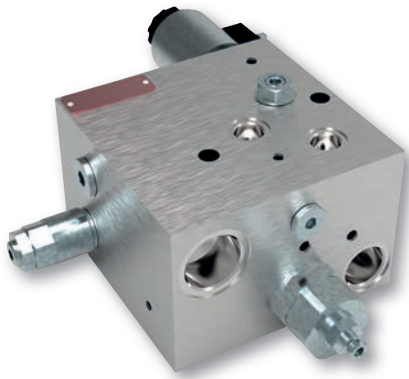


Finally, in accordance with jazz music in a splendid ambience, delicacies from the French cuisine were served and it was toasted with champagne on the successful completion of a new era for ARGO-HYTOS France.

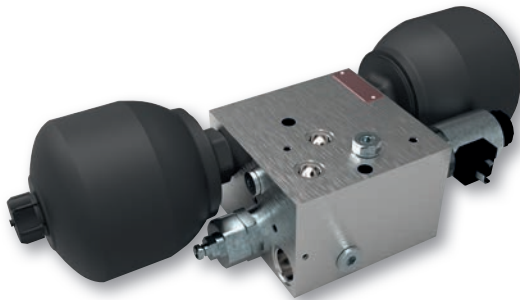
ARGO-HYTOS wishes the team of France all the best and lots of fun with the new very well designed premises.

## Comfort Hydraulics: Pitching Vibration Damping

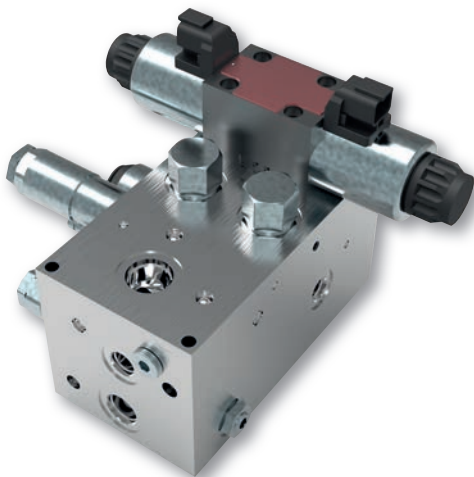
### Coordinated solutions: Design to dedication



Damping block for wheel and telescopic loaders



Damping block with hydraulic accumulator



Damping block with pipe rupture protection

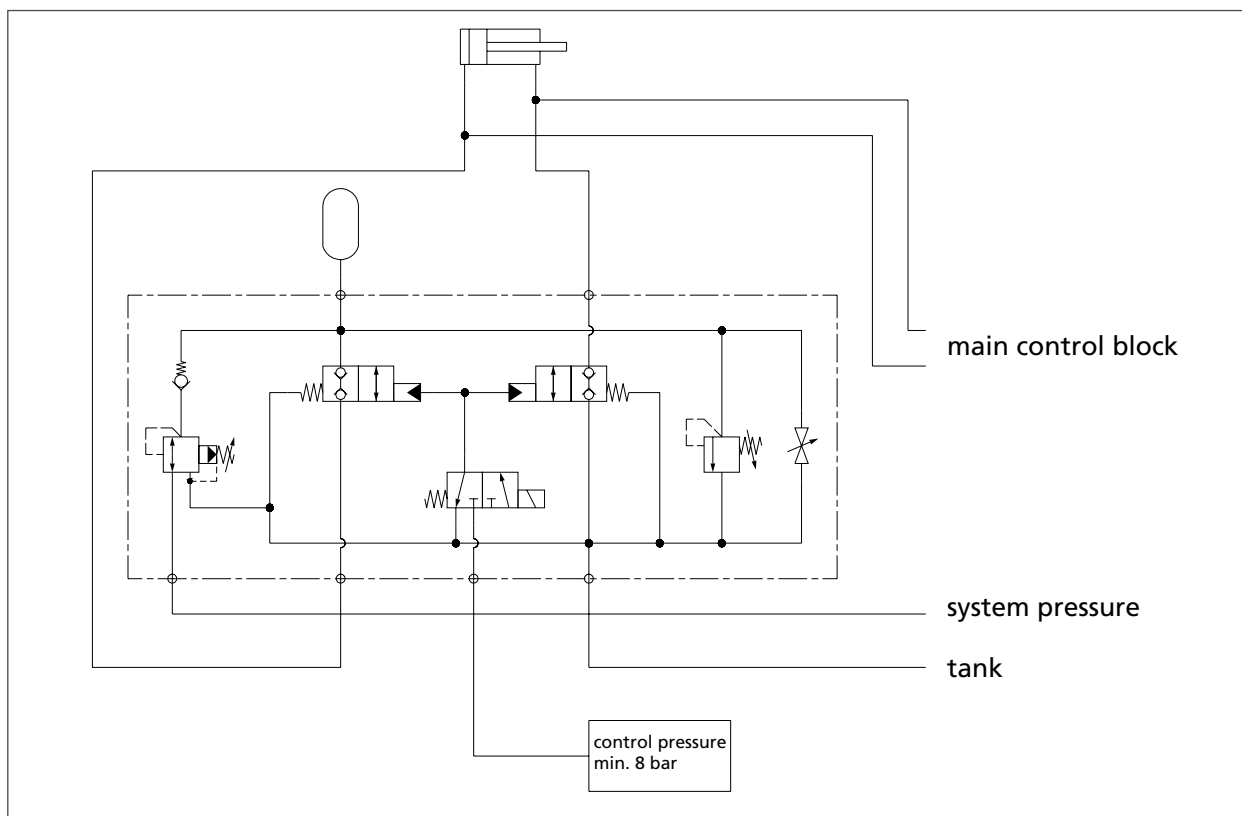
The driving speeds of mobile machines in agriculture have steadily risen in recent years. This affects tractors with front loader as well as yard and wheel loaders and telescopic loaders. These mostly unsuspended vehicles tend to oscillate due to the mass distribution and the spring effect of the tires in both speed and direction changes as well as when driving over bumps.

The kinematic of the lift mast, the tires and the weight of the cargo have a very big influence on these "pitching vibrations". The lift mast, which acts as a lever arm, passes the impulse to the machine. Via the frame of the machine, this force is directed into the tires and results in deformation of the tire as single spring element in the chain. When driving over bumps, the movement impulse runs in reverse direction from the floor to the tire via the frame to the lift mast to the lifted mass.

The resulting pitching vibrations, on the one hand, stress the machine parts and also lead to an impairment of the driving comfort and the driving safety.

The driver must reduce the driving speed in order to safely operate the machine: a declining handling rate is the result. The goal is to reduce pitching vibrations and to dampen vibrations from the system "machine" as quickly as possible. The overall objective is to reduce initiated accelerations, so that disturbing pitching movements do not arise at all.

Through connection of hydraulic accumulators on the pressure-loaded cylinder side and activation of the opposite side to the tank, there is a decoupling of the lift mast to the machine. Thanks to this decoupling, accelerations of the lever arm will not be transmitted to the machine and vice versa. The decoupling is effected by the gas filling of the hydraulic accumulator, the damping via fluid friction and gas friction in the hydro-pneumatic system. Depending on the cylinder size, lever arm ratio and driving speed, there are very different flow rates, which oscillate back and forth between accumulator and cylinder. The control blocks can be fitted with valves for flow rates from 70 up to 300 l/min.



Schematic diagram

### Info

Depending on the application, requirements and request, various functional elements can be combined almost arbitrarily.

- › Directional control valves for switching on and off 70 - 300 l/min
- › Pressures up to 350 bar
- › Block material of galvanized aluminum or steel
- › With or without accumulator protection and accumulator discharge
- › Accumulator without pre-charge
- › With constant or load-dependent pre-charge of the accumulator
- › With / without pipe rupture protection in the block
- › Piloting or bypassing of the pipe rupture protection in the activated state
- › Accumulator integrated in the control block
- › Control block for pipeline installation
- › Control block for flange mounting directly at the lifting cylinder

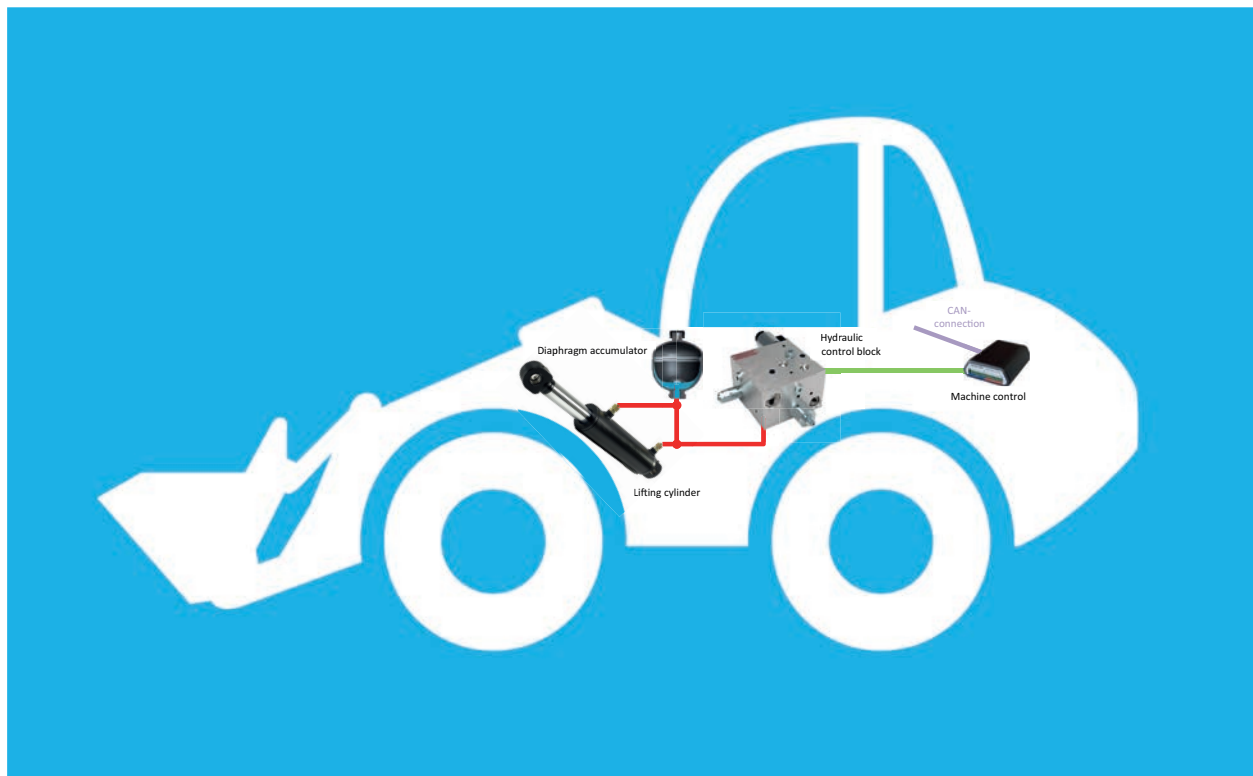
The customized control blocks out of aluminum or steel are almost always adapted to the structural conditions of the machine. By using screw-in or flange valves, the degrees of freedom in the design of the block are kept as high as possible. The integration of accumulators or other functions such as pipe rupture protection are always possible.

If necessary, the pitching vibration damping of ARGO-HYTOS can also easily be implemented afterwards in the current series of the OEMs. Depending on the design, a connection of the control block with the control pressure supply of the machine and a separate tank line may be required, in the simplest case only an electrical signal is required. Due to the experience in the hydro-pneumatic suspension and damping systems, ARGO-HYTOS precisely designs the pitching vibration damping that matches your machine. Already in the design phase, possible solutions are discussed with you, also with regard to the relevant rules and regulations.

### Possible fields of applications



## Pitching Vibration Damping in a Wheel Loader



If a manufacturer turns to ARGO-HYTOS with the task of realizing a pitching vibration damping in a wheel loader, the customer accompanies the development process in close cooperation with our application experts up to a successful testing of the project. In a first step, the current state is analyzed together with the customer. A matched to the wheel loader pitching vibration damping can only work efficiently, if the development engineer of ARGO-HYTOS is aware of all peculiarities of the present system. It is therefore not unusual that we name potential weak points on the wheel loader directly on site. This can, for example, be the realized pipe rupture protection or the type of pre-charge pressure. An optimally to the system adapted pitching vibration damping increases in addition to the driving comfort also the driving safety and the handling performance. For this reason, it is equally important to incorporate the machine user's experiences during the design phase.

After all the weak points of the present system have been analyzed, customized solutions are developed. The proposed solutions are subsequently discussed at eye level with the customer. A discussion on the strengths and weaknesses of the developed concepts provides the necessary transparency. Such a transparency has the advantage that the customer can choose the best possible approach for himself. On the basis of years of experience in pitching vibration damping, the approach is checked for compliance with applicable standards (DIN EN ISO 4413) and directives (machinery directive).

When all technical aspects relating to the function and the behavior of the pitching vibration damping have been discussed with the customer, the block can be designed. The control block which includes the pitching vibration damping is specifically tailored to the wheel loader. In addition to the arrangement of the ports, good accessibility to the valves is taken into account as well. The block design is made available to the customer in the form of a 3D model. On the basis of a first model, it is possible for the customer to quickly and easily detect collisions with other components. Thus the optimal block design can iteratively be determined together with the customer.

When the block design has been determined, the operation of the pitching vibration damping will be tested on the basis of a prototype. In the context of testing, in addition to a normal operating behavior even extreme situations can be tested. The damping behavior as well as the ease of use is optimized in the testing phase to such an extent that it corresponds to the requirements of the customer.



## APPLICATION HIGHLIGHTS

### Comfort Hydraulics: MHPS - Hydro-Pneumatic Suspension Systems

Modularity for faster and more cost-effective development

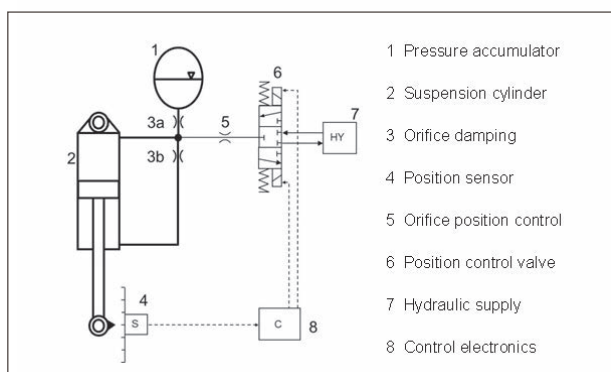


Fig. 1: Schematic of a hydro-pneumatic suspension system

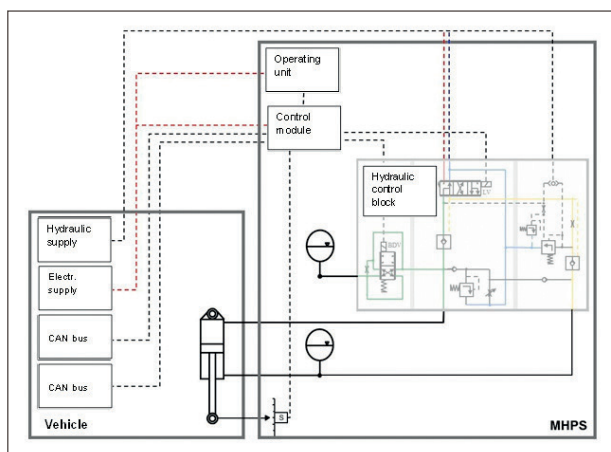


Fig. 2: Modular control system



System components

Hydro-pneumatic suspension systems improve comfort and productivity of vehicles. The fact that these systems are currently utilized in only a small number of vehicles is mainly due to high development efforts and the additional costs of the suspension components. ARGO-HYTOS now offers a modular system, which features an improved cost-benefit ratio and a reduced development effort. Moreover, two specially developed hydraulic solutions offer distinct advantages over currently used systems.

Comfort, productivity, and profitability are among the most important qualities customers request from work machines today. Higher standards demanded with regard to comfort are impelled particularly by the Health and Safety directive 2002/44/EG, which defines the daily permissible vibration exposure to the driver. In other words, the less vibration the driver feels, the more comfortably the driver rides and therefore, the longer the driver is allowed to work. Especially during off-road work, this criterion may determine whether a driver is allowed to perform a certain job for the entire workday or whether the drivers must stop their work before the workday is done.

Hence, comfort is not merely a condition of personal well-being; it is an important factor when it comes to the actual permissible daily working hours. Therefore, it also influences profitability. Additionally, an increase in comfort will allow the driver to complete work processes faster and with more precision, which in turn makes the driver's work more productive. This helps to enhance profitability, as well.

In order to achieve this kind of comfort it is necessary to have a suspension system that isolates the vehicle's chassis, or rather, the driver from the unevenness of the ground. Hydro-pneumatic suspension systems can be located in various parts of a vehicle.

Typically, there are three different applications – wheel or axle suspension, operator's cab suspension, and boom suspension or suspension of payload. There is another important advantage with regard to wheel and/or axle suspensions – wheel load or ground pressure is equalized, which in turn enhances road-holding and wheel traction. This leads to increased efficiency and productivity, which consequently improves profitability.

Typically, vehicles subjected to frequent load changes have level-controlled suspensions. In many cases, this is a hydro-pneumatic suspension, i.e. a system consisting of suspension cylinders and accumulators as well as a position control system (schematic see fig. 1).

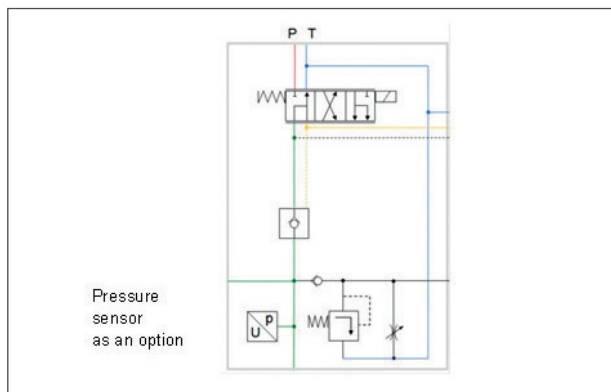


Fig. 3: Basic module with 4/3 position control valve

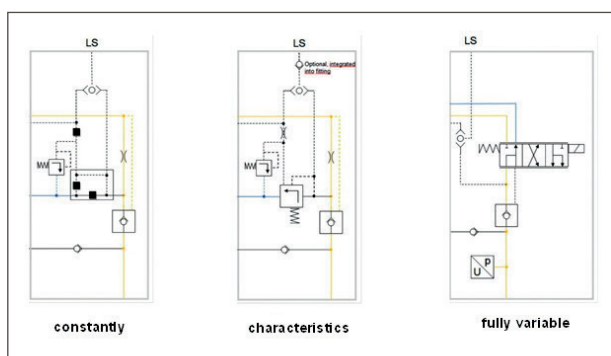


Fig. 4: Rod-side modules for setting the spring rate

At present, usually only premium-class vehicles and vehicles that are produced in large quantities are equipped with such suspension systems. Various special applications, for which a suspension is indispensable, also use them. There are two main reasons for this – high development costs (hence, product costs), and long development times. These two reasons apply especially when an OEM introduces a suspension system into their vehicle for the first time or when the next evolutionary stage of suspension is to be launched. Often, these are exactly the obstacles that make OEMs decide against a suspension system, despite the clear advantages described above.

The target of ARGO-HYTOS is therefore to remove these barriers for vehicle manufacturers and to advance the technology of hydro-pneumatic suspension systems. Development costs and development time shall be reduced considerably. This is accomplished with a new system solution, which is characterized by three particular benefits:

1. A standardized, modular control system for hydro-pneumatic suspension systems – including hydraulics and electronics
2. A straightforward adaptation of the system to customer-specific needs simply by choosing appropriate modules and parameter settings
3. Technical advice and support concerning the layout of the overall suspension system and its interaction with the vehicle

#### The advantages for OEMs:

1. Prototype systems are available very quickly
2. Standard modules that have been adapted for a specific application can be utilized as a series production solution for small to medium quantities
3. For large quantities and/or specific requirements concerning installation space, a customer-specific hydraulic manifold can be derived from the prototype

The modular control system developed on this basis consists of a hydraulic manifold, which is connected to an electronic control unit, as shown in fig.2. The electronic unit is the command and control center; it coordinates and regulates all of the functions of the hydraulic manifold. The necessary input for these decisions is provided by data from the operating panel, various sensors and the vehicle's bus system. The hydraulic manifold is connected to the suspension cylinder so it can control the position of the cylinder and the pressure within the cylinder's rod-side chamber. Additionally, the connection between the cylinder's piston chamber and the piston chamber's pressure reservoir can be damped (damping control) or disconnected (blocking of the suspension) by a valve in the hydraulic manifold.

Moreover, there is a connection between the control system and the vehicle for hydraulic and electric energy supply. Load-sensing systems (standard and 'common rail') with fixed and variable displacement pumps are supported; supply voltage of 12 to 24V is possible.

The adaptation of the system to customer-specific requirements is achieved by selecting appropriate modules and their settings. With regard to hydraulics, there are various modules which can operate all types of hydro-pneumatic suspension systems (single-acting, double-acting, constant or variably preloaded, etc.)



The basic module consists of a minimum of required hydraulic components. It is a manifold that provides position control of the suspension: it feeds or drains oil to/from the suspension cylinder's piston chamber. A special feature of it: it needs just one proportional valve with only one solenoid (see fig.3), for upward and downward leveling. There are two advantages here as opposed to suspension manifolds commonly used at present; one solenoid can be eliminated, additionally the position adjustment can be done proportionally. This means that the valve can react very sensitively to small changes in position and open fully (control range 2.5 to 25lpm at 20bar ?p). Therefore the required position can be reached faster, for example while under extreme load changes or in cold temperature conditions with high oil viscosity. Patent applications have been filed for the valve and its integration in the circuit of the position control manifold.

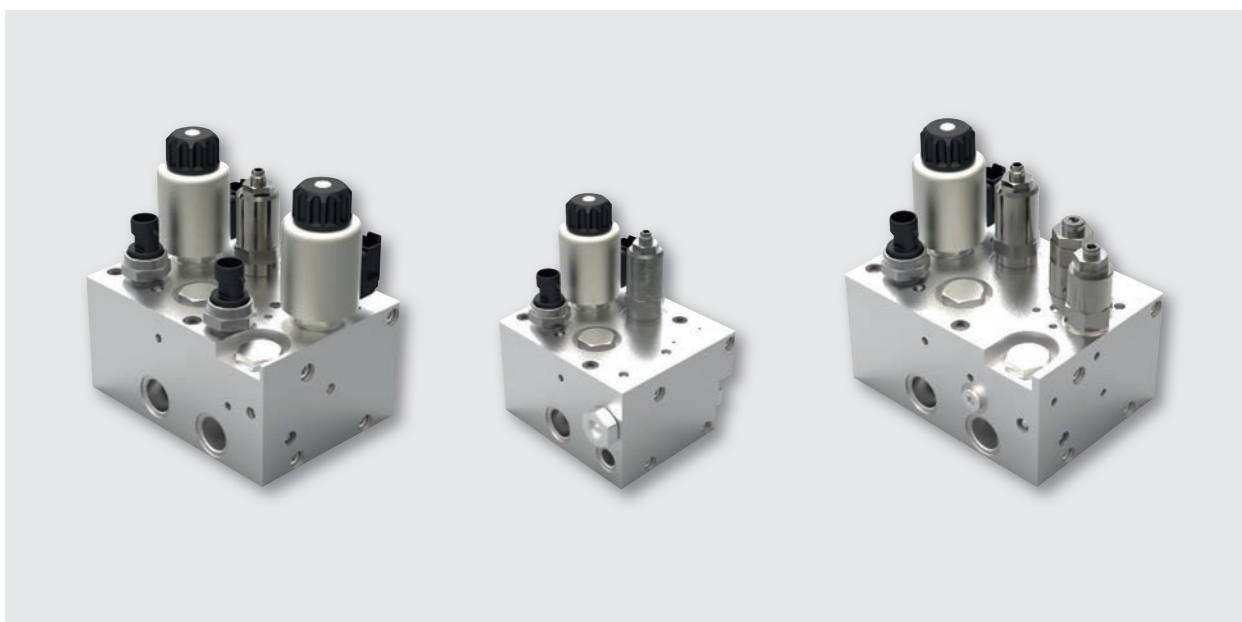
Additionally, there are rod-side control modules for the setting of the rod-side pressure in preloaded suspension systems (fig.4). Using these, the spring rate of the system can be varied in a wide range. A first module is equipped with a hydro-mechanical pressure control and is available in two versions – one with a constant rod-side pressure, and one with a rod-side pressure following a characteristic curve depending on the suspended load. The latter is especially designed for tractors, a patent has been granted in Germany. In comparison to a two-step variation of the rod-side pressure, it offers the benefit of a smooth, continuous transition of the rod-side pressure in the switching point, hence an increase in spring rate continuous to the load reduction.

A second module utilizes the technology of the 4/3 directional prop valve mentioned above for electro-hydraulic rod-side pressure setting; hence, combined with a pressure sensor, it provides fully variable pressure control. Consequently, the spring rate can be optimally adjusted to the given working conditions.

Furthermore, the piston-side module offers the possibility to control the oil flow between the piston chamber of the suspension cylinder and the accumulator. This allows for a specifically adjusted damping or the complete hydraulic blocking of the suspension. Correspondingly, proportional or switching valves are used here. A possible in-line arrangement of the piston-side modules also allows for the selective deactivation of the piston-side accumulators.

Instead of the piston-side module, in the same flange mounting face a multi-cylinder module can be used. It allows the separation of two hydro-pneumatic springs, thereby providing roll stabilization, for instance.

The individual hydraulic modules are bolted together. They are easy to handle since the individual surfaces of the manifolds follow a strict separation of functions (see fig.5): module flange surfaces left and right, hydraulic supply in the rear, suspension hydraulics in front, valves on top, and mounting at the bottom. The whole manifold can be mounted in any orientation. Pressure accumulators, varying in size and pressure range according to the design of the given suspension system, can also be supplied.



Module combinations

The electronics needed to operate the manifold can be supplied as well should the customer request it. They consist of a position sensor and a position control unit in its most basic form. It is preconfigured according to the given hydraulic setup and can be adapted to an application by selecting algorithms and parameters. The electronics can be also equipped with operating elements, which enable the operator to manually adjust the normal position or the suspension characteristics (damping/spring rate). The control unit is able to receive further data from the vehicle's CAN bus. At present, it is available for the CANopen protocol, other protocols are possible. There is a touch-screen display available for simple parameter setting, maintenance and diagnostic work, as well as for special, large-scale suspension solutions.

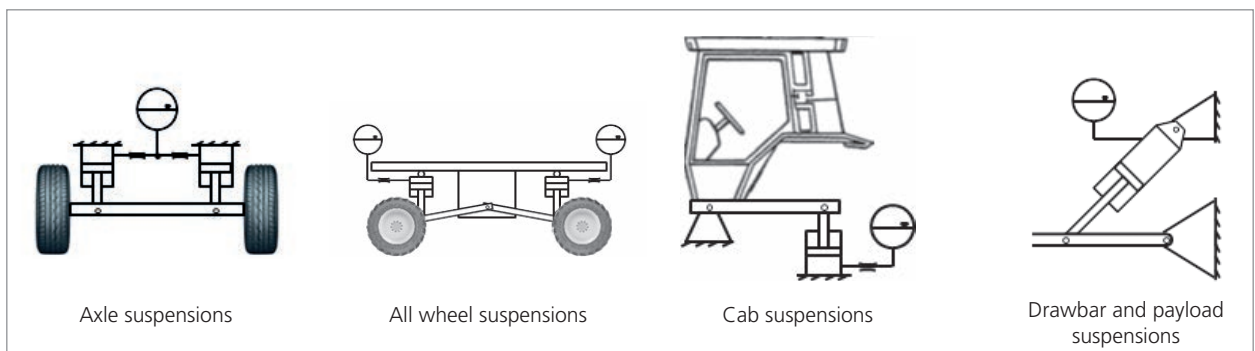
The electronics provide a proportional position control, and a spring rate and damping control. In order to improve comfort and ride quality, the suspension characteristics can be automatically adapted to the given riding and working situation with the help of our adaptive control technology.

Manual adjustment is also possible. A semi-active damping control based on a proportional valve is currently being developed.

When starting customer projects, it is convenient to use the modular system for first prototypes due to its quick availability and adaptability. As a first step, ARGO-HYTOS develops suggestions for the layout of the suspension and suitable combinations of modules – this step is simplified and accelerated by dedicated calculation and simulation programs. Subsequently, the combinations of modules are tested in the vehicle in order to find the best suitable solution and the optimum control of the respective parameters. The next step is for the customers to decide whether they want the modular solution directly for the serial production or whether they prefer a customized hydraulic manifold. The latter option will most likely be chosen when there are specific limitations concerning installation space, or to further reduce costs for large quantities. In this case, ARGO-HYTOS will design a new, custom-made hydraulic manifold - using exactly the same components and valves as in the modular setup for the serial solution.

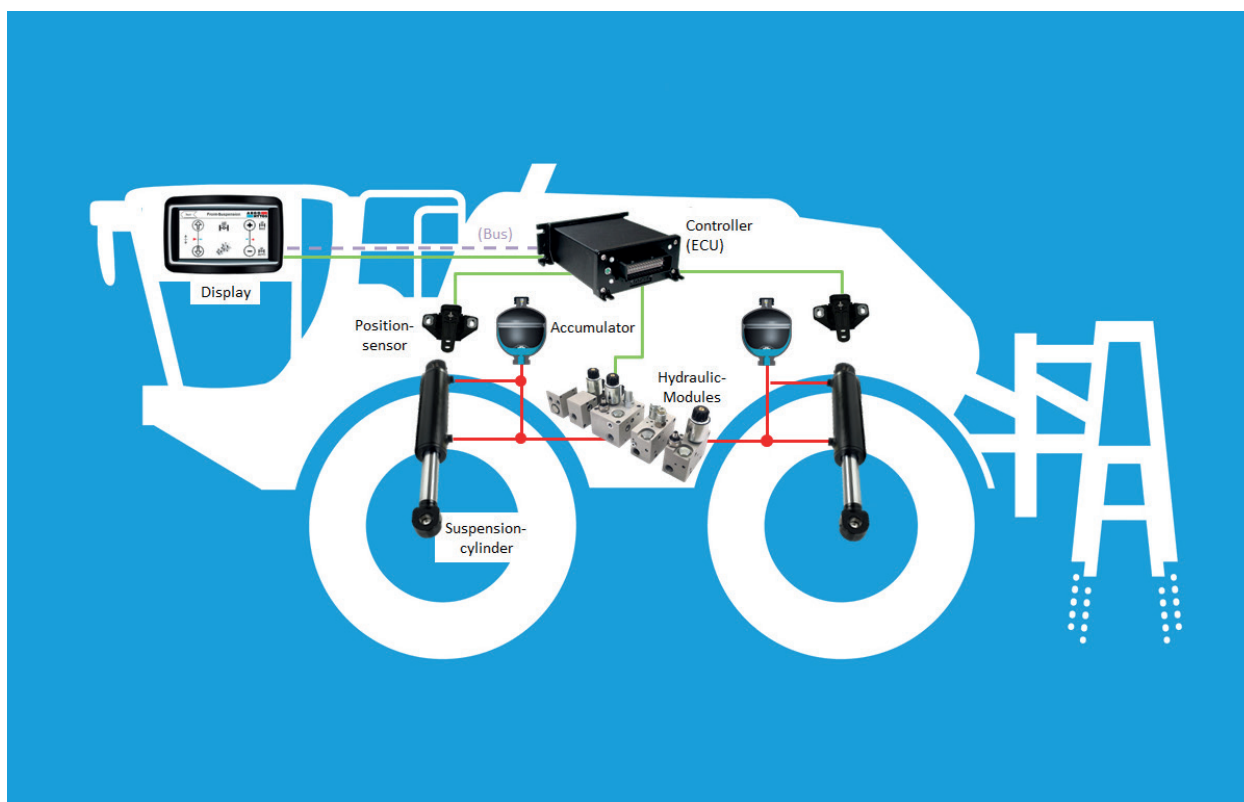
Hydro-pneumatic suspension systems improve comfort and productivity of vehicles. ARGO-HYTOS offers a modular system, which features an improved cost-benefit ratio and a reduced development effort.

## Possible fields of applications



## APPLICATION HIGHLIGHTS

# MHPS - Hydro-Pneumatic Suspension in a Self-Propelled Sprayer



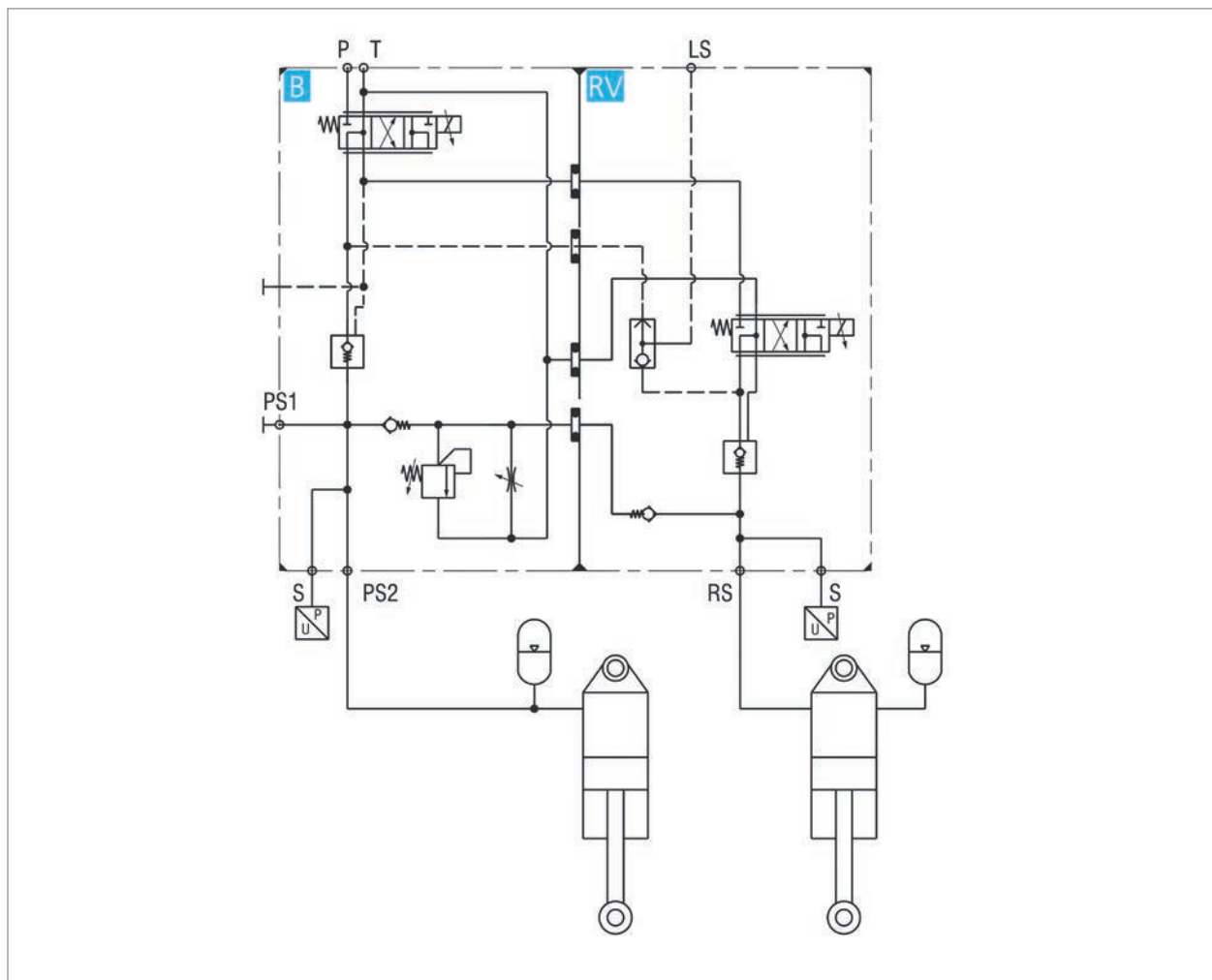
System control block

The best way to demonstrate the advantages of the modular concept is by using the example of the wheel suspension of a self-propelled sprayer with a production quantity of 15 - 20 machines per year:

Due to the ever-growing demand on comfort and safety, chassis suspensions (the so-called wheel suspension) at self-propelled sprayers belong for quite some time to the delivery spectrum of the major manufacturers.

In order to remain in business, a small manufacturer has to make large investigations in development times and costs as well as in building up relevant know-how, to come up with an all-wheel-suspension machine. By working together with our application specialists and through the use of complete MHPS modules, expenditure for development times and for building up know-how can significantly be reduced.

Together with the customer, the application team of ARGO-HYTOS prepared an analysis of the current state. On this basis, it was discussed, how to attain improvements, both on economic and technical side.



Schematic diagram

The machine data such as weight of the machine, loading conditions, speed, etc. were the basis for the calculation of the new system.

The design of cylinder sizes, pre-charging of the diaphragm accumulators or cable diameters was made by ARGO-HYTOS, based on these parameters.

Based on the layout, the software has been configured and loaded into the control electronics, the control blocks and other accessories have been compiled. A first functional test was carried out at ARGO-HYTOS, at the load test rig belonging to the company.

Before the system has ever been installed, all basic settings and functions were tested and checked.

In the next step, the system was installed at the customer's premises and jointly taken into operation. Constantly present: the engineers of ARGO-HYTOS. Therefore fine tuning such as changing of the valve settings or adapting the software to customer requests constituted no problems and could quickly and easily be implemented. After final tests and measurements, the final set-up has been established and the series production could begin. If special machines should be built over the series, additional modules can be flange-mounted to or omitted from the existing solution, guaranteeing the highest flexibility even in series production.

#### Info

##### **"Only as many valves as the function requires"**

In drawn and self-propelled sprayers, many movements and functions are implemented hydraulically. Some of the key operating functions in an open circuit are:

- › Chassis suspension and height control
- › Track width adjustment
- › Boom height control and tilt
- › Folding in and out the booms
- › Pump control
- › Fan drive

Components and control blocks for the implementation of functions can be found in the portfolio of ARGO-HYTOS. Different designs and nominal sizes can be combined to control blocks and multi-flanges in almost any shape. According to the motto "only as many valves as the function requires" ARGO-HYTOS combines in its control blocks valves of different valve kits for technical and economical optimized system blocks. Flanged valves (ISO 4401) and directional control valves are used as well as screw-in valves. All valves are designed and manufactured in-house.

## APPLICATION HIGHLIGHTS

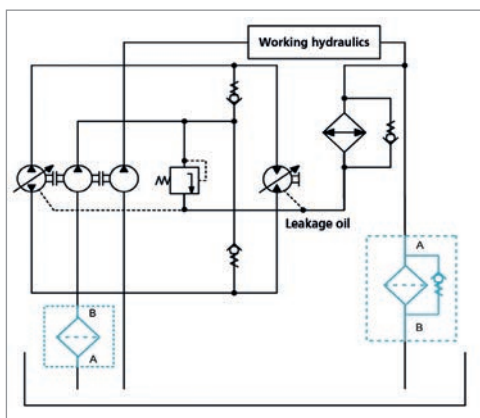
# Energy Efficiency & Integration: Return-Suction Filters

Simple and exact design for maximum customer benefit

Particularly in self-propelled machines that are equipped with a hydrostatic drive and combined working hydraulics, the filter concept furthermore often consists of a return filter (working hydraulics) and a suction or pressure filter (hydrostatic drives).

The filter finenesses have to be co-ordinated so that the cleanliness classes 20/18/15 ... 19/17/14 (acc. to ISO 4406) demanded by the drive manufacturers will be reached.

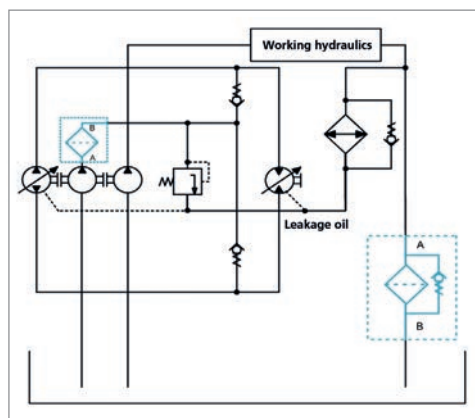
### Closed circuit with suction filter and open circuit with return filter



#### Disadvantage:

Due to the high kinematic viscosity of the hydraulic fluid at low temperatures, suction problems arise especially in the cold start phase.

### Closed circuit with pressure filter and open circuit with return filter

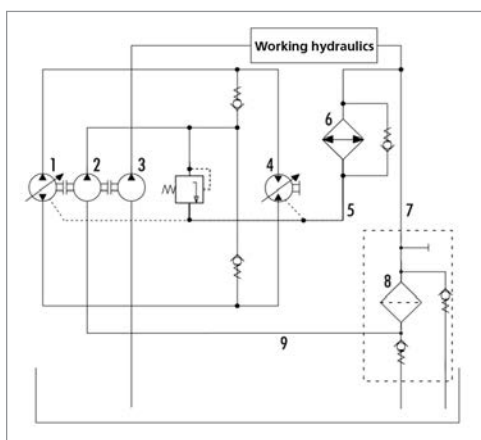


#### Disadvantage:

The pressure filter protects the axial piston pump in the closed circuit, but the filling pump is not protected. Suction problems still arise in the cold start phase.

### Return-suction filter concept

The use of a return-suction filter offers far-reaching functional improvements. In machines with a hydrostatic drive and combined working hydraulic system, return-suction filters replace the suction or pressure filters required for the feed pump of the closed-loop hydrostatic drive circuit as well as the return filter for the open-loop working hydraulic circuit. Compared to these filter concepts, often also a cost reduction can be achieved.



- 1 Variable pump of the closed hydrostatic drive
- 2 Filling pump of the closed hydrostatic drive
- 3 Working pump of the open hydraulic circuit
- 4 Hydraulic motor of the closed hydrostatic drive
- 5 Drain line
- 6 Cooler
- 7 Return line
- 8 Return-suction filter
- 9 Suction line

### Conceptional advantages

- › Only one filter for both circuits
- › In both circuits the total oil volume is filtered in the return line
- › Continuously more oil is flowing in the return line than it is taken off via the suction line
- › The feed pump sucks pre-charged oil via a pressure control valve – therefore excellent cold start behaviour
- › The feed pump is always supplied with filtered oil. No bypass available (except for in-line versions).  
A pressure relief valve is installed to protect the shaft seals against overloading.

While each circuit operates independently with separate filters, the combination of the two circuits via the return-suction filter causes interaction between the circuits.

If the design criteria described below are taken into account, you can take full advantage of the benefits provided by the return-suction filter concept.

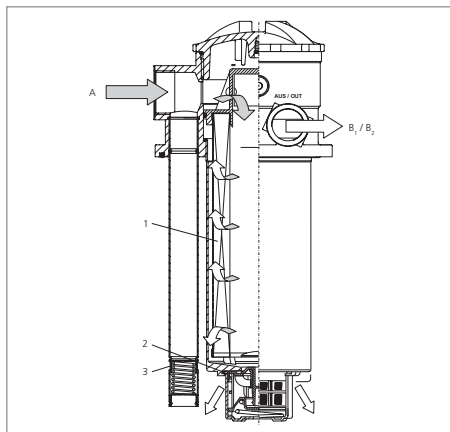
### Required return flow in the system

In order to maintain a pre-charging pressure of approx. 0.5 bar at the intake of the feed pump, the return flow must exceed the suction flow under any operating condition, varying depending on the filter size and the design.

### Permitted flow rate of the feed pump

- › At operating temperature and rated speed, the volume flow of the filling pump should not exceed 50 % of the nominal flow rate of the filter (e.g. with a return-suction filter with a nominal volume flow / return flow of 200 l/min, the volume flow of the filling pump should not be higher than 100 l/min).
- › At extreme cold starts ( $v = 1000 \text{ mm}^2/\text{s}$ ) and slightly increased idle speed ( $n = 1000 \text{ min}^{-1}$ ) the volume flow of the filling pump should be 20 % less than the nominal flow rate of the filter.

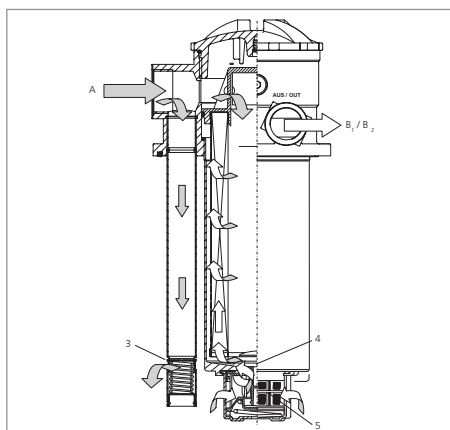
### Normal operating conditions



Section through return-suction filter E 158

The hydraulic oil returning from the circuit (A) passes the filter element (1), is pressurized by a 0.5 bar check valve (2) and supplied to the feed pump of the hydrostatic drive (B). The surplus oil between return and suction volume flows filtered into the reservoir.

The pre-charging of 0.5 bar in the suction line minimizes the risk of cavitation in the filling pump and allows full performance even during the critical cold start phase. In normal operation, a lack of oil is excluded.



The integral pressure relief valve (3) prevents too high back pressure in the return line. As this valve leads the oil directly into the tank there is no connection between the return line (A) and the connection of the feed pump (B) (no bypass).

The emergency-suction valve (4) with protection strainer (5) supplies the feed pump in case of a short term of lack of oil (ventilation/cold start).



# EXAPOR<sup>®</sup> ///MAX2



## Pressure loss in the suction lines

Under above mentioned cold start conditions, the pressure loss in the suction lines must not exceed 0.4 bar. This ensures that the filling pump is supplied with sufficient oil even with partly contaminated filter element.

## Backpressures in the system return lines

When the drain oil from the hydrostatic drive is routed across the filter, the permitted leakage oil pressures have to be observed in order to protect the shaft seals. Here, besides the backpressure of the filter, also the pressure loss caused by the leakage oil pipes and the oil cooler are to be considered.

Depending on the application, the use of a cooler bypass valve is recommended.

## Filter fineness and oil cleanliness grades

As standard, for all return-suction filters two ARGO-HYTOS filter grades are available: 10EX2 and 16EX2.

Both with the patented EXAPOR<sup>®</sup>MAX2 design.

The following oil cleanliness according to ISO 4406 can be achieved:

- › 10EX2                    18/15/11 ... 14/11/7
- › 16EX2                    20/17/12 ... 17/14/10

The manufacturers of hydrostatic drives mostly recommend for normal operation an oil cleanliness of 20/18/15 as well as of 19/17/14 for increased requirements ( $t > 90^\circ\text{C}$ ).

Even with the filter fineness 16EX2 these requirements are met by 100 %.

The structure of the specially developed 3-layer filter material, using glass and polyester fibers of different finenesses combined with an improved hybrid support fabric (patented) made of stainless steel and polyester sets the standard for:

- › Pressure loss
- › Dirt holding capacity
- › Flow fatigue stability

The plastic sleeve used offers the following benefits:

- › Custom label
- › Protection from damage
- › Improvement of flow fatigue stability



For the user, these improvements bring:

- › Extended service intervals
- › Higher operational reliability
- › Improved oil cleanliness
- › Increased performance
- › Positive element identification
- › Reduced operating and maintenance costs

As an alternative to EXAPOR@MAX2, the newly developed and less expensive EXAPOR@Light filter elements are available on request.

Due to reduced dirt holding capacity, they are especially suitable for systems with less stringent requirements (e.g. approx. 500 operating hours / year).

#### Available filter series

Depending on the mounting position and the required performance, at ARGO-HYTOS one can choose between the following designs and series:

#### Summary

In the design of return-suction filters, the specific requirements of hydrostatic drives have even more to be taken into account than in the design of separate filters for the filling pump and the working circuit.

#### The advantages of the return-suction filter concepts

- › Excellent cold start characteristics of the system, as the filling pump is supplied with pre-charged oil (reduced risk of cavitation)
- › Protection of the filling pump by supplying with micro-filtered oil
- › Fewer components by saving a filter
- › Reduction of spare parts and maintenance costs

come with exact design into their own, thus ensuring maximum efficiency and performance of the system even under extreme operating conditions.

Design	Series	Nominal flow rate
In-line mounting	E 068 / E 088	up to 100 l/min
In-line mounting	E 178 / E 258	up to 250 l/min
In-tank-mounting	E 084	up to 80 l/min
In-tank-mounting	E 158 / E 198 / E 248	up to 250 l/min
In-tank-mounting	E 328 / E 498	up to 600 l/min
In-tank-mounting	E 598 / E 998	up to 850 l/min

The in-tank mounting versions are equipped with pressure relief valves; the in-line mounting variants are equipped with a bypass. The modular design of the filter allows for easy implementation of customer wishes such as e.g. special connection configurations.

## APPLICATION HIGHLIGHTS

# Return-Suction Filtration in a Self-Propelled Harvesting Machine



With the return-suction filter, ARGO-HYTOS was the first filter manufacturer to launch a new, revolutionary filter system on the market.

Since then, this filter concept for mobile machines has become a standard in many applications, because it provides far-reaching functional improvements and lowers the system and maintenance costs.

Using the example of the harvester shown below, the reasons for the success of the return-suction filter concept can be illustrated.

The hydraulic system of such a beet harvester typically consists of:

### Hydrostatic drive (1)

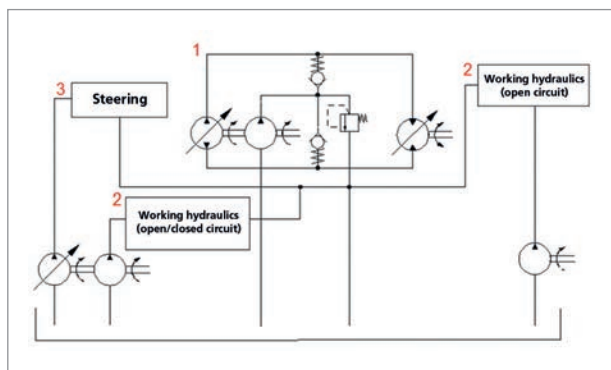
A variable pump in the closed circuit, connected to the hydraulic motor at the axles, ensures locomotion

### Working hydraulics (2)

Fixed or variable pumps supply the users in the open or closed circuit

### Steering system (3)

A variable pump in the open circuit supplies the steering system



Hydraulic circuit without filtration

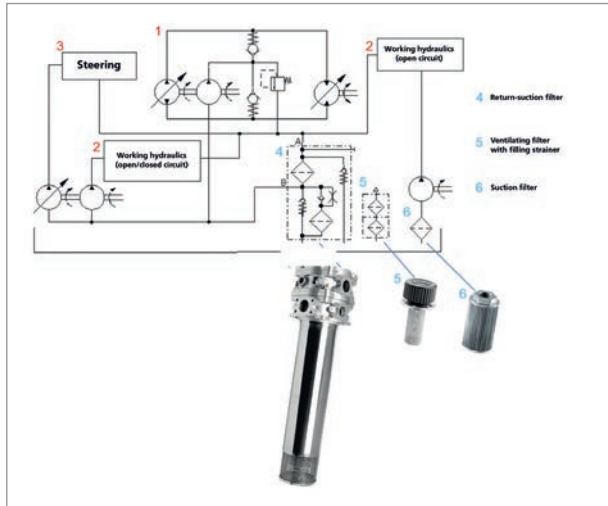
### Filter selection

Filters in the hydraulic circuit guarantee function and / or wear protection. Thus one differentiates between protective filters (function protection = coarse hydraulic filters / strainers) and working filters (wear protection = fine hydraulic filters).

What concerns the drive, protecting the filling pump and / or the hydrostat as well as ensuring the oil cleanliness and thus the wear protection are of primary importance. Here a working filter is required.

The same applies for the working hydraulics (open / closed circuit), because also here the pump has to be protected and the necessary oil cleanliness has to be ensured.

The main focus with steering systems mostly lies on the function protection of the steering unit and is implemented by a protective filter.



Simplified presentation of the hydraulic circuit incl. filter concept

A single return-suction filter (4) takes over almost all the tasks mentioned above.

The filter concept for the entire machine is completed by two more filters from the ARGO-HYTOS portfolio:

#### › Ventilating filter with filling filter (5)

For ventilation of the hydraulic tank. The filling strainer downstream of the ventilating filter prevents coarse dirt from entering the tank while filling or with re-filling of oil due to maintenance or repair work.

#### › Suction filter (6)

The working hydraulics have - at the suction side - not been connected to the return-suction filter, but suck oil from the tank via a separate and maintenance-free suction filter.

Explanation: In order to maintain the pre-charge pressure of approx. 0.5 bar at the connection of the filling pump, a minimum surplus between return and suction volume is necessary under all operating conditions.



If necessary, more than two plates can be stacked, to save e.g. a collector – as decided upon in this example.

The adjacent picture shows the return-suction filter with three connecting plates. All lines could be guided and directly connected to the filter. Just as uncomplicated, a housing ventilation was integrated in the filter cover.

This example shows, how and how quickly, based on existing technical solutions, trendsetting products arise with the relevant application know-how and intelligent concepts.

### Production launch

Since all ARGO-HYTOS filters are developed and manufactured by the company itself, the users can be provided with a lot of information such as e.g. pressure loss characteristics at an early stage. Thus, the suitable version was selected from the catalogue series E 598 / E 998 and installed into a harvester.

This was followed by extensive testing under real conditions. After successful completion of these tests, the preparations for the production launch could be started.

To make the new return-suction filter even more advantageous, in our example, a customized filter on the basis of the catalog part was generated for the machine manufacturer.

The series E 598 / E 998 features a very high modular connection concept with two stackable connecting plates. For the return and suction side, two connecting plate variants are already available in the standard, which can be positioned turned through 90° to each other. Thus, a variety of connection configurations are possible.

### Customer benefit

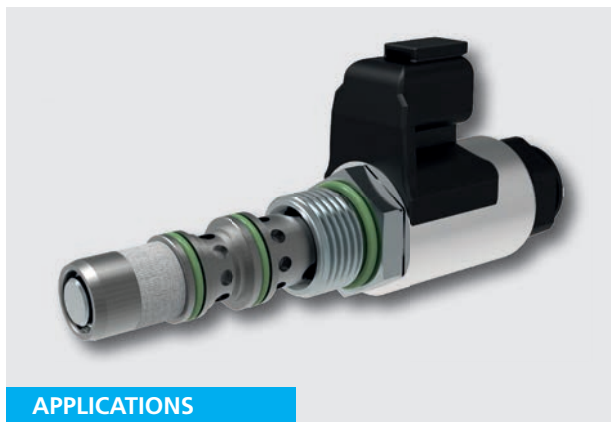
- › Improved cold start characteristics of the system, as the filling pump is supplied with pre-charged oil (prevention of cavitation)
- › Fewer components by saving a filter
- › Reduction of spare parts and maintenance costs

All the more pleasing, when in addition to the technical improvements, the customer benefit is significantly increased also by reducing the system costs.

## Valves

# SP4P1-B4 Proportional, Pilot-Operated Reducing / Relieving Valve

for proportional control of hydraulic clutches



## APPLICATIONS



SP4P1-B4

The pilot-operated reducing valve SP4P1-B4 is a screw-in, cartridge-style, spool-type hydraulic pressure reducing/relieving valve which allows to adjust the reduced pressure in a defined range. Pressure level is proportional to DC current excitement.

## Features

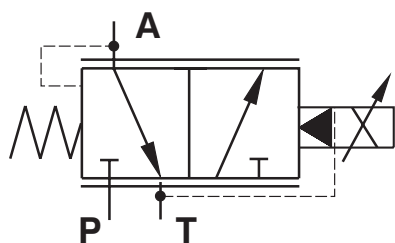
- › High nominal pressure level
- › Low pressure drops
- › Stable performance in a variety of working conditions
- › Adaptable pressure gain for client application
- › Small and compact
- › Low power consumption 4W at nominal conditions

## Technical Data

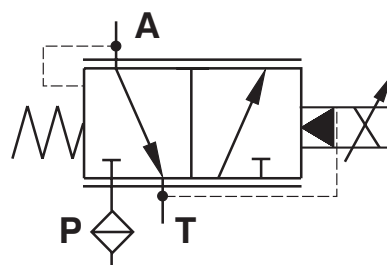
- › Nominal reduced pressure 30 bar (435 PSI)
- › Nominal Flow: 40 l/min (10,58 GPM)
- › Hysteresis:  $\leq 5\%$
- › Cycle life: 10 million peak impulse cycles at nominal pressure
- › Fluid temperature range:  $-30 \dots +100 \text{ }^{\circ}\text{C}$  ( $-22 \dots 212 \text{ }^{\circ}\text{F}$ )
- › Ambient temperature range:  $-30 \dots +100 \text{ }^{\circ}\text{C}$  ( $-22 \dots 212 \text{ }^{\circ}\text{F}$ )
- › Cavity size 7/8-14 UNF

## APPLICATIONS

- › Hydraulic clutch gear boxes control
- › Agriculture and construction machines



Without filter



With filter



## Pressure Relief Valves in Hydraulic Accumulator Circuits



Pressure relief valve SR1A-B2

Hydro-pneumatic accumulators are considered in part as a safety-related component due to their use as accumulators in hydraulic applications.

The use is therefore specified in various legal regulations (country-specific) and standards (2014/68 / EU).

One of the requirements of the guidelines is to protect the accumulator circuits against pressure peaks and overload.

This is achieved by pressure relief valves, which should meet the following requirements:

- › Reliable operation
- › Robust design
- › Vibration resistance and stable function
- › Rapid response to pressure changes
- › Low leakage

To ensure reliable operation, direct-operated pressure relief valves are used in most cases. These are - in contrast to the pilot-operated pressure relief valves - less sensitive to contamination and have lower leakage.

There are additional requirements that should be followed by the design of the pressure valve:

- › Damping of the valve cone with a suitable degree of damping, while complying with the valve stability and reaction speed
- › Max. overloading of the system pressure of 10% of the set opening pressure (acc. Directive 2003/26 / EU + ISO4126-1)
- › Verification of the reliable function and continuous monitoring by a named person

As a well-known manufacturer of hydraulic valves, control blocks and complete hydraulic systems, ARGO-HYTOS extends its product portfolio to include the pressure relief valve SR1A-B2, which was generally designed for use in hydraulic accumulator circuits.

This is a direct-operated pressure relief valve in screw-in design 7 / 8-14UNF. The structure of a poppet valve ensures minimal leakage when the valve is closed. By optimizing the damping behavior, a very good valve dynamic could be achieved while maintaining a stable function. The maximum operating pressure is 420 bar, the maximum flow rate is 60 l/min. For a precise pressure setting, 7 valve pressure levels are at the customer's disposal. The opening pressure can be adjusted in the respective pressure level range by an adjusting screw and secured with a lock nut. It is also possible to obtain the valve in preset condition (setting sealed).

With regard to the surface protection, the valve body and the adjustment screw are zinc-coated. The sleeve and the seat are protected by carbonitriding, which further optimizes the mechanical characteristics.

In order to be able to work in limited work spaces, the plastic cap was adjusted. The seals, either NBR or FKM enable the use of the valve at -30 °C up to +120 °C. The valve was certified by the TÜV Süd according to the application for hydraulic accumulator circuits.

In summary ARGO-HYTOS launches a high-quality product that combines the best cost / benefit ratio with reliable function and long service life.



## A Multifunctional Hydraulic Filter System Sets New Standards



Filter systems of the future must meet market requirements regarding the highest variability in combination with an excellent cost / benefit ratio. The state of the art is to be redefined by pioneering developments. Therefore, ARGO-HYTOS has developed a highly modular filter system with a large integration density of various functions.

The filter system comes with a variety of unique features. A cost-saving integrated quick coupling connects both add-on modules to the filter housing and external components such as pipes and hoses to the filter head. Via this unique mounting system, standard hoses can be connected to the head. There is a variety of connector couplings available: Straight connection nozzles, manifolds (45° and 90°), in a large number of nominal widths.



### Cost-saving tank interface

The newly developed tank connection revolutionizes the assembly of the popular tank-top filters. Using standard tools, the tank-top filter is quickly and securely mounted into a simple tank cutout. The fastening system adapts automatically to material thicknesses between 0.5 ... 8 mm. In conjunction with the recently developed seal concept, unevenness of the tank up to 2 mm is completely leveled out and reliably sealed.

The new filter system thus only requires a very simple tank interface. In many cases users can realize significant cost savings.

### Ventilating filters and service

As another highlight, a ventilating filter can be integrated in the filter cover. The ventilating filter - as a separate module – can be changed easily and quickly. An aeration and deaeration valve for tank pressurization is optionally available, whereby the integration density is further increased.

Particular emphasis was placed on clean filter maintenance by constructively preventing the hydraulic fluid from escaping during filter element change.



## Filter types

The following filter types can be realized:

- › **Return filter:**  
The module consists of a return filter housing with up to three connections. Heart-piece is the one-piece manufactured head part with molded housing.
- › **Suction filter:**  
By reversing the flow direction, a suction filter is created. By means of an optional add-on module, the filter is suitable for horizontal installation below oil level. This add-on module is connected via the quick coupling system.
- › **Return-suction filter:**  
Likewise, using the quick coupling system, a complex return-suction filter module can be connected. It contains a pressure holding valve, a pressure relief valve and a suction valve. A modification in the head part adjusts the flow configuration to the needs of a return-suction filter.
- › **In-line filter (instead of tank-top filter):**  
By installing an end cap or a connection nozzle to the tank outlet, the in-tank-return or in-tank-suction filter converts to an in-line filter.

Two housing sizes are available. The nominal flow rates are approx. 150 l/min and approx. 300 l/min resp. with return and return-suction filters and approx. 50 l/min and approx. 100 l/min resp. with suction filters. In particular, through the use of the current EXAPOR®MAX2 filter element generation, excellent cleanliness levels are achieved.

Technologically, this easy-to-install filter system with unprecedented integration density represents a new milestone in the hydraulic filtration.

## Filtration

# Return, Suction & Return-Suction Filters



## APPLICATIONS



After the successful launch of this newly developed series, ARGO-HYTOS extends the product family.

The ECO-friendly and efficient alternative to spin-on filter provides the necessary security for the oil cleanliness and reduces life-cycle-costs significantly.

This new filter series for inline mounting now offers filter solutions in the suction, return and return-suction filter area up to  $Q = 330 \text{ l/min}$ .

The patented filter element technology EXAPOR®MAX 2 is also available for these filters and offers excellent values in terms of low pressure drop and dirt holding capacity and is thus ideally suited for modern machines.

## Advantages

- › Efficient and environmentally friendly alternative to spin-on
- › Serviceability in compact designed machines
- › Robust and corrosion-resistant construction
- › Flexible choice in the fineness of the filter elements

## Filtration

# Clogging Indicators



## APPLICATIONS



The new screw-in clogging indicators from ARGO-HYTOS offer the greatest possible flexibility and reliability in monitoring the filter contamination of pressure and high-pressure filters. The modular design allows a variety of connector configurations for industrial and mobile applications.

Since 2015, the five electrical interfaces, most commonly used in the hydraulics, have been available. Visual displays with automatic or manual reset complete the new product range.

## Advantages

- › Large range of parts for various applications
- › Robust design for reliable monitoring
- › IP67; dust-tight and protected against temporary immersion
- › For all pressure and high-pressure filters from ARGO-HYTOS
- › Also suitable for block mounting
- › Simple retrofitting possible

## Tank Ventilation



### APPLICATIONS



The ARGO-HYTOS ventilating filter series L1.0807/L1.0808/L1.0809 are now available in a new design. The improved outer contour of the filters facilitates assembly and service. Inside, there is still the proven technology:

- › As standard, a 2µm composite filter material is used to clean the sucked air from dirt.
- › Versions with double check valve allow an increase of the pressure level in the tank, which prevents cavitation. Simultaneously, air exchange with the environment is minimized, reducing dirt ingress and thus extending the filter lifetime.
- › The oil separator is used against splashing oil in mobile operation.
- › The patented vandalism proof versions can only be removed by means of a special tool. Unwanted access to the tank or theft of the ventilating filter is made more difficult.

Part of the new design is the robust silver-colored adhesive label. Printing of the label during final assembly also allows customer specified configuration.

All improvements are also incorporated in the filling and ventilating filters of the series LE.0817/LE.0827/LE.0818/LE.0819.

## Suction Filter



### APPLICATIONS



### Characteristics

- › Tank mounting
- › Connection up to G1¼
- › Nominal flow rate up to 45 l/min
- › Pressure fluid temperature range - 30°C ... + 100°C (temporary - 40°C ... + 120°C)

### Advantages

- › Vertical and horizontal mounting position
- › The integrated closing valve allows simple filter maintenance also with installation below oil level
- › Unchanged space, therefore exchangeable with the previous series ES 074
- › Low pressure loss and excellent oil cleanliness by the use of EXAPOR®MAX 2 filter elements

## Filters

# Lightline



## APPLICATIONS



## Applications

- › Hydraulic and lubrication systems with up to 500 h service life
- › Low and medium specified systems with low cold start requirements and flow dynamics

## Price Advantage

- › 30 % for filter assemblies compared with *EXAPOR®MAX2*
- › 40 % for *EXAPOR®Light* filter elements compared with *EXAPOR®MAX2*

## Performance

- › Nominal flow rate and pressure drop are similar to those of *EXAPOR®MAX2*
- › *EXAPOR®Light* filter elements are fully compatible with *EXAPOR®MAX2* filter elements:
  - Dirt holding capacity is approx. 40% lower, compared with *EXAPOR®MAX2*\*
  - 500 h recommended service life

Type of filter	Flow rate, max. [l/min]	Filter fineness [µm]	Bypass valve setting [bar]	Connection	Breather	Indicator
RFT 050 RFT 090	50 90	10 µm (glass fibre) 20 µm (glass fibre) 30 µm (cellulose)	2.5 bar (glass fibre) 1.5 bar (cellulose)	G¾	available with or without breather	optical / electrical
RFT 125 RFT 175	125 175			G1		
RFT 270	270			G1¼		
RFT 500 RFT 650	500 650			G1½ / SAE2	not available	

\*...30 µm cellulose elements have not been modified for the Lightline range. Their design is the same as in our existing standard product range.

## Valves

# Lightline



## APPLICATIONS



This range offers two lines: modular and screw-in cartridge valves.

A wide variety of designs with different spool versions, solenoid coils (voltages) and terminals can be used in hydraulic systems of both stationary and mobile machines and equipment.

## Features

- › Saves money due to weight-optimized design
- › Modular valves sizes CETOP 02 / 03
- › Screw-in valves sizes 3/4-16 UNF and 7/8-14 UNF
- › High variety of electrical terminals (DIN, AMP JET, Deutsch DT04, flying leads)
- › Surface finish options for 240 h and 760 h salt spray protection

Symbol	Type Code Data Sheet	Cavity/Size	Type Code l/min (GPM) / bar (PSI)
<b>2/2, 3/2, 4/2 and 4/3 Solenoid Operated Directional Valves</b>			
	RPEL1-04 / HA4037 RPEL1-06 / HA4056	D02 / NG4 D03 / NG6	30 (8.0) / 250 (3600) 50 (13.2) / 250 (3600)
	SD2E-A2/L / HA4040 SD2E-B2/L / HA4060	08 / 3/4-16 UNF 10 / 7/8-14 UNF	20 (5.3) / 250 (3600) 50 (13.21) / 250 (3600)
	SD2E-A3/L / HA4041 SD2E-B3/L / HA4056	08 / 3/4-16 UNF 10 / 7/8-14 UNF	20 (5.3) / 250 (3600) 50 (13.21) / 250 (3600)
	SD2E-A4/L / HA4042 SD2E-B4/L / HA4062	08 / 3/4-16 UNF 10 / 7/8-14 UNF	20 (5.3) / 250 (3600) 50 (13.21) / 250 (3600)
	SD3E-A2/L / HA4043 SD3E-B2/L / HA4063	08 / 3/4-16 UNF 10 / 7/8-14 UNF	20 (5.3) / 250 (3600) 50 (13.21) / 250 (3600)
	SD1E-A2/L / HA4070	08 / 3/4-16 UNF	20 (5.3) / 250 (3600)



## Gear Pumps

# Lightline



## APPLICATIONS



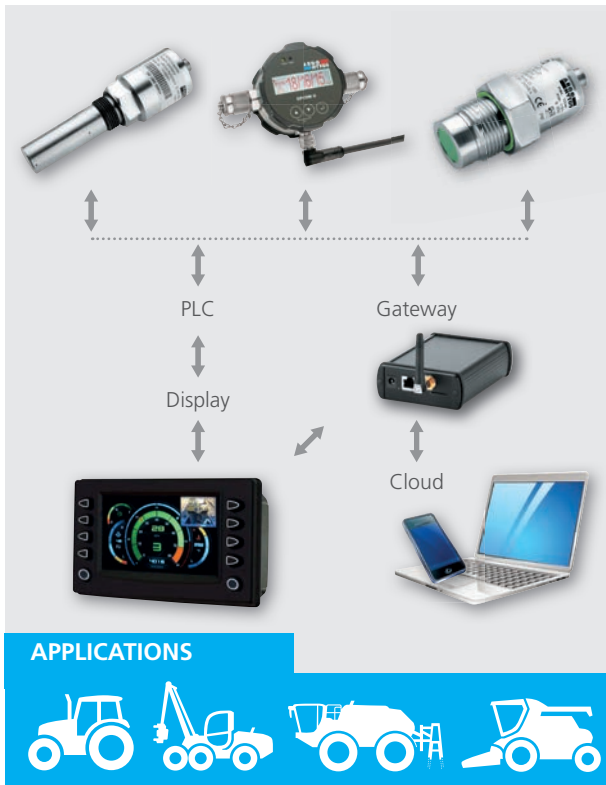
Thanks to a variety of designs with various drive shafts, flanges, fluid inlets and outlets, these pumps can be used in hydraulic systems of both stationary and mobile machines and equipment. The pumps are available with clockwise and counter-clockwise rotation, as well as in a reversible configuration; multiple pump units are also available. Connecting dimensions correspond to all worldwide standards.

## Features

- › Price advantage
- › High operational reliability
- › Cost optimized design
- › High cleanliness level
- › High quality aluminium
- › High volumetric efficiency
- › Further pumps (special function, multiple versions) are available

Type Code Data Sheet	$p_{max}$ bar (PSI)	Max. Displacement ccm (cin/rev)	$Q_{max}$ l/min (GPM)
GPOL HA 8013	250 (3643)	2 (0.122)	6 (1.60)
GP1L HA 8014	270 (3650)	8 (0.488)	16,3 (4.34)
GP2L HA 8015	300 (4372)	30 (1.830)	65 (17.30)
GP3L HA 8016	280 (4080)	71 (4.331)	170 (45.24)

# Oil Condition Monitoring



According to studies, 80% of all breakdowns in fluid power systems can be detected before they occur by monitoring the fluid condition.

## Advantages

- › Detection of fluid ageing, wrong fluids, lack of additives or dangerous acid numbers
- › Measurement of water content, particle concentration and viscosity of the fluid
- › Triggering alarms at critical levels
- › Preventing breakdowns and increasing longevity
- › Providing remote access and service-on-demand planning

ARGO-HYTOS Systems and sensors can be used in almost all fluid power systems.

# Wear Monitor OPCom FerroS



The new Wear Monitor OPCom FerroS from ARGO-HYTOS allows the establishment of cost-effective monitoring systems, through which the operational and consequential costs for the plant operator are effectively lowered. The OPCom FerroS reliably detects ferromagnetic wear and is insensitive to disturbances, such as foaming, soot and vibrations.

## Advantages

- › Continuous measurement of ferromagnetic particles
- › Automated condition evaluation, manual inspection or sampling are no longer necessary
- › Robust against interferences (air, vibrations, humidity ...)
- › Ideal for monitoring of drive units

## APPLICATIONS



## Condition Monitoring

# OPCom Particle Monitor



## APPLICATIONS



The OPCom particle monitor allows continuous monitoring of contamination and wear in fluid power systems. Condition changes can be detected at an early stage and countermeasures can be taken. Subsequent damages and failures are minimized and costs are effectively reduced.

## Advantages

- › Continuous monitoring of contamination and wear to avoid damages and failures
- › Display according to ISO 4406, NAS 1638, SAE AS 4059, GOST 17216
- › Communication via 4-20mA, RS232, CANopen and J1939
- › Compact and robust design

## Condition Monitoring

# Particle Counter OPCount



## APPLICATIONS

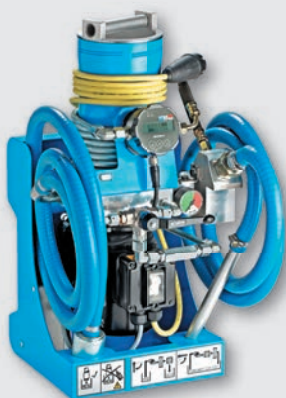


The OPCount is a particle counter of the latest generation which can be used for stationary and mobile operation. The high measuring accuracy of the OPCount and the support of all common measurement standards, allow use in a variety of applications. Measurement can be carried out directly at a pressure line or from a bottle, using the integrated pump.

## Advantages

- › Accurate mobile and stationary measurement
- › Intuitive operation via touch display or keypad
- › Measurement with integrated pump or at system pressure up to 420 bar

## Oil Service Unit FAPC 016



### APPLICATIONS



The new FAPC offers you the perfect combination of filtration and contamination control. The integrated particle monitor OPCom allows reading off the cleanliness classes at a glance and cleaning off until the desired cleanliness has been reached. The unit can be intuitively operated via display and keyboard and has an internal memory, which can store up to 3000 records. The data can comfortably be read out via an RS232 interface by using a PC.

### Equipment

- › Compact unit, ready for connection (incl. filter element)
- › Nominal flow rate 16 l/min
- › Suction and return tube, electric cable, oil pan
- › Clogging indicator for filters
- › Integrated particle monitor for monitoring the oil cleanliness

## Oil Service Unit UMPC 045



### APPLICATIONS



The new UMPC offers the perfect combination of oil control and filtration. Due to the mixture of proven function and modern advanced technology, operation and functionality have considerably been improved. Besides a high-performance filtration, all relevant oil characteristics such as temperature, humidity and cleanliness classes are now also displayed.

### Equipment

- › Compact unit, ready for connection (incl. filter element)
- › Nominal flow rate 45 l/min
- › Suction and return tube, electric cable, oil pan
- › Electric clogging indicator for the filter
- › Integrated particle monitor and humidity sensor
- › Mobile unit with wireless data transmission

## INNOVATION HIGHLIGHTS

# ARGO-HYTOS: Top Innovator 2015



## TOP-INNOVATOR 2015

Unter der wissenschaftlichen Leitung des Instituts für Entrepreneurship und Innovation der Wirtschaftsuniversität Wien werden jedes Jahr die innovativsten Unternehmen des deutschen Mittelstands ermittelt. Die Prüfung des Innovationsmanagements des oben genannten Unternehmens brachte hervorragende Ergebnisse. Damit zählt das Unternehmen zu den Top-Innovatoren im Mittelstand.

*Prof. Dr. Nikolaus Franke*

PROF. DR. NIKOLAUS FRANKE  
Institut für Entrepreneurship und Innovation  
Wirtschaftsuniversität Wien

26. Juni 2015

*Ranga Yogeshwar*

RANGA YOGESHWAR  
Mentor  
von TOP 100

Germany's most innovative medium-sized enterprises in 2015

A project coordinated by the Institute for Entrepreneurship and Innovation at the Vienna University of Economics and Business Administration was launched to find Germany's most innovative small and medium-sized enterprises. As a result of this survey, the quality of the innovation management practised by ARGO-HYTOS was rated 'outstanding'.

ARGO-HYTOS is therefore one of the most innovative small and medium-sized enterprises in Germany.

## Develop solutions with passion

The fact that tractors, wheel loaders, wind turbines and machine tools can perform their work efficiently is attributable to a powerful hydraulic and sensor system. With passion develops, manufactures and distributes the ARGO-HYTOS GmbH worldwide products and system solutions for these mobile working machines and stationary applications. A strong process orientation and the intensive networking of the top management and the specialist world ensure these fluid technology experts continuous growth.

Today, software tools provide enormous support on innovation projects: they provide a structured approach, accelerate the innovation process and optimize the lead time. At ARGO-HYTOS all steps of the innovation process are displayed in a process management system that works according to the Wiki principle. In addition, powerful design and simulation tools support the developers. Thus, processes can be continuously improved.



## Beyond the innovation process

In this company, a basic distinction in development is made between innovation, development and variation processes, depending on the complexity of the task. A steering committee, consisting of the managing directors and heads of the departments, evaluates each individual stage of the five-stage innovation process in the so-called product development meeting. Only then a project is released for the next higher level. Level five begins one year after series start-up of a product: It is now undergoing a revision, during which potential planning deviations can be discussed and corrected, if necessary.

## Intensive networking

The members of the management board are very active and strongly linked within the research and innovation landscape, e.g. with some universities to which they place research contracts. In addition, they support the Endowed Chair for Mobile Working Machines of the Karlsruhe Institute of Technology, where the technical manager of the company belongs to the scientific advisory board. Moreover, the company is active in various forums, working groups and committees of the "Research Fund of the Professional Community Fluid Technology", which is part of the "German Machinery and Plant Manufacturing Association". Also the collaboration with engineering companies is very important for the top management, because they serve as a source of ideas and project partners. On "Tech-Days", the developers of the company exchange ideas with the customer's developers. By so much valuable input, innovations succeed almost as if by magic - which is evidenced by numerous patents.

"Innovation is within our corporate culture".  
Dr. Marcus Fischer, Matthias Vorbeck and  
Christian Kienzle, managing directors



We make your products better. **Worldwide.**