SECURITY FOR AVIATION AND SPACE TRAVEL

The airplane is one of the safest modes of transport in the world. This can be attributed to the excellent training of the pilots and the sophisticated technology both on board and on the ground. This applies even more so to space travel. This is where KELLER AG für Druckmesstechnik joins the ranks of suppliers of high-security technology with its transmitters.

Safe aviation

Many people get an uneasy feeling when they board an airplane, as opposed to when using a car, even though the latter presents a significantly higher likelihood of being involved in an accident. According to the Federal Association of German Aviation (BDL) and the Aviation Safety Network (ASN), a total of 4 billion passengers were transported by air in 2017, 79 of whom died in ten civil aviation accidents. In 2017, the risk of losing your life on a commercial flight had fallen to its lowest level since records began. According to the BDL, 13 times more passengers are being transported by airlines than in 1970. Despite this growing number, the statistical probability of being killed in a plane crash averaged 1 in 264,000 in the 1970s and stood at around 1 in 92,750, 000 in 2017. This means that flights were 350 times safer in 2017 than they were in the 1970s. These records do not take account of accidents involving military aircraft or smaller airplanes with less than 14 passenger seats on board. This success is due to the improvement in aviation technology, airport infrastructure and air traffic control. Nowadays, airplanes are generally less susceptible to interference. This success can also be due down to the careful selection and strict screening of suppliers and their products.

KELLER pressure transmitters in aviation

KELLER has been supplying pressure sensors to all manner of aircraft fleet sectors since 1997. The main application areas are:

- Cabin pressure control
- Hydraulic distributors and filters
- Valve control
- Fuel pumps
- Refueling systems
- Air conditioning systems
- Ventilation
- Emergency oxygen supply for pilots

As can be seen in the graphic below, ten different pressure transmitters are used throughout the entire aircraft. Depending on the type of aircraft, either all application areas are handled by KELLER, or only certain parts of them. The specific application description is subject to an obligation of secrecy. Three types of improvement in aviation technology, airport infrastructure and air traffic control. Nowadays, airplanes are generally less susceptible to interference. This success can also be due down to the careful selection and strict screening of suppliers and their products.

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Airbus A380

The four-engined wide-bodied A380 aircraft has two fulllength passenger decks and a capacity of up to 853 passengers, making it the largest civil series aircraft. It has an operating range of 15,200 km and a cruising speed of approximately 900 km/h. Two compact air conditioning systems ensure the right temperature is maintained. These packs have an output of around 450 kW. When the systems are running at full capacity, the cabin air is completely replaced every three minutes. Unlike common commercial aircraft, the A380 has just two hydraulic circuits. The third hydraulic circuit has been replaced by local electro-hydraulic actuators. This saves weight as there are fewer cables and valves. The fuel tanks are part of the supporting structure and are located in the wings and the elevator unit. By means of controlled emptying of the tanks, the centre of gravity of the airplane can be automatically adjusted during the entire flight, thus optimising the load on the aircraft structure. The system automatically controls re- and defueling.

Airbus A400M

The Airbus A400M is to replace or supplement the largely obsolete fleet of transport aircraft in the air forces of seven European NATO states. The four-engined machine has turboprop engines and an accessible tail ramp, and can take off from short, unpaved runways. Although the A400M is already widely used, its technical development has not yet been concluded.

"There are currently around 40,000 pressure sensors from us in the air – 30,000 or so of which are just for regulating cabin pressure. The precise regulation of the cabin pressure is a clear added bonus for passengers comfort, particularly during take-off and landing. At present, practically the entire Airbus fleet, the Brazilian Embraer, the "Dreamliner" from Boeing and various business jets are flying with KELLER pressure measurement technology."

Boeing 787

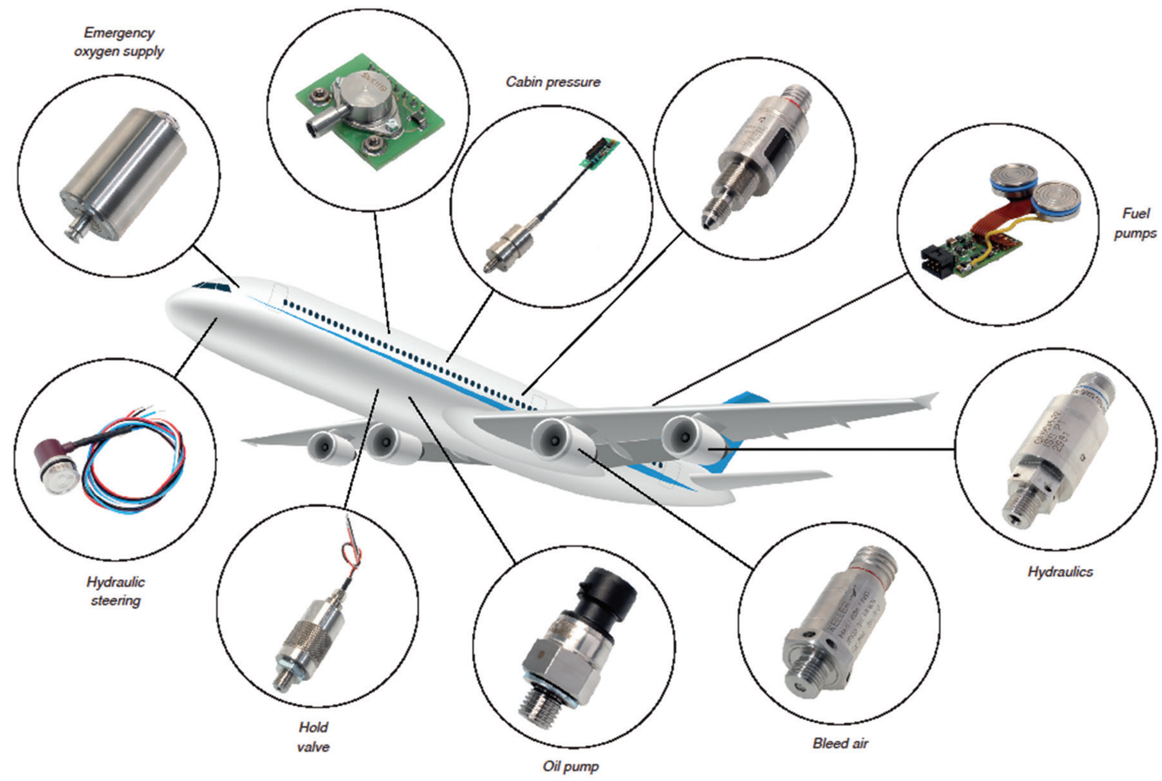
The so-called "Dreamliner" is a twin-engined long-haul aircraft with space for up to 300 passengers. It is the first "twin-aisle" wide-bodied aircraft whose body is made primarily of carbon-fibre reinforced plastic (CFRP). In view of the reduced weight, the newly developed engines and improved aerodynamics should save 20% of fuel and be significantly quieter. Yet, despite the lightweight design, the "Dreamliner" stil meets the specified cabin noise limits.

The special feature of the engines is that they do not release any bleed air into the air conditioning system. This means that engine oil cannot contaminate the cabin air. Each engine has two starter generators, each 250 kVA, that are used to start up the engines and generate electricity. The air conditioning system works electrically too. The 787 has a so-called inerting system as standard. This extracts nitrogen from the air using a special filter system and directs it into the tanks. This reduces the oxygen percentage to such an extent that a fire cannot be triggered, even in the event of flying sparks.

"KELLER's pressure measurement technology has proven its reliability over hundreds of thousands of flying hours. For example, error-free operating times of between 200,000 and 400,000 hours are required for cabin pressure sensors. In most cases, field data is hard to come by. However, some time ago, one of KELLER's major clients confirmed that, over an observed year, an MTBF (mean time between failure) of more than 1 million hours could be detected – a figure that KELLER employees can be proud of."

Safe space travel

The International Space Station (ISS) with ESA's Columbus laboratory on board flies around the Earth at an average altitude of around 400 km at a good 28,800 kilometers per hour. It therefore takes the station just 90 minutes to go around the Earth. For the astronauts, this translates as 16 sunrises and sunsets each day. Several space agencies have joined forces for the ISS project – the American NASA, the Russian Roskosmos, the European ESA, the Canadian CSA and the Japanese JAXA.



The ISS was permanently inhabited by astronauts for the first time in November 2000. The space station is a modular construction and now measures 110 x 100 x 30 m and weighs in at around 450 tons. The individual modular components were put into orbit by launchers and space shuttles and assembled there. The modular component of the European Columbus research laboratory was installed in February 2008 by the 16th long-term crew. The Columbus laboratory is the ESA's greatest contribution to the station.

Since May 2009, an average of six astronauts have been working on the ISS. With the participants, the space station is suitable for operation until at least 2024. From a technical perspective, operation until 2028 is feasible.

KELLER pressure transmitters in space travel

Requirements that apply to aviation apply to an even greater extent to space travel. Emergency landings are not an option and providing replacements is also not as easy as it is with airplanes. A few years ago, KELLER was approached by a leading German aviation and space travel company. It required highly reliable absolute and differential pressure sensors for the ACLS (advanced closed loop system) that would ultimately be used in the ISS.

The aim of the ACLS is to remove carbon dioxide from the module atmosphere and generate breathable oxygen in a closed circuit. This system, featuring 37 KELLER sensors, was transported in the HTV-7 supply ship of the H-IIB rocket to the Columbus laboratory on the ISS in September 2018.

In order to generate breathable oxygen, a subsystem of the ACLS concentrates CO_2 from the cabin air. A so-called Sabatier reaction ensures that hydrogen and carbon dioxide react through a catalyst to create water and methane. The condensed water is separated from the gas flow and directed back into the water management system. An electrolyser splits the water into hydrogen and oxygen. The methane is vented.

The ACLS is designed for a crew of three astronauts and saves 450 kg of additional water load per year. It also removes 3 kg of CO_2, supplies 2.5 kg of O_2 and produces 1.2 kg of water a day. This dramatically boosts the efficiency of the overall system and reduces the demand for supplies from Earth.

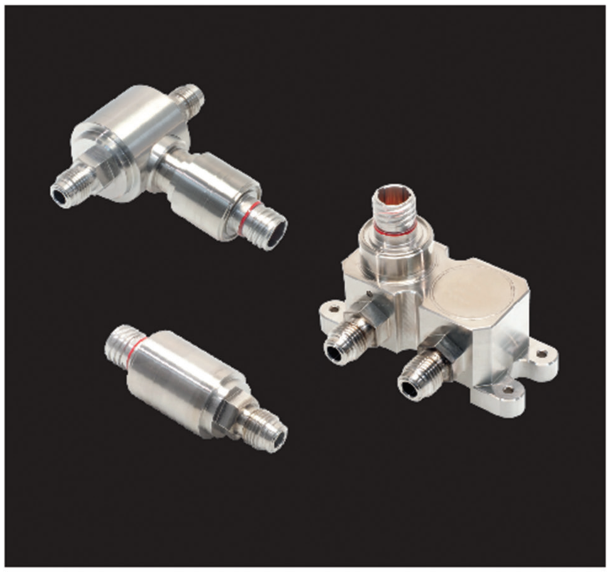
As is commonly the case in space travel, a set of sensors for the ACLS was manufactured and delivered twice in advance, which were included in the device samples for development and qualification. Findings from this were then considered in the final version. These samples remain on Earth and will continue to be used for test procedures, simulations, and for briefing the ISS crew on malfunctions, repairs, and maintenance of the ACLS.

Criteria for aviation and space travel

In aviation, just like in space travel, cutting-edge technology is not used. For both, maximum reliability is more important, and the products being used have proved themselves in this regard. Furthermore, airplanes are usually used in operation for 25 to 30 years and beyond and the replacement parts need to be available for this long. According to the meticulous maintenance instructions of the aircraft manufacturers, a component may not simply be replaced by any other component, but only by exactly the same component from the same supplier. That is why it makes sense to not use standard products in this case. KELLER develops all its components with specific customers in mind in order to ideally take care of the respective task. This means that there is also no universal solution, but rather custom-designed technology to be used for all manner of requirements. This is the only way to meet the requirements for maximum reliability under the required environmental conditions.

Contrary to the initial positive statistics, some events in the last two years can occasionally leave the impression that economic interests outweigh the reliability requirements. KELLER opposes the idea with a careful and detailed examination of each customer inquiry to ensure the highest reliability for all

Commander Alexander Gerst from the European Space Agency (ESA) successfully installed the ACLS module on the International Space Station (ISS) on 24 October 2018



Absolute and differential pressure transmitters regulate regenerative processes in the oxygen supply...

... on the International Space Station (ISS)

components. Unfortunately, that means that two thirds of inquiries are rejected due to incomplete specifications.

Special technology for special applications

The developments made in aviation and space travel over the last decade would not have been possible without reliable underlying technology. KELLER, with its high-precision and reliable pressure transmitters, has thus also played its part in this development since 1974.

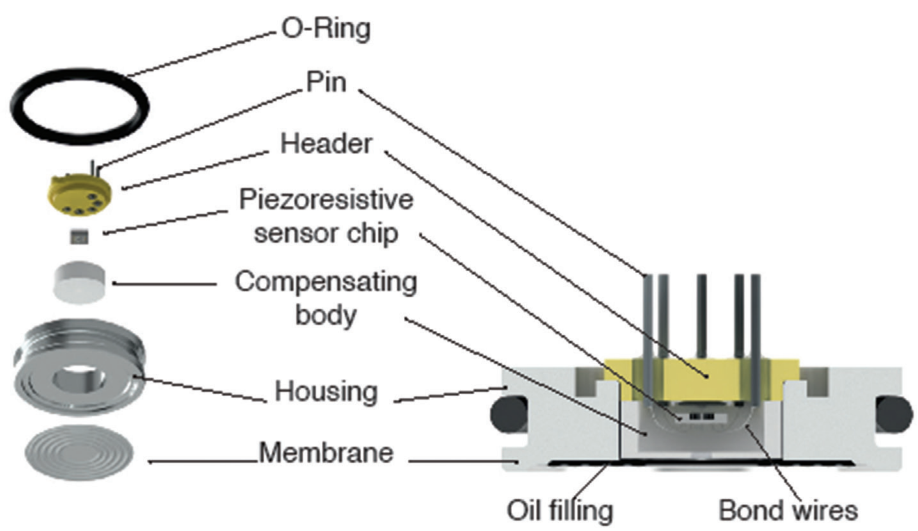
Underlying piezoresistive technology[1]

The core of the pressure transmitters being used in aviation and space travel is a piezoresistive silicon pressure sensor. The actual sensor is made from an elastic silicon diaphragm that is malleable when pressure is applied. The diaphragm bends to both sides according to the pressure difference, which causes mechanical tension in the surface. In order to be able to measure this mechanical tension, resistors are diffused into the peripheral zone of the diaphragm where this tension is greatest. The resistors react much more strongly to the mechanical tension due to the piezoresistive effect than conventional strain gauges, which only follow geometric changes. The major benefit is thus the extremely high sensitivity paired with the good zero-point stability. The latter results from the use of single crystal silicon material, which unlike metal, knows no deformations.

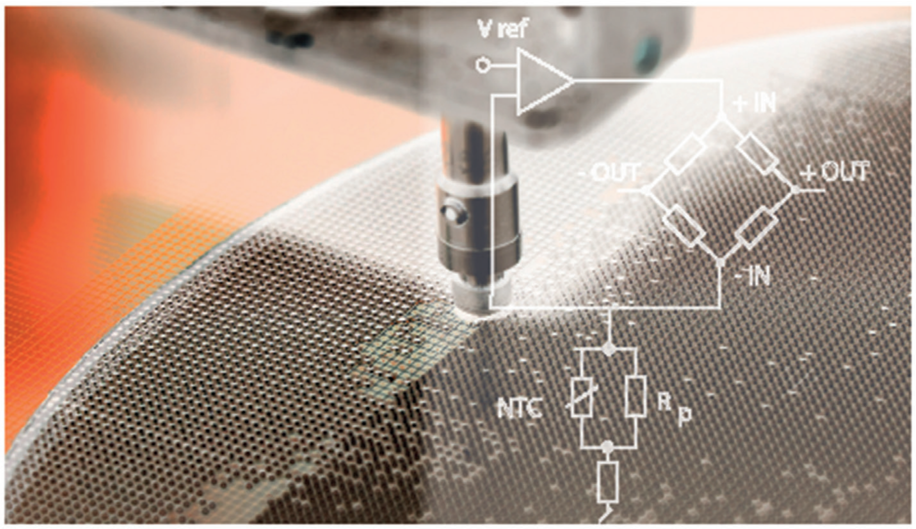
The piezoresistive technology, based on silicon chips, has proven itself in day-to-day use and is being used in ever more extreme environments. The key to its respective use is thus less about the technology itself, but rather the "packaging" of the piezoresistive sensor chips. Unlike metallic diaphragms, the silicon sensor was not so media-resistant and initially could only be used in dry, clean air or in non-conductive media. However, with the silicon diaphragm, an intelligent enclosure and the corresponding circuitry can be used to build high-precision, reliable pressure sensors.

As one, or both, measurands may be incompatible with the silicon sensor, it is necessary to protect the sensor from the media. For KELLER, pressure measurement against a vacuum seemed like the best option in aviation and space travel as only one side needs to be protected against media. The electrostatic bonding of the silicon measuring cell onto glass was a process that provided the necessary vacuum on the back almost free of charge. Without the vacuum, electrostatic bonding, which is based on ion migration between the glass plate on the back and the silicon, does not work. Even the design of the oil filling and insulation against the media to be measured was a problem. Due to the many effects that need to be controlled when constructing a piezoresistive silicon measuring cell, it is understandable that a sensor of this kind is always 10 to 100 times more expensive that the silicon measuring cell alone. "In other words, the customer buys the packaging and receives the cells virtually free of charge", summarises Jürg Dobler.

Thanks to their high level of accuracy and major reliability, oil-filled piezoresistive pressure transmitters have now secured a leading role in pressure measurement technology and are at the heart of the pressure transmitters of aviation and space travel with this technology.



Construction of an insulated, oil-filled piezoresistive pressure sensor



[1]For more information see Piezoresistive Pressure Measurement Technology

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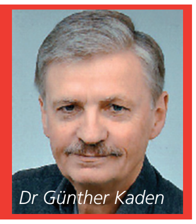

Dr Günther Kaden