VACUUM SYSTEMS FOR MOBILE ANALYTICS

Mass spectrometers and leak detectors for field use

Applications increasingly require analytical systems that are easy to transport and are suitable for mobile use. Mobile gas analysis, mass spectrometry and leak detection are used, for example, for investigating pollution caused by road and air traffic, for analyzing the quality of water, for detecting explosives and toxins at airports, and for mobile analysis of respiratory gases.

Mobile analytics pose sizable challenges for the vacuum equipment used: First and foremost, backing pumps and high vacuum pumps, and mass spectrometers must be small and lightweight. They must also use very little energy and work reliably in motion even when exposed to light vibrations. Table 1 provides a detailed overview of the requirements. The information which follows describes some examples of existing mobile analysis systems and the types of application they are used for.

Mobile mass spectrometer system in a vehicle – with Pfeiffer Vacuum solutions

Scientists at the University of North Texas in the USA, led by Dr. Verbeck, have developed a mobile mass spectrometer system which was fitted in the trunk of a hybrid vehicle. It is used there directly in situ, for example, to investigate any negative influences of fracking fields on the environment. Key challenges posed by this mobile system:

Application	Requirements for	
	Turbomolecular pump	Backing pump
Portable mass spectrometer	Small	
	Lightweight	
	24V DC power supply	
	Reduced power requirement	
	Operates while in motion	
	Final vacuum < 10^{-4} – 10^{-5} hPa	Final vacuum < 3 hPa
	Pumps air	
	10 l/s-class very robust	Very robust
	30 – 80 l/s-class portable	
Portable helium leak detector	Small	
	Lightweight	
	Reduced power requirement	
	Operates while in motion	
	Compression ratio for helium > 10^5	Final vacuum < 10 hPa
	Pumps helium	
	Helium pumping speed > 30 l/s	Helium pumping speed > 1.5 m^3/h
	SplitFlow version for high/low	Multi-stage (diaphragm pump)
	Fast operational readiness	
	Short recovery time after helium ingress	

Table 1: Vacuum equipment requirements in mobile systems

All vacuum components must work on 24V DC. Further criteria for selecting the best possible equipment were

- Light weight
- Small installation footprint
- Low power input for long battery operation
- Insensitivity of vacuum equipment to vibration

Faced with these tough quality requirements, researchers opted for Pfeiffer Vacuum solutions. In addition to the analyzer,the system shown in figure 1 is fitted with a special small SplitFlow turbopump and an MVP 003 diaphragm pump with DC drive as a backing pump.

Portable mass spectrometer systems

In a pilot project, Pfeiffer Vacuum has developed a prototype vacuum system for use with a mass spectrometer system. This is mounted on a carrying frame (figures 2 and 3) and can easily be carried like a backpack due to its light weight of only nine kilos. It is powered by an integrated 24 V DC lithium-ion battery. This makes the system completely independent of an energy source. A weight-optimized HiPace 10-type turbopump with a pumping speed of 10 l/s and a two-stage MVP 003-2 diaphragm pump with a pumping speed of 0.1 m^3/h are responsible for the lightweight design of the system. It is equipped with a cold cathode high vacuum transmitter and a piezo/Pirani fore-vacuum gauge for conducting vacuum measurements. The analyzer can be incorporated in the vacuum chamber.

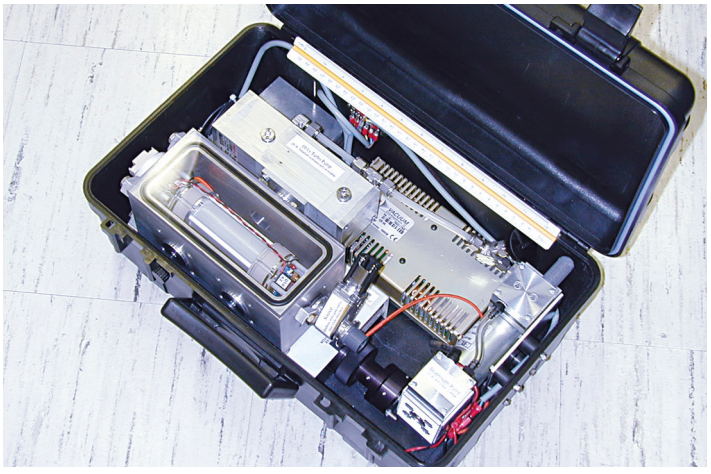


Figure 1: Johns Hopkins University, Baltimore, USA mass spectrometer system with vacuum equipment from Pfeiffer Vacuum

INFOBOX

Applications for mobile analyzer systems

- Investigating environmental impact of road and air traffic
- Analyzing pollution
- Personal protection following accidents in chemical and petrochemical plants
- Determining explosive atmospheres in hazardous plants
- Analyzing water
- Mobile geochronological dating (e.g. of glacier ice)
- Characterizing volcano emissions locally for early warning of volcano eruptions
- Localizing underwater volcanoes using CO_2 detection on board a submarine
- Determining the environmental impact of fracking
- Analyzing oil and gas during exploration and processing
- Observing climate changes caused by global warming
- Detecting explosives and toxic substances, such as for baggage monitoring at airports or on airplanes
- During police investigations, such as for examining traces of smoke
- Military applications, such as detecting toxic gases during war missions
- Detecting illegal drugs during roadside checks on motor vehicles and persons and when searching for drugs
- Mobile analysis of respiratory gas
- In situ leak detection in plants and in vacuum systems

Infobox 1: Applications for mobile analyzer systems

Mobile mass spectrometer system for measuring emissions from volcanoes

Seismological measurements often lack validating data from the site of activity to enable future volcano eruptions to be forecast more precisely. Accurate predictions to back up rapid response measures to evacuate inhabitants and divert air traffic away from heavy ash emissions, can only be made if these data are available. These measures can save lives and prevent considerable commercial losses.

Measuring equipment for in-situ use to monitor and analyze gases from volcano smoke plumes was developed jointly in a project by JPL (NASA), INGV Vesuvius Observatory, Inficon Inc. USA/Germany, Creare Inc., USA with the University of Costa Rica and the NASA Ames Research Center, USA.

Optimizations that were necessary for satellite calibration and validation were also developed. The result was a mobile system with a mass spectrometer for analyzing gases, a radiometer, and laser optical particle counters (figures 5 and 6).

Figures 2 and 3: Pfeiffer Vacuum portable vacuum system for mass spectrometry

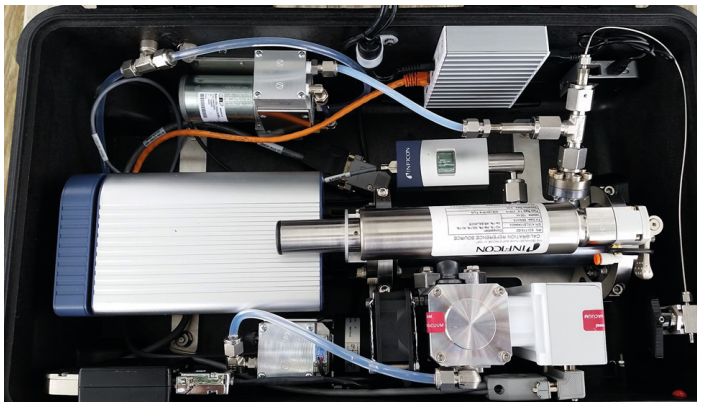


Figure 4: Mobile mass spectrometer system with Inficon analyzer and transmitter, Pfeiffer Vacuum HiPace 10 turbo-pump and MVP003-2 diaphragm pump in a 24 V DC version

This system can be used for conducting the following measurements:

- Gases such as SO_2, H_2S, CO_2, helium, CH_4
- Temperature, pressure and humidity
- GPS coordinates and elevation
- Emitted particles
- Ash samples (aerosol particles) for analyzing the influence on air traffic

The smoke plume zones over the volcano are monitored. To enable measurements to be taken, the system is combined with an unmanned aerial system which flies over this area of the volcano.

Besides measuring volcano emissions, these systems have also been used for numerous other analyzing purposes:

- Detecting toxic BTEX substances (benzene, toluene, ethylbenzene, xylenes) in the field of oil and gas extraction and processing sites

Figure 6: ASM 310 mobile helium leak detector made by Pfeiffer Vacuum

Figure 5: Professor Dr. Andres Diaz, of the University of Costa Rica with the mobile system on a volcano in Italy

- Environmental analyses on the subantarctic continent (Chile)
- Analyses on volcanoes in Italy, Costa Rica and Hawaii
- Detection of illegal drugs

Portable helium leak detectors

Mobile and portable leak detectors are essential for a wide range of uses - for assembling and installing vacuum systems or for quantifying leaks in service applications. Both mobile and stationary leak detection is particularly accurate and reliable when helium is used as the tracer gas.

There are two basic operating modes available for helium leak detectors:

- The vacuum method, where either a section or the whole system is evacuated and exposed to the tracer gas helium from the outside
- The sniffing method, where the test sample is filled with tracer gas at an overpressure of $\Delta p > 100$ hPa. The escaping helium tracer gas is sucked into the leak detector through a sniffer valve and then detected

Both methods, together with their operating principle and detection limits, can be referred to in table 2. Detectors whose overall weight does not exceed roughly 25 kilos are classed as mobile or portable detectors. They are portable, can be transported in a vehicle and checked as baggage on airline flights.

Pfeiffer Vacuum has an array of mobile leak detector systems in its product portfolio, covering a broad range of applications.

Figure 7: MiniTest 300 portable leak detector

Figure 8: Mobile case on wheels for the MiniTest 300

The ASM 310 (figure 6) is suitable for both vacuum detection and sniffing detection of leaks. It offers a whole range of convincing advantages:

- Dry pumping system
- Fore-vacuum pumping speed of 1.7 m^3/h
- Ultralight (only 21 kilograms) and mobile
- Smart design with retractable handle
- For horizontal or vertical operation
- Removable control panel with magnets for positioning on a metal surface
- SD memory card provides storage capabilities (bitmap or text file) and makes it easy to post-process leak detector results
- Large bright color touchscreen with graphics
- Intuitive and customizable menu

The MiniTest 300 (figures 7 and 8) is a quartz window leak detector weighing only 5 kg. It is available with a mobile case on wheels and can be used in inaccessible places thanks to its compact dimensions of about 30 x 20 x 26 cm. The MiniTest works on the vacuum detection method only. By dispensing with a backing pump, this model is extremely lightweight. Advantages at a glance:

- Rugged, reliable and easy to service
- Vacuum leak detection with a quartz window sensor for localizing and quantifying even the smallest of leaks
- Compact size and lightweight – ideal for service call-outs
- Leaks of up to $5 \cdot 10^{-7}$ hPa l/s detectable at a pumping speed of 1 l/s
- Good water vapor tolerance
- Inlet pressure up to 200 hPa abs.
- Option to connect an external compact gauge
- Low maintenance costs

Do you need help choosing or designing the best vacuum solution for your application? Please feel free to contact us!

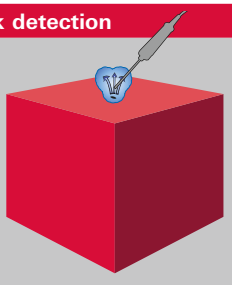
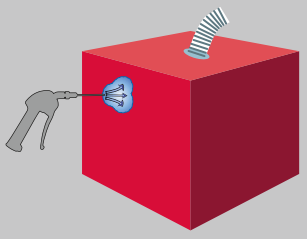
	Sniffer leak detection	Vacuum leak detection
Portable leak detector		
Method	Sniffing the test gas-filled test object	Spraying with helium
Mechanical strength	Against overpressure	Against atmospheric pressure from outside against vacuum (differential pressure 1000 hPa)
Detection limit	$< 1 \cdot 10^{-8}$ Pa m^3 s^{-1}	$< 5 \cdot 10^{-13}$ Pa m^3 s^{-1}

Table 2: Sniffing and vacuum methods with their detection limits

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