



## BAM ensures safe oxygen cylinder filling with FLIR thermal imaging camera

*We all breathe oxygen. Without it life as we know it would not be possible. But oxygen, especially when pressurized, can be extremely dangerous. It is highly reactive and can form chemical bonds with almost all other elements. Pressurized oxygen is used in chemical plants and iron ore smelting, but also in hospitals and for scuba diving. To ensure user safety all equipment and components that come into contact with pressurized oxygen therefore need to be thoroughly tested. This is the task of the Federal Institute for Materials Research and Testing (BAM), Berlin, Germany, working group 'Safe Handling of Oxygen'.*

The Federal Institute for Materials Research and Testing aims to improve safety in technology and chemistry through research and development, testing, analysis, approvals, advice and information. The working group 'Safe Handling of Oxygen' is part of the division 'Chemical Safety Engineering'. At their lab in Berlin the researchers of the working group 'Safe Handling of Oxygen' test the reactions of different materials and component designs to oxygen at varying pressures and temperatures.

### Reaction with oxygen is unpredictable

"To handle oxygen safely it is of utmost importance that each material and each component used in any setup that involves pressurized oxygen is tested thoroughly", says Thomas Tillack, researcher at the working group 'Safe Handling of Oxygen'. "The reaction of certain materials and

designs to high quantities of oxygen can be very strong and is highly unpredictable. We've had situations where certain valves that had always performed well in the tests suddenly responded strongly to the presence of oxygen. This was usually caused by a subtle change in the composition of certain alloys by one of the materials suppliers or by a small change in the geometry of the internal design. Such tiny changes can have disastrous consequences if implemented unchecked."

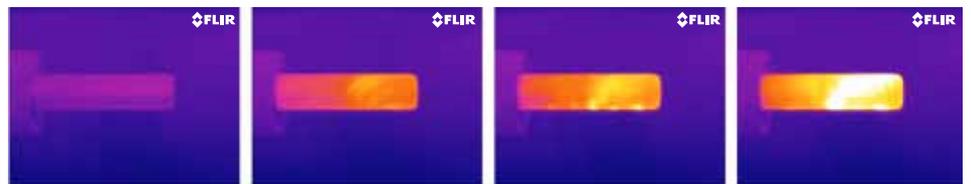


*Thomas Brock and Thomas Tillack, researchers at working group 'Safe Handling of Oxygen'.*

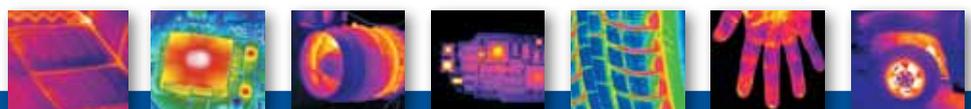
Even if a tiny part starts to react with the oxygen the end result can be devastating. "If one small part of a component starts to react this causes a rise in temperature. This in turn may cause other parts to react as well. This starts a positive feedback loop that can be very destructive, even explosive, as more and more parts ignite."

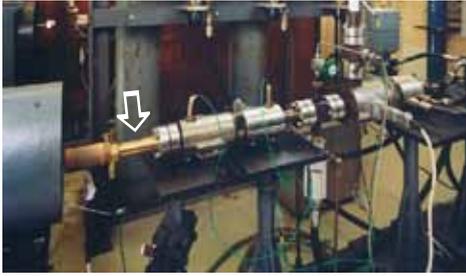
### Advantages of thermal imaging

One of the tools used in the safety tests is a FLIR SC4000 thermal imaging camera. "One of the main criteria for determining whether a material or piece of equipment reacts with oxygen is a temperature rise", explains Tillack. "We acquired the FLIR thermal imaging camera to perform non contact temperature measurements. Other methods to measure



*Ignition of a finely divided nonmetallic sealing material by an oxygen pressure shock; the movement of the material within the container as it reacts with the oxygen can be seen in the thermal sequence.*





During an oxygen pressure shock test, the material in the container is exposed to a rapid pressure rise e.g. from ambient pressure up to 300 bar.



This valve showed a devastating positive feedback loop during an oxygen pressure shock test which consumed the valve in the process. Needless to say the client discarded it as a flawed design.

temperature are thermocouple sensors and spot pyrometers, but thermocouples can be easily destroyed if there is a strong reaction with oxygen and spot pyrometers measure only temperatures at one location, while the thermal imaging camera gives us temperature readings across the entire scene. That is why we prefer to use a thermal imaging camera."

The FLIR SC4000 used at the BAM working group Safe Handling of Oxygen contains a Focal Plane Array (FPA) made of Indium Antimonide (InSb) providing thermal images at a resolution of 320x240 pixels and a sensitivity of 13mK (0.013 °C) and it captures these high contrast thermal images at a frame rate of 432 Hz. Increased frame rates can also be achieved with windowing. For BAM requirements, it is calibrated to accurately measure temperatures as high as 1,800 °C.

With its wide temperature range, excellent thermal sensitivity, fast frame and its feature packed and user friendly analysis software the FLIR SC4000 thermal imaging is a perfect

tool for these safety tests and fulfills all demands of BAM. "The software we use is ThermaCAM Researcher", explains Tillack. "This complete software solution from FLIR Systems can be used to analyze the high speed thermal footage we record and it allows us to process the vast amount of thermographic data we capture during those recordings."

### Determining reaction thresholds

The FLIR SC4000 thermal imaging camera is often used with so-called 'pressure shock tests'. The test material is finely divided to small flakes or grains, put into a stainless-steel container and exposed to the pressurized oxygen. The thermal imaging camera is used to detect the temperature rise on the outer surface of the container. "Using the thermal imaging camera it is possible to detect a temperature rise which involves a chemical reaction of the material with oxygen. Performing these tests at different starting temperatures and at different oxygen pressures, potential reaction thresholds could be determined." To be able to better utilize the FLIR thermal imaging camera the researchers use black paint with a high emissivity to coat the container. "This allows us to more accurately measure the temperature of the material", explains Tillack. He admits that he was happily surprised with the results. "The thermal images show a surprising amount of detail. You can even see the movement of the burning particles as they are blown about in the container by the oxygen pressure shock."

### New test setups

The success with the pressure shock test has led to an expanding amount of applications at BAM, according to Tillack. "We're working on a new version of a test to determine the combustion properties of certain metals in pressurized oxygen. We suspend a thin rod of the material inside a pressure chamber and start the combustion process with an ignition pill made of a material that reacts with the oxygen immediately. The rise in temperature causes the test material to ignite as well."

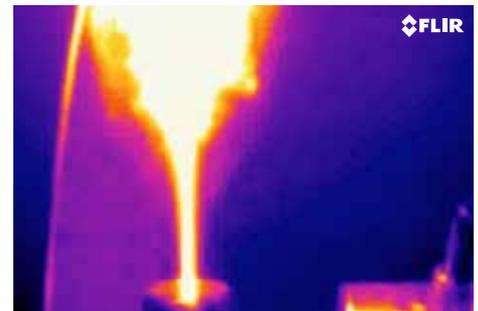
Currently Tillack uses a CCTV camera and three spot pyrometers to detect the burning behavior and the velocity with which the reaction travels up the rod. But the CCTV is blinded by the flash caused by the reaction and the pyrometers give too little information for a proper analysis, due to the fact that it just tells the temperature at a single spot. Therefore, an infrared window shall be installed in the test setup to allow the FLIR thermal imaging camera to be used instead. "This should give more detailed information on the burning velocity of the metallic material in oxygen, which is an important criterion for evaluation."

### Worth the investment

All in all, for BAM the purchase of a thermal imaging camera system was the right decision. The FLIR SC4000 thermal imaging camera meets all the criteria that are important for the mentioned experiments at BAM and the researchers of BAM are still finding new possibilities to apply it.



Test apparatus for determining the combustion behavior of metallic materials in high pressure oxygen - the test setup will include the FLIR thermal imaging camera in the near future with the inclusion of an infrared window.



This oxygen component shows high ignition sensitivity to a promoted ignition impact during an ASTM- G175 test.



The ASTM- G175 test investigates the ignition sensitivity of oxygen components to a promoted ignition impact. Ignited material is blown into the oxygen component and the thermal sequence is used to determine how strongly the component reacts.

For more information about thermal imaging cameras or about this application, please contact:

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