Thomas Graf inspects the mixer unit of the Perseus A500, shown here in his hands.
Custom-Made in Series

The production of an **anesthesia machine** is precision work, almost all of the machines are made to customer-specific requirements. Yet they are alike in one respect: extensive and thorough tests are part of the manufacturing process.

This 20-liter glass bottle is supposed to be the lung? “Well,” says Ludovic Vieillemard, “for our new anesthesia machine, there isn’t much of a difference between this bottle and a human lung in our final test of the system!” The Frenchman leads the startup of Dräger’s series production for the Perseus A500. He nimbly winds his way through the manufacturing hall in Lübeck where production of the anesthetic workstation has been under way since March 2012. With this product, Dräger is once again defining the state-of-the-art; technology that starts here.

The green light for a product so complex and individual as this one was naturally given at a much earlier point in time. “We plan the individual steps from development to production in a cross-functional team, or CFT,” says Vieillemard, a trained mechanical engineer who previously worked at Renault, among other places. He explains the CFT as follows: “In this team they come from product management to service, research and development, purchasing and quality assurance to production, all project leaders meet regularly to share their needs.” This process has to get past six carefully defined milestones called ‘gates’. Only the products that fulfill all these requirements ultimately pass through the last gate for shipping and are then sent all over the world on pallets. After Gate 3, a project leaves what Vieillemard refers to as the ‘paper-intensive phase’.

In the case of the Perseus A500, the last phase of this process—series production—has been reached. “First we produce the part of the anesthesia machine that’s the same for all later variants,” explains Vieillemard as he opens the door of a climatic test chamber. Inside here the mixer unit—one of the two central assemblies of the anesthesia machine—is currently being artificially aged (at temperatures fluctuating between 5° and 55° C). The second assembly is the ‘base unit’ (see also Dräger Review 105, p. 56).

**Substantial investments in quality assurance**

“Here we have one of the most expensive test stations in the entire company,” says Vieillemard as he closes the door with the observation window. For the first time in the production of anesthesia machines, Dräger is adding a component stress test to the classic functional test. This additional test is carried out prior to the product system test. “That accelerates production and simultaneously increases quality and reliability,” says Vieillemard, sketching out a shape like a bathtub on a piece of paper. “If something is going to break down, it will probably happen during the first weeks. After that, things are quiet for a long time. And only after years of trouble-free oper-
There is little debate when it comes to investing in quality assurance.

> ...tion does the likelihood of component failure begin to rise again."

At each station, sophisticated methods test the system’s behavior during the critical initial operating period at time-lapse speed. The machines are subjected to a great deal of stress: severe temperature fluctuations, abrupt changes in settings, frequent switching on and off with voltage spikes, and continuous operation. Artificial aging is a complex production method that has been increasingly perfected in recent decades. It isn’t enough to simply increase the temperature so that the days shrink in proportion. “That would be too mundane,” says Vieillemard, referring to the long series of tests that lead precisely to the stress profiles that reliably cause the service life to decrease. “It isn’t just the high temperature gradients in the climatic test chambers. What’s just as important is the software we’ve developed that allows us to simulate several days of normal machine operation in just four hours by running more than 200 test cycles.”

**RFID technology for even greater safety**

After every procedure the testing module responds with a specific code indicating whether everything is OK, or whether an expected value was not reached. And if not? “Then we cool it down to 20°C, find out the reason, and eliminate the source of the fault – then we send it off on our obstacle course again,” says Vieillemard. Did he have to justify the investments in climatic test...
chambers and so forth from an economic standpoint? The answer is obvious: “When it comes to investments that improve our quality, there’s little debate!” he says.

The mixer unit has approximately 30 design-specific parts; these are usually so special that they are manufactured exclusively for a single purpose. In addition, the base unit is made up of five times as many parts that are found in the mixer, and the machine as a whole has many more. The assembly and testing processes are therefore correspondingly elaborate. On the production line, a cover plate hasn’t yet been mounted on one of the machines, leaving a huge number of printed circuit boards, modules, and control elements open to view. They show the challenges involved in combining mechanics and electronics into a life-sustaining system. Any mistake—whether it occurs during development, manufacturing, or the final assembly stage—would be a potential source of hazard later on. “This is where the RFID modules are located,” says Vieillemand, pointing to some small circuit boards. “For instance, they ensure that the ‘water trap’ is replaced for the sake of patient safety before it stops carrying out its protective and filtering function.”

Finishing with an ultra-marathon

In the base unit test, the 20-liter glass bottles come into play as ‘artificial lungs’. “The copper-colored specialized wool inside the bottles helps to simulate the respiratory cycle by providing mechanical and thermal resistance similar to lung tissue,” Vieillemand explains.

Finally, at the end of the assembly line, the Perseus A500 is finished in accordance with customer specifications and is ready for delivery. Now a final system test is carried out—a ten-day period of continuous operation, with the respiratory bag and the attached breathing-tube-set. “It’s a real marathon,” says Vieillemand, opening the door to the shipping department. That’s familiar!

“Not quite,” counters the Frenchman, pointing to the special lowered pallet that keeps the anesthesia machine under 1.60 meters in height for shipment. “Otherwise the shipping costs would be much higher,” Vieillemand explains. Money is again saved at precisely the point where this can be done, without sacrificing quality or safety—to the very end.

Optical image processing and infrared

Among the many innovations Dräger is using for the first time in an anesthesia machine, one of the most prominent is the optical interface between the Perseus A500 and the anesthetic vaporizers (the “Vapor” models). “With this development,” says Project Manager Claus Bunke, “we considered how the classic field-tested and fully mechanical Vapors can be integrated with regard to the data connections.”

A Bluetooth link was ruled out, for example, because it would have required a supply of electrical power for the Vapors. Instead, an optical solution was developed. In the immediate vicinity of every Vapor there is an LED and a camera behind a red pane of glass. The light-emitting diode gives off infrared light toward the Vapor; the camera records this image, and it is then evaluated by software. “We chose infrared light, which is invisible to the human eye, because the long wavelength doesn’t disturb anyone. The ambient light can’t disturb the camera either,” says Bunke.

Three types of information read from the optical interface:

- The type of anesthetic—in which the Vapor’s filling nozzle always receives only the specific anesthetic.
- The handwheel position—and thus the fresh gas concentration of the chosen anesthetic.
- The fill level—if a minimum capacity is exceeded.