

Leak test process for closed receptacles, test chamber, test set-up and testing device for this process

(With Annex A)

EP 97107520.5

The present invention concerns a process according to the characterizing portion of Claim 1, a test chamber according to that of Claim 7, in addition a test set-up with such a test chamber according to Claim 12 and, finally, a test device according to that of Claim 20.

Leak test processes for closed receptacles during which a pressure difference is created towards their environment, between the interior of the receptacle and its environment, by applying a suction source at the test chamber, are known. Determination of leaky receptacles is carried out by detaching a required suction source from the test chamber after applying a given pressure difference, and, basically, the pressure difference between the interior of the receptacle and its environment is observed over time and recorded. For instance, this is carried out by measuring the pressure values in the environment of the receptacle at no less than two different times.

Depending on the size of the leak, the pressure adjustment between the interior of the receptacle and its environment occurs faster or slower. With regard to a technique such as this, reference can be made, for instance, to WO94/05991 of the same applicant as here.

- 2 -

The process described above, in particular according to the aforementioned WO94/05991, permits detection of extremely small leaks. Problems arise when the receptacles to be tested are at least partially filled with free-flowing filler, in particular with a filler of thin liquid. Then the applied pressure difference extends across the receptacle wall, between the liquid filler and the environment, and the effect of the suction or pressure, if there is a leak, is that liquid filler escapes through the leak into the environment, i.e. onto the exterior wall of the receptacle. Due to the sealing effect of the escaping liquid filler, a leak in the liquid-loaded area of the receptacle wall can only be detected (if at all) by means of pressure measurement, if the observation takes place over a relatively long period of time which, in particular in the case of series testing of receptacles on a production line, is very disadvantageous.

Therefore, the object of the present invention is to provide a process of the initially mentioned type, in which the disadvantages of the pressure test, which were mentioned at the beginning, are eliminated. To this end, the aforementioned process distinguishes itself according to the characteristics in Claim 1: If, as in the above case, liquid filler escapes to the exterior through a leak in the receptacle wall due to the applied pressure difference, this is detected by measuring the electrical impedance according to the invention.

The escaping liquid filler in the area of the receptacle's exterior wall causes a change in the electrical impedance between at least one pair of impedance-measuring electrodes set up in this

area, and measurement of the impedance permits detection of the change in impedance caused by the filler.

Whereas in certain cases it may be expedient to identify escaping filler by means of measuring the electrical AC impedance, it is suggested, in particular for testing receptacles with electrically insulating walls such as plastic walls, and in the case of fillers that are electrically conducting, that a DC measurement, advantageously a low-voltage DC resistance measurement be carried out, for instance using DC voltages below 50 V.

Even though the provision of a single impedance measuring path in the area of the section of the receptacle to be tested may be sufficient if, for instance, very specific points on the receptacle are to be tested for leaks, it is further suggested to provide several parallel impedance measuring paths along the receptacle to be tested in order to detect leaks over the whole receptacle.

According to the invention, this leak testing process based on measuring impedance can be very advantageously combined with the above-mentioned pressure measurement. If receptacles are to be tested that are, as is usually the case, only partially filled with free-flowing filler, so that, besides the liquid filler, there are air inclusions in the receptacle, it is never certain where the air and where the liquid are located in the receptacle. Since, in addition to measuring the impedance for tightness or leakage detection, the pressure difference over time, in particular by monitoring

the pressure in the sealed environment of the receptacle, is also recorded, regardless of whether air inclusions are present and where these are located in the receptacle at any given moment, this results in a combined statement regarding the leakiness of a receptacle: The electrical impedance measurement represents leaks in the sections of the receptacle wall momentarily filled with filler, whereas the detection of a pressure difference represents leaks with regard to the sections of wall with air inclusions. Here, too, after establishing a preset underpressure between the interior of the receptacle and the sealed environment, and after pressure release of the system from a suction source, the high-precision technology known from WO94/05991 is used to determine tightness or leakiness by the pressure difference that occurs, namely by recording the pressure in the sealed environment at no less than two different times, and by evaluating the pressure difference as an indication of tightness. In order to create a highly sensitive measuring process, at the first point in time when the pressure is measured, a zero deviation signal is determined as a reference signal, together with the pressure value, and at the second point in time, the pressure difference is determined with regard to the zero adjustment value to the first point in time. This allows a reinforcement of the aforementioned difference and the evaluation signal corresponding to this difference in order to get a higher resolution.

In this respect it is highly advantageous that the evaluation of a signal indicating a developing impedance difference can be carried out using the same procedure as for the evaluation of a developing pressure difference.

As already mentioned, Claim 7 defines a test chamber according to the invention. Advantageous variations of this tests chamber are specified in Claims 8 to 11.

A test set-up with at least one such test chamber is defined according to the invention in Claim 12, with advantageous embodiments according to Claims 13 to 19. A highly advantageous arrangement of this set-up is achieved in that, in the case of the much preferred variation, measurement of the impedance as well as the pressure is provided for, and one and the same evaluation unit is used. If, for instance, a DC voltage is applied via a precision resistor for measuring impedance on the path between (advantageously) several, parallel electrode paths, and the voltage on the precision resistor is evaluated as a measuring signal, a voltage is applied to the evaluation unit, namely that of the fixed resistance and the voltage that depends on the current that varies with the resistance on the measuring path. The evaluation unit itself becomes a voltage measuring device. By switching to a measuring sensor provided on the test chamber, the same evaluation unit can be used for measuring the pressure-dependent output voltage of the sensor.

A test device according to the invention is specified in Claim 20, preferred embodiment variants in Claims 21 and 22. It is of particular advantage that for multiple test set-ups with at least one test chamber, a main evaluation unit for pressure measurement and a main evaluation unit for impedance measurement are provided, which can be switched respectively between the test

set-ups, or even just one evaluation unit that can be switched back and forth between the individual set-ups and between pressure and impedance measurement.

We refer to application no. filed by the same applicant at the same time (Annex A).

The process according to the invention, the test chamber, the test set-up as well as the test device are, according to Claim 23, advantageously used for testing receptacles with electrically insulating walls, advantageously glass or plastic walls, in particular for receptacles from the field of medicine such as plastic ampoules. The tightness test is advantageously carried out on multiple receptacles forming a set, whereby if one of these receptacles or one of these ampoules has a leak, the whole set is rejected indiscriminately.

The invention is then explained by means of diagrams:

Fig. 1 shows a basic set-up according to the invention in order to explain the process according to the invention in its general aspects;

Fig. 2 shows the design of a test chamber and set-up according to the invention for carrying out the process in its most advantageous embodiment;

Fig. 3 shows an advantageous evaluation configuration of the set-up according to the invention and of the process according to the invention corresponding to Fig. 2;

Fig. 4 shows an advantageous embodiment of an evaluation unit according to Fig. 3 in the form of a logic diagram/functional block diagram;

Fig. 5 shows a simplified, perspective view of an embodiment of the test chamber according to the invention for testing sets of ampoules, whereby only one half of the test chamber according to the invention is represented; and

Fig. 6 shows a logic diagram/functional block diagram of an advantageous embodiment of a test device according to the invention.

According to Fig. 1, a pressure difference Δp is created against the environment U, between the interior I and the environment U of a receptacle 1 to be tested. In the area of the exterior wall of the receptacle at least one impedance measuring path is provided, several according to Fig. 1, as indicated by the complex impedances Z_x . The impedance measuring paths are formed between each pair of measuring electrodes 3a and 3b, whereby these are alternately electrically connected as schematically represented by means of conductors 5a and 5b. This means that the impedance measuring paths Z_x are shown to be connected in parallel to conductors 5a and 5b. The pick-up

conductors 5a and 5b are connected to an impedance measuring unit 7 whose output affects a unit 9 which is sensitive to threshold values. If filler liquid escapes from the receptacle 1 into the environment U due to a leak, at least one of the impedances Z_x changes. The impedance and its change is detected by the impedance measuring unit 7. If the impedance changes more than the threshold value preset on the unit 9, the receptacle 1 that was just tested is recognized as having a leak and is rejected.

Even though, depending on the individual case, complex AC impedances on the impedance paths can be measured and evaluated by means of the unit 7, impedance measurement is advantageously implemented as a DC resistance measurement, in particular for testing receptacles with electrically insulating walls and with electrically conducting filler, whereby the impedance measuring unit 7 actually becomes an ohmmeter.

The process explained in principle in Fig. 1, which is based on impedance measurement, can be optimally combined with a previously known tightness testing process that is based on measuring pressure and is of great importance for the present invention, as will be explained by Fig. 2.

According to Fig. 2, a test chamber 9 according to the invention includes at least two parts for inserting the receptacle(s) 1 to be tested, advantageously an upper and a lower half, as

represented with 9_o and 9_u . With the receptacle 1 inside it, the test chamber 9 defines a sealed receptacle environment U. A pattern of electrically conducting surfaces is provided on the walls 11 of the interior of the test chamber that form the electrodes 3b and 3a according to Fig. 1. Of course, the electrodes 3 are separated from each other by insulating wall material. This advantageously provides an even distribution of impedance measuring paths along the whole interior of the test chamber situated directly alongside receptacle 1.

In addition, at least one pressure sensor 13 (represented in Fig. 2) is provided and is suitably connected with the interior of the test chamber. It measures the pressure P_u prevailing in this interior space according to the environment U. After inserting the receptacle 1 to be tested, advantageously with insulating walls, the test chamber is sealed and the pressure difference Δp noted in Fig. 1 is created, e.g. by means of a pump 15. During this process, the receptacle walls will cling closely to the electrode areas 3 on the interior walls of the test chamber 9. If liquid filler F escapes into a wall area of the receptacle 1, as represented at 17, the impedance between the assigned electrodes 3 changes, which is measured by the impedance measuring unit 7' which is advantageously designed as an ohmmeter. The threshold value unit 9' detects whether the measured resistance drops below the preset threshold or exceeds it. Then the receptacle that was just tested is rejected as leaky. If a leak is present in a receptacle's areas G which are filled with air inclusions, the leak causes a pressure increase in the environment U due to the pressure adjustment between the area G and the environment U. This pressure change is measured by a

pressure measuring unit 19 that is suitably connected to the sensor 13 and whose output signal is passed to a further threshold-sensitive unit 21. Advantageously, the pressure of the environment is measured at a first point in time t_1 and, according to a preset time interval, at a later point in time t_2 , and the resulting difference in pressure Δp_u is recorded. If this difference falls below a threshold value set in the threshold unit 21, the tested receptacle 1 is also rejected as leaky. The interior wall of the test chamber is advantageously designed in such a way that even if the walls of the receptacle cling to this wall due to the pressure difference, a continuous environmental space 23 extends around the receptacle. In principle, this is achieved by supports as individually represented in 25 and which, in a most advantageous way, are realized by roughening the interior wall 11. This permits the tightness to be measured on the whole receptacle, regardless of where the areas G and F are located in the receptacle. With regard to the technology to ensure a continuous environmental space 23 despite the receptacle's walls clinging to the interior wall of the chamber, please refer to EP-A-0 379 986 of the same applicant.

Whereas in the embodiment of the invention according to Fig. 2, one evaluation unit 7' for impedance measurement and one for recording pressure differences 19 are provided, according to Fig. 3 one single evaluation unit 197 is advantageously provided. Basically, this is possible because identical measuring signals are provided for impedance measurement and measuring the output signal of the pressure sensor 13. According to Fig. 3, this can, for instance, be achieved by connecting the measuring paths 3a/5a // 3b/5b (according to the resistance to be measured,

represented by R_x in Fig. 3) to a DC voltage source 27, advantageously in the low-voltage range, e.g. 15 V, on the one hand, and to a measuring resistance R_M , on the other hand. The input of the evaluation unit 197, in this case designed as a voltmeter, is alternately switched to the output of the sensor 13 and to the measuring resistance R_M by means of a manual or automatic switch 29. In the one case, it measures the output voltage of the sensor 13, and in the other case, the voltage dependant on R_x at the measuring resistance R_M , namely U_M .

With regard to the pressure measuring technique, refer completely to the aforementioned WO94/05991. The evaluation unit described there, as represented in Fig. 4 in the present case is, however, also used for very precise impedance and resistance measurement, following the process in Fig. 3. The output signal of the sensor 13 and from the measurement resistance R_M or generally from the resistance measurement path is fed to a transducer stage 121, which includes an analog/digital transducer on the input side (121a), which is directly followed by a digital/analog transducer (121b). The output of the digital/analog transducer 121b is fed to a difference amplifier unit 123 set up in a known manner, as is the output signal from the pressure and resistance measurement units 13 and R_M . The output of the difference amplifier unit 123 is connected to a further amplifier stage 125, whose output is superimposed via a storage element 127 onto the input signal to the amplifier 125 at 128. The transducer unit 121 and the storage unit 127 are controlled by a time pulse controller 129. This set-up permits measurement of the pressure difference, as well as the impedance difference and resistance difference. For measuring

the resistance, at a first point in time the measuring voltage is connected to the transducer unit 121 and simultaneously, if necessary via another transducer unit 122, to both inputs of the amplifier unit 123. A resulting zero signal at the output side of the amplifier 123 would be ideal. If the signal deviates from zero, this signal value is stored as a zero compensation signal in the storage unit 127. If the resistance is measured again at a later point in time in order to create a resistance difference signal, the previous value stored in the storage unit 127 acts as a zero compensation signal, and the value that is stored at the unit 121 acts as a reference signal. This allows an amplification that drastically increases the resolution to be set at the amplification unit 125. The same zero adjustment principle is used at two points in time when measuring the pressure difference, as described in detail in WO94/05991. The storage unit 127 is designed for storing a resistance-difference zero compensation signal as well as a pressure-difference zero compensation signal and, similarly, the unit 121 is in duplicate for storing the assigned reference values. Depending on the measuring cycle, pressure or resistance measurement, the assigned compensation signal value is fed to the difference unit 128 and the assigned reference signal value is stored in or fed to the assigned unit 121.

Fig. 5 shows a simplified perspective of the one half 9a or 9b of the test chamber, specially designed for testing sets of ampoules as used particularly for medical applications. The sets of ampoules are placed in the roughened mould 30 designated for this purpose, and then the chamber 9 is sealed by placing a second chamber half on top. As shown, the chamber may be

constructed of conducting lamina 34 separated and insulated from each other by insulation material 32, and into which the moulds 30 are integrated. This creates a gapless pattern of impedance measuring electrodes on the interior wall of the moulds 30. They are alternately connected, as shown with the connecting conductors 5a and 5b.

Fig. 6 shows the advantageous design of a test device according to the invention by means of a logic/functional block diagram (see also Annex A). It includes several test chambers 9, whose pressure sensor and impedance path outputs (identified as 13 and R_M in Fig. 6) are connected to switching units 36. These inputs are sequentially connected to an output of the units 36, which are connected to an actual multiplexer unit 38. On the multiplexer unit 38 the inputs fed from the units 36 are selectively connected to an evaluation unit 40, for instance advantageously set up as shown in Fig. 4. A timer 50 controls the switching cycles specific to the chambers (pressure sensor / impedance measurement) and, on the multiplexer 28, the connection of the individual test chambers 9 to the unit 40 designed as an impedance and pressure evaluation unit. This allows the measurement of the tightness of receptacles in multiple test chambers 9 with advantageously few electronic units, namely based on impedance and pressure measurements, i.e. regardless of whether, and if so, where the respective receptacles 1 are filled with liquid and gas.

In addition, advantageously, at least one cleansing gas line 36 (Fig. 5) is provided in the test chamber 9, with which the chamber can be blown out and dried after testing a leaking receptacle.

Annex "A"**Leak test device for receptacles****(Annex A)**

The present invention concerns a leak test device for receptacles according to the characterizing portion of Claim 1.

Test devices of the aforementioned type are known in which the respective testing stations, observed on a carousel, are subjected to pressure in the position of the first angle of rotation of the carousel, whether on their interiors in the case of open receptacles or, in the case of closed receptacles, on respective test chambers at the testing station, in which the pressure that depends on the tightness of the receptacles to be tested is measured and evaluated at no less than one more, preset angle of rotation of the carousel. Some aspects of this known procedure and test devices such as these are disadvantageous. Because pressure measurement is carried out by the respective test chamber during movement through a specific angle of rotation (for instance, generally in the case of linear conveyors through a specific position), there is only a limited amount of time for measuring the pressure because of the rotation speed or the speed in general and, therefore, the throughput rate. This limits the rate of receptacles that can be tested per time unit and is problematic, in particular if the carousel is in continuous operation. In addition, monitoring the leak-related pressure over time is not possible, because the pressure sensors provided were only activated for measuring at certain times.

Annex "A"

Therefore, devices for highly reliably leak testing each have at least one pressure sensor firmly assigned to the testing stations rotating with the carousel, and one electronic evaluation device which is also firmly assigned, thus permitting free testing at the testing stations throughout the whole time period, during which a receptacle loaded in a testing station on the carousel rotates with the carousel.

This latter procedure and the respective devices have a high detection accuracy, but are accordingly expensive since, as mentioned earlier, each testing station is autonomously equipped with the required evaluation electronics.

The object of the present invention is to create a receptacle leak test device of the type initially mentioned in which, for one (if at all), the detection accuracy is only minimally reduced in comparison with the last-mentioned devices, but which can be realized with considerably less expense. To this end, the type of device initially mentioned distinguishes itself according to the characteristic portion of Claim 1.

In the leak test of filled receptacles, in particular those filled with liquid, as described in detail in Application No. (Annex A) filed at the same time as the present application, there is the problem that when underpressure is applied, a leak in the wall portions loaded with filler liquid is difficult to detect. The liquid escaping to the exterior has a self-sealing effect. A reliable leak test

Annex "A"

is only ensured with such receptacles if a leak in a wall area is adjacent to an air inclusion in the interior of the receptacle. For this reason, in the above- mentioned application filed at the same time (Annex A), the suggestion is made to carry out an impedance measurement on the walls of the receptacle at the same time as the leak test is carried out by observing the pressure in the environment of the receptacle, because the escaping liquid immediately results in an impedance change on a measuring path between at least one pair of measuring electrodes.

Considering this aspect, it is now suggested that, for testing receptacles that are filled with liquid filler, each insertion space for at least one receptacle be provided with at least one pair of bare, spaced electrodes, whereby there is a central evaluation unit (under the aspect of Claim 1) suitably connected with the respective pairs of electrodes via a multiplexer unit. This permits the provision of one evaluation unit for the pressure measuring test and one evaluation unit for the impedance test for all the testing stations provided on the carousel, and the ability to multiplex the respective pressure sensors as well as the outputs of the impedance measuring paths in staggered time.

In a further advantageous embodiment, the evaluation unit that is connected to the electrodes and the evaluation unit that is suitably connected to the pressure sensors is one and the same central evaluation unit. This is possible because, on the one hand, the pressure sensors normally emit a voltage signal and, in particular in the case of a DC resistance measurement as impedance

Annex "A"

measurement, a measuring circuit equipped with the variable resistance to be measured, such as a voltage divider, can also be designed so that the resistance-related output signal is a voltage signal. This procedure minimizes the expense for simultaneous pressure and impedance testing.

This also provides the possibility of realizing the multiplexer units between the impedance measuring paths and the evaluation unit, on the one hand, and between the pressure sensors and the evaluation unit, on the other hand, in a single, common and respectively time-controlled multiplexer unit which switches the respective number of inputs of the pressure sensor and impedance measuring paths via a single output to the central evaluation unit provided.

In WO94/05991 of the same applicant as the present application, a pressure tightness measuring procedure is described in detail, in which the output of a pressure sensor is switched to both inputs of a difference unit at a first point in time. The (possibly) amplified output signal of the difference unit is interpreted as a zero offset signal, and stored. When the pressure is measured at a second point in time, the zero offset signal stored previously is added as a zero compensation signal which allows the respective pressure difference signal to be electrically evaluated with high amplification.

This procedure is also used in the device according to the present invention, in that the evaluation unit is designed in such a way that a signal that is dependent on an input signal occurring at a

Annex "A"

first point in time is stored as a zero reference signal value and is then added as a zero adjustment signal. With regard to the adjusted zero value as a difference, at a second, subsequent point in time, a further input-related signal (amplified, if applicable) is evaluated as a difference, this being the evaluation signal. If a pressure sensor evaluation and an impedance evaluation are present simultaneously, this procedure can be used for both evaluations, in that (also with regard to impedance measurement, which is ultimately based on an impedance difference measurement) the impedance difference that occurs can ensue in relation to the exact, adjusted zero reference.

The invention is explained below by means of diagrams:

Fig. 1 shows a logic/functional block diagram of a leak test device for receptacles according to the invention, in which the leak test is carried out based on a pressure measurement at the respective testing stations;

Fig. 2 shows, in a representation analogous to that of Fig. 1, the further development of the leak test device according to the invention by means of pressure as well as impedance measurement;

Fig. 3 shows an example of test pressure or test resistance over time and an advantageous procedure for signal evaluation.

Annex "A"

According to Fig. 1, multiple n testing stations such as $1_1, 1_2, \dots 1_n$ are provided on a carousel (not shown). In the figure, they are arranged linearly for purposes of clarity; on the carousel, they are arranged along the periphery of the carousel.

At least one corresponding pressure sensor $3_1, 3_2, 3_3, \dots 3_n$ is allocated to each testing station 1 .

Depending on the leak in at least one of the receptacles arranged at the respective testing station 1 , the pressure sensors 3_x pass an electrical signal according to p_1 to p_n .

The testing stations 1_x and the respective pressure sensors 3_x assigned to them can be the following:

- a) Stopping stations for sealing open receptacles on which an interior pressure, overpressure or underpressure is created with respect to environmental pressure. The assigned pressure sensor measures the leak-related interior pressure of such a receptacle.
- b) Closed receptacles are placed in a leak test chamber of station 1_x , or are sealed by the latter, whereby the receptacles are filled or empty. A pressure difference is created between the interior of the receptacle and the surrounding chamber, either by applying underpressure or overpressure to the interior of the receptacle and/or by applying underpressure or overpressure to the surrounding chamber. The assigned pressure sensor

Annex "A"

measures the course of the pressure, either in the interior of the receptacle or in the test chamber. Normally, this procedure is used for closed, filled receptacles, and underpressure is applied to the test chamber in relation to the interior pressure of the receptacle, and the pressure development in the chamber surrounding the receptacle is measured with the assigned pressure sensor.

According to Fig. 1, the electrical outputs of the sensors 3_x are switched to a multiplexer unit 5 which, controlled by a timer 7, connects one pressure sensor at a time in sequence to an evaluation unit 9, according to the signal $p_1 \dots p_n$. Each forwarded leak-dependent signal p_1 to p_n is evaluated in sequence at the evaluation unit 9 and, according to preset threshold values for these signals, a display at output A, shows in which of the stations 1_x a leaky receptacle has been identified. Of course, in order to do this a comparator unit is provided at the evaluation unit 9, in which the threshold value has been entered for determining the selection leaky / not leaky, as well as a storage unit on the output side for registering the testing stations whose sensor output signals indicate a leak in the receptacles they contain.

This procedure permits a number of testing stations corresponding to the size of the carousel, each assigned a pressure sensor, to be handled by a single evaluation unit.

Annex "A"

As initially mentioned, when receptacles filled with liquid filler are tested for leaks according to the principle described briefly under b) above and as described in detail in application no.

(Annex A) filed at the same time, problems arise that can be eliminated by simultaneous pressure evaluation and impedance evaluation directly outside the receptacle.

In Fig. 2 of the invention according to the present application, a suitable device is shown analogous to that of Fig. 1. Accordingly, besides at least one pressure sensor 3_1 to 3_n , each of the testing chambers 1_1 to 1_n is assigned an impedance measuring path with at least two electrodes, represented schematically in Fig. 2 by 11_1 to 11_n . With the impedance measuring paths that include at least two pick-up electrodes in the test chamber of the testing stations 1_x arranged directly at the exterior wall of the respective receptacle to be tested, a measurement is taken when filler liquid escapes to the exterior through a leak, driven to the exterior by an underpressure in relation to the interior pressure of the receptacle, which was created in the test chamber.

Also following the principle of Fig. 1, the electrical outputs with the signals p_1 to p_n are fed to the multiplexer unit 5_p , whereas the outputs of the impedance measuring paths 11_x are fed to a further multiplexer unit 5_R . According to Fig. 2, the outputs with the signals p_1 to p_n and R_1 to R_n are fed to the evaluation units 9_R and 9_p assigned to them. At the respective evaluation units, the respective signals are measured in sequence against a preset threshold value, and a resulting output signal A_R or A_p indicates in which of the chambers 1 there is a receptacle that has been

Annex "A"

determined to be leaky. If, with this configuration of the device, signals identifying a leak are determined at one of the two evaluation units, i.e. according to pressure and/or impedance, the respective receptacle is recognized as having a leak and the respective chamber number is stored.

Normally, the impedance measurement is implemented as a DC resistance measurement.

Because pressure sensors normally give a voltage signal that is dependent on the detected pressure, and it is certainly possible to carry out a resistance measurement in such a way that the resistance-related signal is a voltage signal, in a further advantageous embodiment, besides a single multiplexer 5_{pR} , a single evaluation unit 9_{pR} is provided (as shown with a broken line in Fig.2), whereby the multiplexer 5_{pR} is connected with a single output to the input of the provided evaluation unit 9_{pR} . A timer unit (not shown here) adds a corresponding pressure threshold value or a corresponding resistance threshold value as a basis for comparison at the combined evaluation unit, depending on whether a pressure measuring signal or a resistance measuring signal is being fed at that moment, and the two sequential test signals relating to a single chamber are stored, as can be imagined, in a buffer for later evaluation.

WO94/05991 of the same applicant as the present invention contains the description of a procedure with respect to pressure testing by means of which the implemented resolution can be drastically increased, i.e. very small leaks can be detected. In this regard, please refer to the

Annex "A"

contents of this document. Fig. 3 contains a brief explanation of the principle mentioned in WO and how it can be integrated into the device upon which this application is based.

Fig. 3, above the time axis t , shows the course of a recorded pressure or a resistance value R_x measured on one of the measuring paths 11_x . This course must be seen as purely qualitative. Basically, if a leak is present, it results in an excessive decrease over time of the underpressure that was created in the test chamber, because there is a balancing of pressure between the interior of the receptacle and the volume of the test chamber, whereas filler liquid escaping through a leak normally results in a decrease in the measured resistance directly at the receptacle wall. According to Fig. 3 and following the above-mentioned principle, the present pressure or resistance value is measured at each chamber of the stations 1_x at a first point in time t_{1x} . This signal value is stored and transmitted to both inputs of the evaluation unit containing a difference-generating unit. With ideal adjustments, and after respective amplification, the signal "zero" should appear on the output side of the difference-generating unit. A signal that deviates from the zero value is interpreted as a zero-point deviation and is also stored. At a second, subsequent point in time t_{2x} , a second pressure and resistance value is measured. The value measured at the second point in time is compared to that measured and stored at the first point in time, whereby the zero-point deviation signal which was also measured is taken into account according to its sign. The result of the comparison, Δ_p or Δ_R , can now be correctly evaluated with high amplification. If this procedure is implemented on the device according to Fig. 1 or Fig. 2,

Annex "A"

the measuring paths provided (whether they are pressure sensor and/or impedance measuring paths) are scanned in sequence at the first and second points in time, which occurs through respective triggering of the multiplexers that are provided. It is not essential that the scanning is carried out in direct sequence according to t_{1x} and t_{2x} in Fig. 3. Depending on the optimization of the time frame, all the t_{1x} values can be measured first, for instance, with respective buffer storage, followed by all the t_{2x} values for the evaluation.

In this case, too, the whole evaluation can be carried out with a single evaluation unit to whose input the sequentially queried pressure and impedance values are fed. In this way, even complex query rhythms and correspondingly high leak resolutions can be achieved with a single evaluation unit and an adapted multiplexer unit.

Annex "A"

Claims:



1. Leak test device for receptacles with a conveyor with multiple testing stations (1_x), each for at least one receptacle, with at least one pressure sensor (3_x) at each testing station (1_x) that, on the output side, is suitably connected to the input of an evaluation unit (9), characterized in that there is one common evaluation unit (9) for several of the pressure sensors (3_x), and that a pulsed multiplexer unit (5) interfaces with an input of the evaluation unit (9) and the outputs of the pressure sensors (3_x) by means of a timer unit (7).
2. Device according to Claim 1, characterized in that the testing station (1_x) includes at least one pair of bare, spaced electrodes in a receptacle insertion space, and that an evaluation unit (9_r) is provided which is suitably connected with the electrode terminals on each of the multiple testing stations (1_x) via a multiplexer unit (5_R) that is pulsed by means of a timer unit.
3. Device according to Claim 2, characterized in that the evaluation unit that can be suitably connected to the electrode terminals and the one that is suitably connected to the outputs of the pressure sensors is one and the same evaluation unit (9_{PR}).
4. Device according to Claim 2 or 3, characterized in that the multiplexer units that are connected to the input of the evaluation unit that is suitably connected to the electrode terminals



Annex "A"

and to the evaluation unit that is suitably connected to the pressure sensors are formed by one multiplexer unit (S_{pR}).

5. Device according to one of the Claims 1 to 4, characterized in that the evaluation unit is designed in such a way that a signal value that depends on an input signal and occurs at a first point in time (t_1) is stored as a zero reference value and is subsequently added as a zero adjustment signal, and the signal value occurring at a second, subsequent point in time (t_2) is evaluated as an evaluation signal / tightness evaluation signal.

6. Device according to one of the Claims 1 to 5, characterized in that the conveyor is a carousel.



WO 98/50769

PCT/CH98/00181

- 28 -

Annex "A"

Abstract:

With regard to leak test devices with multiple testing stations (1) it is suggested that the measuring signals that are relevant to the tightness be transmitted from the chambers via multiplexers (5) to a central evaluation (9).

(Fig. 1)



THIS SHEET HAS BEEN
REPLACED

PCT/CH98/00181

-29-

WO 98/50769

Claims:

1. Process for testing the tightness of closed receptacles, at least partially filled with liquid filler, in which a pressure difference (Δp) is created between the interior of the receptacle (I) and the receptacle's environment (U) which is directed against the latter, characterized in that in the area of the exterior wall of the receptacle an electrical impedance measurement (Z_x, R_x) is carried out on the receptacle's environment (U) and/or along its exterior wall which permits the identification of leaky and tight receptacles.
2. Process according to Claim 1, characterized in that the impedance measurement is a DC measurement, advantageously a low-voltage DC resistance measurement (R_x).
3. Process according to Claim 1 or 2, characterized in that several parallel impedance measuring paths ($Z_1, Z_2, \dots$) are provided.
4. Process according to one of the Claims 1 to 3, characterized in that the pressure difference (Δp) is created by applying a preset underpressure to a sealed receptacle environment, then the sealed receptacle environment with the receptacle (1) is left on its own with regard to pressure development and identification of leaky and tight receptacles can occur by observation of the pressure difference (Δp_u) over time, in addition to impedance measurement (Z_x).

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

WO 98/50769

PCT/CH98/00181

-30-

5. Process according to Claim 4, characterized in that after creating the pre-settable underpressure and after leaving the pressure on its own, one uses the ambient pressure as a leak indicator, advantageously by measuring the ambient pressure (p_u) at no less than two points in time, and by evaluating the determined pressure difference (Δp_u) as an indication of tightness, advantageously by determining a zero reference (127) to the assigned pressure at the first point in time, using the corresponding evaluation signal of the pressure value at the second point in time with regard to the signal at the first point in time and zero-adjusted for determining leakiness.
6. Process according to Claim 5, characterized in that the same procedure (197) is used for measuring the pressure difference and a difference in impedance.
7. Test chamber for testing the tightness of closed receptacles with liquid filler, the test chamber being vacuum-sealed, characterized in that at least one impedance measuring path with at least one pair of spaced electrodes (3a, 3b) are provided in the test chamber.
8. Test chamber according to Claim 7, characterized in that multiple pairs of electrodes are distributed in the test chamber and are advantageously arranged in parallel (5a, 5b).
9. Test chamber according to Claim 7 or 8, characterized in that the interior of the chamber wall is formed by a pattern of electrically conducting electrode sections (34) and insulating sections (32) separating them.

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

WO 98/50769

PCT/CH98/00181

-31-

10. Test chamber according to one of Claims 7 to 9, characterized in that at least one pressure sensor (15) is provided at the test chamber.
11. Test chamber according to one of Claims 7 to 10, characterized in that at least one cleansing-gas connection (36) enters into the chamber.
12. Test set-up with at least one test chamber according to one of the Claims 7 to 11, characterized in that at least one pair of electrodes (3a, 3b) is suitably connected to an impedance measuring unit (7).
13. Test set-up according to Claim 12, characterized in that the impedance measuring unit is a DC resistance measuring unit (7'), advantageously a low-voltage resistance measuring unit.
14. Test set-up according to one of the Claims 7 to 13, characterized in that leaky/tight identification is carried out in an evaluation unit by means of a unit that is sensitive to threshold values.
15. Test set-up according to one of the Claims 12 or 13 with at least one test chamber with multiple pairs of electrodes (3a, 3b), characterized in that the pairs of electrodes are suitably connected in parallel (5a, 5b) to the input of the impedance measuring unit (7, 7').

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

WO 98/50769

PCT/CH98/00181

-32-

16. Test set-up according to one of the Claims 12 to 15, characterized in that the impedance measuring unit (7, 7') includes a unit that is sensitive to threshold values (9, 9') located on the output side.

17. Test set-up according to one of the Claims 12 to 16, whereby a pressure sensor (13) is provided at the test chamber, characterized in that the output of the pressure sensor is suitably connected to an evaluation unit (19) which advantageously registers the sensor's output signal at a first point in time, and also at a second, subsequent point in time, and transmits the registered output signal of the pressure sensor to a difference unit (123, 125) whose output affects a unit that is sensitive to threshold values.

18. Test set-up according to Claim 17, characterized in that the sensor's output signal registered at the first point in time is transmitted to both inputs of the difference unit (123), and a zero difference signal is created as an output signal of the difference unit and stored.

19. Test set-up according to one of the Claims 12 to 18, whereby at least one test chamber is provided with a pressure sensor (13), characterized in that the pressure sensor (13) as well as the pair of electrodes (3a, 3b) are suitably connected to the same evaluation unit (197) which (advantageously switchable (29)) generates a signal as a function of the impedance of the pair of electrodes and of the output signal of the sensor.

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

WO 98/50769

PCT/CH98/00181

-33-

20. Test device with multiple test set-ups according to one of the Claims 11 to 19.
21. Test device according to Claim 20, characterized in that a central impedance measuring unit (40) is provided for the test set-ups, which can be switchably (38) connected to the respective test set-ups (9).
22. Test device according to Claim 20 or 21, in which a pressure sensor (13) is provided for the test chambers, characterized in that a central evaluation unit (40) is switchably and suitably connected to the pressure sensors (13) of the test chambers (9) of the test set-ups and their pairs of electrodes (3a, 3b).
23. Use of the process according to one of the Claims 1 to 6, and use of the test chamber according to one of the Claims 7 to 11, or the test set-up according to Claims 12 to 19, and use of the test device according to one of the Claims 20 to 22 for testing receptacles with electrically insulating walls, advantageously glass or plastic walls, in particular for medical applications.

This Sheet Has Been Replaced

