

METHOD FOR ASSESSING THE STATE OF A WATER DISTRIBUTION SYSTEM

TECHNICAL FIELD OF THE INVENTION

The invention relates to the field of water distribution.

The invention relates more specifically to a method for determining
5 parameters suitable for assessing the state of one or more water distribution systems (or networks).

STATE OF THE ART

The aim of the invention is to allow a manager of water distribution
10 networks to monitor its water network, to detect, and above all to act preventively on its network, even to implement means which increase the life span of the network, and ensure its regulatory conformity.

Indeed, in most urban zones, the portable water distribution ducts are reaching a critical age and are at great risk of deterioration. A knowledge
15 of the state of the network, mostly buried, is essential to control the corrective actions (soundings, interventions, repairs, renewal, descaling, cleaning, etc.) but also the preventive actions to mitigate the effects of degradation. The main problem is that the ducts are mostly buried and invisible. It is then difficult to detect and measure the degradation phenomena in order to act
20 preventively and accurately, without having to dig up the circuits (and therefore a good part of the network).

Solutions are known for detecting past or current incidents (leaks, degradation of the water quality). These primarily involve detecting and/or locating consequences of a malfunction. For example, the following patent
25 applications can be cited.

The patent application WO2013121298 relates to a computerized method for modeling a utility network (distribution network). The method comprises the retrieval of geographical information system (GIS) data, data
30 on the assets of the network, and sensor archive data of one or more elements of the utility network. The method includes the generation of one or more mathematical elements (graphs) from the retrieved data, in order to perform analyses on the system.

The appreciation of the data with mathematical graphs potentially linked between waters (reporting) is based on:

- identification of zones for monitoring and maintaining the flow of water in the utility network;
- 5 - identification of optimal locations in the network for installing sensors and meters;
- modeling of the network based on the links between the known locations of leaks in the utility network and of values such as historical leak data, characteristics or factors which influence the leak rates: age of the
- 10 equipment; complexity of the network (quantity of pipes, couplings, valves, other connections, etc.); geographic properties contributing to the concealment of the leaks, high pressures or significant pressure variabilities; rate of leaks estimated from historical repair files; historical data from
- flowmeters and pressure meters; frequencies of leaks, rate of water loss,
- 15 delay in detecting a leak, repair costs, etc.;
- generation of alerts and proposing maintenance actions.

The patent application WO2013084068 relates to a system and a method for identifying events linked to one another in a water supply network

20 monitoring system. The method comprises the identification of at least two reference events (called candidate events) from event data originating from a plurality of sensors. The anomaly is identified by the comparison of the data of an event with those of said candidate events.

The determination whereby the two candidate events, or more,

25 have a ratio with a common anomaly event is reported to a user via a user interface.

The patent application WO2012098467 relates to a method and a system for statistically determining one or more potential geographic

30 locations of an anomaly that is suspected to have occurred in a region or a zone of a water distribution network.

A water distribution network is composed of a network of pipelines to convey the water to consumers and includes meters positioned within the water distribution network. The meters are generally disposed at various

35 positions, irregular in the network, and supply an incomplete series of data

dealing with the circulation and the quality of the water on the network as a whole. The meters measure values such as the flow rate, the pressure, the reservoir levels, the acidity, the turbidity, the chlorination, the noise, etc. The meters can be placed inside or outside the pipelines, in proximity to network
5 devices, or at other arbitrary locations.

The patent application WO2012098467 more specifically addresses the meters disposed within the limits, in proximity, or at locations hydraulically linked to the region or the zone of an anomaly and supply values which can be linked to the anomaly.

10 The method can comprise the reception of the data of an abnormal event, the abnormal event data constituting an indication of an anomaly that is occurring or that has occurred, in a region or a zone of the water distribution network. Types of anomalies include leaks, pressure drop, unusual increase in flow rate or water consumption, increased turbidity,
15 unusual modifications in the chlorination rates, unusual modifications of pH levels, etc.

The method can comprise a plurality of tests carried out on the abnormal event data, each of the tests being designed to statistically determine a potential geographic location of the anomaly in a region or a
20 zone. Some of the tests are performed using abnormal event data and associated meter data. Some tests, for example those linked to the leaks, are performed on abnormal meter event data representing some of the following quantities: flow rate, pressure, reservoir level, noise, or other hydraulic activity indicators.

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The patent application WO2011107864 relates to a system and a method for monitoring water in a water distribution network, which is based on retrieval of data from meters (at least flow rate and pressure), and secondary data from other sources (telesurveillance type data and data
30 acquisition, for example meteorological data, calendar data, etc.) and the application of statistical models to predict other values.

The secondary data represent one or more conditions that can affect the flow rate and/or the consumption of water in a region served by the water distribution network. They can be: meteorological data; calendar data
35 representing one or more factors affecting the consumption of water on a

given date; repair data representing one or more repairs carried out on the water distribution network; structural data representing a structure of the water distribution network.

The detection of anomalies (leaks) is done by comparison
5 between the measured values and the predicted values.

The patent application WO2006073502 relates to a system for detecting, in real time, contaminants in a water distribution network. The system makes it possible to monitor the quality of the water at points away
10 from a water distribution network by means of water sensors installed in end user locations, in order to detect contaminants downstream of the distribution network, and to send a signal in case of an anomaly.

The patent application WO2010109117 relates to a device and a
15 method for checking the quality of the water in a potable water network. The physical device for checking the quality of the water is intended to be mounted on a duct dedicated to the distribution of water to a consumer. It comprises:

- a probe for measuring at least one parameter of the flow of
20 water;
- a device for detecting contamination from the measurement of the probe;
- a device for detecting reverse flow in the water duct;
- a device for disinfecting (based on the detection or non-detection
25 of contamination) and/or a blocking device for shutting off the duct (based on the detection or non-detection of a reverse flow);
- and a control member.

All of the information from the device can be sent to a control center capable of collecting the data from the network and of actuating the
30 valves remotely.

The patent application WO2008148952 relates to a method and an installation for monitoring in real time the water quality of a distribution network.

The method for real-time monitoring of the quality of the water of a potable water distribution network comprises, on the one hand, consumption meters equipped with remote-reading devices, and, on the other hand, in-line analyzers distributed at surveillance points for measuring at least one water quality parameter. Furthermore:

- the consumption data from the meters equipped with remote-reading devices, and the measurements from the analyzers are transmitted to a computation unit comprising a hydraulic model and a kinematic model of decay of the quality parameter considered;

- the computation unit permanently updates the hydraulic model according to the consumption data received from the meters;

- the computation unit establishes estimated values of the quality parameter considered at the different network surveillance points;

- and a pre-alert system performs a comparison between the estimated values of the quality parameter and the values measured at different points of the network, an alert being triggered when the deviation between the measured value and the estimated value exceeds a predetermined threshold.

The water quality parameter constitutes a tracer of the quality of the water which makes it possible in real time to note whether the network has been degraded and/or the water has been polluted. The parameters described are the chlorine content and the turbidity, but it is essentially the chlorine content which is used for examples.

Thus, it can be seen that the great majority of the solutions from the state of the art are based on one or two categories of solutions.

The first category of solutions is based on the determination by statistical methods of the consequences of the degradation (detection of leaks, historical frequency of breaks) or on theoretical notions concerning the degradation (age of the ducts). These solutions try to anticipate the future occurrences based on past incidents. These solutions have major drawbacks:

- the past is not necessarily representative of the future. The degradation of the equipment (for example the ducts) does not change

linearly. The consequences of the degradation tend to increase exponentially and the forecasting of future performances based on the past can considerably underestimate the state of degradation of the ducts and therefore the needs for intervention;

5 - it is essential to wait for occurrences and malfunctions to be detected in sufficient quantities to allow for the modeling of the future. Now, for serious incidents, and in particular those which concern strategic ducts (for example large diameter ducts for water transportation) and have to meet regulatory and contractual constraints on the distributed water, it is preferable
10 to avoid or limit the measurable effects of the degradation;

 - parts of the network or the immediate environment of the equipment may have undergone changes, for example in cases of repair, or in cases of early action aiming to reduce the degradation factors. It then becomes even more complicated to anticipate the future by referring only to
15 the past conditions and events;

 - the anticipation of the anomalies on critical zones of the network may not be sufficiently fine, since the solutions notably do not include major precursor factors linked to the chemical and physical phenomena which act on the elements (ducts, valves, bends, etc.) of the
20 network, precursor factors originating as much from inside these elements as from outside.

The second category of solutions is based on solutions of continuous data analysis type for detecting drifts of a parameter relative to a
25 normal parameter or for triggering an alert and/or other action(s) in the event of anomalies on the water quality, and doing so locally and in real time. These solutions have major drawbacks:

 - the detection is local and does not extend to the network;
 - the detection is in real time and does not make it possible to
30 anticipate future anomalies;

 - in the event of the detection of an anomaly, the part of the network that is degraded must be isolated, and since it was not able to be anticipated, that can generate interruptions in all or part of the distribution system.

Furthermore, for all of the solutions presented:

- none addresses the issue of the corrosive potential of distributed water;
- none provides for the inclusion of data on the quality of the ground;
- no known solution provides for the inclusion of information on the state of the ducts of the distribution network;
- not one aims to capitalize on historical data in order to carry out analyses on the evolution trend of the parameters and of the phenomena over a long period;
- no solution includes a scientific, and/or physical and/or physical-chemical computation model for generating data, known computation methods aiming primarily to compare data and detect incidents;
- no solution aims to locate and determine the intensity of the phenomena of degradation of the equipment and of the quality of the water on the distribution network;

Finally, all the solutions are designed to be declined to a given network or system. No solution aims to have a method which can be exploited on multiple networks, for example to compare data characterizing the state of degradation between several networks, several locations, and/or different network typologies.

The parameters which characterize the chemistry of the water, and its potential for interaction with the elements of the network to trigger degradation phenomena are generally not exploited, and sometimes unavailable.

Indeed, the monitoring of the quality of the distributed water is often done through a limited number of parameters which are easy to measure, for example sensors, field methods, even often require more complex and/or longer tests, such as laboratory tests. To qualify the corrosive or aggressive potential of the water, it is however notably necessary to have more comprehensive data concerning the chemical composition of the water.

The invention aims to overcome the abovementioned drawbacks of the prior art.

More particularly, the aim of the invention is to have a method suitable for predictively and accurately assessing the state of degradation of elements or of zones of a water distribution network, or of a network as a whole, even for several water distribution networks.

5 In other words, an assessment method is sought which is not purely local, which can provide prediction of elements of the network or of zones at risk of being degraded, and which can provide an accurate assessment, notably more accurate than the purely statistical methods.

Furthermore, the method must be simple to use, rapid, and must
10 not require lengthy and/or complex measurements or tests, for example laboratory-type tests.

Furthermore, the invention aims to make most use of the data measured and capitalized on the network and on the water which circulates in the network, so as to increase the assessment accuracy.

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SUMMARY OF THE INVENTION

One object of the invention that makes it possible to achieve this aim is a method for determining parameters that can give information on the state of a water distribution system comprising at least one duct suitable for
20 transporting water, the method comprising the following steps:

- an import step suitable for importing, to a computer, input values of at least one parameter of the water previously measured, recorded at at least one entry point of the water distribution system and over a recording period comprising at
25 least one recording date;
- a selection step suitable for selecting at least one current point;
- an association step suitable for associating said current point with at least one entry point in the water distribution system;
- 30 - a determination step suitable for determining a current value of said at least one parameter of the water at the current point from input values at said at least one entry point associated with said current point.

The determination step is preferably carried out using the
35 computer.

In the example of the present description, a recording period should be understood as a time interval lying between two given dates, said time interval comprising at least one date on which a recording was made at the entry point, said date being called "recording date".

5 The input values of at least one parameter of the water recorded at at least one entry point of the water distribution system are generally produced by measurements performed regularly by the operator, at a frequency which depends on the distribution system, on the number of inhabitants, etc.

10 In the example of the present description, the terms upstream and downstream are defined relative to the main direction of circulation of the water in the distribution system.

 In the example of the present description, the entry point or points are said to be associated with a current point when they are situated
15 upstream of said current point, and the water which reaches said current point originates from the entry point or points.

 According to one embodiment, the method also comprises a step of measurement of at least one current parameter measured at at least one
20 current point during a measurement period, the determination step being performed on the basis of input values at said at least one entry point associated with the current point and said at least one measured current parameter, the measurement period comprising at least measurement date, later than or equal to the recording period.

25 In the example of the present description, measurement period should be understood to mean a time interval lying between two given dates, said time interval comprising at least one date on which a measurement was performed at the current point, said date being called "measurement date".

30 According to one embodiment, the method also comprises an implementation step suitable for implementing, in the computer, system data for the water distribution system, said system data comprising at least data on the duct or ducts and data on the direction of flow of the water in the duct or ducts.

The system data implementation step can precede the selection step.

According to one embodiment, the method also comprises a modeling step, subsequent to the system data implementation step, and
 5 suitable for generating a model of flow of the water in the water distribution system, said model being obtained from the system data.

The model of flow of the water can be generated from software such as EPANET and system data.

According to one embodiment, the import step is suitable for
 10 importing input values of at least one parameter of the water at several entry points. In this case, the association step of the method is suitable for associating with one another N current point or points and M entry points, in which $M > 1$ and $N \geq 1$. The values of the numbers M and N and the ratio between these numbers depend on the network, on the number of
 15 inhabitants.

According to one embodiment, the association step is performed as a function of the model of flow of the water in the system, preferentially obtained in the modeling step.

20 According to one embodiment, the method also comprises a step of zoning of the water distribution system into several zones, suitable for defining several zones, a zone comprising at least one current point associated with one or more entry points.

The zoning step is preferentially performed on the basis of the
 25 model of flow of the water in the system, preferentially obtained in the modeling step.

According to one embodiment, a parameter of the water is the content in the water of at least one chemical compound, for example calcium
 30 (Ca) and/or magnesium (Mg) and/or sodium (Na) and/or potassium and/or sulfates and/or nitrates and/or silicates and/or chlorides of bicarbonate (HCO_3^-).

According to one embodiment, a parameter of the water is the total chemical composition of the water.

35 According to one embodiment, a parameter of the water is the pH and/or the conductivity and/or the temperature.

According to one embodiment, the determination step comprises the following steps:

- 5 - if the current point is associated with a single entry point, then the current value of at least one parameter of the water is assigned the time average value of the input values of said parameter;
 - if the current point is associated with at least two entry points then:
 - 10 ○ either the time average of the input values of at least one parameter of the water is calculated for each entry point associated with said current point, each calculated time average is weighted by a first weighting coefficient, and the current value of said parameter is assigned a value
 - 15 equal to the sum of all the entry points of the weighted time averages, the sum of the first weighting coefficients being equal to 1;
 - or the current value of at least one parameter of the water is assigned the time average value of the input values of said parameter at the entry point hydraulically closest to
 - 20 the current point;
- the time average of the input values of a parameter of the water being the average of said input values over a calculation period comprising at least one recording date.

25 In the example of the present description, calculation period should be understood to mean a time interval lying between two given dates, said time interval comprising at least one recording date.

 The calculation period can coincide with the recording period. It can be staggered relative to the recording period. It can be included in the recording period.

30 If, in the chosen calculation period, there is only one recording date, then the time average of the input values of a parameter of the water at an entry point is equal to the input value at this entry point on the recording date.

35 date.

The weighting by a first weighting coefficient will be able to be done arbitrarily or be calculated.

According to one embodiment, the first weighting coefficient of an entry point can be equal to the time average of the input values for an entry point divided by the sum of the time averages of the input values of all the entry points.

The terms “entry point hydraulically closest to the current point” should be understood to mean: the entry point whose distance relative to the current point, following the distribution network, is the shortest.

According to one embodiment, a parameter of the water is the value of the conductivity of the water.

According to one embodiment, the input conductivity of the water is measured at at least one entry point.

According to one embodiment, the input conductivity of the water is calculated at at least one entry point, from input values of parameters of the waters at said at least one entry point.

According to one embodiment, a measured current parameter is the current conductivity of the water measured at a current point on a measurement date.

According to one embodiment, the determination step comprises the following steps:

- if the current point is associated with a single entry point, and:
 - if the absolute value of the deviation between the current conductivity and the input conductivity is less than or equal to a percentage x of the current conductivity, then the current value of at least one parameter of the water is assigned the input value or values of said parameter recorded on the recording date before and temporally closest to the measurement date, or equal to said measurement date;
 - if the absolute value of the deviation between the current conductivity and the input conductivity is greater than a percentage x of the current conductivity, then the current

- value of at least one parameter of the water is assigned the time average of the input values of said parameter;
- if the current point is associated with at least two entry points and:
 - 5 ○ if the absolute value of each deviation between the current conductivity and the input conductivity at each entry point associated with said current point is less or equal to a percentage x of the current conductivity, then the current value of at least one parameter of the water is assigned
 - 10 the time average of the input values of said parameter at the entry point at which the input conductivity of the water is closest to the current conductivity of the water;
 - if the absolute value of at least one deviation between the current conductivity and the input conductivity at each
 - 15 entry point associated with said current point is greater than a percentage x of the current conductivity, then:
 - either the time average of the input values of at least one parameter of the water are calculated for each
 - 20 entry point, the time average calculated for each entry point is weighted by a second weighting coefficient that is a function of the ratio between the input conductivity of the water at said entry point and the current conductivity, and the current value of said parameter is assigned a value equal to the sum of the
 - 25 weighted time averages;
the sum of said second weighting coefficients being equal to 1;
 - or the current value of at least one parameter of the
 - 30 water is assigned the time average of the input values of said parameter at the entry point hydraulically closest to the current point;
- the time average value of the input values of said parameter being the average of said input values over a calculation period comprising at least one recording date and one measurement

date, the recording date being before or equal to the measurement date, and
the value of the percentage x being defined as a function of the desired accuracy.

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In this case, the calculation period must therefore also comprise at least one measurement date.

The value of the percentage x can for example be defined according to the variability of the quality of the water and/or the accuracy of
10 the measurement.

According to one embodiment, if the current point is associated with a single entry point, and if the absolute value of the deviation between the current conductivity and the input conductivity is greater than a
15 percentage x of the current conductivity, then the current value of at least one parameter of the water is assigned the time average of the input values of said parameter, weighted by the ratio between the input conductivity of the water and the current conductivity of the water,

the time average value of the input values of said parameter being
20 the average of said input values over a calculation period comprising at least one recording date and one measurement date, the recording date being before or coinciding with the measurement date.

According to one embodiment, the calculation period is obtained by using the water flow model, preferentially obtained in the modeling step.

25 According to a preferred embodiment, the calculation period is obtained empirically.

If a calculation period is chosen in which there is only one recording date, then the time average of the input values of a parameter of the water for an entry point is equal to the input value on the recording date.

30 In this case, it is preferable to choose a calculation period in which the recording date is close to the measurement date.

According to one embodiment, the method also comprises a step of calculation of at least one degradation index at at least one point from at
35 least one value of parameters of the water at said at least one point.

According to a particular embodiment, the step of calculation of at least one degradation index is performed at at least one current point from at least one current value of parameters of the water, determined in the determination step at the at least one current point.

5 A degradation index makes it possible to determine the potential degradation of ducts of the network (inside and outside the ducts), including the bends, the valves, the pumps, and more generally the network, even the quality of the water.

10 According to one embodiment, the step of calculation of at least one degradation index at at least one current point is performed also from a current parameter measured at said current point.

According to one embodiment, a current parameter measured at a
15 current point is the pH of the water, the step of calculation of at least one degradation index comprising the following steps:

- a step of calculation of an equilibrium pH (pHs) of the water from current values of concentration of chemical compounds in the water determined at said current point then;
- 20 - a step of comparison of the pH and of the equilibrium pH (pHs) at said current point then;
- a step of deduction of a degradation index of the water distribution system at said current point.

In this case, that makes it possible in particular to assess the risk
25 of degradation of a duct made of cement at said current point.

According to one embodiment, the at least one parameter of the water comprises at least the chlorides and/or sulfates concentration of the water, and the step of calculation of at least one degradation index
30 comprising a step of deduction of a degradation index of the water distribution system at at least one current point as a function of current values determined at said current point of at least one chlorides and/or sulfates concentration of the water.

In this case, that makes it possible in particular to assess the risk
35 of degradation of a duct made of ferrous material at said current point.

According to one embodiment, the step of calculation of at least one degradation index comprises the use of a corrosion index suitable for calculating a rate of corrosion.

5 According to one embodiment, the step of calculation of at least one degradation index comprises the use of a particulate emission index that can give information on the quality of the water at at least one current point.

 Said indices notably make it possible to determine the release of particulates due to the corrosion in the water.
10

 According to one embodiment, the method also comprises a step of estimation of the life span of one (or more) duct(s) of the distribution system by combining one or more of the degradation indices with system input data.
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 According to one embodiment, the method also comprises a step of definition of critical zones from among the zones defined in the system zoning step.

20 According to one embodiment, the method also comprises a step of verification of at least one degradation index of the water distribution system comprising:

- a step of measurement of degradation quantities of said system at at least one point of the distribution system;
- 25 • a step of comparison of the measured degradation quantities with the degradation indices calculated at said at least one point in the step of calculation of degradation indices.

 The point can be an entry point or a current point.

30 According to one embodiment, the method also comprises a step of adjustment of the at least one degradation index of the water distribution system, by using the measured degradation quantities of said system at current points or at entry points in the verification step.

 According to one embodiment, the step of calculation of at least
35 one degradation index and/or the verification step, and/or the adjustment

step comprises a step of analysis of the environment and/or of the water distribution system.

In particular, that can comprise a step of measurement of samples of the ground around said system, and/or of direct measurement on the ducts
5 in order to verify the real state of degradation of the system.

Thus, the invention relates to a method which makes it possible to generate information on the state of degradation of a distribution network, and in particular of the potable water distribution ducts, in order to identify
10 points and/or zones that are at risk of breaking and/or of significant deterioration of the quality of the water transported.

The results can be geolocated using an intuitive interface which displays the critical zones (in other words those at risk of degradation) in order to allow the managers of the network to launch actions to prevent
15 serious incidents such as major breaks and nonconformities.

These preventive actions can include putting in place transported water conditioning treatments, the strategic renewal of the ducts with greater risk of breakage, the implementation of network cleaning interventions.

According to one embodiment, the method also comprises a
20 correction step comprises a step of sending, to a control system, of at least one calculated and/or adjusted degradation index, the control system being able to act on the water distribution system and/or on the water so as to correct the state of said water distribution system.

According to a particular embodiment, the correction step consists
25 in the addition of one or more reagents in the water, the quantity of a reagent being calculated by the control system as a function of at least one calculated and/or adjusted degradation index.

Contrary to the methods which use a history of past occurrences
30 to anticipate future incidents, which often proves too late to act preventively, the method according to the invention exploits a maximum of measured and/or capitalized data, addresses phenomena of interactions between the water whose quality and parameters (speeds, pressure, etc.) vary at all points of the network and the distribution system itself (ducts, valves, pumps,
35 etc.), even between the distribution system and its outside environment.

Thus, the invention presented combines information on the real state, measured or calculated, of the water and of the network, with information on the physical and chemical degradation phenomena which act at the interface between the water and the network, in particular between the
5 water and the ducts of the network.

DESCRIPTION OF THE FIGURES

Other features and advantages of the invention will become
10 apparent from the following description which is given in an illustrative and nonlimiting manner, in light of the attached figures in which:

- figure 1 illustrates a first example of a part of a water distribution network;
- figure 2 illustrates a second example of a part of a water
15 distribution network;
- figure 3 illustrates a third example of a part of a water distribution network;
- figure 4 illustrates a fourth example of a part of a water distribution network;
- 20 - figure 5 illustrates a first embodiment of the method according to the invention;
- figure 6 illustrates a second embodiment of the method according to the invention;
- figure 7 illustrates a third embodiment of the method
25 according to the invention;
- figure 8 illustrates a fourth embodiment of the method according to the invention;
- figure 9 illustrates a fifth embodiment of the method according to the invention;
- 30 - figure 10 illustrates a first embodiment of the determination step;
- figure 11 illustrates a second embodiment of the determination step;
- figure 12 illustrates a third embodiment of the determination
35 step.

DETAILED EXPLANATION OF PARTICULAR EMBODIMENTS

Figures 1 to 4 illustrate several schemes which correspond to several examples of parts of a water distribution system 100.

A water distribution system can also be called distribution network
5 in the present description.

A water distribution system 100 is able to transport water from a production site to consumption sites.

A computer C makes it possible to perform the various steps of the method according to the invention. It is not generally linked physically to the
10 distribution system.

The system 100 comprises one or more ducts 2 that can transport water 3, notably between an entry point 10 and a current point 110.

An entry point can be situated in a water treatment plant. It can also be called “water distribution point”.

15 A current point corresponds generally to a point of the distribution network in which all or some of the following parameters are measured: pH, conductivity, temperature. These are points positioned shrewdly and/or according to regulation by the manager or the designer of the distribution network at points of the water distribution system, and equipped to perform
20 such measurements. The number of these points vary as a function of the network length, of the population. This is regulated, for example, in France.

The various parameters of interest for a water distribution system are as follows:

Parameters	Value obtained	Obtaining means
Calcium	Concentration	Measured or correlated
Magnesium	Concentration	Measured or correlated
Sodium	Concentration	Measured or correlated
Potassium	Concentration	Measured or correlated
Alkalinity (HCO_3^-)	Concentration	Measured or correlated
Chloride	Concentration	Measured or correlated
Sulfates	Concentration	Measured or correlated
Nitrates	Concentration	Measured or correlated
Silicates	Concentration	Measured or correlated

pH	pH value	Measured
Conductivity	Conductivity value	Measured or calculated
Temperature	Temperature value	Measured
pHs	Equilibrium pH value	Calculated

While, generally, there is access to the concentration parameters of the water at the entry points, which notably makes it possible to deduce therefrom a conductivity value (which can also be measured at the entry point), there is not generally access to all the concentration parameters at the current points, and even less over all the length of the pipeline.

Furthermore, if the water at a current point originates from various plants, there is a mix of water, and consequently a mix of different water qualities.

A current point 110 can be associated with a single entry point 10, in other words the water passing through said current point 110 can be supplied by a single entry point 10.

A current point 111, respectively 112, can be associated with several entry points 11, 21, respectively 12, 22, 32, in other words the water passing through said current point 111, respectively 112, can be supplied by several entry points 11, 21, respectively 12, 22, 32.

The system 100 can be organized in several zones 101, 102, 103, each zone can for example group together entry points and current points that are associated with one another.

Figure 5 illustrates a first embodiment of the method for monitoring a water distribution system 100 comprising the following steps:

- an import step IMPORT for importing input values VE of at least one parameter of the water recorded at at least one entry point 10 of the water distribution system 100 and over a recording period $\Delta t_{\text{recording}}$ comprising at least one recording date $t_{\text{recording}}$ then,
- a selection step SELECT suitable for selecting at least one current point 110, then,

- an association step ASSO suitable for associating said current point with at least one entry point 10 in the water distribution system 100, then,
- a determination step DETER suitable for determining a current value VC of said at least one parameter of the water at the current point 110 from input values VE at said at least one entry point 10 associated with said current point.

The current point 110, and the entry point or points 10 are stored in the computer C.

The determination step DETER is performed using the computer C.

There can be recording periods $\Delta t_{\text{recording}}$, and recording dates $t_{\text{recording}}$ that are different depending on the entry points.

Thus, the method according to the invention must begin by using data originating from one or more water production points (entry points). The data are the input values VE of parameters of the water.

Next, it is essential to select at least one current point, situated downstream of the entry point or points. The association of the selected current point with one or more entry points is formed by knowledge of the configuration of the flow of the water in the network. And it is essential to know the qualities of the waters which originate from the entry points and which reach the current point, and notably to know the different waters which mix before reaching the selected current point.

Figure 5 illustrates the 4 steps performed one after the other. Alternatively, only the DETER step can be performed after the other steps, all or some of the IMPORT, SELECT and ASSO steps being able to be performed in any order, or in parallel, before the DETER step.

Generally, for all the embodiments of the method illustrated in figures 5 to 9, the different steps may not be performed in the order illustrated.

Figure 6 illustrates a second embodiment of the method, in which the SYSTEM, MODEL steps are added.

The SYSTEM step is a step of implementation, in the computer, of system data S, for the water distribution system 100. The system data comprise at least data on the ducts or ducts and data on the direction of flow of the water in the duct or ducts.

5 These are generally data that are geolocated over all the distribution network being studied, which can notably and not exclusively comprise:

- the equipment of the ducts, the diameters, the lengths, the laying dates, the laying depths;
- 10 - the hydraulics of the network with, notably, the flow rates, the directions and the speeds of flow;
- the internal service pressures (min, max, average);
- the history of the water quality analyses performed at different points of the potable water network;
- 15 - the typology of the grounds;
- the history of breaks on ducts recorded on the network;
- the result of duct diagnostics;
- the history of client complaints on deterioration of quality.

20 The SYSTEM step of implementation of system data can precede the selection step SELECT.

The MODEL step is a modeling step suitable for generating a model M of flow of the water in the water distribution system 100, said model being obtained from the system data. The MODEL step follows the SYSTEM step.

25 The model of flow of the water can be generated from software such as EPANET and system data.

The association step ASSO can thus be performed by using the model generated in the modeling step MODEL.

30 That is very advantageous when there is a complex network, with several entry points associated with several current points.

Figure 7 illustrates a third embodiment of the method, in which a MESUR step is added, compared to the first embodiment. This step provides measurement and at least one current point 110 of at least one current parameter P. This measurement is performed during a measurement

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period Δt_{mesur} . The determination step DETER is then performed on the basis of input values VE and of said at least one measured current parameter, the measurement period Δt_{mesur} comprising at least one measurement date t_{mesur} , after or coinciding with a recording date $t_{\text{recording}}$.

5

Figure 8 illustrates a fourth embodiment of the method, which is a combination of the second and third embodiments.

Figure 9 illustrates a fifth embodiment of the method according to the invention in which the ZONAG, DEGRAD, ESTIM, CRITIC steps are added.

The step of zoning ZONAG of the water distribution system 100 makes it possible to define several zones 101, 102, 103 for said system, a zone comprising at least one current point 110, 111, 112 associated with at least one entry point 10, 11, 21, 12, 22, 32, 13.

The zoning step consists in dividing up the distribution system 100 into different geographic zones 101, 102, 103, which are so many zones in which the flow of the water and the quality of the water can be more specifically modeled. Thus, these water flow and water quality data can be associated with each zone, for example for a given time period.

The modeling step MODEL can contribute to or be used for the dividing up of the water distribution system 100 into zones, in the zoning step ZONAG.

In fact, in order to perform the zoning step, it is important to understand the configuration of the flow of the water in the network, to know where the water qualities are similar, how the different water sources mix.

Together, the zones represent the general organization of the water distribution system 100. Thus, once the calculations have been done for each zone, the grouping together of the different zones makes it possible to reestablish the water distribution system 100 as a whole, enriched with the data and information determined in the DETER steps performed in each zone.

The import IMPORT, selection SELECT, association ASSO and determination DETER steps can be performed for each of the zones, in order to determine a current value VC of parameter or parameters of the water at

the current point contained in a zone 101 from input values VE of at least one entry point 10 associated with said current point 110 and contained in the zone 101. This has the advantage of performing extrapolation calculations in a less complex manner, for each zone, above all for a complex water distribution system. In each zone, the flow configuration is simplified.

Each configuration by zone is associated with one or more time periods, which often correspond to seasons of the year. That means that the entry points, with their set of data recorded at different dates, can be assigned to different flow configurations and different zones depending on the season.

The calculation step DEGRAD consists in determining at least one degradation index ID at at least one current point 110, 111, 112 from at least one current value VC of parameters of the water at said at least one current point determined in the determination step DETER.

The DEGRAD step can consist in determining values of internal and/or external degradation kinetics of the distribution network, in particular of the ducts, for specific current points and/or for zones defined in the ZONAG step, even at entry points.

The calculation step DEGRAD at current points implements the calculation of values of different indices relating to the degradation potential, on the basis of the data extrapolated in the DETER step, notably in combination with data measured in the MESUR step.

Several degradation characterization indices are considered, such as, for example, the Langelier index, the Larson index, the SUEZ corrosion index and the SUEZ particle release index.

The values of the indices are then converted into concepts of internal and external degradation kinetics of the distribution network for specific points and/or zones defined in the ZONAG step. This conversion can be done with degradation models developed specifically by SUEZ or with degradation models from the literature.

One degradation index considered can be the Langevier saturation index (LSI). In this case, a current parameter measured at the

current point is the pH of the water, the step of calculation of the degradation index at this current point comprising the following steps:

- a step of calculation of a pHs (equilibrium pH) of the water from current values of concentration of chemical compounds in the water determined at said current point, then;
- a step of comparison of the pH and of the pHs at said current point, then;
- a step of deduction of a degradation index of a duct at said current point.

The Langelier is therefore an index which corresponds to the formula $LSI = pH - pH_s$, with the following results:

- if $LSI > 0$: it is encrusting or scaling water
- if $LSI < 0$: it is aggressive water for $CaCO_3$
- if $LSI = 0$: the water is in equilibrium, saturated with $CaCO_3$, which means that the deposits of $CaCO_3$ are neither deposited nor dissolved.

The Langelier index is advantageous for characterizing the degradation of ducts made of cement.

Another degradation index considered can be the Larson index. In this case, at least one parameter of the water at a current point comprises at least the chlorides and/or sulfates concentration of the water, the step of calculation of the degradation index comprising a step of deduction of the Larson index at this point as a function of current values of at least one chlorides and/or sulfates concentration of the water determined at at least one current point.

The Larson index (metal corrosion index or La) corresponds to the formula:

$$La = ([Cl^-] + 2 \cdot [SO_4^{2-}]) / [HCO_3^-] \text{ Concentration expressed in mol/l.}$$

Or even $La = [(\text{sulfates} \times 2) + \text{chlorides}] / \text{alkalinity}$.

Thus, the tables give the corrosion tendencies as a function of the calculated Larson index La :

- if $La < 0.2$: no corrosion tendency
- if $0.4 < La \leq 0.2$: low tendency
- if $0.5 < La \leq 0.4$: slight tendency

- if $1.0 < La \leq 0.5$: average tendency
- if $La \geq 1.0$: clear tendency to corrosion

It is therefore considered that the risk begins from $La \geq 0.5$. However, depending on the countries, the recommendations may differ.

5 The Larson index is advantageous for characterizing the degradation of ducts made of ferrous materials.

Other indices can be used, such as, for example, the buffer index (β) :

10

$$\beta = 2.3 \left(\frac{[H_2CO_3][HCO_3^-]}{C_T, CO_3} + \frac{[HCO_3^-][OH^-]}{C_T, CO_3} \right)$$

in which C_T, CO_3 are total concentrations of carbonated species, expressed in moles/L.

15 Two other indices considered can be the SUEZ corrosion index IC_{SUEZ} and the SUEZ particle release index PR_{SUEZ} . These indices are explained in the publication "*Predicting the effect of water quality on water distribution cast iron and steel pipes using two novel indices*". M. Philibert et al. | *Novel corrosion indices for iron and steel pipes Water Science & Technology: Water Supply* | in press | 2017.

The corrosion index IC_{SUEZ} makes it possible to calculate a rate of corrosion: it is calculated on the basis of the Buffer index (β), the Langelier index (LSI) and the Larson index (La).

25

$$IC_{SUEZ} = \frac{K \times (1 + \sqrt{La}) \times (1 + \beta)^p}{\beta}$$

in which the index β (in mmol/L) is determined by chemical simulation of injection of HCl, and in which:

$p = 1$ if $LSI < 0$ or $p = -1$ if $LSI \geq 0$

30

$K = 1$ if $pH > 7$ or $K = \frac{La}{(1 + La)}$ if $pH \leq 7$

- if $IC_{SUEZ} \leq 2$: low risk of corrosion

- if $2 < IC_{SUEZ} \leq 9$: moderate risk of corrosion
- if $9 < IC_{SUEZ} \leq 16$: high risk of corrosion
- if $IC_{SUEZ} > 16$: very high risk of corrosion

5 The particle release index PRI makes it possible to provide information on the quality of the water at at least one current point: it is calculated also on the basis of the Buffer index (β), the Langelier index (LSI) and the Larson index (La).

$$PRI_{SUEZ} = (1 + La) \times (1 + \beta)^p$$

10 in which the index β (in mmol/L) is determined by chemical simulation of injection of HCl, and in which

$$p = 1 \text{ if } LSI < 0 \text{ or } p = -1 \text{ if } LSI \geq 0$$

- if $PRI_{SUEZ} \leq 1$: very low risk of particle release
- 15 - if $1 < PRI_{SUEZ} \leq 4$: low risk of particle release
- if $4 < PRI_{SUEZ} \leq 10$: high risk of particle release
- if $PRI_{SUEZ} > 10$: very high risk of particle release

20 The estimation step ESTIM makes it possible to estimate the lifespan of at least one duct 2 of the distribution system 100 by combining at least one degradation index ID with system input data S.

It consists in performing calculations which combine the results of the DEGRAD step (degradation indices) with the data which characterize the distribution system, and notably the ducts of the network (age, dimension, 25 type of materials, distribution pressure, laying depth, etc.) consolidated in the SYSTEM step, in order to estimate a residual lifespan for specific current points and/or zones defined in the ZONAG step.

30 The definition step CRITIC makes it possible to determine the critical zones from among the zones defined in the step of zoning ZONAG of the system 100, and to distinguish them geographically.

The criticality of a zone is determined by one or more of the following factors:

- very high theoretical potential for degradation of the ducts;

- very high theoretical potential for degradation of the quality of the water;
- very high measured level of degradation of the ducts;
- very high measured level of degradation of the quality of the water;
- combination of high theoretical potential for degradation of the ducts and high measured level of degradation of ducts;
- combination of high theoretical potential for degradation of the quality of the water and high measured level of degradation of the quality of the water.

The aim of the determination step DETER is to extrapolate the values of parameters, and in particular of chemical composition of the water, known and recorded at the entry points of the network in order to perform the calculations which characterize the degradation phenomena throughout said distribution network.

The aim is to make the best use of these values, that are also called data, and determine therefrom values correlated at other points of the network.

The step of determination of these correlated values at the current points can be performed in different ways, based on the configuration of the distribution network and/or the zoning of this network. These various ways are illustrated in figures 10 to 12.

For all of figures 10 to 12:

- the “complete input data” at a recording date $t_{\text{recording}}$ at an entry point concern the input values of the following parameters of the water: the conductivity σ (measured or calculated), the concentrations of chemical compounds in the water, and possibly the pH and the temperature;
- the “complete current data” on a calculation date t_{calc} at the current point concern at least the current measured values of the following parameters of the water: the conductivity σ , and possibly the pH and the temperature.

Figure 10 illustrates the case where the current point 110 is associated with a single entry point 10. The following steps are illustrated:

- step A1: for a selected calculation period Δt_{calc} , selection of a first calculation date t_{calc} included in the period Δt_{calc} and on which the current data are complete at the point 110;
- step A2: selection of at least one recording date $t_{\text{recording}}$ prior to the first calculation date t_{calc} selected in the step A1 for which the input data are complete at the point 10 (preferably the recording date $t_{\text{recording}}$ of the entry point 10 is chosen to be as close as possible to the calculation date t_{calc}) ;
- step A3: calculation of the absolute value $|\Delta\sigma|$ of the difference between the conductivity σ_{10} of the point 10 at the date $t_{\text{recording}}$ and the conductivity σ_{110} of the point 110 on the date t_{calc} ;
- step A4: if $|\Delta\sigma|$ is less than or equal to x % of the conductivity σ_{110} , then, for the date t_{calc} , the values of the concentrations of chemical compounds recorded at the point 10 on the date $t_{\text{recording}}$ closest to the date t_{calc} are referred to the point 110;
- step A4_{bis}: if $|\Delta\sigma|$ is greater than x % of the conductivity σ_{110} , then, for the date t_{calc} , the average values for the time period Δt_{calc} of the concentrations for each chemical compound recorded at the point 10 on the dates $t_{\text{recording}}$ are referred to the point 110;
- step A5 (DEGRAD step): calculation of the degradation indices ID making it possible to qualify the interactions between the water and the materials at the points 10 and 110;
- step A6 (optional): application of the preceding steps A1 to A5 for a second calculation date t_{calc} on which the data are complete at the point 110.

Figure 11 illustrates the case where the current point 111 is associated with two entry points 11, 21.

- step B1: for a selected calculation period Δt_{calc} , selection of a first calculation date t_{calc} included in the period Δt_{calc} and on which the current data are complete at the point 111;

- step B2: selection, for each entry point 11, 21, of at least one recording date $t_{\text{recording}}$ prior to the first calculation date t_{calc} selected in the step B1 for which the input data are complete (preferably the recording date $t_{\text{recording}}$ of each entry point is chosen to be as close as possible to the calculation date t_{calc});
- step B3: calculation, for each entry point, of the absolute value $|\Delta\sigma|_1$ (respectively $|\Delta\sigma|_2$) of the difference between the conductivity σ_{11} (respectively σ_{12}) of the entry point 1 (respectively 21) on the date $t_{\text{recording}}$ and the conductivity σ_{111} of the current point 111 on the date t_{calc} ;
- step B4: if $|\Delta\sigma|_1$ and/or $|\Delta\sigma|_2$ is less than or equal to $x\%$ of the conductivity σ_{111} of the point 111, then, an entry point is selected for which the value $|\Delta\sigma|$ is the smallest and, for the date t_{calc} , the point 111 is assigned the values of the concentrations of chemical compounds recorded at said entry point on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} ;
- step B4_{bis}: otherwise, the weighting coefficients $\frac{|\Delta\sigma|_1}{\sigma_{11}}$ and $\frac{|\Delta\sigma|_2}{\sigma_{21}}$ are calculated and, for the date t_{calc} , and for each chemical compound for which the concentration in the water is known at the entry points 11 and 21, the current point 111 is assigned a concentration value C_{111} equal to $\frac{|\Delta\sigma|_1}{\sigma_{11}} \times C_{11} + \frac{|\Delta\sigma|_2}{\sigma_{21}} \times C_{21}$ in which C_{11} is the concentration of said chemical compound in the water recorded at the entry point 11 on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} and C_{21} is the concentration of said chemical compound in the water recorded at the entry point 21 on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} ;
- step B5 (DEGRAD step): calculation of the degradation indices ID making it possible to qualify the interactions between the water and the materials at the points 11, 21 and 111;
- step B6 (optional): application of the preceding steps B1 to B5 for a second calculation date t_{calc} on which the data are complete at the point 111.

Figure 12 illustrates the case where the current point 112 is associated with more than two entry points 12, 22, 32.

- step C1: for a selected calculation period Δt_{calc} , selection of a first calculation date t_{calc} included in the period Δt_{calc} and on which the current data are complete at the point 112;
- step C2: selection, for each entry point 12, 22, 32, of at least one recording date $t_{\text{recording}}$ prior to the first calculation date t_{calc} selected in the step C1 and for which the input data are complete (preferably the recording date $t_{\text{recording}}$ of each entry point is chosen to be as close as possible to the calculation date t_{calc});
- step C3: calculation, for each entry point, of the absolute value $|\Delta\sigma|_1$ (respectively $|\Delta\sigma|_2, |\Delta\sigma|_3$) of the difference between the conductivity σ_{12} (respectively σ_{22} , respectively σ_{32}) of the entry point 12 (respectively 22, 32) on the date $t_{\text{recording}}$ and the conductivity σ_{112} of the current point 112 on the date t_{calc} ;
- step C4: if $|\Delta\sigma|_1$ and/or $|\Delta\sigma|_2$ and/or $|\Delta\sigma|_3$ is less than or equal to $x\%$ of the conductivity σ_{112} of the point 112, then an entry point 12, 22, 32 is selected for which the value $|\Delta\sigma|$ is the smallest and, for the date t_{calc} , the point 112 is assigned the values of the concentrations of chemical compounds recorded at said selected entry point on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} , otherwise:
- step C4_{bis}: the weighting coefficients $\frac{|\Delta\sigma|_1}{\sigma_{12}}$, $\frac{|\Delta\sigma|_2}{\sigma_{22}}$ and $\frac{|\Delta\sigma|_3}{\sigma_{32}}$ are calculated and, for the date t_{calc} , and for each chemical compound for which the concentration in the water is known at the entry points 12, 22 and 32, the current point 112 is assigned a concentration value C_{112} equal to $\frac{|\Delta\sigma|_1}{\sigma_{12}} \times C_{12} + \frac{|\Delta\sigma|_2}{\sigma_{22}} \times C_{22} + \frac{|\Delta\sigma|_3}{\sigma_{32}} \times C_{32}$,
in which C_{12} is the concentration of said chemical compound in the water recorded at the entry point 12 on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} , C_{22} is the concentration of said chemical compound in the water recorded at the entry point 22 on the date $t_{\text{recording}}$ closest to the calculation date

t_{calc} and C_{32} is the concentration of said chemical compound in the water recorded at the entry point 32 on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} ; or:

- 5 - step C4_{ter}: the hydraulic flow is analyzed to associate the current point 112 with the entry point 12 hydraulically closest and, for the date t_{calc} , the values of the concentrations of elements recorded at said entry point 12 on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} are referred to the point 112 (case of figure 10);
- 10 - step C5 (DEGRAD step): calculation of the degradation indices ID making it possible to qualify the interactions between the water and the materials at the points 12, 22, 32 and 112;
- 15 - step C6 (optional): application of the preceding steps C1 to C5 for a second calculation date t_{calc} on which the data are complete at the current point 112.

As an alternative to the values of the concentrations of chemical compounds recorded at said entry point on the date $t_{\text{recording}}$ closest to the calculation date t_{calc} , it is possible to take an average value of the concentrations of chemical compounds recorded on several recording dates $t_{\text{recording}}$, each recording date being earlier than or coincident with the calculation date t_{calc} .

25 A step of verification VERIF of at least one calculated degradation index ID can be performed after the step of calculation of the degradation index DEGRAD. It comprises:

- 30 • a step of measurement of degradation quantities of said system at at least one current point 110;
- a step of comparison of the measured degradation quantities with the degradation indices ID calculated at said at least one current point in the calculation step DEGRAD.

35 This step makes it possible to check information produced on the basis of the preceding calculations based on the water/material interactions

of the network and providing calculated indicators, corresponding to theoretical risks, with measured quantities which give real degradation indicators.

These measured quantities can be derived from records of water quality deterioration events (water analyses, client complaints), results of diagnostics and/or autopsies on the network, for example on ducts.

That can also be enriched by analyses of the close environment of the network, for example on the ground surrounding the ducts.

For each current point and/or each zone defined in the zoning step ZONAG, calculated degradation indicators are compared with the indicators of the real degradation state.

This verification step VERIF can be followed by a step of adjustment RECAL of the calculated degradation index, by using the degradation quantities of said system measured at at least one current point in the verification step (VERIF).

The various embodiments presented can be combined with one another.

Thus, the method according to the invention makes it possible to qualify, event predict, the state of degradation of the distribution ducts and the consequences on the lifespan of the assets and the quality of the water.

The method according to the invention also makes it possible to intervene to avoid a degradation, or to prevent a degradation from becoming worse.

Thus, the method can comprise steps of intervention on the water distribution system, and/or on the water to avoid a degradation, or to prevent a degradation from becoming worse.

The two examples below, which are nonlimiting, illustrate two intervention modes that can be envisaged.

Example 1: based on degradation indices calculated at a point of the network, a setpoint for correction of the quality of the water, and notably of the pH, is transmitted to one or more automata or to several operators in

one or more plants upstream of said point. This setpoint could be reflected by a correction at an entry point. The setpoint may also be reflected by the addition of a suitable dose of reagents. This can be a dose of an acid or of a soda.

5 Example 2: based on degradation indices calculated at one or more points of the network (or in one or more zones), a setpoint for operation of the various water resources supplying said point is transmitted to one or more automata or to one or more operators to adapt the quality of the water at the entry points supplying the point or points (or one or more zones)
10 exhibiting degradation indices above predefined thresholds. This setpoint could be reflected by the preferential starting up of certain boreholes or plants which supply said points or said zones.

 The method can be implemented via software. It can thus be
15 distributed as a Cloud service, compatible for consultation and/or supply. Several access rights levels can be managed. The software can be installed on a computer, a tablet, a smartphone.

 Thus, the software implementing the method can comprise several modules, each module being able to perform all or some of the following
20 steps:

- integration and structuring of geolocated data on the distribution network, and/or data on the quality of the water, and/or data on the ground;
- creation of zones of the distribution network;
- determination of data on parameters of the water missing at
25 points and/or in zones, based on data previously integrated and structured (calculation algorithms);
- calculation, for points and/or zones, of internal and external degradation kinetics of the distribution network, based on calculations of interactions between water and materials and between grounds and
30 materials and on data previously integrated and determined.
- calculation, for points and/or zones, of the theoretical lifespan of the distribution network and of the theoretical risks of degradation of the quality of the water;
- comparison of the results generated on the basis of the
35 calculations of interactions between waters and materials (theoretical risks)

with measurements of the real state of the network and/or records of water quality deterioration events;

- comparison of the results generated on the basis of the calculations of interactions between grounds and materials (theoretical risks)
- 5 with measurements of the real state of the network and/or records of water quality deterioration events;
- identification, over all of the distribution network, of the critical zones, in which there may be risks of breaks and/or of deterioration of the quality of the water transported;
- 10 - notification to the users by display mechanisms indicating a state of risk or critical state;
- comparison of the indicators of one network with another (benchmarking function) to the scale of a specific perimeter (country, company) or of the overall perimeter of the application (world base).

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Furthermore, the present invention is not limited to the embodiments previously described but extends to any embodiment lying within the scope of the claims.

CLAIMS

1. A method for determining parameters that can provide information on the state of a water distribution system (100) comprising at least one duct (2) capable of transporting water (3), the method comprising the following steps:
 - 5 - an import step (IMPORT) suitable for importing, to a computer (C), input values (VE) of at least one previously measured parameter of the water, recorded at at least one entry point (10) of the water distribution system (100) and over a recording period ($\Delta t_{\text{recording}}$) comprising at least one recording date ($t_{\text{recording}}$);
 - 10 - a selection step (SELECT) suitable for selecting at least one current point (110);
 - an association step (ASSO) suitable for associating said current point with at least one entry point (10) in the water distribution system (100);
 - 15 - a determination step (DETER) suitable for determining a current value (VC) of said at least one parameter of the water at the current point (110) from input values (VE) at said at least one entry point (10) associated with the current point (110).
 - 20

2. The method as claimed in claim 1, the determination step (DETER) comprising the following steps:
 - 25 - if the current point (110) is associated with a single entry point (10), then the current value (VC) of at least one parameter of the water is assigned the time average value of the input values (VE) of said parameter;
 - if the current point (111) is associated with at least two entry points (11, 21), then
 - 30 o either the time average of the input values (VE) of at least one parameter of the water is calculated for each entry point (11, 21) associated with said current point, each calculated time average is weighted by a first weighting

- coefficient (y_{11} , y_{21}), and a value equal to the sum of the weighted time averages of all the entry points is assigned to the current value (VC), the sum of the first weighting coefficients (y_{11} , y_{21}) being equal to 1;
- 5 ○ or the current value (VC) of at least one parameter of the water is assigned the time average value of the input values (VE) of said parameter at the entry point (11) hydraulically closest to the current point (111);
- 10 the time average of the input values (VE) of a parameter of the water being the average of said input values over a calculation period (Δt_{calc}) comprising at least one recording date ($t_{\text{recording}}$).
3. The method as claimed in claim 1, also comprising a step of measurement (MESUR) of at least one current parameter measured at at least one current point (110) during a measurement period (Δt_{mesur}), the determination step (DETER) being performed on the basis of input values (VE) at said at least one entry point associated with the current point (110) and of said at least one measured current parameter, the measurement period (Δt_{mesur}) comprising at least one measurement date (t_{mesur}), later than or equal to the recording period ($\Delta t_{\text{recording}}$).
- 15 20 25 30 35
4. The method as claimed in claim 3, a parameter of the water being the value of the conductivity of the water and a measured current parameter being the current conductivity of the water measured at a current point (110) on the measurement date (t_{mesur}).
5. The method as claimed in claim 4, the determination step (DETER) comprising the following steps:
- 30 - If the current point (110) is associated with a single entry point (10), and:
- if the absolute value of the deviation between the current conductivity and the input conductivity is less than or equal to a percentage x of the current conductivity then the current value (VC) of at least one parameter of the water

- is assigned the input value or values (VE) of said parameter recorded at the earlier recording date ($t_{\text{recording}}$) and temporally closest to the measurement date (t_{mesur}) or equal to said measurement date;
- 5 ○ if the absolute value of the deviation between the current conductivity and the input conductivity is greater than a percentage x of the current conductivity then the current value (VC) of at least one parameter of the water is assigned the time average of the input values (VE) of said
- 10 parameter;
- if the current point (111) is associated with at least two entry points (11, 21) and:
- 15 ○ if the absolute value of each deviation between the current conductivity and the input conductivity at each entry point associated with said current point is less than or equal to a percentage x of the current conductivity then the current value (VC) of at least one parameter of the water is assigned the time average of the input values (VE) of said
- 20 parameter at the entry point (11) at which the input conductivity of the water is closest to the current conductivity of the water;
- 25 ○ if the absolute value of at least one deviation between the current conductivity and the input conductivity at each entry point (11, 21) associated with said current point is greater than a percentage x of the current conductivity then:
- 30 ■ **either** the time average of the input values (VE) of at least one parameter of the water is calculated for each entry point (11, 21), the time average calculated for each entry point (11, 12) is weighted by a second weighting coefficient (z_{11} , z_{12}) that is a function of the ratio between the input conductivity of the water at said entry point and the current conductivity, and the current value (VC) of said parameter is assigned a
- 35 value equal to the sum of the weighted time averages;

the sum of said second coefficients (z_{11} , z_{12}) being equal to 1;

- **or** the current value (VC) of at least one parameter of the water is assigned the time average of the input values (VE) of said parameter at the entry point (11) hydraulically closest to the current point (111);

the time average value of the input values (VE) of said parameter being the average of said input values over a calculation period (Δt_{calc}) comprising at least one recording date $t_{\text{recording}}$ and one measurement date t_{mesur} , the recording date being earlier than or equal to the measurement date ; and the value of the percentage x being defined as a function of the desired accuracy.

6. The method as claimed in claim 5, wherein, if the current point (110) is associated with a single entry point (10), and if the absolute value of the deviation between the current conductivity and the input conductivity is greater than a percentage x of the current conductivity, then the current value (VC) of at least one parameter of the water is assigned the time average of the input values (VE) of said parameter, weighted by the ratio between the input conductivity of the water and the current conductivity of the water weighted by the ratio between the input conductivity of the water and the current conductivity of the water.

7. The method as claimed in one of the preceding claims, comprising a step of zoning (ZONAG) of the water distribution system (100) suitable for defining several zones (101, 102, 103), a zone comprising at least one current point (100, 111, 112) associated with at least one entry point (10, 11, 21, 12, 22, 32, 13).

8. The method as claimed in one of the preceding claims, also comprising a step of calculation (DEGRAD) of at least one degradation index (ID) at at least one current point (110, 111, 112) from at least one current value (VC) of parameters of the water at

said at least one current point determined in the determination step (DETER).

- 5 9. The method as claimed in claim 8, the step of calculation (DEGRAD) of at least one degradation index (ID) at at least one current point being performed also on the basis of a current parameter measured at said current point.
- 10 10. The method as claimed in claim 9, a current parameter measured at at least one current point (110, 111, 112) being the pH of the water, the step of calculation (DEGRAD) of at least one degradation index comprising the following steps:
- 15 - a step of calculation of an equilibrium pH (pH_S) of the water on the basis of current values (VC) of concentration of chemical compounds in the water determined at said current point (110, 111, 112) then;
 - a step of comparison of the pH and of the equilibrium pH (pH_S) at said current point then;
 - 20 - a step of deduction of a degradation index (ID) of the water distribution system (100) at said current point (110, 111, 112).
- 25 11. The method as claimed in claim 8, the at least one parameter of the water comprising at least the chlorides and/or sulfates concentration of the water, and the step of calculation (DEGRAD) of at least one degradation index comprising a step of deduction of a degradation index of the water distribution system (100) at at least one current point (110, 111, 112) as a function of current values (VC) determined at said current point of at least one determined chlorides and/or sulfates concentration of the water.
- 30 12. The method as claimed in claim 8, the step of calculation (DEGRAD) of at least one degradation index comprising the use of a corrosion index (CI) suitable for calculating a rate of corrosion and of a particle emission index (PRI) that can provide information

on the quality of the water at at least one current point (110, 111, 112).

- 5 13. The method as claimed in claim 12, comprising a step of estimation (ESTIM) of the lifetime of at least one duct (2) of the distribution system (100) by combining at least one degradation index (ID) with data on the water distribution system (100).
- 10 14. The method as claimed in claim 13 in combination with claim 7, also comprising a step of definition (CRITIC) of critical zones from among the zones defined in the step of zoning (ZONAG) of the system (100).
- 15 15. The method as claimed in one of claims 8 to 14, also comprising a step of verification (VERIF) of at least one degradation index (ID) of the water distribution system (100) comprising:
- a step of measurement of degradation quantities of said system at at least one point (10, 110) of the distribution system (100);
 - 20 - a step of comparison of the measured degradation quantities with degradation indices (ID) calculated at said at least one point in the calculation step (DEGRAD);
- 25 followed by a step of adjustment (RECAL) of at least one degradation index (ID) of the water distribution system (100), by using the degradation quantities of said system measured in the verification step (VERIF).
- 30 16. The method as claimed in one of claims 8 to 15, also comprising a step of sending, to a control system, of at least one calculated and/or adjusted degradation index, the control system being able to act on the water distribution system and/or the water so as to correct the state of said water distribution system.
- 35 17. The method as claimed in claim 16, the correction step consisting in the addition of one or more reagents in the water, the quantity of

a reagent being calculated by the control system as a function of at least one calculated and/or adjusted degradation index.