

Claims

1. A method of operating a group of one or more devices (1) on an operating site (3) and of calibrating said devices (1), wherein: each device (1) is a measurement device (1) and calibrations of said devices (1) are executed based on time schedules determined based on calibration time intervals (A) determined for each of the devices (1), said method comprising the steps of:
- 5 a) during each calibration of each device (1): determining a degree of compliancy of the respective device (1) to a requirement specified for this device (1), based on said degree of compliancy determining a recommended interval (R) for the next calibration of the respective device (1) and determining a ratio (r) of the recommended interval (R) and the calibration time interval ($A(t_{n-1})$) currently applied to this device (1),
- 10 b) reviewing the calibration time intervals (A) based on said ratios (r) and a predetermined set of ratio ranges (I, II, III) by: for each device (1) performing a procedure predetermined for the ratio range (I, II, III) comprising ratios of the size of the ratio (r) determined for the respective device (1) or a replacement device (1) replacing the device (1) and updating the calibration time interval ($A(t_{n-1})$) currently applied to the respective device (1) based on at least one of: a rule defined for the respective ratio range (I, II, III) and a rule applicable to the respective device (1), and
- 15 c) determining the time schedule providing scheduled calibrations times (t_s) at which the devices (1) shall be calibrated again based on the updated calibration time intervals ($A(t_n)$) determined for each of the devices (1) and performing the next calibrations of the devices (1) according to the scheduled calibration times (t_s).
2. The method according claim 1, wherein the set of ratio ranges (I, II, III) comprises:
- 25 a lower ratio range (I) comprising ratios (r) ranging from zero to an upper limit (L1) of the lower range (I) smaller than 1 or smaller or equal to 0.75,
- an intermediate range (II) comprising ratios (r), wherein the recommended interval (R) and the currently applied calibration time interval ($A(t_{n-1})$) are of the same order of magnitude, or comprising ratios (r) ranging from the upper limit (L1) of the lower range (I) to an upper limit (L2) of the intermediate range (II) larger than 1, smaller or equal to 1,25 or smaller or equal to 2, and
- 30 a higher ratio range (III) comprising ratios (r), wherein the recommended interval (R) is larger or significantly larger than the currently applied calibration time interval ($A(t_{n-1})$), or comprising all ratios (r) exceeding a given threshold or a threshold given by the upper limit (L2) of the intermediate ratio range (II).
3. The method according claim 2, wherein: the procedure performed with respect to all devices (1) exhibiting ratios (r) comprised in the lower ratio range (I) comprises: a first procedure step of performing at least one of: adjusting, servicing and repairing the device (1), a second procedure step of re-calibrating the device (1), re-determining the recommended interval (R) and re-determining the ratio (r) based on the re-determined recommended interval (R), and a third procedure step of
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determining the updated calibration time interval ($A(t_n)$) for the respective device (1) or a replacement device (1) replacing the device (1).

4. The Method according claim 3, wherein: the procedure performed with respect to all devices (1) exhibiting ratios (r) comprised in the lower ratio range (I) further comprises at least one of the procedure steps of:
- a) performing the first, the second and the third procedure step only with respect to devices (1) exhibiting a ratio (r) exceeding a predefined threshold (r_{min}) and replacing devices (1) exhibiting a ratio (r) smaller than this threshold (r_{min}),
 - b) replacing the respective device (1) in case the re-determined ratio (r) belongs to the same ratio range (I) as the previously determined ratio (r),
 - c) determining the updated calibration time interval $A(t_n)$ for the respective device (1) based on the rule applicable to the respective device (1) or by determining a product of the re-determined recommended interval (R) and a predefined constant and determining the updated calibration time interval ($A(t_n)$) to be equal to an interval shorter than the product and longer than a minimum interval (CTI_{min}) defined for the device (1), and
 - d) determining the updated calibration time interval $A(t_n)$ for the respective replacement device (1) based on a recommendation of a manufacturer of the replacement device (1).
5. The method according claim 1 to 4, wherein:
- the procedure performed with respect to all devices (1) exhibiting ratios (r) comprised in the intermediate ratio range (II) comprises at least one of the steps of:
 - a) determining the updated calibration time interval $A(t_n)$: a1) based on at least one of: the recommended interval (R) and the currently applied calibration time interval ($A(t_n)$), a2) to be equal to the currently applied calibration time interval ($A(t_{n-1})$), to be equal to the recommended interval (R) or to be equal to the longer or the shorter of the currently applied calibration time interval ($A(t_{n-1})$) and the recommended interval (R), a3) based on a rule taking into account at least one requirement, restriction or circumstance prevailing at the operating site (3), and/or a4) based on the rule applicable to the respective device (1), and
 - b) performing at least one of: servicing the device (1), cleaning the device (1) and replacing of at least one part of the device (1), and
 - the procedure performed with respect to all devices (1) exhibiting ratios (r) comprised in the higher ratio range (III) comprises at least one of the steps of determining the updated calibration time interval ($A(t_n)$): c1) to be longer than the currently applied calibration time interval ($A(t_{n-1})$) and shorter or equal to the recommended interval (R) determined for the respective device (1), c2) based on a rule accounting for at least one requirement, restriction or circumstance prevailing at the operating site (3), c3) to be equal to the longest or one of the longest intervals comprised in a predefined set of intervals comprising a limited number of intervals of different lengths that is shorter than or equal to the recommended interval (R) determined for the respective device (1), c4) to be shorter or equal to at least one of: a maximum permissible interval length defined for the respective device (1) and a

maximum permissible interval length defined for the operating site (3), and/or c5) based on the rule applicable to the respective device (1).

5 6. The method according claim 1 to 5, further comprising the steps of: repeating the performance of the method for at least one more calibration cycle, by:

during each cycle performing the method steps of performing the calibrations, determining the ratios (r), reviewing and updating the currently applied calibration time intervals ($A(t_{n-1})$) and of scheduling and performing the next calibrations,

10 wherein during each cycle following the first performance of the method, the currently applied calibration time intervals ($A(t_{n-1})$) are given by the corresponding updated calibration times intervals ($A(t_n)$) determined during the previous cycle.

7. Method according claim 1 to 6, wherein:

15 each recommended interval (R) is determined such, that recommended intervals (R) determined for devices (1) exhibiting a higher degree of compliancy are longer than recommended intervals (R) determined for devices (1) exhibiting a lower degree of compliancy and vice versa,

each calibration of each device (1) scheduled according to one of said time schedules is performed at a calibration time (t_n) terminating an operating time interval (OTI) during which the respective device (1) has been operated at the operating site (3), and/or

20 each scheduled calibration time (t_s) determined for one of the devices (1) corresponds to a scheduled interval (S) of a length given by a time difference between the respective scheduled calibration time (t_s) and a calibration time (t_n) at which the respective device (1) or its predecessor in case the device (1) has been replaced has last been calibrated prior to the scheduled calibration time (t_s).

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8. Method according claim 1 to 7, further comprising the steps of:

for at least one or each calibration of at least one or all devices (1) of the group recording a data set (k) comprising a device identification (d) of the respective device (1) and at least two or all of: the recommended interval (R), the currently applied calibration time interval ($A(t_{n-1})$), the updated calibration time interval ($A(t_n)$), the scheduled interval (S) and the operating time interval (OTI) following the respective calibration, and

30 performing at least one of the steps of: determining at least one indicator indicative of the performance of the method for at least one of the data sets (k) or based on the intervals comprised in at least one of the data sets (k), recording at least one of said indicators, displaying at least one of said indicators, monitoring at least one of said indicators and of issuing a notification when one of said monitored indicators exceeds a threshold defined for the respective indicator.

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9. Method according claim 8, wherein said indicators comprise at least one of:

- a first asset value ($V1(k)$) quantifying an increased cost associated with updates wherein the currently applied calibration time interval ($A(t_{n-1})$) is shortened such that the updated calibration time interval ($A(t_n)$) is shorter than the recommended interval (R),
- 5 a second asset value ($V2(k)$) quantifying an increased risk associated with updates, wherein the currently applied calibration time interval ($A(t_{n-1})$) is extended such that the updated calibration time interval ($A(t_n)$) is longer than the recommended interval (R),
- a third asset value ($V3(k)$) quantifying a cost reduction potential used by updates, wherein the currently applied calibration time interval ($A(t_{n-1})$) is extended such that the updated calibration time interval ($A(t_n)$) is shorter or equal to the recommend interval (R),
- 10 a fourth asset value ($V4(k)$) quantifying a risk reduction potential used by updates, wherein the currently applied calibration time interval ($A(t_{n-1})$) is reduced such that the updated calibration time interval ($A(t_n)$) is longer or equal to the recommended interval (R),
- a combined asset value ($VC(k)$) given by the only one of the first asset value ($V1(k)$), the second asset value ($V2(k)$), the third asset value ($V3(k)$) and the fourth asset value ($V4(k)$) defined for the
- 15 respective data set (k),
- at least one scheduled asset value ($VS1(k)$, $VS2(k)$, $VS3(k)$, $VS4(k)$, $VCS(k)$) each determined in the same way as one of the first asset value ($V1(k)$), the second asset value ($V2(k)$), the third asset value ($V3(k)$), the fourth asset value ($V4(k)$) and the combined asset value ($VC(k)$) by replacing the
- 20 updated calibration time intervals ($A(t_n)$) applied in the respective determination by the scheduled interval (S),
- at least one implemented asset value ($VI1(k)$, $VI2(k)$, $VI3(k)$, $VI4(k)$, $VCI(k)$) each determined in the same way as one of the first asset value ($V1(k)$), the second asset value ($V2(k)$), the third asset value ($V3(k)$), the fourth asset value ($V4(k)$) and the combined asset value ($VC(k)$) by replacing the
- 25 updated calibration time intervals ($A(t_n)$) applied in the respective determination by the operating time interval (OTI),
- at least one calibration value ($W(k)$), wherein each calibration value ($W(k)$) is determined based on the intervals comprised in one of the data sets (k) based on or as a difference or an absolute value of the difference between or a quotient of the operating time interval (OTI) and the scheduled
- 30 calibration time interval (S) comprised in the respective data set (k),
- at least one indicator value determined based on the intervals comprised in one of the data sets (k) based on or as a difference or an absolute value of the difference between or a quotient of the recommended interval (R) and the currently applied calibration time interval ($A(t_{n-1})$),
- at least one indicator value determined based on the intervals comprised in one of the data sets (k) based on or as a difference or an absolute value of the difference between or a quotient of the
- 35 recommended interval (R) and the updated calibration time interval ($A(t_n)$),
- at least one indicator value determined based on the intervals comprised in one of the data sets (k) based on or as a difference or an absolute value of the difference between or a quotient of the updated calibration time interval ($A(t_n)$) and the scheduled interval (S),

at least one indicator value determined based on the intervals comprised in one of the data sets (k) based on or as a difference or an absolute value of the difference between or a quotient of the updated calibration time interval ($A(t_n)$) and the currently applied calibration time interval ($A(t_{n-1})$), and at least one other indicator.

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10. Method according claim 8 to 9, further comprising the steps of:

defining at least one device group, wherein said device groups comprise at least one of: at least one device-group each comprising a single specific device (1), at least one device-group each comprising devices (1) of a given class or type, at least one device-group each comprising devices (1) operating on a specific section of the operating site (3) or on a section, that needs to be shut down every time one of the device (1) operating on this section is calibrated, a device-group comprising all devices (1) operating on the operating site (3) and/or at least one other device-group,

determining at least one group-indicator for each of at least one of the device-groups, wherein each group-indicator is determined based on, as an average or an average of the absolute values of one of the indicators determined for each of the data sets (k) recorded for the devices (1) comprised in the device-group during a given time period (Δt_i), and

performing at least one of the steps of: determining at least one of the group-indicators for several consecutive give time periods (Δt_i), recording at least one of said group-indicators, displaying at least one of said group-indicators, monitoring at least one of said group-indicators and of issuing a notification when one of said monitored group-indicators exceeds a threshold defined for the respective group-indicator.

11. Method according claim 8 to 10, further comprising the step of: based on at least one of: the first asset values ($V1(k)$), the second asset values ($V2(k)$), the third asset values ($V3(k)$), the fourth asset values ($V4(k)$), the combined asset values ($VC(k)$), the scheduled asset values ($VS(k)$), the implemented asset values ($VI(k)$) and/or at least one of the group-indicators (V_G) each determined based on one of the first asset values ($V1(k)$), the second asset values ($V2(k)$), the third asset values ($V3(k)$), the fourth asset values ($V4(k)$), the combined asset values ($VC(k)$), the scheduled asset values ($VS(k)$) or the implemented asset values ($VI(k)$) performing at least one of identifying, quantifying, providing, displaying and monitoring at least one of: increased risks, increased costs, used or unused risk reduction potentials available according to the recommended intervals (R) and used or unused cost reduction potentials available according to the recommended intervals (R).

12. Method according claim 11, further comprising the step of: in case one of said increased risks, increased costs, unused cost reduction potentials and/or unused risk reduction potentials exceeds a given threshold determining at least one root cause root causing the threshold to be exceeded based on the indicators and/or the group-indicators.

13. Method according claim 12, further comprising at least one of the steps of:

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identifying at least one of the rules and/or at least one of the procedure steps of the procedures predetermined for the ratio ranges (I, II, III) as root cause when at least one said increased risks, increased costs, unused cost reduction potentials and/or unused risk reduction potentials quantified based on the first asset values (V1(k)), the second asset values (V2(k)), the third asset values (V3(k)), the fourth asset values (V4(k)) and/or at least one of the group indicators determined based on the first asset values (V1(k)), the second asset values (V2(k)), the third asset values (V3(k)) and/or the fourth asset values (V4(k)) exceeds the corresponding threshold,

identifying scheduling as a root cause when the increased risks, the increased costs, the unused risk reduction potentials and/or the unused cost reduction potentials quantified based on least one of the scheduled asset values (VS1(k), VS2(k), VS3(k), VS4(k)) and/or at least one of the group indicators determined based on the scheduled asset values (VS1(k), VS2(k), VS3(k), VS4(k)) exceeds the value of the corresponding property quantified based on the first asset values (V1(k)), the second asset values (V2(k)), the third asset values (V3(k)) and/or the fourth asset values (V4(k)) by more than a predefined threshold, and

identifying adherence to schedule of the performed calibrations to the time schedule as a root cause when the increased risks, the increased costs, the unused risk reduction potentials and/or the unused cost reduction potentials quantified based on least one of the implemented asset values (VI1(k), VI2(k), VI3(k), VI4(k)) and/or at least one of the group indicators determined based on the implemented asset values (VI1(k), VI2(k), VI3(k), VI4(k)) exceeds the value of the corresponding property quantified based on the scheduled asset values (VS1(k), VS2(k), VS3(k), VS4(k)) by more than a predefined threshold.

14. Method according claim 13, further comprising at least one of the steps of:

once a root cause has been identified amending the method by taking a corresponding countermeasure, and

amending at least one of: at least one of the rules and at least one of the procedure steps of the procedures predetermined for the ratio ranges (I, II, III) that has been identified as root cause, the scheduling identified as root cause and/or the calibration performance procedure when adherence to schedule has been identified as root cause.

15. A calibration optimization system (17) designed to perform at least one of the method steps of the method according to claims 8 to 14, wherein:

said system (17) comprises:

a memory (15),
an interface (21) designed to receive data required by the system (17) to store or to determine and to store the data sets (k) in said memory (15),

computing means (19) and a computer program (SW) implemented on said computing means (19) and causing said computing means (19) to perform the determination of the indicators and/or the group indicators based on the data sets (k) stored in the memory (15), and

wherein said system (17) is designed to perform at least one of:

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recording at least one of said indicators and/or said group-indicators,
providing at least one of said indicators and/or said group-indicators via an output (25) of system (17),

5 displaying at least one of said indicators and/or said group-indicators on a display (23) comprised in or connected to said system (17),

monitoring at least one of said indicators and/or said group-indicators, and

issuing a notification when one of the monitored indicators and/or said monitored group-indicators exceeds a threshold defined for it.