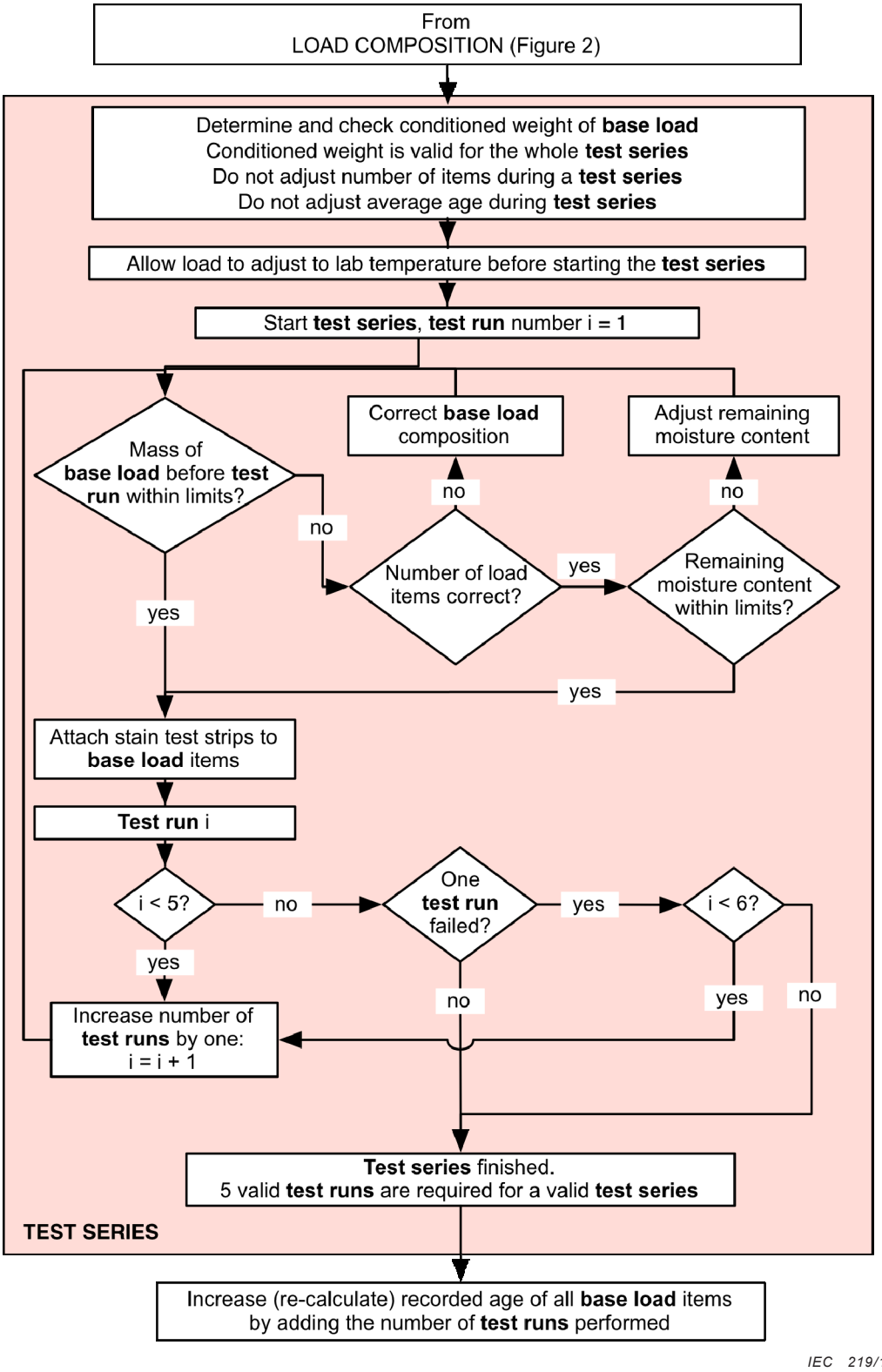


Figure 4 – Test series: process and decisions for load mass and age

[A11] For **test series** with **treatment full, treatment half** and **treatment quarter** specific validity criteria for **test runs** and the **combined test series** of the **test washing machine** are set out in Annex ZA. [A11]

[A11] For the **combined test series** consisting of 10 **test runs** for the **test washing machine** a schematic representation is set out in Figure ZA.2. [A11]

8.3 Measurements to determine washing performance

8.3.1 General

This clause contains specific requirements for the measurement of washing performance. Evaluation of the measurements performed in this clause are set out in 9.2.

8.3.2 Removal and drying of stain test strips

After completion of each **test run** in accordance with 8.2, the stain test strips are removed from the **test load** at the completion of the **programme.**

Before taking reflectance measurements (8.3.3), the test strips shall be dried and flattened. Any method of drying and flattening may be used provided it can be shown to produce the same reflectance result as one of the following options:

- air dry and flatten by placing the wet stain test strip under tension at ambient temperature in the dark; or
- air dry at ambient temperature in the dark, then flatten by ironing; or
- dry and flatten by ironing the wet stain test strip.

If an ironing appliance is used it shall comply with 5.4.6 and it shall be used in such a way that it does not cause a surface shine on the test strip. This can be achieved by placing a piece of fabric between the hot plate and the stain test strip.

Once dry, the stain test strips may be stored in a dry dark place until the reflectance measurement is undertaken (refer to 8.3.3).

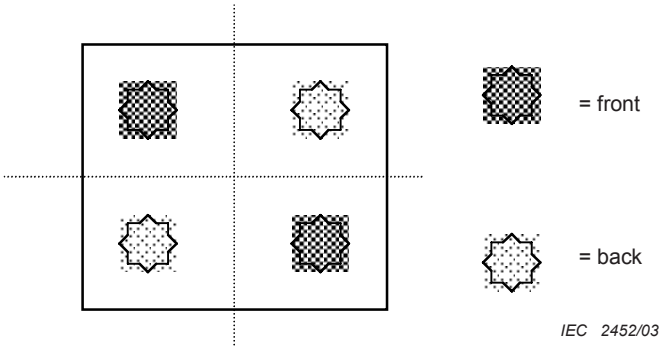
NOTE Residual humidity in the stain test strips will influence the measurement results, as will overheating during ironing. Exposure of the stain test strips to direct daylight at any time is not advisable.

8.3.3 Assessment of stain test strips

To assess washing performance, tristimulus Y reflectance measurements are carried out on each of the individual soil types and the unsoiled test piece which make up the stain test strip. Reflectance measurements shall be taken with a spectrophotometer as specified in 5.4.3.

For any complete set of tests, the reflectance of all stain test strips (reference machine and test machines) shall be measured under the same ambient conditions. The stain test strips shall be allowed to stabilise at these conditions before the reflectance measurements are undertaken.

Reflectance measurements are taken with not less than four layers of the same washed soil type as backing for the piece being measured. Every washed piece is measured twice on both sides, at the positions indicated in Figure 5. Each of the 4 individual readings shall be recorded. The average value of the four readings for each soil type is used in the subsequent evaluation for that soil type.



Positions for measuring each soil type are in the centre of the four square quadrants.

Figure 5 – Positions for measuring soiled test pieces

8.4 Measurements to determine water extraction performance

8.4.1 General

This clause contains specific requirements for the assessment of water extraction performance, which is a measure of the residual water in the **base load**. Evaluation of the measurements performed in this clause are set out in 9.3.

〈C〉 For the combined **test series** additional requirements for the measurement of water extraction performance of the **test washing machine** are included in Annex ZA. 〈C〉

The water extraction performance is expressed as the amount of remaining moisture in the **base load** after the final spinning operation at the end of the **programme** relative to the conditioned mass of the same **base load**.

This method is intended for the assessment of **automatic washing machines** that have spin **operation** at the completion of the **programme**. It is also intended to be used to assess the performance of separate **spin extractors** and **manual washing machines** that have a separate **spin extractor**.

NOTE The **spin extraction** of **manual washing machines** with a spinning **operation** (including **washing machines** with a separate spinning device such as twin tubs) can be assessed using this method. While this method could also be used for assessment of hand operated wringing machines, this is not generally recommended as the results are somewhat dependent on the skill of the operator. However, the method could provide some qualitative assessment of such a device.

8.4.2 Washing machines

The **test load** shall be subjected to the performance test procedure specified in 8.2.

At the completion of the test **programme** as set out in 8.4.1, without delay, remove the soiled **test strips** and weigh the **base load**. The mass of the moist **base load** at the completion of the **programme** is recorded.

NOTE The final mass of the **base load** has to be measured prior to any subsequent water extraction to assess rinse performance, see 8.4.

8.4.3 Spin extractors

For the measurement of water extraction performance of separate **spin extractors** the washing and rinsing **operations** are performed in accordance with 8.2 but without a final spin **operation**. The **programme** selected shall be suitable for the **base load** to ensure repeatable conditions. At the completion of the **programme**, without delay, weigh the **base load**.

The **spin extractor** shall be loaded evenly, with the items placed along the drum wall of the **spin extractor**. When the items reach about one-third of the height of the drum, the items are pushed from the circumference to the centre so as to fill the hollow in the centre of the drum.

This is repeated once or twice as the drum gets filled further. The **base load** is finally covered at the top with the last **base load** item, which is folded over double for this purpose.

The water is extracted from the **base load** for the time recommended by the manufacturer or for 4 min if instructions are not given.

8.5 Measurements to determine rinsing performance

8.5.1 General

This clause contains specifications for a test using the residual alkalinity of the detergent solution in a base load after **spin extraction** as a measure of the rinsing performance. The purpose is to evaluate how well a typical textile load is rinsed as regards water-soluble residues. This clause contains specific requirements for the measurement of rinsing performance. Evaluation of the measurements performed in this clause are set out in 9.4.

〚A11〛For the **combined test series** specific requirements for the measurement of rinsing performance (rinsing effectiveness) are included in Annex ZA.〈A11〛

This test is conducted in accordance with Clause 8.2. At least five complete **test runs** shall be carried out using the selected **programme** (refer to 8.2.4).

After the completion of the **programme**, the **spin extraction** and sampling is carried out in accordance with 8.5.2.

This method is intended for **automatic washing machines** that have spin operation at the completion of the **programme**. It is not intended to be used to assess separate spin extractors or **manual washing machines** that have a separate spin extractor.

8.5.2 Spin extraction and sampling

Before each spin extraction the standard extractor (refer to 5.4.5) shall be thoroughly cleaned from alkalinity remaining from previous spin operations by flushing it with laboratory supply water, tilting it – if possible – and dried by running it for an appropriate time.

NOTE 1 Ensuring that the standard extractor is empty is critical to avoid dilution of the water subsequently extracted from the base load.

A sample of approximately 1 l is taken from the laboratory supply water used for the **test washing machine**.

After a complete **programme** including washing, rinsing and spinning, the **test load** shall be removed from the washing machine, then the mass of the **base load** (with any stain test strips removed) is determined (noting that the mass of the **base load** is also required for determination of the water extraction index in Subclause 8.4).

Without delay the **base load** shall be split into bundles. Each bundle of cotton load shall contain one sheet, two pillowcases and six towels. Each bundle of synthetic/blend shall contain four pillowcases and four shirts. The mass of each bundle is determined.

Every bundle shall be spun in separate spin extractors immediately.

NOTE 2 The measurement of alkalinity is seriously affected by interactions of the **base load** with the atmosphere.

Each bundle shall be treated in the following way:

For cotton load bundles: Treat one sheet in the same way as described in J.3 and place it flat on the base of the standard extractor. Treat two pillowcases (separate) in the same way as described in J.3 and place them along the wall of the standard extractor. Treat five towels

(separate) in the same way as described in J.3 and place them along the wall of the standard extractor. Finally fold one towel in the middle of the longer side and place it flat at the top.

Each bundle is spun separately in the standard extractor for 10 min or the spin time determined in 5.4.5. Each bundle and the extracted water is weighed after extraction.

If no bundle can be formed due to the number of items requested (i.e. < 3,5 kg) proceed as follows:

Bundle specifications for cotton loads			
Nominal load size (kg)	Number of sheets	Number of pillowcases	Number of towels
Greater than 3,5 kg	1	2	6
3,0 kg to 3,5 kg	1	2	up to 6
Less than 3,0 kg	all items		

For synthetic/blend load bundles: Treat shirts and pillowcases as described in J.3 and distribute them evenly along the wall of the standard extractor and spin it for 5 min. The bundles and the extracted water are weighed after extraction.

All the extracted water from the bundles is collected, the last amount, if possible, by tilting the standard extractor towards the outlet. It is thoroughly mixed and a sample is transferred into a dry and clean bottle and closed tightly if the sample is not titrated within 1 h.

Remaining items after the splitting into bundles are weighed. They are spun separately in the standard extractor for 10 min for cotton and 5 min for synthetic/blends or the spin time determined in 5.4.5. The extracted water of this spin extraction is weighed and rejected. The remaining items are weighed after extraction.

If a **spin extractor** other than one complying with the primary **standard extractor** specification in 5.4.5 is used, the actual spin time above shall be adjusted (reduced) as specified in 5.4.5 to meet the specified **remaining moisture content** requirements.

A large **standard extractor** may be used in which several bundles may be spun simultaneously. The large **standard extractor** shall be loaded according to the procedure described in Annex J. If the load size exceeds the capacity of the large **standard extractor** the load shall be divided into two equal bundles.

NOTE 3 Recorded weights are used to check validity of the spin extraction process (see Annex K).

8.5.3 Alkalinity measurements

8.5.3.1 General

The residual alkalinity in the **base load** is defined as the milliequivalents alkali per kilogram of **base load**. It is determined by titration with 0,1 N hydrochloric acid to a pH of 4,5. The corresponding value of the laboratory supply water is subtracted.

The titration itself is performed by one of two alternative methods: manual or automatic. Automatic titration is preferred for reasons of precision and reproducibility.

8.5.3.2 Alkalinity measurement

Two samples of the extracted water shall be titrated. The temperature of the samples shall be at (20 ± 5) °C. If the values of alkalinity concentration found are different by more than 2 %, a third sample shall be titrated and the average of the values obtained.

A sample of the laboratory supply water collected as described in 8.5.2 shall be tested for alkalinity in the same way as the extracted water.

8.5.3.3 Titration

The alkalinity shall be determined through titration as set out in Steps (A) to (C) below.

Step (A): after mixing the sample, put an amount of about 50 g to 100 g (see note) of the sample into a titration beaker and weigh the exact amount of sample on a scale. Record sample name and mass.

NOTE Amount depending on the expected alkalinity and on the volume of sample available; if necessary add reverse osmosis, distilled or demineralised water up to about 100 g.

Step (B): prepare the measurement equipment as needed for your specific device and start the automatic measurement. While stirring the sample titrate with HCl 0,1N to a steady (10 s) pH 4,5 endpoint. Near to the endpoint, ensure the titration speed is reduced to avoid overshooting. In case of automatic titration set speed profile accordingly.

Step (C): once terminated record all further data like titration volume n_e (alkalinity of extracted water), n_s (alkalinity of the laboratory supply water) (in ml, two decimal places) and titration time for each sample. The normal titration time should be around 2 min to 10 min per sample. If possible add a record printout.

8.6 Measurements to determine water and energy consumption and programme time

8.6.1 General

This clause specifies the procedure and measurements required for the determination of water and energy consumption during typical **operations** such as washing, rinsing and **spin extraction**. It also specifies the method for determination of the duration of the complete **programme** and total water and energy consumption.

The purpose is to obtain reproducible data for the calculation of environmental impacts and cost of operation based on water and energy consumption.

Evaluation of the measurements performed in this clause are set out in 9.5.

Determination of power consumption in **off mode** and **left on mode** is specified in Annex L.

[A11] For the **combined test series** specific requirements for the measurement of water consumption, energy consumption and **programme time** of the **test washing machine** are included in Annex ZA. [A11]

NOTE 1 This clause is applicable also to **washing machines** without **spin extraction**.

NOTE 2 Information on other low power mode energy consumption of **washing machines** is also contained in Annex L.

8.6.2 Procedure

The **test load** shall be subjected to the performance test procedure specified in 8.2. During these tests instrumentation for the measurement of water volume, water temperature and electrical energy shall record the required parameters. It is recommended that data for all parameters be recorded at regular intervals throughout the test using a data logger or computer. Data collection should commence well before the programme is initiated and continue after the **end of programme**.

Measurements are commenced when the **programme** is initiated (without any user programmed delay). They are stopped at the **end of programme**.

A **test series** consisting of five complete **test runs** shall be carried out using the selected **programme.**

[A11] Annex ZA consists of 3 **treatments** with 10 **test runs** in total for the measurement of water consumption, energy consumption and **programme time** of the **test washing machine**. [A11]

[C] For the combined **test series** according to Annex ZA a **test series** consists of seven complete **test runs** for the measurement of water consumption, energy consumption and **programme time** of the **test washing machine**. [C]

9 Assessment of performance

9.1 General

This section sets out the primary evaluation methods for the assessment of washing machine performance under this document. While these methods are intended as the main basis for **washing machine** comparisons, a range of other methods and approaches for evaluation of measured test data are included in Annex O which can yield more useful information in some cases.

This section includes the evaluation of

- washing performance
- water extraction performance
- rinsing performance (soluble components)
- energy consumption
- water consumption
- programme time

For the evaluation of washing performance (9.2) and rinsing performance (9.4) the result from the **test washing machine** is compared to the result from the **reference machine** which is operated in parallel. Assessment and information about low power mode energy consumption are included in Annex L.

[C] For the combined **test series** additional requirements for evaluation for the **test washing machine** are included in Annex ZA.

[A11] *Text deleted* [A11]

In case of an invalid **test run** (in either the **test washing machine** or the **reference machine**) neither the **test run** result in the **test washing machine** nor the corresponding **test run** result from the **reference machine** shall be used for any evaluation of that **test washing machine** within the **test series**.

9.2 Evaluation of washing performance

The washing performance shall be evaluated below using the reflectance values (Y-values) measurements determined in 8.3.3.

Steps a) to d) below are calculated for both the **test washing machine** and the **reference machine** which have been operated in parallel.

[C] For the combined **test series** additional steps of evaluation for the **test washing machine** are included in Annex ZA. Steps a) and b) are calculated for the test machine. Steps a) to d) below are calculated for the **reference machine** which has been operated in parallel. [C]

a) The average reflectance values $\bar{x}_i$ for each soil type i is given as the mean value per **test run** of the readings for each of the n stain test strips used in the test, calculated as follows:

$$\bar{x}_i = \frac{\sum_{j=1}^{n} x_{ij}}{n}$$

where

x_{ij} is the average reflectance value of the 4 individual readings for each of the 5 soil types on a stain test strip;

n is the number of stain test strips per **test run.**

NOTE 1 The standard deviation s_i for each soil type i, i.e. x_{ij}, within a given **test run** may be calculated as

$$s_i = \sqrt{\sum_{j=1}^{n} \frac{(x_{ij} - \bar{x}_i)^2}{n-1}}$$

b) The sum C_k of the average reflectance values in each **test run** is calculated as follows:

$$C_k = \sum_{i=1}^{m} \bar{x}_i$$

where

$\bar{x}_i$ is the average reflectance value for each soil type, as calculated in a);

m is the number of soil types per stain test strip.

c) The average sum $\overline{C}$ of the reflectance values for each of the five types of soil, for all **test runs**, is calculated as follows:

$$\overline{C} = \frac{\sum_{k=1}^{w} C_k}{w}$$

where

C_k is the sum of the average reflectance values in each **test run**, as calculated in b);

w is the number of **test runs** in the **test series.**

d) The standard deviation s_C of C_k, is defined as

$$s_C = \sqrt{\frac{\sum_{k=1}^{w} (C_k - \overline{C})^2}{w-1}}$$

where

C_k is the sum of the average reflectance values in each **test run**, as calculated in b);

$\overline{C}$ is the average sum of the reflectance values in each of the five types of soil, for all **test runs** in the **test series**. This is calculated in c);

w is the number of **test runs.**

e) The ratio q of the average sum is calculated as

$$q = \frac{\overline{C}_{\text{test}}}{\overline{C}_{\text{ref}}}$$

where

$\overline{C}_{\text{test}}$ is the average sum of the reflectance values for the **test washing machine**, as calculated in c);

$\overline{C}_{\text{ref}}$ is the average sum of the reflectance values for the **reference machine**, as calculated in c).

The calculated ratio q shall be rounded to the nearest 0,001.

f) The standard deviation s_q of the ratio q, is defined as

$$s_q = \sqrt{\frac{\sum_{k=1}^{w} \left(\frac{C_{k\,\text{test}}}{\overline{C}_{\text{ref}}} - q\right)^2}{w-1}}$$

where

$C_{k\,\text{test}}$ is the sum of the reflectance value in each **test run** of the **test washing machine**, as calculated in b);

$\overline{C}_{\text{ref}}$ is the average sum of the reflectance value in each **test run** of the **reference machine**, as calculated in c);

q is the ratio of the average sum, as calculated in e);

w is the number of **test runs.**

g) The confidence interval p for the ratio of the average sum is defined as

$$p = q \pm \frac{s_q}{\sqrt{w}} \times t_{w-1,\ 0,05}$$

where

s_q is the standard deviation of the ratio q, as calculated in f);

$t_{w-1,\,0,05}$ is the “Student T” factor for (w-1) degrees of freedom for a confidence level of 95 % (i.e. 2,776 for 5 **test runs**, which equals 4 degrees of freedom);

w is the number of **test runs.**

NOTE 2 If for the reference wash **programme** cotton 60 °C the ratio $\frac{s_C}{\overline{C}}$ (data calculated in c) and d)) is higher than 0,0175 (= 1,75 %) the laboratory conditions should be checked. Tolerances for other **programme**s are under consideration.

NOTE 3 The equation assumes parallel running of the **test washing machine** and the **reference machine**.

NOTE 4 Additional information can be obtained from the wash performance measurements as set out in Annex O.

9.3 Evaluation of water extraction performance

The water extraction performance shall be evaluated below using the measurements determined in 8.4.

〈C〉 For the combined **test series** the evaluation for the **test washing machine** is included in Annex ZA. 〈C〉

The **remaining moisture content** RMC is calculated for each **test run** in the **test series** and is expressed as a percentage:

$$RMC = \frac{M_r - M}{M}$$

where

M is the mass of the conditioned **base load**;

M_r is the mass of the **base load** at the end of the test run (i.e. after **spin extraction**).

The water extraction performance is the arithmetic mean of the RMC values obtained in the **test series**. It is expressed as a percentage, rounded to the nearest whole percent.

9.4 Evaluation of rinsing performance

9.4.1 General

The rinsing performance shall be evaluated as described below using the measurements determined in 8.5.

〈A11〉 For the **combined test series**, the evaluation for the **test washing machine** is included in Annex ZA. 〈A11〉

〈A11〉 *Text deleted* 〈A11〉

9.4.2 Calculations

Alkalinity concentration W (W_e or W_s) of each sample is calculated by the volume amount (in ml) of used HCl for the sample, and is usually expressed as milliequivalents *meq* alkalinity per kg water:

$$W = \frac{n_{HCl} \times 0{,}1 \frac{meq}{ml}}{m}$$

where

n_{HCl} is the amount (volume) of HCl used (measured in ml);

m is the actual mass of the sample (entered into calculation in kg);

m_e is the mass of the extracted water;

m_s is the mass of the laboratory supply water.

W_e shall be the average for the extracted water from the bundles, W_s that for the laboratory supply water.

9.4.3 Evaluation

The increased alkalinity concentration of spin-extracted water relative to the laboratory supply water is calculated as

$A_r = W_e - W_s$ [milliequivalents per kg water]

where

A_r is the increased concentration of alkalinity in the extracted water;

W_e is the averaged concentration of alkalinity in the extracted water;

W_s is the averaged concentration of alkalinity in the laboratory supply water.