# Non Half Hourly (NHH) Meter Reading Validation Algorithm

The following paper was presented to the Supplier Volume Allocation Group (SVG) in August 2002. It sets out a meter reading validation algorithm ("the algorithm") which was developed to demonstrate how a more robust set of non-half hourly meter reading validation rules than those required by the Balancing and Settlement Code (BSC) could be applied.

The algorithm was not progressed further and thus the rules within it were never formally incorporated into the BSC. There is, therefore, no obligation on BSC Parties to adopt its use.

## How can I use the algorithm?

We have re-published this SVG paper so that the algorithm is available to Market Participants should they choose to build elements of it into their systems. The algorithm rules may be of use in Meter Reading Validation systems and also in the systems used to deal with exceptions.

## What are the benefits of the algorithm?

The meter reading validation rules defined in BSCP504 are the minimum requirements placed on Non Half-Hourly Data Collectors. The rules were deliberately designed as a simple minimum to allow agents to incorporate their own processes.

The following algorithm provides an example of how more robust rules than those required by the BSC could be applied. The use of tighter meter reading validation may help improve the quality of Non Half-Hourly data, which in turn would reduce the number of erroneous EAC/AAs and the number of unreliable deemed readings on Change of Supplier.

## Limitations on the use of the Algorithm

The majority of the rules in the algorithm can be implemented by NHHDCs without the approval of a Change Proposal. However, BSCP504 paragraph 4.6 allows NHHDCs to adjust meter readings, but describes this as a "manual" adjustment. Therefore, even if a system were able to establish 'beyond reasonable doubt' that a reading had for example been transposed, the reading could only be switched back with manual intervention. To allow full implementation of the algorithm a Change Proposal would be required.

**The SVG paper** (SVG/19/242) **is re-published below.**

**Meeting name** SVG

**Date of meeting** 6 August 2002

**Paper Title** REVIEW OF METER READ VALIDATION RULES

**Purpose of Paper** For Decision

**Synopsis** This paper identifies various defects in the current rules for meter read validation, detailed in BSCP504. The impact of these defects is described, and various proposals are made to improve the strength of the validation process. SVG is invited to approve that these changes be progressed.

# 1. BACKGROUND

**1.1** Several problems in the NHH market related to the quality of consumption data have root causes that may be traced back to the meter reading validation process. These include excessive consumption problems (Large EAC/AA) and unreliable deemed reading on CoS. This paper considers the options for making improvements to the meter reading validation process.

**1.2** The validation of NHH meter readings is defined in BSCP 504 section 4.2. Some of the rules relate to the integrity of the reading (e.g. must have all the registers) and others are related to the magnitude of the energy measured. These rules are the minimum requirements placed on the NHHDC agents. When these rules were defined it was argued (and expected) that agents would use existing tried and proven processes to create stronger validation. Therefore the rules were deliberately designed as a simple minimum to allow agents to incorporate their own processes. In practice most modern NHHDC systems are built to meet only these minimum requirements, relying heavily on manual review processes to correctly validate unusual or suspect readings.

# 2. SUMMARY OF CURRENT VALIDATION RULES

**2.1** The validation of the magnitude of energy measured is based on the comparison of an expected advance with the advance generated from the reading being validated. There are no rules for how this expected reading should be generated although it is recommended that the expected advance be generated using the EAC and profile data. Clearly establishing a realistic expected advance is key to achieving a robust validation process.

**2.2** If the reading being validated gives rise to a meter advance between zero and twice the expected advance then the NHHDC can accept the reading into settlement without any further tests.

**2.3** If the reading being validated is less than the previous reading the NHHDC must check for a meter rollover. There are no rules for how a rollover should be detected and it is not clear that the advance from the rollover should be subject to any further validation.

**2.4** Reading that have failed the above checks are deemed to be suspect and are marked for manual review. There are no rules for how this review should be conducted or what information should be considered during the review, but if the reviewer can establish a good reason to accept the reading then it can be marked as valid. At this stage the reviewer can decide to manually adjust the reading(s) where they believe that either the 10th digit has been included in the reading, two of the digits have been transposed, a digit has been incremented on an analogue meter, or the registers have been swapped. There are no overriding rules that mandate when a reading must be rejected.

**2.5** These rules have proven to be incapable of ensuring that only correct meter readings are accepted into settlement.

# 3. WEAKNESSES OF CURRENT RULES

## 3.1 Derivation of Expected readings

The validation process needs to establish a benchmark to gauge the new reading against, i.e. an expected reading. The ability to derive a good expected reading is essential to a sound validation process. The current rules do not detail how the expected reading is to be produced. This was left undefined because PES agents planned to use a variety of methods that had existed before the 1998 arrangements based on the routines used for billing estimates. The BSCP recommends that the EAC and profile data be used to create the expected read, but is silent on the algorithm to use. It is expected that a process akin to the deemed reading process be used to create the expected reading. The flaw in this approach is that at times the EAC can hold a correct but unsuitable value for forecasting an expected reading. (E.g. EACs can have negative values). There is no compliant mechanism for the NHHDC to modify the EAC to a more sensible value.

## 3.2 Meter rollover detection

Meters have a finite amount of energy that they can record depending of the number digits on the register (e.g. a 6 digit meter can only record up to 999,999 units). After the maximum reading the meter returns to zero. This is termed a meter rollover. The current rules do not specify how a meter rollover should be detected. Incorrect detection of a rollover can cause significant error in the apparent energy measured and has been found to be the root cause of some large AAs. The rules do not make it clear that an advance calculated from a rollover should be subjected to further validation.

## 3.3 Tolerance

The principal part of meter reading validation is the comparison of the actual meter advance with the expected meter advance. If the expected advance is greater than zero and not greater than twice the expected advance the reading can be considered valid without further tests. Whilst it would be desirable to make the tolerance tighter it is not practicable as it needs to take into account seasonal variations that are not always accounted for when deriving the expected advance. Many agents use a simple 1/365 of annual consumption per day formula when calculating the expected advance. With such a wide tolerance it is inevitable that some invalid reading will pass validation. Note that this problem may be overcome if the rules for calculating the expected advance including consideration of the profile shape across the year.

## 3.4 Previous readings

The current validation rules assume that the previous reading has been correctly validated. The new reading is validated against the previous reading in isolation of other readings. There is no recognition that the previous reading can be further validated once the DC has readings either side of it. This can result in one bad validation decision resulting in several further good readings being mistakenly invalidated. Clearly, as the history of meter readings increases there is more reference data to judge the validity of the readings. No specific provision is made for the consideration of group of readings together.

## 3.5 Reviews of suspect readings

Any reading that fails the +/- 100% tolerance test is considered suspect and may be passed to a manual review process. There is no guidance for conducting this review or what information should be considered. Clearly the effectiveness of the review will depend on the information presented to the reviewer and the skill of the reviewer. Experience has shown that many NHHDCs use unskilled or temporary staff to conduct reviews. However, the systems provide limited data that assume a highly skilled reviewer. In order to accept the reading in to settlement the reviewer needs to establish a good reason. There is no further guidance on what may constitute a good reason. There is potential for some of the review to be automated but the BSCP offers no guidance on this.

### 3.6 Manual adjustments

Under some defined circumstances the NHHDC is allowed to create new readings to correct an error. These are termed manual adjustments, and could easily be automated in most situations if suitable checks and controls are included in the implementation details.

### 3.7 Supplier feedback

Most suppliers will perform their own validation on meter readings before using them to bill their customers. In some cases the settlement validation status is ignored in the process. One or two suppliers have implemented a feedback mechanism whereby any inconsistency between the supplier view on meter reading validity and the status provided by the NHHDC is reported back to the data collector. This feedback can be used by the data collector to inform the decision on meter reading reviews. The defined process does not include this feedback.

## 4. IMPACT OF WEAKNESSES

**4.1** Where the meter reading validation process fails and incorrectly validates or rejects a meter reading the underlying consumption data quality is damaged. The existence of poor quality data can lead to further failures in the validation process and therefore the magnitude of the issue increases and the error become more extreme. The main areas that are damaged by failures in meter reading validation are:

### 4.2 Subsequent validations

The processing and validation of a meter reading relies on the previous reading and an expectation of the meter's consumption. Clearly, if the previous reading was incorrectly validated then both of these are unreliable. The same would be true to a lesser extent if a previous reading had been incorrectly rejected. Ultimately this leads to an increased number of validation failures and either a reduction in energy settled on AAs or a temptation to allow more readings to pass validation (potentially incorrectly).

### 4.3 Deemed reads for CoS

Deemed readings are based on the EAC, which in turned is based on the AA calculated from a meter reading and the previous reading. Any incorrectly validated reading will disturb the EAC value and therefore make the deemed reading unreliable.

### 4.4 Erroneous excessive consumption

Any incorrectly validated reading will give rise to incorrect consumption in settlement. At the extreme this can be detected through the monitoring of large EAC/AAs. This is a considerable error resulting in significant amounts of energy being allocated to the wrong supplier. The processes and disputes to rectify this issue have cost the industry many thousands of pounds and are still largely unresolved.

### 4.5 Incorrect and volatile energy allocation

When a meter reading is incorrectly accepted into settlement the error is normally reversed if a further good reading is processed. However, this creates a skew in the allocation of the energy either side of the erroneous meter readings. This will create an allocation of energy that is hard to predict and potentially volatile.

### 4.6 Supplier billing

Information from suppliers suggests that they do not rely on the NHHDC validation status preferring instead to perform their own validation. This will largely protect their customer from NHHDC validation problems. However, this does become a drawback where a deemed CoS reading is calculated or "must read" policies are initiated unnecessarily. Additionally, the energy used for billing will become inconsistent with the energy used in settlement.

## 5. PROPOSED ALTERNATIVE VALIDATION RULES

**5.1** The issues in the market place shows that the minimum level of validation is being applied for most meter readings. There are many problems that would be alleviated if the validation algorithms were stronger. It is therefore proposed that a new meter reading validation algorithm be established that overcomes the weaknesses of the current rules.

**5.2** In order to demonstrate the type of sophistication that is possible within meter reading validation whilst remaining compliant with the BSCP, ELEXON has developed an algorithm that automates many of the currently defined rules. This model has been called the Barasi Algorithm after its author. This algorithm attempts to validate the read, and if it falls outside the tolerances, tries making various corrections to the read (e.g. switching registers, transposing first two digits etc.). These amended reads are then validated, and if it appears sufficiently likely that the cause of the amendment is the reason that the read failed, the read is corrected and the algorithm moves onto the next read. A model of this algorithm has been built in a spread sheet that simulates validation of one and two register meters. From this model we estimate that up to 80% of meter reading reviews and manual adjustments could be automated.

**5.3** The Barasi Algorithm has been well received by the agents who have seen it. At least one has decided to incorporate parts of it within their new validation routines. The appealing part is the potential to reduce the number of manual reviews required. A technical definition of the Barasi Algorithm can be found in Appendix 1.

### 5.4 Proposed features of new rules

The new rules should:

- Include specific rules on deriving an expected reading;
- Allow manual adjustment of expected reads;
- Improve validation to increase data quality;
- Reduce the level of manual intervention required;
- Provide a mechanism for feedback from supplier's billing systems;
- Be suitable for an automated correction process;
- Have a clear process for meter rollover detection;
- Incorporate the sophistication demonstrated by the Barasi Algorithm;
- Include processes to verify meter reading using all available data.

# 6. PROPOSAL

**6.1** It is proposed that BSCP 504 Section 4.2 be updated to specify a more complete and sophisticated validation procedure. This will have the following features:

## 6.2 Meter read integrity checks

- Check the meter serial number;
- Check that the reading date is not in the future;
- Check that all the meter's registers have been read;
- Check that any error flags for remotely read meters are addressed;
- Address any meter reports.

## 6.3 Derive expected meter reading

- Specify a procedure for creating expected reads using the same process as is used for creating deemed reads. All NHHDCs will already have the functionality to create deemed reads so this should not have a significant impact on their processes. Deemed readings are considered as acceptable readings for settlement, so they should produce good expected readings if the NHHDC has the capability to maintain the EAC.
- Specify a process whereby the NHHDC can set the EAC to a sensible value when certain that the current value is incorrect. This would need to have sensible controls to ensure that this only occurs to improve the validation process. An audit trail must be maintained.

## 6.4 Meter rollover detection

- Specify a method for detecting meter rollover. Ensure that the consumption calculated from a rollover is subject to validation.

## 6.5 Consumption validation

- Define a consumption validation process using the Barasi Algorithm as the basis. This should include validation of previous readings and well as the current reading. As far as possible there should be provision for automated processes.

## 6.6 Adjustments

- Define rules and checks for detecting and making adjustments to correct common error (e.g. transposed digits and swapped registers).

## 6.7 Suspect reading review

- Specify a reading review process. Define what data should be presented to the reviewer. Provide guidance on what would constitute a good reason to accept the readings. Specify checks to ensure that unreasonable readings cannot be accepted.

## 6.8 Supplier feedback

- Define a process and associated flows to allow suppliers to feed back to data collectors where they believe the DC's validation is incorrect.

## 7. RECOMMENDATIONS

**SVG is invited to:**

7.1 AGREE that there is a requirement to revise the meter read validation rules described in BSCP504;

7.2 AGREE that the new rules should include the features described in section 6; and

7.3 AGREE that ELEXON Service Delivery define the rules that should be included in BSCP504.

Fred Barasi

ELEXON Service Delivery

# Appendix 1 – Technical documentation of Barasi Algorithm

N.B. If the previous read was deemed, it should be ignored. For the purpose of this algorithm, 'previous read' refers to the previous actual read.

Level 1 recommendations refer to tight guidelines that should be followed if possible. Level 2 refers to the minimum standards required. All guidelines are Level 2 unless otherwise stated. If not otherwise stated, assume that the algorithm proceeds through the paragraphs in numerical order.

1. Calculate New Meter Advance ($M_o$) as

$M_o = R_0 - R_{-1}$

Where

$R_0$= New Meter Read

$R_{-1}$= First Meter Reading prior to $R_o$

If $M_o > 0$, see paragraph 2. If $M_o = 0$, go to paragraph 6. If $M_o < 0$, go to paragraph 16.

## Check whether the meter advance is within the expected range

2. BSCP 504, Appendix 4.2 Section 5 requires the NHHDC to 'Check consumption does not exceed twice the expected advance'. The expected advance (Ao) is used to calculate low (LT) and high (HT) threshold values. The algorithm compares the actual advance with these threshold values to determine whether the actual advance is greater than LT and below HT i.e. within the expected range.

Calculate the threshold value for the highest expected advance (HT).

HT=2[1]($A_0$)

Where

$A_0$= Expected Advance

Calculate the lowest expected threshold value for the meter advance (LT)

LT=1/2 ($A_0$)

If $M_o$<HT and $M_o$>LT see paragraph 3, otherwise go to paragraph 4.

*[Level 1: Define HT as 1.25($A_0$); LT as 4/5 ($A_0$)]*

3. If Mo<HT and Mo>LT the meter advance is within the expected range and is considered valid – stop.

*[Level 1: Calculate advance (A') for last inter-read period but one, based on previous expected advance (A-1). This needs to be scaled to reflect the different period lengths. If the sum of profile coefficients for the current period is x, and the sum for the previous period is y, the previous advance needs to be multiplied by x/y. Now calculate new highest expected advance, HT' = 1.5(A'), and LT' = 2/3 (A'). If $M_o$<HT' and $M_o$>LT' AND $M_o$<HT and $M_o$>LT then meter advance is within the expected range and is considered valid - stop.]*

[1] All numbers used in this document can be varied to alter the level of accuracy required to allow a read to be validated. The values given are suggested initial values.

4. If not, calculate a new meter advance ($M_0'$) as $M_0' = R_0 - R_{-2}$

Determine the expected Advance (A'') for the period spanning reads $R_0$ to $R_{-2}$. This can be done by scaling A-1 by (1 + x/y), where x is sum of profile coefficients for period between reads $R_0$ and $R_{-1}$, y the sum for period $R_{-1}$ to $R_{-2}$. This value should then be used to calculate a value of HT' and LT' [Level 1: HT' = 1.5(A''), LT' = 2/3(A''); Level 2: HT' = 2(A''), LT' = 1/2(A'')]. If $M_o'$<HT' and $M_o'$>LT' see paragraph 5, otherwise go to paragraph 7.

5. In this case, calculate the 'score' of the current advance (Mo') and the previous advance ($M_{-1}$) as follows:

Score of advance M = M – LT' if LT' < M < A

HT' - M if HT' > M > A

0 if M => HT' or M <= LT'

In the case of $M_o'$ the value of A used should be A''. For scoring $M_{-1}$, the value of A used should be $A_{-1}$. The advance with the smaller score is therefore closer to the threshold, and so should be treated as invalid. If this advance is $M_{-1}$, then further investigation is required, as the previous reading may be in error. If not then go to paragraph 7.

6. If $M_o$ = 0 then this may be considered as a valid meter advance, as it suggests the meter has been unused in the period since the last read. Stop.

### Check whether an additional one tenth kWh digit has been incorrectly added

7. If $M_o$>HT or $M_o$<LT the meter advance is not within the expected range. Calculate a Meter Advance ($M_d$) assuming an additional one-tenth digit has been incorrectly added to the meter reading.

$M_d = (R_o/10) - R_{-1}$

If $M_d$<HT and $M_d$>LT see paragraph 8, otherwise go to paragraph 9. [Level 1: If $M_d$<HT' and $M_d$>LT' AND $M_d$<HT and $M_d$>LT then go to paragraph 8, otherwise go to paragraph 9].

8. If Md<HT and $M_d$>LT the meter reading may have failed validation following the addition of a 'one tenth kWh register digit'. BSCP 504 Section 4.7.2 states that NHHDC may correct meter readings considered to be in error, where the NHHDC is able to establish beyond reasonable doubt that the 'one tenth kWh' register digit has been incorrectly added to the end of a meter reading by the customer or meter reader. Calculate and store the score for $M_d$ as described in paragraph 5 above, and go to paragraph 9.

### Check whether a meter reading is allocated to the wrong register

9. If $M_o$ is not within the expected range, determine whether the metering system has more than one settlement register. If there is more than one settlement register go to paragraph 10, otherwise go to paragraph 12.

10. If there are two settlement registers, switch the register readings and calculate the switched meter advance (Ms) for each register.

$M_s=R_0-R_{-1}$

Where

$R_o$= Potential swapped register reading.

If the meter advance ($M_s$) is within range for this register (Level 2: $M_s$<HT and $M_s$>LT) see paragraph 11, otherwise go to paragraph 12. [Level 1: If $M_s$<HT' and $M_s$>LT' AND $M_s$<HT and $M_s$>LT then go to paragraph 11, otherwise go to paragraph 12]. If there are more than two settlement registers, it is recommended that this fact is noted and a manual review is conducted if no other explanation can be found for the discrepancy in the readings. Proceed to paragraph 12.

11. The meter reading may have failed validation following the incorrect allocation of meter readings to registers. BSCP 504 Section 4.7.1 states that NHHDC may correct meter readings considered to be in error, where the NHHDC is able to establish beyond reasonable doubt from the meter reading history that the meter readings were incorrectly allocated to the meter register identifiers by the customer or meter reader. Calculate and store the score for $M_s$ as described in paragraph 5 above, and go to paragraph 12. Note that swapping the resisters will have repercussions on the validation of readings for the other register. To this end, it should be checked that switching the two reads results in a satisfactory read for each register before proceeding.

### Check whether the digits in the reading have been transposed

12. If $M_o$ is not within the expected range, it may be possible that two digits in the reading $R_o$ have been transposed.

Define $M_t = R'_0 - R_{-1}$

Where $R'_0 = R_0$ but with its first two digits transposed. Calculate LT and HT as defined within paragraph 2. If the meter advance ($M_t$) is within expected range see paragraph 13. (Level 2: $M_t$<HT and $M_t$>LT; Level 1: If $M_t$<HT' and $M_t$>LT' AND $M_t$<HT and $M_t$>LT). If not, continue to calculate a new Mt by swapping the second and third digits, and so on until (n-3) swaps have been made (Level 2) [or (n-2) swaps, Level 1], or one of the $M_t$ is in the expected range (where n = no. of meter digits). If a value of $M_t$ falls in the expected range go to paragraph 13, otherwise go to paragraph 14.

13. It is possible that two digits of the meter read were transposed in error. Calculate and store the score for $M_t$ (as described in paragraph 5), and go to paragraph 14.

## Check whether an analogue meter has been misread

14. It is possible that analogue meters may be misread. A symptom of this may be that every other digit is one unit too high (or if zero, should be nine).

Define $M_a = R'_0 - R_{-1}$

Where $R'_0 = R_0$ but with its first, third, fifth etc. digits reduced by one (or changed to nine if it is zero). Similarly, define $M_a' = R''_0 - R_{-1}$

Where $R''_0 = R_0$ but with its second, fourth, sixth etc. digits reduced by one (or changed to nine if it is zero).

15. If Ma or Ma' lies within the expected range, it is possible that an analogue meter has been misread. Calculate and store a score for Mrc according to paragraph 5, and go to paragraph 21.

## Check whether a meter rollover has occurred

16. If the new Meter Advance (Mo) is negative calculate the meter rollover advance (Mrc).

$M_{rc}=10^n – R_{-1}+R_o$

Where

$R_o$ = New Meter Read

$R_{-1}$= Meter Read prior to $R_o$

n = number of meter digits.

Calculate LT and HT as defined within paragraph 2. If $M_{rc}$<HT and $M_{rc}$>LT the meter rollover advance is within the expected range; go to paragraph 17, otherwise go to paragraph 18. [Level 1: If $M_{rc}$<HT' and $M_{rc}$>LT' AND $M_{rc}$<HT and $M_{rc}$>LT go to paragraph 17, otherwise go to paragraph 18]

17. If $M_{rc}$ is within the expected range, it is possible that a meter rollover occurred. Calculate and store a score for $M_{rc}$ according to paragraph 5, and go to paragraph 18.

18. Check if the read would be valid for a meter rollover if the number of digits was too large.

Calculate Meter Advance ($M_{rc}'$):

$M_{rc}'=10^{n-1} – R_{-1} +R_o$

Where $R_o$, $R_{-1}$ and n are as defined above.

19. If $M_{rc}'$ is within the expected range, it is possible that a meter rollover occurred and the number of digits stored is incorrect. Calculate and store a score for $M_{rc}'$ according to paragraph 5, and go to paragraph 20.

### Check whether the previous reading may be considered invalid following a meter rollover

20. If Mo is negative, calculate a new meter advance ($M_0'$) as $M_0' = 10^n + R_0 - R_{-2}$

Where

$R_o$ = New Meter Read

$R_{-2}$= Meter Read prior to R -1

n = number of meter digits.

Use the expected advance for period spanning reads $R_0$ to $R_{-2}$, A'', derived in paragraph 4, to calculate a value of HT'' and LT'' [Level 1: HT'' = 1.5(A''), LT'' = 2/3(A''); Level 2: HT'' = 2(A''), LT'' = 1/2(A'')].

If $M_o'$> LT'' and $M_o'$< HT'' the meter reading may be considered valid, and the previous meter read may be invalid. In this case further investigation is necessary.

### Change of Supplier (customer own) reads

21. If a read is a change of supplier (customer own) read (CoS), then it cannot be automatically amended. Instead, the only options available are to accept the read as it stands, or to suggest a manual review. In this case, a new, larger acceptance range is defined:

HT*=2.5($A_0$), LT*=0.4($A_0$). If HT> $M_0$ and $M_0$>LT, then the read is accepted, go to paragraph 23. If not, go to paragraph 22.

22. If a meter rollover attains the highest score of the amendments suggested above, and this score is above the specified limit, then the CoS read should be accepted as a meter rollover. Otherwise, CoS reads should be rejected and a manual review recommended.

23. If any of the alterations tried above, resulting in $M_d$, $M_s$, $M_t$ or $M_{rs}$ have values within the expected range, then select the one with the highest score as the new advance – i.e. the one closest to the estimated advance. If the score of this alteration is above the specified score limit, it should be accepted and the amendment made. Details of any alterations made should be stored and used for future checking. If none of the alterations resulted in a value within the expected range, or with a score above the score limit, a manual review would again be advised.

### Maximum units per day check

24. If the read has been accepted, or an amendment has been made to the read, the proposed new advance should be checked to ensure that it does not imply consumption which is greater than a certain tolerance, provided by the user. This would consist of simply dividing the advance by the number of days it spans, and comparing it to the maximum tolerable units per day value entered into the algorithm.

### Least squares validation of reads

25. If the read has been accepted, or an amendment has been made to the read, at this point it is desirable to check that the read is consistent with the preceding reads that have been passed as valid. A technique for doing this is to calculate a line of best fit through the set of all available valid reads, based on a least squares technique.

26. Least squares regression models consumption as an equation y = A + Bx, where y is the consumption, x is a measure of time, and A and B are constants. Rather than using number of days elapsed since start of period for x, it would be preferable to use Cumulative Fractions of Yearly Consumption (FYCs). This would have the advantage of incorporating seasonal variations in consumption into the model. The formulae for A and B are given as follows:

$$B = \frac{\sum_i x_i y_i - n\bar{x}\bar{y}}{\sum_i x_i^2 - n\bar{x}^2} \; ; \; A = \bar{y} - B\bar{x}$$

Where $\bar{x}$, $\bar{y}$ are the mean of *x* and *y*, respectively, and n is the number of reads.

This technique will give an equation for the line of predicted consumption, based on the reads in the period to be validated. For each read, an 'expected read' may then be calculated, by evaluating A + Bx, where *x* is the cumulative sum of FYCs up to the point at which the read was taken.

This is most easily demonstrated by use of an example:

| Cumulative FYC (x) | Read (y) | xy | $X^2$ |
|---|---|---|---|
| 0 | 2000 | 0 | 0 |
| 0.75 | 8000 | 6000 | 0.5625 |
| 1.5 | 17000 | 25500 | 2.25 |
| 2 | 23000 | 46000 | 4 |
| 3 | 33000 | 99000 | 9 |
| | **Sum** | **176500** | **15.8125** |
| **Average x** = 1.45 | | | |
| **Average y** = 16600 | | | |
| **N** = 5 | | | |

So in this case,

B = (176500 – 5*1.45*16600) / (15.8125 – 5*1.45*1.45) = 10594.34

A = 16600 – 1.45*10594.34 = 1238.2

So we can calculate an expected read for each point at which we have an actual read:

| Cumulative FYC (x) | Actual Read | Expected Read |
|---|---|---|
| 0 | 2000 | 1238.2 |
| 0.75 | 8000 | 9184.0 |
| 1.5 | 17000 | 17129.7 |
| 2 | 23000 | 22426.9 |
| 3 | 33000 | 33021.2 |

Each actual read may now be validated against the expected read. An appropriate level of validation would be that a read may be passed as valid if it is within 0.25 times the expected annual consumption (B) of the expected read.

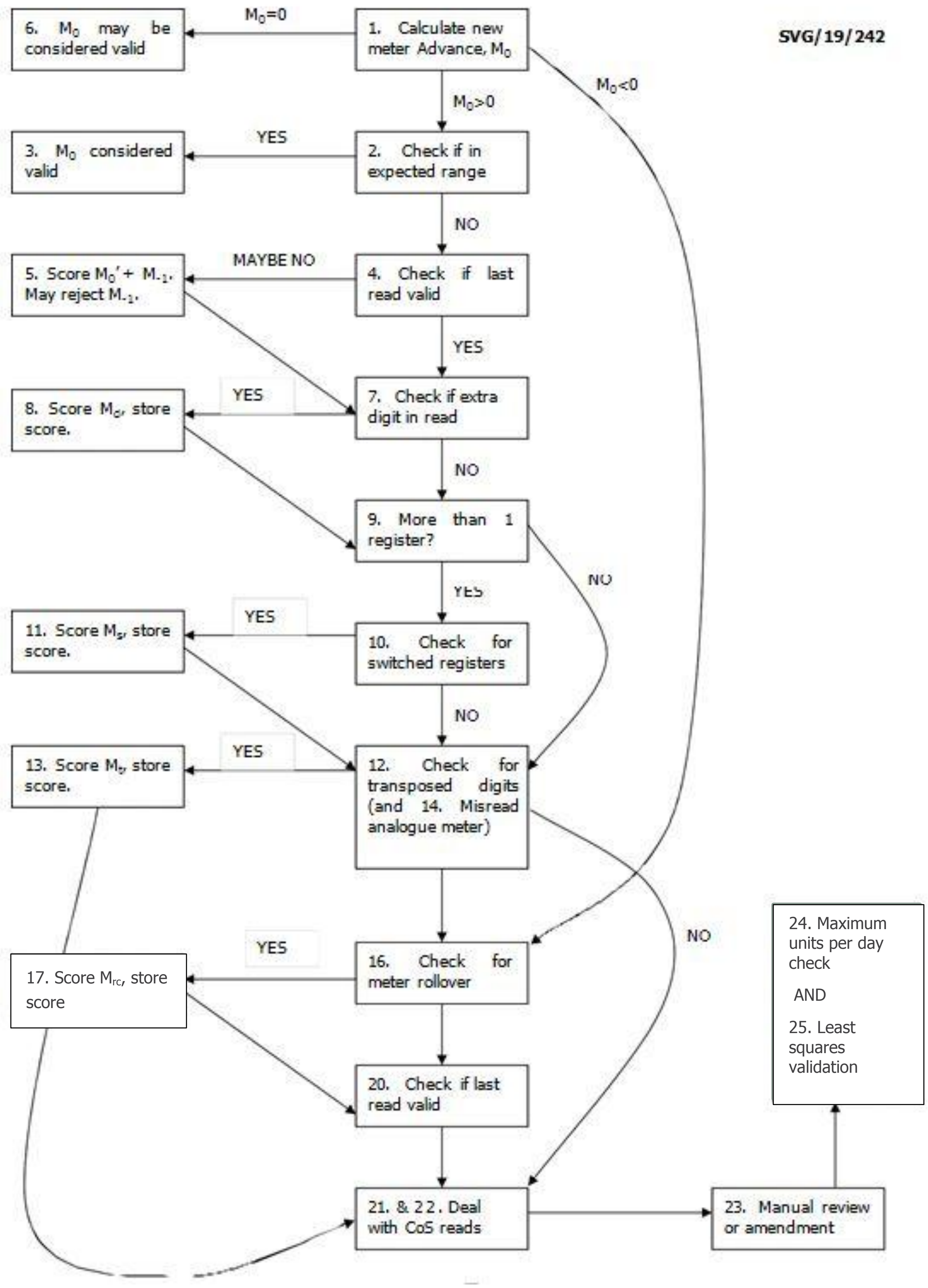
Consecutive reads should also be checked to ensure that there are no negative advances. If all reads pass both of these validations, the set of reads may be considered valid.

## Notes

If more than two settlement registers have been noted according to paragraph 10, a manual review should investigate the potential for swapped registers. Similarly, if the alteration suggested was also used to correct the previous read, a manual review is suggested. This will prevent registers being swapped for two reads in succession, for example.

A manual review can suggest that the new read is invalid, or that the old read is likely to be invalid, or note that the read is a CoS.

Note that the least squares validation and the maximum units per day check have not been incorporated into the latest spread sheet model of the algorithm.



## Need more information?

For more information please contact the **BSC Service Desk** at bscservicedesk@cgi.com or call **0870 010 6950**.