**Sensor quality examination process**

Input: sensor data in 60-sec intervals, including volumes (Q) and speeds (V)

Output: Sensor quality estimation and relevant recommendations

**Stage 1**

Calculate the total number of 60-sec intervals under consideration and let it be M.

Count the number of records with available data and let it be N.

Calculate data availability F=N/M

**If** F<= 75%, **then**

Conclude “the sensor should be replaced/maintained.”

**Else if** 75% < F <= 95%, **then**

Conduct the **further examination1**.

**Else if** F> 95%, **then**

Go to the **stage 2** screening.

**Else**

**Stage 2**

**For** each data record *i*,

Set Ii =0 (data record *i* is not faulty data)

**For** *j*=1-5,

**If** Rule *j* has been satisfied for data record *i*, **then**2

Ii = 1 (data record *i* is a faulty data)

**Else**

Calculate data faulty rate H= count(Ii = 1)/N

**If** H>= 30%, **then**

Conclude “the sensor should be replaced/maintained.”

**Else if** 5% <= H < 30%, **then**

Conduct the **further examination1**.

**Else if** H < 5%, **then**

Go to the **stage 3** screening.

**Else**

**Stage 3** (this stage is to check whether the data violates speed-flow relations)

**For** each data record *i*,

Set Zi =1 (data record *i* is faulty data)

**For** *j*=1-4,

**If** data record *i* can satisfy all equations for Zone j, **then**3

Zi = 0 (data record *i* is not a faulty data)

**Else**

Calculate data faulty rate K= count(Zi = 1)/N

**If** K>= 30%, **then**

Conclude “the sensor should be replaced/maintained”.

**Else if** 5% <= K < 30%, **then**

Conduct the **further examination1**.

**Else if** K< 5%, **then**

Conclude “Field calibration for detector accuracy and precision”.

**Else**

**Appendix**

**1Further examination**

Examine the distribution of missing data/faulty data:

**If** all missing/faulty data records in the current stage satisfy any of below criteria4, **then**

Remove all data of unstable periods (defined by the first and last missing/faulty data), go back to check the availability/faulty rate and run the current stage again.

**Else,**

Conclude “The sensor should be replaced/maintained.”

**4Criteria for systemic pattern:**

Criterion 1: All missing/faulty data are during the peak hour

Criterion 2: All missing/faulty data are during the off-peak hour

Criterion 3: All missing/faulty data are during the congested day

Criterion 4: All missing/faulty data are during the non-congested day

**2Decide the faulty data in stage 2:**

**Rule 1**: Congested day and peak hour and Q> 2300 vphpl

**Rule 2**: Congested day and off-peak hour and Q> 1120 vphpl

**Rule 3**: Non-congested day and peak hour and Q> 1910 vphpl

**Rule 4**: Non-congested day and off-peak hour and Q> 975 vphpl

**Rule 5:** V> 110 mph

**3Decide the faulty data in stage 3:**

If the data doesn’t fall in one of the zones’ boundaries, the data is faulty

**Zone1**: If the following 3 formulas hold, the data falls in the zone 1

|  |  |
| --- | --- |
|  | (1) |
|  | (2) |
|  | (3) |

**Zone2**: If the following 5 formulas hold, the data falls in the zone 2

|  |  |
| --- | --- |
|  | (1) |
|  | (2) |
|  | (3) |
|  | (4) |
|  | (5) |

**Zone3**: If the following 4 formulas hold, the data falls in the zone 3

|  |  |
| --- | --- |
|  | (1) |
|  | (2) |
|  | (3) |
|  | (4) |

**Zone4**: If the following 4 formulas hold, the data falls in the zone 4

|  |  |
| --- | --- |
|  | (1) |
|  | (2) |
|  | (3) |
|  | (4) |