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DACA II Review Task Force Conference Call Minutes (Meeting #6)
Thursday March 31, 2022
9:00-10:30 AM Central

Minutes recorded by Patrick Lang
Direct any comments or corrections to: patrick.lang@swri.org

Membership:

The attendance list can be found as Attachment # 1.

Agenda:

The proposed agenda can be found as Attachment # 2.

Approval of Minutes:

Pat Lang reported that the minutes from the October 27, 2021 conference call were distributed to the panel with the meeting invite two weeks previously. The group had no corrections or additions. The minutes will be posted as written.

Continued review of the Quality Index Section:

The focus of the meeting was to continue the discussion of the Quality Index section. The LZ presentation was shared on the screen starting with Slide #7 (see Attachment #3).

Slide 7 ("Replacement")

The discussion started out with a review of the flow chart. The initial focus was on the "Suspected BQD" leg of the flow chart.

Pat Lang asked about the over/under values and what they truly added to the process. The concern expressed was that the over/under values would still yield a negative QI so what is the point?

Bob commented that the resulting negative QI when using the over/under values forces the deviation to be reviewed by the lab and potentially the TMC. Bob also advised that the over/under values are determined by calculating the value for a specific parameter that would drive the QI to zero with one data point (yes, one data point!).

Sean from the TMC stated that he has never seen the over/under range data used in the tests that he has reviewed. He feels that labs are not taking advantage of this option as well as the determination of bad quality data (BQD) to eliminate some of the negative QI's that are reported.

George brought up the topic of "surrogate" data. This would essentially be data that could be used to estimate what the outlying parameter actually was during the incident/deviation. As an example, the delta that is normal between engine coolant-in and coolant-out temperature can be used to estimate the in or out temperature if one of them is providing erroneous data.

This lead into a discussion on whether or not it is appropriate to use surrogate data in the QI calculation since it is not currently shown in the flow chart. Sean commented that he felt that it was reasonable to use surrogate data and if it is used it is not mandatory for it to be reviewed by the TMC as long as it can be backed up technically later if questioned.

At this point John White showed a revised flow chart that SwRI created. The flow chart can be found as Attachment #4. The revised flow chart attempts to simplify the process by removing the step about asking if "related parameters exhibit inflections". No decisions were made on the modified flow chart since this was the first time that the group saw it.

Bob stated that the fundamental question that we have to ask is whether or not the process was impacted. Once that is determined, we have to decide how to deal with it. Do we use surrogate data or just use the over/under values. The concern is that the over/under values will not provide an accurate representation of the actual QI.

The group agreed that we should modify the flow chart and to add in a section about how to proceed with surrogate data.

Action:

SwRI will modify the flow chart to include a path for handling surrogate/replacement data.

The discussion then switched to addressing "Missing Data".

John White described a scenario where all data is missing/not retrievable for some portion of the test. The question now is whether or not the test continued to run properly if there is no operational data to prove it. John advised that SwRI has real-time QI's that would be an indication that the test ran properly during the time of missing data.

Al Lopez stated that there are times where you just won't know definitively if the controllers were affected. He further asked if manual readings were considered a means of determining if the stand continued to control properly.

Bill Buscher stated that sometimes all you have to determine, if the test continued to run well, are the comments from the engine operator stating that everything seemed ok during the incident, i.e., it sounded ok and appeared to be running normal.

Bill brought up the scenario if you have a parameter that is supplied over a network such as intake air humidity. If there is an interruption of that data stream, you could essentially get it from another source. Can those numbers be substituted into the test data file?

Al Lopez asked where the 1% data loss rule came from. This rule states that you are allowed to be missing 1% of the test's operational data file and still consider the test valid. Anything over 1% will force the test to be invalid.

Bill mentioned that DACA II started with the transition to computer data acquisition systems being used in place of the old manual stands. The 1% value for missing data was probably chosen in that transition time based on the issues that were common with the early systems.

John White showed his presentation on the reduced formula for QI calculation, see Attachment #4. There wasn't much time to go through this during the call.

John also asked if we should consider some working in the document for handling transient parameters. Bill Buscher advised that the stats group did work on that during the IVB development and perhaps we can get some information from them.

Meeting was adjourned at 10:30 AM CDT.

Next meeting Topic:

Pat Lang recommended that for the next meeting we continue reviewing the Quality Index (QI) section. If time permits, we will move to the final topic which will be accuracy/uncertainty.

Adjournment:

The meeting was adjourned at 10:30 AM CDT.

Next meeting at the call of the chairman.

Attachment #1

Attendance List

Attendance List for DACA II Document Review Task Force

Name	Company	Present 3-31-22 X= present
Amol Savant	Valvoline	
Al Lopez	Intertek	X
Bill Buscher		X
Andrew Stevens	Lubrizol	X
George Szappanos		X
David Doerr		
Jim Matasic		
Randy Harmon	Southwest Research	x
John White		X
Ron Barthold		X
Khaled Rais		
Bob Warden		X
Mike Lochte		
Tom Wirries		
Chris Desruisseau		
Bob Campbell	Afton	X
Tim Cushing	General Motors	
Jim Gutzwiller	Infineum	X
Andy Ritchie		
Michael Tucker	Exxon Mobil	X
Rohit Rao		
Jason Griffin		X
Mike Deegan	Ford	
Robert Stockwell	Oronite	
Jeff Clark	Test Monitoring Center	
Rich Grundza		
Sean Moyer		X

Attachment #2

Agenda

AGENDA

Data Acquisition and Control Automation II (DACA II) Review Task Force Virtual Meeting (WebEx) #6

Patrick Lang – Chairman

Thursday March 31, 2022– 9:00 AM to 10:30 AM (CDT)

1. Attendance

2. Review of the minutes from the 10-27-21 conference call.

3. Review Items:

    1) Continue to review Quality Index (QI) section of the DACA II document using the LZ presentation provided at last meeting and additional SwRI presentation.

4. Determine topic for next meeting

5. New Business

6. Next Meeting will be at the call of the chairman.

7. Adjournment

Attachment #3

LZ Presentation on Quality Index

DACA review

Quality Index

The following slides contain `all the detail in DACA II related to Qi.`

Prepared by George Szappanos, Lubrizol, 10/26/2021

DACA II text:

Statistical Calculations:

The quality of the control of the parameter being measured shall be calculated through the use of the Quality Index (QI):

$$QI_i = 1 - \frac{1}{n}\sum_{1}^{n}\left(\frac{U + L - 2X_i}{U - L}\right)^2$$

where:

U = Upper QI limit

L = Lower QI limit

Xi = Data reading at instance i

n = Number of readings thus far in the test

No issues and good to go!

Perfect control of a parameter results in a QI of 1.00. Any deviation from the target lowers the QI. The amount and duration of the deviation affects the final QI for the parameter. How often the QI is updated, and conversely, how many readings are taken also affect the effectiveness of the QI to capture the quality of the control of the parameter.

For multi-stage tests, the test developer/surveillance panel should determine whether or not a separate QI will be calculated for each stage. If separate Qls are calculated, and a single final QI is desired, the final QI should be an appropriately weighted average of the individual Qls.

Sampling period

~~The test developer/surveillance panel should determine, for each parameter, whether variations in the signal are random or cyclical. If random, a minimum of 103 samples must be used for the QI calculation. If cyclical, the period at which the data for the QI calculation is sampled for a parameter can be dependent upon the "period of the phenomenon of interest" (ti). Phenomenon of Interest is defined as that quality of the measured parameter that is primary interest to the surveillance. For example, oil pressure may fluctuate with each oil pump gear mesh, but that is limited interest compared to larger fluctuations in pressure due to more macro processes. The QI sampling period can be derived from the t period by the following equation:~~

~~QI SamplingMax(sec) = t/2~~

~~where:~~

~~t = period of phenomenon of interest in sec~~

~~note: the Nyquist theorem is 2 readings/period to reproduce the waveform~~

~~Any new test development shall include a determination of the cyclic period for each of the parameters of interest to be measured, if applicable. For parameters such as speed, intake vacuum, etc, that have an extremely fast response rate, with a corresponding cyclic period shorter than 2 sec, the minimum required QI sampling period should be determined from data from the Golden stand.~~

The "period of interest" is usually a result of controller tuning. Most tests calculate Qi on recorded data at a rate of about 30-60 sec per sample, rarely any more frequent. This is probably good enough for slow loops, but not for others (rpm, load…)

Sampling (logging) period is determined by the SP and should be based on the requirements of the test. Remove this section.

logging

The final, reported QI is to be based on the final recorded data set captured at the minimum data logging rate as defined by the SP. The QI could optionally be calculated and updated each time a reading is logged to allow monitoring of the controlled parameter during the test. ~~, or the samples logged and the QI calculated from logged data. Laboratory systems employed should be able to calculate QI from in-progress test data, either in real time or on command.~~

~~For purposes of TMC verification, the laboratory data acquisition system should be capable of "dumping" sufficient data onto permanent media in electronic format. The data should include a time stamp for each reading, the data reading, and a final QI for that set of data. The data should be from an actual test stand and acquired, at a minimum, at the required QI calculation rate.~~

This seems confusing, test stands can acquire "real time" data at up to 1000 hz, but save data only ever minute. The QI is normally based on the saved data.

This section is revised as indicated in yellow.

Limits determination

The upper and lower limits for the QI calculations are derived from the operating conditions of the test development or from a matrix of stands, or based on the engineering judgment of the SP. The limits should be set such that minimum acceptable system performance results in a QI value of 0. ~~These limits should be calculated from the operational data. This will result in a uniform criteria for assessing the quality of a test.~~

~~For test validity, the QI threshold should be below the QI of the test development Golden stand. This threshold should be determined after sufficient operational data from multiple labs have been generated.~~

In many cases the “golden” standard is the collection of stands involved in the precision matrix. The Qi limits are based on what level of control performance is reasonably achievable for all labs.

These limits should be tempered with knowledge of what effect a parameter’s variability has on the test, if that insight is available. Reworded.

BQD (bad quality data)

~~Some automated test cells may employ separate systems for the control of operating parameters, and for the acquisition and logging of data. In these systems, it is possible for the data acquisition system to suffer a temporary malfunction while the control system continues to maintain the proper conditions, or one control system "channel" may malfunction while the rest are unaffected. These malfunctions may result in missing or erroneous (such as 9999 deg C on a temperature) data points. These data points are referred to as Bad Quality Data (BQD). In cases of malfunctions in the test control system, in which the actual test conditions are affected, the deviations must be recorded, estimated, or otherwise incorporated into the final test QI for the parameter.~~

Occasionally, data acquisition systems can malfunction and record erroneous data. These data are usually a result of faulty instrumentation where the reported value is missing or saturated (such as 9999°C). If averaging or filtering is employed, then data points immediately following the malfunction can also be affected. These data points are referred to as Bad Quality Data (BQD). These occurrences must be counted and the actual values estimated and incorporated into the statistical calculations for the parameter. The SP may provide a table of maximum and minimum values (over-range and under-range) for parameters which should be used in cases where missing or erroneous values need to be estimated.

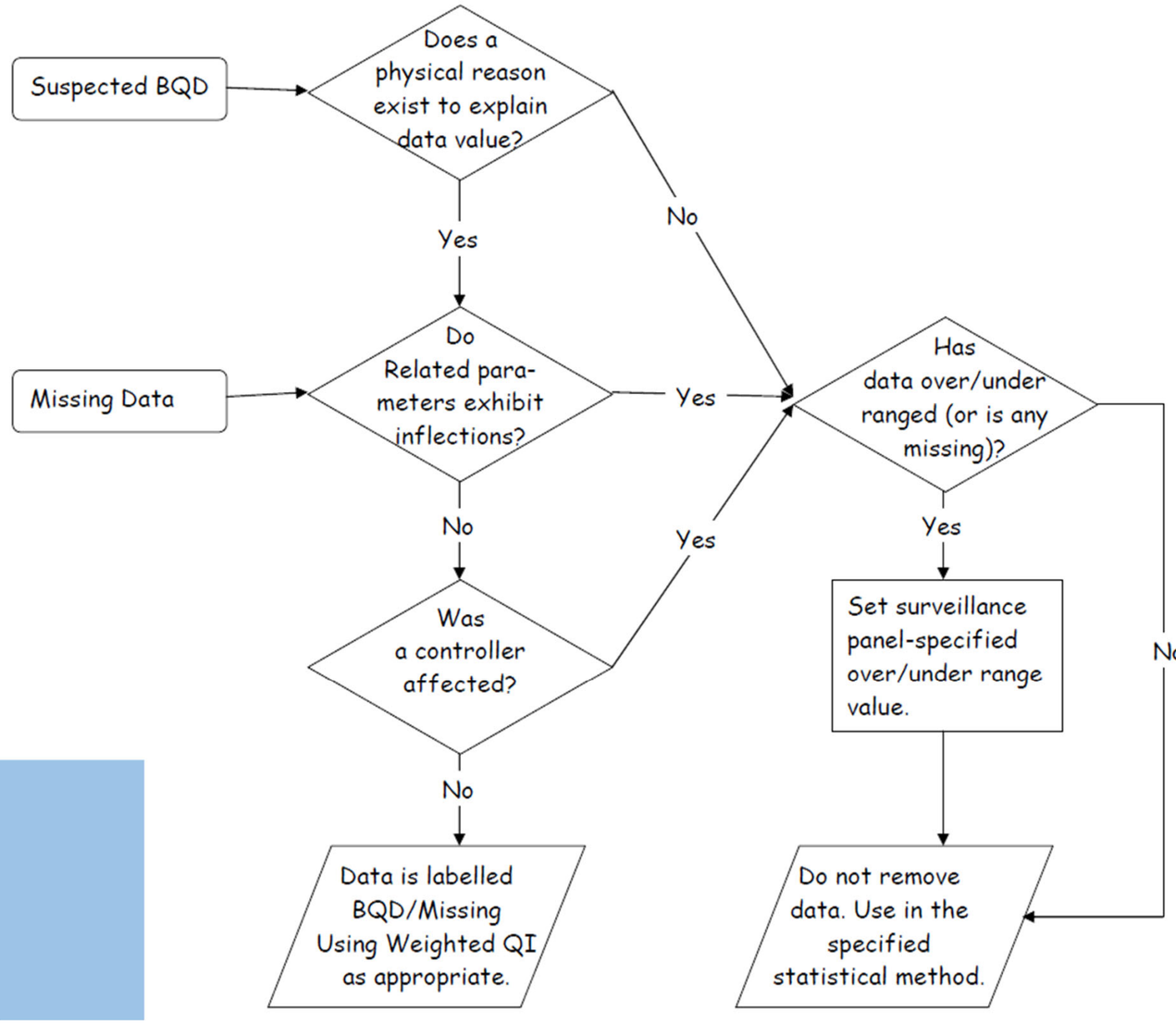
Obsolete wording. In the vast majority of cases, BQD is caused by faulty instrumentation (open TC, saturated transducer, etc) and the reading is very obviously erroneous or “bad”. In such cases, that data should be replaced (not deleted). Values reported for QI as well as maximum, minimum, average, and percent over/under should also be based on corrected BQD values. Reworded.

replacement

~~For each occurrence of suspected BQD or missing data, the following flowchart should be used:~~

For each occurrence of BQD, data shall be replaced with a surrogate value that can be derived from other operational data, or from over-range and under-range values provided by the respective test procedure. Comments are to be provided in the test report explaining the data replacement rationale and methodology.

- Should be limited to known bad or missing data
- If data is “real” then Qi should use all the data
- No data is removed
- Section revised and flowchart removed.



Over / under values

~~This procedure includes a requirement for each test Surveillance Panel to set over/under-range limits. These limits will be used as substitutions for data that is acquired, but is physically impossible, such as a negative fuel flows, or temperatures of 9999°C. In cases where the flowchart does not adequately fit the situation, the final determination of test validity and the disposition of the BQD will depend more upon engineering judgment.~~

This procedure includes a requirement for each test Surveillance Panel to set over/under-range limits. These limits will be used as substitutions for data that is acquired, but is physically impossible, such as a negative fuel flows, or temperatures of 9999°C.

- Each surveillance panel should carefully determine reasonable limits for over and under values. In cases of BQD where no surrogates are available, then the over / under values are to be used. This section was reworded.

TABLE A10.2 L and U Constants and Over- and Under-Range Values

Quantity, unit	Stages	L	U	Over-Range	Under-Range
Coolant flowrate, L/min	1	38	42	267	0
	2	68	72	267	0
Coolant-out temperature, °C	1	44.5	45.5	134	0
	2	84.5	85.5	134	0
Exhaust back pressure, kPa	1	102	106	304	0
	2	105	109	304	0
Humidity, g/kg	1, 2	10.4	12.4	109.9	0
Inlet-air pressure, kPa	1, 2	0.03	0.07	2	–1.9
Inlet-air temperature, °C	1, 2	31.5	32.5	81.2	0
Oil gallery temperature, °C	1	49.5	50.5	149.2	0.8
	2	99.5	100.5	149.2	0.8
Engine speed, r/min	1	1545	1555	2992	1058
	3	2495	2505	2992	1058
Torque, N·m	1	48	52	325	0
	2	126	130	325	0
Coolant pressure, kPa	1, 2	68	72	267	0
Air-charge temperature	1, 2	29.5	30.5	79.2	0
Lambda	1	0.73	0.83	5.9	0
	2	0.95	1.05	5.9	0

calculation

In cases where data is labeled as BQD/missing, per the flowchart, the Adjusted QI is calculated

as follows:

1) Remove BQD/missing data from data set per the flowchart

2) Calculate QI with remaining data points

3) Adjust QI by multiplying number of data points and dividing by the number of data points per the procedure, to obtain the QIBQD:

$$QIBQD = QI\left(\frac{n}{n_{total}}\right)$$

where: QI = QI calculated without missing/BQD points

n = number of data points used to calculate QI

ntotal = total number of data points for a complete data set

4) Obtain the EOT QI as follows:

$$EOTQI = QI\left(\frac{n}{n_{total}}\right) + QIBQD\left(\frac{n_{BQD}}{n_{total}}\right)$$

where: QI = QI calculated without missing/BQD points

n = number of data points used to calculate QI

ntotal = total number of data points for a complete data set

nBQD = number of missing/BQD data points (nBQD = ntotal – n)

This is much more complex way of just saying: replace the bad data with the over/under data.
This section can be deleted.

Maximum BQD limit

~~Suitable backups should be employed by the labs to use as supporting evidence. The maximum logging interval for these backups should be 1 hour.~~
Missing data should not be more than 1% of the test length.

1% of 100 hr test x 1 sample per minute = 60 samples (1 hour’s worth of data)
What IF missing data > 1%? Invalid test?

Attachment #4

SwRI Presentation on Quality Index

DACA III System Quality Index

SOUTHWEST RESEARCH INSTITUTE®

Prepared By: John White, Randy Harmon, Pat Lang

November 2021 (revised March 2022)

QI for variable target parameters

- For tests that have parameters that are transient, the test procedure may specify Variable Target QI control limits
- Used when the set point for parameter is changing.
- For example, engine speed from the ASTM Sequence IVB implements a variable target QI.

TABLE 4 Engine Speed (Variable Target) QI Control Limits

Cycle Time, s	Set point, r/min	U, r/min	L, r/min
1	800	950	650
2	800	900	700
3	800	875	725
4	800	850	750
5	800	850	750
6	800	850	750
7	800	850	750
8	927	1077	777
9	1357	1607	1107
10	1888	2288	1488

QI calculation using BQD

BQD QI formula from DACA II – Not clear (see page 8 of DACA II)

1) Remove BQD/missing data from data set per the flowchart
2) Calculate QI with remaining data points
3) Adjust QI by multiplying number of data points and dividing by the number of data points per the procedure, to obtain the QIBQD:

$$QIBQD = QI\left(\frac{n}{n_{total}}\right)$$

where: QI = QI calculated without missing/BQD points
n = number of data points used to calculate QI
n_{total} = total number of data points for a complete data set

4) Obtain the EOT QI as follows:

$$EOTQI = QI\left(\frac{n}{n_{total}}\right) + QIBQD\left(\frac{n_{BQD}}{n_{total}}\right)$$

where: QI = QI calculated without missing/BQD points
n = number of data points used to calculate QI
n_{total} = total number of data points for a complete data set
nBQD = number of missing/BQD data points ($n_{BQD} = n_{total} - n$)

QI calculation using BQD

Simplified BQD QI formula:

$$QI_{EOT} = QI\left(\frac{n}{N}\right) + QI\left(\frac{n}{N}\right) \times \left(\frac{N-n}{N}\right)$$

Where:

QI = QI Calculated without BQD/missing points

n = number of data points used to calculate QI

N = number of data points for a complete data set

Note that $N_{BQD} = N - n$ *and when there is no BQD then* $N = n$ *and* $QI_{EOT} = QI$

Recommendations

- DACA III should address transient QI calculations
- DACA III BQD QI formula should be clearer.

DACA II Bad Quality Data Statement from page 6

Bad Quality Data:

Some automated test cells may employ separate systems for the control of operating parameters, and for the acquisition and logging of data. In these systems, it is possible for the data acquisition system to suffer a temporary malfunction while the control system continues to maintain the proper conditions, or one control system "channel" may malfunction while the rest are unaffected. These malfunctions may result in missing or erroneous (such as 9999 deg C on a temperature) data points. These data points are referred to as Bad Quality Data (BQD). In cases of malfunctions in the test control system, in which the actual test conditions are affected, the deviations must be recorded, estimated, or otherwise incorporated into the final test QI for the parameter.

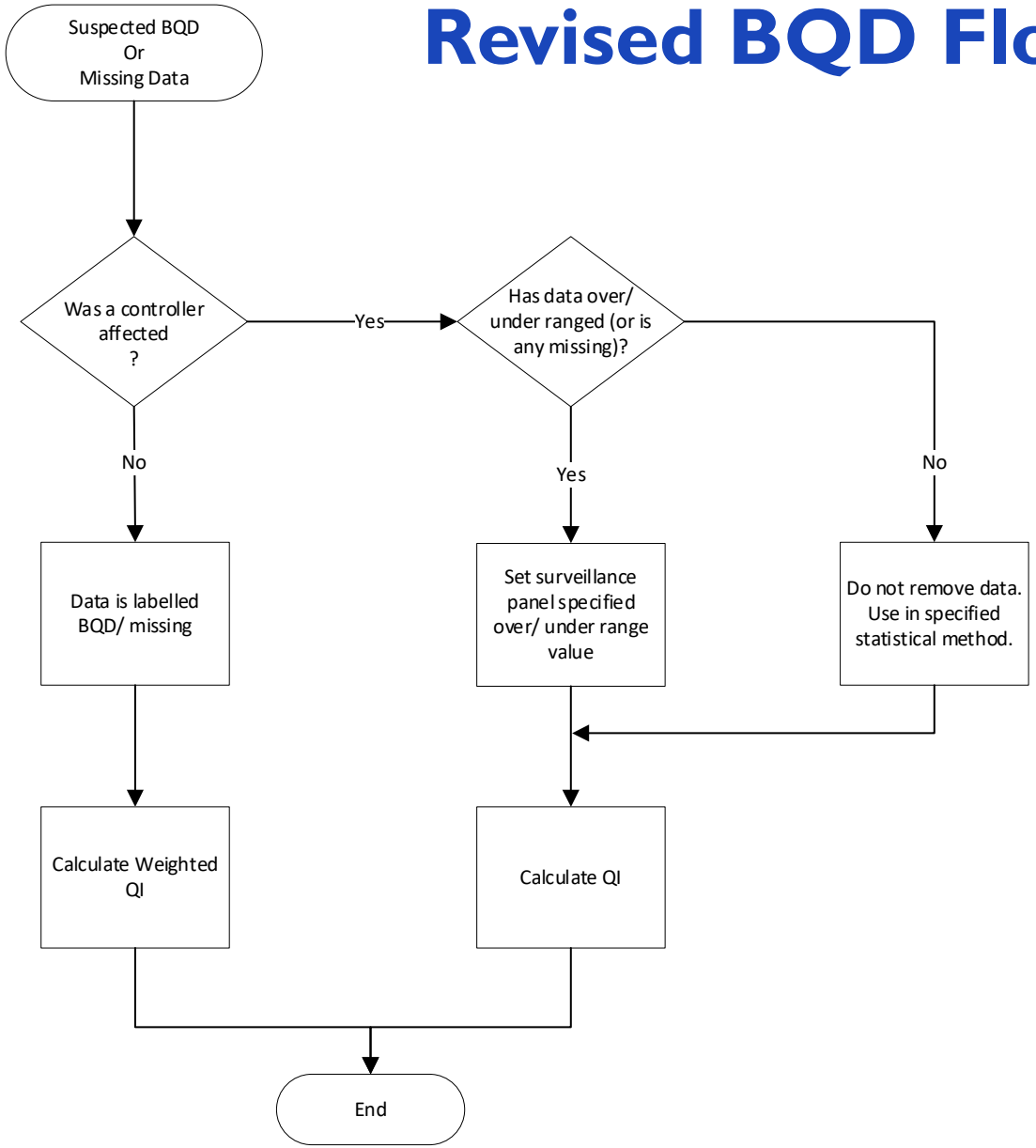
Observations

- Most Quality Index calculations are performed on controlled parameters.

- In systems where the control and data acquisition are separate, you may have missing data while maintaining control.
  - How do you demonstrate that control was maintained with missing data?

- “In cases of malfunctions in the test control system, in which the actual test conditions are affected, the deviations must be recorded, estimated, or otherwise incorporated into the final test QI for the parameter.”

Revised BQD Flow Chart



Questions?