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DACA II Review Task Force Conference Call Minutes (Meeting # 4)
Thursday September 16, 2021
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 advised that there were no requested changes or comments on the July 28, 2021 minutes. A motion was made by Pat Lang and seconded by John White to approve the minutes. The motion passed unanimously.

Scope and Objectives:

The group reviewed the additional revisions that were proposed to the scope and objectives section of the DACA II document. See attachment # 3 for the final version of the Introduction and the Scope and Objectives portion of the document. The group approved this version.

Review of the DACA III Draft with Changes Accepted From Last Meeting:

At this point the group reviewed the draft DACA III document with the changes accepted and the MS Word change tracker off (see attachment # 4). The group approved this version.

The only requested change was to move the "TMC Verification" section out of the QI area and put it in the system time response section. This change is incorporated into attachment # 4.

Review of the TMC document on System Time Response Guidelines:

The group thoroughly reviewed the TMC document that was dated May of 1998. The changes that were recommended can be found as attachment #5.

Some areas of discussion were as follows:

1) The triggering switch for determining the point at which the stimulus was imposed was discussed at length. There was some opposition to this being a requirement for many reasons one of which was centered on the amount of unnecessary effort it takes to add a triggering switch. Most felt that it is not needed and the point at which the stimulus is imposed can be determined by observing a change in the logged data.

2) One lab expressed concerns about the document specifically stating that the time response data had to be logged at 10 hertz as opposed to being sampled and displayed in a plot. They have limitations on their data acquisition system on the number of channels that can be logged at the 10 hertz rate. The group agreed that it was acceptable to perform the assessment based on data displayed on a DAC system plot.

3) The group agreed that it isn't necessary to state specific values that should be used for the step change process. As a result the values were removed and it is now stated to use the "appropriate" value.

In general, the wording was simplified and adjusted based on the best practices that the labs have developed over time. It was important that these changes didn't leave the process too vague for the TMC to perform a thorough audit. Sean Moyer from the TMC agrees that the wording still covers the intent of the process and is descriptive enough to perform lab audits.

Next meeting Topic:

Pat Lang recommended that for the next meeting we start reviewing the Quality Index (QI) section.

Adjournment:

The meeting was adjourned at 10:30 AM CDT.

Next meeting at the call of the chairman with a tentative date one month out.

Attachment #1

Attendance List

Attendance List for DACA II Document Review Task Force

Name	Company	Present 9-16-21 X= present
Amol Savant	Valvoline	X
Al Lopez	Intertek	
Bill Buscher		X
Andrew Stevens	Lubrizol	X
George Szappanos		
David Doerr		X
Jim Matasic		
Randy Harmon	Southwest Research	X
John White		X
Ron Barthold		X
Khaled Rais		X
Bob Warden		
Mike Lochte		
Ankit Chaudhry		
Tom Wirries		X
Chris DesRuieeeau		X
Bob Campbell	Afton	X
Tim Cushing	General Motors	
Jim Gutzwiller	Infineum	X
Andy Ritchie		
Michael Tucker	Exxon Mobil	X
Rohit Rao		X
Jason Griffin		X
Mike Deegan	Ford	X
Robert Stockwell	Oronite	X
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) #4

Patrick Lang – Acting Chairman

Thursday September 16, 2021– 9:00 AM to 10:30 AM (CDT)

1. Attendance

2. Review of the minutes from the 7-28-21 conference call.

3. Review Items:

   3.1. Review revision # 2 of Scope (revised version based on last call).
   3.2. Review DACA II document with changes incorporated into document.
   3.3. Continue review of TMC document on system time response guidelines.
      3.3.1. Change /add wording to identify the best practices
      3.3.2. Goal is to incorporate wording from this document into DACA III.

4. Determine topic for next meeting

5. New Business

6. Next Meeting: Tentatively Wednesday October 13, 2021 at 10:00 to 11:30 EDT; chairman to send out calendar invite.

7. Adjournment

Attachment # 3

Scope and Objective, Final Wording

Data Acquisition and Control Automation III
Task Force Report

Introduction

The Technical Guidance Committee was tasked to review the DACA II document and make any appropriate changes. As a result the Data Acquisition and Control Automation III (DACA III) Task Force was formed in August, 2020, to perform this task. The recommendations in this report are meant to be guidelines for use by test developers/surveillance panels in developing test specifications.

Scope

The DACA III Task Force was charged with specifying minimum performance specifications for Data Acquisition and/or Control systems suitable for use with all targeted testing. These minimum performance requirements shall apply to those parameters that have been defined by the individual test type as being critical. In addition, a means by which TMC engineers can verify compliance of a specific test apparatus will be specified.

Performance Specifications – Controlled Parameters, Steady State Conditions

Logging Rate:

The maximum period between successive logs of recorded data should be 2 minutes.

System Time Response:

In this report, discussions of the response time will refer to the overall response of the complete measurement and data acquisition system of a parameter, from the measurement probe to the final displayed or logged value.

A system's time response can be determined by measuring the amount of time to reach a certain percentage of an imposed step change. A widely used value is 63.2%, which is the definition of a time constant for a first order system. For example, for a thermocouple at 25°C ambient temperature being immersed into an ice/water mixture at O°C, the step change is 25°C. The response time of this measurement system is the time required for the temperature reading to reach 9.2°C:

Attachment # 4

DACA III Draft, Rev 9-16-21 with Changes Incorporated

Data Acquisition and Control Automation III
Task Force Report

Introduction

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$$\mathbf{t} = \text{time to (start value - (start value - end value)} \times 0.632)$$

or

$$\mathbf{t} = \text{time to } (25 - (25 - 0) \times 0.632) = \text{time to } 9.2°\text{C}$$

For each new test type being developed, a particular stand should be designated as the "Golden" stand, i.e. the stand used for test development, from which minimum test requirements will be derived. The maximum allowed response time of each system is derived from a measurement of the system used by the "Golden" stand during the test development. Because the response of a system can vary with different excitation modes, a uniform method of measurement of a system response time is necessary. The techniques used to measure the response times are:

Parameter	**Step Change**
Temperature	Insert probe from ambient air into ice/distilled water mixture to cover the length of the probe.
Pressure	Pressurize system from the measurement point (to include the entire system), then instantly release pressure. Time constant is of the response to the release in pressure.
Load	Remove previously applied weights quickly from the load cell.
Speed	Impose step change at the pickup connection through a frequency generator.
Flow	Method used to measure the time constant on the Golden stand.

Response time is measured from the imposition of the stimulus. Step change deltas should be at least 100 times the resolution of the measurement system. Time response resolution should be no less than 0.1 seconds

Systems are to be designed with components that, when working together, will not exceed the maximum specified system response time.

TMC Verification:
For the purpose of aiding in TMC verification of a laboratory's filtering of input signals to their acquisition system, the step change method will be used. The TMC will use this information to verify that the system response meets the specifications in the test procedure.

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
X_i = Data reading at instance i
n = Number of readings thus far in the test

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.

The test developer/surveillance panel should determine, for each parameter, whether variations in the signal are random or cyclical. If random, a minimum of 10^3 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" (t_i). 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:

$$\text{QI Sampling}_{Max}(\text{sec}) = t/2$$

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 laboratory systems employed must be able to calculate QI from in-progress test data, either in real time or on command. That is, the QI could be calculated and updated each time a reading is sampled, or the samples logged and the QI calculated from logged data.

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.

The upper and lower limits for the QI calculations are derived statistically from the operating conditions of the test development "Golden" stand. The limits should be adjusted and set during test development to result in a final QI of approximately .80 to .90 for each parameter on the Golden stand. These limits can 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.

Accuracy

The System Accuracy Table listed on the following page is the generic capability of an entire measurement system based on current conventional cost effective technology, taking into account reasonable environmental effects.

The inclusion of this table is intended to serve as a guide to the test developers and surveillance panels as to what is commonly possible using current technology. It is not intended to be an all inclusive summary of available technology. The DACA II task force has deliberately not listed the capabilities of equipment that, in its judgement, is not appropriate for use in an engine testing environment due to reliability, cost, or performance concerns.

Accuracies are stated for systems that have been calibrated using due diligence with NIST traceable equipment, and have been applied using good engineering practices. The recommended method to calculate the system accuracy is the Square Root of the Sum of the Squares of the component accuracy.

Current Measurement System Capabilities

Measurement Type	System Type	System Accuracy
Temperature	Thermocouple	0-200° ± 0.50 °C 200-1000° ± 2.00 °C
	RTD	± 0.12 °C
Pressure High (> 6.9 kPa)	Capacitive	± 0.2 % of Full Scale
	Strain	± 0.25 % of Full Scale
Pressure Low (0 - 6.9 kPa)	Capacitive	± 15 Pa
	Strain	± 14 Pa
Flow	Orifice Venturi	0.75% of reading
	Vortex (Liquid) Vortex (Gas)	± 0.75 % of reading ± 3.0 % of Full Scale
	Magnetic	± 1 % of reading
	Coriolis	± 0.25 % of reading
Speed	Frequency	± 1 rpm
Load	Strain Gage	± 0.25% of Full Scale

Non Controlled Parameters:
For non controlled (read-only) parameters, the following apply:

- The specification of response time of the measurement system is optional.
- Non controlled parameters do not lend themselves to QI calculations.

Transitory Conditions:
During a change in conditions, from one stage to another, or during scheduled startups or shutdowns, it may be desirable to keep tighter control of test conditions. During transitions, the minimum required data logging rate is 10% of the allowable transition time, or it is the steady state logging rate. whichever is fastest.

If a QI is to be calculated during transitory conditions, then it should be calculated independently from the steady state QI.

Resolution:
Minimum resolution of the acquired data should be at least 4 times the required system accuracy. Example: Test procedure requires an accuracy of 1.0 N. The minimum resolution is .25 N.

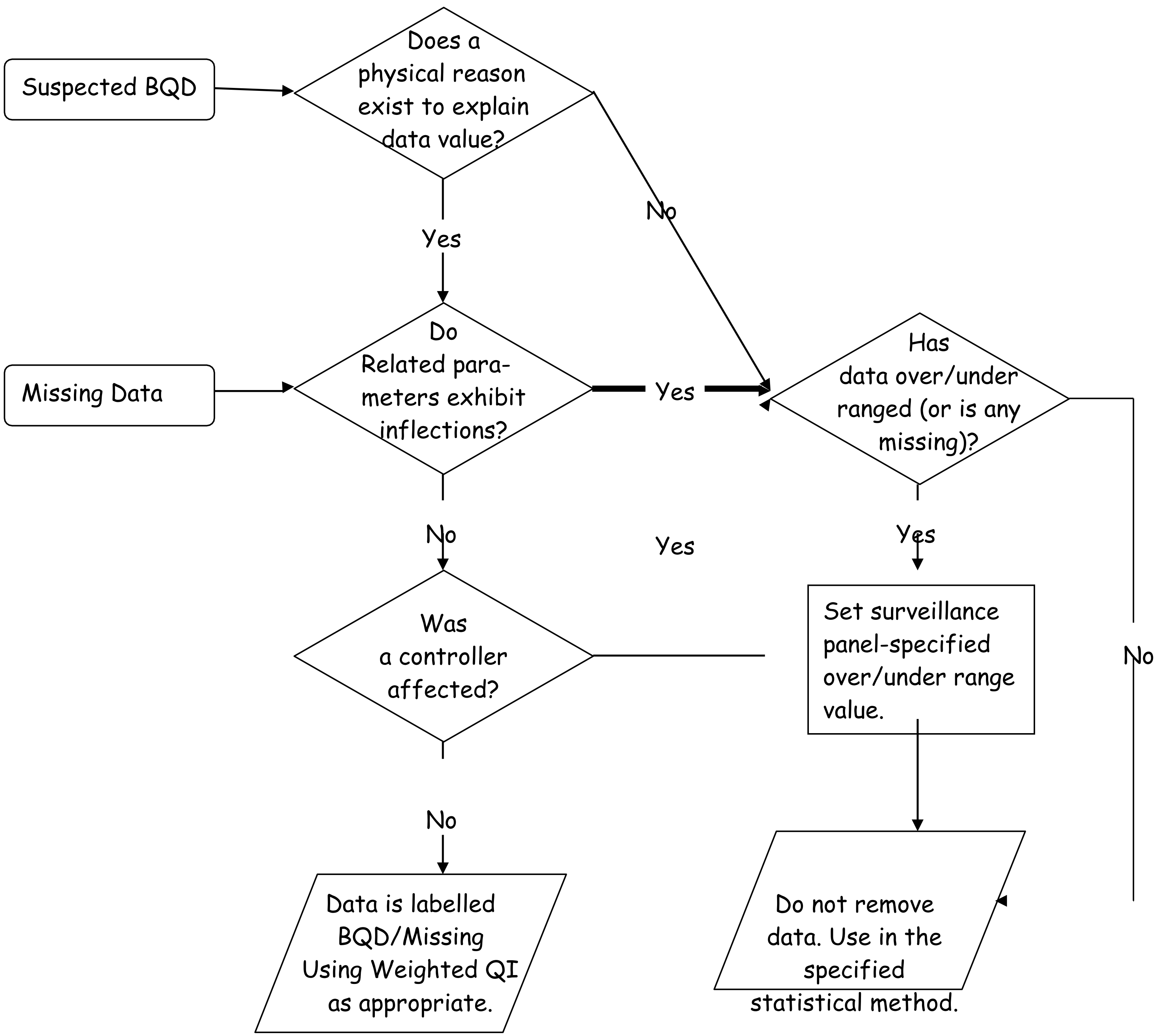
Calibration & Stability Requirements:
The calibration of laboratory equipment can affect its accuracy. The instruments used to calibrate the data acquisition system must have an accuracy four times that of the system it is calibrating.

1. The laboratory calibration standards will be traceable to a defined national standard, e.g., National Institute of Standards and Technology, and be verified at least annually.
2. Test measurement systems shall be calibrated using the laboratory standards mentioned in item 1 above at a frequency as prescribed by the individual test procedures. It is the Task Force's recommendation that all systems be calibrated a minimum of once every six months, or at any time the readout data indicates the need.
3. Whenever measurement equipment is changed, the system it is a part of should be calibrated.

Backup Data:
It is recommended each lab employ sufficient safeguards and redundancy to assure adequate test data logging in the event of electronic systems failure. Examples are redundant data storage, manual logging, screen dump, etc.

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.

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



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.

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
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 ($n_{BQD} = n_{total} - n$)

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

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Definitions:

PRECISION: The degree of mutual agreement between individual measurements from the process.

ORDER: The number of energy storage devices in the system. (Most process systems can be reduced to first order, i.e. one dominant energy storage device.)

FILTER: A means of attenuating signals in a given frequency range. They can be mechanical (volume tank, spring, mass) and/or electrical, which can be analog (capacitance, inductance) and/or digital (mathematical formulas). Typically, a low-pass filter attenuates the unwanted high frequency noise. Some signal filtration is necessary in order to assure sampled readings are not compromised due to noise. However, excessive filtration will mask irregularities in the process being measured and can result in an artificially high QI.

TIME CONSTANT (τ): A value which represents a measure of the time response of a system. For a first order system responding to a step change in input, it is the time required for the output to reach 63.2% of its final value.

CUTOFF FREQUENCY (f_c): The frequency point that divides the frequencies that pass through the system almost unattenuated and the frequencies that pass through the system but are greatly attenuated. For a first Order system, this value is calculated as follows:

$$f_c = \frac{1}{2\pi\tau}$$

where τ is the time constant

QI SAMPLING RATE: The rate at which data is acquired for use in the calculation of the QI.

SAMPLE FREQUENCY (f_s): The frequency at which a value is obtained for processing. This is normally considered for computer data acquisition, but is also true of a manual reading, i.e. once per hour.

DECIBEL (dB): A unit for measuring the ratio of the magnitude of two quantities (normally output voltage to input voltage). Calculated as follows:

$$dB = 20 * \log\left(\frac{Output}{Input}\right)$$

INPUT FREQUENCY (f_{in}): The frequency of the input signal. This is most certainly changing and includes real but unwanted noise. (Normally the noise is a higher frequency than the frequency of the expected signal.)

ACCURACY: The degree of agreement of an individual measurement with an accepted reference level.

DATA POINT: The value of a parameter after appropriate digital/analog filtering with due consideration for the time response of the system.

APPENDIX A
TMC Verification of System Filter Characteristics

Introduction

Engine Sequence testing laboratories may utilize statistical measures to indicate how tightly critical parameters are controlled. These measures can be affected by the amount of filtering associated with the acquisition of the data. In order to be able to make meaningful comparisons of data between different laboratories, testing procedures should be developed that require use of equivalent electrical and mechanical filtering. Data can be accurately compared and used in statistical calculations only when processed using equivalent filtering strategies that do not overly filter the data signals. The implementation of the testing procedure requires a method by which each lab can be tested to ensure minimum specifications are met. This document suggests verification procedures that could be used.

Filters

There are two types of filters to consider when measuring the performance of data acquisition and control systems; mechanical and electrical. Since both mechanical and electrical storage (or filtering) systems can exist in a control loop, the entire end-to-end signal path should be tested to determine a "system" time response.

Verification Process

Each lab is responsible for meeting or exceeding (i.e. faster response) the procedural system response times for feedback control loops and any other selected parameters. The test developer will utilize a filtering strategy based on the minimum smoothing needed to provide a useable signal. Each lab will submit the known type of electrical and mechanical storage devices along with their loop response times. System response times longer than the maximum allowable response time will not be permitted.

APPENDIX A
TMC Verification of System Filter Characteristics

The TMC may visit test sites to verify stated filtering techniques and response times. This verification process is as follows:

Verification Procedure

1) Loop Response Time
   Each system will be tested as outlined in the DACA III Report for various parameter types. The loop response time test will capture the system response from sensor to logged value. The response time measurement is based on a time response to 63.2% of final value.
   a. Compare response time of test system to response time in procedure on a loop by loop basis.

Attachment # 5

TMC System Time Response Document with Change Tracker Displayed

TMC

System Time Response Measurement Guidelines

5/27/1998

The following information is to assist laboratories in measuring system time response.

System time response refers to the time that a complete data acquisition system takes to log a step change for a given parameter. **The complete data acquisition system takes into account sensor, any associated wiring leads or piping along with signal conversion, computer processing and any other manipulation of data to the point of logging that would be in place during normal test operation.** During TMC lab visits engineers ~~should~~ may note sensor information (manufacturer, model number, principal employed for measurement, thermocouple type (J, K, E) or RTD, grounded or ungrounded. Also, make note of unusual wiring, piping layout and the use of snubbers, condensate traps or electrical capacitance caps in control panels.

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A system time response can be determined by measuring the amount of time to reach a certain percentage of an imposed step change. For this document, the value of 63.2 % of the amount of the imposed step change will be used. ~~for 1st order systems. For linear moving average channels 45.4% should be used.~~

In order to provide an accurate measurement of system time response, a channel ~~should~~ may be optionally used to display a triggering switch that indicates when the stimulus was imposed. Response time starts when the stimulus is imposed ~~triggering switch is activated~~ and ends when the process reaches 63.2% of the final value. In addition, because some system time responses are in the millisecond range, an adequate sampling rate should be used to record values.

Typically, a system that can ~~log~~ record and display values at ~~of~~ 10 hertz or more frequently is necessary to measure an accurate system time response. Recommended step changes are shown below. If these step change deltas are inadequate, step changes should be at least 100 times the resolution of the measurement system and representative of typical operating conditions when possible. Permanent digital record of the response values and triggering are to be made. ~~Data interpreted from graphical screen displays is not recommended.~~

The techniques used to measure response time for typical parameter are as follows:

Parameter	Step Change
Temperature	Quickly insert probe at ambient conditions into ice/distilled water mixture ~~@ 0± 5 °C~~ to cover the length of the probe. Care must be exercised to insure that handling of the thermocouple does not change the initial temperature reading, i.e. the temperature plot should be flat prior to inserting into ice bath.
Pressure	Pressurize system to an appropriate value ~~400 ± 5 kpa (~60 psig) for high pressure channels and 35 ± 3 kpa (~5 psig) for low pressure channels from the measurement probe (to include the entire system),~~ then instantly release pressure. ~~through the use of an electric solenoid actuated valve to atmosphere. Valve must have an exit diameter large relative to the diameter of the pressure measurement line. The pressure source leg should have a shut-off valve so that the pressure source can be removed prior to testing. All lines should be as short as possible. To, operate, the system is pressurized with the calibrated pressure source (typically this is a standard transducer calibration rig), the shut-off valve closed, and the pressure source removed. The solenoid is then triggered, releasing the pressure.~~ Response time pertains to the response to the release in pressure.
Torque	Apply the appropriate load to dynamometer arm. ~~to achieve 120 ± 12 Nm of torque.~~ Then remove applied weights quickly from the load cell. ~~For a typical Midwest 1014 dynamometer with arm ~15.75" use 570 lb weight.~~ Response time will start when the torque signal begins changing.

Speed	Configure a small electric motor to operate at 2000± 5 r/min speed using the appropriate speed sensor. Remove transducer to simulate step change to 0 rev/min.(Does anyone do this?) An alternative and less desirable method is to iImpose a step change to an appropriate equivalent to 2000 r/min at the sensor connection through a frequency generator.
Flow	Flow meters and the like require special procedures to impose a step input on the system. For flow meters, in general, the system is filled with the appropriate fluid and operated. At the desired time, a shutoff valve is closed the fluid pump is switched off and the system response is measured. Other systems will require some other procedure that will have to be determined. Step inputs are typically test area dependent.

A IIIE=160 Nm, VE=95 Nm, VJIA=98 Nm, IVA=25 Nm