Data Validation Using PMAX® and PI™

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Abstract

This paper presents modifications performed on the PMAX Input Validation Module (IVM) and how they are applied to protect and record substitutions to model input data.

The IVM is utilized with the PI data historian to modify and maintain records for all the data included in the calculation of unit heat rate and various other parameters. The PI data historian maintains a record of the status of each validated instrument. The record includes signal quality, measurement validity, last acceptable reading, and correction method. This information may be utilized to troubleshoot an instrument problem quicker and inform the unit operator when an instrument reading substitution was made.

Introduction

The success of an on-line performance monitoring system is heavily dependent on the amount and accuracy of the instruments that are input to the model. If there is a lack of field instruments that measure the parameters effecting the unit heat rate, it cannot be calculated accurately. If a critical instrument temporarily loses its signal or drifts out of calibration, the unit heat rate and other critical calculations stop or incur a significant error. If the on-line performance monitor is being utilized to calculate a unit's cost of generation, significant errors can result in unit loading decisions if several units are included in a generation fleet. Therefore, the quantity and quality of the plant instrumentation is very important to the success of a performance monitoring system.

The Fossil Division of ComEd utilizes PMAX as its on-line performance monitor and integrates the calculation results into a PI data historian which is capable of trending all outputs to aid in analysis. The IVM is a feature in the PMAX model that can be utilized to substitute values for instruments that are temporarily out of service (I.E. broken thermocouple wire or bad card in the data acquisition system) or are out of a predetermined calibration limits (I.E. instrument calibration is necessary). A substituted value may be in several forms: constant, calculated, obtained from a curve, or predetermined minimum/maximum limits. Previously, when a substitution was made by the IVM, the only way to determine that there was a change was to manually execute a report that produced the status changes of the instruments that were being substituted during the requested time period. This report was useful in determining which instruments were in question when the user was troubleshooting the model but could not be utilized to track the history of an instrument's performance.

The authors of this paper have designed a more effective method of reporting the actions of the IVM. The IVM has been modified to "remember" not only that a point's status (I.E. good/bad) changed but also *why* it changed. It has also been given the capability of utilizing the Data Acquisition Interface to send this information back to the PI system where it can be stored. The PI data historian maintains a record of the status of each validated instrument. The record includes signal quality, measurement validity, last acceptable reading, and correction method. This information can be utilized to troubleshoot an instrument problem more quickly and inform the unit operator when an instrument reading substitution was made in the PMAX model. This information also assists the operator in determining why a particular controllable cost (I.E. throttle temperature, throttle pressure, hot reheat temperature, etc.) is high or negative.

The IVM helps answer the following question: Is the reason for the deviation from bogey a real problem or is the instrument reading incorrectly? Determining the answer to this question helps the unit operator or performance engineer make a quicker, more informed decision on corrective action. The instrument status information can also be utilized by the instrument mechanics to determine whether the signal to the instrument was temporarily lost or whether the instrument is out of calibration.

System Functionality

The IVM is designed to protect and validate the PMAX arming plan input data. It has the capability to verify that the analog or digital input signal for a corresponding point is of good quality and whether the reading is within specified limits. When the IVM is triggered to substitute or flag a PMAX input point; ten possible actions may be taken. An eleventh action exists for the case when a point is not being validated by the IVM. Each action is numbered and assigned to a PMAX point ID or status tag that is associated with the input point. The status tag is a separate PMAX point ID that is utilized to display and output the status of an associated point in the arming plan. A separate program has been written to translate the IVM statuses into PI digital status tags. The value associated with the status tag remains constant as long as the IVM continues to take the same corresponding action.

If the input point signal is of good quality and the instrument reading is within specified limits, then the IVM does not make a substitution and the point status tag is given a value corresponding to this action (I.E. no action taken). If the input signal status is of good quality and the instrument reading is beyond specified limits, or the input signal status is bad, the IVM makes the appropriate substitution and a corresponding action is assigned to the respective instrument's digital status tag (I.E. good signal status but reading is outside limits and replaced with bogey value). The associated numbers are digital state values of the PMAX status tag that may be cross-referenced to a PI data point for historical trending.

The eleven numbered actions are:

1. "Point is not being validated by the IVM".
   These points currently are not in the database but may be in the future. A PI status tag is created for all averaged Point ID's for future use.

2. "Good signal status. No action taken".
   These points are in their normal state with a good signal being supplied by the instrument to the PI system and an instrument reading that is within the error criteria that is specified to the IVM.

3. "Good signal status. Replaced with constant value".
   These points are supplying PI with a good signal but the parameter is not within the specified IVM error criteria. Therefore the IVM is making a substitution of a constant value instead of utilizing the current reading.

4. "Good signal status. Replaced with bogey value."
   These points are supplying PI with a good signal but the parameter is not within the IVM specified error criteria. Therefore the IVM is substituting a bogey curve value instead of utilizing the current reading.

5. “Good signal status. Replaced with a min/max”
These points are supplying PI with a good signal but the parameter is not within the IVM specified error criteria. Therefore the IVM is substituting either the specified minimum or maximum (whichever is closer to the actual reading) value instead of utilizing the current reading.

6. “Good signal status. Tagged only”
These points are supplying PI with a good signal but the parameter is not within the IVM specified error criteria. The IVM is not making a substitution but is tagging the value to denote that it is in question.

7. “Bad signal status. Replaced with constant”
These points are not supplying PI with a good signal. Therefore the IVM is substituting a constant value for the current reading.

8. “Bad signal status. Replaced with a point value”
These points are not supplying PI with a good signal. Therefore the IVM is making a substitution of a bogey curve for the current reading.

9. “Bad signal status. Replaced with a bogey curve value”
These points are not supplying PI with a good signal. Therefore the IVM is substituting a bogey curve value for the current reading.

10. “Bad signal status. Replaced with a minimum/maximum value”
These points are not supplying PI with a good signal. Therefore the IVM is substituting either the specified minimum or maximum (whichever is closer to the Actual reading) value for the current reading.

11. Bad signal status, Tagged only”
These points are not supplying PI with a good signal. The IVM is not making a substitution but is only tagging the value to denote that it is in question.

Programming

To program the concepts mentioned above involves four main steps:

1. Set up IVM functionality for all the PMAX points desired. Generally, the raw inputs coming through the data historian or the data acquisition system are not validated, but their averages are (although it is not typical to IVM all averaged points). This process maintains a consistent source of the input data to the model and aids in instrument and arming plan troubleshooting.

2. On the computer or server, depending on the PMAX installation, that executes the calculations, move the values of the validated points to a range of points in the PMAX EU table. These points will function as the status tags for the validated point I.D.’s.

3. Create a range of digital tags on the data historian (PI or RTIME) that the validated point statuses may be written to.

4. Write the validated point statuses to the data historian tags utilizing the PMAX FOXPROW PI Cross Reference utility. These points must be written as digital outputs from PMAX.

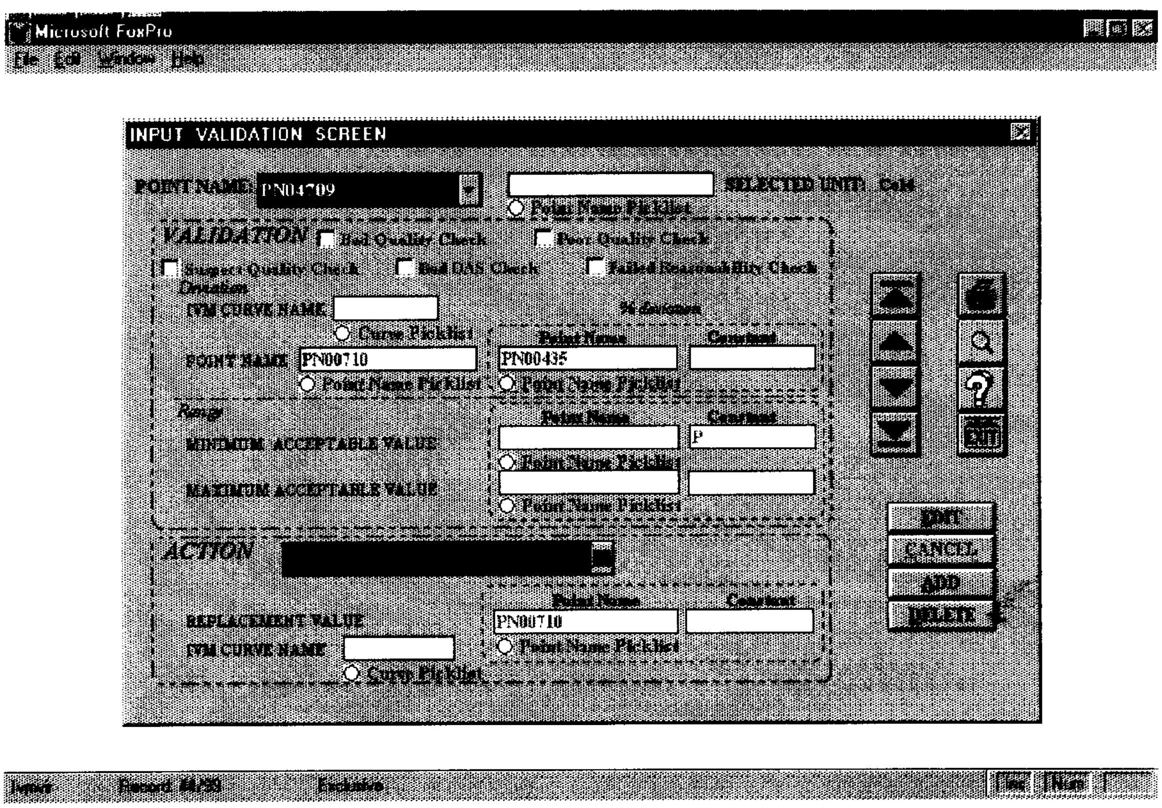
5. When the IVM takes action, it will be labeled with an "R" when a "Point bad quality list" is executed on the PMAX MMI.

Examples

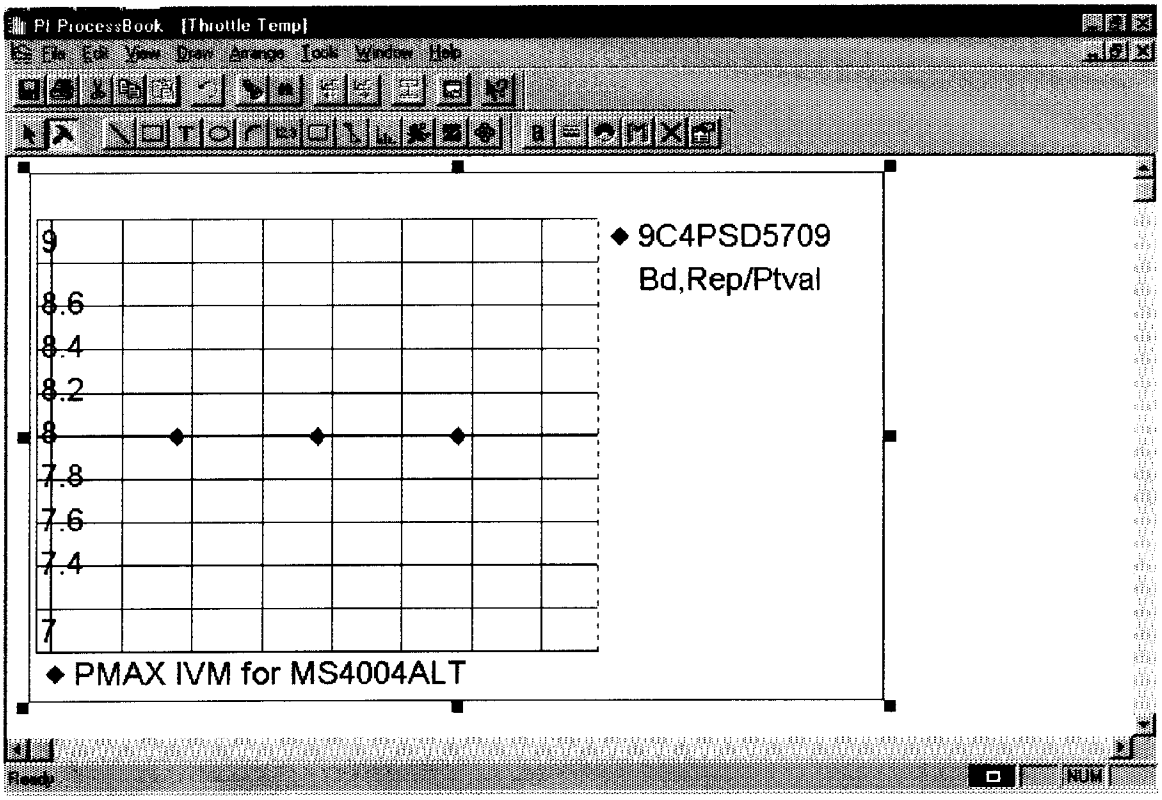
The following examples illustrate the application of the data validation system to simulated operating situations.

<u>Example 1</u>

The throttle temperature on Collins Station Unit 4, PMAX point ID 109, that is input to the model is reading 1000°F, but is questionable (I.E. the signal quality is bad). The point is time averaged using the Average Module and placed in point ID 4709, which is validated using the IVM. The validation criteria for the point is that it be replaced with a point value (point ID 710, bogey throttle temperature) if it deviates from it by more than a specified degree of error (15% in this case) depicted by point ID 435. The IVM input screen is illustrated below.



The IVM status for the point is transferred to point ID 5709. This is the digital point that contains the tag status that corresponds to the IVM corrective action. The IVM is substituting a value of 1000°F for point ID 4709. Point 5709 is assigned a value of 8 which implies that the signal is of bad quality and has been replaced with a point value. The PI Process Book trend for the point 5709 is shown below:



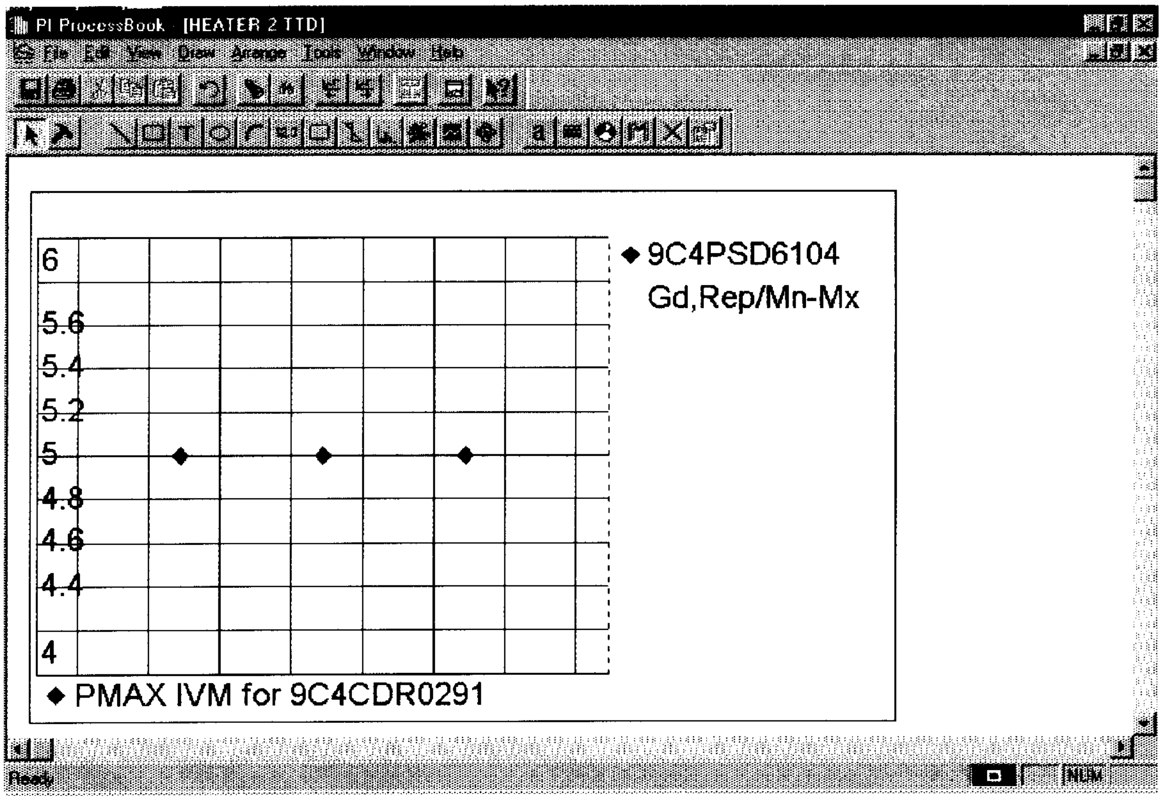
Upon noticing the IVM status, the operator contacted the Instrument Maintenance department concerning the problem and it was determined that the throttle temperature thermocouple had slipped out of the thermowell and that the wire connecting it to the control system was broken. The thermocouple and wiring were replaced to resolve the problem.

After the repair, the throttle temperature reading increased to 998°F. The IVM status tag (point ID 5709) for the throttle temperature point 4709 returned to a value of 2 which implied that the signal is of good quality and the instrument reading is within specified limits.

<u>Example 2</u>
The terminal temperature difference for Fisk Station No. 19-2 feedwater heater, PMAX point ID 1104, that is being calculated by the model is 2.0°F. Feedwater heater 2 is the second low pressure heater. The validation criterion for the point is that it be replaced

with the bogey value if it is not within the specified maximum/minimum limits. The IVM status for the point is transferred to point ID 6104.

The IVM is substituting a value of 2.0°F (the bogey terminal temperature difference for Heater 2 is 5.0°F and the IVM is programmed to only allow it to deviate from bogey by 3.0°F on the lower end) for point ID 1104. Point 6104 is assigned a value of 5, which implies that the value is of good quality and that it has been replaced with a min/max value.



The performance engineer executed the PMAX feedwater heater calculation module through the Man Machine Interface (MMI) and the output illustrated that the actual terminal temperature difference reading was -4 °F. Without a desuperheater section in low pressure feedwater heater No. 2, we would not expect a negative TTD. Therefore, this value indicated that an instrument associated with the heater was malfunctioning.

The performance engineer also discovered that the feedwater heater shell pressure was being substituted with a bogey curve in the IVM. He contacted the Instrument Maintenance Department and it was determined that the No. 2 feedwater heater shell pressure transmitter was malfunctioning. The transmitter was replaced and the shell pressure and terminal temperature difference returned to their normal values. The IVM status tag (point ID 6104) for the terminal temperature difference returned to a value of 2 which implied that the signal is of good quality and the instrument reading is within specified limits.

Conclusion

This paper has described and illustrated a methodology that has been developed to validate PMAX arming plan input data. A validation method is vitally important to the success of a performance monitoring system because it protects input data and promotes trust by plant personnel in the information being displayed. This helps insure that the performance monitor is utilized to its full potential: To calculate the unit's heat rate and help identify areas where performance improvements can be achieved.

Acknowledgement

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References

1. Scientech, Inc., "PMAX Training Manual", Scientech, Inc., 1994

2. Oil Systems, Inc., "Plant Information System Manual", Oil Systems, Inc., 1995