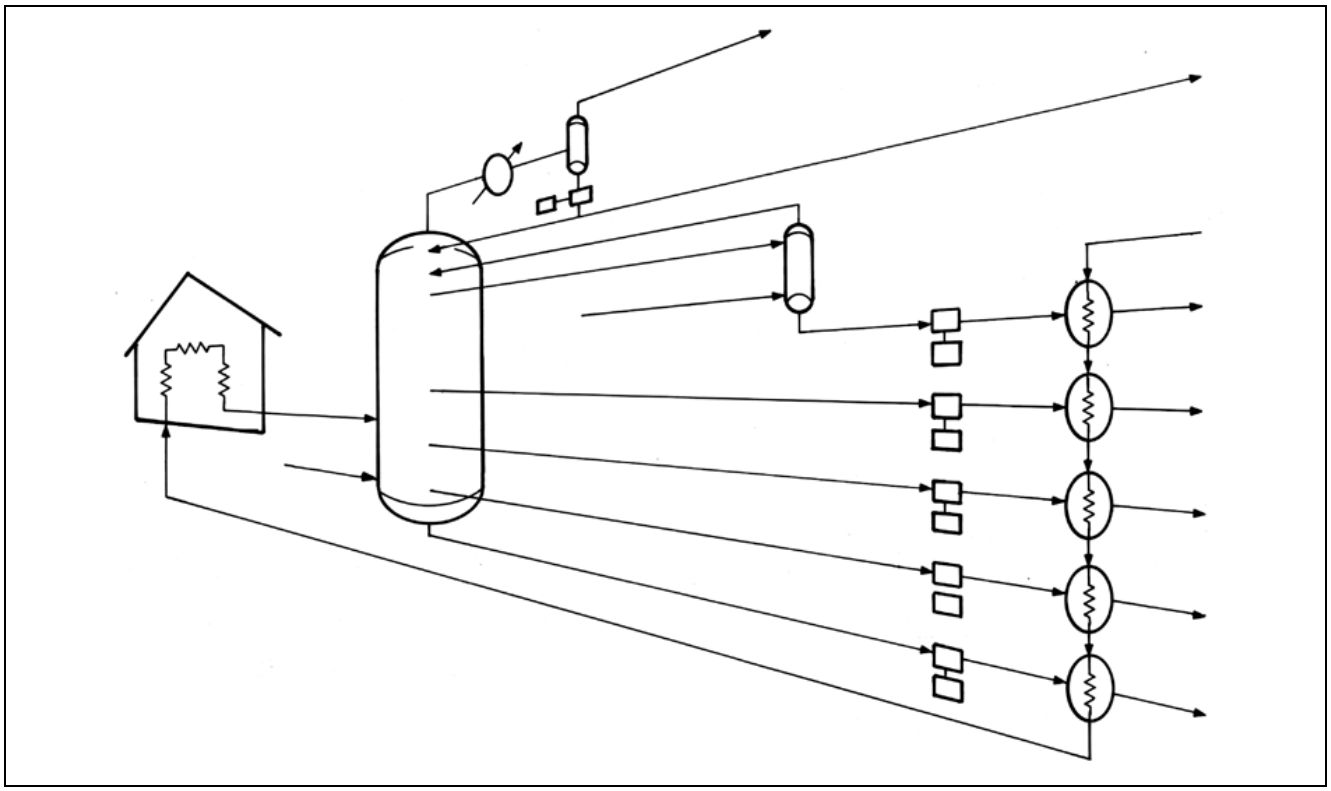
FOXBORO®

PSS 21S-4D1 B3

I/A Series® Software
Data Validator



The Data Validator performs material and component balances, systematic error correction, and random error corrections for process flow measurements to provide optimally adjusted measurements that can be used in other applications.

DATA VALIDATION

The Data Validator is an I/A Series Industrial Software package that performs context validation. Context validation is data validation in which variables are adjusted based on a known relationship among the variables. The known relationship used in this package is mass conservation.

Because measurement often forms that basis for judging plant or unit performance, it is important to be able to assess the possibility of measurement errors.

The adjusted measurements that result from running the Data Validator provide the user with a current “best estimate” of process flow values, including unmeasured flows.

These estimates can provide guidance in a measurement improvement program designed to locate sources of measurement error. Adjusted measurements produced by the Data Validator may be used in plant management activities, such as operations accounting.

MATERIAL AND COMPONENT BALANCES

The Data Validator calculates optimum adjustments for a set of mass flows and individual components that make up mass flows. Using statistical methods, the Data Validator performs material balances to adjust components (fractions of mass flow). Adjustments are based on a weighted least squares fit with balance constraints, as illustrated in Examples 1 and 2. Once adjustments have been determined, systematic errors and random errors can be isolated.

SYSTEMATIC ERRORS

A systematic error exists when the optimum adjustment for a mass flow or component exceeds the expected error based on confidence in the measurement. Systematic errors may be the result of leaks and Calibration errors. Using the Data Validator to locate systematic errors helps you to:

- Detect errors in instrument calibration
- Estimate magnitude of losses
- Create a directed maintenance program, focusing on suspect meters
- Provide a statistically consistent set of mass flow and component measurements for activities such as inventory control and operations accounting

RANDOM ERRORS

A random error exists when the optimum adjustment for a mass flow or component is within the expected error based on confidence in the measurement.

Example 1: Material Balance

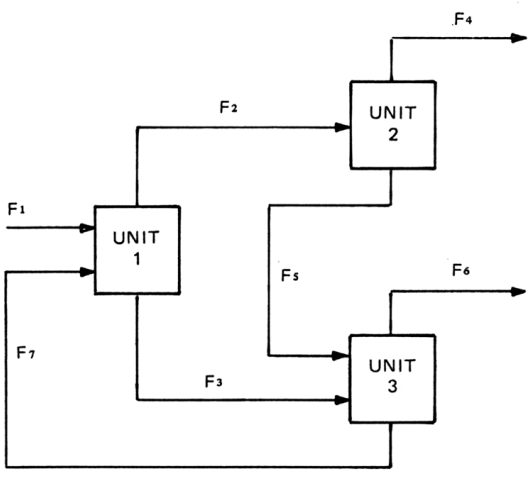


Figure 1. Mass Flow Relationships

Given that, at steady state, the adjusted mass flows into each unit equal the adjusted mass flows out of each unit, the mass balance equations for the relationships in this example are:

- Unit 1 Balance: $F_1 - F_2 - F_3 + F_7 = 0$
- Unit 2 Balance: $F_2 - F_4 - F_5 = 0$
- Unit 3 Balance: $F_3 + F_5 - F_6 - F_7 = 0$

Subject to the constraints imposed by the balance equations, the adjusted mass flows are calculated using a weighted least squares fit. That is, without violating the equality relationships in the balance equations, adjustments are calculated by minimizing the sum of the weighted squares of the differences between the adjusted mass flows and the measured mass flows:

$$\text{Minimize } J = W_1(F_1-f_1)^2 + W_2(F_2-f_2)^2 + \cdots + W_7(F_7-f_7)^2$$
$$F_1,F_2,\ldots,F_7$$

where:

J =	sum of the weighted squares
$W_1,\ldots,W_7$ =	weight factors
$F_1,\ldots,F_7$ =	adjusted mass flows
$f_1,\ldots,f_7$ =	measured mass flows

Weight factors reflect the degree of confidence in the validity of each measured mass flow. A high degree of confidence is indicated by a large weight factor.

If the absolute value of the difference between a measured mass flow and an adjusted mass flow exceeds the expected random error, it is interpreted as a systematic error. If not, the difference is interpreted as a random error.

Example 2: Component Balance

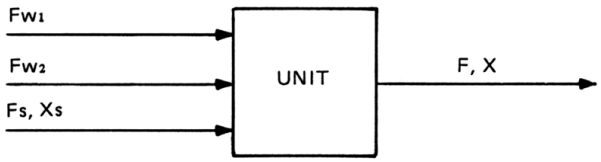


Figure 2. Component and Mass Flow Relationships

Given that, at steady state, adjusted mass flows into the unit equal adjusted mass flows out of the unit, the unit mass balance equation is:

Unit Balance: $F_{W1} + F_{W2} + F_S - F = 0$

where:

F_{W1}, F_{W2} =	adjusted mass flows of water
F_S, F =	adjusted mass flows of water/solids mixtures

Subject to the equality constraint imposed by the unit balance equation, the adjusted mass flows are calculated by minimizing the sum of the weighted squares of the differences between the adjusted mass flows and the measured mass flows:

Minimize:

$$J_1 = W_1(F_{W1}-f_{W1})^2+W_2(F_{W2}-f_{W2})^2+W_3(F_S-f_S)^2 +W_4(F-f)^2$$

F_{W1},F_{W2},f_S,F

where:

J_1 =	sum of the weighted squares
W_1, W_2, W_3, W_4 =	weight factors
F_{W1}, F_{W2}, F_S, F =	adjusted mass flows
f_{W1}.f_{W2},f_S,f =	measured mass flows

If the absolute value of the difference between a measured mass flow and an adjusted mass flow exceeds the expected random error, it is interpreted as a systematic error. If not, the difference is interpreted as a random error.

At steady state, assuming that there is no transfer of mass between the solids component and the water phase, the adjusted mass flow of the solids component going into a unit equals the adjusted mass flow of the solids component going out of a unit. The component balance equation is:

Component Balance: $X_SF_S-XF = 0$

where:

X_S,X =	component mass fractions of solids
F_S,F =	adjusted mass flows of water/solids mixture

Subject to the equality constraint imposed by the solids component balance equation, the adjusted solids mass fractions are calculated by minimizing the sum of the weighted squares of the differences between the adjusted solids mass fractions and the measured solids mass fractions:

Minimize $J_2 = W_5(X_S-x_S)^2 + W_6(X-x)^2$ X_S,X
X_S,X

where:

J_2 =	sum of the weighted squares
W_5, W_6 =	weight factors
X_S, X =	adjusted solids mass fractions
x_S, x =	measured solids mass fractions

If the absolute value of the difference between a measured solids mass fraction and an adjusted solids mass fraction exceeds the expected random error, it is interpreted as a systematic error. If not, the difference is interpreted as a random error.

OPERATION

The Data Validator is a menu-driven software package. A Help function, selectable from the menu bar on any screen, provides information on current menu options.

The user can run Data Validator functions interactively or schedule functions on either a one-time or a periodic basis. The user can view the results of scheduled actions on a screen or request a printed report of the results.

FUNCTIONS

The Data Validator consists of four functions that can be accessed from the main menu when the package is run.The menu options are:

- Specify Balance Model
- Scheduler
- Perform Balances
- Report Generator

Specify Balance Model

In order to run material or component balances, the Data Validator must have a balance model. The balance model consists of:

- A view
- A source of mass flow and component values
- A weight factor for each flow and component
- An options list (for scheduled balances)

View

A view is a closed system describing a configured group of units and connections between units. A unit describes a material processing entity; a connection describes the transfer of material between units. The Data Validator needs a view to establish the logical connections among mass flows and components required to perform balances.

The user can select a view from the Production Model data base or the Data Validator solution data base. All views configured for the system reside in the Production Model data base. Views are saved in the solution data base when they are part of a balance model that has been run and saved by the user.

Mass Flow and Component Data

Values for mass flows and components are gathered through the Historian or entered by the user. When gathering data through the Historian, the user defines reduced data groups to collect and reduce mass flow and component values. Average and standard deviation are the reduction operations performed on the collected mass flow and component values. Reduced data groups can be defined without leaving the Data Validator.

Weight Factors

For each mass flow and component in the selected view, the Data Validator requires a weight factor. The weight factor indicates the level of confidence the user has in the validity of the measurement. The user can enter weight factors. The Data Validator can calculate weight factors based on one of the following user selections: percent of scale (full capacity of a mass flow), percent of a mass flow data value, or standard deviation.

Options List

The user can run a balance model by selecting either the Perform Balances option or the Scheduler option in the main menu. When balances are run by a user request in the Scheduler, an options list defined by the user directs operations. For example, the user can specify procedures for data storage and error logging in the options list.

Scheduler

The user can schedule requests for balances and report generation with the Scheduler. When a balance request is scheduled, the Scheduler also activates any required Historian data collection prior to running the scheduled balances. Balances and reports can be scheduled to run once or periodically, as specified by the user.

Once a request has been created and saved, the user can activate the request as required without re-entering the same information each time. Also, the user can modify existing requests.

Perform Balances

The Perform Balances function performs material and component balances for a user-specified balance model and stores the results for further use.

After a balance model has been run, the user may elect to identify systemic errors and/or random errors. The user also may edit measurements and weight factors and run the balance model again.

If a run-time error occurs while the Perform Balances function is running, balances are stopped, intermediate values are saved, and an error message is sent to the user. The user also may request that error message be saved in an error message data base.

The results of a balanced model, referred to as a solution, can be saved in a solution data base and accessed by other applications. A solution contains:

- A view
- Measured mass flow and components
- Optionally, unmeasured mass flows and components
- Adjusted mass flows and components
- Weight factors
- Percentage of change required to adjust each mass flow and component
- Quality tags associated with each mass flow and component

Quality tags indicate the current status of measured and unmeasured mass flows and components in the solution data base. For example, if the Validator assigns the quality tag GOOD to a measurement, it indicates that no systematic error is suspected as a result of running the balance model.

Report Generator

The Report Generator saves a solution in a file that can be printed by the user. Using the Scheduler, the user can schedule report generation on a one-time or periodic basis.

SPECIFICATIONS

The Data Validator is designed to run on an Application Processor 20 or compatible personal computer with I/A Series industrial Software. A hard disk is required.

The following software is required to run the Data Validator:

- Production Model
- Historian

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