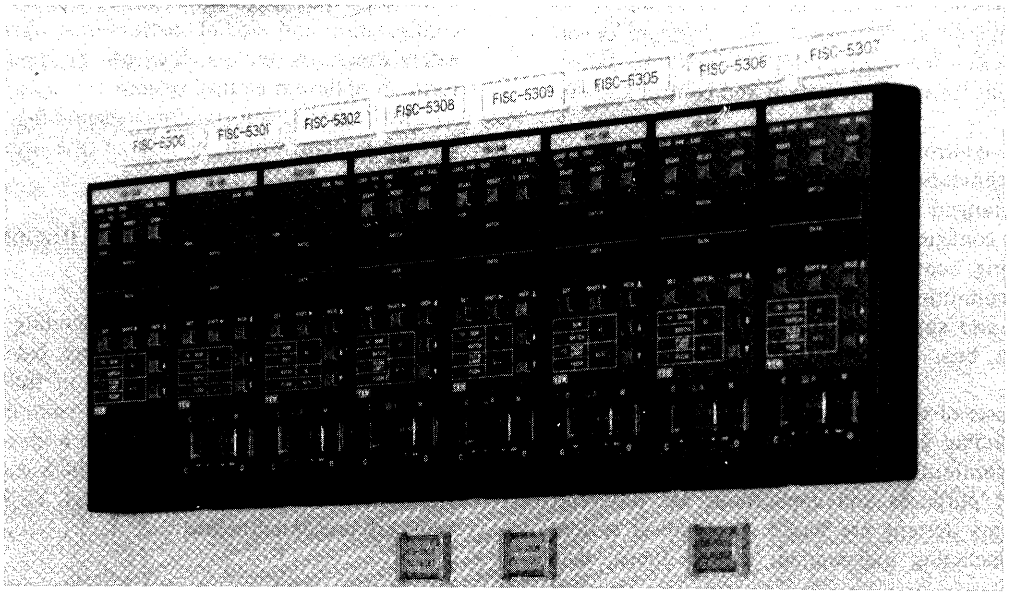
Technical Information

YEWSERIES BCS

YEWSERIES BCS
BATCH-BLENDING CONTROL SYSTEM



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1. GENERAL.

1-1. YEWSERIES 80 Electronic Control System.

The YEWSERIES 80 electronic control system (YS-80) is a new microprocessor-based control system developed by YOKOGAWA ELECTRIC WORKS to satisfy the diverse needs for instrumentation and control systems in the 1980s.

The YS-80 control system is, like an conventional analog instrumentation system, composed of individual instruments arranged on a loop-by-loop principle. However, it can be configurated as a hierarchical system capable of providing centralized monitoring and operation through data communication with the supervisory operator's console and supervisory computer via the system communication bus. Figure 1-1-1 illustrates this configuration.

YS-80 consists of three subsystems: basic control system, batch-blending control system, and centralized supervisory and communication system.
Although their purposes and applications are different, these subsystems designs are based on identical system specifications including independent control loops, data communication protocols, power supply specifications, configuration and size of instruments, operating method, safety measures, etc., so they can be freely combined to form an optimum control system.

This technical information explains the batch-blending control system which is one of the three subsystems listed above.

1-2. YEWSERIES BCS Batch Blending Control System.

The YEWSERIES BCS batch-blending control system (YS-BCS) is capable of performing batch loading and blending control for various types of fluids either independently or in combination with a centralized supervisory computer. It is possible to create a diversified range of systems by making use of the YS-BCS control and communication functions. Three typical YS-BCS configurations are presented below.

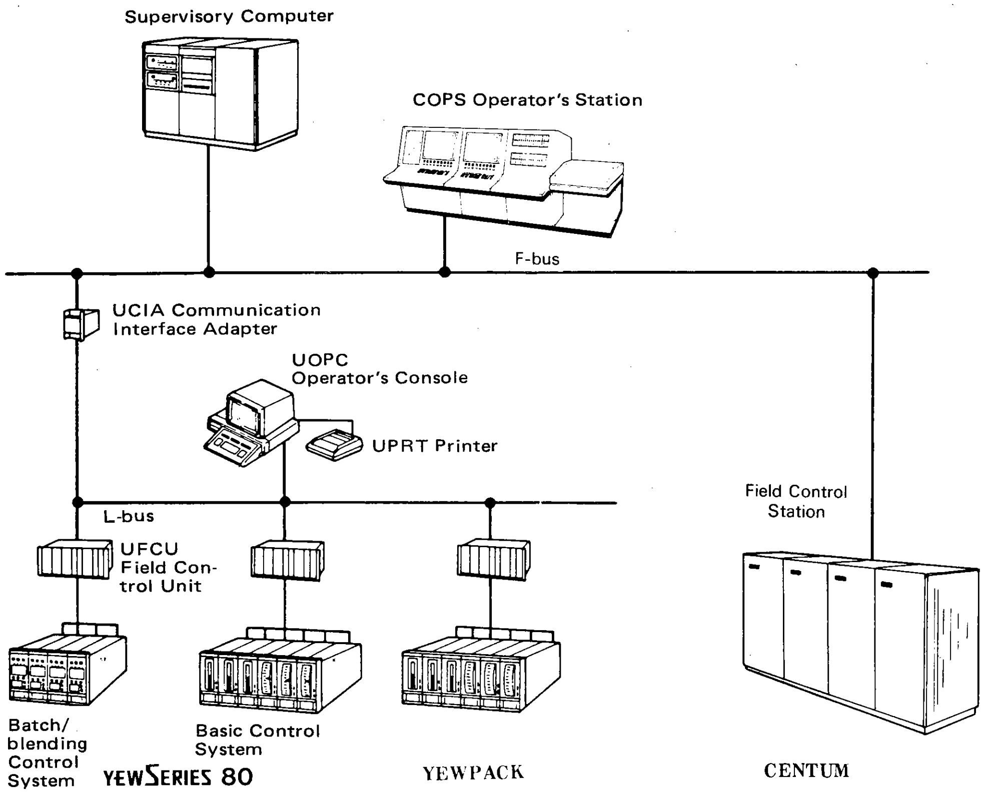


Figure 1-1-1.

(1) **Control performed only by YS-BCS instruments.**
YS-BCS is composed of independent instrument groups for each loop. One YS-BCS unit may be used to configurate a batch loading loop or two or more units may be used in combination to configurate a blend-batch loading system. (Note) (Figure 1-2-1)

Note:
Blend-batch loading system: Batch loading system with blending control.

(2) **YS-BCS combined with operator's console.**
With YS-BCS, the batch loading loop and blend-batch loading loop controlled by the YS-BCS can be monitored and operated from the operator's console (UOPC). (Figure 1-2-2)

(3) **YS-BCS combined with supervisory computer.**
Blending and loading of the products are determined according to the operational schedule for the entire plant. Where YS-BCS is combined with a host computer for management and control, a series of operations such as parameter computation, parameter setting, batch start and batch end can be performed from a remote system. (Figure 1-2-3)

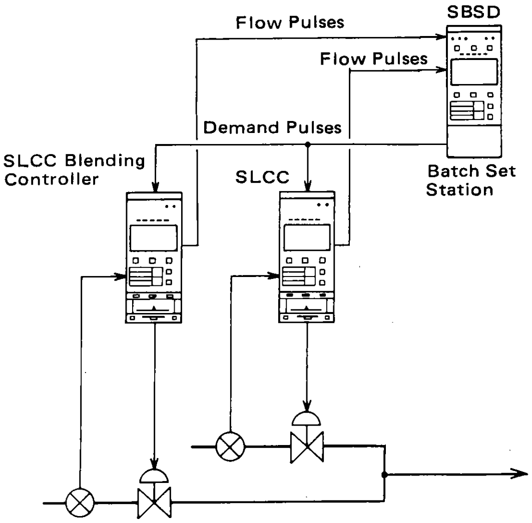


Figure 1-2-1. Two-component Blending and Delivery Systems.

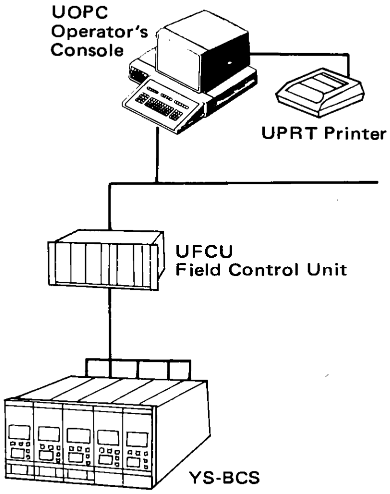


Figure 1-2-2. YS-BCS with Operator's Console.

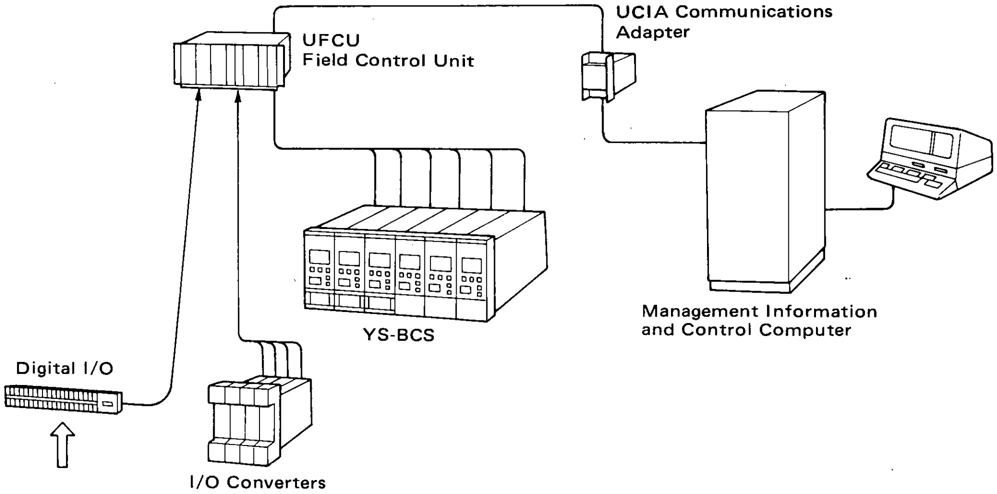


Figure 1-2-3. YS-BCS with Supervisory Computer.

2. CONFIGURATION.

2-1. YS-BCS Component Instruments.

YS-BCS is composed of individual instruments which do not require signal converters which are equivalent to rack instruments in the YS-80 basic control system. Any control system can be configured by using the four types of direct input type panel instruments (SBSD batch set unit, SLCC blending controller, SLBC batch controller and STLD totalizer) shown in Figure 2-1-1.

Moreover, many functions which were conventionally available in the form of hardware are now provided as firmware by fully utilizing the microprocessor. Thus, the user is now able to choose such functions freely to create the desired system.

Functions can be selected by using switches on the side panel. Data can then be set by using the front panel switches and data indicator.

The functions of each component unit are outlined below.

○ **SBSD batch set station**

This unit may be used in three different ways.

(1) ON-OFF batch loading output (hereafter called simplified batch)

SBSD measures the batch loading line flow and temperature to compensate the measured flow. When the totalized value of the flow reaches the preset prebatch level, SBSD issues a contact output to half close the control valve in the line. When the totalized value reaches the batch level, a contact output is issued to completely close the control valve and stop the loading of fluid. The batch start instruction and batch restart instruction can be given by using the sequence pushbutton located on the front face of the instrument or by using the status input signal.

(2) Master transmitter in blend-batch loading system (Batch master station)

SBSD is used in combination with the SLCC blending controller to perform high-precision in-line blending.

In this case, SBSD outputs a demand pulse signal to SLCC to determine the totalized flow and the instantaneous flow rate.

The demand pulse is started and stopped by means of the sequence pushbutton switch on the front panel of the instrument or by the status input. It is given according to the programmed flow velocity pattern corresponding to the batch loading.

The batch loading can be monitored by the sequence progress display lamps.

(3) Blending master station

SBSD is used as a blending master station in combination with the SLCC blending controller to perform blending.

For this case, only start and stop sequences are performed.

○ **SLCC Blending Controller**

This SLCC is a PI controller which receives a demand signal from a master station such as SBSD mentioned above or retransmitted pulses from other instruments and performs PI control to accurately maintain the totalized value of the demand signal and the totalized value of the measured flow at a constant ratio. This controller permits high precision blending.

○ **SLBC Batch Controller**

This PI controller programatically controls the instantaneous flow so the accumulated value of the measured flow reaches a predetermined batch quantity when the batch start command is issued. This controller is used in high precision control either singly to configure a batch loading loop or in a blending batch loading system in combination with an SLCC blending controller.

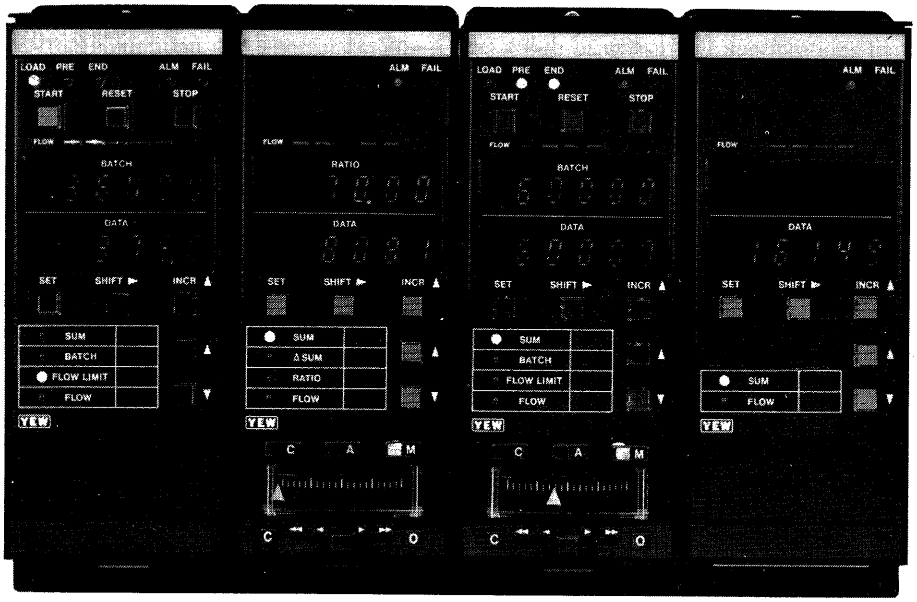
The program can be set freely in the field to correspond to the control objective. The batch start/end can be activated by using the pushbutton on the front face of the unit, or by using the status input signal.

This controller can also be used as fixed flow PI controller for which batch function is not provided.

○ **STLD Totalizer**

This totalizer receives pulse signals from a positive displacement (PD) meter or vortex flow meter or analog signals (1 to 5V DC) from an orifice type flow meter, and displays the totalized result directly or after compensation.

This totalizer includes power supplies (12V DC and 24V DC) for the pulse output flow meter and can therefore be connected directly to a flowmeter. An RTD (resistance temperature detector) can also be connected directly to this unit for temperature compensation.



SBSD Batch Set Station

SLCC Blending Controller

SLBC Batch Controller

STLD Totalizer

Figure 2-1-1. YS-BCS Component Instruments.

2-2. YS-BCS Control System Configuration.

Figure 2-2-1 shows the functional classification of the batch and blending control systems with examples configurated with YS-BCS instruments.

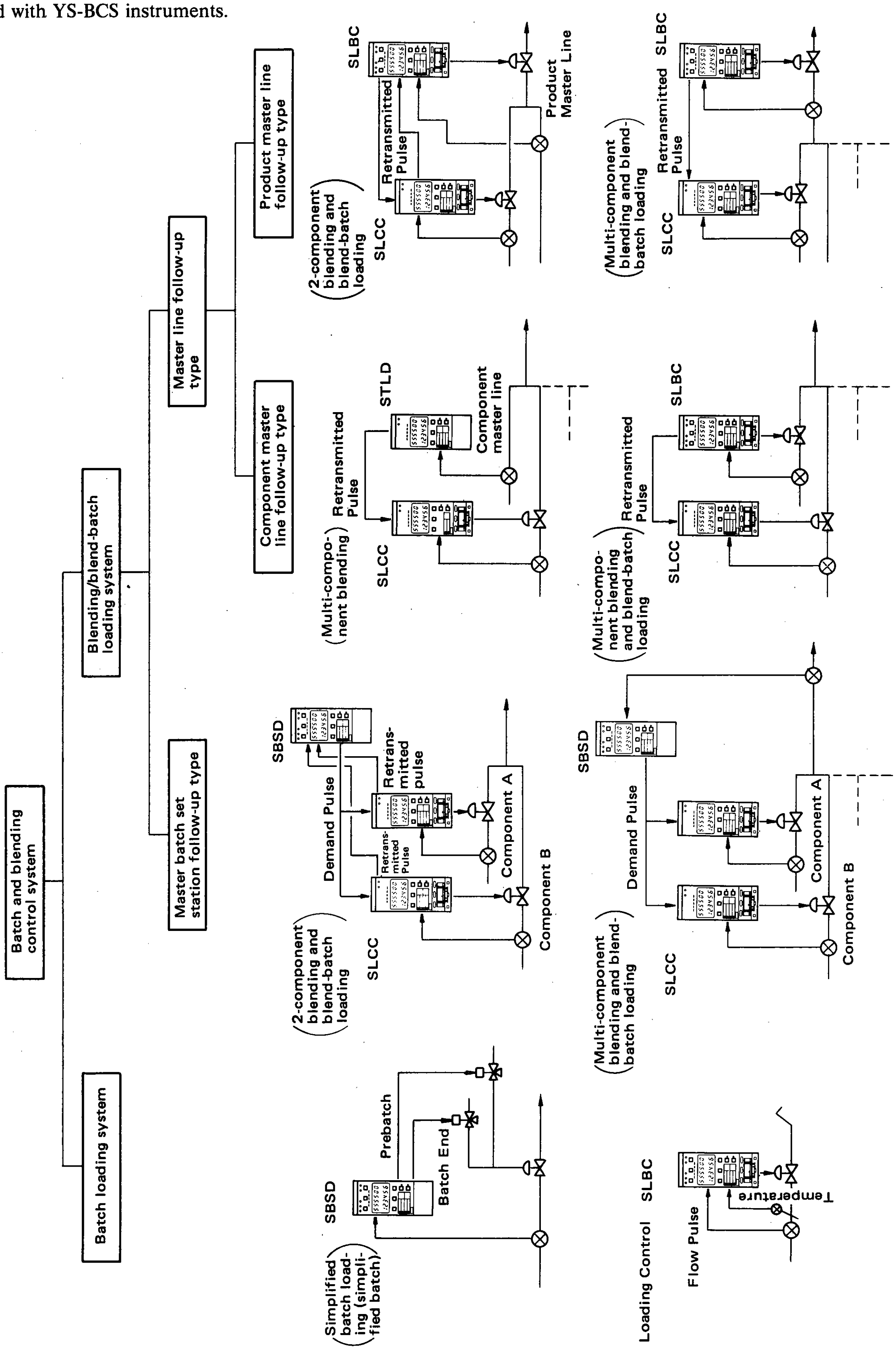


Figure 2-2-1.

3. PROCESS I/O CIRCUITS.

The YS-BCS inputs include the process variable input (pulse), process variable or added/subtracted flow input (1 to 5V), added/subtracted flow input (pulse), compensation input (RTD Pt 100Ω, 1 to 5V) and status input. The outputs include the demand output (pulse), flow retransmission output (pulse or 1 to 5V), control output (4 to 20mA) and status output. The analog I/O signal is not isolated from the computing and control circuit, and the minus line is used as common. The pulse and contact signal are isolated from the computing and control circuit. (The computing and control circuits are isolated from the power supply circuits.) ↗

3-1. Measured Flow Pulse Input Circuit.

The signal format for conventional pulse flow signal transmitters is not standardized and the instrument power supply, signal amplitude, frequency, load resistance and other specifications vary with the transmitters. Previously, it was necessary to prepare different interfaces for different transmitter specifications.

Now, however, YS-BCS is capable of covering a wide range of transmitter specifications by using the side panel switches and the flow rate/pulse conversion factor. Table 3-1-1 shows the measured flow pulse input specifications.

Table 3-1-1. Measured Flow Pulse Input Specifications.

Frequency Input make-to-break ratio	0 to 6 kHz, zero-elevation not allowed Greater than 35% and less than 65% at max. frequency Make-to-break ratio $= \frac{\text{ON time}}{\text{ON time} + \text{OFF time}} \times 100\%$
Pulse specification	Voltage level pulse (2 wire power distributed type transmitter) Voltage level pulse (3 wire power distributed type transmitter) Voltage level pulse Contact
Voltage level pulse	
ON (E_H)	3 to 24V DC
OFF (E_L)	−1 to 8V DC
Peak value of pulse	Greater than 3V ($E_H - E_L$)
Input resistance	Greater than 10kΩ
Power distributor voltage for transmitter	12V DC or 24V DC, Less than 30 mA
Contact	
ON	Signal source resistance Less than 200Ω
OFF	Signal source resistance Greater than 100 kΩ
Rating of signal source	30V DC, greater than 30 mA

Figure 3-1-1 shows the block diagram of the measured flow pulse input circuit. Each model incorporates a transmitter power supply that is isolated from the circuitry. The transmitter power supply voltage and load resistance can be changed to correspond to the transmitter specifications by means of a side panel switch, as shown in Figure 3-1-2. (Note: No transmitter power supply is provided for the added/subtracted flow pulse input signal.)

The input pulse is first wave-shaped and then fed to the input circuit where the photocoupler provides signal isolation. Conventionally, it has been necessary to determine circuit constants for filters and threshold level as well as frequency and DC level from the specifications in order to shape the flow pulse. YS-BCS, however, is able to accurately detect pulses using the pulse waveform shaping circuit shown in Figure 3-1-1, irrespective of the input pulse. Accordingly, input adjustments on the YS-BCS side of the flow pulse transmitter can be performed by changing the transmitter power supply voltage and load resistance from the side panel switches (See Figure 3-1-2). or by setting the flow/pulse conversion factor in the auxiliary data. (Refer to the "Input-output signal processing function" for each instrument.)

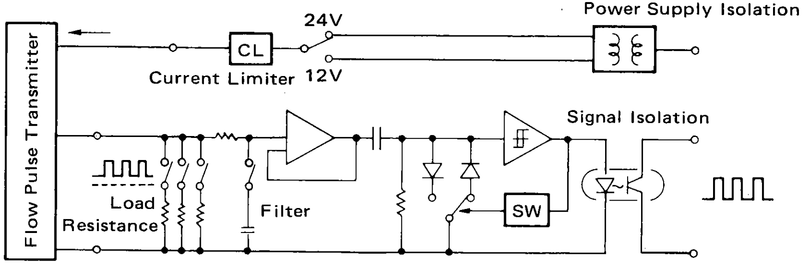


Figure 3-1-1. Measured Flow Pulse Input Circuit.

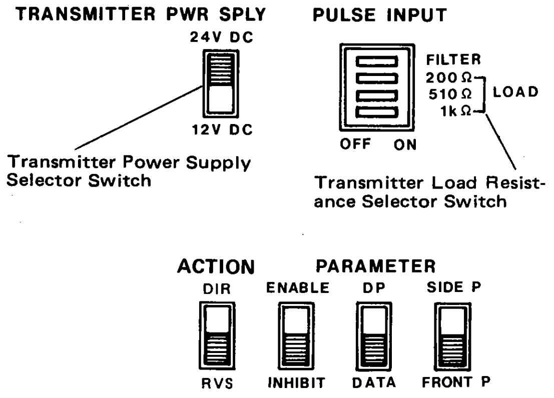


Figure 3-1-2. YS-BCS Side Panel Switches.

3-2. Temperature Compensation Input Circuit.

This circuit is available in two types. One type is provided with a temperature compensation input circuit utilizing a direct input from a three-wire type RTD (Pt 100Ω). The other type uses a 1 to 5 V input for compensation. Figure 3-2-1 shows the RTD temperature input circuit. The circuit configuration is basically the same as that of the STED temperature converter for the basic control system except that the input is not isolated. The outstanding feature of this circuit is the microprocessor that is utilized to perform measurements with automatic ranging. Since the subject fluid varies widely, this input circuit has been designed for measurement temperature range of −50 to 220°C.

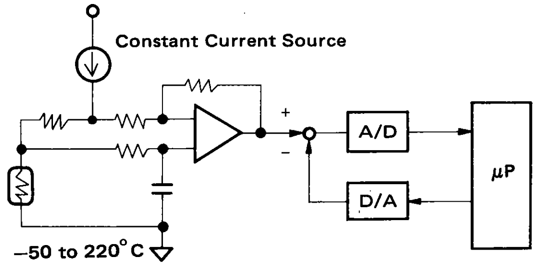


Figure 3-2-1. RTD Temperature Input circuit.

3-3. Status I/O Circuit.

3-3-1. Status Input Circuit.

This input circuit can accept inputs such as a relay contact or a voltage level.
The computing circuit is isolated from the status input.
Most status inputs use the minus (−) line as common.

Input status Input signal	ON	OFF
Contact	CLOSE (Signal source resistance: 200Ω or less)	OPEN (Signal source resistance: greater than 100 kΩ)
Voltage level	LOW (Input voltage: −1 to +1V)	HIGH (Input voltage: +4.5 to 25V)

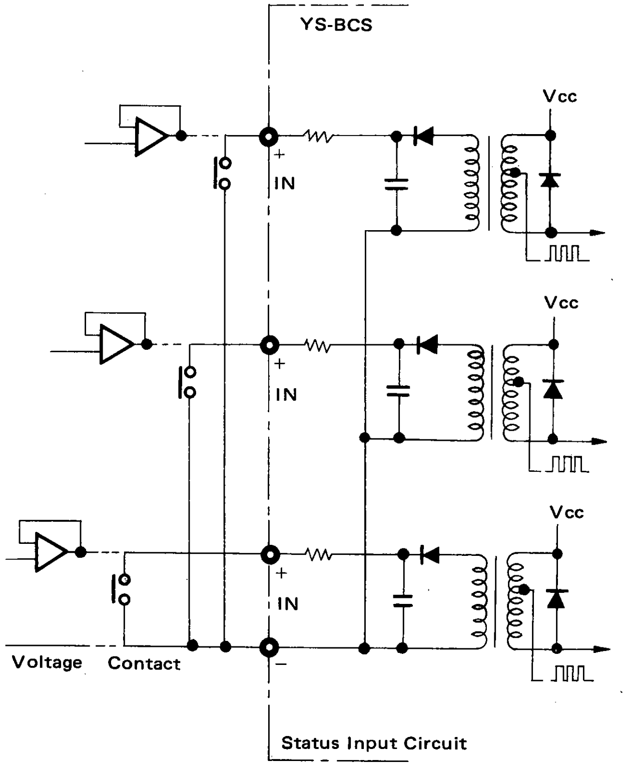


Figure 3-3-1. Usage of Status Inputs.

3-3-2. Status Output Circuit.

The status output is a transistor open collector contact. For this reason, only DC loads can be switched.

The computing circuit is isolated from the status output.

Most status outputs use the minus (-) side as common.

Notes:

1) A protective diode must be added when the circuit is used to energize a relay or other inductive device.
2) This circuit cannot be used with reverse polarity.
3) This circuit cannot be used to open or close an AC load.
   Note that, if cautions 1), 2) and 3) are not observed, the transistor in the output circuit may be damaged.

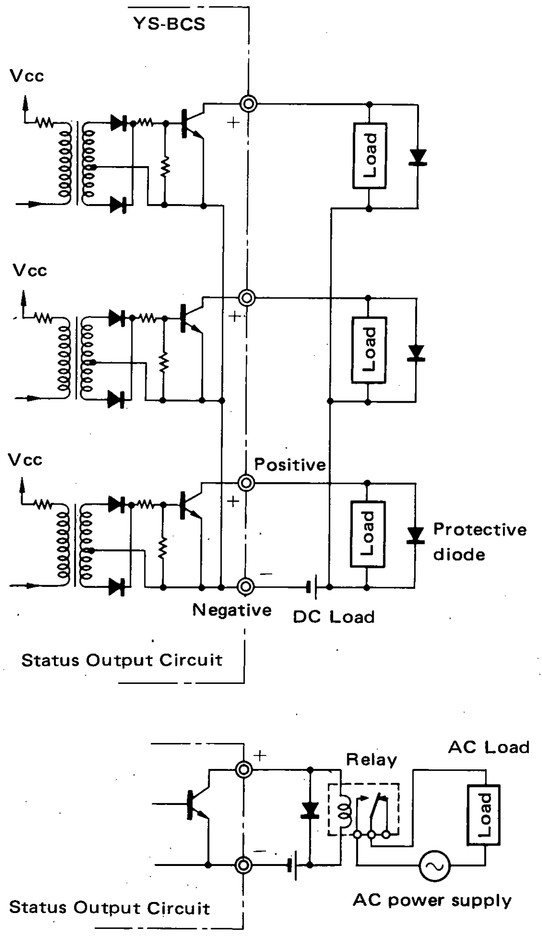


Figure 3-3-2. Usage of Status Outputs.

4. BASIC INSTRUMENT FUNCTIONS.

4-1. SBSD Batch Set Station.

4-1-1. Display, Data Setting, and Operating Functions.

Figure 4-1-1 shows the front panel of the SBSD batch set station.

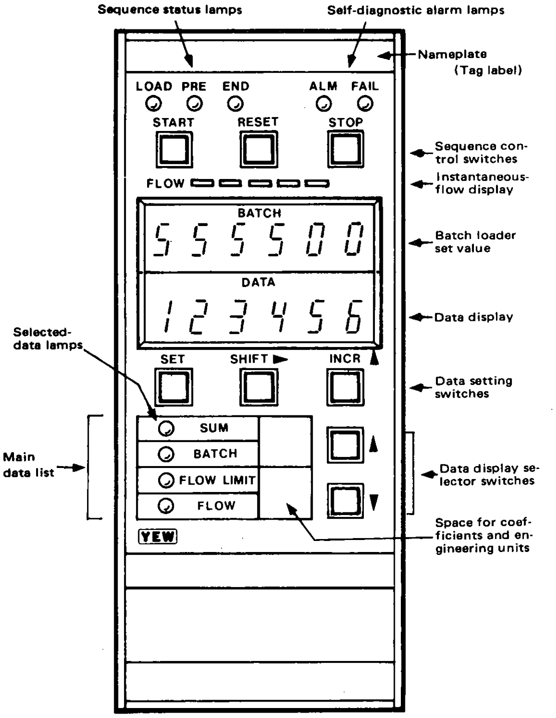


Figure 4-1-1. SBSD Front Panel.

(1) **Status display.**

Two types of status are displayed: alarm status and batch sequence status.

Alarm statuses are classified into two types: instrument failures detected by self-diagnosis and process failures. They are indicated respectively by a red LED (FAIL) and a yellow LED (ALM) indicators.

The status of the batch sequence is displayed by a green LED.

(2) **Sequence command push button switch.**

The start, reset and stop pushbuttons for batch sequence are located at the upper portion of the data display apart from other switches to prevent careless or erroneous operation.

The batch sequence can be activated by pressing these buttons or by an external status input.

(3) **Instantaneous flow display.**

The instantaneous flow can be displayed as a digital value and also in analog form on a horizontal bar graph consisting of five LEDs. This analog indication of the instantaneous flow may be conveniently utilized to check the batch sequence progress.

(4) **Data display.**

A two-stage 6-digit indicator is used to display the data. The upper stage displays the set value to be used during operation and the lower stage displays the other data such as process variable. That makes it possible to simultaneously monitor the batch set value and the batch totalized value.

The lower data display window may be used to indicate various data necessary for system operation as well as setting parameters or other data.

The data items to be displayed are classified into the major items that are necessary for daily operation and the minor items that are used less frequently. The former items are listed as main data in the data display selector at the center of the front panel, and the latter items are shown in the table (data label) as auxiliary data on the side panel, as shown in Figure 4-1-2. The four main SBSD data items are batch totalized flow (SUM), batch set value (BATCH), maximum flow set value (FLOW LIMIT) and instantaneous flow (FLOW). In addition, there are 30 auxiliary data items. Table 4-1-1 shows the auxiliary data items, and Table 4-1-2 shows the contents of the auxiliary data function specification items.

The data display normally indicates the main data, and the auxiliary data can be indicated by changing the side panel switch (FRONT P/SIDE P) as necessary. (See Figure 4-1-2.)

The data to be displayed can be selected by using the "▲▼" pushbuttons on the data display selector. The list of main data is shown to the left of these pushbuttons and the selected data can be confirmed by an illuminated indicator. Each auxiliary data item is numbered, and can be called by using the "▲▼" pushbuttons in the same manner as the main data. The data item number of the called data is indicated on the upper display, and the data itself on the lower display.

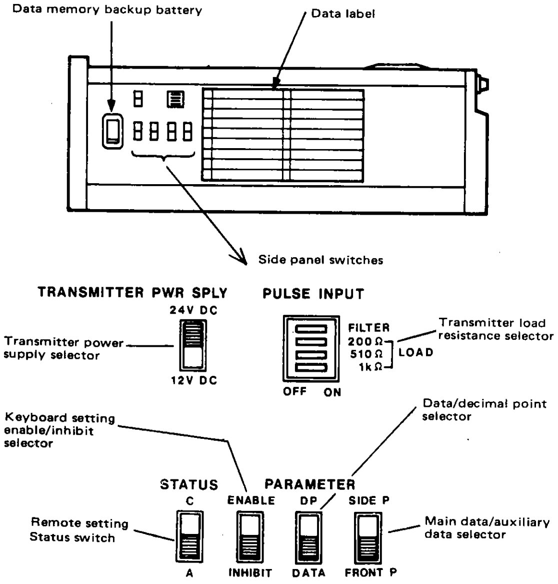


Figure 4-1-2. Side panel of SBSD.

(5) Data settings.

To set data, select the desired data items as described in paragraph (4) above by using the SHIFT ▶ pushbutton. Then, set the value of each digit by using the INCR ▲ pushbutton, and input the set value by pressing the SET pushbutton. This system permits quick setting of batch set values and other data consisting of a number of digits.

The set data may be filled into the data label on the side panel and entered as data. For the method of entering the data, refer to IB4A3-11E "Auxiliary data label/worksheet filling procedure."

(6) Side panel.

Figure 4-1-2 shows the side panel.

Arranged on the side panel are the transmitter power supply voltage selector switch and main/auxiliary data selector switch along with other switches, and the data label that indicates the auxiliary data items.

Table 4-1-1. SBSD Data Label.

SBSD Batch Set Station				Tag. No.			
01	Alarm (ALM) code	▨	▨	17	Function specification (1)		▨
02	Batch flow totalizer value (uncompensated)	▨		18	Function specification (2)		▨
03	Batch flow totalizer value (compensated)	▨		19	Flow process variable span		
04	Cumulative totalizer value (uncompensated) *	▨		20	Added/subtracted flow span		
05	Cumulative totalizer value (compensated) *	▨		21	K factor for flow process variable		
06	Initial totalized flow limit			22	K factor for added/subtracted flow		
07	Prebatch set value			23	K factor for demand/repeater pulse		
08	Predicted leakage value			24	Totalizer scale factor		▨
09	Leakage detection set value			25	Analog display/repeater span*		
10	Initial flow setting			26	Compensation reference temperature		°C
11	Flow low limit setting			27	Maximum value of measured temperature		
12	Flow rise time		sec	28	Minimum value of measured temperature		
13	Flow fall time			29	Compensation factor	▨	▨
14	▨	▨	▨	30	Flow transmitter error compensation coefficient α		▨
15	▨	▨	▨	31	First order compensation coefficient β /specific gravity ρ		▨
16	Measured temperature	▨	°C	32	Second order compensation coefficient γ		▨

SBSD*B

Table 4-1-2. Contents of Function Specifications.

Function specification (1) A B C D E F

A Operation mode
- 0: Simple batch set station.
- 1: Batch master (with flow input).
- 2: Batch master (without flow input).
- 3: Blending master (with flow input).
- 4: Blending master (without flow input).

B Flow signal repeater pulse width
- 0: Duty cycle 50%
- 1: 20 ms
- 2: 33 ms
- 3: 50 ms
- 4: 100 ms

C Communications write inhibit switch
- 0: OFF
- 1: ON

D Instantaneous power fail restart mode
- 0: COLD
- 1: HOT

E External stop input, master pacing input inhibit/enable

	External stop input	Master pacing input
0:	Inhibit	
1:	Enable	Inhibit
2:	Inhibit	Enable
3:	Enable	

F START/RESET/STOP switch
- 0: Inhibit
- 1: Enable

Function specification (2) G H I J K L

G Time unit of flow
- 0: */h
- 1: */min

H Flow signal/simulation specification
- 0: Pulse flow signal
- 1: Analog flow signal
- 2: Simulation D/O inhibit
- 3: Simulation D/O enable

I Added/subtracted flow signal
- 0: None
- 1: Provided, pulse, added
- 2: Provided, pulse, subtracted
- 3: Provided, analog, added
- 4: Provided, analog, subtracted

J Resetting of stored totalizer and demand/repeater pulse values:
- 0: All values reset.
- 1: Demand/repeater & non-displayed totalizer digits preserved.
- 2: Like 1, but least-significant totalizer display digit also preserved.
- 3: Like 1, but two least-significant totalizer display digits also preserved.

K

Compensation computation provided for:	Process variable input	Added/subtracted input
0: ·····	Not provided	
1: ·····	Provided	Not provided
2: ·····	Not provided	Provided
3: ·····	Provided	

L Compensation computation
- 0: ASTM method using Pt 100Ω.
- 1: General quadratic formula using Pt 100Ω.
- 2: ASTM method with 1 to 5 V temperature input signal.
- 3: General quadratic formula using 1 to 5 V temperature input signal.
- 4: General compensation with 1 to 5 V signal.

4-1-2. I/O Signal Processing Functions.

Figure 4-1-3 shows the SBSD functional block diagram.

(1) I/O signal types and scaling.

Five types of input signals are available: measured flow pulse input FI-1 which is input directly from the flow transmitter, analog (1 to 5V) flow input FI-2 which can be used for process variable flow input or added/subtracted flow input, pulse added/subtracted flow input FI-3, RTD temperature compensation input TI-1 and analog compensation input TI-2. The signal type used is determined by the model and suffix code and the auxiliary data function specification. Table 4.1.3 shows combinations of inputs together with model and suffix codes.

The frequency of the input pulse varies with the flow transmitter used. However, since the scaling is performed in the input processor section, no special consideration need be given to the internal signal processing.

The scaling constant K is set in the auxiliary data but, since it is given simply as number of pulses/flow totalizing unit, it can be easily set once the flow transmitter type is determined.

The process variable input usually uses pulse input FI-1. Analog input FI-2 can also be used for the process variable flow input. FI-2 is subject to V/F conversion, and the signal is treated as pulse signal equivalent to FI-1. FI-2 is a multi-purpose input that can also be used as an added/subtracted flow input. Added/subtracted flow pulse input FI-3 is used as the adding/subtracting input for the measured flow. It uses the pulse signal retransmitted from other YS-BCS devices. This addition and subtraction can be made by using an auxiliary data function specification.

(2) Flow compensation.

In batch and blending systems, flow compensation is an important function requiring a high degree of accuracy. This compensation must be applicable to a wide range of fluid types. To meet this requirement, SBSD uses the following three types of compensation, which can be selected by means of auxiliary data function specifications.

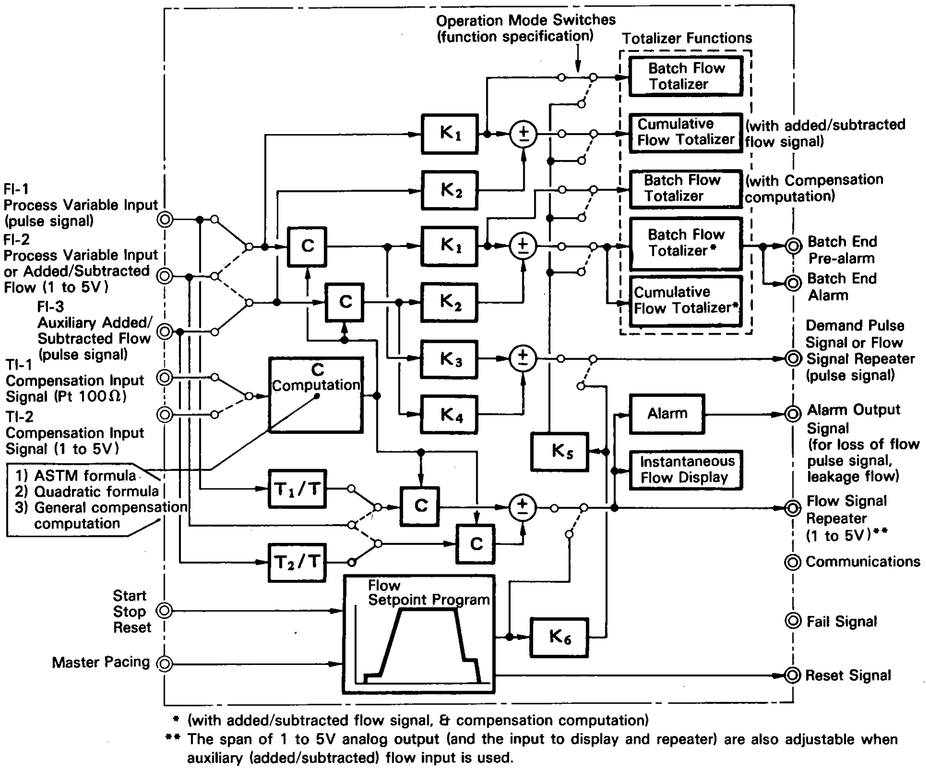
$$V_0 = V[(1+\alpha)\, f(\rho,\, t)] \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

$$V_0 = V[(1+\alpha)\ \{1+\beta(t-t_0)10^{-2} + \gamma(t-t_0)^2 10^{-6}\}] \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

$$V_0 = V[(\mathrm{TI}-2) + 0.5],\ \mathrm{TI}-2 = 0 \text{ to } 1.0 \text{ (analog compensation input)} \ \ldots\ldots\ldots\ldots\ldots \ (3)$$

Table 4-1-3.

Model and suffix codes Input signal	SBSD-100	SBSD-200			SBSD-300		
Measured flow: pulse	○	○	○		○	○	
Measured flow: analog				○			○
Added/subtracted flow: pulse	○	○		○	○		○
Added/subtracted flow: analog			○			○	
Compensation input: Pt 100Ω					○	○	○
Compensation input: analog		○	○	○			



* (with added/subtracted flow signal, & compensation computation)

** The span of 1 to 5V analog output (and the input to display and repeater) are also adjustable when auxiliary (added/subtracted) flow input is used.

	Pulse input	1 to 5V input
K_1	$\frac{1}{\text{K factor for flow process variable}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_2	$\frac{1}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_3	$\frac{\text{Repeater pulse K factor}}{\text{Flow process variable K factor}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
K_4	$\frac{\text{Repeater pulse K factor}}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
T_1	$\frac{\text{h or min}}{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{K factor for flow process variable}}$	
T_2	$\frac{\text{h or min}}{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{K factor for added/subtracted flow}}$	
T	Period of input pulse	
K_5	$\frac{1}{\text{K factor for demand pulse}}$	
K_6	$\frac{(\text{Flow process variable span} + \text{Added/subtracted flow span}) \times \text{Totalizer scale factor} \times \text{K factor for demand pulse}}{\text{h or min}}$	
C	Compensation computation	

Figure 4-1-3. SBSD Functional Block Diagram.

where

V_0: Volume at reference temperature t_0

V: Volume at temperature t

t_0: Reference temperature (°C)

t : Measured temperature (°C)

α: Instrument error compensation coefficient (−9.9999 to 0.9999)

β: First order compensation coefficient (−0.9999 to 0.9999)

γ: Second order compensation coefficient (−0.9999 to 0.9999)

ρ: Specific gravity (0.5000 to 1.2000)

Equation (1) is used to perform compensation together with the ASTM specific gravity-volume conversion table which is widely used in the petroleum industry. With this equation, the compensation coefficient at an actual temperature is calculated automatically from the specific gravity of a fluid at the reference temperature (15°C). In this case, the specific gravity of the fluid must be set in the auxiliary data section. The coefficient α is the instrument error compensation coefficient which may be needed to compensate for various characteristics of the fluid such as viscosity. It must be set in the auxiliary data.

Equation 2 may be used conveniently for polynominal compensation in processes other than petroleum. This feature gives it a wide range of application. The temperature-density curve is matched to a quadratic equation to determine compensation coefficients β and γ, which are set as auxiliary data.

Equation 3 is used in special cases where equations 1 and 2 cannot be applied. The results of compensation computations performed externally with the SPLR programmable computing unit and by other means are input to the analog compensation input TI-2.

The RTD temperature input is not isolated from the field. If field isolation is required, it must be input to the analog compensation input TI-2 after conversion to a 1 to 5V signal in the STED temperature converter. In this case, the minimum value (zero) of the measured temperature and the maximum value of the measured temperature (zero + span) must be set in the auxiliary data to correspond to the conversion range of the temperature converter.

(3) Added/subtracted flow.

A major advantage of SBSD is the subtraction function that supplements the addition function.

When loading LNG and other fluids having low vaporization points, the quantity of fluid that returns in the form of vapour (vapour return) amounts as much as several percent. This causes an error in the totalized loading value. With this subtraction function, it becomes possible to compensate the vapour return and to perform precise fluid loading control.

Adding and subtracting can be selected by using an auxiliary data specification.

Flow signal range after addition or subtraction (analog display/flow signal repeater span) can be set in the auxiliary data.

(4) Demand pulse transmitting and flow signal repeater functions.

The simplified batch station, batch master station and blending master station mode is selected by setting auxiliary data items. These can be selected by using the auxiliary data function specifications.

When using SBSD as a batch master station or a blending master station, a demand pulse is issued to the downstream SLCC blending controller. The scaling factor in this case is set in the auxiliary data as [number of pulses/flow totalizing unit] as it is for an input signal. If an analog I/O is provided, an analog (1 to 5V) two-input added/subtracted flow compensated signal is retransmitted.

When SBSD is used as a simplified batch station, it is possible to output a retransmitted two-input added/subtracted flow signal with compensation. This retransmitted signal may be a pulse or an analog 1 to 5V signal (if an analog I/O is provided.) The scaling factor for a pulse output is set in the auxiliary data as [number of pulses/flow totalizing unit]. The pulse/analog nature of the retransmitted signal and the pulse width of the former are specified by using the auxiliary data function specification.

4-1-3. Totalizing Function.

The totalized value is the most important data in batch and blending control. SBSD permits display of the following five types of totalized values (see Figure 4-1-3).

(a) Batch totalized flow
 .....Uncompensated total measured flow

(b) Batch totalized flow with compensation
 .....Compensated total value of measured flow

(c) Batch totalized flow with two-input adding/subtracting and compensation)
 .....Total value after compensation and two-input adding/subtracting

(d) Cumulatively totalized flow value with added/subtracted inputs
 .....Cumulative total value after added/subtracted inputs without compensation

(e) Cumulatively totalized flow value with added/subtracted input and compensation
 .....Cumulative total value after added/subtracted input with compensation

The totalized values are classified into two types; a batch totalized value which is reset for each batch and a cumulative totalized value which is not reset. The batch totalized value is displayed with six digits and the cumulative totalized value is displayed with eight digits by using both the upper and lower stages of the indicator. From among these five total values, the batch totalized flow (with added/subtracted inputs and compensation) is used as the main data for batch processing. It is displayed as the item SUM on the front panel. The other four types are treated as auxiliary data.

4-1-4. Batch Function.

The batch sequence is controlled by means of the START, STOP and RESET pushbuttons on the front panel or by an external status input (the RESET and START status inputs use non-locking contacts which are "reset" or "start" in the ON state (minimum on time at least 400 ms) while the stop status input uses a locking contact which is "stop" in the OFF state). The status of the batch sequence is indicated on the front panel by the LOAD, PRE and END lamps while prebatch, batch end and reset statuses are issued to a remote destination.

(1) Batch master station and flow setting operation sequences.

Figure 4-1-4 shows the batch master station sequence and flow rate setting operation.

When a reset signal is input, the batch totalized value is reset. If the external stop status input is on, all lamps are turned off to indicate a ready-to-start status. If the stop status input is off, the LOAD lamp flashes to indicate that the operation should not be started.

Then, the start signal raises the demand signal to the initial flow set level to start flow totalizing. This causes the LOAD lamp to light continuously.

When the totalized value reaches the initial totalized flow limit, the demand signal is raised to the maximum flow setting at the rate (gradient) set in the auxiliary data.

When the totalized value reaches the (batch set value − prebatch set value) value, the prebatch status is attained, the PRE lamp lights and the demand signal is lowered to the minimum flow setting at the rate (gradient) set in the auxiliary data.

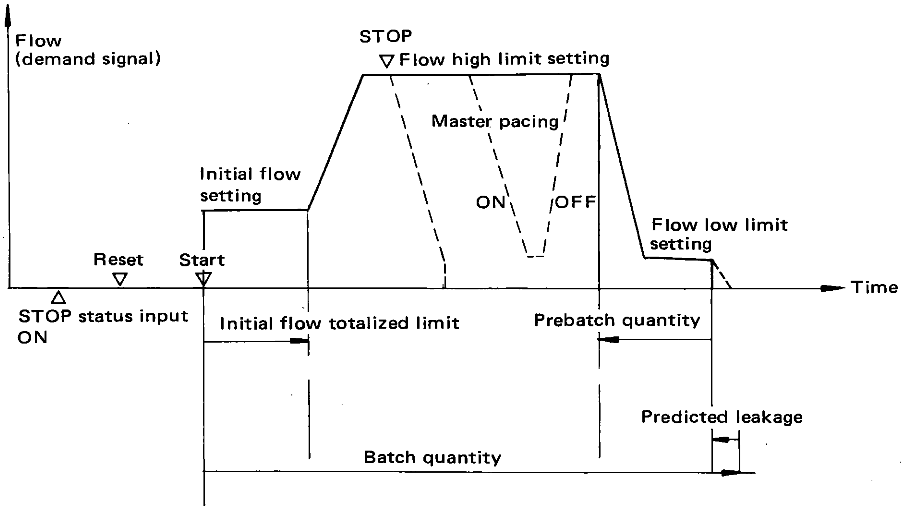
When the total value reaches the (batch setting − leakage predicted) value, the batch end state is attained, the END lamp is illuminated and the LOAD lamp is turned off. At the same time, the demand signal returns to zero.

(2) Batch master station and master pacing emergency stops.

If a stop signal is input, the emergency stop operation is initiated to lower the flow rate setting to zero irrespective of the state of the batch sequence. The LOAD, PRE and END lamps begin to flash to indicate that the system is in the emergency stop status (the LOAD lamp does not flash' when the external STOP status input is on). Since the totalized value is not reset, it is possible to continue the batch from this status by again issuing a start signal. The totalized value can be reset if necessary by inputting a reset signal. The batch can then be restarted.

When SBSD is used as a batch master station, its master pacing function can be used.

When performing multi-component blending control by using the SBSD and SLCC blending controllers together, it may happen that the flow of each component fails to follow the demand signal sent from the batch master station. To prevent this, SBSD is provided with a master pacing function to lower the demand signal to the lower flow limit setting with a pace-down signal (the totalized deviation alarm output signal) from each component controller (SLCC).



				Stop state				
Lamps	LOAD		▨	▨	✳ Note	▨	▨	
	PRE				✳		▨	▨
	END				✳			▨
Status (contact)	Prebatch	Open	Open	Close	Open	Close	Open	Open
	Batch end	Open	Close	Close	Open	Close	Close	Open
	Reset	Momentary close contact	Open	Open	Open	Open	Open	Open

✳ Flashes

▨ Lighted

Note: Does not flash when the STOP status input is on.

Figure 4-1-4. Batch Master Station Sequence and Flow Settings.

(3) Blending master station sequence and flow setting operation.

Figure 4-1-5 shows the sequence for the blending master station and its flow setting operation.

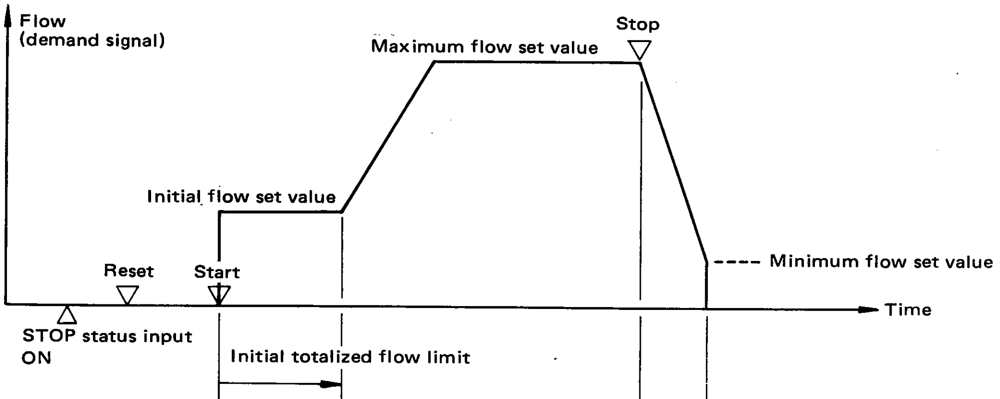
When a reset signal is input, the batch totalized value is reset, and all lamps are turned off to indicate that the sequence is ready to start.

If a start signal is input at this time, the demand signal is raised to the initial flow set value, flow totalizing starts and the LOAD lamp is lighted continuously.

As the totalized value reaches the initial flow total limit value, the demand signal is raised to the maximum flow set value at the rate (gradient) set in the auxiliary data.

If the stop signal is input, the PRE lamp is turned on, and the demand signal is lowered to the minimum flow rate setting at the rate (gradient) set in the auxiliary data. As the minimum flow set value is reached, the demand signal goes to zero, the END lamp lights and the LOAD lamp turns off.

Master pacing function can also be used in this station similar to that of the batch master station.



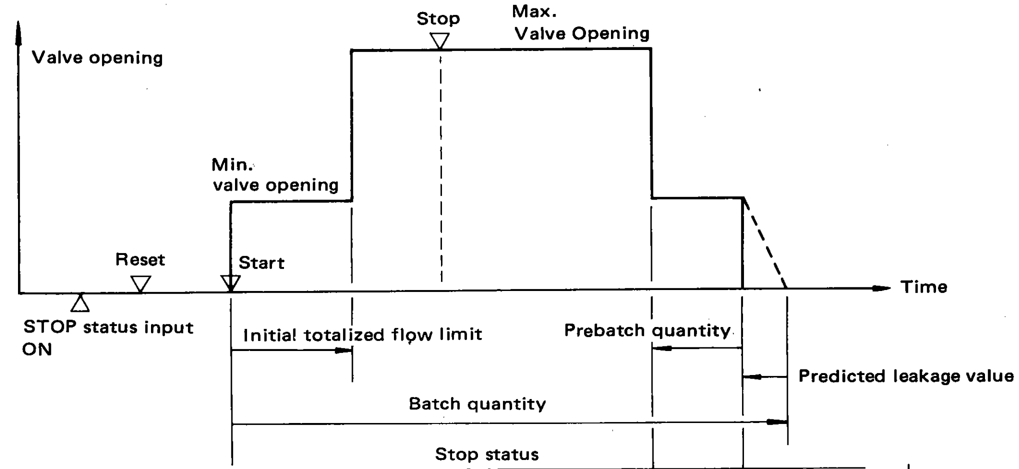
Lamp	LOAD		▨	▨	▨	
	PRE		Open		▨	▨
	END		Open			▨
Status (contact)	Prebatch	Open	Open	Close	Open	Open
	Batch	Open	Close	Close	Close	Open
	Reset	Momentary close contact	Open	Open	Open	Open

▨ Lit

Figure 4-1-5. Fixed Flow Set Station Sequence and Flow Setting Operation.

(4) Sequence of simplified batch station.

Figure 4-1-6 shows the sequence of the simplified batch station.



Lamp	LOAD		●	●	✸ Note	●	●	
	PRE				✸		●	●
	END				✸			●
Status (contact)	Prebatch	Open	Open	Close	Open	Close	Open	Open
	Batch	Open	Close	Close	Open	Close	Close	Open
	Reset	Momentary contact for close	Open	Open	Open	Open	Open	Open

✸ Flashing

● Lit

Note: LOAD lamp does not flash when STOP status contact input is on.

Figure 4-1-6. Simplified Batch Station Sequence.

If the reset signal is input to reset the totalized value with the external stop signal on, all the lamps are extinguished to indicate that the sequence is ready to be started. (If the external stop input is off, the LOAD lamp flashes, indicating that the sequence can not be started.)

Then, the start signal closes the batch end status (contact signal), and causes the LOAD lamp to light continuously.

When the totalized value reaches the initial flow totalized limit, the prebatch status contact is closed.

When the totalized value reaches (batch set value − prebatch set value), the prebatch status is attained, the prebatch status contact is opened and the PRE lamp is turned on.

When the totalized value reaches (batch set value − predicted leakage), a batch end status is attained, the batch end status (contact signal) is opened, the END lamp is lighted and the LOAD lamp is turned off.

4-1-5. Alarm Functions.

The alarm functions peculiar to SBSD are unarrived input pulse and leakage detection.

Figure 4-1-7 shows the relationship between the alarm functions and batch sequence.

(1) Unarrived pulse detection.

If the measured flow input signal falls below 0.78% of the measuring span during the time when the maximum flow setting is detected, this condition is detected as a unarrived pulse. The ALM lamp lights and the alarm output contact is opened.

(2) Leakage detection.

Leakage is monitored from batch end until reset. If the leakage reaches the auxiliary data leakage set value, the ALM lamp lights and the alarm output contact opens.

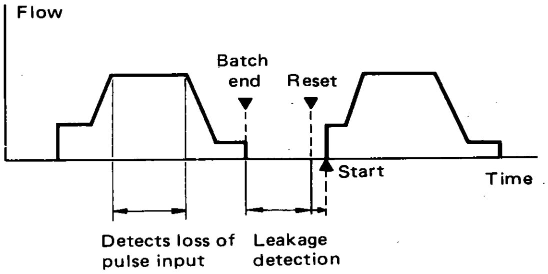


Figure 4-1-7.

4-2. Basic Functions of SLCC Blending Controller.

4-2-1. Display, Data Setting and Operating Functions.

Figure 4-2-1 shows the front panel of the SLCC blending controller.

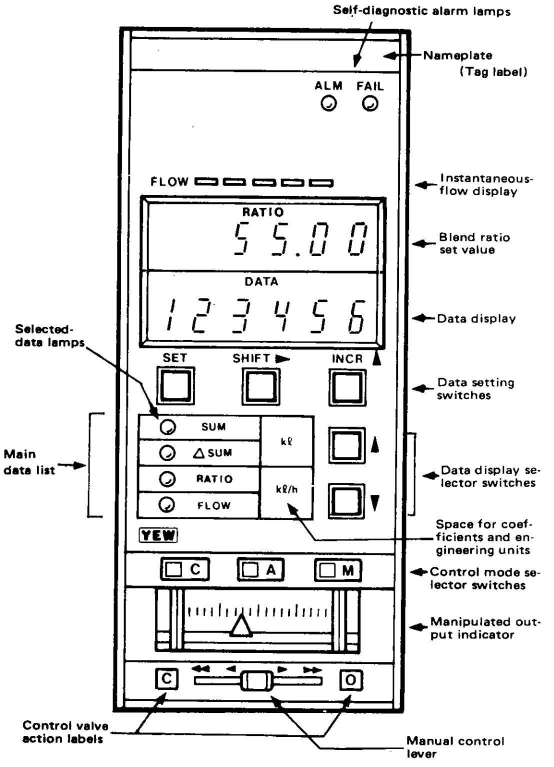


Figure 4-2-1. Front Panel of SLCC.

(1) Status display.
Equipment failures detected by self-diagnosis and process failures detected by alarms are indicated by red LED (FAIL) and yellow LED (ALM) lamps, respectively.

(2) Instantaneous flow display.
The instantaneous flow can be read on the digital display and it is also displayed in analog form on the horizontal bar graph using five LEDs.

(3) Data display.
Data is displayed on a two-stage 6-digit indicator. The upper stage indicates the set value used during normal operation, and the lower stage indicates the process variable or other data simultaneously. With this display, the ratio setting and totalized value can be monitored simultaneously.

The lower stage data display window is used to display all the operation data as well as parameter settings and other data.

The data items to be displayed are classified into the major items that are necessary for daily operation and the minor items that are used less frequently. The former items are listed as main data on the data display selector in the center of the front panel, and the latter items are shown in the data label table as auxiliary data on the side panel, as shown in Figure 4-2-2.

SLCC has four main data items: measured flow totalized value (SUM), totalized deviation (△ SUM), blending ratio (RATIO) and instantaneous flow (FLOW). The auxiliary data contains approximate 30 items. Table 4-2-1 shows the auxiliary data items, and table 4-2-2 shows the contents of the auxiliary data function specifications. The main data is normally displayed on the data indicator while the auxiliary data is displayed by changing the side panel switch (FRONT P/SIDE P) as required (See Figure 4-2-2).

The data to be displayed is selected by using the " ▲▼ " pushbuttons of the data display selector. The main data list is provided to the left side of the pushbuttons, and the indicator lamp illuminates to confirm the data selection.. The auxiliary data can be called by using the " ▲▼ " pushbuttons. Each auxiliary data item is numbered. This item number is displayed in the upper indicator while the data itself is displayed in the lower indicator.

(4) Data setting.
To set data, select individual digits of the data described in paragraph (3) above with the SHIFT ▶ pushbutton, set the value for each digit with the INCR ▲ pushbutton, and then load the data with the SET pushbutton. By this method, data consisting of a number of digits can be set as quickly as data can be set with the conventional thumb-wheel switch.

The data item to be set may be entered in the data label on the side panel, and this value may be loaded as data. For the method of entering data, refer to TI 1B4A3-11 "Explanation of auxiliary data and filling procedure for data label/work sheet".

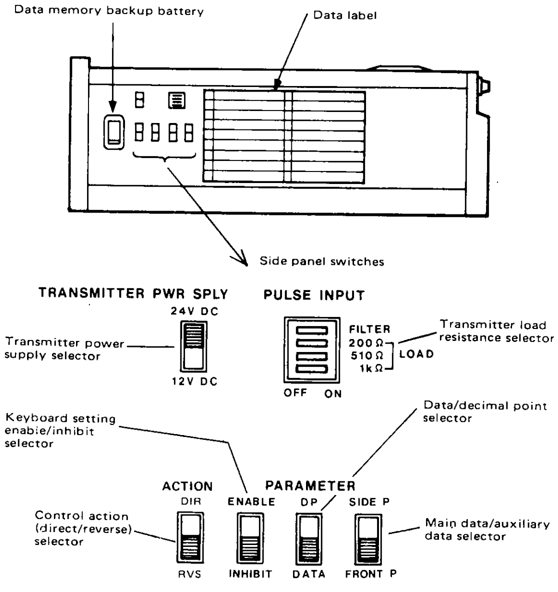


Figure 4-2-2. Side panel of SLCC.

(5) Operation mode selector and manual operation.
The operating mode can be changed by using the C, A and M illuminated pushbutton switches. The operating state can be confirmed by observing the illuminated indicator lamp.

C: Automatic operation. The C mode (setting and operation allowed) is transmitted to a remote system.
A: Automatic operation.
M: Manual operation.

The manual operation can be performed by using the "◀◀ ◀ ▶ ▶▶" control lever located at the bottom of the front panel.

Operating time: Slow: 40 sec/full scale
FAST: 4 sec/full scale

(6) Side panel.
Figure 4-2-2 shows the side panel.
Located on the side panel are the transmitter power supply voltage selector switch, main auxiliary data selector switch as well as other switches and the data label table and auxiliary data items.

Table 4-2-1. SLCC Data Label.

SLCC Blending Controller				Tag. No.			
01	Alarm (ALM) code	▨	▨	17	Function specification (1)		▨
02	Flow totalizer value (uncompensated)	▨		18	Function specification (2)		▨
03	▨	▨		19	Flow process variable span		
04	Cumulative totalizer value (uncompensated)			20	Flow setpoint span		
05	Cumulative totalizer value (compensated)	▨		21	K factor for flow process variable		
06	Deviation alarm 1st stage set value			22	K factor for flow setpoint		
07	Deviation alarm 2nd stage set value			23	K factor for repeater pulse		
08	▨	▨	▨	24	Totalizer scale factor		▨
09	▨	▨	▨	25	Dilution ratio		
10	▨	▨	▨	26	Compensation reference temperature		°C
11	▨	▨	▨	27	Measured temperature maximum value		
12	▨	▨	▨	28	Measured temperature minimum value		
13	Blend ratio			29	Compensation factor	▨	▨
14	Integral time		sec	30	Flow transmitter error compensation coefficient α		▨
15	Proportional band		%	31	First order compensation coefficient β /specific gravity ρ		▨
16	Measured temperature	▨	°C	32	Second order compensation coefficient γ		▨

SLCC•B

Table 4-2-2. Contents of Function Specifications.

Function specification (1) A B C D E F

A Supervisory system backup function
- 0: Manual backup
- 1: Automatic backup

B Flow signal repeater pulse width
- 0: Duty cycle 50%
- 1: 20 ms
- 2: 33 ms
- 3: 50 ms
- 4: 100 ms

C Communications write inhibit switch
- 0: OFF
- 1: ON

D Reset totalized deviation when manual to auto transfer
- 0: Not provided
- 1: Provided

E External A/M Mode transfer
- 0: Inhibit
- 1: Enable

F Instantaneous flow display and analog repeater signal.
- 0: Process variable
- 1: Set point

Function specification (2) G H I J K L

G Time unit of flow
- 0: */h
- 1: */min

H Flow signal/simulation specification
- 0: Pulse flow signal
- 1: Analog flow signal
- 2: Simulation MV inhibit D/O inhibit
- 3: Simulation MV inhibit D/O enable
- 4: Simulation MV enable D/O inhibit
- 5: Simulation MV enable D/O enable

I Flow setpoint signal specification
- 0: Pulse
- 1: Analog

J Resetting of stored totalizer and repeater pulse values:
- 0: All values reset.
- 1: Repeater & non-displayed totalizer digits preserved.
- 2: Like 1, but least-significant totalizer display digit also preserved.
- 3: Like 1, but two least-significant totalizer display digits also preserved.

K Compensation computation
- 0: Not provided
- 1: Provided

L Compensation computation
- 0: ASTM method using Pt 100Ω
- 1: General quadratic formula using Pt 100Ω.
- 2: ASTM method using 1 to 5 V temperature input.
- 3: General quadratic formula using 1 to 5 V temperature input.
- 4: General compensation using 1 to 5 V signal.

4-2-2. Signal Processing Function.

Figure 4-2-3 shows the SLCC functional block diagram.

(1) Input signal types and scaling.

Six input signal types are available: pulse measured flow (FI-1) which is directly input from the flow transmitter, analog measured flow (1 to 5) input (FI-2), RTD (resistance temperature detector) compensation input (TI-1), analog compensation input (TI-2), flow set pulse input (SV-1) and flow set analog (1 to 5V) input (SV-2). The type of signal used is determined by the model and suffix codes and the function specification in the auxiliary data.

Table 4-2-3 shows the combination of inputs and model suffix codes.

The frequency of the input pulse varies with the flow transmitter used. However, since the scaling is performed in the input processing section, no special consideration need be given to the internal signal processing.

The scaling constant is set as factor K in the auxiliary data. Since it is given in the simple form of [number of pulses/totalized flow unit], it can be easily set once the type of flow transmitter is determined.

The measured flow input usually uses pulse input FI-1. Analog input FI-2 can also be used as a measured flow input. FI-2 is subject to V/F conversion and the signal is treated as pulse signal equivalent to FI-1. The flow setting input normally uses pulse input SV-1, but analog input SV-2 can also be used. The scaling constant for pulse input is set in the auxiliary data as [number of pulses/totalized flow unit], in the same manner as the measured input pulse.

Table 4-2-3.

Model code / Input signal	SLCC-200				SLCC-300			
Measured flow, pulse	○	○			○	○		
Measured flow, analog			○	○			○	○
Set flow, pulse	○		○		○		○	
Set flow, analog		○		○		○		○
Compensation input Pt100Ω					○	○	○	○
Compensation input, analog	○	○	○	○				

(2) Flow compensation computation.

In batch and blending systems, flow compensation is a very important function requiring high accuracy and a wide range of compensation methods applicable to various fluids. To meet this requirement, SLCC uses the following three compensation methods selected by function specifications in the auxiliary data.

$$V_0 = V[(1+\alpha)\,f(\rho,\,t)] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$V_0 = V[(1+\alpha)\,\{1+\beta(t-t_0)10^{-2} + \gamma(t-t_0)^2 10^{-6}\}] \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$V_0 = V[(\mathrm{TI}-2)\ +0.5],\ \mathrm{TI}-2 = 0 \text{ to } 1.0 \text{ (analog compensation input)} \quad \ldots\ldots\ldots \quad (3)$$

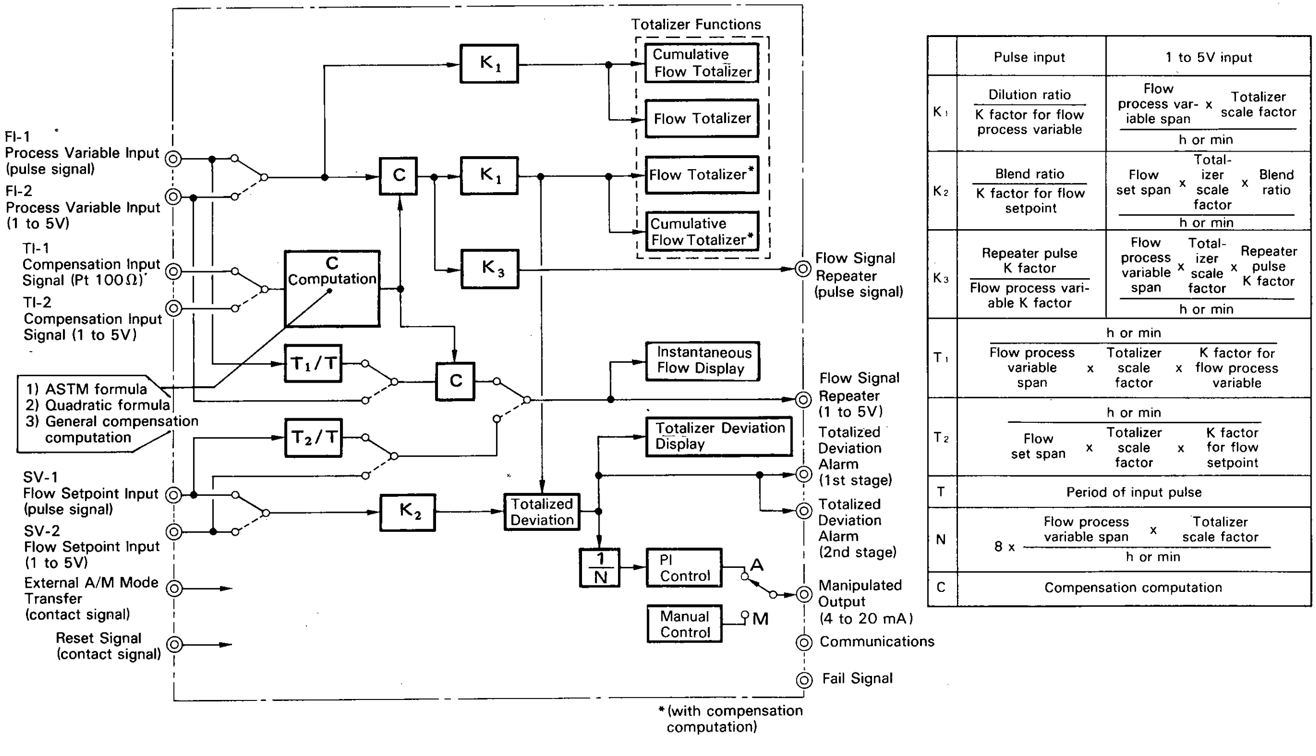
where

V_0: Volume at reference temperature t_0

V: Volume at temperature t

t_0: Reference temperature (°C)

t : Measured temperature (°C)



	Pulse input	1 to 5V input
K1	$\frac{\text{Dilution ratio}}{\text{K factor for flow process variable}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K2	$\frac{\text{Blend ratio}}{\text{K factor for flow setpoint}}$	$\frac{\text{Flow set span} \times \text{Totalizer scale factor} \times \text{Blend ratio}}{\text{h or min}}$
K3	$\frac{\text{Repeater pulse K factor}}{\text{Flow process variable K factor}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
T1	$\frac{\text{h or min}}{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{K factor for flow process variable}}$	
T2	$\frac{\text{h or min}}{\text{Flow set span} \times \text{Totalizer scale factor} \times \text{K factor for flow setpoint}}$	
T	Period of input pulse	
N	$8 \times \frac{\text{Flow process variable span} \times \text{Totalizer scale factor}}{\text{h or min}}$	
C	Compensation computation	

Figure 4-2-3. SLCC Functional Block Diagram.

α: Instrument error compensation coefficient (-9.9999 to 0.9999)

β: First order compensation coefficient (-0.9999 to 0.9999)

γ: Second order compensation coefficient (-0.9999 to 0.9999)

ρ: Specific gravity (0.5000 to 1.2000)

Equation (1) is used with the ASTM specific gravity-volume conversion table which is widely used in the petroleum industry. With this equation, the compensation coefficient at the actual temperature is calculated automatically from the specific gravity of a fluid at the reference temperature (15°C) and the measured temperature of the fluid. For this case, the specific gravity of the fluid must be set in the auxiliary data section. The coefficient α is an instrument error compensation coefficient which is needed due to various fluid characteristics such as viscosity. It must be set in the auxiliary data.

Equation (2) may be conveniently used for polynominal compensation computations in processes other than petrochemical and features a wide range of application. The density-temperature curve is matched to a quadratic equation to determine the compensation coefficients β and γ, which are set to the auxiliary data.

Equation (3) is used in special cases where equations (1) and (2) cannot be applied. The results of compensation computations performed externally by using the SPLR Programmable Computing Unit and other means are input on analog compensation input TI-2.

RTD (resistance temperature detector) input is not isolated from the field. If field isolation is required, analog compensation input TI-2 must be used after the signal is converted to a 1 to 5V signal in the STED temperature converter. In this case, the minimum (zero) value of the measured temperature and the maximum value of the measured temperature (zero + span) corresponding to the conversion range of the temperature converter must be set in the auxiliary data.

(3) **Flow signal repeater function.**

The measured flow can be output as a retransmitted signal after compensation. It is also possible to output the measured flow after compensation or the flow set signal in the form of an analog 1 to 5V signal.

The scaling for the retransmitted pulse is set in the auxiliary data as [number of pulses/totalized flow unit], as it is for the measured input signal.

The measured flow/flow set signal specification and the retransmitted pulse width specification are made by using an auxiliary data function specification.

4-2-3. Totalizer Functions.

Totalized values are the most important data in batch and blending control. SLCC displays the following four totalized values. (See Figure 4-2-3.)

(a) Measured flow totalized value
..... Totalized value of uncompensated flow.

(b) Measured flow totalized value with compensation
..... Totalized value of compensated measured flow.

(c) Cumulatively totalized measured flow value
..... Cumulative total value of uncompensated measured flow.

(d) Cumulatively totalized measured flow value with compensation
..... Cumulative total value of compensated measured flow.

Totalized values (a) and (b) are reset by a reset status input signal, while cumulative values (c) and (d) are not reset.

The RESET status input uses non-locking contact which is "reset" in the ON state (minimum on time at least 400 ms).

Totalized values (a) and (b) are displayed in six digits, while the cumulative totalized values (c) and (d) are displayed in eight digits by using both the upper and lower stages of the indicator.

Measured flow totalized values (with compensation) are classified as main data under item SUM on the front panel. The other three totalized values are classified as auxiliary data.

4-2-4. Flow Ratio Control Function.

PI control is performed, as shown in Figure 4-2-3, so that the deviation between the totalized measured flow and the totalized flow value obtained by multiplying the flow setting at the master station by the blending ratio equals zero. This type of PI control based on totalled deviation values permits highly accurate fluid blending.

For this type of control, the blending ratio is set and displayed as main data under RATIO while the PI constant is set and displayed as auxiliary data. The total deviation value can also be displayed as △SUM under main data and effectively utilized to supervise the control state.

(Major specifications)

Blending ratio setting:
Five digits and decimal point (Max. 299.99%)

Totalized deviation value:
Indicated by four digits

Proportional band (P):
6.3 to 999.9%

Integrating time (I):
1 to 9999 sec

Operation mode changing:
A ⟷ M balanceless and bumpless changeover with A/M selection by external contact or by manual (M) changing when status input is OFF.

With direct/reverse control action selector.

4-2-5. Alarm Function.

The SLCC blending controller is provided with a two-stage totalized deviation alarm system. This alarm signal is used as a master pacing command signal for the SBSD batch set station.

When the totalized deviation exceeds the alarm set value, the ALM lamp illuminates and the alarm output contact opens.

The totalized deviation set value is set in the auxiliary data.

4-3. Basic Functions of SLBC Batch Controller.

4-3-1. Display, Setting and Operating Functions.

Figure 4-3-1 shows the front panel of the SLBC batch controller.

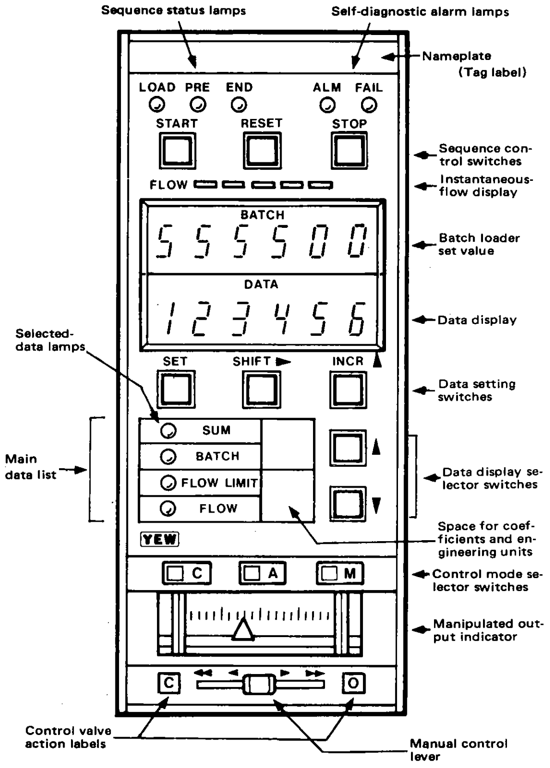


Figure 4-3-1. Front Panel of SLBC.

(1) Status display.

Two types of status are displayed: alarm status and batch sequence status.

The alarm status is classified into two types; instrument failures detected by a self-diagnostic function and process abnormalities. They are indicated respectively by a red LED (FAIL) and yellow LED (ALM) indicators.

The batch sequence status is displayed by a green LED.

(2) Sequence command switch.

The start, reset and stop pushbuttons for batch sequence are located at the upper portion of the data display apart from the other switches to prevent careless or erroneous contact.

The batch sequence can be activated from these pushbuttons or from a remote status input.

(3) Instantaneous flow display.

The instantaneous flow can be displayed as a digital value, but it is also indicated as an analog value on a horizontal bar graph consisting of five LEDs. This analog indication of the instantaneous flow is very convenient for checking the progress of the batch sequence.

(4) Data display.

A two-stage 6-digit digital indicator is used to display the data. The upper stage displays a set value for the operation while the lower stage displays a process variable or other data. Thus, it is possible to simultaneously monitor the batch setting and the batch totalized value.

The lower data display window may be used to display various data necessary for system operation and also for setting parameters or other data.

The data items to be displayed are classified into major items that are necessary for daily operation and other minor items that are used less frequently. The former items are listed as main data on the data display selector located at the center of the front panel. The latter items are shown in the data label table on the side panel as auxiliary data, as shown in Figure 4-3-2. The four main SLBC data items are batch totalized flow (SUM), batch setting (BATCH), maximum flow setting (FLOW LIMIT) and instantaneous mass flow (FLOW). The auxiliary data table contains approximately 30 items.

Table 4-3-1 shows the auxiliary data items, and Table 4-3-2 shows the auxiliary data function specifications.

The data display normally displays the main data but auxiliary data can be displayed if the FRONT P position of the side panel switch is changed to the SIDE P position. (See Figure 4-3-2.)

The data for display can be selected by using the " ▲▼ " pushbuttons provided on the data display selector. The main data items are listed to the left of these pushbuttons and the data selected is confirmed by an illuminated lamp. Each auxiliary data item is numbered, and can be called by using the " ▲▼ " pushbuttons in the same manner as the main data. The number of the selected data is displayed in the upper stage of the data display and the data itself in the lower stage.

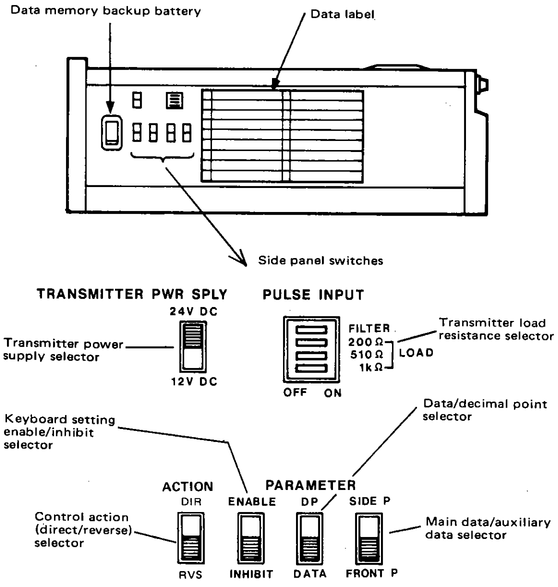


Figure 4-3-2. Side Panel of SLBC.

(5) **Data setting.**

To set data, select the desired data digit as described in paragraph (4) above by using the SHIFT ▶ pushbutton and set each digit with the INCR ▲ pushbutton. Then, load this value by pressing the SET pushbutton. This system permits quick setting of batch settings and other data consisting of digit strings.

The settings may be entered in the data label on the side panel and these value loaded as data. For the method of entering the data, refer to TI 1B4A3-11E "Explanation of auxiliary data and filling procedure for data label/work sheet".

(6) **Operating mode selection and manual operation.**

The operating mode can be changed by using the C, A and M back-lighted pushbuttons. The selected operating state can be confirmed by an illuminated indicator lamp.

C: Automatic operation. Sends C mode status (settings and operation permitted) to a remote supervisory system.
A: Automatic operation.
M: Manual operation.

A manual operation can be performed by using the " ◀◀ ◀ ▶ ▶▶ " operating lever located at the bottom of the panel.

Operating time: SLOW: 40 sec/full scale
FAST: 4 sec/full scale

A manual operation is possible during the period from batch start to batch end. When the desired

Table 4-3-1. SLBC Data Label.

	SLBC Batch Controller				Tag. No.		
01	Alarm (ALM) code	▨	▨	17	Function specification (1)		▨
02	Batch flow totalizer value (uncompensated)	▨		18	Function specification (2)		▨
03	Batch flow totalizer value (compensated)	▨		19	Flow process variable span		
04	Cumulative totalizer value (uncompensated) *	▨		20	Added/subtracted flow span		
05	Cumulative totalizer value (compensated) *	▨		21	K factor for flow process variable input		
06	Initial totalized flow limit			22	K factor for added/subtracted flow input		
07	Prebatch set value			23	K factor for repeater pulse		
08	Predicted leakage value			24	Totalizer scale factor		▨
09	Leakage detection set value			25	PI control input/analog display/repeater span*		
10	Initial flow setting			26	Compensation reference temperature		°C
11	Flow low limit setting			27	Measured temperature maximum value		
12	Flow rise time		sec	28	Measured temperature minimum value		
13	Flow fall time			29	Compensation factor	▨	▨
14	Integral time			30	Flow transmitter error compensation coefficient α		▨
15	Proportional band		%	31	First order compensation coefficient β /specific gravity ρ		▨
16	Measured temperature	▨	°C	32	Second order compensation coefficient γ		▨

SLBC•B

Table 4-3-2. Contents of Function Specifications.

Function specification (1) A B C D E F

A Operation mode

	Batch function	Supervisory system backup function
0:	Provided	Manual backup
1:	Provided	Automatic backup
2:	Not provided	Manual backup
3:	Not provided	Automatic backup

B Flow signal repeater pulse width
0: Duty cycle 50%
1: 20 ms 3: 50 ms
2: 33 ms 4: 100 ms

C Communications write inhibit switch
0: OFF 1: ON

D Instantaneous power fail restart mode
0: COLD 1: HOT

E External stop input, master pacing input inhibit/enable

	External stop input	Master pacing input
0:	Inhibit	
1:	Enable	Inhibit
2:	Inhibit	Enable
3:	Enable	

F START/RESET/STOP switch
0: Inhibit
1: Enable

Function specification (2) G H I J K L

G Time unit of flow
0: */h
1: */min

H Flow signal/simulation specification
0: Pulse flow signal
1: Analog flow signal
2: Simulation MV inhibit, D/O inhibit
3: Simulation MV inhibit, D/O enable
4: Simulation MV enable, D/O inhibit
5: Simulation MV enable, D/O enable

I Added/subtracted flow signal
0: None
1: Provided, pulse, added
2: Provided, pulse, subtracted
3: Provided, analog, added
4: Provided, analog, subtracted

J Resetting of stored totalizer and repeater pulse values:
0: All values reset.
1: Repeater & non-displayed totalizer digits preserved.
2: Like 1, but least-significant totalizer display digit also preserved.
3: Like 1, but two least-significant totalizer display digits also preserved.

K

	Compensation computation provided for:	Process variable input	Added/subtracted input
0:	.....	Not provided	
1:	.....	Provided	Not provided
2:	.....	Not provided	Provided
3:	.....	Provided	

L Compensation computation
0: ASTM method using Pt 100Ω.
1: General quadratic formula using Pt 100Ω.
2: ASTM method with 1 to 5 V temperature input.
3: General quadratic formula using 1 to 5 V temperature input.
4: General compensation with 1 to 5 V signal.

batch quantity is reached during a manual operation, the manual operation automatically stops and a batch end status is created.

(7) **Side panel.**
Figure 4-3-2 shows the side panel.
Arranged on the side panel are the transmitter power supply voltage selector switch, main auxiliary data selector switch and other switches as well as the data label listing the auxiliary data items.

4-3-2. I/O Signal Processing Function.

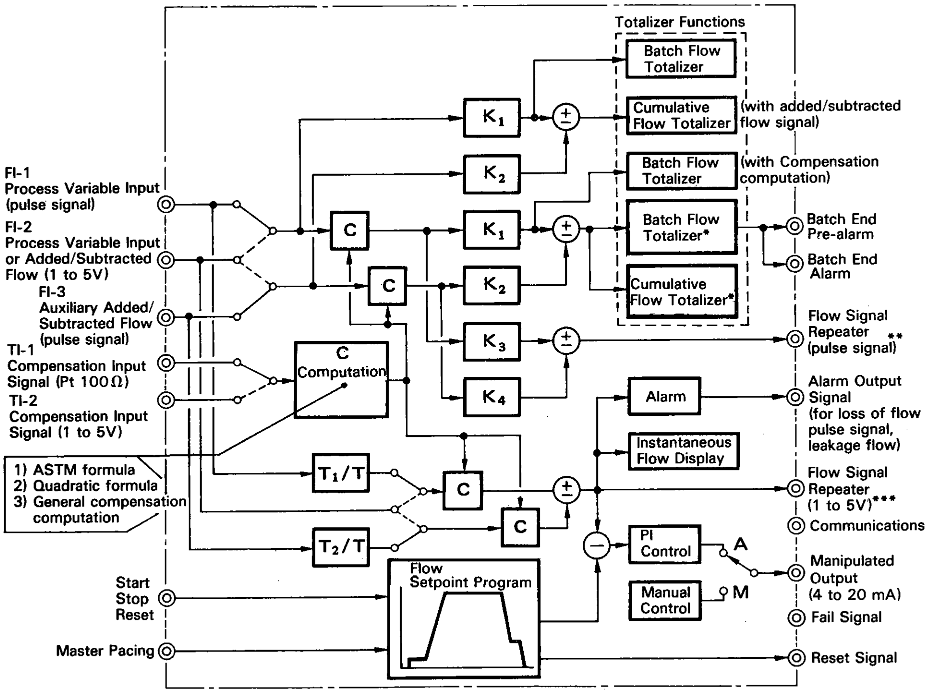
Figure 4-3-3 shows the SLBC functional block diagram.

(1) **Input signal types and scaling.**
Five types of input signals are used: measured flow pulse input FI-1 from a flow transmitter, analog (1 to 5V) flow input FI-2 for measured flow or added/subtracted flow input, added/subtracted flow pulse input FI-3, RTD compensation input TI-1 and analog compensation input TI-2. The signal type to be used is determined by the model suffix code and auxiliary data function specifications. Table 4-3-3 shows combinations of inputs and model suffix codes.
The input pulse frequency varies with the flow transmitter used. However, since the scaling is performed in the input processing section, no special consideration need be given to the internal signal processing.
The scaling constant K is set in the auxiliary data. Since it is given in the simple form [number of pulses/flow totalizing unit], it can easily be set once the flow transmitter is determined.
Pulse input FI-1 is usually used as a measured flow input but analog input FI-2 can also be used as a measured flow input. FI-2 is subject to V/F conversion, and the signal is treated as a pulse signal equivalent to FI-1. FI-2 is multi-purpose input that can also be used as an added/subtracted flow input.
Added/subtracted pulse flow input FI-3 is used as an added/subtracted input for the measured flow. It uses the retransmitted pulse signal transmitted from other YS-BCS devices. Addition or subtraction is designated by a auxiliary data function specification.

Table 4-3-3.

Input signal / Input signal	SLBC-200			SLBC-300		
Flow process variable, pulse	○	○		○	○	
Flow process variable, analog			○			○
Flow setting, pulse	○		○	○		○
Flow setting, analog		○			○	
Compensation input, Pt100Ω				○	○	○
Compensation input, analog	○	○	○			

(2) **Flow compensation computation.**
In batch and blending system, flow compensation must be accurately performed and this compensation must be applied to a wide range of fluid types. To meet this requirement, SLBC uses the following three types of compensation. These can be selected by an auxiliary data function specifications.



	Pulse input	1 to 5V input
K_1	$\frac{1}{\text{K factor for flow process variable}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_2	$\frac{1}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_3	$\frac{\text{Repeater pulse K factor}}{\text{Flow process variable K factor}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
K_4	$\frac{\text{Repeater pulse K factor}}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
T_1	$\frac{\text{h or min}}{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{K factor for flow process variable}}$	
T_2	$\frac{\text{h or min}}{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{K factor for added/subtracted flow}}$	
T	Period of input pulse	
C	Compensation computation	

* (with added/subtracted flow signal, & compensation computation)
** e.g. demand pulse output.
*** The span of 1 to 5V analog output (and the input to PI algorithm, display and repeater) are also adjustable when auxiliary (added/subtracted) flow input is used.

Figure 4-3-3. SLBC Functional Block Diagram.

$$V_0 = V[(1+\alpha)\, f(\rho,\, t)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$V_0 = V[(1+\alpha)\ \{1+\beta(t-t_0)10^{-2} + \gamma(t-t_0)^2 10^{-6}\}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$V_0 = V[(\mathrm{TI}-2)\ +0.5],\ \mathrm{TI}-2 = 0 \text{ to } 1.0 \text{ (analog compensation input)} \ldots\ldots\ldots\ldots (3)$$

where

V_0: Volume at reference temperature t_0

V: Volume at temperature t

t_0: Reference temperature (°C)

t : Measured temperature (°C)

α: Instrument error compensation coefficient (-9.9999 to 0.9999)

β: First order compensation coefficient (-0.9999 to 0.9999)

γ: Second order compensation coefficient (-0.9999 to 0.9999)

ρ: Specific gravity (0.5000 to 1.2000)

Equation (1) is used to perform compensation together with the ASTM specific gravity-volume conversion table which is widely used in the petroleum industry. This equation yields the compensation coefficient at an actual temperature from the specific gravity of the fluid at the reference temperature (15°C) and the actual temperature of the fluid. In this case, the specific gravity of the fluid must be set as auxiliary data. The coefficient α is the instrumental error compensation coefficient which is needed to compensate for unusual fluid characteristics. It must be set in the auxiliary data.

Equation (2) is convenient for polynominal compensation computations in processes other than petrochemical processes. It offers a wide range of application. The density-temperature curve is matched to a quadratic equation to determine the compensation coefficients β and γ, which are set in the auxiliary data.

The RTD (resistance temperature detector) input is not isolated from the field. If field isolation is required, it must be input to analog compensation input TI-2 after being converted to 1 to 5V signal in the STED temperature converter. In this case, the minimum value (zero) of the measured temperature and the maximum value of the measured temperature (zero + span) corresponding to the conversion range of the temperature converter must be set in the auxiliary data.

(3) Addition and subtraction functions.

One of the outstanding SLBC features is a subtraction function that supplements the addition function. While loading LNG and other fluids having low vaporization points, the quantity of fluid returned in the form of vapour (vapour return) amounts to as much as several percent. This causes an error in the totalized loaded value. With the subtracting function, it becomes possible to compensate for the vapor return and exercise precise loaning control over the fluid.

Addition or subtraction is designated with an auxiliary data function specification.

Flow signal range after addition or subtraction (PI control input/analog display/flow signal repeater span) can be set in the auxiliary data.

(4) Flow signal repeater function.

Two-input added/subtracted flow is output as a retransmitted signal in the form of pulse signal or analog (1 to 5V) signal after compensation.

The scaling factor for the retransmitted pulse is set in the auxiliary data as [number of pulses/flow totalling unit], as it is for the process variable input signal. The retransmitted pulse width is also set with an auxiliary data function specification.

4-3-3. Totalizer Functions.

Totalized values are the most important data in batch and blending control. SLBC permits display of the following five totalized values (See Figure 4-3-3).

(a) Batch measured flow totalized value
..... Uncompensated total value of measured flow.

(b) Batch measured flow totalized value with compensation.
..... Compensated total value of measured flow.

(c) Batch flow totalized value with two-input adding/subtracting adjustment and compensation.
..... Total value after compensation and two-input added/subtracted flow signal adjustment.

(d) Cumulatively totalized flow value with two-input adding/subtracting function
..... Cumulative total value after two-input adding/subtracting adjustment and no compensation.

(e) Cumulatively totalized flow value with two-input added/subtracted signal and compensation
..... Cumulative total value after two-input adding/subtracting and compensation.

Totalized values are classified into two types: a batch totalized value which is reset for each batch and a cumulative totalized value which is not reset. The batch totalized value is displayed with six digits and the cumulative totalized value is displayed with eight digits using both the upper and lower indicator stages.

Of these five totalized values, the batch flow totalized value with two-input adding/subtracting and compensation is used as main data for batch processing and displayed as the item SUM on the front panel. The other four totalized values are used as auxiliary data.

4-3-4. Batch Functions.

The batch sequence is controlled by means of the START, STOP and RESET pushbuttons on the front panel or by an remote status input (the RESET and START status inputs use the non-locking contacts which are "reset" or "start" in the ON state (minimum on time at least 400 ms) while the stop status input uses the locking contact which is "stop" in the OFF state). The batch sequence status is indicated on the front panel by the LOAD, PRE, and END lamps while, at the same time, the three remote status signals prebatch, batch end and reset are issued to a remote system.

(1) Batch sequence and flow setting.

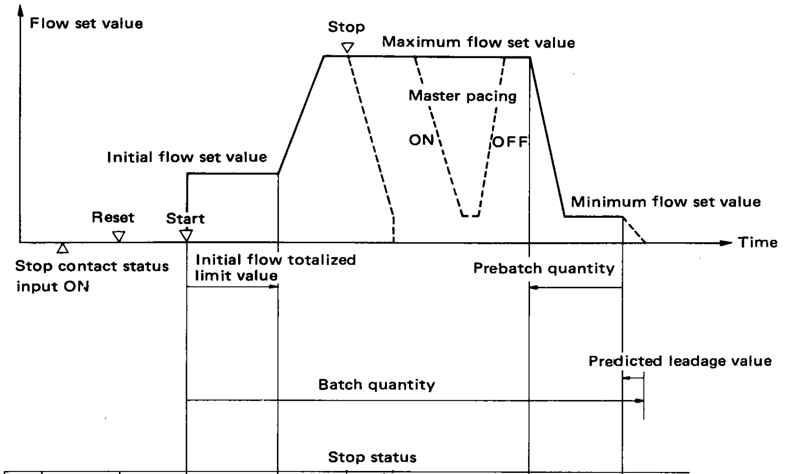
Figure 4-3-4 shows the batch sequence and flow setting operation for the SLBC.

When the reset signal is input, the batch totalized value is reset. All lamps are turned off if the external stop status is on to indicate that sequence can be started. (If the stop status input is off, the load lamp flashes.) When a start signal is input, the flow set value is raised to the initial flow set level and flow totalizing starts. The LOAD lamp remains illuminated.

When the total value reaches the initial flow totalized limit value, the flow setting increases with time to the maximum flow setting specified in the auxiliary data.

When the totalized value reaches the (batch set value – prebatch set value), the pre-batch state is attained, the PRE lamp lights and the flow setting decreases with time to the flow setting specified in the auxiliary data.

When the totalized value reaches the (batch set value – predicted leakage value), the batch end state is attained, the END lamp illuminates, the LOAD lamp is turned off and, at the same time, the flow setting goes to zero.



Lamps	LOAD		●	●	☀ Note	●	●	
	PRE				☀		●	●
	END				☀			●
Status (contact)	Prebatch	Open	Open	Close	Open	Close	Open	Open
	Batch	Open	Close	Close	Open	Close	Close	Open
	Reset	Momentary close contact	Open	Open	Open	Open	Open	Open

☀ Flashing
● Lit

Note: Load lamp does not flash when stop status input is ON.

Figure 4-3-4. SLBC Batch Sequence and Flow Setting Operations.

(2) Emergency stop and master pacing in batch loading control.

Once a stop signal is input, an emergency stop operation takes place to lower the flow setting to zero irrespective of the batch sequence stage and the LOAD, PRE and END flash to indicating the emergency stop state. (The LOAD lamp does not flash if the external stop status input is ON.) In this case, the totalized value is not reset, so the batch can be continued if a start signal is again input. If the totalized value must be reset, it is necessary to input a reset signal and the batch can be started again by inputting the start signal.

When SLBC and SLCC blending controllers are combined for blending control, the component flow may fail to follow the demand signal given from the SLBC. To prevent this, SLBC is provided with a master pacing function which lowers the flow setting to the minimum flow setting according to a pace-down signal (totalized deviation alarm output signal) from the SLCC component controller.

(3) Fixed flow PI controller sequence and flow setting.

The SLBC can also be used as fixed flow PI controller for which batch function is not provided.

Figure 4-3-5 shows the fixed flow PI controller sequence and flow setting operation.

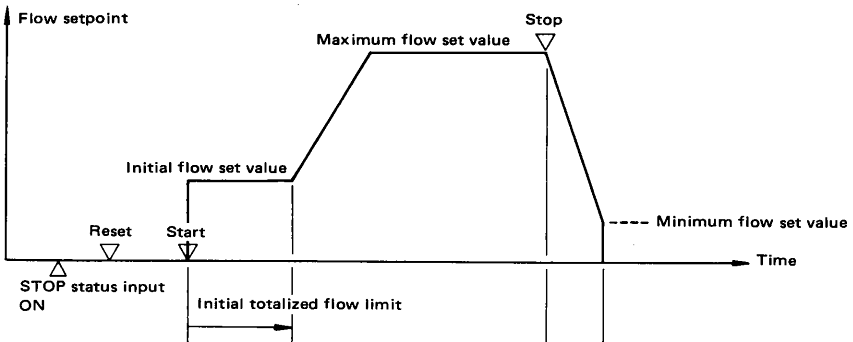
When a reset signal is input, the totalized value is reset, and all lamps are turned off to indicate that the sequence is ready to start.

If a start signal is input at this time, the flow setpoint signal is raised to the initial flow set value, flow totalizing starts and the LOAD lamp is lighted continuously.

As the totalized value reaches the initial flow total limit value, the flow setpoint signal is raised to the maximum flow set value at the rate (gradient) set in the auxiliary data. ↗

If the stop signal is input, the PRE lamp is turned on, and the demand signal is lowered to the minimum flow rate setting at the rate (gradient) set in the auxiliary data. As the minimum flow set value is reached, the flow setpoint signal goes to zero, the END lamp lights and the LOAD lamp turns off.

Master pacing function can also be used in this PI controller similar to that of the batch loading control mode.



Lamp	LOAD		▨	▨	▨	
	PRE		Open		▨	▨
	END		Open			▨
Status (contact)	Prebatch	Open	Open	Close	Open	Open
	Batch	Open	Close	Close	Close	Open
	Reset	Momentary close contact	Open	Open	Open	Open

▨ Lit

Figure 4-3-5. Fixed Flow PI Controller Sequence and Flow Setting Operation.

4-3-5. Flow Control Function.

As shown in Figure 4-3-3, PI control is performed so the two-input added/subtracted flow value after compensation coincides with the flow setting programmed for the above-mentioned batch sequence.

The PI constant necessary for this control is set and displayed in the auxiliary data.

(Major specifications)

Proportional band (P): 6.3 to 999.9%

Integral time (I): 1 to 9999 sec

Operation mode switching: A ⟷ M balanceless and bumpless changeover

With direct/reverse control action selector.

4-3-6. Alarm Function.

The SLBC special alarm features detect unarrived input pulses and leakage.

Figure 4-3-6 shows the relationship between the alarm function and the batch sequence. ↗

(1) Unarrived pulse detection.

When the measured flow pulse input falls below 0.78% of span during the time when maximum flow setting this condition is detected as unarrived pulse causing SLBC to lights the ALM lamp and open the alarm output contact.

(2) Leakage detection.

SLBC supervises all leakage during the period between the batch end and reset. If the leakage reaches the value preset in the auxiliary data, SLBC lights the ALM lamp and opens the output contact.

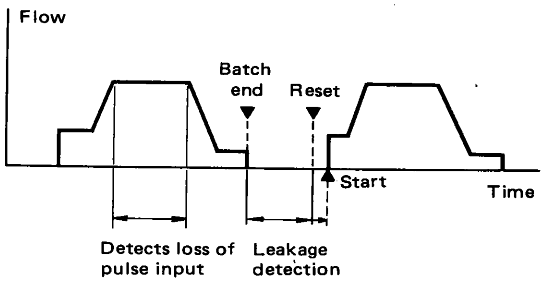


Figure 4-3-6.

4-4. Basic Functions of STLD Totalizer.

4-4-1. Display, Data Setting and Operating Functions.

Figure 4-4-1 shows the front panel of the STLD totalizer.

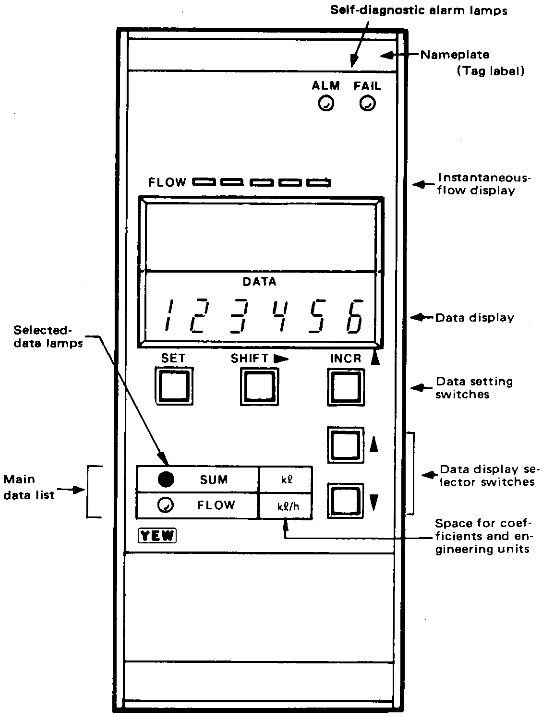


Figure 4-4-1. Front Panel of STLD.

(1) Status display.

Equipment failures detected by self-diagnosis and alarms due to process failures are indicated on the red LED (FAIL) and yellow LED (ALM) indicators, respectively.

(2) Instantaneous flow display.

The instantaneous flow can be displayed as a digital value, and it is also indicated in analog form on a horizontal bar graph consisting of five LEDs.

(3) Data display.

A two-stage 6-digit indicator is used to display the data.

The data items to be displayed are classified into the major items necessary for daily operation and the minor items that are used less frequently. The major items are listed as main data on the data display selector at the center of the front panel as shown in Figure 4-4-1, and the minor items are shown in the data label table on the side panel as auxiliary data (see Figure 4-4-2). The main STLD data contains totalized flow with 2-input added/subtracted compensation (SUM) and instantaneous flow (FLOW). The auxiliary data contains approximately 20 items. Table 4-4-1 lists the auxiliary data items, and Table 4-4-2 shows the auxiliary data function specifications.

The data display normally indicates the main data, but auxiliary data can also be indicated by changing the side panel switch (FRONT P/SIDE P), as necessary. (See Figure 4-3-2.)

The data for display can be selected by using the " ▲▼ " pushbuttons provided on the data display selector. The list of main data items is shown to the left of the pushbuttons and the selected data can be confirmed by an illuminated indicator. When the auxiliary data is called, the data itself is displayed in the lower stage of the display. Auxiliary data items can be called by using the " ▲▼ " pushbuttons just like main data.

(4) Setting data.

To set data, specify individual digits of the selected data as described in par. (3) above with the SHIFT ▶ pushbutton, set the value of each digit with the INCR ▲ pushbutton. Then, input the set value by pressing the SET pushbutton. This system permits quick setting of data containing a number of digits.

The data to be set may be entered in the data label on the side panel and this value loaded as data. For the method of entering the data, refer to TI 1B4A3-11E "Explanation of auxiliary data and filling procedure for data label/work sheet".

(5) Side panel.

Figure 4-4-2 shows the side panel layout.

Arranged on the side panel are the transmitter power supply voltage selector switch, main auxiliary data selector switch and other switches together with the data label which indicates the auxiliary data items.

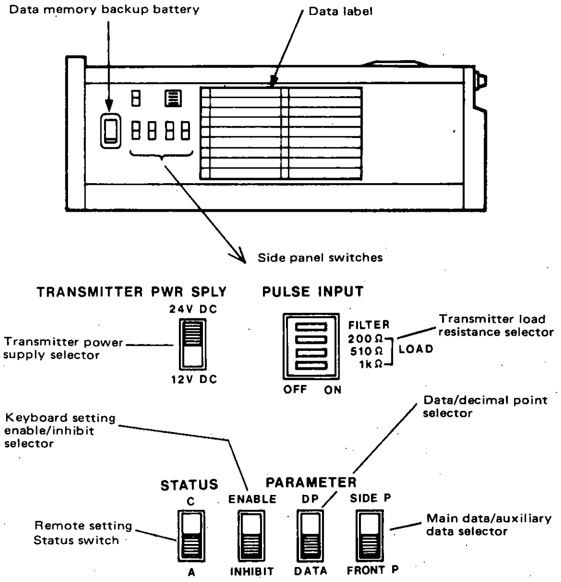


Figure 4-4-2. STLD Side Panel.

Table 4-4-1. STLD Data Label.

	STLD Totalizer				Tag. No.		
01	Alarm (ALM) code	▨	▨	17	Function specification (1)	- ☐ ☐ - ☐ -	▨
02	Flow totalizer value (uncompensated)	▨		18	Function specification (2)	☐ ☐ ☐ ☐ ☐ ☐	▨
03	Flow totalizer value (compensated)	▨		19	Flow process variable span		
04	Cumulative totalizer value (uncompensated) *	▨ ▨ ▨ ▨ ☐ ☐ ☐ ☐		20	Added/subtracted flow span		
05	Cumulative totalizer value (compensated) *	▨		21	K factor for flow process variable		
06	Flow totalizer reset command (enter 0 to reset)	▨	▨	22	K factor for added/subtracted flow		
07	▨	▨	▨	23	K factor for repeater pulse		
08	▨	▨	▨	24	Totalizer scale factor		▨
09	▨	▨	▨	25	Analog display/repeater span*		
10	▨	▨	▨	26	Compensation reference temperature		°C
11	▨	▨	▨	27	Measured temperature maximum value		
12	▨	▨	▨	28	Measured temperature minimum value		
13	▨	▨	▨	29	Compensation factor	▨	▨
14	▨	▨	▨	30	Flow transmitter error compensation coefficient α		▨
15	▨	▨	▨	31	First order compensation coefficient β /specific gravity ρ		▨
16	Measured temperature	▨	°C	32	Second order compensation coefficient γ		▨

STLD*B

Table 4-4-2. Contents of Function Specifications.

Function specification (1) −BC−E−

- B Flow signal repeater pulse width
  - 0: Duty cycle 50%
  - 1: 20 ms
  - 2: 33 ms
  - 3: 50 ms
  - 4: 100 ms
- C Communications write inhibit switch
  - 0: OFF
  - 1: ON
- E Totalizer reset input
  - 0: Enable
  - 1: Inhibit

Function specification (2) GHIJKL

- G Time unit of flow
  - 0: */h
  - 1: */min
- H Flow signal/simulation specification
  - 0: Pulse flow signal
  - 1: Analog flow signal
  - 2: Simulation
- I Added/subtracted flow signal
  - 0: Not provided
  - 1: Provided, pulse, added
  - 2: Provided, pulse, subtracted
  - 3: Provided, analog, added
  - 4: Provided, analog, subtracted
- J Resetting of stored totalizer and repeater pulse values:
  - 0: All values reset.
  - 1: Repeater & non-displayed totalizer digits preserved.
  - 2: Like 1, but least-significant totalizer display digit also preserved.
  - 3: Like 1, but two least-significant totalizer display digits also preserved.

K

Compensation computation provided for:		Process variable input	Added/subtracted input
0:	·····	Not provided	
1:	·····	Provided	Not provided
2:	·····	Not provided	Provided
3:	·····	Provided	

- L Compensation computation
  - 0: ASTM method using Pt 100Ω.
  - 1: General quadratic formula using Pt 100Ω.
  - 2: ASTM method with 1 to 5 V temperature input.
  - 3: General quadratic formula using 1 to 5 V temperature input.
  - 4: General compensation with 1 to 5 V signal.

4-4-2. I/O Signal Processing Function.

Figure 4-4-3 shows the STLD functional block diagram.

(1) Input signal types and scaling.

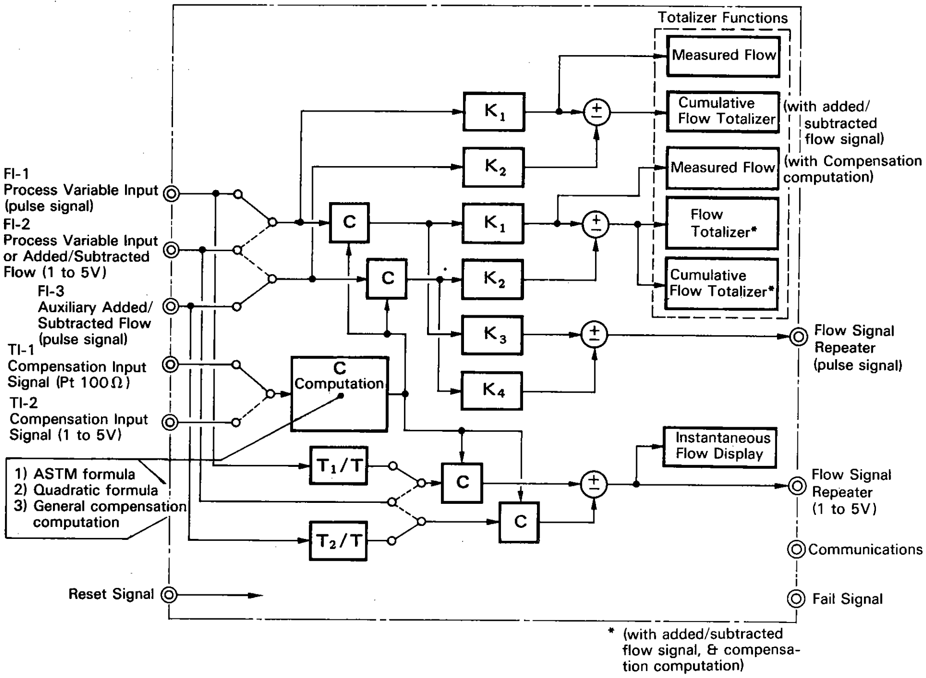
Five types of input signals are used: measured flow pulse input FI-1 from the flow transmitter, analog (1 to 5V) flow input FI-2 for measured flow input or added/subtracted flow input, added/subtracted pulse flow input FI-3, RTD compensation input TI-1 and analog compensation input TI-2. The signal type used is determined by the model suffix code and the auxiliary data function specification. Table 4-4-3 shows combinations of inputs and model suffix codes.

The input pulse frequency varies with the flow transmitter used. However, since scaling is performed in the input processor section, no special consideration need be given to the internal signal processing.

The scaling constant K can be easily loaded in the auxiliary data as [number of pulses/flow totalizing unit] once the flow transmitter type is known.

Pulse input FI-1 is usually used for the measured flow input. Analog input FI-2 can also be used for a process variable flow input. FI-2 must first be subjected to V/F conversion and the signal then treated as a pulse signal equivalent to FI-1. FI-2 is multipurpose input that can also be used as the adding/subtracting flow input.

Added/subtracted pulse flow input FI-3 is used as the added/subtracted input for the measured flow. It uses the retransmitted pulse signal from other YS-BCS devices. This addition or subtraction is determined with an auxiliary data function specification.



	Pulse input	1 to 5V input
K_1	$\frac{1}{\text{K factor for flow process variable}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_2	$\frac{1}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor}}{\text{h or min}}$
K_3	$\frac{\text{Repeater pulse K factor}}{\text{Flow process variable K factor}}$	$\frac{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
K_4	$\frac{\text{Repeater pulse K factor}}{\text{K factor for added/subtracted flow}}$	$\frac{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{Repeater pulse K factor}}{\text{h or min}}$
T_1	$\frac{\text{h or min}}{\text{Flow process variable span} \times \text{Totalizer scale factor} \times \text{K factor for flow process variable}}$	
T_2	$\frac{\text{h or min}}{\text{Added/subtracted flow span} \times \text{Totalizer scale factor} \times \text{K factor for added/subtracted flow}}$	
T	Period of input pulse	
C	Compensation computation	

Figure 4-4-3. STLD Functional Block Diagram.

Table 4-4-3.

Model codes / Input signal	STLD-100	STLD-200			STLD-300		
Measured flow: pulse	○	○	○		○	○	
Measured flow: analog				○			○
Added/subtracted signal: pulse	○	○		○	○		○
Added/subtracted signal: analog			○			○	
Compensation input: Pt 100Ω					○	○	○
Compensation input: analog		○	○	○			

(2) Flow compensation computation.

In batch and blending systems, flow compensation must be accurately performed to achieve high accuracy, and this compensation must be applicable to a wide range of fluid types. To meet this requirement, STLD uses the following three types of compensation, all of which can be selected by an auxiliary data function specification.

$$V_0 = V[(1+\alpha)\, f(\rho,\, t)] \tag{1}$$

$$V_0 = V[(1+\alpha)\ \{1+\beta(t-t_0)10^{-2} + \gamma(t-t_0)^2 10^{-6}\}] \tag{2}$$

$$V_0 = V[(\mathrm{TI}-2)\ +0.5],\ \mathrm{TI}-2 = 0 \text{ to } 1.0 \text{ (analog compensation input)} \tag{3}$$

where

V_0: Volume at reference temperature t_0

V: Volume at temperature t

t_0: Reference temperature (°C)

t : Measured temperature (°C)

α: Instrument error compensation coefficient $(-9.9999$ to $0.9999)$

β: First order compensation coefficient $(-0.9999$ to $0.9999)$

γ: Second order compensation coefficient $(-0.9999$ to $0.9999)$

ρ: Specific gravity (0.5000 to 1.2000)

Equation (1) is used for compensation together with the ASTM specific gravity-volume conversion table which has gained wide acceptance in the petroleum industry. This equation calculates the compensation coefficient at an actual temperature from the specific gravity of a fluid at the reference temperature (15°C) and the actual temperature of the fluid. In this case, the specific gravity of the fluid must be set as an auxiliary data specification. The coefficient α is the instrument error compensation coefficient which may be needed depending on the fluid characteristic (such as viscosity). It must be set in the auxiliary data.

Equation (2) is convenient for polynominal compensation computation in the processes other than petrochemical processes and it has a wide range of application. The density-temperature curve is matched to a quadratic equation to determine the compensation coefficients β and γ, to be loaded as auxiliary data.

Equation (3) is used in special cases where equations (1) and (2) are not applicable. The results of external compensation computations from the SPLR programmable computing unit and other sources are input to analog compensation input TI-2.

The RTD (resistance temperature detector) input is not isolated from the field. If field isolation is required, the signal must be input to analog compensation input TI-2 after conversion to a 1 to 5V signal in STED temperature converter. In this case, the minimum value (zero) of measured temperature and the maximum value of measured temperature (zero « span) corresponding to the conversion range of the temperature converter must be set in the auxiliary data.

(3) Add and subtract functions.

A subtraction function that supplements the addition function is one of the outstanding STLD features.

In loading LNG and other fluids having low vaporization points, the quantity of fluid returned in the form of vapour (vapour return) amounts as much as several percent. This causes an error in the totalized loaded value. With the subtraction function, it becomes possible to compensate for the vapour return and to perform precise fluid loading control.

Adding and subtracting functions are selected with an auxiliary data function specification.

Flow signal range after addition or subtraction (analog display/flow signal repeater span) can be set in the auxiliary data.

(4) Flow signal repeater function.

Two-input added/subtracted flow after compensation is retransmitted in the form of a pulse signal or analog (1 to 5V) signal where an analog I/O is provided.

The retransmitt pulse scaling is set as an auxiliary data specification with [number of pulses/flow totalizing unit], in the same manner as the process variable input signal scaling. The retransmitted pulse width is also set with an auxiliary data function specification.

4-4-3. Totalizer Function.

The totalized value is the most important data in batch and blending control. STLD permits display of the following five types of totalized values (See Figure 4-4-3).

(a) Batch measured flow totalized value
..... Uncompensated total value of measured flow.

(b) Batch measured flow totalized value with compensation
..... Compensated total value of measured flow.

(c) Batch flow totalized value with two-input adding/subtracting adjustment and compensation
..... Total value after compensation and two-input added/subtracted flow signal adjustment.

(d) Cumulatively totalized flow value with two-input added/subtracted function
..... Cumulative total value after two-input added/subtracted signal adjustment and no compensation

(e) Cumulatively totalized flow value with two-input added/subtracted signal and compensation
..... Cumulative total value after two-input added/subtracted adjustment and compensation.

Totalized values (a), (b) and (c) are reset by a reset status input or by data entry and (d) and (e) are not reset.

The RESET status input uses non-locking contact which is "reset" in the ON state (minimum on time at least 400 ms).

Totalized values (a), (b) and (c) are displayed with 8 digits while the cumulative values (d) and (e) are displayed with eight digits by using both the upper and lower indicator stages.

The process variable totalized flow value (with two-input adding/subtracting and compensation) is indicated by the main data item SUM on the front panel, and the other four total values are classified as auxiliary data.

5. COMMUNICATION FUNCTION.

The standard version of YS-BCS is provided with a communication function. This permits a connection to a YS-80 Centralized Supervisory and Communication System in order that supervisory, control and management tasks such as the changing of fluid types can be performed from a remote supervisory system.

5-1. System Configuration.

Figure 5-1-1 shows an example of system configuration in which the YS-BCS and the Centralized Supervisory and Communication System are combined.

UFCU Field Control Unit:

This unit interconnects a maximum of 24 YS-BCS units to the system.

UOPC operators console:

This centralized supervisory unit contains a 14-inch CRT.

UPRT printer:

Various logs, trend records and hard copies can be created with this printer.

UCIA communication interface adapter:

This is a communication data converter used for coupling the YS-BCS to a supervisory computer.

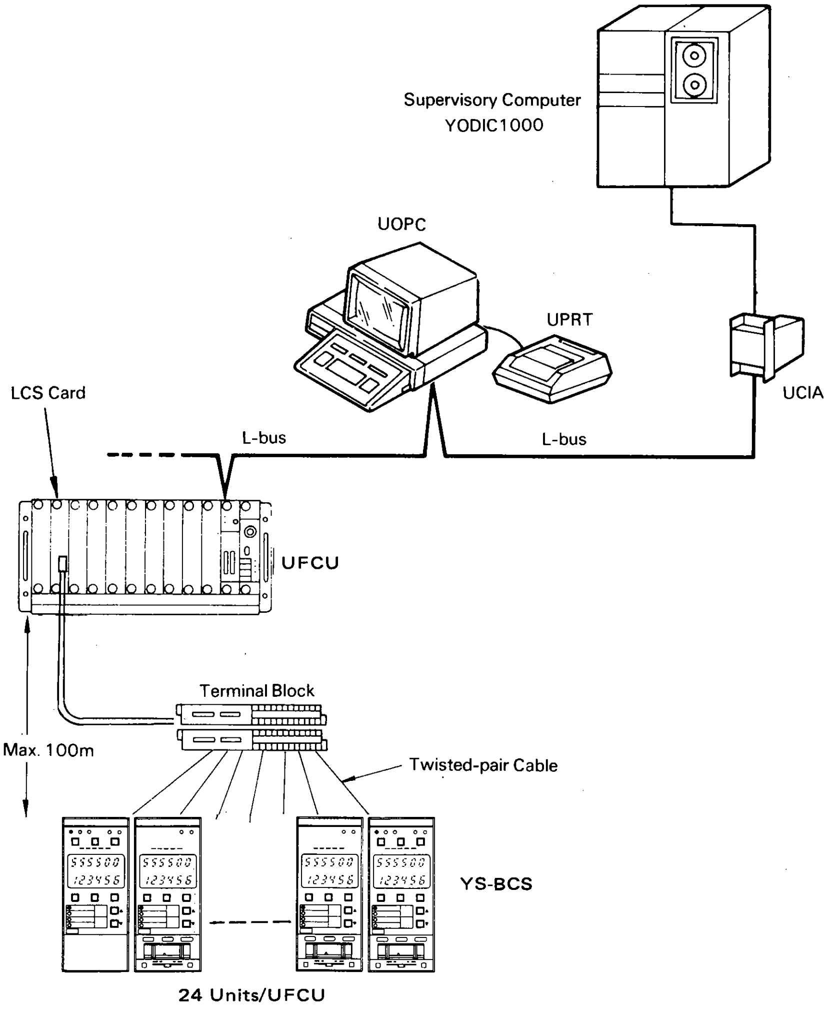


Figure 5-1-1. Centralized Supervisory and Communication.

5-2. Communication Items.

Table 5-1-1 shows the YS-BCS communication function.

5-3. Setting and Operating from a Remote Supervisory System.

From among the communication items listed in Table 5-1-1, those that permit settings and operation from a remote supervisory system are not restricted by the C/A/M operation mode of the individual YS-BCS units as data can be set in any mode. Allowable data settings and operations are determined by the supervisory system by monitoring the operating mode of each YS-BCS unit.

This means that mode C (permits data settings and operations from a supervisory system) is transmitted to the supervisory system by the C-mode switch on the SLCC and SLBC front panels and the C-A selector switch on the SBSD and STLD side panels. Upon receiving these signals, the supervisory system performs its independent management functions.

5-4. Communication Write Inhibit Status.

Each YS-BCS unit uses a write inhibit switch as one method of specifying this function in the auxiliary data. Writing can be inhibited with this switch if necessary.

Table 5-1-1. YS-BCS Communication Items.

Model Communication item	SBSD	SLCC	SLBC	STLD
Instantaneous flow	○	○	○	○
Batch flow totalized value	●	●*	●	●**
Batch set value	●		●	
Initial flow set value	●		●	
Initial flow totalized limit	●		●	
Maximum flow set value	●		●	
Blending ratio		●		
Totalized deviation		○		
Demand output	○			
Manipulated output variable		●	●	
Batch status	●		●	
Operation mode C, A or M	○	●	●	○
Leakage detecting alarm	○		○	
Totalized deviation alarm		○		
Instrument error compensation coefficient α	●	●	●	●
First order compensation coefficient β	●	●	●	●
Second order compensation coefficient γ	●	●	●	●

Notes:
- * : Process variable totalized value.
- ** : Flow totalized value.
- ○ : Monitoring only.
- ● : Permitting data settings and operations from supervisory system.

6. POWER FAILURE COUNTERMEASURES AND RESTARTS.

YS-BCS recovers from power failures and determines power failure restart processing according to the duration of the power suspension.

Power failures are classified into the following types according to the duration of the power failure.

T1 (Instantaneous power failures)
Approx. 1 ms (24V DC version)
Approx. 40 ms (100V DC version)
T2 (Momentary power dropout)
Approx. 2 sec
T3 (Long-term power failures)
Data is protected by a built-in data-protect battery
Battery life: Exceeds one year if instrument is powered down.
Exceeds five years if instrument remains operational

Table 6-1-1 shows the restart processing that corresponds to different durations of power failures.

Table 6-1-1. Power Failure Duration and Corresponding Restart Processing.

Function	Model Power failure duration	SBSD	SLCC	SLBC	STLD
Totalizing function	T_2 (power failures approx. 2 sec.)	Totalizing continues	Totalizing continues	Totalizing Continues	Totalizing Continues
	T_3 (long power failure)				
Batch function	T_2 (power failures approx. 2 sec.)	HOT/COLD mode selectable		HOT/COLD mode selectable	
	T_3 (long power failure)	COLD mode		COLD mode	
Control function	T_2 (power failures approx. 2 sec.)		HOT mode	HOT/COLD mode selectable	
	T_3 (long power failure)			COLD mode	

Note 1. HOT mode: The batch and control functions existing just prior to the power failure are continued.
Note 2. COLD mode: Emergency stop status.
Note 3. HOT/COLD mode: Either HOT or COLD modes can be selected with an auxiliary data function specification.

7. SELF-DIAGNOSTIC FUNCTION.

Each YS-BCS unit is provided with various failure detecting functions. If any I/O or instrument failure is detected, an indicator lamp is illuminated and a contact output is issued. The failure type is displayed as a 4-digit hexadecimal number on the data display as auxiliary data item 1.
Table 7-1-1 shows the YS-BCS self-diagnosis function.

Table 7-1-1. Self-diagnostic Functions of YS-BCS.

Panel indicator lamp		Alarm code	Diagnosis	Control operation performed
FAIL lamp (RED) lights		—	CPU failure	○ Fail contact opens. ○ Manipulated output is hold-status. ○ Output operation possible in MAN mode.
		0001	A/D converger abnormal	
		0002	D/A converter abnormal	
ALM lamp (Yellow)	Lights	0004	Computing range overflow	○ Computes with limit value. ○ Control continues.
		0008	Compensation input signal range overflow.	
		0010	Compensation computation abnormal	
	Flashes	0020	Data protect battery not installed or voltage too low	○ Operation remains normal unless power fails.
	Lights	0040	Control output (current) open*	○ Control continues.
		0080	Internal data lost	○ Control stops.
		0100	Process variable input overrange or unarrived pulse detected**	○ If overrange, limit value is used for computation. ○ Control continues. ○ Alarm contact opens if unarrived pulse or leakage is detected or deviation alarm activated.
		0200	Added/subtracted input or data set input overrange	
		0400	Abnormal leakage detection**	
		0800	1st stage totalized deviation alarm***	
		1000	2nd stage totalized deviation alarm***	
		2000	Overflow of retransmitted internal data	
		4000	Overrange setting	
		8000	Power failure	○ Refer to "Power failure recovery processing".

* SLCC and SLBC only
** SBSD and SLBC only
*** SLCC only

8. SIMULATION FUNCTION.

YS-BCS enables the user to build up and immediately confirm various functions in the field by setting auxiliary data specifications.

Generally, pulse signal handling equipment requires pulse generators, counters and other test equipment. YS-BCS, however, is provided with a simulation function to check its own operation without the use of this additional test equipment.

Table 8-1-1.

H Measured flow signal/simulation specificaton
- 0: Pulse
- 1: Analog
- 2: Simulation-MV (manipulated value) inhibit, D/O inhibit
- 3: Simulation-MV (manipulated value) inhibit, D/O enable
- 4: Simulation-MV (manipulated value) enable, D/O inhibit
- 5: Simulation-MV (manipulated value) enable, D/O enable

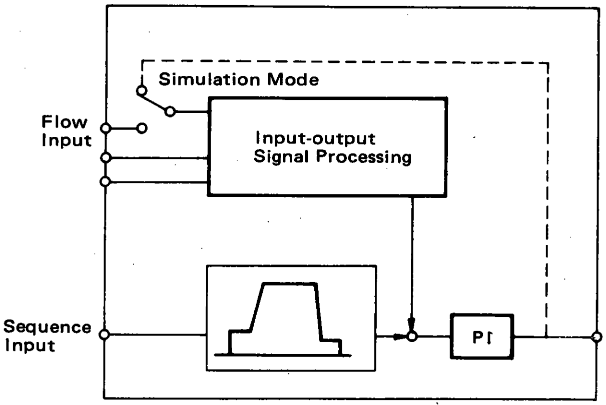


Figure 8-1-1. SLBC Simulation Mode.

Figure 8-1-1 shows an outline of operation where the simulation mode is specified using the auxiliary data function specification in SLBC. The control output can be fed back internally for configurating a closed loop by the equipment alone, thereby checking the batch function and control function.

It is also possible to inhibit the issue of the status output (D/O) and control output (MV) to the outside if so specified. Table 8-1-1 shows the simulation function specifying items of the auxiliary data.

Explained below is the operation of each model at the time of simulation.

(1) **SBSD batch setting station.**
The measurement input that is equivalent to the set value is generated internally.

a) Batch master station
When the batch is started, the measurement input is generated internally according to the preset batch sequence for performing the batch master station operation. If the totalized value reaches "the batch set value − predicted leak value", the batch end status is attained.

b) Blending master station
When the start pushbutton is pressed (or when the contact input is made), the measurement input is generated internally according to the initial flow set value and flow high limit set value, and totalizing operation of the simulated input is continued.

c) Simplified batch station
When the batch is started, the measurement input is generated internally according to the sequence of Figure 8-1-2, and the operation of the simplified batch station is performed. This operation is continued until the totalized value reaches the "batch set value − predicted leakage value".

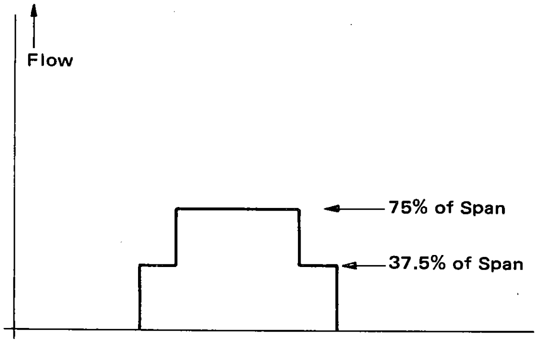


Figure 8-1-2. Simplified batch simulation.

(2) **SLCC blending controller.**
If the demand input is given from the outside, the measurement input is generated internally according to the preset blend ratio for performing the blend ratio control operation.

(3) **SLBC batch controller.**
The measurement input equivalent to the control output is generated internally. Accordingly, if the batch is started the measurement input is generated inside the instrument, and the batch operation is performed according to the preset batch sequence.

(4) **STDL totalizer.**
The measurement input that is 75% of the span is generated inside the instrument. Accordingly, totalizing operation is continued as if an input of 75% of the span is being applied.