SAMA Symbols White Paper #2 – A Process Control "Language"

SAMA Symbols are another "language" just like plot plans, logic drawings, flow sheets, P&ID, and elevation views.

With the price of fuel rising and concern about stack emissions, global warming, and the carbon footprint increasing, industries and utilities alike are renewing their emphasis on boiler efficiency and energy savings. Energy conservation through control has placed the process control engineer in the forefront of control system analysis and his tools of choice are SAMA symbols.

SAMA stands for Scientific Apparatus Makers Association, the organization that came up with the symbolic language to represent the various pieces of control loop hardware and how they interact together to create a process control scheme.

SAMA symbols are just one of the engineering "languages" that we use to convey information and this paper provides a perspective of how SAMA symbols complement those other "languages." From idea through concept, design, procurement, construction, startup, and training, engineers use a vast variety of tools, symbols, drawings, and "languages" to convey their thoughts on paper to facilitate the building process.

SAMA symbols are just another engineering "language" that we carry in our tool box of skills and competencies. I didn't realize how many "languages" engineers spoke until my attorney neighbor looked at my construction schedule and asked me what "language" that was. I said this was just a schedule. I then showed him the logic diagram for the elevator. Then he saw the single line diagram for the power panels. He then responded that he "just wrote everything in English on legal sized paper."

Using words alone was a limiting factor for the attorney that forced him into using English to explain, in multiple pages, a legal description for a piece of irregular shaped property of a past cogeneration project. The site plan was a single page drawing and clearly showed the curved two lane road to the east and the lake to the west. A portion of the curved road was described as follows: "...a line along the east side of power plant drive the following courses and distances S.16° 28' 31" E. 87.19 feet, S. 22° 56' 47"E…." The legal description went on and on with 24 of these segments describing the curve of the road. You can only imagine what the lake description was like. The drawing was so much easer to use.

As engineers, we use a variety of "languages" or drawings as tools to convey our thoughts to others in the engineering and construction process. Consider the following list and think about how many of these you use.

Site plan	Equipment layout
Plan views	Electrical one line
Flow sheets	Short circuit graphs
Shop drawings	Schematic drawings
Block diagrams	Civil drainage plans
Logic drawings	Sequence of operation
Panel schedules	Steel connection details
Elevation views	Structural steel drawings
Ladder drawings	Piping and Instrument drawings
Conduit Schedule	Equipment dimensional drawings

In each of these drawings we use shapes, layouts, and lines to convey fluids or electrical power. Each drawing type has its own legend or "language" of shapes that allows the user to quickly understand the symbology used in the presentation of thoughts. For instance, a pump with motor can be represented as:

- a rectangle with bolt holes on a layout drawings;
- a pump symbol on a flow sheet; or
- a circle on a ladder diagram.

While it is the same pump / motor piece of equipment, we use different symbols because each drawing has its own unique focus so as to convey the thoughts from idea to hardware. A layout drawing is concerned with anchor bolts and dimensions for piping. The flow sheet is explaining the flow of the overall process and primarily focuses on the material and energy balances. The ladder diagram is focused on the permissive and safety logic involved in motor operation. In the ladder diagram the motor regardless of horsepower, voltage, or phase is represented with a circle and a single line on either side.

SAMA symbols are used to develop and convey the inner workings of complex control schemes. While the P&ID is adequate to show simple single feedback control loops as circles, it gets very confusing when complexity is introduced. At that point additional symbols and drawing layouts help the presentation of thoughts.

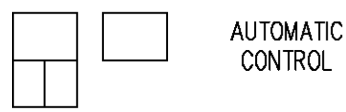
The Drawing: The control drawing used for SAMA symbols is laid out from top to bottom as follows:

- The top row shows all the process mounted transmitter inputs and also represents all the wired connections coming into the control system from the process area.
- The bottom row shows all the final control elements such as control valves, dampers, and speed controllers. These also are wired connections that leave the control room and go back out to the process.
- The middle section is the largest space on the drawing and contains all the control functions, logic, and math. The interconnecting lines located here are sometimes called rubber wires and indicate the software connections between functions.

The Shapes: As we saw in other drawings, shapes are used to convey information and SAMA symbols use several standard shapes as follows:

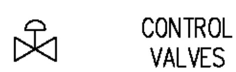
The transmitters are all round circles;

The automatic control functions are squares, and / or rectangles;



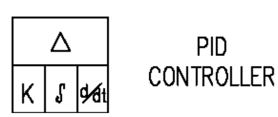
The manual functions are diamonds;

The control valves are shown as control valves;



The damper drives are shown as trapezoids; and

The PID Controller has the delta Δ symbol in the top to denote the difference between the feedback signal and the set point. Also shown are the three functions of proportional, integral, and derivative action.



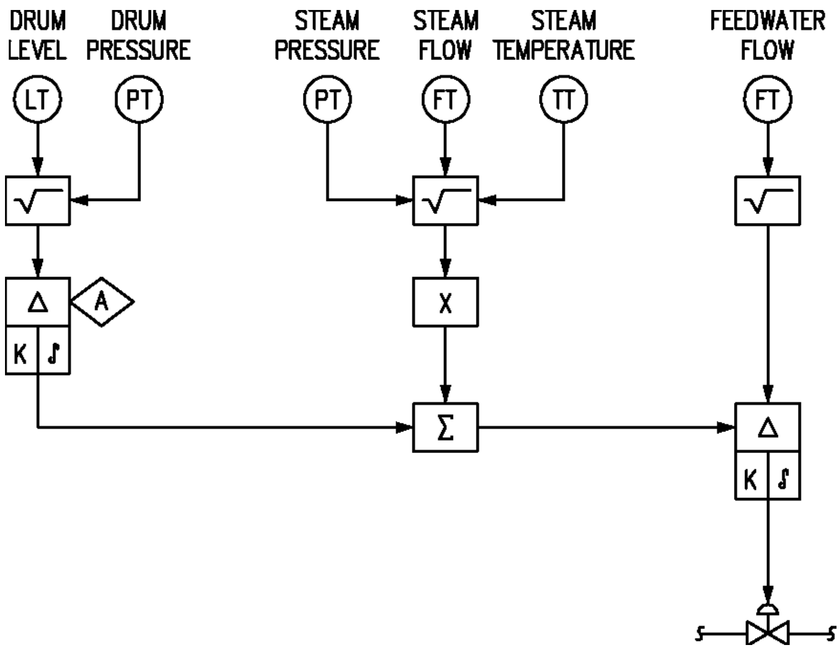
Transmitter nomenclature: The round circle of the transmitter can contain any of the following letters to indicate the process variable being measured.

A = Analysis (or use specifics such as O_2 , pH , etc.)
C = Conductivity
D = Density
F = Flow
L = Level
M = Moisture
P = Pressure
S = Speed
T = Temperature
V = Viscosity
W = Weight
Z = Position

The transmitter symbol can also contain additional information with a second and third letter as follows;

R = Recording
I = Indicating
T = Transmitter
RT = Recording Transmitter
IT = Indicating Transmitter

Now let's use this information to describe a three-element drum level control system which is one of the most common boiler control schemes. Additionally, we will show pressure and temperature compensated steam flow and pressure compensated drum level.



The meaning and functions of this SAMA drawing are quite clear. There is a feedwater control loop receiving its set point from a feedforward steam flow signal which is trimmed by the drum level controller. Both the steam flow and feedwater flow are measured by an orifice plate and the square root function is clearly seen. The temperature and pressure compensated steam flow is clearly indicated and we know where to select this signal for possible indication and or recording. Moreover, this same signal can be used for an oxygen trim control loop. Likewise, the pressure compensated drum level signal can be trended and indicated. We can also use this signal to set high and low steam drum water limits and alarms.

SAMA symbols are a powerful tool that can help convey complex control schemes at a glance. This in turn allows the process control engineer to focus his brain on improvements to control or tuning that can save fuel. Moreover, for those boilers that can accommodate multiple fuels, the control connection points are quite clear as we will see in the next SAMA symbols article on Drum Level.

This article on SAMA symbols was written to convey the power, elegance, and ease of designing complex control schemes. This article is not a full, complete, or correct design of any control system. The reader shall retain the services of a licensed professional engineer with extensive process control experience. The professional engineer must first analyze the specific process in question. As my college professor used to say, "You can't design a control system ***until*** you understand the process."

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