THE USE OF PROCESS AND INSTRUMENTATION DRAWINGS FOR ACCELERATOR AND BEAMLINE CONTROL APPLICATIONS AT THE CANADIAN LIGHT SOURCE*

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Abstract

In 2001 at the start of the Canadian Light Source Project, the CLS began to adopt the use of Process and Instrumentation Drawings not only for process systems but also for accelerator and beamline optical components. Given existing industry standards have only been formulated for process applications this posed unique challenges. This paper describes the internal standards that were adopted, how they evolved over the past nine years and operation benefits we have been able to achieve through the use of PID drawings. The paper also examines the benefits from using AutoCAD scripts to automate the implementation of PID drawings.

INTEGRATION WITHIN THE ENGINEERING PROCESS

For control system and software engineering a process is followed that parallels the unified process where the design is refined as we move from the initial proposal to commissioning. Figure 1 illustrates this process with the top bar outlining the system engineering process and the second bar showing the relationship to the unified process. Under each stage is a list of the deliverables that are normally developed.

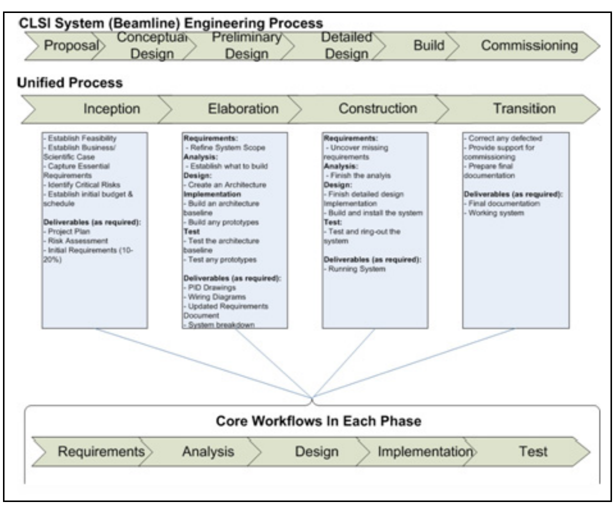

Figure 1: Control system engineering process.

At each step in the process we review and refine the requirements, analysis, design and implementation as appropriate. The Processing and Instrumentation Drawings (P&ID) are created in a draft form at the beginning of the project and refined as the design progresses. They are then used to support operations and operational changes that occur through the life of the facility.

DRAWINGS

All drawings at the CLS are centrally managed by a common drawing office that supports the mechanical, electrical, and controls engineering activities [1]. Each drawing is individually numbered, and tracked in a central database. Historical revisions to drawings are also archived and retained.

To automate the drawings process an AutoCAD based menu system was developed using AutoCAD scripts. The use of facility specific automation permits us to achieve a high level of commonality while effectively reducing effort.

INPUTS TO THE P&ID

The Process Flow Drawings (PFD) are developed as part of the mechanical engineering process. The PFD define the optical elements of the accelerator or beamline, and other supporting mechanical systems (water flow, heat exchangers etc.) as well as vacuum and water flow design and trip levels that are then used for machine protection. The PFD therefore acts as a primary input into the P&ID.

Additional input is gained by working with other engineering and scientific groups to define the functional requirements for the system.

NAMING CONVENTION

A common equipment naming convention is used on all mechanical, electrical, P&IDs and PFDs as well as the PLC software, EPICS control system software and documentation [2].

The naming convention consists of a one to four letter equipment type code, followed by room number with an optional sub-area identified followed by a serial number. For example, IOP1408-01 would be the first ion pump in room 1408.

OPTICAL COMPONENTS

P&IDs are commonly used in the process industry and generally follow industry standards. They have not traditionally been used in accelerator applications. The

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CLS has had to develop a graphical nomenclature to represent common accelerator and beamline optical components.

Figure 2 illustrates a portion of a P&ID drawing for such an application. Beam (in this example photons) move from left to right. Initially the photons pass through a BPM block (BPM1406-B20-01) that contains an ion-pump shown on the bottom and two pico-am meters (A1408-01/2) shown on the top. The meters are then connected by serial lines to ports P1, and P2 on an EPICS Input/Output Controller (IOC1408-001). The blue and red lines coming from the top indicate that the BPM is water cooled and the return line is equipped with a RTD temperature sensor and flow switch that are monitored by a PLC.

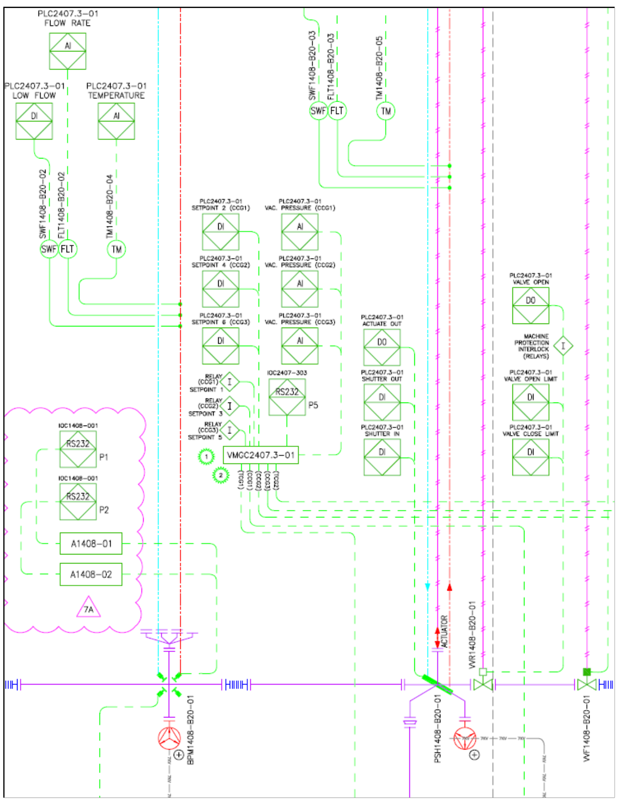

Figure 2: Control system interface to optical components shown on a P&ID.

The BPM is then followed by a photon shutter that is pneumatically actuated. From the control system various digital inputs (DI), digital outputs (DO), analogue inputs (AI), and analogue outputs (AO) are identified.

Shown above the beam pipe and between the BPM and photon shutter is a Varian multi-gauge controller that connects to various vacuum gages (not shown) and has a series of hardwired interlocks, analogue and digital IO as well as a serial connection.

Following the photon shutter are two valves, one being a fast valve and the second one being a regulate valve.

Though not relevant from a controls perspective bellows, and ports are also shown on the P&IDs. When changes are made to the drawings the most recent changes are clouded in blocks and the revision number of the drawings that resulted in the change shown in a triangle.

IDENTIFING INTERLOCKS

During the first few years of using P&IDs interlocks were not shown. Over time we have added more and more detail to these drawing. Operationally this has the advantage of having controls, engineering, scientific and operational staff working from the same information that is readily available to all.

Interlocks are identified on tables that appear near the bottom of the PID drawings. An example from a beamline front-end is show in Figure 2. Interlock 1 on this drawings causes six vacuum valves (VVR) to be closed as indicated in the table. This interlock is initiated by two ion pump power supply channels (PS2407.3-02 HV 1 and PS2407.3-02 HV2).

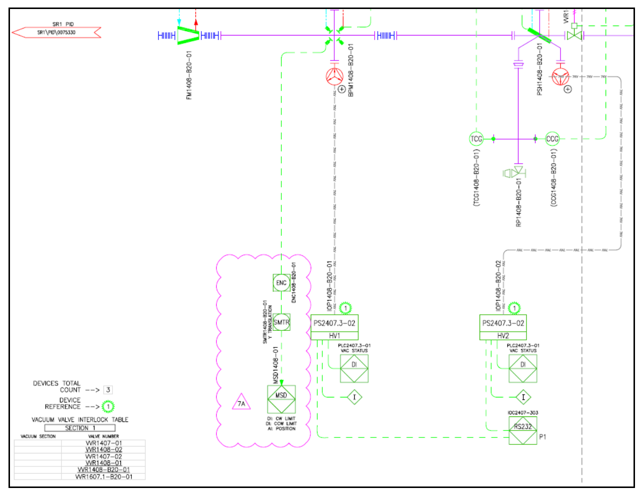

Figure 3: Interlock shown on a P&ID.

As illustrated in the figures these drawings capture information about the relationship between the optical, mechanical equipment and the control system. This serves to both define the control system requirements and interfaces.

Since there were no pre-existing standard symbols available we needed to develop our own. The standard optical symbols are shown in Figure 4. In addition standard RF symbolism was also developed (not shown).

CONCLUSION

The use of P&IDs have been an effective method of communicating the design between the scientists, mechanical engineering staff and controls staff. These form a common share bases for establishing the design during the initial development stages.

Once into operations our practice has been to maintain reference printed versions of all the facility P&IDs in the control room. These have proven valuable in permitting operational staff to understand the relationship between equipment and interlocks and the components within a facility. This is especially the case with systems that have matured in operations and are not undergoing extensive changes.

We have found a critical aspect in the use of these drawings is that it is important that processes are in place for revision control and adequate attention is pawed to ensure these are maintained up to date.

Over the past nine years the importance these drawings play in the design process has increased as well as the information captured.

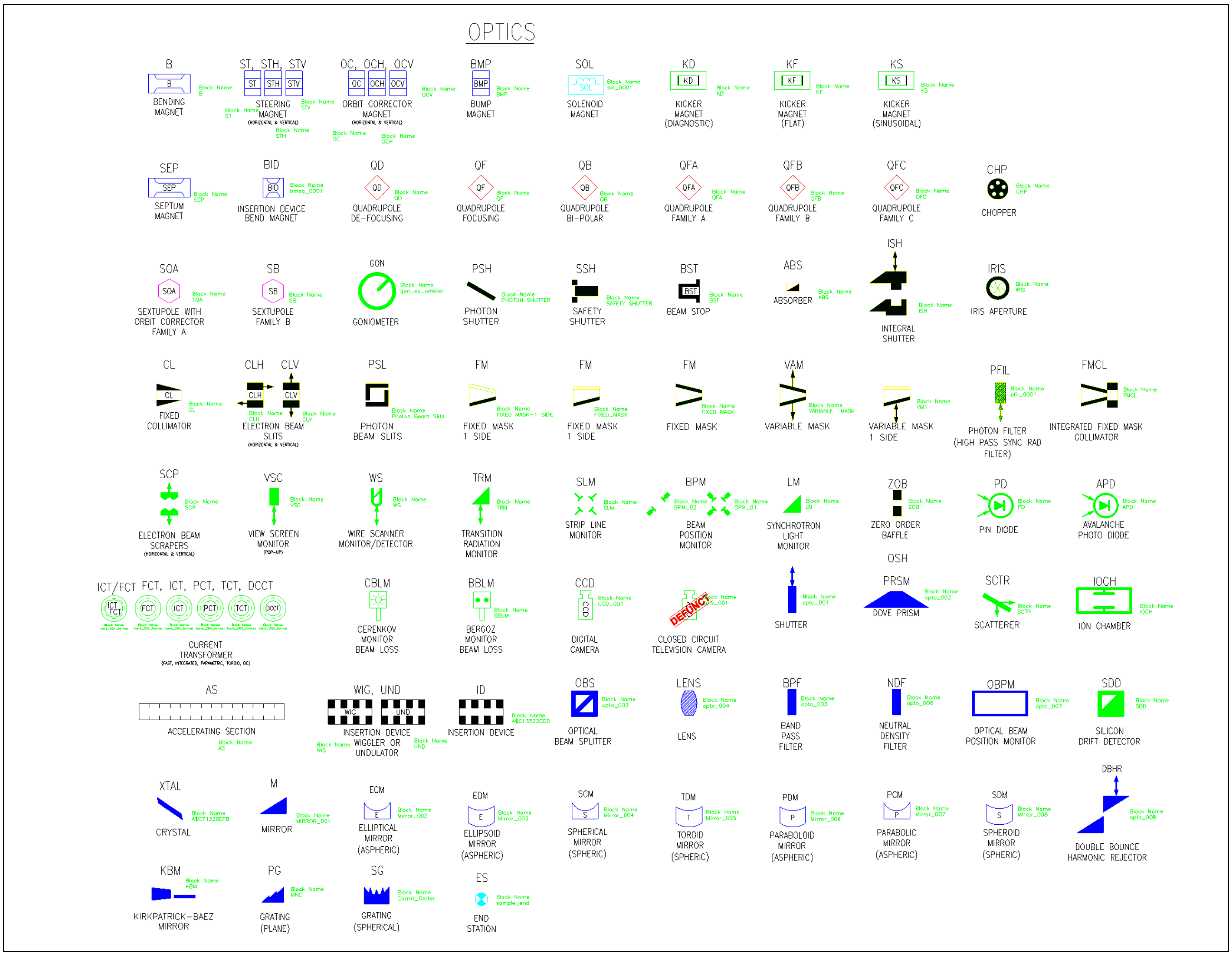

Figure 4: Accelerator and beamline optical symbols.

REFERENCES

[1] J. Swirsky. “CAD/Drawing Guide”. Canadian Light Source Technical Report 0.1.1.8 Rev. 1. Nov. 2005.

[2] G. Wright, and B. Harvey “CLS Naming and Numbering Convention,” Canadian Light Source Technical Report 0.2.1.1 Rev 4. July 2008.