EngineeredSoftware, Inc.

Streamlining Control Valve Selection & Evaluation Process Using Electronic Data Exchange

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Introduction

In every major piping project, technical information is exchanged between the various stakeholders; specifically the plant owner, engineering design firm, purchasers, suppliers, contractors, operations, and maintenance. This information is acquired during the design process and is used during the entire life of the plant.

For example, when purchasing a control valve for a piping project the requirements of the control valve are based on hydraulic calculations performed in the design process, the client's specification documents, as well as a variety of industrial standards. This information for each control valve is typically entered onto a control valve datasheet and forwarded to the procurement group of the engineering contractor. The procurement group compiles the data sheets for all the control valves in the project and includes this information in the control valve purchase specification.

The purchase specification package is transmitted to the various control valve suppliers on the approved bidders list. Valve suppliers create their bid submittal package based on the customers purchase specification document. The valve supplier's bid package is then reviewed by the client and the winning bid is selected. The final step in the purchasing process is the issuance of the purchase order that contains all the terms and conditions. Finally, the control valves, spare parts, and documentation are delivered and the valves are installed in the system. Typically, word processors and electronic spreadsheets are used to create the necessary documents, which are then printed out or converted to a Portable Document Format (.pdf) and transmitted electronically. This exchange of information is a very labor-intensive process, in which the data sheets and specifications documents must often be manually transcribed from one format to another. Any manual transcription of data is prone to error and can lead to information being misinterpreted or improperly translated throughout the process.

In order to standardize and streamline the equipment specification and procurement process, a number of organizations are promoting and working to utilize Electronic Data Exchange (EDE). With EDE, the information typically found on data sheets is transmitted as electronic files that facilitate equipment selection. This is a major effort involving the owners, operators, design firms, and sellers of capital equipment. Like every major process change, it builds with success, and the first successes need to be rooted in the existing workflow. Only when all the stakeholders see value will EDE be widely adopted.

The following information is based on work that has been accomplished within a commercial fluid piping program to streamline the selection and evaluation of capital equipment. In this example, we will be focusing on control valves specifically. The architecture of the software application must be flexible enough to accomplish today's manual purchasing process, outlined above, and grow to become part of a much more integrated exchange of electronic data between various applications. Many industry initiatives are currently underway to further facilitate EDE between buyers and sellers of equipment found in piping systems, and this article will touch on these initiatives as well.

Determining the Control Valve Requirements

The first step in selecting a control valve is determining its requirements. This typically consists of specifying the connecting pipe sizes, physical properties of the process fluid, valve specifics including preferences for body style, characteristic trim, pressure rating, and the various design set points. The valve's set points include the inlet pressure, flow rate, and differential pressure based on the expected operating conditions. In addition, it is customary to include the maximum and minimum flow data to ensure the control valve can operate within the range of expected conditions.

Evaluating how the control valve will operate in the total piping system and determining its design set points requires extensive hydraulic calculations. Using one of the many commercially available piping simulation packages the designer can assemble a total piping system model by inserting the tanks, pipelines, pumps, flow meters, components, and control valves onto a schematic drawing (See Figure 1). The various design elements in the system are entered using data tables within the software. For example, when the user enters the pipeline details on the inlet pipe of a control valve, they choose a user created pipe specification that defines the pipe material and schedule or wall thickness to be used. The program then retrieves and displays the available nominal sizes associated with the pipe specification and the user chooses the appropriate size. Once the diameter is selected, the program retrieves the pipe's absolute roughness and inside diameter to perform the pressure drop calculations.

The physical property data for the process fluid can be retrieved from fluid data tables used by the program or looked up outside the program and manually entered by the user. Once sufficient details have been entered, the program calculates the pressure drop and flow rates throughout the system. This information can then be used for pump selection. Once a pump is selected for the system, its operating data can be inserted into the piping system model, allowing the program to calculate how the pump and piping operate as a total system. The pipeline material and fluid data used in the head loss calculations is automatically used in the control valve selection process, eliminating the need to manually re-enter data.

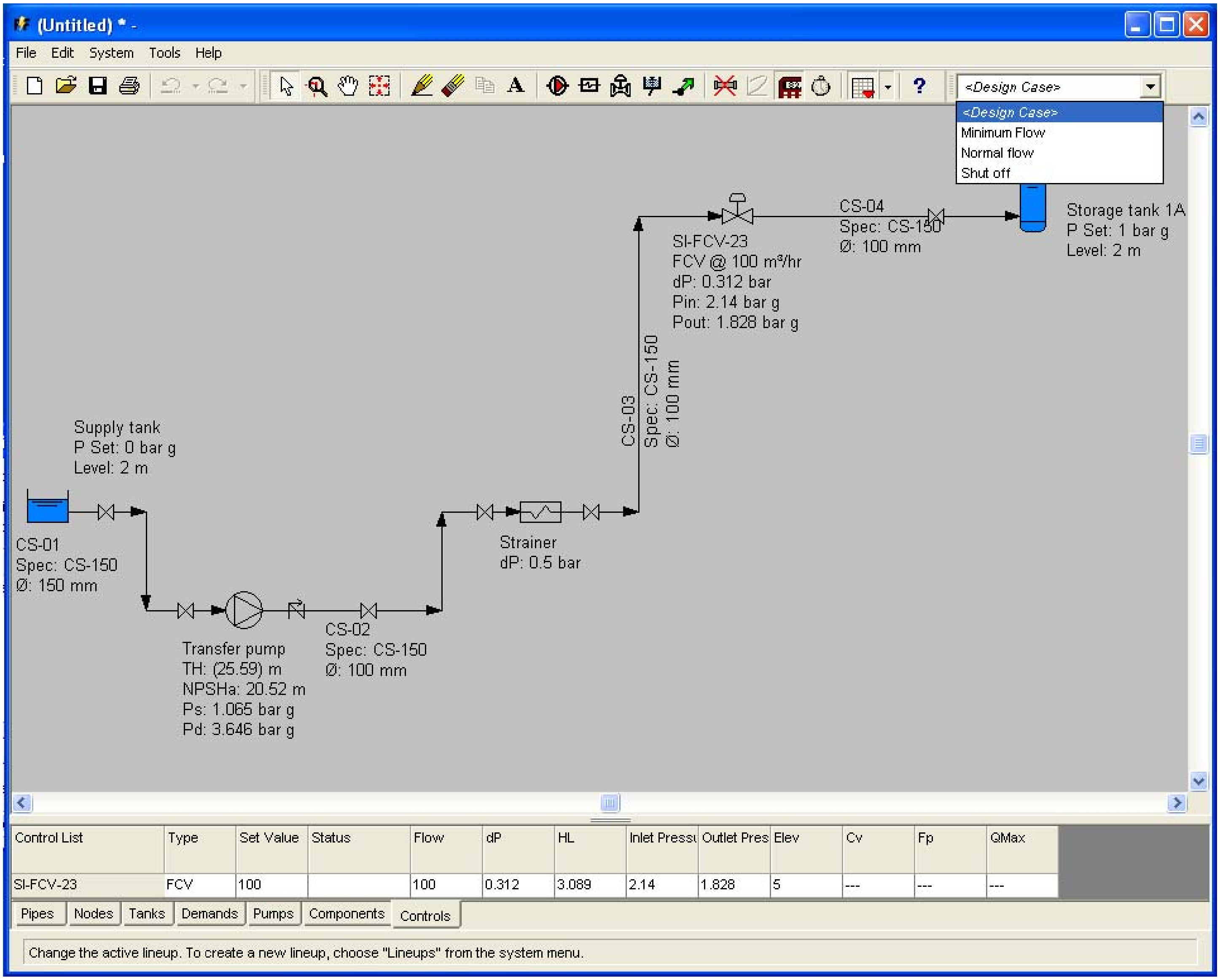

Figure 1 - This is an example piping system showing the various operating model of the system along with the design information about the selected control valve. Notice on the list view the type of control, set point, flow rate, inlet pressure, outlet pressure, and differential pressure across the control valve are displayed.

A variety of control valve types (flow control, downstream pressure control, and backpressure control) can be simulated and inserted into the piping system model. Once pump performance data and the design set point for the control valve is entered into the model, the software can accurately calculate the inlet pressure, differential pressure, and flow rate through the control valve needed to meet the design conditions. The majority of available piping simulation programs allow the user to evaluate the system under a variety of operating conditions. As a result, the user is able to calculate the control valve design requirements for any expected operating condition. This greatly streamlines the process of determining the design conditions of each control valve found in the system. Once the calculations are performed, the control valve data is typically manually entered into valve data sheets.

A few of the commercially available software packages allow for the exportation of design data to Microsoft® Excel®. This allows the user to load a previously created electronic data sheet in Excel and automatically fill it in by extracting the design data from the piping simulation model. This method also allows the software to integrate with commercially available data sheet generation programs, minimizing the amount of data that must be manually entered onto a data sheet. Appendix A shows an example of a typical ISA data sheet in which the data has been automatically inserted by one of the available piping simulation programs.

After the data sheets and written specifications documents are completed, they can then be forwarded to an approved list of valve manufacturers.

Selecting the Control Valve

Many of the control valve manufacturers (e.g. Fisher, Masoneilan, Nels-Jamesbury) have created and distributed their own proprietary programs used in the selection of their control valves. These programs require the user to enter pipe, fluid, and control valve operating properties, and the programs display a list of control valves meeting the customer's needs. Since these manufacturers' programs are designed to meet the workflow requirements of the valve manufacturers, many of them have the ability to export data to other programs within their company.

The majority of these applications utilize eXtensible Markup Language (XML), a widely used method for defining data formats. XML can be used to define complex documents and there data structures such as data sheets, equipment lists, parts lists, and purchase documents. This allows the manufactures to easily transfer data between their various applications. The manufacturers' programs typically allow the end user to create their own export files, in an XML format, that can supply design data about the selected control valve to other programs.

Reviewing the Recommended Control Valves

Once the valve suppliers return their completed bid packages, the purchaser reviews the valve selections. In addition to the review of the seller's commercial terms, an engineering evaluation of the recommended control valves must take place. This should consist of an operational evaluation of the control valves using piping system simulation software. The majority of piping system simulation software allows the user to enter the control valve characteristics (Cv or Kv), dimensions, and any other pertinent information. With the appropriate control valve data entered into the piping system model, the user is able to evaluate the control valve under not only the design conditions, but also any expected operating condition. Many of the programs will indicate when the control valve cannot pass the required flow rate, or is experiencing choked flow, cavitation, or differential pressures outside its range of operability. These checks ensure that any potential valve problem is identified in the design phase, rather than after the system is built and operating.

The addition of the valve characteristics for a detailed analysis requires the user to manually enter the data for each control valve in the piping system model. As mentioned above, many of the control valve manufacturers' programs can export data about a specific valve in a form that can be read into other programs. Engineered Software, a manufacturer of piping simulation software, has implemented an XML interface for importing control valve data. This allows their PIPE-FLO® program to import control valve data directly from the Fisher Specification Manager program in a format that can be used by the piping system modeling software to simulate how the selected control valve will operate in the completed piping system. Appendix B shows the Schema of the data file exported by the Specification Manager program and Appendix C shows the data structure returned by the Specification Manager program.

The advantages of using piping system simulation software for the selection of control valves lie in its ability to:

- Accurately calculate the control valve requirements for the design flow conditions
- Quickly calculate the control valve requirements for minimum and maximum flow conditions.
- Evaluate how the selected control valve will operate in the piping system model, which will provide accurate indication of how the valve will operate in the total system once operational.

Future Applications

The most effective way to utilize EDE is to eliminate the need for the purchasers and sellers to communicate by paper. This paper centered document process includes the shipping of paper documents, or the e-mailing of electronic documents in PDF format that must be read by a user prior to starting the selection and configuration process.

Many efforts underway utilize a purely electronic format for the information exchange of data sheets, quotes, and specifications between purchaser and seller. The purchaser can create and send their specifications electronically to the manufacturer or seller, who then, with the aid of their equipment selection and configuration software, can assemble their bid package and transmit the data back to the purchaser for review.

In order to take full advantage of this integrated Electronic Data Exchange solution, the following conditions must be met:

- The procurement software must be able to assemble the information supplied by the buyer from diverse users within their organization.
- There must be a means of ensuring that the software fits into the normal workflow of the buyers and sellers. This includes capabilities such as revision tracking and approval control of any changes.
- The information to be exchanged must be defined in a schema that is used by the developers of both control valve supplier and end user software packages.
- There must be a sufficient number of potential users to make the process economically viable.

Data Sheet Centered Selection

As mentioned above, many of the manufacturer's equipment selection programs support the use of XML. By publishing the definition list for their application, along with the ability for each program to create a mapping file for the data to be imported or exported, a manufacturer's selection program is capable of sharing data with other applications.

The data elements in a program are defined by the XML schema. A mapping file used by the exporting program defines the information being exported along with the XML tags that are used by the program importing the data. The major advantage of using XML is that the software developers can modify the operation of their applications without effecting the operation of the other programs. As long as the exporting program exports the information as outlined in the mapping file, the importing program will be able to accept the data.

Using the data sheet centered approach, a manufacturer of a piping system simulation program could export the data to an Excel spreadsheet, as defined by the importing programs mapping file. The control valve data sheets along with a text document outline of the non-data sheet requirements could be sent to the manufacturers on the approved bidders list.

If the control valve supplier receives an electronic document in a form that can be used directly by their selection software, they can:

- Read the data sheets items into their selection program.
- Perform a selection.
- Automatically update the data sheets with the information about the selected control valves.
- Send the completed bid package back to the supplier in electronic form.

The receiver of the electronic purchase specification would still need to read the supplied text file that contains information, such as required materials of construction and shipping instructions, typically not found on a data sheet.

If a valve supplier receives the electronic bid package and does not have an automated process, they can still read all the documents, manually make the valve selection, and complete the data sheets.

The advantages of the data sheet method are:

- Easy implementation using readily available office based software tools.
- The control valve data is placed into a format that can be imported into other applications used throughout the life of the plant
- It is an easily understood, first step, following the traditional workflow, and allowing for valve suppliers that do not have an automation method to participate.

The disadvantages of the data sheet method are:

- Each program requires its own schema along with a mapping file for every program they will be communicating with.
- The non-data sheet values are stored in a text file that still must be read by the recipient to insure all requirements are met.
- There must be a method developed for revision control and it must be ensured that the electronic data is not corrupted in the exchange process.

FIATECH AEX Project

The Automating Equipment Information Exchange (AEX) Project from FIATECH (http://www.fiatech.org/projects/idim/aex.htm) has developed an XML schema for the exchange of information about equipment within capital facilities. The schemas, covering both project and technical information, are designed to support multi-party collaboration of the work process for the entire equipment life cycle, including the design, procurement, delivery, installation, operation and maintenance of that equipment.

The creation of the AEX 1.0 XML schemas has been a joint industry effort involving over twenty-five organizations. The XML schemas are governed by open source licenses and are freely available for general use. This allows various organizations to use the same information at no cost.

Since the XML schema is developed by a committee of equipment buyers and suppliers, a common schema is created that all parties can utilize. One can think of the schema as a vocabulary of terms that can be used, and as long as everyone is using the same schema, the various programs can communicate.

The work done by the FIATECH AEX project is intended to include every item typically found on a purchase specification in the schema. This eliminates the need to attach support documents that must be manually read by the recipient. As one can imagine, this would require an extensive set of terms in the schema, but just like any language, each group only uses a small subset of the total to get their specific task completed.

Phase one of the XML schemas were developed with an object-oriented framework supporting equipment data, process material data appearing on equipment datasheets, procurement data and associated project data. The initial focus of this work consists of indentifying and utilizing:

- Basic equipment information found on equipment lists and bill of materials documents.
- Equipment datasheets for centrifugal pumps and shell and tube heat exchangers.
- Process and construction materials and their associated properties.
- Calculation methods and experimental property data.
- Equipment documents used over the life cycle of capital facilities.

The AEX project has delivered XML specifications, along with detailed object information and example files for control valves and numerous other valve types.

Phase 2 of the AEX project is underway and includes improving the AEX Phase 1 schemas, developing trial implementation of the AEX Phase 1 schemas, and working with NIST on establishing the AEX test.

Building Information Model

Building Information Model (BIM) is another initiative to streamline the exchange of data throughout the life of a capital asset. It is a model-based technology linked with a database of project information. The BIM model typically consists of a 3-D computer model showing the geometry, spatial relations, along with the quantities and properties of building components (i.e. manufacturers' details). Unlike a typical CAD drawing that represents items on the drawing as vectors, a BIM model represents the actual parts and related information used to build the project.

The requirements of the BIM construction documents are extremely robust and include the drawings, along with information about the procurement details, submittal process, and specifications used to design and build the project. Another requirement for the BIM model is that the information about the project is added by all the users through the project life.

For example, when a control valve is entered into a project design, the data sheets, specification, and other referenced data are included in the BIM. Once the control valve is purchased and installed, the manufacturers operation and maintenance manual would be added to the BIM as a reference. During the life of the plant, if maintenance is required on the valve, the valve tag information, the specific location of the valve within the plant, the specification document the valve was purchased under, the operations and maintenance manual, and the maintenance records for that specific valve, can all be viewed in the BIM.

As one might assume, this type of model requires a tremendous amount of storage capability and the integration of a variety of mission critical applications, but promises to significantly streamline and facilitate the process of designing, building, operating and maintaining capital facility systems.

Conclusion

The design, procurement, and purchasing of capital equipment is a very labor-intensive process. To date, many of the advances in streamlining the procurement process of control valves has focused on eliminating the use of actual paper specifications documents and replacing them with electronic documents in PDF format. This method eliminates the physical paper document, but still requires the intervention of individuals for each item that must be specified.

The introduction of piping simulation software, equipment selection software, and equipment configuration software packages has made it much easier for all parties involved with the design of capital projects to streamline their repetitive tasks, but the entire process is still based on the paper document that must be interpreted by an individual.

The next major step in streamlining the design, procurement, construction, and operation of large capital projects will provide everyone with the ability to quickly access any necessary information from a single location. This will require a major commitment by all parties involved, but the advantages of the exchange of electronic information through the life of the plant will more than justify the investment.

Appendix A – ISA Data Sheet for Control Valves

ISA S20.50, Rev. 1 — CONTROL VALVE DATA SHEET — Second Printing

ISA	PROJECT ____ UNIT ____ P.O. ____ ITEM ____ CONTRACT ____ *MFR. SERIAL	DATA SHEET ____ of ____ SPEC ____ TAG SI - FCV - 23 DWG ____ SERVICE ____

1 Fluid 20% Ethelyne Glycol — Crit Press PC

			Units	Max Flow	Norm Flow	Min Flow	Shut-Off	
2	SERVICE CONDITIONS	Flow Rate	m^3/hr	100	80	30	—	
3		Inlet Pressure		2.14	2.79	3.56	3.68	
4		Outlet Pressure	bars	1.83	1.78	1.78	1.70	
5		Inlet Temperature	C	5	5	5		
6		Spec Wt/Spec Grav/Mol Wt	KG/m^3	1029	1029	1029	—	
7		Viscosity/Spec Heats Ratio	cP	2.55	2.55	2.55	—	
8		Vapor Pressure P_V	bars	.0085	.0085	.0085	—	
9		*Required C_V					—	
10		*Travel	%				0	
11		Allowable/*Predicted SPL	dBA	/	/	/	—	
12								

13	LINE	Pipe Line Size In 100 mm sch. 40	53	ACTUATOR	*Type ____
14		& Schedule Out 100 mm sch. 40	54		*Mfr & Model ____
15		Pipe Line Insulation	55		*Size ____ Eff Area ____
16	VALVE BODY/BONNET	*Type ____	56		On/Off ____ Modulating ____
17		*Size ____ ANSI Class ____	57		Spring Action Open/Close ____
18		Max Press/Temp ____	58		*Max Allowable Pressure ____
19		*Mfr & Model ____	59		*Min Required Pressure ____
20		*Body/Bonnet Matl ____	60		Available Air Supply Pressure:
21		*Liner Material/ID ____	61		Max ____ Min ____
22		End In ____	62		*Bench Range ____ / ____
23		Connection Out ____	63		Actuator Orientation ____
24		Flg Face Finish ____	64		Handwheel Type ____
25		End Ext/Matl ____	65		Air Failure Valve ____ Set at ____
26		*Flow Direction ____	66		
27		*Type of Bonnet ____	67	POSITIONER	Input Signal
28		Lub & Iso Valve ____ Lube ____	68		*Type ____
29		*Packing Material ____	69		*Mfr & Model ____
30		*Packing Type ____	70		*On Incr Signal Output Incr/Decr ____
31			71		Gauges ____ By-pass ____
32	TRIM	*Type ____	72		*Cam Characteristic ____
33		*Size ____ Rated Travel ____	73		
34		*Characteristic ____	74	SWITCHES	Type ____ Quantity ____
35		*Balanced/Unbalanced ____	75		*Mfr & Model ____
36		*Rated C_V ____ F_L ____ X_T ____	76		Contacts/Rating ____
37		*Plug/Ball/Disk Material ____	77		Actuation Points ____
38		*Seat Material ____	78		
39		*Cage/Guide Material ____	79	AIR SET	*Mfr & Model ____
40		*Stem Material ____	80		*Set Pressure ____
41		____	81		Filter ____ Gauge ____
42			82		
43	SPECIALS/ACCESSORIES	NEC Class ____ Group ____ Div ____	83	TESTS	*Hydro Pressure ____
44		____	84		ANSI/FCI Leakage Class ____
45		____	85		____
46		____	86		
47		____			
48		____			
49		____			
50		____			
51		____			
52					

Rev	Date	Revision	Orig	App

*Information supplied by manufacturer unless already specified — ISA FORM S20.50, Rev.1

Appendix B – XLM Schema Map File for Importing Control Valve Data into Piping Simulation Software

Control Valve Import File for PIPE-FLO
File is to be in standard ANSI XML format - (file extension .xml)
ExportData tag must be either the first tag or within the first tag

PIPE-FLO Tag	Sample Values	Max Length	Notes
<ExportData>			
<Date>	date of valve selection	20	informative for user
<ValveMFR>	Fisher Valve Company	30	required
<Weblink>		60	optional - links valve on FLO-Sheet to manufacturer's website
<ValveBodyType>	ISA standard type names	18	required data
<PressureRating>	Class 300	18	optional data
<ValveModel>	ET	18	optional data
<Description>	Fluted Vane	18	optional data
<CharacteristicTrim>	Linear, Equal Percentage	18	optional data
<GuideStyle>	Standard	18	optional data
<FlowDirection>	Open or Up Close or Down		optional data
<Actuator>	Linear or Rotary		if missing and CV100 exists, assume Linear if missing and CV100 == "--", assume Rotary
<Fs>	positive no		if missing, will assume turbulent flow
<Fd>	positive no		
<Unit>	in or mm or DN		required data, DN is assumed to match mm
<ValveBodySize>			required data
<SeatSize>			if missing, assume equal to body size
<Stroke>			required for linear valves, ignored for rotary valves
Single data values			
<Fl>			if present, uses same Fl at all openings
<Xt>			if present, uses same Xt at all openings

PIPE-FLO Tags	Notes
For Linear actuators:	
<Cv5> <Fl5> <Xt5>	if missing, values at 5% default to half the 10% value
<Cv10> <Fl10> <Xt10>	if missing, values at 10% default to half the 20% value
<Cv20> <Fl20> <Xt20>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv30> <Fl30> <Xt30>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv40> <Fl40> <Xt40>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv50> <Fl50> <Xt50>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv60> <Fl60> <Xt60>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv70> <Fl70> <Xt70>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv80> <Fl80> <Xt80>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv90> <Fl90> <Xt90>	Cv is required data, Fl required for liquids, Xt required for vapors
<Cv100> <Fl100> <Xt100>	Cv is required data, Fl required for liquids, Xt required for vapors

Appendix C – Typical XLM File with Data Entered for Sample Control Valve


```
<FirstVue>
   <ExportData>
      <Tag ID="1" />
      <ValveMFR>Fisher</ValveMFR>
      <ValveBodyType>Globe</ValveBodyType>
      <PressureRating>CL150/150</PressureRating>
      <ValveModel>A</ValveModel>
      <CharacteristicTrim>Quick Opening</CharacteristicTrim>
      <Fd>0.350</Fd>
      <Unit>Inch</Unit>
      <ValveBodySize>6</ValveBodySize>
      <SeatSize>6</SeatSize>
      <Stroke>2</Stroke>
      <Fl>0.87</Fl>
      <Xt>0.756</Xt>
      <Cv10>158</Cv10>
      <Cv20>318</Cv20>
      <Cv30>437</Cv30>
      <Cv40>505</Cv40>
      <Cv50>547</Cv50>
      <Cv60>572</Cv60>
      <Cv70>589</Cv70>
      <Cv80>600</Cv80>
      <Cv90>606</Cv90>
      <Cv100>606</Cv100>
  </ExportData>
</FirstVue>
```