Allegheny Energy Supply

Performance Testing System

By

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Abstract

In 1996, Allegheny Energy began a program aimed at revising and improving our power station performance testing and monitoring program. As part of this program, we needed a test system that would improve testing accuracy as well as reduce the time necessary for data quantification and results calculations. We wanted a system that was user friendly with the ability to interface easily with PC based software products that are commonly used for performance calculations such as Excel and Pepse. Due to the various types, sizes, and ages of the generating units in Allegheny Energy; versatility was of paramount importance.

Portability was also a consideration, as we decided that the corporate performance group would be responsible for the system that would be shared between the different power stations as needed. We decided to use a Fisher Rosemount Delta V system and associated field equipment to accomplish this task. This paper will describe the reasoning behind our choosing this particular system, its implementation, and its use.

History of Performance Testing at Allegheny Energy

Allegheny Energy's service territory is located in parts of Pennsylvania, West Virginia, Maryland, and Ohio. An unregulated arm of our company also markets generation on the wholesale and retail markets. Twenty-four fossil-fired units located in ten power stations throughout our service territory provide the bulk of our generation. We also have several small hydroelectric stations, partial ownership of a pumped storage project, and two combustion turbines. Our turbines and boilers are of different ages and makes, but our ten supercritical coal-fired units produce over 90 percent of our generation.

Performance testing is not a new concept to our power stations. We have always had a testing program in place at our power stations and have performed many types of tests, from routine enthalpy drop to unit acceptance heat rate tests. As this testing program has evolved, we have accumulated a great deal of valuable information about all of our turbines and boilers as well as associated ancillary equipment.

Our testing program is based on accepted ASME test codes, and is implemented in a manner that best suits our corporate needs. Over the years it has remained flexible enough to accommodate changes in the test codes as well as technological improvements. Testing schedules have been developed and followed for turbines, boilers, feedwater heaters, boiler feed pumps, condensers, and cooling towers. Turbine cycle heat rate tests are run after major turbine outages, and to verify the effectiveness of turbine upgrades.

Results of our testing program have been used as a tool for making cost effective decisions regarding the operation of our units. Successful testing has allowed us to plan maintenance outages effectively and to justify rebuilds and upgrades of many plant components when necessary. Testing has also been used to satisfy regulatory performance audits.

The 'Old' Way of Testing

All of the testing discussed here doesn't just happen. It takes a lot of planning and effort. Prior to our developing a test system, all test readings were taken manually. High-pressure readings were taken from calibrated test gauges. Low pressures and flow differentials were taken from manometers located around the unit. Temperatures were read using milli-volt meters and turbine test thermocouples. The necessary power readings were taken in the control room or from power metering devices installed specifically for the test. A single test could be very labor intensive, especially a full turbine cycle heat rate test. Also, do to the fact that some of this 'older' test instrumentation was not of the best accuracy, the results of some tests sometimes questionable.

Tests often required eight or more people manually taking readings every ten minutes and logging them with paper and clipboard. Each test would typically last two hours, and there could be five or more tests covering the different load ranges. All of the test instrumentation needed calibrated prior to the test. After the test was completed, it took an extensive amount of time for data validation and reduction. The data was then entered into cumbersome mainframe computer programs. Needless to say, all of this amounted to a long turn around time for results. Although it was acceptable at one time, this long turn around time is no longer acceptable in today's competitive market. Often, the plants want the test results the day of the test or soon thereafter. This is especially important when attempting to benchmark performance monitoring systems.

One of the better things to come out of our original testing program is our thermocouple calibration system. A Techne thermocouple calibration oven and bath are used to obtain an error curve for all turbine test thermocouples. This Techne oven uses three RTD's that are calibrated to a SPRT traceable to the National Bureau of Standards. We then determine the error curves of the thermocouples being checked from the average of these three RTD's. These correction curves are later applied to the temperature values acquired during testing. This system was installed in the early 1990's, and its repeatability record over the years has proven its accuracy. We continue to use this thermocouple calibration system today, although due to advances in PC software we are able to use the correction curves in a more efficient manner. A typical correction curve that is generated from this system is displayed in Figure 1.

The 'New' Way of Testing

When we decided to upgrade our testing program, we knew that the program that we had in place was effective, but perhaps technologically outdated by today's standards. Certain technological improvements were needed to bring it up to date. We wanted to keep the established good things about our existing testing program. So, we focused on changes needed to make it more efficient. The best way to test more efficiently was obviously by using an accurate data acquisition system.

Why purchase a data acquisition system for performance testing? First, due to an increasingly competitive electric industry, we needed to test more efficiently with a faster results turn around time. Second, there would be fewer man-hours required for instrumentation set-up and calibration with a new data acquisition system. Third, the availability of PC based performance software made the mainframe computer programs obsolete. Also, most of the people who wrote and used the mainframe programs are no longer available for support. Fourth, we needed an accurate system that was capable of ASME code testing. Finally, we wanted a reliable way of benchmarking our PMAX on-line performance monitoring systems that were being installing on most of our units.

Our vision was to purchase one system that could be moved between our various power plants, as it was needed. The reason for doing this, rather than providing each unit with its own system, is three-fold: First, it costs less to purchase one system than twenty-four. By concentrating our efforts on a single system, we were able to purchase instrumentation of the best accuracy available. Second, it was important that the central performance group had control over the system, and its use, from a calibration and quality control aspect. Finally, since each unit was getting a PMAX system anyway, we planned to use this system for a benchmarking tool. Once the initial operation of PMAX was verified the test system need be on site only for periodic checks.

Much thought went into the design of our test system. Since the system would be shipped to each of our stations, it had to be portable and rugged. Also, the system would have to adapt easily to the various sizes, ages, and layouts of our different units. Since time and labor are an issue, it would need to be equipped for quick set-up and tear down. Also, the test system needed to be equipped with instrumentation that was more accurate than standard power plant instrumentation.

Since the accuracy of test instrumentation directly affects the quality of test results, we wanted the best instrumentation available. Its accuracy would have to be at least good enough to meet the requirements for an ASME code test, better if possible. We desired digital communication between the system and it's associated field devices to eliminate the error associated with A / D conversion. A user-friendly interface was important so that plant personnel could adapt to it quickly. Also, the system had to be capable of continuous data logging for periods of up to twelve hours.

Once we decided what tools were necessary, we set out to find the appropriate equipment for the job. We met with different vendors and discussed our options. We even considered purchasing hardware and writing a user interface ourselves, but time and personnel limitations prohibited this. Finally we awarded the job to the equipment vendor who best fit our requirements for the system. Engineering and field support capabilities were also considered.

The 'Delta V' Test System

The system that we chose uses a Fisher Rosemount Delta V control system hardware and user interface as its backbone. At that time (late 1996) the Delta V system was new to the market, and ours was actually one of the first Delta V systems sold. It does have all of the capabilities of a control system, although we do not use it for control. Our interest is in its data gathering abilities and its user friendly software interface. The Delta V best met all of our requirements, and the Fisher representative was able to package it in an acceptably portable manner.

The system itself is divided into three self-contained units each capable of 32 analog or hart inputs for a total of 96 inputs. Any combination from one to three of the units can be used as necessary. Figure's 2 and 3 illustrate two different configurations for the same system at different power stations. Each Delta V unit is powered by 120 volts AC and has an integral 24 volt DC power supply to power its field instrumentation. A Dell Latitude Pentium laptop is used to run the interface software and performance programs. The computer and the Delta V units communicate via Ethernet wiring. All stations have installed an Ethernet backbone to support the Delta V system. We also ship temporary Ethernet wiring with quick connects to assure versatility when needed. One person can easily lift one of the Delta V units.

The pressure transmitters used with the system are Fisher Rosemount 3051 Reference Class transmitters with an accuracy of .05 percent of full scale. Communication with the Delta V is via hart protocol. The pressure transmitters that accompany the system were chosen so that the available ranges would be adequate for testing any of our units. Some of the transmitters are reserved for high pressures (up to 4000 psig), while others are calibrated to the maximum range of 800 psig. Still others are reserved for pressures ranging from 50 psig to 200 psig. Likewise, various ranges of differential pressure transmitters ship with the system for flow readings and low pressure extractions. A barometric pressure transmitter is also used for conversion to psia. (See table 1).

Since Allegheny Energy already had a good way of verifying the accuracy of turbine test thermocouples with our Techne oven, we decided to continue to use our existing fleet of turbine test thermocouples. We purchased Rosemount 3244 smart temperature transmitters that interface these test thermocouples with the Delta V system. Once again, communication between the Delta V units and the transmitters is via hart protocol. (See table 1).

Another advantage of the Delta V system is that, with a quick programming change, a 4 to 20 milli-amp (or other common range) signal can be read. This is a benefit on the occasions that we need to collect data from existing plant instrumentation.

The Delta V software interface is very user friendly. It is versatile in that it is easy to change input configurations to suit our different generating units. Once a unit is tested its profile is stored in the laptop computer. When we return to that same unit, the profile is downloaded and the transmitters are connected accordingly. Training sessions on the use of the system were held for plant performance engineers and technicians. Presently, most plants have personnel capable of setting up and using the equipment. This is advantageous in the occasion that someone from the corporate performance group cannot attend the test or if the plant needs to use the system for their own purposes, as some plants have found short term uses for the Delta V equipment other than performance testing.

The Delta V software writes the test data to an Excel spreadsheet on one-minute intervals while a test is in progress. This data collection period is variable and can be much faster if needed. But, we have determined that the one-minute interval is sufficient for most testing. We chose Excel based on user familiarity and because there are steam table and other performance add-ins readily available. We can calculate turbine efficiencies immediately upon the conclusion of the test. We can also take snapshots of test data during the test and perform calculations on it, which gives us an idea if the test is going as planned or if there is an unforeseen problem. A convenient and useful trending package is also included with the Delta V software. Performance testing results for turbines, feedwater heaters, boiler feed pumps, boilers and air heaters can be quickly quantified using Excel.

The real advantage of the system is that once the test has concluded data can be quickly imported into Pepse. The test data can then be used in Pepse Special Option 6, as we have benchmark turbine cycle models built for all of our units. We can import data into Pepse soon after the conclusion of the test. Results can be quantified much quicker than in the past, as Pepse is installed and runs on the same laptop computer as the Delta V software.

System Maintenance

Routine maintenance, repairs, and calibrations on the Delta V test system are performed by Allegheny Energy’s central E-Lab. They check the calibration and operation of the entire system twice yearly. Individual transmitters can also have field calibration checks performed by power station personnel as necessary.

Technicians use a Heise precision deadweight tester to calibrate the high range pressure transmitters. Low range pressure transmitters and differential pressure transmitters are calibrated with a Heise handheld pressure calibrator that has interchangeable input modules to accommodate different ranges. The accuracy of both of these instruments is better than the transmitters that they calibrate. Both of these Heise calibration instruments are sent out annually for an accuracy check. As mentioned earlier, we check our turbine test thermocouples with a Techne oven. The E-lab checks the associated temperature transmitters with a precision milli-volt source.

The rational for having our central E-lab perform calibrations and maintenance is primarily so that we have control over the instrumentation. This assures that all units in the system are tested against the same standard. This is an important issue when developing incremental heat rate curves for unit loading purposes.

Conclusion

The Delta V test system has become an integral part of Allegheny Energy's testing program. After three years of use, it is evident that the results of our tests are more repeatable than in years prior to the Delta V system. This indicates that we have indeed improved our test accuracy as well as significantly streamlining the time it takes to produce results. The Delta V system enables us to produce highly accurate turbine enthalpy drop test results in a short period of time. Coupled with the Pepse software, the system enables us to calculate unit heat rates in an accurate and highly efficient manner.

The demand for the use of the Delta V system was so great that we have recently purchased a second complete system. Now, there is less of a rush to get it from one plant to the next, so there is greater test system availability for all of our power stations. The next step planned for both of the Delta V systems is extensive PMAX benchmarking and verification along with necessary heat rate testing.

References

The following references were used in the preparation of this paper:

1. Delta V software Version 4.2, Fisher-Rosemount Systems, Inc., 8301 Cameron Road, Austin, Texas.
2. Pepse Manual Volume I, Version GT 3.1, Scientech Inc., 440 West Broadway, Idaho Falls, Idaho.

Table 1

Delta V System 1 Transmitters

Differential Pressure Transmitters

Serial #	Low Range Value	High Range Value	Units	Label	Tag
0433446	0	200	In. H2O	FW/COND. FLOW DIFF A	DP104
0553071	0	250	In. H2O	none	DP103
0424092	0	750	In. H2O	FW/COND. FLOW DIFF B	DP102
0553072	0	1000	In. H2O	none	DP101

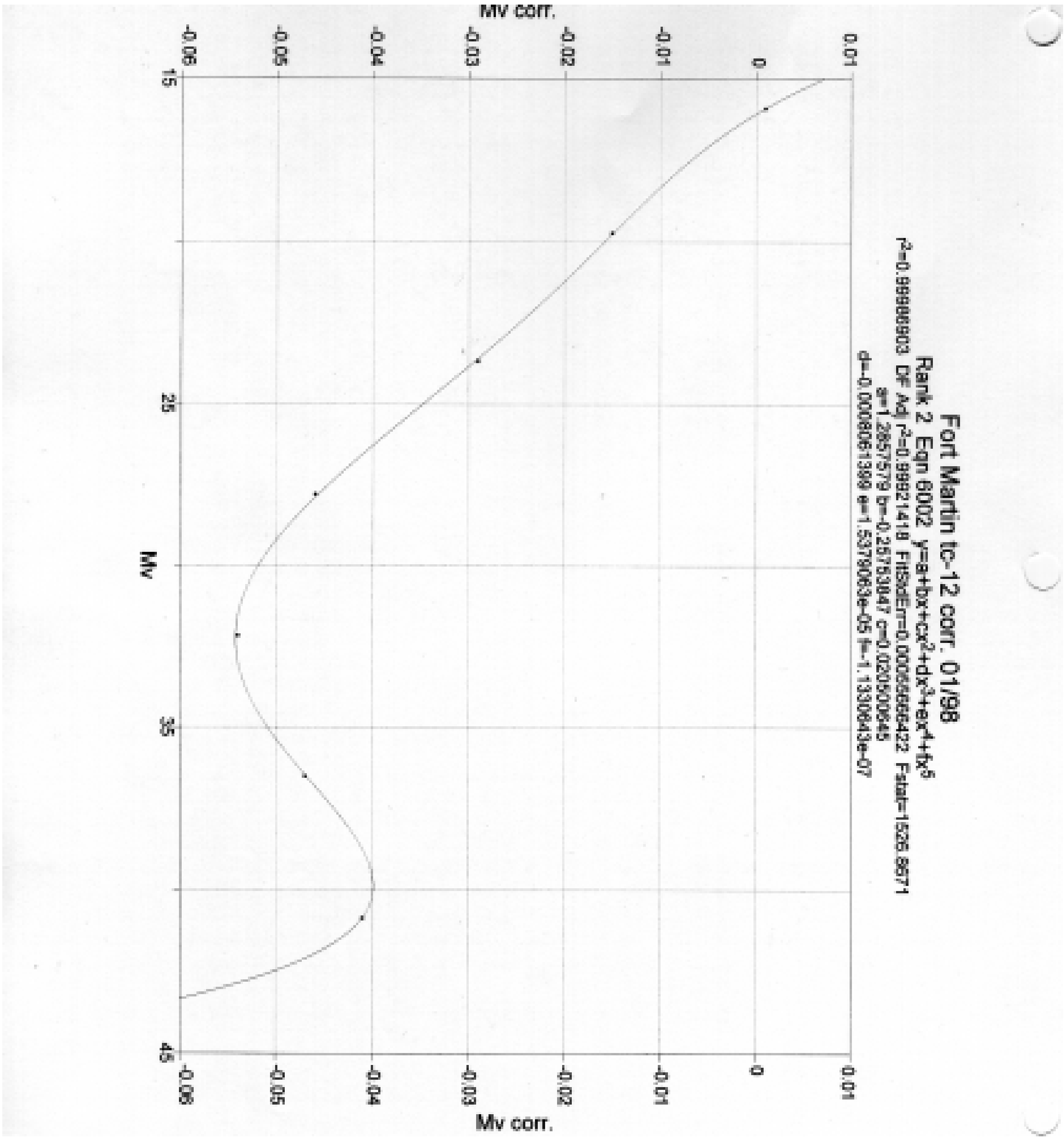
Pressure Transmitters

Serial #	Low Range Value	High Range Value	Units	Label	Tag
0481581	0	3650	PSIG	THROTTLE PRESS.	PT101
0438536	0	3000	PSIG	FIRST STAGE PRESS.	PT102
0424977	0	850	PSIG	COLD REHEAT A PRESS. A	PT103
0424978	0	850	PSIG	COLD REHEAT A PRESS. B	PT104
0424979	0	800	PSIG	HOT REHEAT PRESS. A	PT105
0553073	0	800	PSIG	HOT REHEAT PRESS. B	PT106
0424980	0	400	PSIG	#6 EXTRACT PRESS.	PT107
0424983	0	250	PSIG	5TH STAGE EXTRACT PRESS.	PT108
0424981	0	200	PSIG	CROSSOVER PRESS. A	PT109
0424982	0	200	PSIG	CROSSOVER PRESS. B	PT110
0553070	0	150	PSIG	none	PT111
0586813	0	150	PSIA	Abolute Pressure	PT112

Temperature Transmitters

Serial #	Low Range Value	High Range Value	Units	Label	Tag
0211664	0	55	MV	X-OVER	TT101
0211665	0	55	MV	HOT RH B	TT102
0211666	0	55	MV	COLD RH A	TT103
0211667	0	55	MV	THROTTLE A	TT104
0211669	0	55	MV	HOT RH A	TT105
0211670	0	55	MV	THROTTLE B	TT106
0243476	0	55	MV	SPARE 2	TT108
0243477	0	55	MV	SPARE 3	TT109
0243478	0	55	MV	SPARE 1	TT110
0243479	0	55	MV	SPARE 4	TT111
???	0	55	MV	New Transmitter	TT112

Figure 1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d=-0.0008061389 e=1.5379063e-05 f=-1.1330643e-07
Mv corr.
0.01
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15
25
35
45
Mv

Figure 2

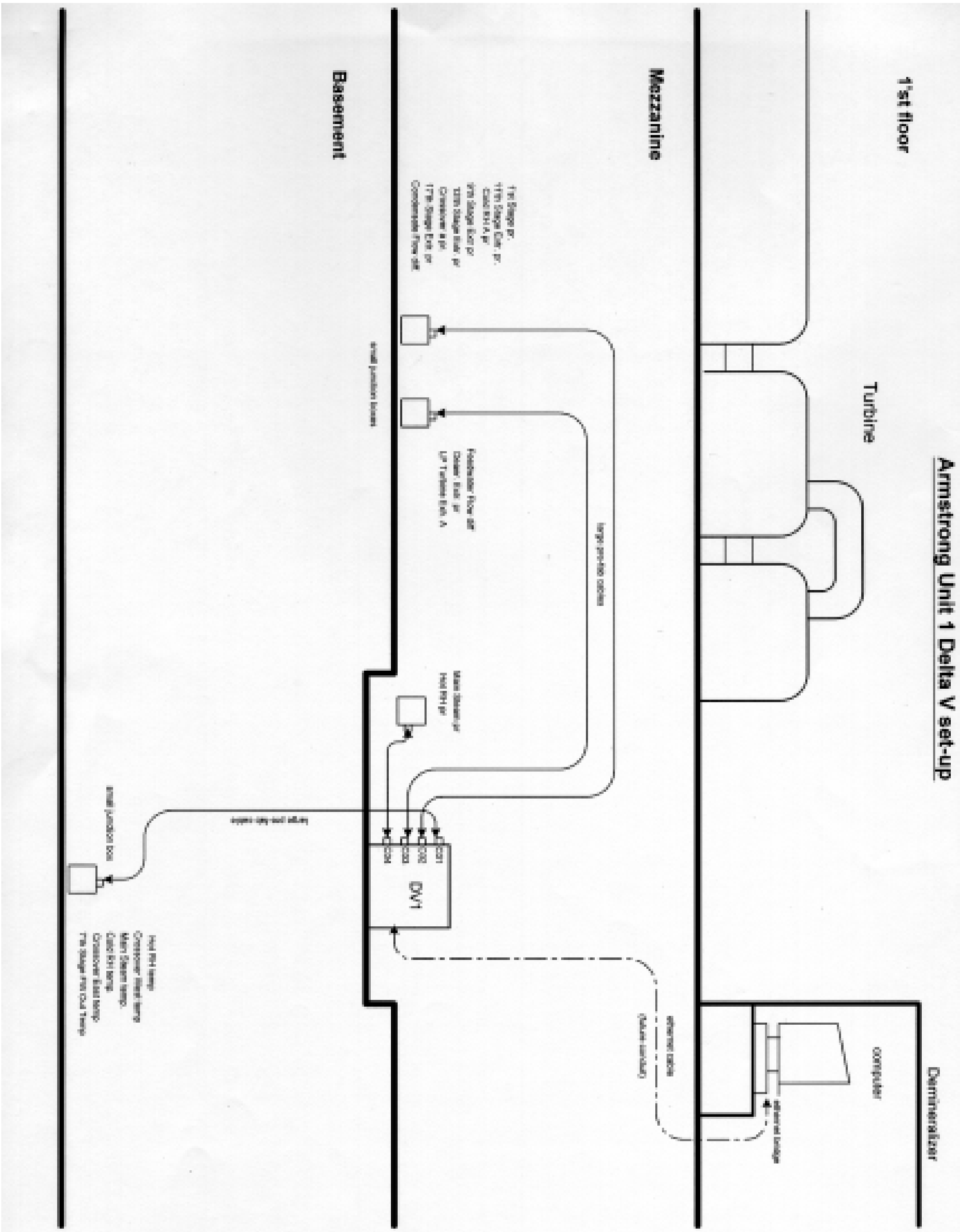
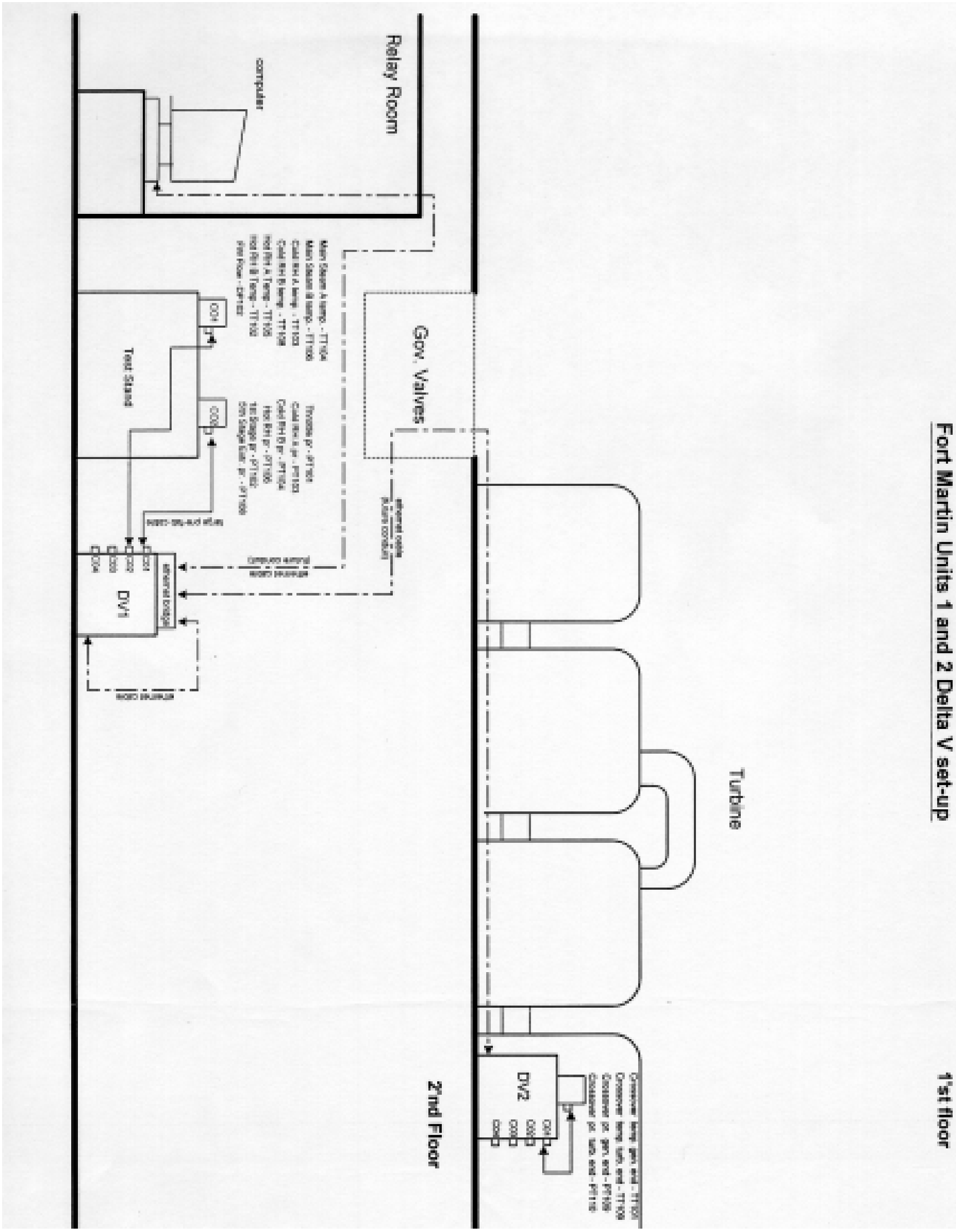

Armstrong Unit 1 Delta V set-up
1'st floor
Turbine
Demineralizer
computer
Mezzanine
Basement
DV1

Figure 3


Fort Martin Units 1 and 2 Delta V set-up
1'st floor
2'nd Floor
Turbine
Relay Room
computer
Gov. Valves
Test Stand
DV1
DV2