555892

Sandia National Laboratories/Carlsbad Programs Group
Waste Isolation Pilot Plant

Data Report for Analysis Plan for Demonstration Test Process: Soil Flume Sixnet Data Acquisition System

AP-148, Rev0

Authors:

Michael Schuhen — 6-7-2011 — Date
Sandia National Laboratories, 6212

Technical Review:

Courtney Herrick — 6/8/11 — Date
Sandia National Laboratories, 6211

QA Review:

Shelly Nielsen — 6-2011 — Date
Sandia National Laboratories, 6210

Management Review:

Christi Leigh — 6-24-11 — Date
Sandia National Laboratories, 6212

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ACRONYMS

A/D	Analog-to-digital
b	Intercept, linear equation
CBFO	DOE Carlsbad Field Office
CD	Compliance Decision
CSV	Comma Separated Value
CV	Control Variable
DAS	Data Acquisition System
DOE	Department of Energy
HMI	Human Machine Interface
Hp	Horsepower
ID	Identification
I/O	Input or Output modules used in the DAS
m	slope, linear equation
mA	milliamp
msec	milliseconds
M&TE	Measurement and Test Equipment
NP	Nuclear Waste Management Procedure
Pa	Pascal
PID	Proportional, Integral, Derivative
psig	Pounds per square inch, gage
PSL	Sandia's Primary Standards Laboratory
PV	Process Variable
QA	Quality Assurance
RTU	Remote Terminal Unit
SEDFlume II	Sedimentary Erosion channel system, version II
SP	Setpoint
TP	Test Plan
WIPP	Waste Isolation Pilot Plant
VAC	Voltage Alternating Current
VDC	Voltage Direct Current

1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Department of Energy Carlsbad Field Office (DOE/CBFO) has directed Sandia National Laboratories to develop an experimental program that will determine the critical shear stress for the initiation of erosion of surrogate waste samples subjected to a hydrodynamic stress. This testing assesses the critical shear stresses that might be experienced as the result of a human intrusion scenario.

The following test parameters will be measured and or controlled by the SEDFlume II system:

- The flowrate of the water through the flume erosion channel. The flowrate when combined with channel dimensions can be used to determine the shear stress applied to the sample.
- The erosion rate of the specimen at its interface with the fluid in the channel by correlating the sample travel over time at a given shear.
- Water conductivity and temperature which verifies the consistency of the fluid used to apply the shear stress to the specimen.
- Specimens that have been developed under various compaction levels designed to simulate the loads expected in the WIPP repository.

To achieve the test objectives, a SEDFlume II system was developed by the SNL WIPP organization. The SEDFlume II system was also referred to as the vertical erosion flume, VEF in TP 09-01, but throughout this report it will only be referred to as the SEDFlume II. This SEDFlume II system differs from previous generations of flume systems in that the SEDFlume II channel was built so that testing could occur in either a vertical or horizontal orientation using the same flume channel. The flow rate would also be controlled by the SEDFlume II data acquisition system (DAS) using closed loop flow control. The advancement of the specimen into the flow stream is accomplished using computer control and the precision displacement is accurately measured by the DAS. By moving to a DAS system and computer interface, several software applications were developed to perform these functions. Additional detail regarding the test objectives and the SEDFlume II design requirements can be found in Test Plan TP 09-01. The plan for validating the performance capabilities of the SEDFlume II DAS system is contained in AP-148, *Analysis Plan for Demonstration Test Process: WIPP Sixnet SixTRAK Data Acquisition Systems*.

1.2 TECHNICAL OBJECTIVE AND SCOPE

This data report documents the results of testing conducted per the steps identified in AP-148, rev 0 and to describe the test procedures and equipment used in the performance of this analysis plan. Furthermore, this report serves to qualify the DAS for acquiring data from the SEDFlume II system. The data acquired from SEDFlume II erodibility testing is used to derive parameter estimates which can be used in WIPP compliance recertification analyses and thus the software used to operate the DAS is considered to be Compliance Decision (CD) software. Qualification of all CD DAS software must meet the requirements of NP 19-1, *Software Requirements*, unless the DAS software is an integral part of an off-the-shelf system and not subsequently modified. Under this exception, DAS software is qualified using the requirements of NP 20-1, *Test Plans*. specifically states that the qualification requirements for off-the-shelf commercial software used without modification are limited to documentation of the software name, version, and hardware for which it is used.

This plan implements a series of test cases to evaluate the operation and performance of the fully assembled SEDFlume II, including both the off-the-shelf software and hardware components. By using this system configuration, an end-to-end assessment can be made directly without relying on inferences drawn from tests conducted on individual components and/or software packages.

Although five test cases were initially identified in AP-148, rev 0 and are listed below, during the final implementation of the plan, Test Case #2 was not performed. AP-148 was written for use in qualifying several DAS systems built using the SixTRAK hardware platform, but each system is customized to accomplish only those functions necessary for the applicable test system. For the SEDFlume II, none of the instrumentation required the use of Signal Value conversion using the equation y = [(Max – Min) * (x / 32768)] identified in Test Case #2.

Initial five test cases are summarized as follows:

1. Evaluated the system's ability to measure an analog input signal, convert the value to an engineering unit using calibration coefficients, and display the feedback at the human machine interface (HMI).
2. Evaluated the system's ability to measure an analog input signal, convert the value to engineering units using Min/Max ranges, and display the feedback at the HMI.
3. Evaluate the system's ability to control/operate devices using an analog input signal as the process variable and for adjusting the output used to drive the control variable. This process is managed using a proportional, integral, derivative (PID) Loop control function in the software.
4. Evaluated the system's ability to let the user enter High and Low alarm limits that when exceeded will notify the operator of an off-normal condition.
5. Evaluates the total system performance in an end-to-end demonstration of the SEDFlume II by eroding a specimen with well understood erosion properties.

Test Case 1 focuses on the ability of the SEDFlume II to measure various types of raw data and convert these raw data to engineering units using simple algorithms and user-supplied coefficients. Test Case 3 demonstrates the ability of the SEDFlume II to perform PID control of the flowrate parameters. Test Case 4 evaluates the HMI software by testing the SEDFlume II's ability to acknowledge user inputs correctly and display alarm limits based on the user input. Finally, Test Case 5 evaluates the complete system under conditions that duplicate the testing of a specimen using materials with well understood erosion properties.

During the performance of the test cases, relevant information including: a list of equipment used, calibration status of instrumentation, operator name(s), date/time/conditions of the test and the data acquired during each test is recorded on the forms (see Appendix C). As appropriate, hand calculations, unit conversions, and data manipulations were performed and the results reviewed, checked, and documented on the standard forms included in Appendix C. This report will receive technical, management, and QA reviews before it is submitted to the Sandia Records Center.

1.3 REPORT ORGANIZATION

Including the introduction, this report is organized into 8 sections, three appendices, and two attachments. The next section, Section 2.0, lists all of the documents that controlled the performance testing activities including test plans (TPs), Nuclear Waste Management Procedures (NPs), and the DAS analysis plan AP-148. Test dates/times, locations and responsible test personnel are listed in Section 3.0. Section 4.0 describes utility software used to evaluate data acquired during the testing and is followed by Section 5.0 which describes, in general terms, the SEDFlume II DAS including software and hardware. Section 6.0 presents the results of the four test cases conducted to assess DAS performance. Next a summary and conclusions are presented in Section 7.0. The report concludes with a list of cited references in Section 8.0, three appendices which contain the program listing, system addressing and test results respectively and finally two attachments, one containing the as-built electrical and mechanical drawings and one containing sketches of the frame and flume channel hardware.

2.0 CONTROLLING DOCUMENTS

Table 1 lists the documents that control the development and testing of the DAS. These documents include: the test plan (TP) that defines the types of data to be acquired during the waste erodibility experiments, applicable NPs, and the DAS analysis plan AP-148. The test plan, Roberts and Herrick (2009) identifies the use of Section 2.0 of NP 19-1, *Software Requirements,* for the qualification of the DAS software and the exception in Section 1.0 which allows for DAS software to be qualified using NP 20-1, *Test Plans*. In addition, because the program only performs simple calculations that can be verified by hand calculations, NP 9-1 *Analyses* process was used to develop and document the plan for validating the functions of the DAS software.

Table 1 Controlling Documents

Document I.D.	Document Title	Applicable Features
TP 09-01, Rev. 0 (July 7, 2009)	*Waste Erodibility with Vertical and Horizontal Erosion Flumes*	Details the test objectives, the parameters to be measured and the general configuration of the test equipment/systems.
NP 9-1, Rev. 8 (November 19, 2009)	*Analyses*	Provides requirement for documenting routine hand calculations needed to verify simple data manipulations, formulae, and unit conversions performed by the DAS software

NP 19-1, Rev 12 (June 21, 2006)	*Software Requirements*	Describes requirements for qualifying off-the-shelf DAS software that is not subsequently modified.
NP 20-1, Rev. 5 (September 17, 2008)	*Test Plans*	Describes requirements for qualifying off-the-shelf DAS software that is not subsequently modified.
AP-148, Revision 0 (May 11, 2010)	*Analysis Plan for Demonstration Test Process: WIPP SIXNET SixTRAK Data Acquisition Systems*	Provides the technical approach for testing the performance of the Sixnet DAS and documenting the results from the testing.

3.0 TEST DATA, LOCATION, AND PERSONNEL

All performance tests were conducted on the SEDFlume II system and DAS installed in the Soil and Sediment Laboratory, Room 804 of the Sandia National Laboratories, Carlsbad, NM facilities. The tests were performed using the SEDFlume II system, instrumentation, hardware and equipment that will comprise the final configuration of the system for the Waste Form Erodibility experiments. The testing was completed on March 23, 2011. The Sandia National Laboratories Carlsbad facility is located at 4100 National Parks Highway, Carlsbad, NM.

The testing was performed by Michael Schuhen (Sandia), Department 6712 and Jesse Roberts (Sandia), Department 6122. Mr. Schuhen served as the DAS design engineer for the system and the author of the analysis plan AP-148 under which the data was collected.

4.0 UTILITY SOFTWARE

During performance testing of the DAS software described in analysis plan AP-148, the only software product utilized in addition to the Sixnet DAS software was Excel Version 2007. Excel was running on a computer using Microsoft Windows XP, Service Pack 3 operating system. The Excel software utilized basic cell math functions to calculate the expected results and test personnel compared these results against the values displayed and recorded from the HMI during the implementation of the software validation plan. Excel was also used to document the test cases described in Section 6.0 (reference Appendix C).

5.0 DATA ACQUISITION SYSTEM DESCRIPTION

5.1 HARDWARE DESCRIPTION

The SEDFlume II DAS was designed to control a flume channel in which specimens would be gradually inserted through an opening in the channel, as a means of measuring the erosion rate while the specimen is exposed to various shear stresses created by the re-circulating fluid. The variables controlled by the SEDFlume II include the flow rate of the re-circulating fluid and the amount and rate at which the specimen is advanced into the channel and exposed to the shearing force. The system is based on a continuous flow design which develops and maintains a stable flow of water that can be equated to a shear stress. The shear stress is determined by the fluid flow rate and the dimensions of the rectangular channel (4.125" x 2.125"). The system is monitored in real time by the data acquisition system to continually assess various test and operational parameters. These parameters include system pressure, fluid temperature and fluid conductivity.

The basic flume channel consists of a clear rectangular Lexan channel of approximately 95" length. The inside dimensions of the channel are 4.125" x 2.125" and the specimen insertion point is located approximately 83.5" downstream from the channel inlet. The flume channel was designed and built by SNL staff from pre-cut Lexan sheets with ½" thickness. The details and dimensions of the fabricated SEDFlume II channel can be seen in sheet 16 of SNL drawing package DWG 09-01. The flume channel is mounted on a frame system developed from a commercial product called 80/20 material. The designed frame is capable of orienting the flume channel either horizontally or vertically depending on the requirements of the testing program. The general frame layout and dimensions is included in the sketch of Attachment II of this report.

All of the control panels, data acquisition system components, and most of the hardware equipment are off-the-shelf items. The primary control panel houses the programmable logic controller, data acquisition I/O, rail table motor control module, and the power supplies for the instrumentation. The data acquisition system is designed around a VT-IPM-241-D programmable controller supplied by Sixnet Corporation based in Clifton Park, NY. Embedded in the processor is a LINUX operating system running on a Motorola Power PC utilizing a 32-bit data bus. This processor is supplied with 512K of retained static RAM memory and 16 megabytes of dynamic memory. The Sixnet VT-IPM-241-D can be programmed using any LINUX-compatible programming software or the system can be programmed using an IEC 61131-qualified code similar to ISaGRAF. For this project, the ISaGRAF programming software was used to develop an application that controls the flow controllers and scales the raw analog signals for display on the HMI. A listing of the ISaGRAF program is contained in Appendix A. The processor is interfaced via an Ethernet to a laptop computer.

For complete details on system layouts, components and electrical schematics for these controls and instrumentation, refer to SNL Drawing package #DWG 09-01-1, sheets 1-16 contained in Attachment I. These drawings represent the as-built configuration of the system during the implementation of this analysis plan.

5.2 SOFTWARE DESCRIPTION

The primary data acquisition computer system was developed to operate on an Intel Core i7 CPU running a Microsoft operating system. For this application, the computer uses Windows XP (Service Pack 3) operating system. In addition, the software described in Table 2 must be installed as part of the overall system. With the exception of the ISaGRAF and Wonderware software, there are no configuration files or custom developed programs involved with these software products. These software products are used to configure the system hardware and to facilitate communication between the DAS hardware and computer. The user is required to develop configurations using functions contained within the applications. These configuration files are subsequently down loaded to the processor or automatically initiated at startup of the computer.

The primary function of the SEDFlume II software is to acquire/measure the raw signal levels from the instrumentation, convert these signals to an engineering unit, and store these data to a file. This function is accomplished using a Sixnet DAS as detailed in SNL Drawing package DWG 09-01, sheets 1-15, provided as Attachment I. The Sixnet input/output (I/O) modules read the voltage or current outputs from calibrated laboratory instrumentation. For voltage or current input signals, the Sixnet I/O reads these values as digital bytes. The Sixnet hardware provides 16-bit resolution; therefore, the raw voltage or current signal from the instrumentation is typically read as -32768 to +32768 bits. The DAS converts these raw signals to an engineering unit using calibration coefficients entered via the HMI by the operator of the system. This HMI software was developed using the Wonderware product series. This plan details the verification of the HMI's interface with the DAS, the accuracy of the DAS in measuring the instrumentation signal levels, the accuracy of the equations used to convert these raw signal values to engineering units, and the storage of these data to a comma separated value (CSV) file.

Both ISaGRAF and Wonderware provide the capability to develop unique applications using their logic tools. For this system, a separate ISaGRAF program was developed (see Appendix B). This program performs the math functions that convert raw data to engineering values and it also controls the flow controllers using manual user inputs. The Wonderware HMI application was developed to interface with the Sixnet DAS and provide a user-friendly HMI from which the system operator can control and monitor the experiments.

Table 2 Software Utilized in SEDFlume II DAS

Software Name	**Version**	**Function**	**Comment**
ISaGRAF	3.47	Program Sixnet RTU (Processor)	ISaGRAF is an IEC61131 compliant off-the-shelf programming package used to develop a program in the RTU which converts the raw values to engineering units and controls humidity and CO_2 concentrations
Sixnet I/O Tool Kit	3.4 or higher	Configure Sixnet Hardware	Sixnet I/O Tool Kit is an off-the-shelf software package that is used to configure the Sixnet hardware. This capability includes configuration of I/O channels, ports, addressing, etc.
Wonderware by Invensys	9.5 or higher	Human Machine Interface	Wonderware is an off-the-shelf software package used by the system operator to create a custom set of

Systems		Software	operator-interface screens that allow the user to view and input parameters to the program running in the Sixnet RTU.
KepWare	4.100.239	OPC Data Exchange	KepWare is device-driver software used during data exchange between the Wonderware HMI software and the Sixnet Universal Driver Resource (UDR) using OPC client protocol.

6.0 RESULTS

6.1 TEST CASE RESULTS

The software validation plan was implemented as detailed in AP-148, with the exceptions as noted. The results were collected and documented in Excel spreadsheets contained in Appendix C. As demonstrated in the spreadsheets, four test cases were successfully implemented and the readings were within the tolerances established in Analysis Plan AP-148. It should be stated that a deviation from AP-148 occurred in that Test Case #2 was not implemented as part of this validation process. AP-148 was written for use in qualifying several DAS systems built using the SixTRAK hardware platform, but each system is customized to accomplish only those functions necessary for the applicable test system. For the SEDFlume II, none of the instrumentation required the use of Signal Value conversion using the equation y = [(Max – Min) * (x / 32768)] identified in Test Case #2 therefore this test case does not apply to the SEDFlume II system.

6.1.1 Test Case 1

Michael Schuhen performed Test Case #1 starting on 03/22/2011. This test case evaluated the conversion of the analog data channels raw outputs to engineering units using the equation $y = mx + b$. The coefficients (m & b) were either derived from the calibration results or the manufacturer's recommended values. The Excel spreadsheet is the tool used to independently verify the calculation performed by the SEDFlume II DAS. The formula in the excel spreadsheet was verified by the technical reviewer as a routine calculation in AP-138 report, issued in April 2008. The results from this test case indicate the error between the calculated values and the values displayed on the HMI were distributed within ±0.044 %. The acceptance criterion for the test case was ±0.5%. This test case was successfully implemented and it meets the acceptance criterion.

6.1.2 Test Case 3

Test case #3 was implemented by Michael Schuhen on 3/22/2011. For the SEDFlume II system, fluid flow rate is the single parameter controlled by the DAS using the PID functionality in the software. The DAS controls the pump motor speed by supplying a 4-20 ma signal to a variable frequency drive which in turn controls the pump motor speed. The flow rate measured by the Endress Hauser flow meter is used as the process variable in the PID loop. The test case was implemented as written and all functions in the PID loop performed correctly.

6.1.3 Test Case 4

Michael Schuhen performed Test Case #4 on 3/23/2011. This test case was developed and implemented as a verification of the system alarms that would be displayed on the HMI. The alarm notifications perform an important function as part of the HMI software. With proper alarm notification, an operator is provided an early warning when conditions exceed normal operating parameters. This warning gives operators the ability to mitigate the condition before it impacts the test or equipment. At this time, only a high pressure alarm condition (> 4 psig) is programmed to shutdown the pump. This safety was required to prevent over pressurization of the SEDFlume II channel. The rest of the alarms provide operator notification, which the operator will then determine if the test should be stopped. In performance of this test, the operator entered either a High and Low alarm set-point for each channel of data. Then a signal was applied to the applicable channel which caused the input value to exceed the high or low alarm limit entered by the operator. Visual observation of the HMI alarm screen was performed to verify the correct alarm was displayed as the signal was adjusted. This observation was annotated on the spreadsheet with an 'OK' entry. All alarms were successfully tested/displayed at the HMI.

6.1.4 Test Case 5

Michael Schuhen and Jesse Roberts performed Test Case #5 on 03/13/2011. This test case was implemented to evaluate the operation of the SEDFlume II system with a specimen that has known erosion properties. Also during the testing of the specimen, the DAS was setup to log the data to memory. A specimen was prepared on site using #4 sand placed inside a 3.124 inch I.D. cylinder of approximately 12" length. The specimen cylinder was inserted into the sample holder on the flume channel and using the rail table motor system the specimen was advanced into the flow stream of the channel. This process was repeated at multiple flow rates (i.e. shear stresses). It was noted that the #4 sand specimen had minimal erosion at shear stresses below 0.35 Pa and that by 0.5 Pa the specimen had consistent erosion occurring. As expected, with increased shear stresses above 0.5 Pa, erosion was near instantaneous.

To document the test case the data was extracted from the data file contained in the Sixnet data logging utility. This data is stored in a *.CSV file format and was imported into an Excel spreadsheet for presentation in this report. In reviewing the printout of the data in Appendix C, the system was able to log the data successfully in each test run. The resulting data displayed in the spreadsheet indicates no changes or impacts to the data. This test case was successfully implemented with no identified impacts to system performance.

7.0 SUMMARY AND CONCLUSIONS

This report documents the results of performance testing described in analysis plan AP-148 conducted to evaluate the capabilities of the DAS (hardware and software) to acquire high-quality data from the SEDFlume II system. As described in the analysis plan, five test cases were identified, of which only test cases 1, 3, 4 and 5 were implemented. Test Case 2 was not implemented as this equation is not utilized by the SEDFlume II software. The test cases performed were designed to assess the DAS' ability to: log analog signals and convert these signals to engineering units, display and store acquired data through a HMI, and display these ranges through the HMI, interpret High and Low alarm limits for control and process variables, and demonstrate the data could be logged reliably. The performance testing concluded with testing of a sand sample with an established erosion rate.

All test cases were successfully completed as planned or with exceptions as noted. Data from the test cases were evaluated against prescribed acceptance criteria. For some test cases, the acceptance criteria were expressed in terms of quantified tolerances. For example, logged converted and displayed data from analog modules needed to be within ±0.5% of reading. For other test cases, the acceptance criteria were simply observations that an event occurred as planned, e.g., an alarm was observed when an alarm limit was exceeded. Using the data acquired during the performance testing, all established acceptance criteria were achieved. Based on the analysis plan requirements and the documentation of test results provided in this report, the Sixnet DAS (hardware and software), as currently configured, meets prescribed acceptance criteria and is qualified for use in WIPP experiments that measure the erosion of surrogate waste samples as detailed in TP 09-01

8.0 REFERENCES

Roberts, J.D. & C.G. Herrick. 2009. "Waste Erodibility with Vertical and Horizontal Erosion Flumes." Test Plan TP 09-01, Rev. 0, Carlsbad, NM: Sandia National Laboratories.

Analysis Plan for Demonstration Test Process: WIPP SIXNET SixTRAK Data Acquisition Systems AP-148, Rev 0. Carlsbad, NM: Sandia National Laboratories.

APPENDIX A

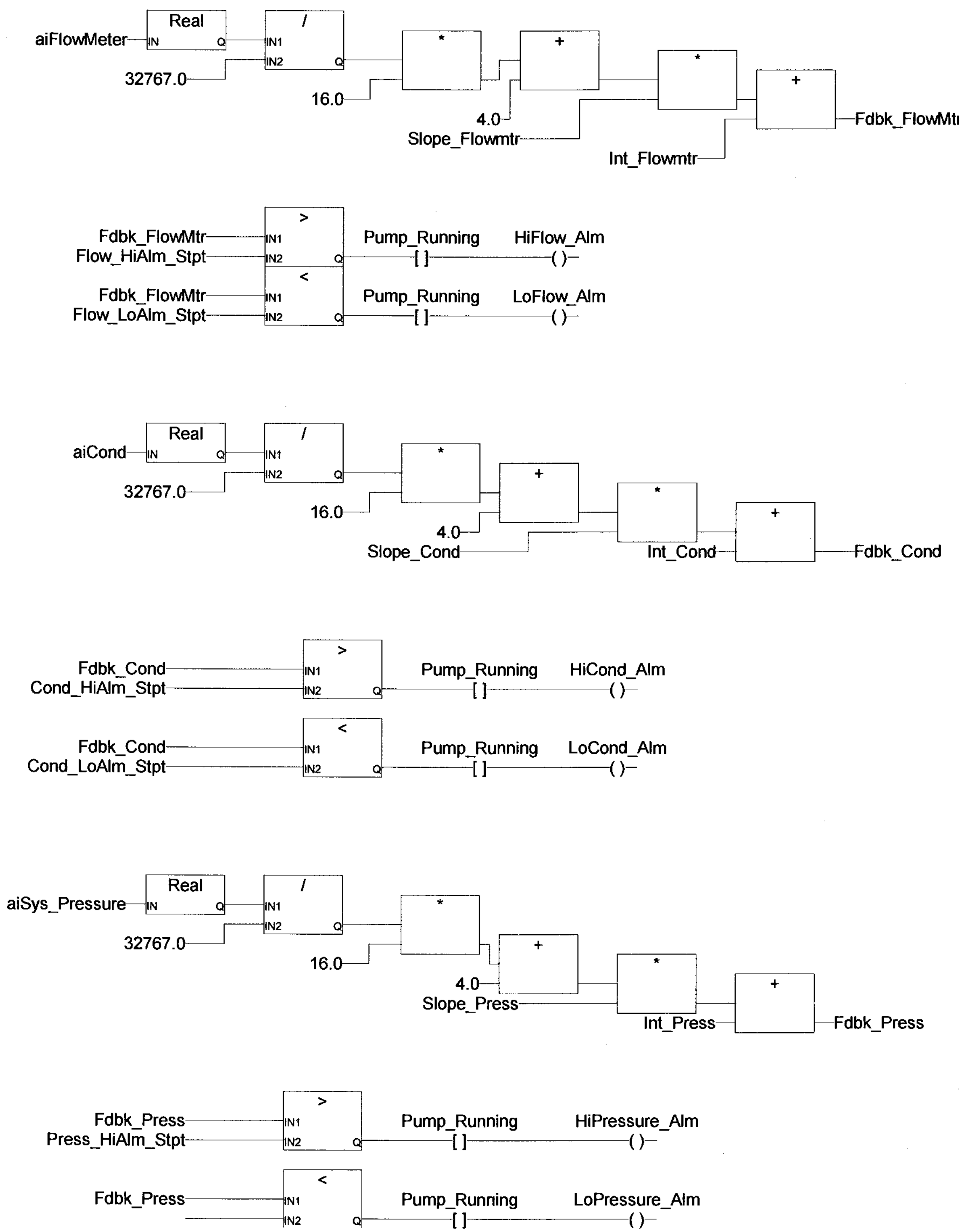
ISaGRAF Program Listing

SIXNET ISaGRAF - SOIL_LAB

5/5/2011	
5/5/2011	

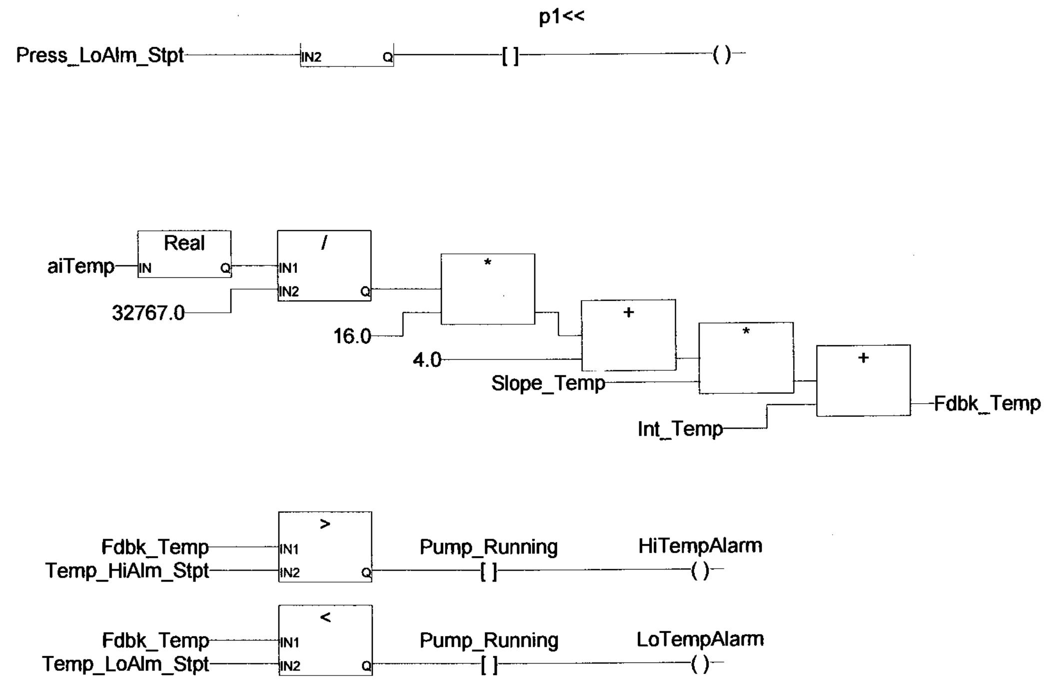
Scaling: Source code

These function blocks are used to scale the raw Sixnet value into an engineering feedback value using User Supplied Slope and Intercept coefficients.



>>p2

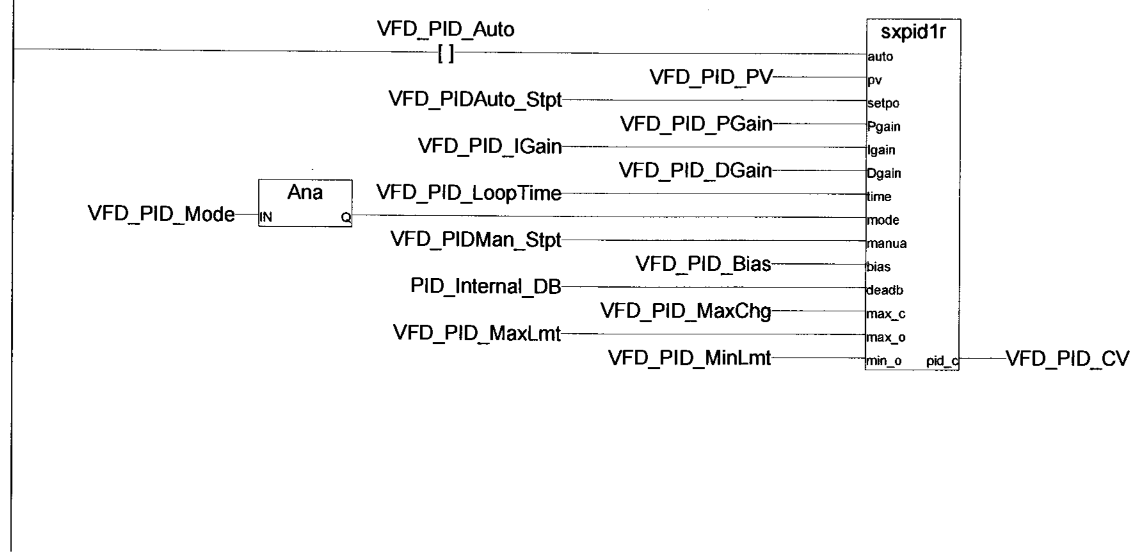
Scaling: Source code



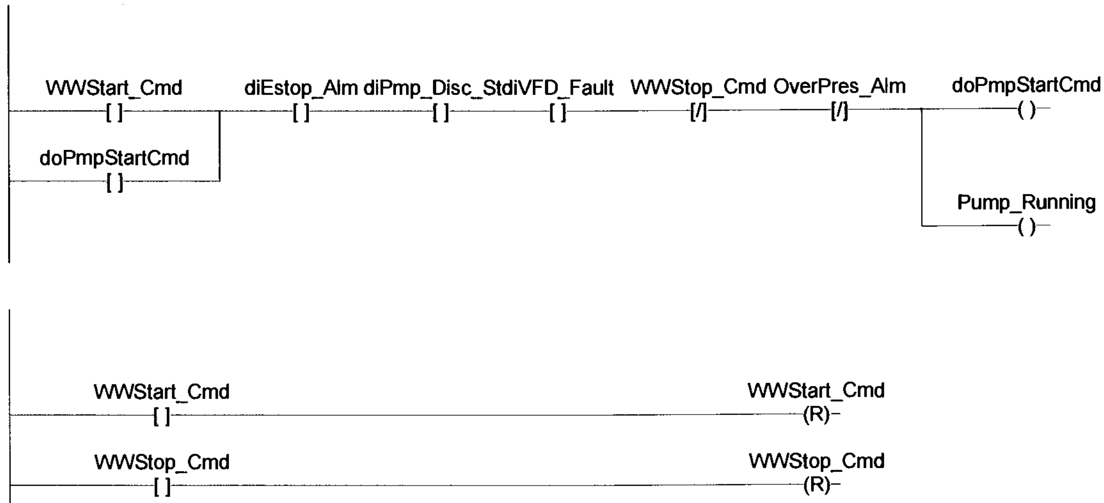
VFD_PID: Source code

Program Contains the Logic to Control the Pumps using a PID Loop in either automatic or manual mode. The PID loop can use either Flowrate or Well Level as the process variable and valve position or pump speed as the control variable.

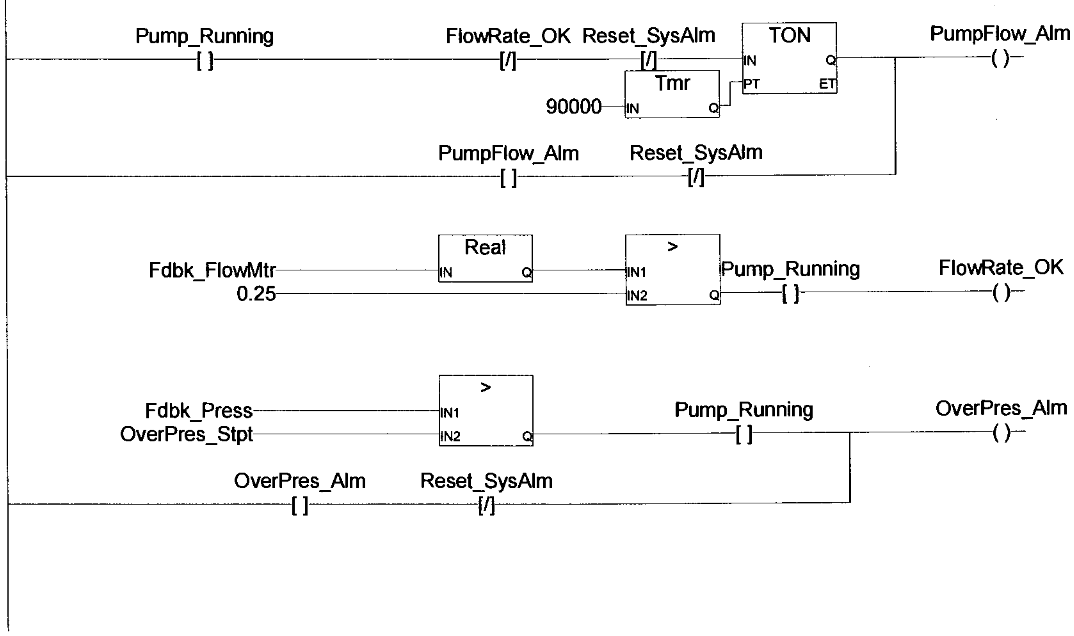
The assignment of the VFD_PID_PV (process variable) & VFD_PID_CV (control variable) are set from program block called Move CMD.



This Program Block contains the logic to perform the Start / Stop function for the pump motor.

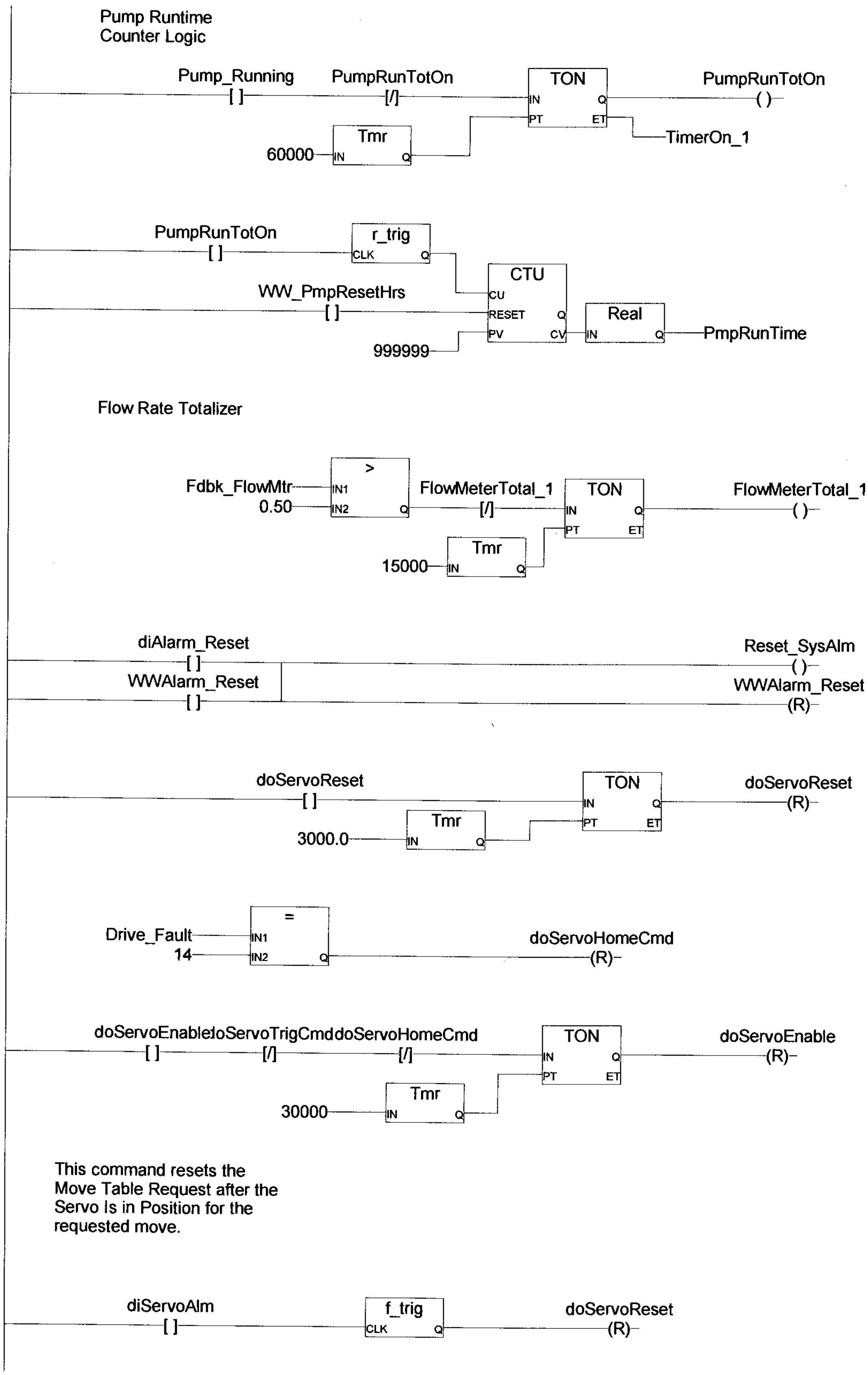


Section develops flow alarms when any pump is running but flow is not



>>p6

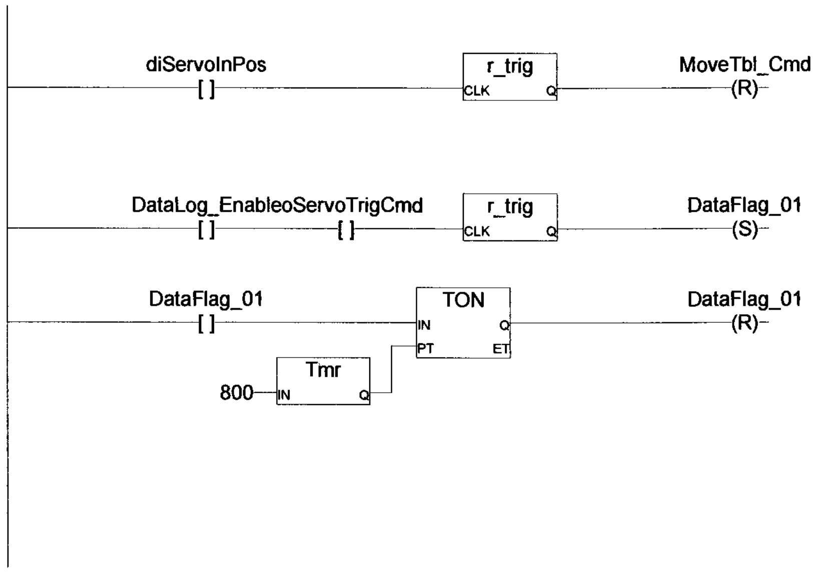
p5<<


Pump Runtime
Counter Logic
Pump_Running
PumpRunTotOn
TON
IN
Q
PT
ET
PumpRunTotOn
TimerOn_1
Tmr
60000
PumpRunTotOn
r_trig
CLK
CTU
CU
RESET
PV
CV
WW_PmpResetHrs
999999
Real
PmpRunTime
Flow Rate Totalizer
Fdbk_FlowMtr
0.50
>
IN1
IN2
FlowMeterTotal_1
TON
Tmr
15000
FlowMeterTotal_1
diAlarm_Reset
WWAlarm_Reset
Reset_SysAlm
WWAlarm_Reset
(R)
doServoReset
TON
Tmr
3000.0
doServoReset
(R)
Drive_Fault
14
=
doServoHomeCmd
(R)
doServoEnable
doServoTrigCmd
doServoHomeCmd
TON
Tmr
30000
doServoEnable
(R)
This command resets the
Move Table Request after the
Servo Is in Position for the
requested move.
diServoAlm
f_trig
CLK
doServoReset
(R)

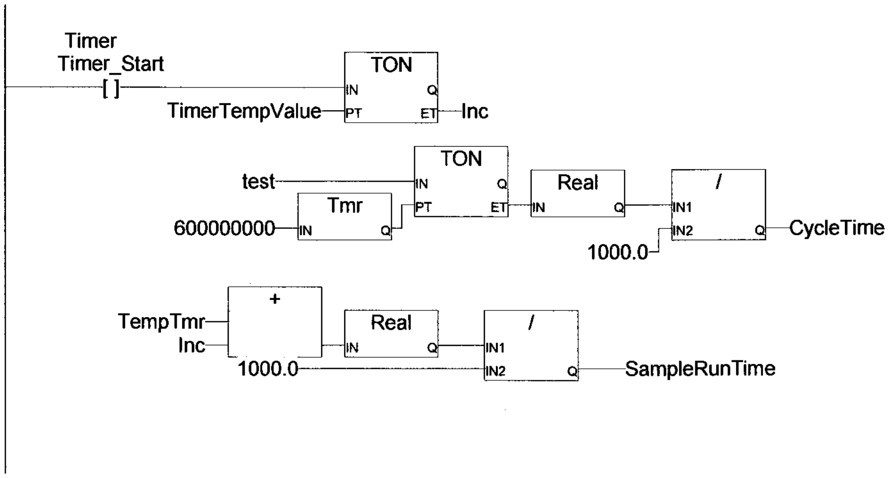
>>p7

PmpCntrl: Source code

p6<<



Timer: Source code



Samples: Source code

```
(*Logic for the Pump VFD PID Control Variables. Assigns 'PV' to
flowrate and assigns 'CV' to VFD Speed.  *)

VFD_PID_PV:= Fdbk_FlowMtr;

aoVFD_Speed:= ANA(VFD_PID_CV*327.68);

aoValv_Cntrl:= ANA(DivertorCmd_Stpt*327.68);

IF VFD_PID_Auto Then
 PID_Internal_DB:= VFD_PID_DB;

Else
 PID_Internal_DB:= 0.0;
End_If;

(*Logic to determine the travel distance request, 10000 cnts of the
encoder = 5.08 mm of travel, the move
command (TotalMove_Cnts) from the GUI must be entered in
millimeters, not inches.  Logic also sets the counts to a
negative number if the direction bit is high, which equals the
reverse direction of the table.  Positive values in the
 Cnts/Rev locations equals a forward direction, negative values
equal a reverse or retract direction*)

If WWTableDirection then

        TotalMove_Cnts:= -1.0* ((Move_Cmd_Total / 5.08) * 10000.0);

        Move_Cmd_Rev:= trunc( TotalMove_Cnts / 10000.0);
        Move_Cmd_Cnts:= TotalMove_Cnts - (Move_Cmd_Rev*10000.0);

Else

        TotalMove_Cnts:= (Move_Cmd_Total / 5.08) * 10000.0;
        Move_Cmd_Rev:= trunc(TotalMove_Cnts / 10000.0);
        Move_Cmd_Cnts:= TotalMove_Cnts - (Move_Cmd_Rev*10000.0);

END_IF;

SetPosCmd_Cnts:= ANA(Move_Cmd_Cnts);
```

```
SetPosCmd_Rev:=  ANA(Move_Cmd_Rev);

(* Logic to Start the Move on the Rail table motor *)

If MoveTbl_Cmd and Not StopTbl_Cmd then

        doServoTrigCmd:= TRUE;


Else

        doServoTrigCmd:= FALSE;
        MoveTbl_Cmd:= FALSE;

END_IF;

(* Calculate the actual distance travel in millimeters by using the
count registers from the rail table encoder*)

Total_Travel:= (Real(TotalPos_Rev) * 5.08) + ((Real(TotalPos_Cnt) /
10000.0) * 5.08);

(* Resets the Clear Command, which is received from the GUI,  to OFF
or FALSE condition after the location
registers have been cleared of their values *)

If doServoClearCmd = TRUE and TotalPos_Rev = 0 and TotalPos_Cnt= 0
and StepPos_Rev = 0 and StepPos_Cnt = 0 then

        doServoClearCmd:= FALSE;

END_IF;
```

APPENDIX B

DAS Address Assignment List

SEDFlume II DAS Address Listing

Tag Name	Station Name	Station Number	I/O Type #	I/O Register #	Data Type
aiFlowMeter	SoilLab_RTU	1	0	0	short
aiDispl_01	SoilLab_RTU	1	0	1	short
aiDispl_02	SoilLab_RTU	1	0	2	short
aiPress_01	SoilLab_RTU	1	0	3	short
aiPress_02	SoilLab_RTU	1	0	4	short
aitemp_01	SoilLab_RTU	1	0	5	short
VFDSpd_230ph3	SoilLab_RTU	1	1	2	short
VFDSpd_230ph1	SoilLab_RTU	1	1	3	short
DivertorVlv_Stpt	SoilLab_RTU	1	1	5	short
diEstop_Alm	SoilLab_RTU	1	10	0	discrete
di120ph1_MtrSel	SoilLab_RTU	1	10	1	discrete
diAlarm_Reset	SoilLab_RTU	1	10	2	discrete
di230ph1_MtrSel	SoilLab_RTU	1	10	3	discrete
diVFD_Bypass	SoilLab_RTU	1	10	4	discrete
di230ph3A_MtrSel	SoilLab_RTU	1	10	5	discrete
diSump_Cntrl	SoilLab_RTU	1	10	6	discrete
di230ph3B_MtrSel	SoilLab_RTU	1	10	7	discrete
diSumpPmp_On	SoilLab_RTU	1	10	8	discrete
diSumpPmp_OL	SoilLab_RTU	1	10	10	discrete
di230_3_3_Disc	SoilLab_RTU	1	10	18	discrete
di230_1_3_Disc	SoilLab_RTU	1	10	19	discrete
di230_1_1_Disc	SoilLab_RTU	1	10	20	discrete
di230_1_3_OL	SoilLab_RTU	1	10	22	discrete
di230_1_3_VFD	SoilLab_RTU	1	10	23	discrete
di230_1_3_Cont	SoilLab_RTU	1	10	24	discrete
di230_3_3_OL	SoilLab_RTU	1	10	25	discrete
di230_3_3_VFD	SoilLab_RTU	1	10	26	discrete
di230_3_3_Cont	SoilLab_RTU	1	10	27	discrete
di230_1_1_OL	SoilLab_RTU	1	10	28	discrete
di230_1_1_Cont	SoilLab_RTU	1	10	29	discrete
di120ph1_OL	SoilLab_RTU	1	10	30	discrete
doAlarm_Lght	SoilLab_RTU	1	11	0	discrete
do230ph3VFDStr	SoilLab_RTU	1	11	4	discrete
do230ph3_MtrStr	SoilLab_RTU	1	11	5	discrete
do230ph1VFDStr	SoilLab_RTU	1	11	6	discrete
do230ph1_MtrStr	SoilLab_RTU	1	11	7	discrete
do120_MtrStr	SoilLab_RTU	1	11	8	discrete
doSumpPmp_Str	SoilLab_RTU	1	11	9	discrete
doSedTbl_Run	SoilLab_RTU	1	11	10	discrete
WWStart_Cmd	SoilLab_RTU	1	11	12	discrete
WWStop_Cmd	SoilLab_RTU	1	11	13	discrete
WWSump_Start_Cmd	SoilLab_RTU	1	11	14	discrete
WWSump_Stop_Cmd	SoilLab_RTU	1	11	15	discrete
WWAlarm_Reset	SoilLab_RTU	1	11	16	discrete
PmpSel_230ph3	SoilLab_RTU	1	11	17	discrete
PmpSel_230ph1_3	SoilLab_RTU	1	11	18	discrete
PmpSel_230ph1	SoilLab_RTU	1	11	19	discrete
PmpSel_120ph1	SoilLab_RTU	1	11	20	discrete
Pump_Running	SoilLab_RTU	1	11	24	discrete
WW_PmpResetHrs	SoilLab_RTU	1	11	25	discrete
PumpFlow_Alm	SoilLab_RTU	1	11	26	discrete

SEDFlume II DAS Address Listing

Tag Name	Station Name	Station Number	I/O Type #	I/O Register #	Data Type
HiFlow_Alm	SoilLab_RTU	1	11	28	discrete
LoFlow_Alm	SoilLab_RTU	1	11	29	discrete
HiDispl_Alm	SoilLab_RTU	1	11	30	discrete
LoDispl_Alm	SoilLab_RTU	1	11	31	discrete
MoveTbl_Cmd	SoilLab_RTU	1	11	34	discrete
StopTbl_Cmd	SoilLab_RTU	1	11	35	discrete
ResetTbl_Cmd	SoilLab_RTU	1	11	36	discrete
Reset_Tbl_Reg	SoilLab_RTU	1	11	37	discrete
ClearSampl_Reg	SoilLab_RTU	1	11	38	discrete
VFD_PID_Active	SoilLab_RTU	1	11	40	discrete
VFD_PID_Auto	SoilLab_RTU	1	11	41	discrete
Table_Auto	SoilLab_RTU	1	11	43	discrete
Timer_Start	SoilLab_RTU	1	11	44	discrete
C_Timer_Reset	SoilLab_RTU	1	11	45	discrete
Timer_Reset	SoilLab_RTU	1	11	46	discrete
Slope_Displcment	SoilLab_RTU	1	23	0	float
Int_Displacement	SoilLab_RTU	1	23	1	float
Slope_Flowmtr	SoilLab_RTU	1	23	2	float
Int_Flowmtr	SoilLab_RTU	1	23	3	float
Sampl_InitLoc	SoilLab_RTU	1	23	6	float
Sampl_FinalLoc	SoilLab_RTU	1	23	7	float
Sampl_Loc_01	SoilLab_RTU	1	23	8	float
Sampl_Loc_02	SoilLab_RTU	1	23	9	float
Sampl_Loc_03	SoilLab_RTU	1	23	10	float
Sampl_Loc_04	SoilLab_RTU	1	23	11	float
Sampl_Loc_05	SoilLab_RTU	1	23	12	float
Sampl_Loc_06	SoilLab_RTU	1	23	13	float
Sampl_Loc_07	SoilLab_RTU	1	23	14	float
Sampl_Loc_08	SoilLab_RTU	1	23	15	float
Sampl_Loc_09	SoilLab_RTU	1	23	16	float
Sampl_Loc_10	SoilLab_RTU	1	23	17	float
Sampl_Travel	SoilLab_RTU	1	23	18	float
StopTravelValue	SoilLab_RTU	1	23	19	float
StartTravelValue	SoilLab_RTU	1	23	20	float
Run_Num	SoilLab_RTU	1	23	21	float
Slope_Press_01	SoilLab_RTU	1	23	24	float
Int_Press_01	SoilLab_RTU	1	23	25	float
Slope_Press_02	SoilLab_RTU	1	23	26	float
Int_Press_02	SoilLab_RTU	1	23	27	float
Slope_Temp_01	SoilLab_RTU	1	23	28	float
Int_Temp_01	SoilLab_RTU	1	23	29	float
Flow_HiAlm_Stpt	SoilLab_RTU	1	23	32	float
Flow_LoAlm_Stpt	SoilLab_RTU	1	23	33	float
Displ_HiAlm_Stpt	SoilLab_RTU	1	23	35	float
Displ_LoAlm_Stpt	SoilLab_RTU	1	23	36	float
DivertorCmd_Stpt	SoilLab_RTU	1	23	38	float
VFD_PIDAuto_Stpt	SoilLab_RTU	1	23	40	float
VFD_PIDMan_Stpt	SoilLab_RTU	1	23	41	float
VFD_PID_PV	SoilLab_RTU	1	23	42	float
VFD_PID_Bias	SoilLab_RTU	1	23	43	float
VFD_PID_DB	SoilLab_RTU	1	23	44	float
VFD_PID_LoopTime	SoilLab_RTU	1	23	45	float

SEDFlume II DAS Address Listing

Tag Name	Station Name	Station Number	I/O Type #	I/O Register #	Data Type
VFD_PID_DGain	SoilLab_RTU	1	23	47	float
VFD_PID_PGain	SoilLab_RTU	1	23	48	float
VFD_PID_IGain	SoilLab_RTU	1	23	49	float
VFD_PID_MaxLmt	SoilLab_RTU	1	23	50	float
VFD_PID_MinLmt	SoilLab_RTU	1	23	51	float
VFD_PID_MaxChg	SoilLab_RTU	1	23	52	float
VFD_PID_CV	SoilLab_RTU	1	23	53	float
VFD_PID_Mode	SoilLab_RTU	1	23	54	float
Fdbk_FlowMtr	SoilLab_RTU	1	23	64	float
Fdbk_Displacment	SoilLab_RTU	1	23	65	float
Fdbk_Press_01	SoilLab_RTU	1	23	66	float
Fdbk_Press_02	SoilLab_RTU	1	23	67	float
Fdbk_Temp_01	SoilLab_RTU	1	23	68	float
Sampl_Travel_01	SoilLab_RTU	1	23	70	float
Sampl_Travel_02	SoilLab_RTU	1	23	71	float
Sampl_Travel_03	SoilLab_RTU	1	23	72	float
Sampl_Travel_04	SoilLab_RTU	1	23	73	float
Sampl_Travel_05	SoilLab_RTU	1	23	74	float
Sampl_Travel_Tot	SoilLab_RTU	1	23	75	float
SamplTrav_Time_1	SoilLab_RTU	1	23	80	float
SamplTrav_Time_2	SoilLab_RTU	1	23	81	float
SamplTrav_Time_3	SoilLab_RTU	1	23	82	float
SamplTrav_Time_4	SoilLab_RTU	1	23	83	float
SamplTrav_Time_5	SoilLab_RTU	1	23	84	float
PmpRunTime	SoilLab_RTU	1	23	90	float
SampleRunTime	SoilLab_RTU	1	23	91	float
CycleTime	SoilLab_RTU	1	23	92	float

APPENDIX C

Analysis Plan Performance Results (Spreadsheets)

AP-148, SEDFlume II Test Case #1

Analog Signal Inputs for 0-10VDC or 4-20ma and Using Equation y = mx + b

Test Case #:	TEST-001 – Analog Signal Conversion using equation y = mX + b		
Platform/OS:	Windows XP 2002, SP #3		Test Plan Reference: TP 11-01
Module I.D.	VtIPM Onboard Analog Inputs (8 Chs), SN: 61488		Date: 3/22/2011
Wonderware Ver:	ver 9.5.1		
ISAGRAF Ver:	ver 3.47		
Description:	Validate analog signal conversion to engineering units using a known calibrated source		
Acceptance Criteria:	The value displayed by the HMI must be with in +/- .5% of the Excel Calculated Value		
Calibrated Source SN:	10641	Cal Due Date: 7/9/2011	Tested By: M. Schhen
			Reviewed By:

Analog Input Channel	Slope (m)	Intercept (b)	Source Sig (vdc or ma)	HMI Feedback	Hand Calc Value	% Delta	Comments
VT mIPM - Ch 1	18.654	-74.514	5.50	28.080	28.083	-0.011	This analog input on the Vt mIPM, Flow Meter connected to this channel. Coefficients m & b derived from the calibration results for the flowmeter.
			8.00	74.720	74.718	0.003	
			12.00	149.320	149.334	-0.009	
			16.00	223.930	223.950	-0.009	
			19.50	289.320	289.239	0.028	
VT mIPM - Ch 2	125.00	-500.00	5.50	187.510	187.500	0.005	This analog input on the Vt mIPM connected to the conductivity meter. Coefficients m & b derived from the range setting of the conductivity meter..
			8.00	499.950	500.000	-0.010	
			12.00	999.790	1000.000	-0.021	
			16.00	1499.740	1500.000	-0.017	
			19.50	1937.930	1937.500	0.022	
VT mIPM - Ch 3	0.757	-0.675	5.50	3.487	3.489	-0.043	This analog input on the Vt mIPM connected to the pressure transducer. Coefficients m & b derived from the calibration results for the transducer.
			8.00	5.379	5.381	-0.037	
			12.00	8.406	8.409	-0.036	
			16.00	11.432	11.437	-0.044	
			19.50	14.083	14.087	-0.025	
VT mIPM - Ch 4	1.500	5.000	5.50	13.2490	13.250	-0.0075	This analog input on the Vt mIPM connected to the temperature sensor. Coefficients m & b derived from the range setting of the temperature probe.
			8.00	16.9990	17.000	-0.0059	
			12.00	22.9990	23.000	-0.0043	
			16.00	28.9980	29.000	-0.0069	
			19.50	34.2550	34.250	0.0146	
VT mIPM - Ch 5	NA	NA					Analog Inputs on the Vt mIPM That is not used for this system
VT mIPM - Ch 6	NA	NA					Analog Inputs on the Vt mIPM That is not used for this system
VT mIPM - Ch 7	NA	NA					Analog Inputs on the Vt mIPM That is not used for this system
VT mIPM - Ch 8	NA	NA					Analog Inputs on the Vt mIPM That is not used for this system

AP-148, SEDFlume II Test Case #3

Analog Signal Output as Controlled by a PID Loop for a Process Variable

Test Case #:	TEST-003 – Analog Signal Output Control via PID Loop Calculation for Control of via a Process Variable				
Platform/OS:	Windows XP 2002, SP #3				
Module I.D.	N/A				Date: 3/22/2011
Wonderware Ver:	ver 9.5.1				Test Plan Reference: TP 11-01
ISAGRAF Ver:	ver 3.47				
Description:	Test the Pump PID loop using the Flowmeter signal as the Control Variable and VFD speed as the Process Variable.				
Acceptance Criteria:	Check or 'OK' text demonstrates acceptance of all values				
Calibrated Source SN:	10641		Cal Due Date:	7/9/2011	Tested By: M. Schuhen
					Reviewed By:
Output Channel	**Parameter**	**Setpoint**	**Measured Output (4-20ma VDC)**	**Results Accepted**	**Comments**
Flow Rate PID Loop	Integral	1.0		√	
	Derivative	1.0		√	
	Proportional	1.0		√	
	Deadband	1.0		√	
	Loop Solve Time	5.0		√	Varied loop solve time between 1 to 5 seconds
	Max. Limit	96.0		√	
	Min Limit	4.0		√	
	Max Change per loop	5.0		√	Varied and tested values between 1 to 5
	Bias	1.0		√	Tested 0 and 1 for bias values
	Automatic Setpoint - % Process Variable	75.0	Value increased from 4 to 20ma	√	
		25.0	Value decrease from 4 to 20ma	√	
	Manual Setpoint (Control Variable Position)	5%	4.812	√	Values increase with an increase in the command from the HMI. The value indicates manual control is working correctly.
		25%	8.025	√	
		50%	11.999	√	
		75%	15.994	√	
		95%	19.190	√	

* The grey area indicate no value was being measured for this input.

Alarm Notification Validation

Test Case #:	TEST-004 – Alarm Verification	
Platform/OS:	Windows XP 2002, SP #3	
Module I.D.	VtIPM Onboard Analog Inputs (8 Chs), SN: 61488	Date: 3/23/2011
Wonderware Ver:	ver 9.5.1	Test Plan Reference: TP 11-01
ISAGRAF Ver:	ver 3.47	
Description:	Validate that High and Low Alarm Limit Logic is functioning properly and the HMI displays the correct alarm messages	
Acceptance Criteria:	The HMI displays an alarm when the alarm threshold values are exceeded	
Calibrated Source SN: Martel SN: 10641	Cal Due Date: 7/9/2011	Tested By: M. Schuhen
		Reviewed By:

Analog Input Channel	High Alarm Limit	Low Alarm Limit	High Alarm Displayed	Low Alarm Displayed	Comments
Flowmter - AI#1	20	2	OK	OK	
Conductivity Sensor - AI#2	1500	100	OK	OK	
Water Temperature - AI#3	30	20	OK	OK	
Water Pressure - AI#4	4	1	OK	OK	
E-Stop Alarm	N/A	N/A	OK	OK	Alarm was active when E-stop engaged
No Flow Alarm	0	N/A	OK	OK	Alarm became active after no flow for 60 seconds
VFD Fault Alarm	N/A	N/A	OK	OK	VFD Fault Alarm Active with loss of power at drive
OverPressure Shutdown	4	N/A	OK	OK	Shuts down the pump

Station:	Flume_RTU								
Sixlog Tag Name:	flume1								
Date and Time	**Sample ID**	**Test ID**	**Move_Cmd Total (mm)**	**Total Travel (mm)**	**Fdbk Flow Meter (gpm)**	**Requested Shear Stress (pa)**	**Fdbk Cond (us/cm2)**	**SIXLOG Record No.**	**Comments**
3/13/2011 8:18	1002	2	0.5	0	25.29	0.25	636.07	138	The changing flowrate was in response to changes made by the operator. Sample was tested at multiple shear stress values as the sample was advanced into the flow stream.
3/13/2011 8:23	1002	2	0.5	1	36.92	0.50	635.76	139	
3/13/2011 8:23	1002	2	0.5	1.5	36.9	0.50	636.56	140	
3/13/2011 8:28	1002	2	0.5	2	54.51	1.00	636.43	141	
3/13/2011 8:29	1002	2	0.5	2.99	54.95	1.00	635.94	142	
3/13/2011 8:37	1002	2	0.5	5.99	55.11	1.00	636.56	143	
3/13/2011 8:39	1002	2	0.5	6.99	78.87	2.00	636.25	144	
3/13/2011 8:39	1002	2	0.5	7.49	80.23	2.00	636.56	145	
3/13/2011 8:39	1002	2	0.5	7.99	80.43	2.00	635.7	146	
3/13/2011 8:39	1002	2	0.5	8.49	80.5	2.00	636.25	147	
3/13/2011 8:39	1002	2	0.5	8.98	80.59	2.00	636.25	148	
3/13/2011 8:39	1002	2	0.5	9.99	80.93	2.00	636.25	149	
3/13/2011 8:39	1002	2	0.5	10.49	81.11	2.00	636.43	150	
3/13/2011 8:40	1002	2	0.5	10.99	80.98	2.00	636.25	151	
3/13/2011 8:40	1002	2	0.5	11.49	80.91	2.00	636.74	152	
3/13/2011 8:40	1002	2	0.5	11.99	80.91	2.00	636.37	153	
3/13/2011 8:40	1002	2	0.5	12.98	80.91	2.00	636.86	154	
3/13/2011 8:42	1002	2	0.5	13.48	54.54	1.00	637.04	155	
3/13/2011 8:42	1002	2	0.5	13.48	54.38	1.00	636.37	156	
3/13/2011 8:44	1002	2	0.5	15.48	54.53	1.00	636.25	157	
3/13/2011 8:46	1002	2	0.5	15.98	69.03	1.50	635.76	158	
3/13/2011 8:47	1002	2	0.5	18.48	81.11	2.00	636.37	159	
3/13/2011 8:47	1002	2	0.5	18.98	81.08	2.00	635.21	160	
3/13/2011 8:47	1002	2	0.5	19.48	81.03	2.00	636.92	161	
3/13/2011 8:48	1002	2	0.5	19.98	81.09	2.00	634.66	162	
3/13/2011 8:48	1002	2	0.5	19.98	81.04	2.00	634.24	163	
3/13/2011 8:48	1002	2	0.5	20.98	81.11	2.00	635.58	164	
3/13/2011 8:48	1002	2	0.5	21.48	81.11	2.00	634.54	165	
3/13/2011 8:49	1002	2	0.5	21.98	91.23	2.00	636.07	166	
3/13/2011 8:50	1002	2	1	24.98	119.37	4.00	633.56	167	
3/13/2011 8:50	1002	2	1	24.98	119.93	4.00	633.56	168	
3/13/2011 8:50	1002	2	1	26.85	120.23	4.00	632.89	169	
3/13/2011 8:50	1002	2	1	27.89	120.28	4.00	631.86	170	
3/13/2011 8:50	1002	2	1	32.98	120.31	4.00	631.49	171	
3/13/2011 8:50	1002	2	1	33.98	120.11	4.00	630.63	172	
3/13/2011 8:50	1002	2	1	34.85	120.11	4.00	631.98	173	
3/13/2011 8:50	1002	2	1	35.87	120.2	4.00	631.49	174	
3/13/2011 8:50	1002	2	1	36.87	120.15	4.00	630.76	175	
3/13/2011 8:50	1002	2	1	36.98	120.03	4.00	628.38	176	
3/13/2011 8:50	1002	2	1	37.98	120.03	4.00	628.25	177	
3/13/2011 8:50	1002	2	1	40.98	120.31	4.00	618.92	178	
3/13/2011 8:51	1002	2	1	41.98	54.68	1.00	637.96	179	
3/13/2011 8:51	1002	2	1	41.98	54.65	1.00	637.23	180	
3/13/2011 8:51	1002	2	1	42.98	54.59	1.00	637.1	181	
3/13/2011 8:54	1002	2	0.5	45.97	57.04	1.00	637.41	182	
3/13/2011 8:54	1002	2	0.5	46.47	55.82	1.00	636.86	183	
3/13/2011 8:57	1002	2	0.5	46.97	55.21	1.00	637.47	184	
3/13/2011 8:58	1002	2	0.5	48.97	80.15	2.00	637.04	185	
3/13/2011 8:58	1002	2	0.5	49.47	80.25	2.00	638.08	186	
3/13/2011 8:58	1002	2	0.5	50.97	80.91	2.00	636.92	187	
3/13/2011 8:59	1002	2	0.5	52.47	80.88	2.00	637.29	188	
3/13/2011 8:59	1002	2	0.5	53.47	80.95	2.00	637.41	189	
3/13/2011 8:59	1002	2	0.5	53.97	81.06	2.00	637.78	190	
3/13/2011 8:59	1002	2	0.5	54.47	81.11	2.00	637.29	191	
3/13/2011 9:00	1002	2	0.5	55.47	81.11	2.00	637.47	192	
3/13/2011 9:01	1002	2	1	58.97	118.48	4.00	634.24	193	
3/13/2011 9:01	1002	2	1	60.97	120.56	4.00	632.83	194	
3/13/2011 9:01	1002	2	1	60.97	119.34	4.00	636.92	195	
3/13/2011 9:01	1002	2	1	64.97	118.28	4.00	633.01	196	
3/13/2011 9:02	1002	2	1	70.97	119.9	4.00	629.96	197	
3/13/2011 9:02	1002	2	1	71.85	119.92	4.00	632.89	198	
3/13/2011 9:03	1002	2	0.5	77.96	54.78	1.00	638.26	199	
3/13/2011 9:09	1002	2	0.5	78.96	54.66	1.00	638.63	200	
3/13/2011 9:11	1002	2	0.5	79.96	54.54	1.00	638.26	201	
3/13/2011 9:11	1002	2	0.5	80.46	54.45	1.00	638.14	202	

3/13/2011 9:13	1002	2	0.5	82.46	81.29	2.00	638.75	203
3/13/2011 9:13	1002	2	0.5	82.96	78.04	2.00	638.33	204
3/13/2011 9:14	1002	2	0.5	84.46	81.23	2.00	638.63	205
3/13/2011 9:14	1002	2	0.5	85.46	81.64	2.00	638.08	206
3/13/2011 9:14	1002	2	0.5	86.45	80.75	2.00	639.24	207
3/13/2011 9:22	1002	2	1	89.95	54.96	1.00	637.23	208
3/13/2011 9:23	1002	2	1	90.95	54.88	1.00	638.57	209
3/13/2011 9:23	1002	2	1	91.95	116.22	4.00	637.29	210
3/13/2011 9:24	1002	2	1	95.95	120.43	4.00	638.45	211
3/13/2011 9:24	1002	2	1	96.95	120.01	4.00	637.1	212
3/13/2011 9:24	1002	2	1	98.95	120.15	4.00	638.63	213
3/13/2011 9:24	1002	2	1	102.94	119.63	4.00	638.75	214
3/13/2011 9:24	1002	2	1	105.94	120.41	4.00	638.45	215
3/13/2011 9:24	1002	2	1	107.94	120.79	4.00	637.04	216
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3/13/2011 14:00	1005	5	1	38.97	119.44	4.00	629.6	384
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3/13/2011 14:00	1005	5	1	43.86	119.4	4.00	630.27	388
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3/13/2011 14:01	1005	5	1	50	119.3	4.00	628.93	393
3/13/2011 14:01	1005	5	1	53.97	119.06	4.00	630.63	394
3/13/2011 14:08	1005	5	1	56.97	119.13	4.00	625.02	395
3/13/2011 14:08	1005	5	1	56.97	119.11	4.00	629.11	396
3/13/2011 15:55	1005	5	20	58.96	0.1	0.00	603.17	397

ATTACHEMENT I

SYSTEM ELECTRICAL DRAWINGS

The attached drawings represent the system as-built configuration at the time of the test. The drawings are numbered DWG 09-01-1, rev 01 with 16 sheets. The drawings have been submitted as controlled documents to the WIPP Records Center.

SANDIA NATIONAL LABORATORIES

Carlsbad, New Mexico

Soils Laboratory Sediment Flume System DAS

TABLE OF CONTENTS FOR DRAWING SET DWG 09-01-1, REV 01

Rev # 01	APPROVAL BLOCK		Effective Date
[illegible]oval	Printed Name	Signature	Date
D[illegible]	Michael Schuhen	[signature]	5-11-11
Checker	Wes DeYonge	[signature]	5/17/11
Safety	Ron Parson	[signature]	5/11/11
QA	Shelly Nielsen	[signature]	5-17-11
Design Eng	Michael Schuhen	[signature]	5-11-11

SUBTITLE

TITLE PAGE

TABLE OF CONTENTS AND TITLE PAGE

SANDIA NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	05/05/2011	SHEET 0 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-0
CAD FILE NAME	DWG 09-01-1			

NO.	CHANGE	BY	DATE
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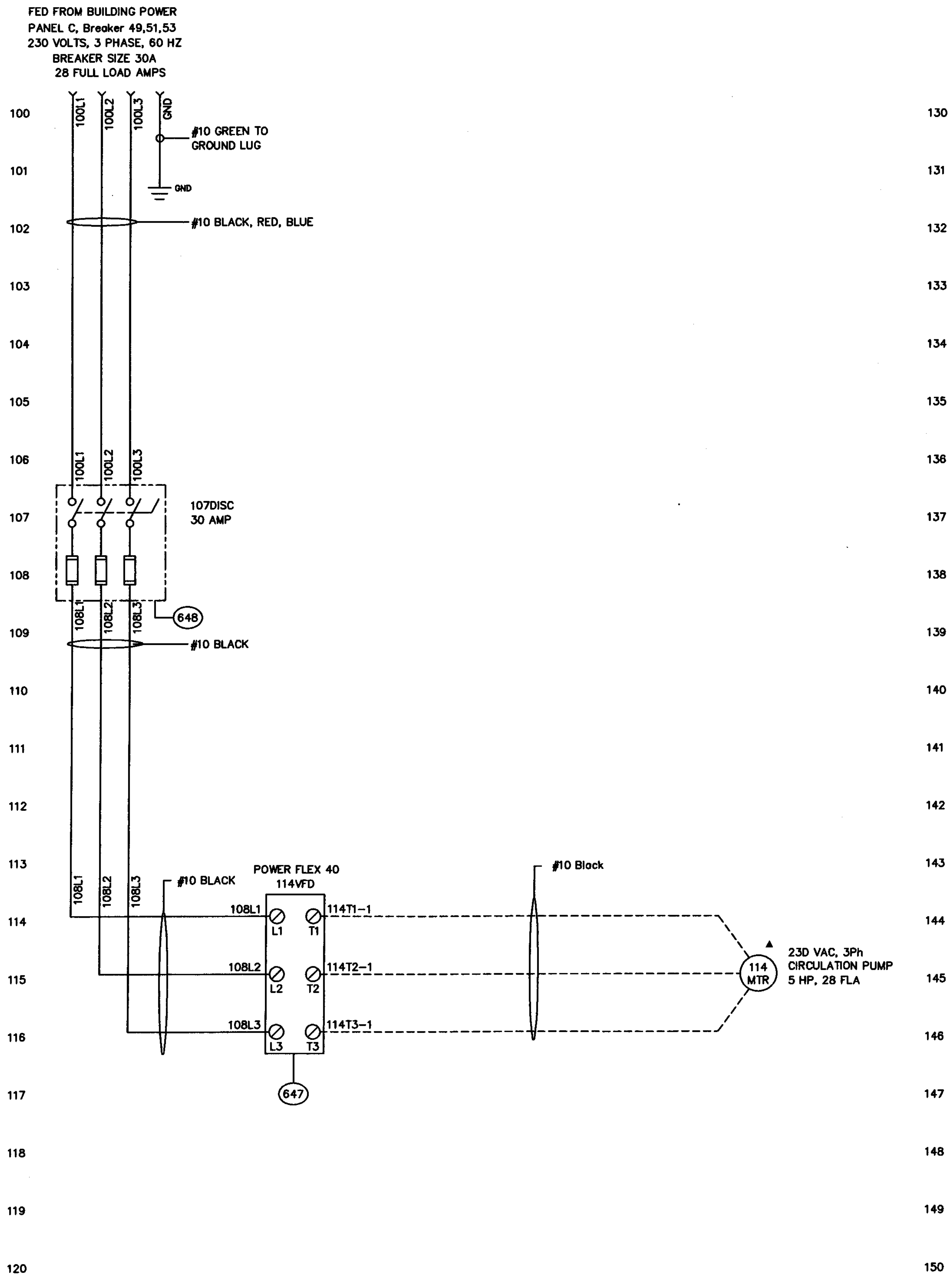
01	Added Breaker Size	MDS	05/05/2011



LEGEND

- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- ---- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

SUBTITLE
MOTOR CONTROL

CIRCULATION PUMP MOTOR
CONTROL AND WIRING DIAGRAM

SANDIA
NATIONAL LABORATORIES

BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN MDS	12/31/09	SHEET 1 OF 16 SHEETS	
APPROVED			DRAWING NO.
DESIGN SOURCE SANDIA			DWG 09-01-1
CAD FILE NAME DWG 09-01-1-01			

NO.	CHANGE	BY	DATE
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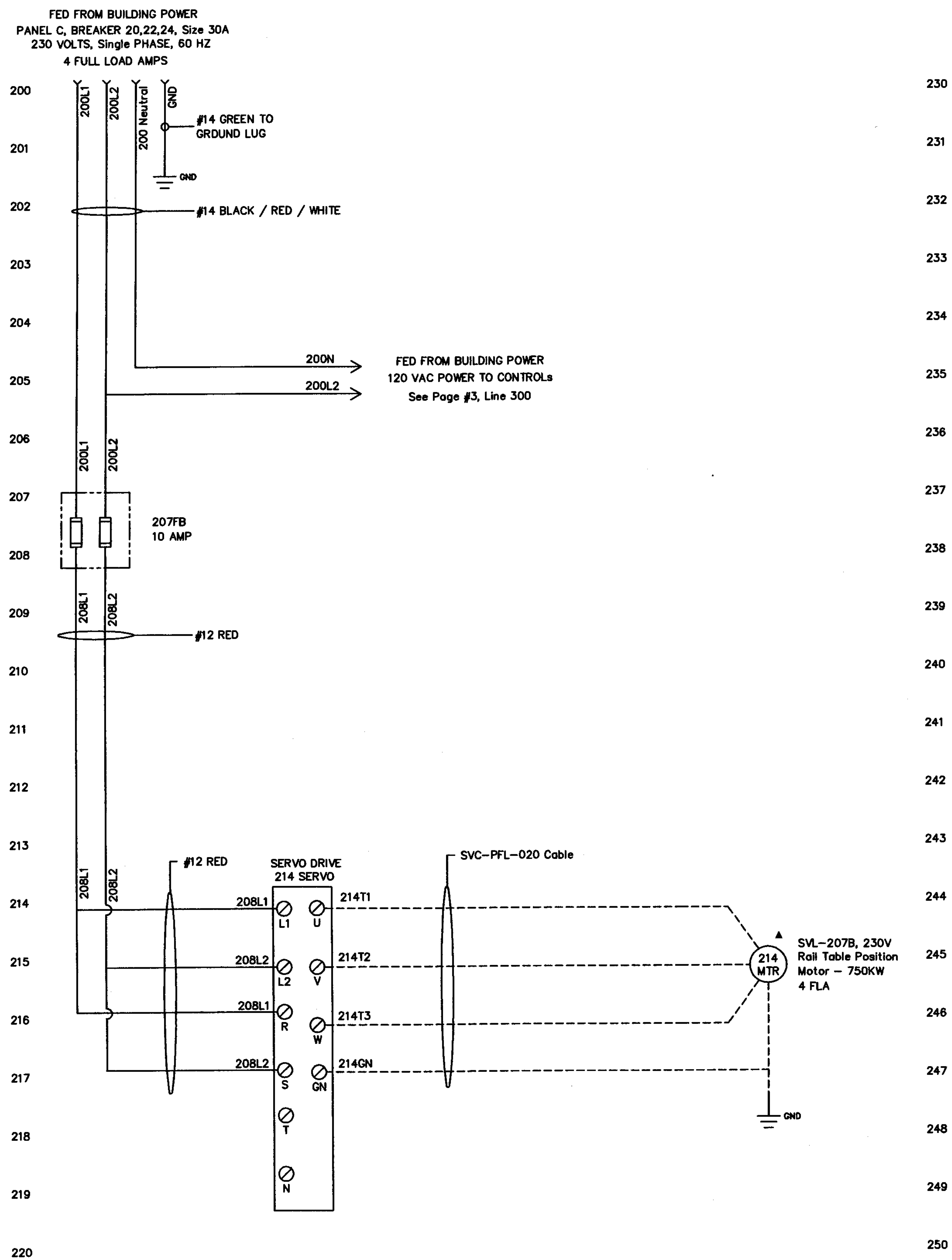
01	Corrected Wiring Sizing, etc		05/05/2011



LEGEND

- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- - - - FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

RAIL TABLE POSITIONING MOTOR

CONTROL AND WIRING DIAGRAM

SANDIA NATIONAL LABORATORIES

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	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	12/30/09	SHEET 2 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-02			

SUBTITLE
RAIL POSITIONING MOTOR

NO.	CHANGE	BY	DATE
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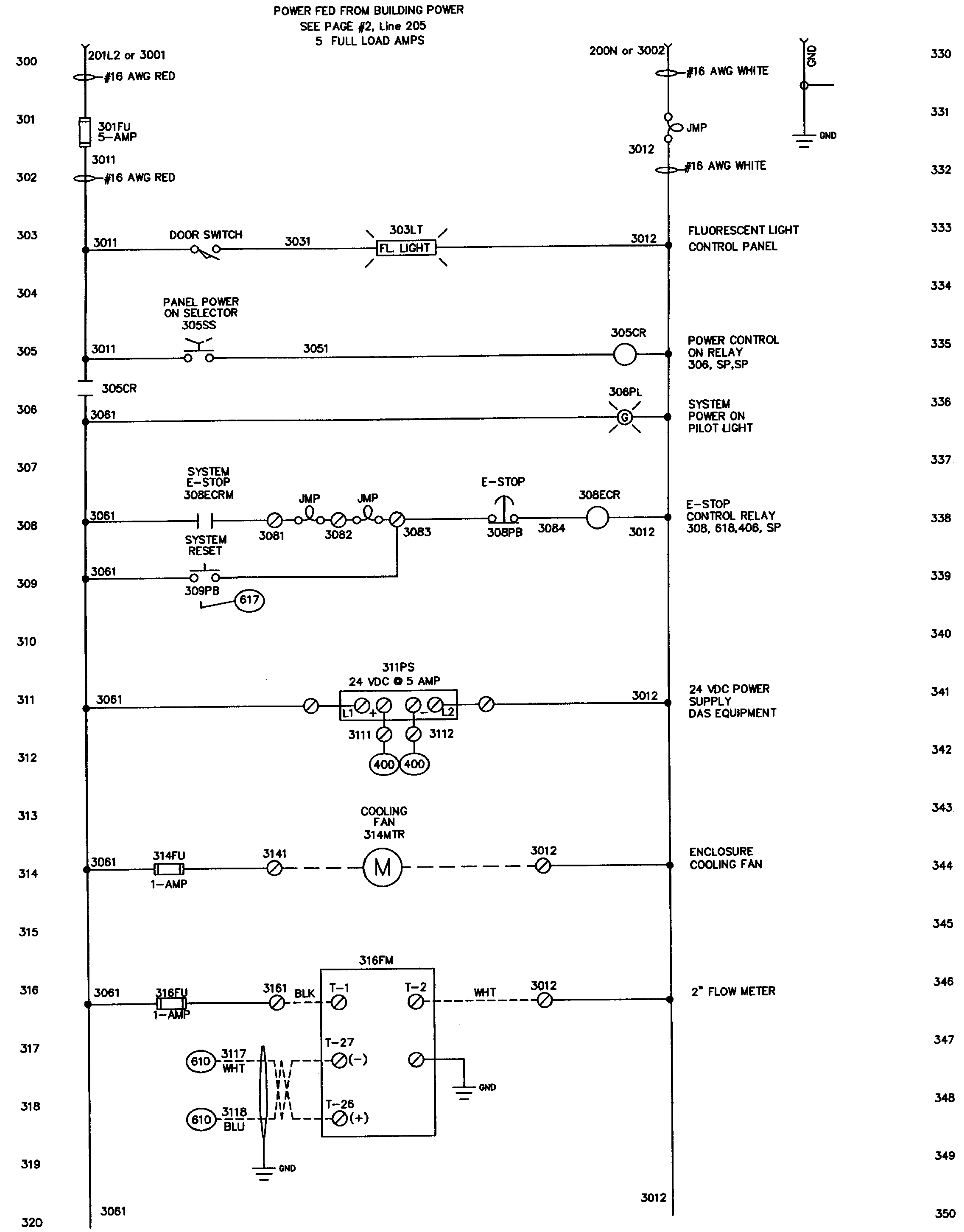
01	Corrected Wire Numbers		05/05/2011



LEGEND
- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- ---- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

120 VOLT CONTROL POWER
WIRING DIAGRAM

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/06/2010	SHEET 3 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-03			

SUBTITLE
120 VAC CONTROL PWR

NO.	CHANGE	BY	DATE
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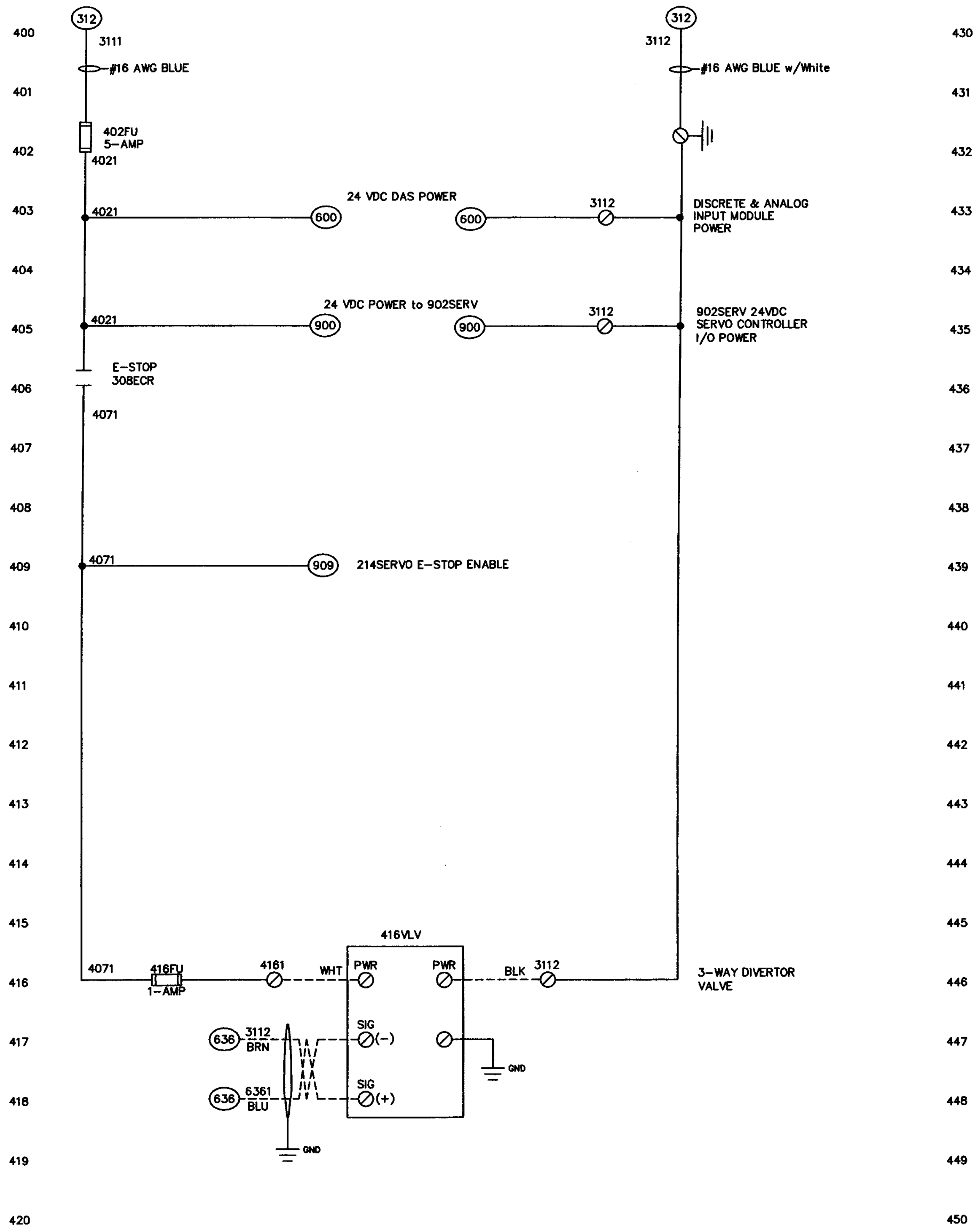

LEGEND

- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- --- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

24 VDC CONTROL POWER
WIRING DIAGRAM

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	12/30/09	SHEET 4 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-04			

SUBTITLE
24 VDC CONTROL PWR

NO.	CHANGE	BY	DATE
00	As-Built		04/19/2010

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LEGEND
▲ LOCATED OUTSIDE THIS PANEL
● ELECTRICAL CONNECTION
TERMINAL
--- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

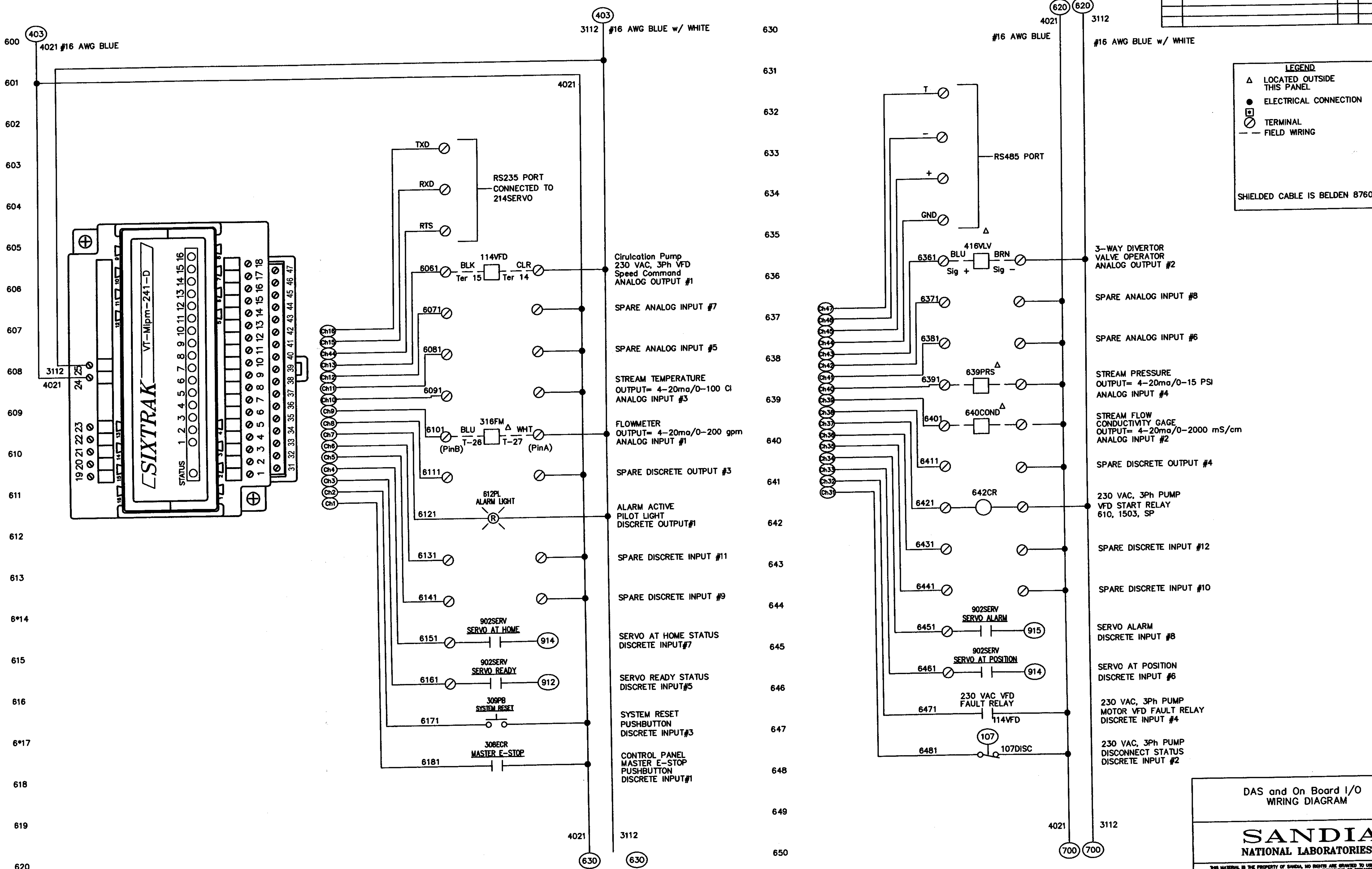
SUBTITLE
SPARE SHEET

SPARE SHEET

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	12/30/09	SHEET 5 of 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-05			

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010
01	Corrected Signal Type for Gage		05/05/2011



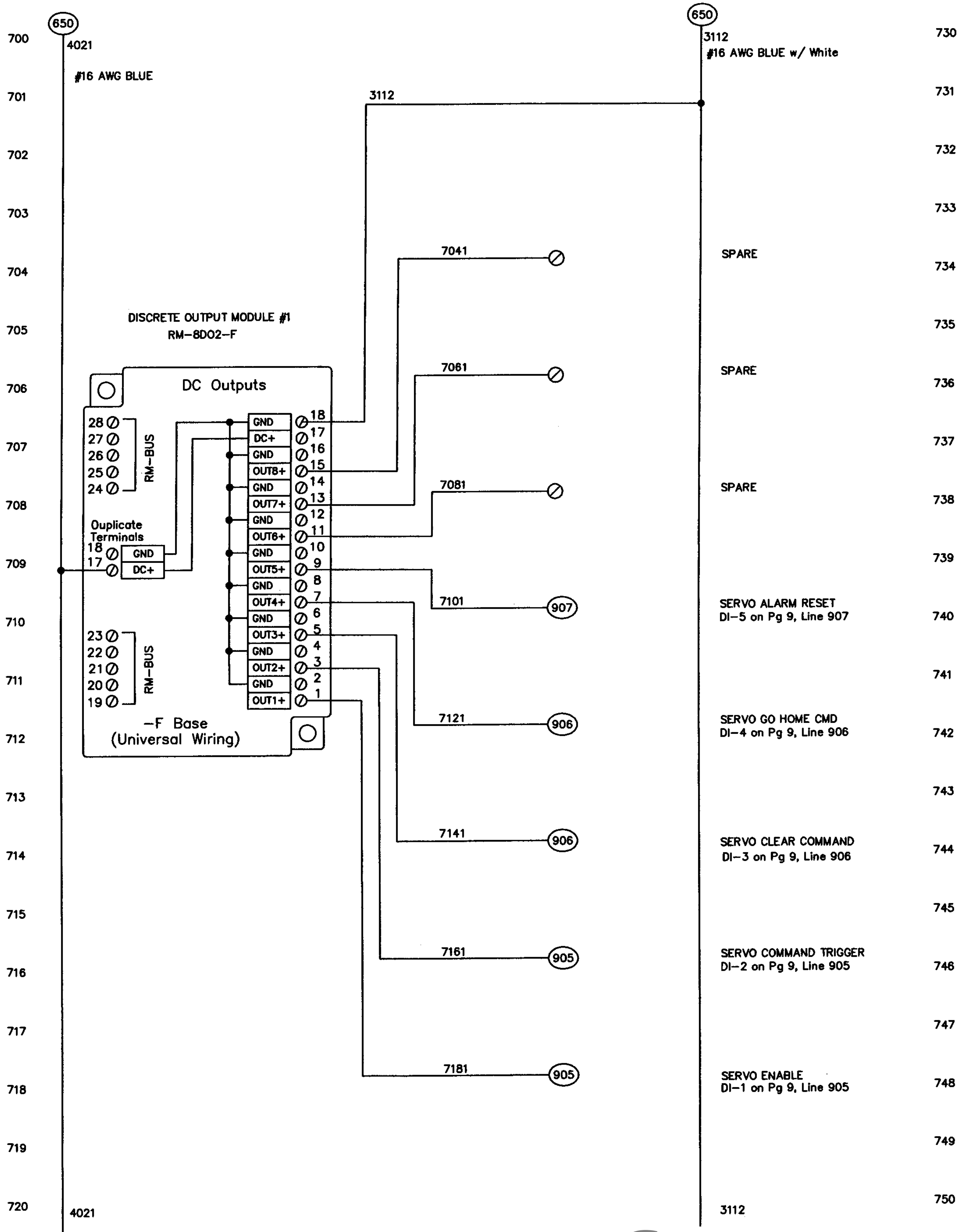
DAS and On Board I/O WIRING DIAGRAM

SANDIA NATIONAL LABORATORIES

DRAWN	MDS	12/23/09	SHEET 6 OF 16 SHEETS	PACKAGE NO.
APPROVED				DRAWING NO. DWG 09-01-1
DESIGN SOURCE	SANDIA			
CAD FILE NAME	DWG 09-01-1-06			

SUBTITLE
DAS and Onboard I/O

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010
01	Corrected Channel Assignments		05/05/2011



LEGEND
- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- --- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

REMOTE MODULE I/O WIRING DIAGRAM

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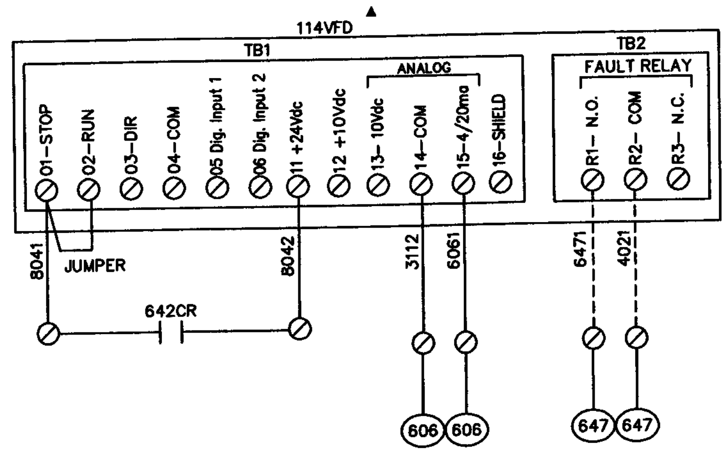
	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 7 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-07			

SUBTITLE
REMOTE I/O MODULES

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010
01	Corrected Wire Numbering		05/05/2011



LEGEND

- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- TERMINAL
- --- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

CIRCULATION PUMP VFD CONTROLLER PARAMETERS

BASIC PROGRAM GROUP

PARAMETER	VALUE OR SELECTION	FACTORY SETTING
P03' MOTOR NP VOLTS	230V	230 OR 460
P032 MOTOR NP HERTZ	60 Hz	60 Hz
P033 MOTOR OL CURRENT	*	0.0
P034 MINIMUM FREQ	30.0	0.0 Hz
P035 MAXIMUM FREQ.	*	60.0 Hz
P036 START SOURCE	2-WIRE	KEYPAD
P037 STOP MODE	RAMP,CR	RAMP,CR
P038 SPEED REFERENCE	4-20ma	DRIVE POT
P039 ACCEL TIME 1 (SECS)	15.0	10.0 SECS
P040 DECEL TIME 1 (SECS)	15.0	10.0 SECS
P041 RESET TO DEFAULTS	N/A	READY/IDLE

REFER TO EQUIPMENT MANUAL TO SET THE ADVANCED PROGRAM GROUP VALUES

DISPLAY GROUP

PARAMETER	VALUE OR SELECTION	FACTORY SETTING
d001 Value of frequency at T1, T2, T3		READ ONLY
d002 Value of the active frequency command		READ ONLY
d003 Output current present at T1, T2, T3		READ ONLY
d004 Output voltage present at T1, T2, T3		READ ONLY
d005 Present DC bus voltage level		READ ONLY
d006 Present operating condition of the drive		READ ONLY
d007–d009 Code that represents a drive fault		READ ONLY
d010 Output freq. scaled by parameter A099		READ ONLY
d012 Source of start command & speed ref.		READ ONLY
d013 Status of control terminal block inputs		READ ONLY
d014 Status of digital terminal block inputs		READ ONLY
d015 Status of the communication device		READ ONLY
d016 Main Control Board software version		READ ONLY
d017 Used by Rockwell Automation Tech		READ ONLY
d018 Accumulated Drive Run Hours		READ ONLY
d019 Value of the function selected in A102		READ ONLY
d020 Value of voltage at I/O terminal 13 (00.0%=10 volts)		READ ONLY
d021 Value of curret at I/O terminal 15 (0.0%=4ma, 100.0%=20ma)		READ ONLY

* NOTE: Unit Programmed to match the full load amp & frequency rating of the pump motor connected to the VFD

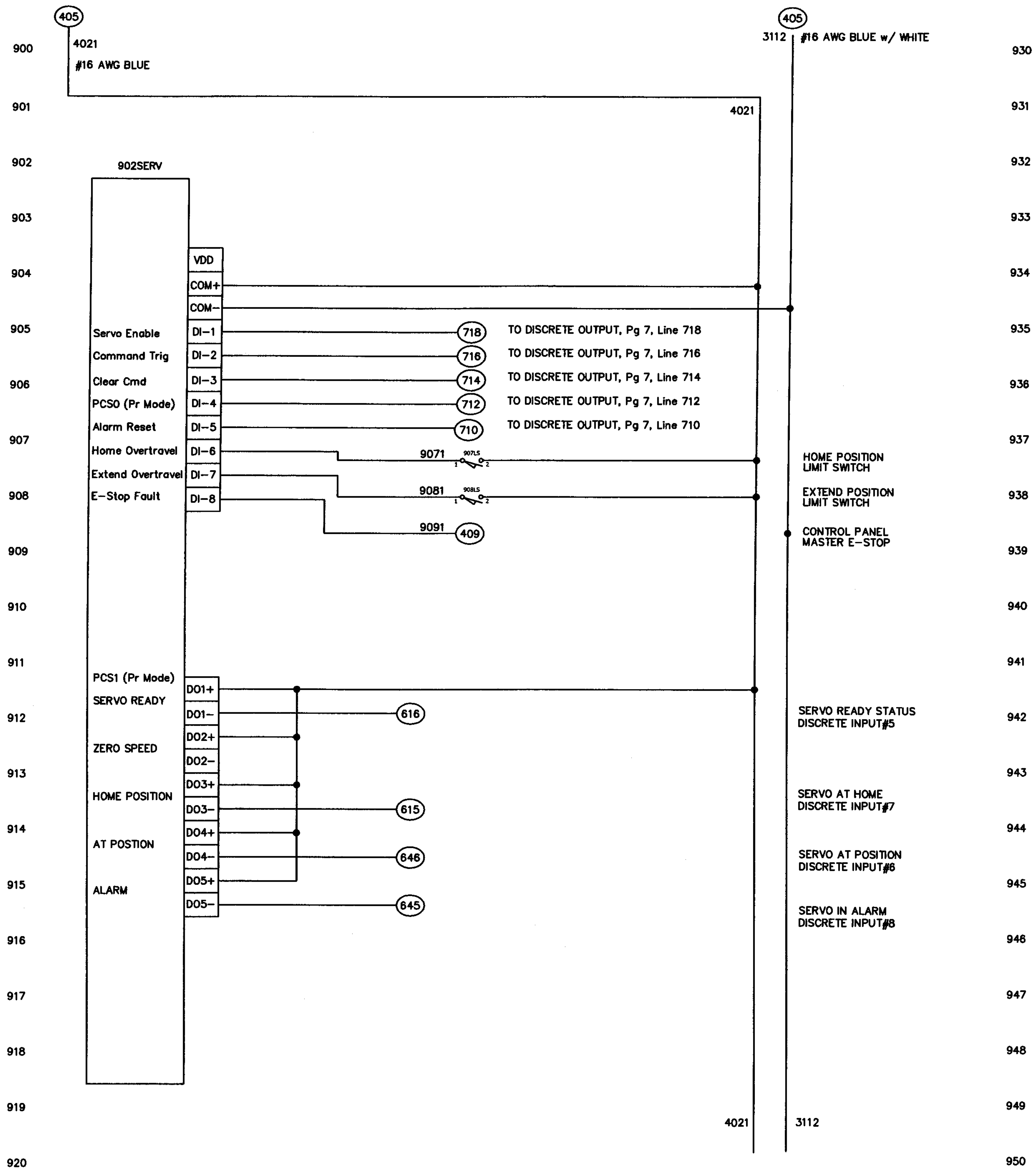
SUBTITLE
VFD WIRING

CIRCULATION PUMP VFD CONFIGURATION & WIRING DIAGRAM

SANDIA NATIONAL LABORATORIES

BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 8 OF 16 SHEETS	
APPROVED				DRAWING NO. DWG 09-01-1
DESIGN SOURCE	SANDIA			
CAD FILE NAME	DWG 09-01-1-08			

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010
01	Corrected Channel Assignments		05/05/2011



LEGEND

- ▲ LOCATED OUTSIDE THIS PANEL
- ● ELECTRICAL CONNECTION
- ⊘ TERMINAL
- --- FIELD WIRING

SHIELDED CABLE IS BELDEN 8760

SPECIMEN POSITIONING CONTROLLER

WIRING DIAGRAM

SANDIA
NATIONAL LABORATORIES

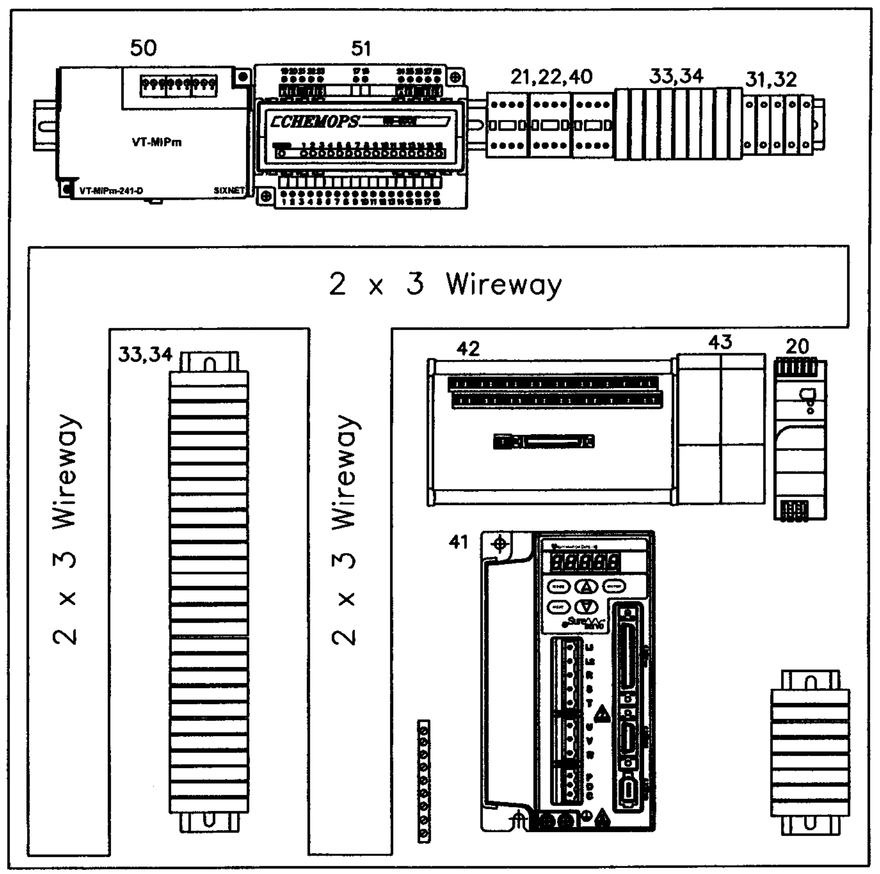
BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	12/23/09	SHEET 9 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-09			

SUBTITLE
Position Controller

NO.	CHANGE	BY	DATE
00	As-Built		04/19/2010
01	Added LED Controller		05/05/2011

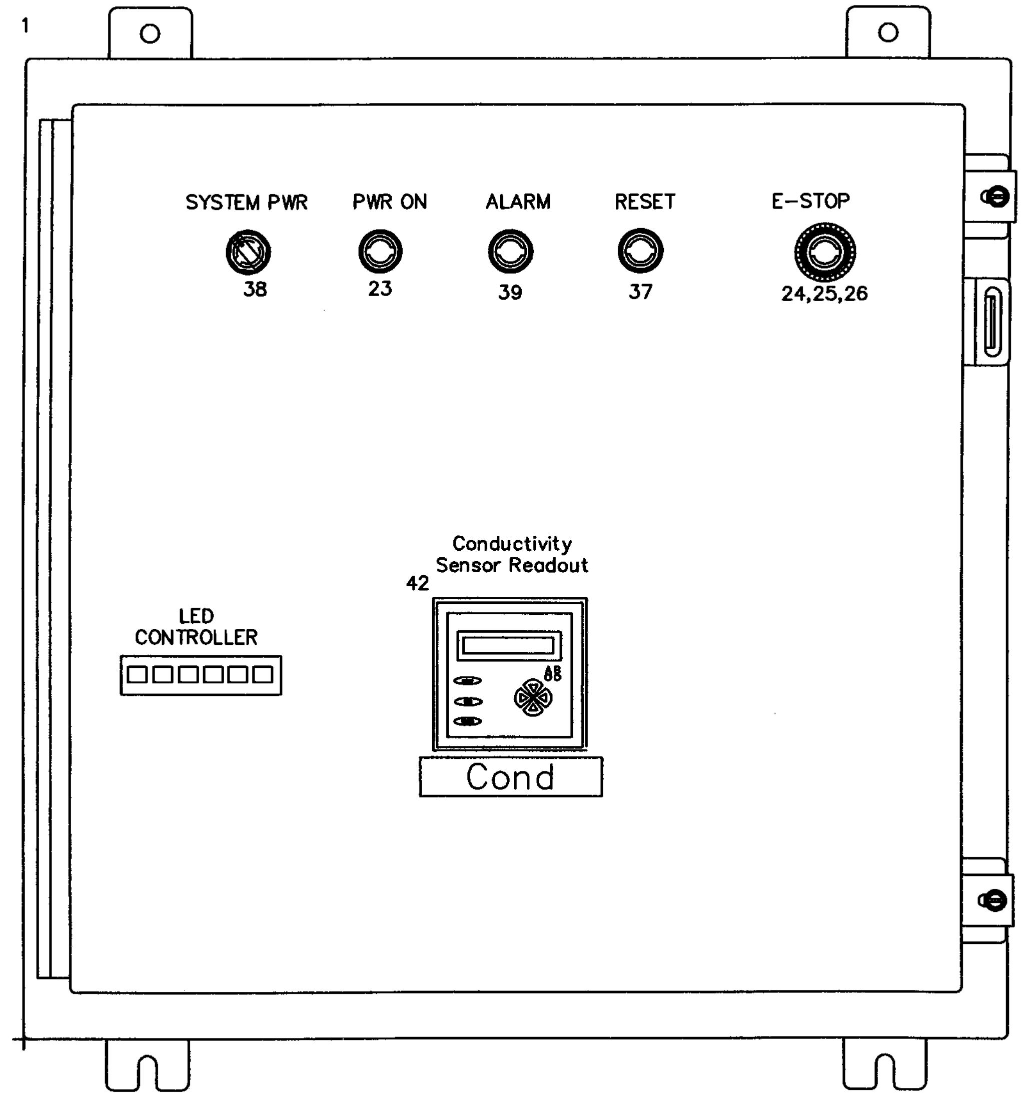
2

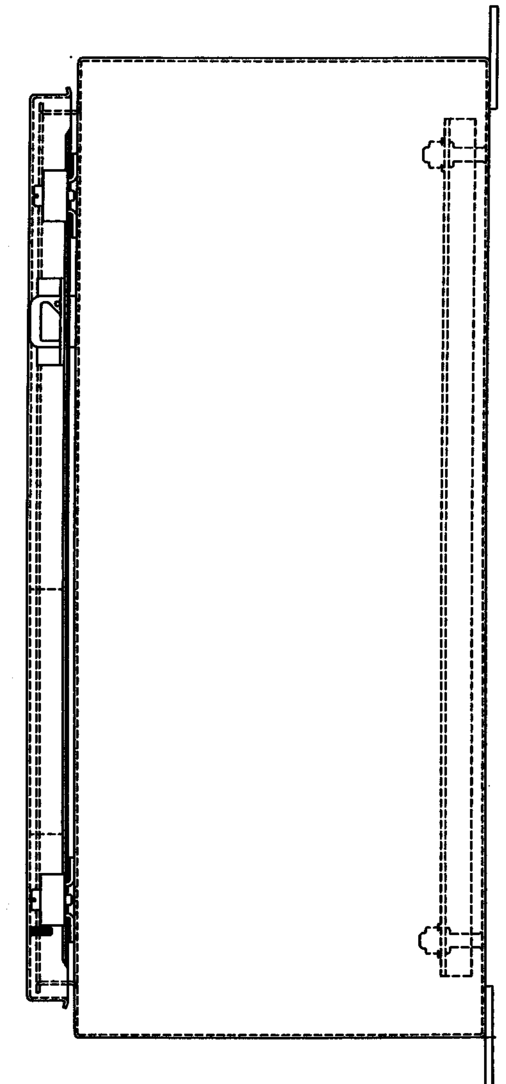
HOFFMAN A-24P24 SUBPANEL



HOFFMAN ENCLOSURE A-242410LP

1





DAS SUB-PANEL and
FRONT PANEL LAYOUT DIAGRAM

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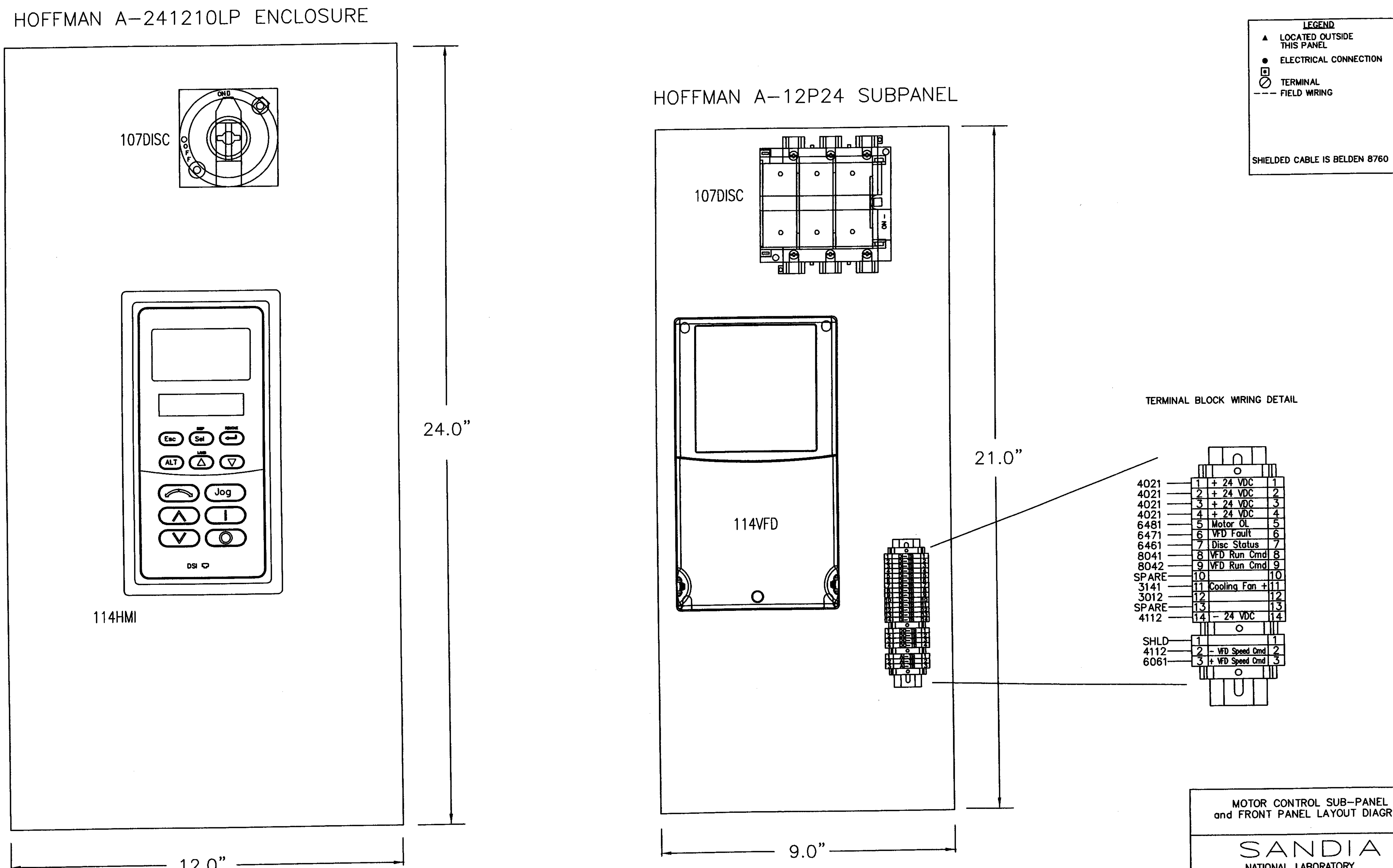
SUBTITLE
DAS PANEL LAYOUT

BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 10 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-10			

NO.	CHANGE	BY	DATE
00	As-Built		04/19/2010



MOTOR CONTROL SUB-PANEL
and FRONT PANEL LAYOUT DIAGRAM

SANDIA
NATIONAL LABORATORY

BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 11 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME DWG 09-01-1-11				

SUBTITLE
MOTOR CONTROL PANEL

NO.	CHANGE	BY	DATE
00	AS-BUILT		05/12/10

MOTOR CONTROL PANEL EQUIPMENT

ITEM NUMBER	DEVICE ID	QTY	PART NUMBER	MANUFACTURER	DESCRIPTION
1	Enclosure	1	A-242410LP	Hoffmann	Enclosure - NEMA 12 (24"x24"x10")
2	Sub-Panel	1	A-24P24	Hoffmann	Sub-panel 24"x24"
3	Enclosure	1	A-241210LP	Hoffmann	Enclosure - NEMA 12 (12"x24"x10")
4	Sub-Panel	1	A-12P24	Hoffmann	Sub-panel 12"x24"
5	114VFD	1	22B-D024N104	Allen-Bradley	230VAC, 3Ph VFD POWER FLEX 40
6	314MTR	1	KP-40	Kooltronics	Cooling Fan for Motor Enclosure
7					
8					
9					
10					
11	107FU	3	JTD-030ID	LittleFuse	Type J 30-Amp Fuses
12	107DISC	1	194R-NJ030P3	Allen-Bradley	30 Amp Disconnect
13	Shaft	1	194R-R1	Allen-Bradley	Disconnect Operating Shaft
14	Handle	1	194R-HS4E	Allen-Bradley	Disconnect Operating Handle
15	DISC Aux Contact	1	195-GA01	Allen-Bradley	Aux Contact for Disconnect
16	Fuse Cover	1	194R-FCA2	Allen-Bradley	Disconnect Fuse Cover
17	Disc Aux Contact Adapter	1	194R-AA	Allen-Bradley	Aux Contact Adapter
18	Disc Aux Contact	1	195-GA11	Allen-Bradley	Aux Contact N.C. & N.O.for Disconnect
19					
20	311PS	1	1606-XLS120E	Allen-Bradley	24 VDC Power Supply
21	642 CR	1	700-HB33Z24-4	Allen Bradley	24 VDC Control Relay
22	305CR, 308ECR	2	700-HB32A1-3-4	Allen Bradley	120 VAC Control Relay
23	306PL	1	800T-QTH10	Allen Bradley	Green Pilot Light (120 VAC)
24	308PB	1	800FP-LMT44	Allen Bradley	E-Stop Push Button
25	308PB	1	800F-2TL5R	Allen Bradley	120 VAC Light Transformer
26	308PB	2	800F-2X10	Allen Bradley	E-Stop N.O. Contacts
27	308PB	1	800F-2X01	Allen Bradley	E-Stop N.C. Contacts
28	303LT	1	ALF16D18R	Hoffmman	Panel Light
29	301FU, 402FU	2			5-Amp Fuse
30	314FU, 316FU, 416FU	3			1-Amp Fuse
31	301FU, 314FU, 316FU	3	1492-WFB4250	Allen Bradley	120 VAC Fused Terminal
32	402FU, 416FU	2	1492-WFB424	Allen Bradley	24 VDC Fused terminal
33	Terminals	12	102010	Weidmuller	Feed Through Terminals
34	Jumpers	10	157906	Weidmuller	4mm Terminal Jumper
35	End Caps	2	105000	Weidmuller	End Cap Covers for Terminals
36	End Anchor	4	106120	Weidmuller	Terminal End Anchor
37	309PB	1	800T-A2A	Allen Bradley	Reset Push Button
38	305SS	1	800T-H2A	Allen Bradley	2-Pos Selector Switch
39	612PL	1	800T-QH24R	Allen Bradley	Red Pilot Light
40	642CR, 305CR, 308ECR	3	700-HN154	Allen Bradley	Relay Plug-in Module Base
41	214SERVO	1	SVA-2100	Automation Direct	1KW, 230V, 1ph/3ph Servo Drive
42	Terminal Block	1	ASD-BM-50A	Automation Direct	Terminal Block Breakout for Servo Drive
43	207FB	1	1492-FB2J30-L	Allen Bradley	Fuse Block Assembly
44	207FB	2	JTD-10-ID	LittleFuse	10 Amp Indicating Fuse
45					
46					
47					
	DAS Hardware				
50	SIXNET VT-MIPM	1	VT-MIpm-241-D	Sixnet	Sixnet RTU Controller
51	SIXNET DISCRETE OUTPUT	1	RM-8DO2	Sixnet	Sixnet Discrete Output I/O Module
52					
53					

MATERIAL LIST

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	02/19/10	SHEET 12 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-12			

SUBTITLE
MATERIAL LIST

NO.	CHANGE	BY	DATE
00	As-Built		04/19/2010

OPERATOR CONSOLE PANEL INTERLOCKS

	FROM OPERATOR CONSOLE PANEL	TO OPERATOR CONSOLE PANEL
1300		
1301		
1302		
1303		
1304		
1305		
1306		
1307		
1308		
1309		
1310		
1311		
1312		
1313		
1314		
1315		
1316		
1317		
1318		
1319		
1320		

DAS CONTORL PANEL INTERLOCKS

	FROM DAS CONTROL PANEL	TO DAS CONTROL PANEL
1330		
1331		
1332		
1333		
1334		
1335		
1336		
1337		
1338		
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1340		
1341		
1342		
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1346		
1347		
1348		
1349		
1350		

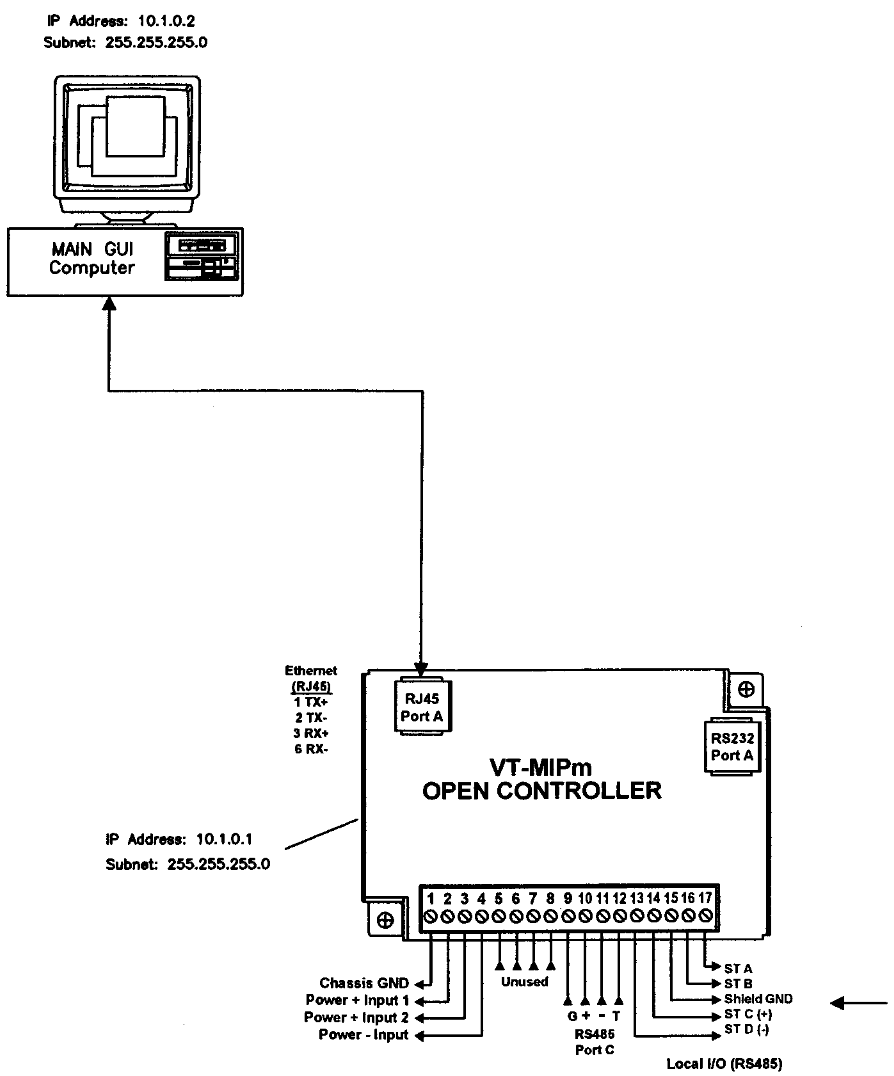
SUBTITLE
INTERLOCK SHEET

INTERLOCK SHEET

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 13 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-13			

NO.	CHANGE	BY	DATE
00	As-Built		04/19/2010



COMMUNICATION CONNECTION DIAGRAM

SANDIA NATIONAL LABORATORIES

SUBTITLE
COMMUNICATION SHEET

BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 14 of 16 SHEETS	
APPROVED				DRAWING NO. DWG 09-01-1
DESIGN SOURCE	SANDIA			
CAD FILE NAME	DWG 09-01-1-14			

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010

SUBTITLE
SPARE SHEET

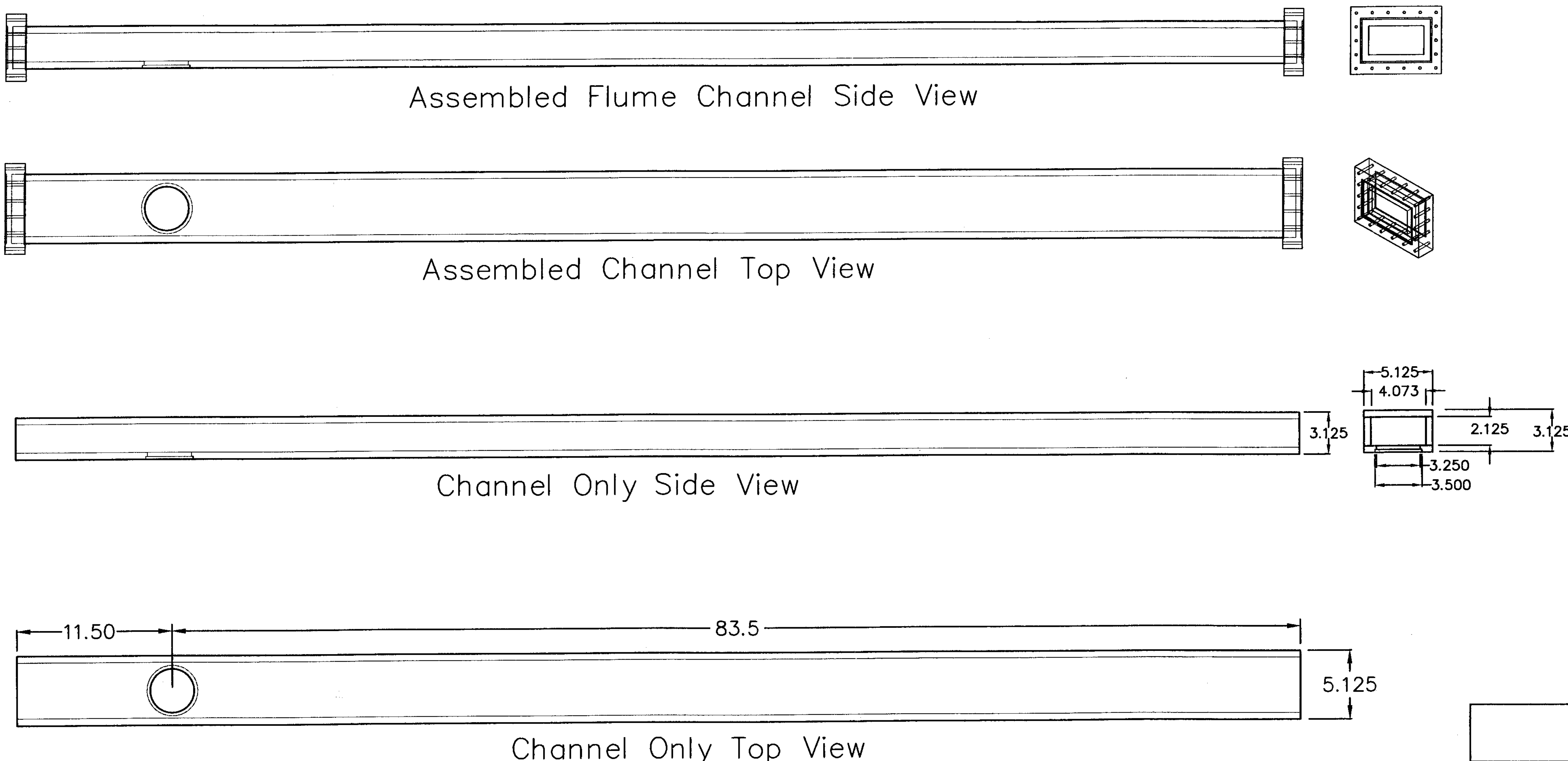
SPARE SHEET

SANDIA
NATIONAL LABORATORIES

	BY	DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/04/10	SHEET 15 OF 16 SHEETS	
APPROVED				DRAWING NO.
DESIGN SOURCE	SANDIA			DWG 09-01-1
CAD FILE NAME	DWG 09-01-1-15			

NO.	CHANGE	BY	DATE
00	As-Built		05/12/2010
01	Added Flume Channel		05/05/2011

Flume channel made from Lexan Clear Polycarbonate, Item #PCCLR0.500AM24X96, Ridout Plastics



Flume Channel

Dimensions

SANDIA
NATIONAL LABORATORIES

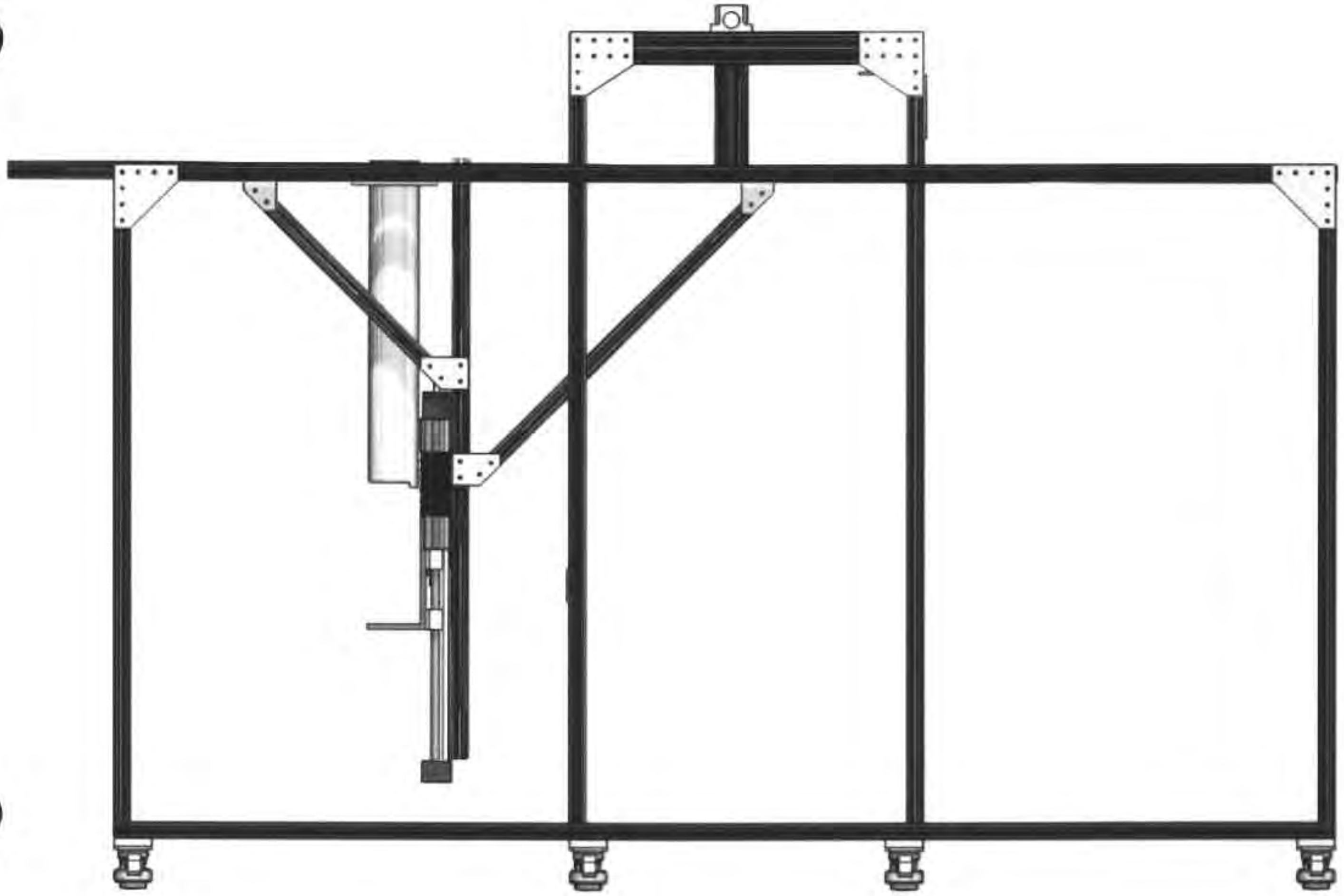
BY		DATE	SCALE NONE	PACKAGE NO.
DRAWN	MDS	01/25/2011	SHEET 16 OF 16 SHEETS	
APPROVED				DRAWING NO. DWG 09-01-1
DESIGN SOURCE	SANDIA			
CAD FILE NAME	DWG 09-01-1-16			

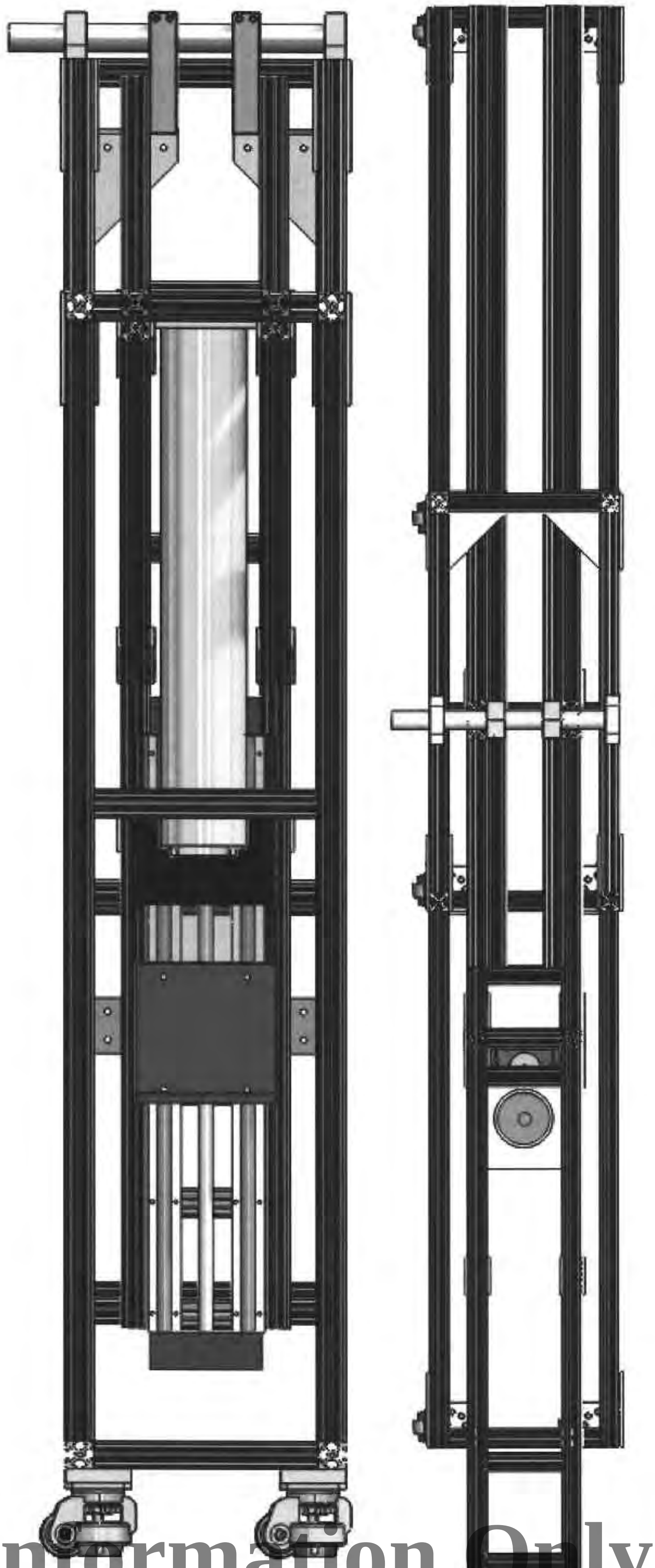
SUBTITLE
FLUME CHANNEL

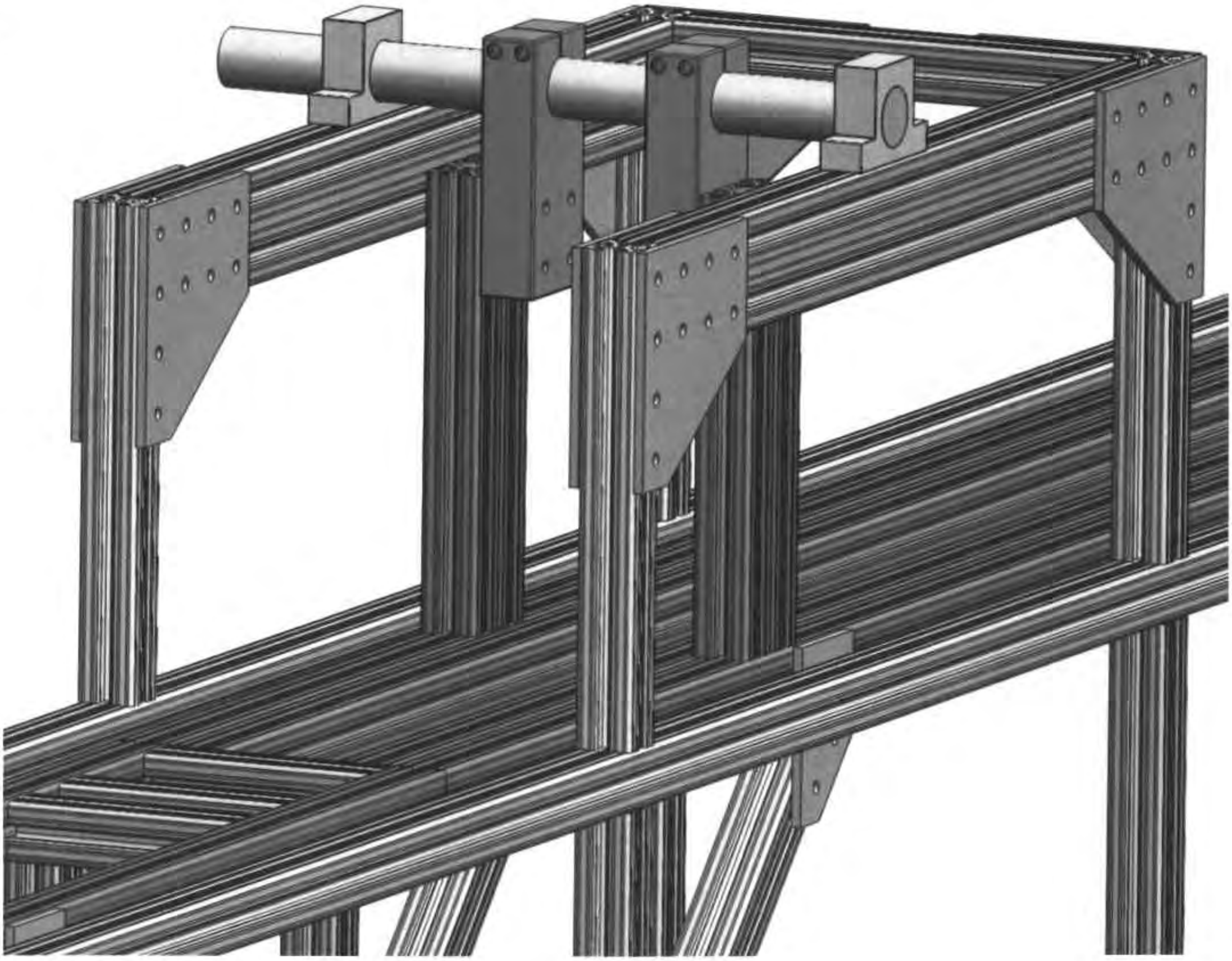
ATTACHEMENT II

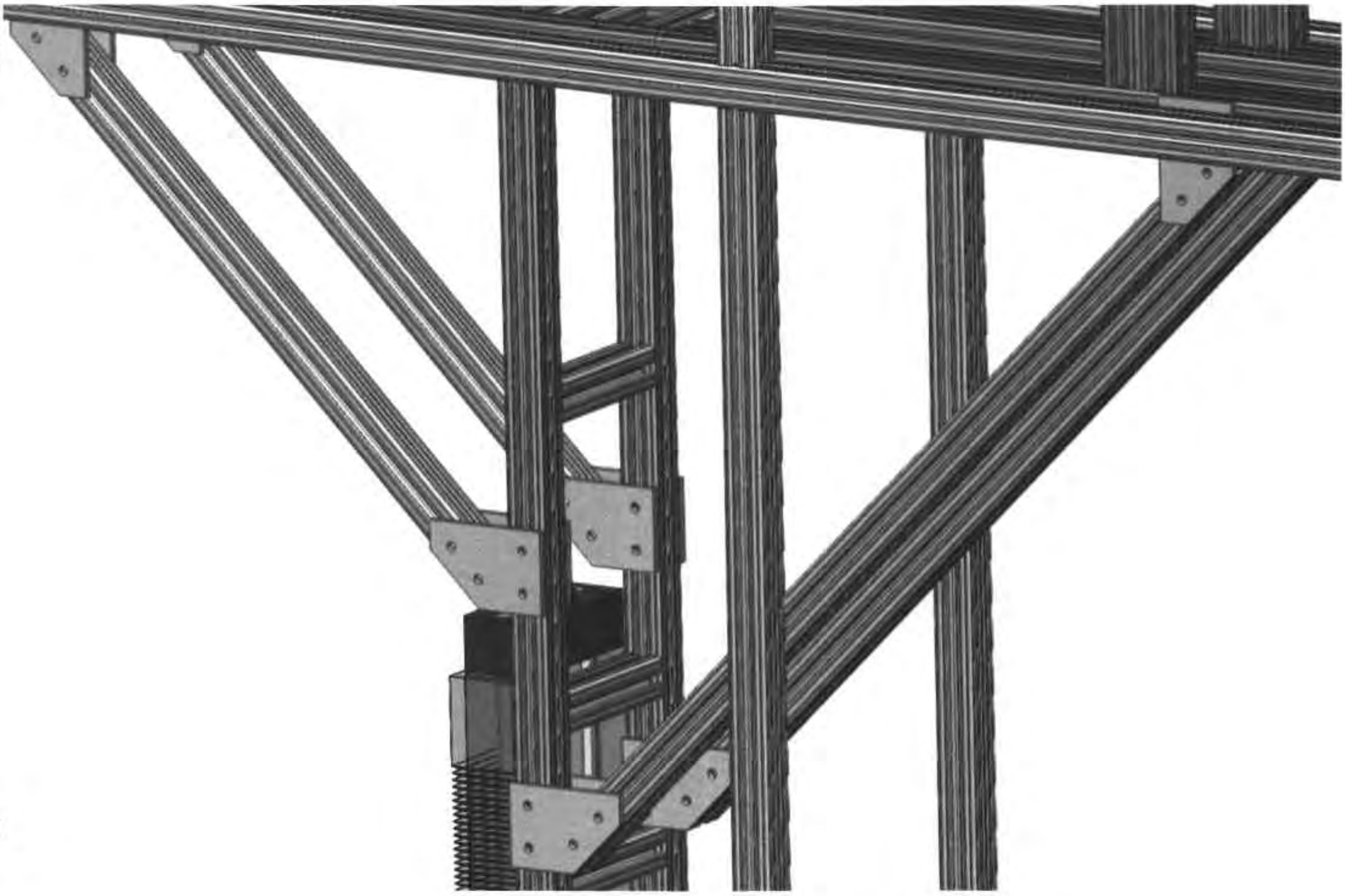
SYSTEM MECHANICAL SKETCH

The attached sketches represent the system mechanical components and the associated 8020 hardware used to build the support frame for the flume.

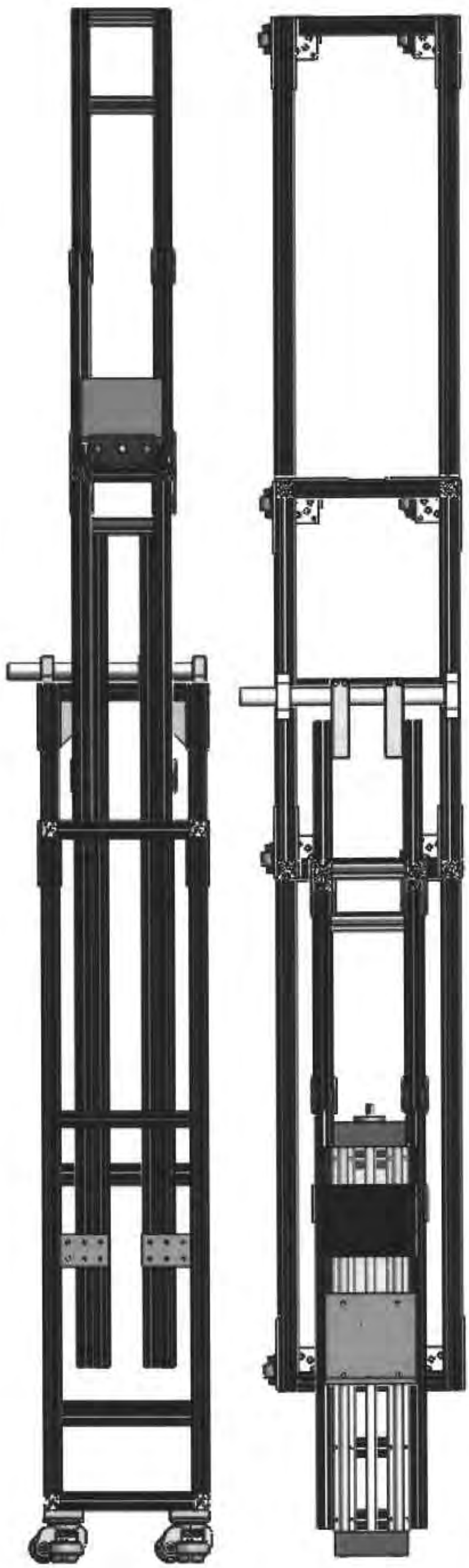


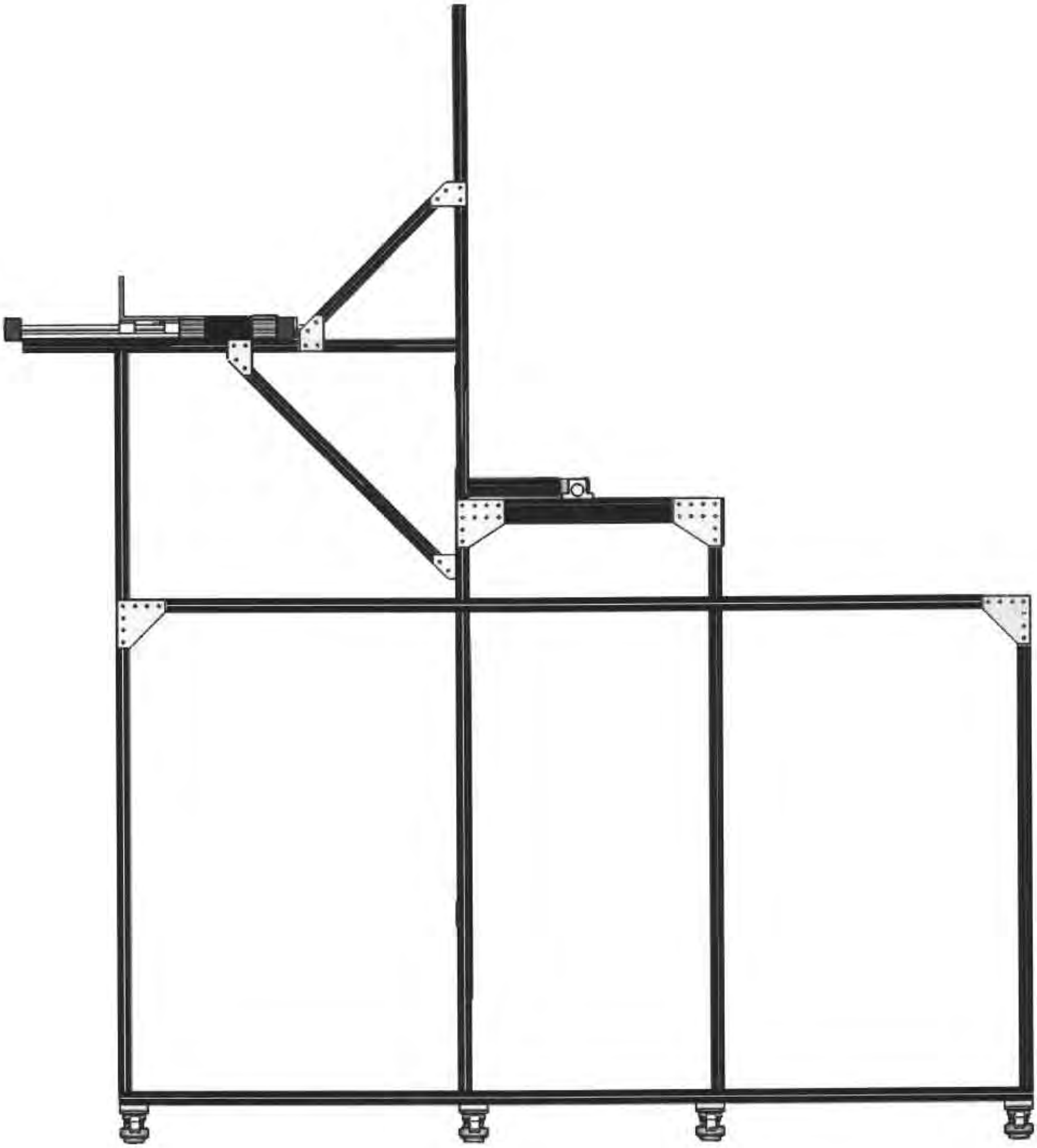


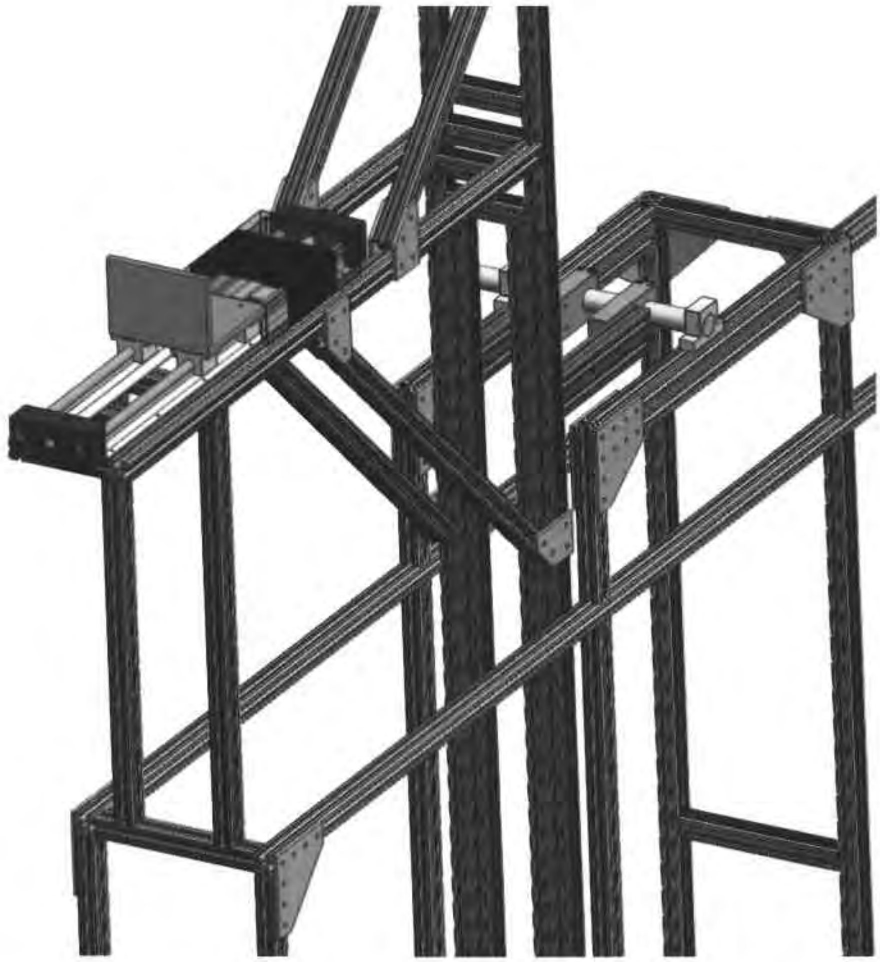


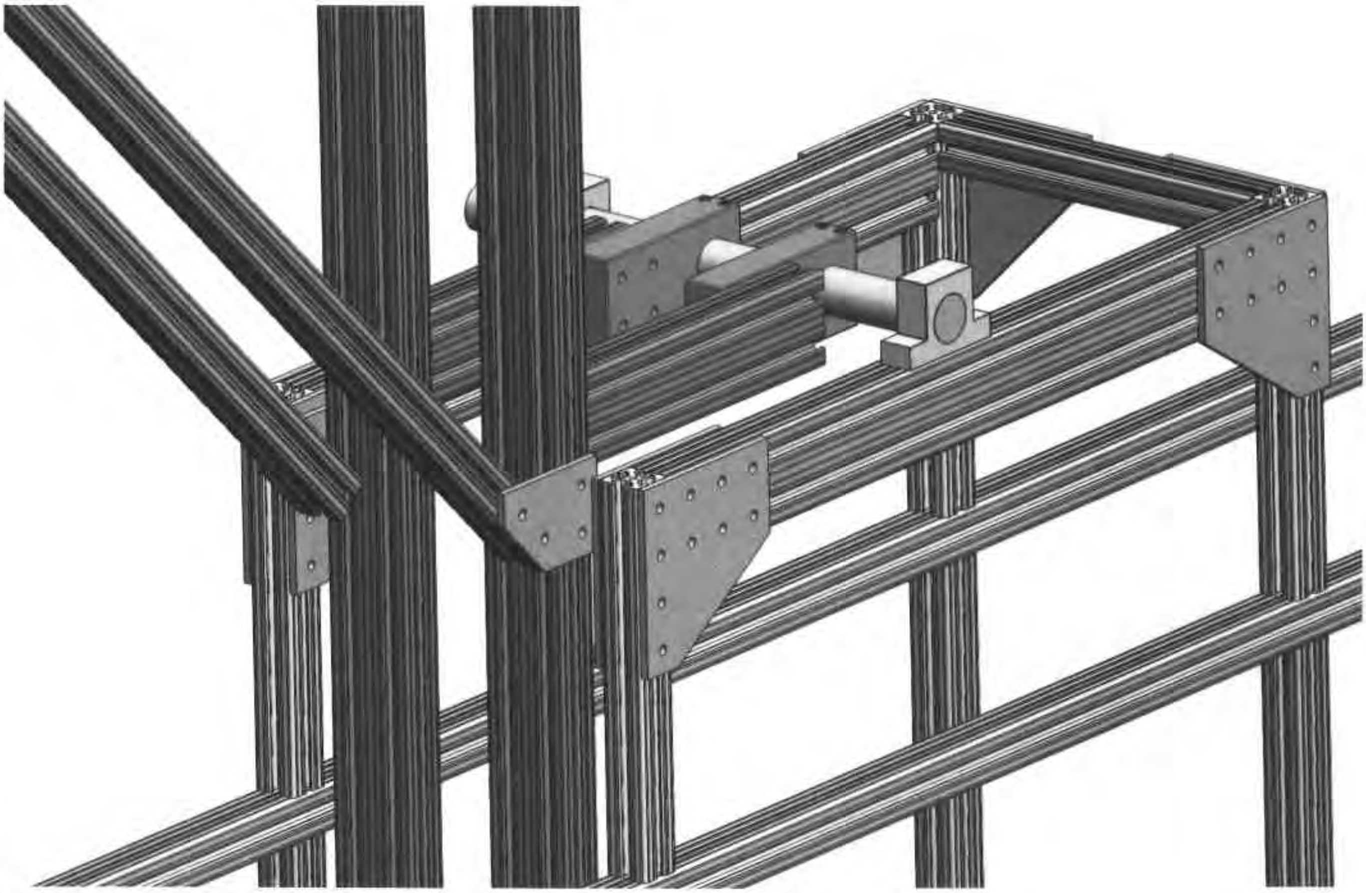


Information Only









Information Only