ATTACHMENT 9

"Data Acquisition System Installation and Test Procedure," Test Procedure, GE Report 26A6499, Revision 2, dated April 22, 2005

EIS IDENT:

REVISION STATUS SHEET

DOCUMENT TITLE DATA ACQUISITION SYSTEM INSTALLATION AND TEST PROCEDURE

LEGEND OR DESCRIPTION OF GROUPS

TYPE: TEST PROCEDURE

FMF: QUAD CITIES 2

| - DENOTES CHANGE

MPL NO: B13-D001

SAFETY-RELATED CLASSIFICATION CODE _N__

REVISION			C
0	FEB 07 2005 RMCN05664		
1	APR 19 2005 RMCN06023		
2	APR 22 2005 JC LAW	RJA	
	RMCN06089 ENGR: JC LAW		

PRINTS TO

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1.0 SCOPE

As part of the QC2 Steam Dryer Instrumentation program, a temporary data acquisition system was designed to measure the flow-induced vibration of the newly designed steam dryer and oscillating pressure within the reactor dome and steam lines. The steam dryer will be instrumented with strain gages, accelerometers and dynamic pressure transducers. In addition, the steam lines will be instrumented with strain gages on the outer surface at selected locations to obtain the oscillating pressure within the pipe. The purpose of this document is to describe the procedure for installing and testing the data acquisition system with all the sensors connected prior to plant startup.

2.0 REFERENCE DOCUMENTS

a. Dryer Vibration Instrumentation Design Specification, 26A6395
b. Steam Dryer Vibration Instrumentation Installation Specification, 26A6493
c. Data Acquisition System Specification, 26A6366
d. Functional Test Procedure for Sensors, 26A6484
e. Functional Test Procedure for JB and DAS, 26A6484
f. Signal Conditioning Enclosure, 105E3903
g. Wiring Diagram, 105E3902
h. Junction Box, 234C6957
i. Charge Converter Enclosure, 234C6958
j. Strain Gage Jumper Cable, 234C7123
k. Pressure Transducer/Accelerometer Jumper Cable, 234C7135
l. Instruction Manual for Kyowa Signal Conditioner Model MCD-16A.
m. Instruction manuals for Vibro-Meter (VM) Signal Conditioner UVC689, Charge Converter IPC629 and Galvanic Separator GSI 130.
n. Instruction manual for Vibro-Meter Charge Generator Model TSU 109.
o. Sensor sensitivity data sheets for pressure transducers, accelerometers and strain gages.
p. Users Manual for LMS SCADAS-III.
q. Users Manual for Sony SIR 1000 Tape Recorder

3.0 ACCESSORIES AND EQUIPMENT REQUIRED

a. Digital Multi-Meter (DMM)

b. Vibro-Meter Charge Generator, Model TSU 109

c. Oscilloscope, dual channel

d. Cabinet with Signal Conditioning Components for Pressure Transducers/Accelerometers (Vibro-Meter UVC 689 and ABE-022 with input/output cables, transducer interconnecting cable, Galvanic Separation Unit GSI-130) and Sony Tape Recording equipment (SIR-1000 tape recorder, SCX-32 expansion units and SAA-24 power supplies) installed.

e. Cabinet with strain gage signal conditioning components (Kyowa MCD-16A with monitor DPE-71A, strain gage amplifier DPM-71A, input/output cables) and LMS equipment (SCADAS 316 front end and SCADAS 317 slave) installed.

f. Charge Converter boxes with Charge Converters (VM IP-629) installed.

g. Junction Boxes with strain gage Printed Circuit (PC) boards and straight through PC boards installed.

h. BNC cables to connect Kyowa and Vibrometer amplifiers output to LMS and Tape Recorder input.

i. LMS SCADAS-III Data Acquisition System

j. Sony SIR 1000 Tape Recorder or equivalent

k. 120 Ohm Half Bridge Strain Gage simulator.

l. 350 Ohm Quarter Bridge Strain Gage Simulator.

m. 12 Volt Power Supply

4.0 DATA ACQUISITION SYSTEM INSTALLATION

4.1 General:

The Data Acquisition System (DAS) consists of two cabinets (Section 2.0.f) located in the data collection area. The first cabinet, Cabinet-1, contains signal conditioning equipment for the dynamic pressure sensors and accelerometers. It also contains a tape recorder for recording output signals from all signal conditioning amplifiers. The second cabinet, Cabinet-2, contains all strain gage signal conditioning amplifiers. In addition, it contains a data analysis unit, which will interface with a desktop computer on a table nearby. The DAS layout is shown in Figure 1. There are two Junction Boxes (JB's) (Section 2.0.h), which will be located a few feet from the DAS cabinets. The first JB, JB-1, is for termination of cables coming from the dryer sensors and the second JB, JB-2, is for the main steam line sensors (strain gages). Both junction boxes contain strain gage bridge completion resistors and shunt calibration resistors installed on printed circuit boards. These printed circuit boards also have relays powered by an external DC voltage source to activate the shunt calibration resistor across the strain gages during shunt calibration. The pressure transducer and accelerometer leads connect to a different type of printed circuit board containing test pins.

4.2 <u>Installation Procedure</u>:

4.2.1 Easy access to the equipment is required for strain gage resistance measurements before and during the test. The location of the enclosures shall follow these guidelines.

4.2.2 Install the DAS cabinets, Cabinet-1 and Cabinet-2, and the Junction Boxes in the data collection location. Allow a minimum of 3 feet clearance behind and 6 feet clearance in front of each cabinet for accessibility.

4.2.3 Install both JB's near the cabinets (~3-6 feet). JB-1, which contains dryer sensor cable terminations, shall be closer to Cabinet-1. JB-2, which contains main steam line strain gage cable terminations, shall be located near Cabinet-2, which contains the strain gage amplifiers.

4.2.4 Terminate the cable leads originating from the dryer sensors (pressure transducers, accelerometers and strain gages) to the left side of the PC board connectors in JB-1 (when viewed from front). Similarly, terminate the cable leads from the steam line strain gages to the left side of the PC boards in JB-2.

4.2.5 Connect the jumper cables for the pressure transducers/accelerometers (Section 2.0.k) between the right side of the PC boards in JB-1 and the Galvanic Separators (GSI-130) at the back of Cabinet-1.

4.2.6 Connect one end of the strain gage jumper cables (Section 2.0.j) to the right side of the strain gage PC boards in JB-1 and JB-2. Connect the other end to the Kyowa strain gage amplifier inputs located in Cabinet-2.

4.2.7 Connect all of the outputs from the amplifiers to both the Sony SIR-1000 tape recorder input and to the data analyzer (LMS SCADAS-III) using coaxial BNC cables and BNC tee connectors.

5.0 STRAIN GAGE CHANNELS CHECKOUT PROCEDURE

5.1 The dryer strain gage channels will be tested one channel at a time. The strain gage wiring diagrams for steam dryer and main steam line gages (inside and outside the drywell) are shown in Figure 2, Figure 3 and Figure 4, respectively. This test shall be performed after the wiring is completed from the JB to the LEMO connectors at the drywell, but before the strain gages are connected. The cable lead resistances shall be measured between JB-1 and the LEMO connector end in the drywell and recorded. It is also necessary to check that the cable leads and shields are not crossed between the LEMO connector at the drywell and the JB.

5.2 Connect the 120 ohm half bridge simulator (Section 3.0.k) to the LEMO connector at the drywell. Remove the connector from the PC board in JB-1 and measure and record the resistances between three leads. Re-install the connector on to the PC board after measuring the resistance.

5.3 Proceed with the following steps for setting up the Kyowa strain gage amplifiers:

a. Set the switches on all DPM-71A on MCD-16A as follows:
- Range switch to OFF
- Monitor switch to the Right (not monitoring) except the first channel (to the Left for monitoring the amplifier output on the DPE-71A monitor)
- Filter switch to 1 kHz

b. Set the amplifier output monitor DPE-71A switches as follows:
- Meter monitor switch to DC
- Bal-Cal switch to the Left (unlock).

c. Turn the MCD-16A power on. After few minutes connect the MCD-16A output to an oscilloscope and to a DMM (set for Voltage mode).

d. Turn the Range switch of DPM-71A (first channel only) to 50 X 100 με range and push the Balance button twice quickly to balance the bridge. The output of the amplifier should be +/- 10 mV DC or less. Now change the Range setting through each range until set to 2 X 100 με. Balance the bridge by pushing the Balance button twice quickly and the output should be less than +/-10 mV DC. Further balance can be achieved by adjusting the Zero Potentiometer. The output can be read from the Monitor, Oscilloscope and the DMM. Record the amplifier output noise level peak-to-peak from the Oscilloscope time trace.

e. Set the DC Power supply to +12 Volts and connect the 12V DC source to the PC board to activate the relay for applying the shunt calibration resistor across the strain gage. Record the DC output from the strain gage amplifier.

f. Turn off the power to the shunt cal resistor relay. The amplifier output should be close to zero volts (+/- 10mV DC). This completes the checkout for the first channel.

g. Turn the Range switch to OFF. Turn the next channel Monitor switch to the Left (Monitoring enabled) and the previous channel Monitor switch to the Right (not monitoring).

h. Repeat steps 5.3a through 5.3g for the rest of the steam dryer strain gage channels.

i. To test the main steam line strain gage channels and the junction box, repeat steps 5.3a through 5.3g using the 350 Ohm quarter bridge strain gage simulator (Section 3.0.l) on each strain gage pair, instead of the 120 ohm half bridge simulator.

6.0 PRESSURE TRANSDUCER CHANNEL FIELD CALIBRATION

6.1 The pressure transducer channels will be tested one channel at a time. The signal conditioning components for the pressure transducers and the accelerometers are made by Vibro-Meter (VM) and are identical except the amplifiers used for the accelerometer channels have additional features for double-integrating the acceleration signals to obtain displacement. The circuit diagram for the pressure transducer channels is shown in Figure 5. The procedure is as follows:

a. Complete the field wiring from JB-1 to the Charge Converter Boxes (Section 2.0.i) in the drywell. Measure cable lead resistances between JB-1 and the Charge

Converter Box as described in Section 5.1. Connect all the 25 ft Low Noise Jumper cables (VM part number EC-271) to the corresponding charge converter inputs. Also, complete the wiring between JB-1 to Cabinet-1 as outlined in 4.2.1-4.2.3.

b. Set the VM UVC 689 Position switch to 1, the gain potentiometer to 1.0 (1.0 is the minimum. Do not force the potentiometer to go below the minimum) and the multiplier switch to X 1. Turn on the Power to the VM Rack and connect the first channel output to the Oscilloscope and to a DMM (set for AC Voltage mode).

c. Connect the portable Charge generator to the Vibro-Meter low noise cable LEMO connector. Set the charge generator dial and multiplier so that it outputs a charge equivalent to 5 psi peak at 50 Hz for that particular pressure transducer, which is available from the sensor data sheets. (Example: if the transducer sensitivity is 15 pC/psi, then adjust the charge output to 75 pC peak for an equivalent 5 psi peak.)

d. Apply the charge by pushing the momentary switch and watch the Oscilloscope and DMM. Adjust the gain such that the output is 5 Volts peak. Record UVC-689 amplifier settings. The channel is now field calibrated for 1 Volt/psi.

e. Follow the procedure for the rest of the channels by repeating 5.1a through 5.1d. Note: all but two of the channels are for VM pressure transducer CP 104. The remaining two channels are VM pressure transducer CP 211. The transducer sensitivity for CP211 is about 1/8 of that of CP104. Hence it will be necessary to input a different value based on the sensitivity data sheet for these sensors. This completes pressure transducer channel checkout and calibration.

7.0 ACCELEROMETER CHANNEL FIELD CALIBRATION PROCEDURE

7.1 Checking the accelerometer channels is similar to checking the pressure transducer channels. The wiring diagram for accelerometer channel is shown in Figure 6 and it is very similar to that of pressure transducer channel. The signal conditioning amplifiers for accelerometer channels, VM-UVC689, have additional features for double integration. The nominal sensitivity of the accelerometers (VM-CA901) used for this program is 10 mV/G. The accelerometer channels will be calibrated such that 1 V represents 1 G in acceleration mode (UVC 689 in switch position 1) and the same 1 Volt to represent 10 mils in displacement mode (UVC 689 in switch position 3). The procedure is as follows:

a. Follow steps 6.1.a and 6.1.b, which describe the procedure for connecting cables and setting the amplifier gain and switch positions.

b. Connect the portable Charge Generator to the Vibro-Meter low noise cable LEMO connector. Set the charge generator dial potentiometer and multiplier so that it outputs charge equivalent to 5 G peak at 31 Hz sine wave. (Example: if the transducer sensitivity is 10 pC/G, then adjust the charge output to 50 pC peak for an equivalent 5 G peak). The charge sensitivity for each particular accelerometer is available from the sensor data sheets.

c. With the Position switch set to 1 on UVC 689, apply the charge by pushing the momentary switch. Monitor the amplifier output on the DMM and the Oscilloscope. Adjust the amplifier gain such that the output is 5V peak. The frequency will remain the same at 31 Hz sine wave. The channel is now calibrated for 1V/G.

d. Change the Position switch on UVC 689 to position 3. The same 5G peak at 31Hz represents 50.9 mils peak after double integration (displacement = Acceleration $/(2\pi f)^2$

e. Apply the charge. The amplifier output should be 5.09 Volt peak (based on 1V = 10 mils). Record the actual output volts, gain and the amplifier switch settings.

f. Repeat steps 7.1.a through 7.1.e for the rest of accelerometer channels. This completes the testing of accelerometer channels.

8.0 STRAIN GAGE CHANNELS FIELD CALIBRATION

8.1 The strain gage channels will be calibrated only after connecting all the strain gages. For pressure transducers and accelerometers, further calibration is not possible after connecting the sensors. The following procedure describes the steps involved in calibrating the strain gages.

a. With all sensors connected, remove the quick disconnect terminals from the PC boards and measure the resistance readings of each strain gage. Record the values (Table-2) and re-install the connector to the PC board.

b. Strain gage resistances, lead wire resistances and natural gage factors will change with temperature and hence the initial calibration process has to be repeated at elevated temperature (~540 deg F) when the reactor reaches operational conditions.

c. After completion of the resistance measurements, calculate the equivalent strain output when a shunt calibration resistor (1 Meg-Ohm) is applied across the strain gage as shown on Table-2.

d. Follow steps 5.3.a to 5.3.d for setting up the Kyowa amplifiers and balancing the bridge.

e. Apply 1 Meg-Ohm calibration resistor by activating the relays on the strain gage PC boards with 12 V DC power and observe the DC output from the amplifier.

f. Adjust the Vernier with a small screwdriver to get desired output based on the calculated equivalent micro strain and engineering units per volt (Table-2). The desired sensitivity is 1 V equals 100 micro strain. Higher sensitivity may be obtained by increasing the gain. The filter setting can be changed to a lower value to eliminate the noise while reading the output DC value but, after calibration, remember to set the switch back to 1 kHz. Repeat the process a few times (Shunt calibration resistor ON and OFF) until the difference agrees with the calculated voltage level.

g. Follow the same procedure, steps 8.1.a through 8.1.f, for calibrating the Main Steam Line strain gages. The Main Steam Line sensor cables are terminated in JB-2 so the strain gage resistances should be measured at JB-2 terminals.

h. When the reactor reaches elevated temperature (~>500 Deg. F), there is a possibility that the bridge may not balance because of the unequal resistance between active and dummy resistor. If the amplifier cannot balance the difference, it will be necessary to install balance resistors on the PC boards.

9.0 LMS DATA ANALYZER SETUP

The LMS data analyzer front end is located in Cabinet-2 where the strain gage amplifiers are located. Connect the BNC input cables from all of the amplifier outputs to the tape recorder input and also to the LMS system. The LMS chassis interconnects with a Desk Top PC loaded with analysis software to perform frequency and time history analysis. The operational instructions are contained in the instruction manual. It will be necessary to undergo training to operate this system and no written instructions are available at this time. Types of analysis used during the testing are Power Spectrum measurements (to determine frequency composition of the signals and their magnitude), Time History and Histogram analysis (to get positive and negative peaks of the signals between certain frequency band to be able to compare with the acceptance criteria) and Transfer Function (to determine phase relationships between the signals, coherence, correlation). Other detailed analysis will be performed later at San Jose site while preparing the final report. Typical parameters for Power Spectrum analysis are as follows:

- Frequency Bandwidth: 400 Hz
- Number of Lines: 800 lines resolution (minimum)
- Window: Flat Top Window
- Type of Averaging: Peak Hold and Stable Averaging
- Number of Averages: 16, 32, 64 (Typical)
- Overlap processing: 10 to 90 percent (typically 50 to 80 percent).

10.0 TAPE RECORDER CHECKOUT

The Tape Recorder, Sony Model SIR 1000 multi-channel PCM recorder will record all analog signals to data cartridge. It has variable input range from 0.5 V to 20 V peak and can record up to 96 channels of data. It can continuously record for 8 hours of data on a single data cartridge and can accommodate a frequency bandwidth from DC to 1.25 kHz. Further operational details and specifications are contained in the users manual. The tape recorder can be checked out by inputting a reference signal of 1 V peak sine wave at 100 Hz from a signal generator and the signal will be recorded on all channels. By playing back the tape, it can be determined if all the channels are functioning correctly.

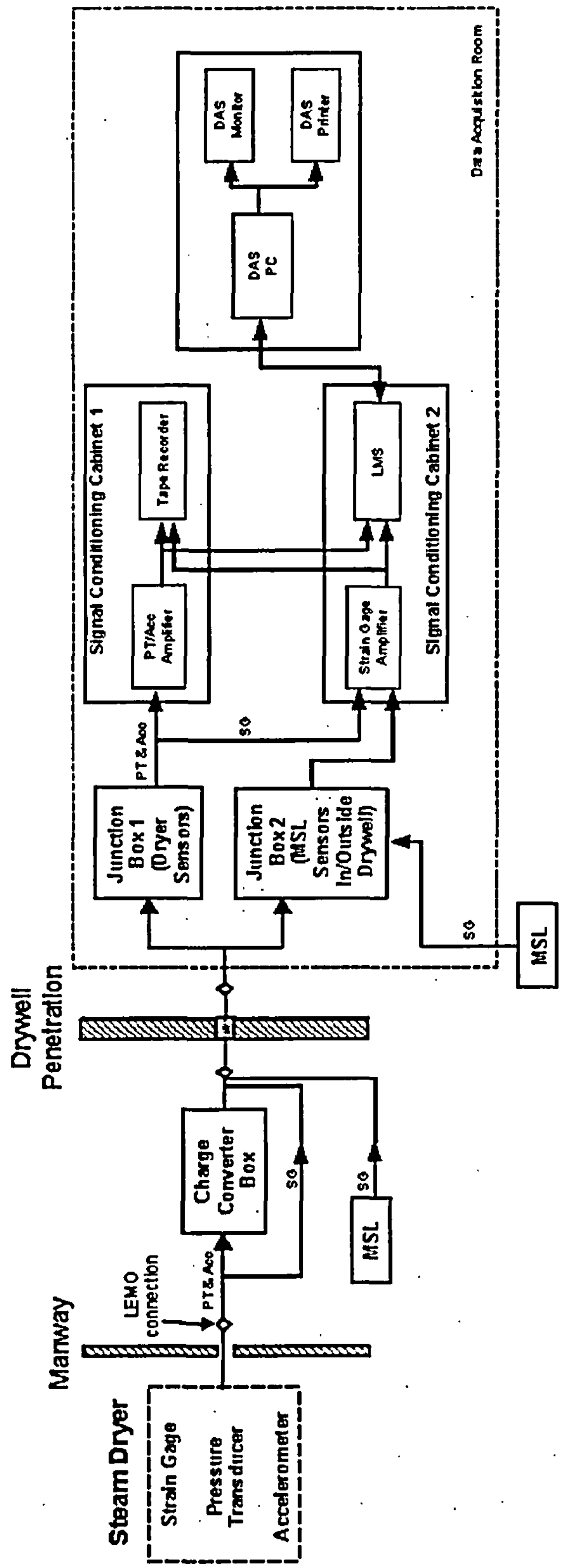
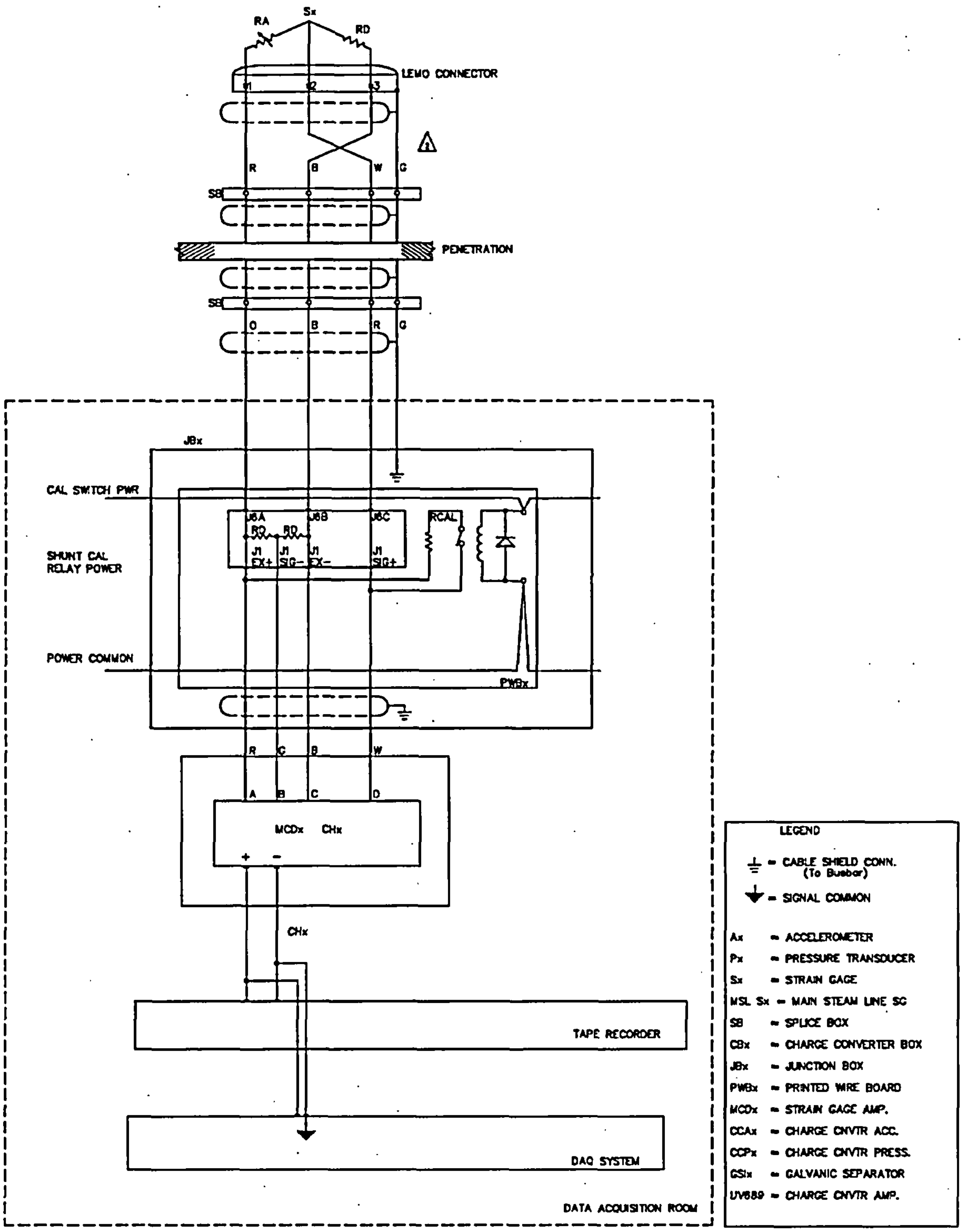


Figure 1. Data Acquisition System Layout

STEAM DRYER STRAIN GAGE



NOTES:
2. Splice GREEN conductor with shield drain

Figure 2. Steam Dryer Strain Gage Wiring

MAIN STEAM LINE STRAIN GAGE
(WITHIN DRYWELL)

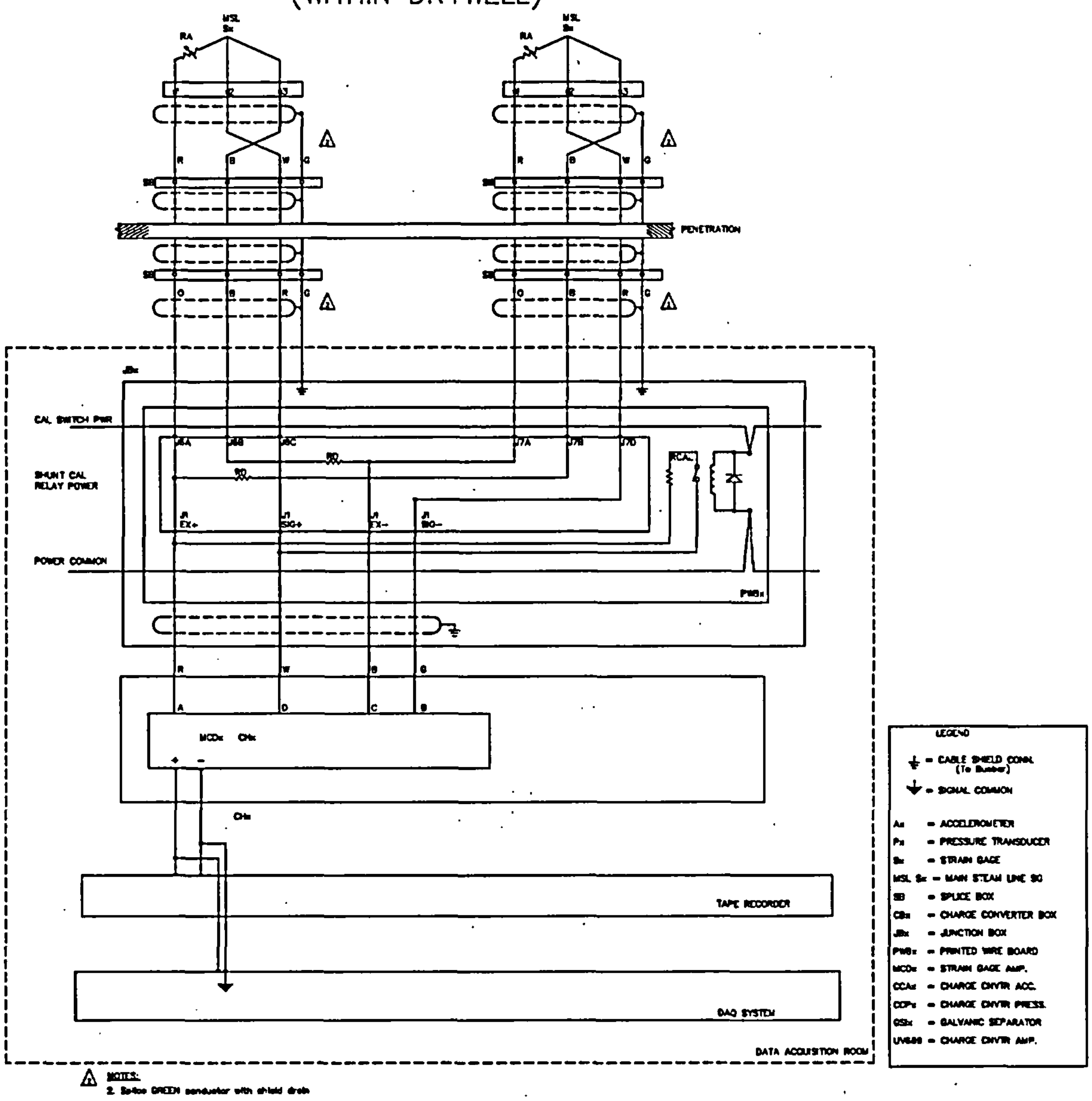


Figure 3. Main Steam Line Strain Gage (Inside Drywell) Wiring

MAIN STEAM LINE STRAIN GAGE
(OUTSIDE DRYWELL)

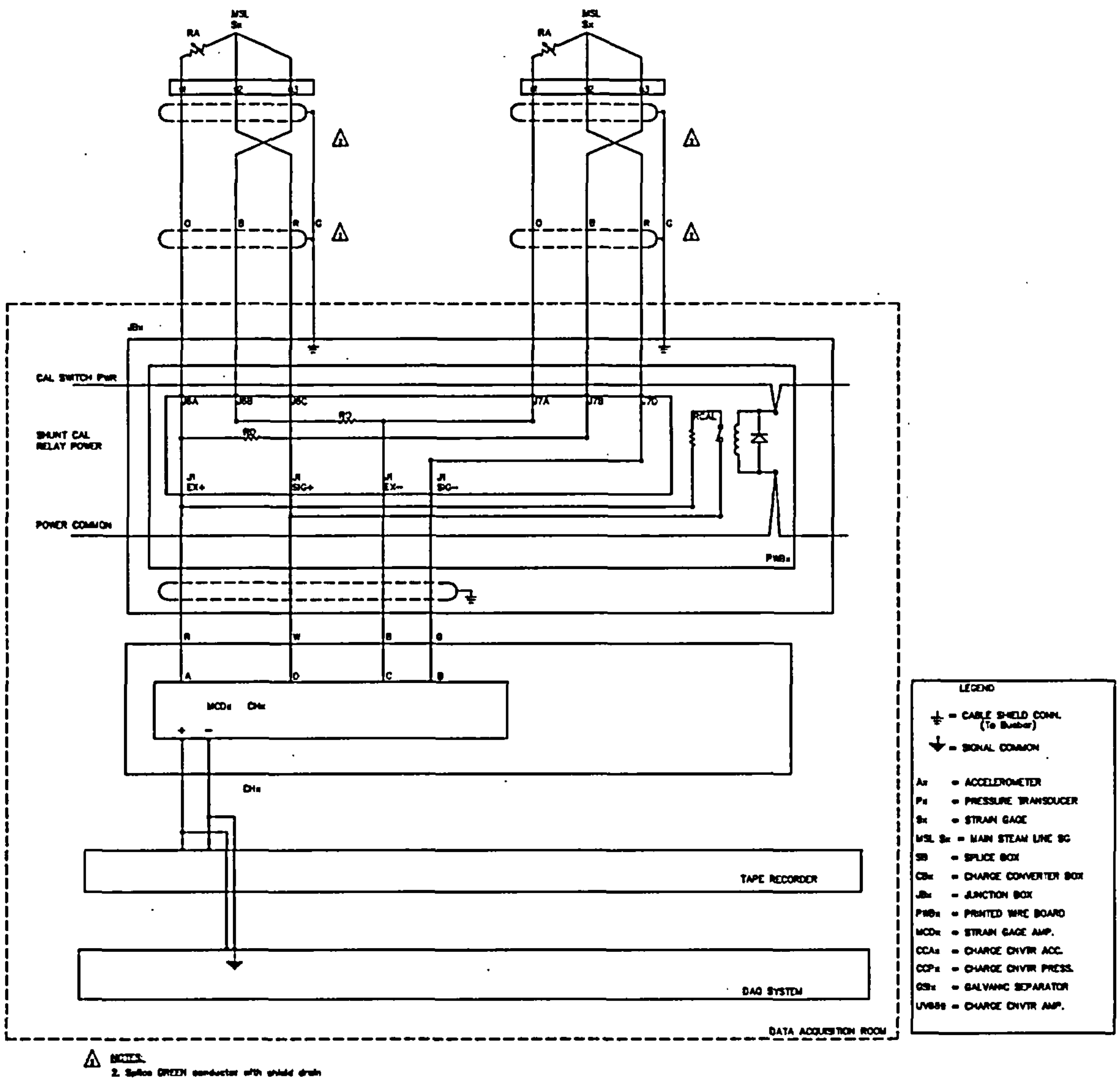


Figure 4. Main Steam Line Strain Gage (Outside Drywell) Wiring

STEAM DRYER PRESSURE TRANSDUCER

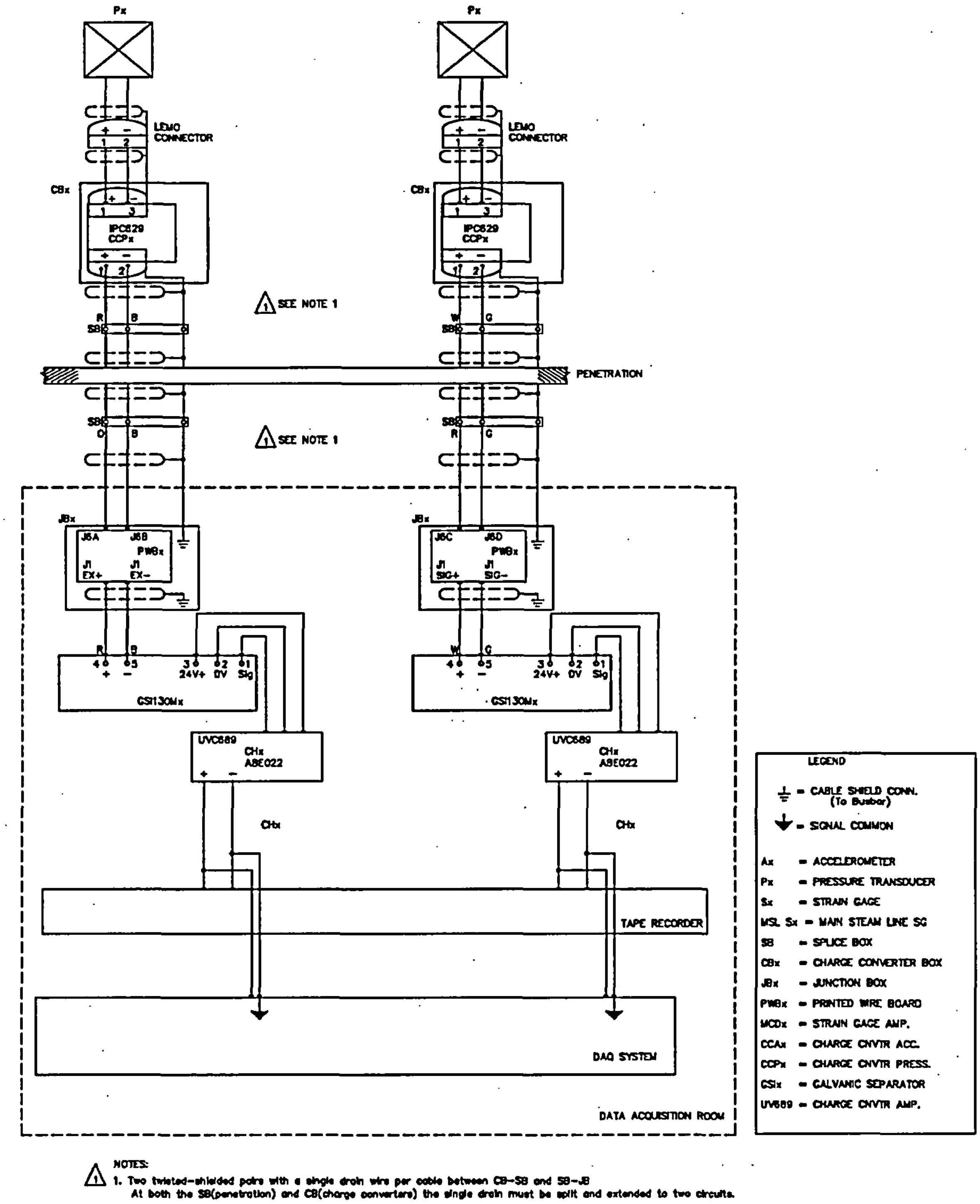
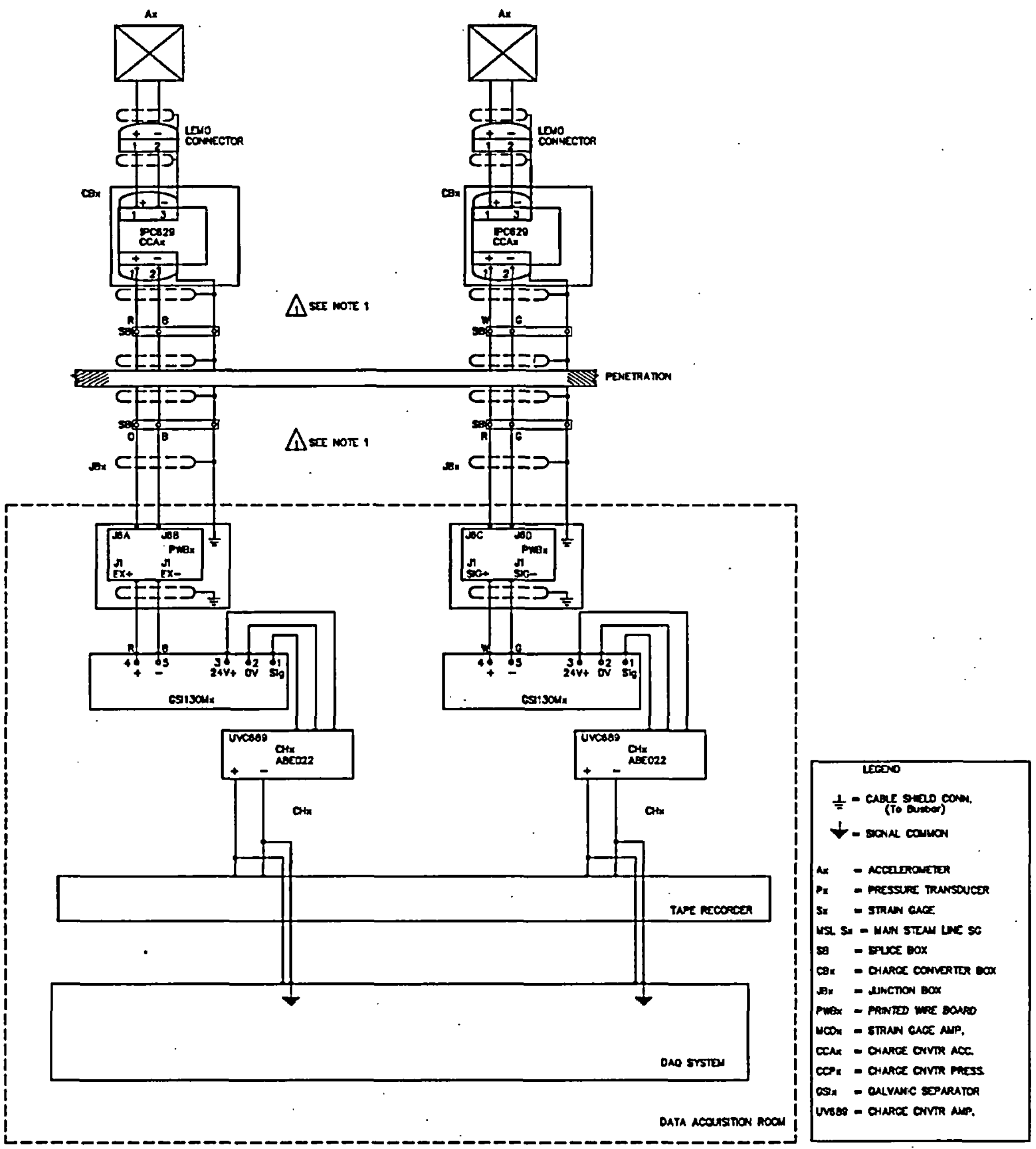


Figure 5. Pressure Transducer Wiring

STEAM DRYER ACCELEROMETER



NOTES:

1. Two twisted-shielded pairs with a single drain wire per cable between CB-SB and SB-JB
At both the SB(penetration) and CB(charge converters) the single drain must be split and extended to two circuits.

Figure 6. Accelerometer Wiring

Table 1. Strain Gage, Pressure Transducer and Accelerometer Resistance Measurement at QC2 Prior to MI Cable Termination to Drywell Cables.

Resistance Measurement Test

	Strain Gages				Pressure Transducers / Accelerometers		
Sensor ID	Test Points 1-2	Test Points 2-3	Test Points 1-3	Insulation	TP1-TP2	Shield-TP1	Shield-TP2

Data Collected By: ______________________ **Signature:** ______________________

Verified By: ______________________ **Signature:** ______________________

Date Performed: ______________________

Test Equip., Serial No. & Calibration Due Date: ______________________

Table 2. Strain Gage Resistance Measurement and Calibration After MI Cable Termination to Drywell Cables

Dryer Vibration Test Program

Date:
Time:
Reactor Temperature:

Plant: Quad Cities -2
Measured By:
Test equipment Model, S/N, Cal Due:

Sensor ID	Rr-w (Active)	Rb-w (Dummy)	Rr-b	Rr-shld	R_L	Rg	Rcal	GFn	Calculated micro Strain

R_L	Sensor Lead Resistance per lead	((Rr-w) + (Rb-w) - (Rr-b)) / 2
R_G	Active Gage resistance	(Rr-w) - 2*(RL)
R_{CAL}	Shunt Calibration Resistor	1E6 Ohms
GFn	Natural Gage Factor	(From Sensor Data Sheet)

Calculated microStrain = ((Rr-w)^2/(Rg*Rcal*GFn))*1E6

Adjust the Amplifier Gain and Vernier for required output volts @ 1V = 100 microStrains