WANL - TME - 904

TITLE: CALIBRATION SPECIFICATION FOR PRESSURE TRANSDUCERS

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INFORMATION CATEGORY

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1.0 SCOPE

This specification outlines the Westinghouse Astronuclear Laboratory (WANL) requirements for the calibration of all pressure transducers used for instrumentation.

2.0 PERFORMANCE OF TESTS

- 2.1 All calibrations will be performed by the Standards Laboratory and/or Sensor Application Engineering, per the requirements of this specification. The sequence of testing in accordance with this specification shall be performed first at room temperature. Any additional testing at various environmental conditions shall be determined by the cognizant Sensor Application Engineer, at the time of testing, per the particular transducer application.
- 2.2 All data taken shall be kept by Sensor Application Engineering as a permanent record for the pressure transducer. The data sheets shall be dated, signed by the technician and forwarded to the Sensor Application engineer responsible for calibrations.
- 2.3 Sensor Application Engineering shall be responsible for correlation of data and furnishing the calibration information in useable form for field and data reduction use.
- 2.4 No deletions, changes or omission of tests covered by this specification shall be made without written approval of Sensor Application Engineering.
- 2.5 Additional tests or repetition of tests will be coordinated through Sensor Application Engineering.
- 2.6 The pressure transducer will be acceptance tested and meet the requirements of the Quality Control inspection procedure before being calibrated.

3.0 TEST EQUIPMENT REQUIREMENTS

- 3.1 The following is the minimum test equipment requirements to perform the calibration test.

Excitation Source	Voltage stability better than 0.1%. Frequency stability better than 1.0%.
Pressure Gage	Better than 0.1% accuracy.
A.C. Meter	Better than 0.1% accuracy.
D.C. Meter	Better than 0.1% accuracy.

- 3.2 The pressure system shall be a pneumatic system using dry nitrogen gas except at cryogenic temperatures where dry helium gas will be used.

4.0 TEST REQUIREMENTS

- 4.1 Whenever possible the pressure transducers should be calibrated through the same type of leads (i.e. demodulators, amplifiers, etc.) that they will experience during reactor test. As in the case of the variable reluctance transducers, the calibration should be performed with the same demodulator it will be used with throughout the test program.
- 4.2 For calibration of pressure transducers the following definitions apply:
- 4.2.1 Calibration step - Each voltage measurement recorded at a level of input pressure.
- 4.2.2 Calibration cycle - One full range excursion of the transducer in the increasing and decreasing direction, consisting of all the calibration steps.
- 4.2.3 Calibration run - a minimum of three (3) calibration cycles taken at a given environmental condition, i.e. temperature, radiation, etc.

5.0 PRE-CALIBRATION MEASUREMENTS

- 5.1 Record all applicable information (i.e. Mfgr., Mfg. Serial No., WANL P/N, etc.) on Westinghouse Calibration Report Form. (See attachment.)

NOTE: Record atmospheric pressure at the time of calibration, for all pressure transducers except differential pressure transducers.

- 5.2 Measure and record, at the operating frequency, the input and output impedance of each transducer at each environmental condition. Record on data sheet as $R + jX_L$. For piezoelectric type, measure and record output capacitance.
- 5.3 Measure and record, at each environmental condition, the insulation resistance between all transducer leads or terminals in parallel and transducer case.

6.0 CALIBRATION PROCEDURE

- 6.1 If applicable, install transducer in its associated mounting bracket.
- 6.2 Connect the pressure transducer(s) to the test system per the attached block diagrams (Fig. I or II). Set up the excitation voltage for the particular transducer being tested.
- 6.3 Energize the test system and allow approximately thirty (30) minutes warm-up. Reset excitation voltage.
- 6.4 For variable reluctance pressure transducer, set up the demodulators by peaking the phase and adjusting zero and/or full scale output(s).
- 6.5 Perform three (3) exercising cycles on all pressure transducers prior to the initial calibration run at room temperature only.
- 6.6 Perform first calibration run. First calibration run for all pressure transducers shall always be performed at room temperature. Another room temperature calibration run may be required after an exceptionally severe environment is performed.

- 6.6.1 Measure and record the output voltage at each step of each cycle. Each cycle of a calibration run for a particular pressure transducer shall begin at 0% and increase to 120% full range and return to 0%. Use 20% full range steps between 0% and 120% full range.

NOTE: In the event a slight input pressure overshoot occurs at any particular step, during any one cycle, this step must be reapproached from the previous step before that particular output voltage is recorded.

7.0 POST-CALIBRATION CALCULATIONS

- 7.1 Calculate and record, for each run, the combined error resulting from effects to linearity and hysteresis. This error shall be that percentage of variations of full range output taken from a straight line drawn through the calibration points over the full calibration range.

NOTE: To calculate linearity and hysteresis:

- (a) Determine the average output at each step for each run.
- (b) Subtract algebraically the average outputs for 0% and 100% inputs. This resultant is the full range sensitivity.
- (c) Determine the linear change in output by dividing full range sensitivity by the number of increasing even calibration steps. This determines the straight line drawn between the 0% and 100% full range output.
- (d) Determine the worst case of linearity and hysteresis from the straight line drawn between 0% and 100% full range output. This can be one of two cases: (1) all points lie on one side of the straight line, and (2) the points lie on both sides of the straight line.

The maximum voltage difference between the straight line and the hysteresis curve (1), or the maximum voltage difference between the increasing and decreasing hysteresis curve (2), is the worst case of linearity and hysteresis. This maximum voltage difference is designated as L.

(e) Linearity and hysteresis, $\%FR = \frac{L}{2S} \times 100$

where; FR = full range

S = sensitivity at the particular environmental calibration run.

- 7.2 Calculate and record the sensitivity for each run. Sensitivity is the average output voltage change observed resulting from one hundred per cent (100%) input pressure. (Subtract algebraically the average outputs for 0% and 100% inputs.)
- 7.3 To determine residual unbalance, calculate and record for each run the average output voltage observed at zero applied pressure.
- NOTE: For absolute pressure transducers, record whether zero psia or zero psig is used.
- 7.4 To determine the repeatability calculate and record, in % of full range, the maximum deviation from the average value of the three continuous full excursions under identical conditions, i. e., for each run establish the maximum output voltage difference between cycles at each calibration step.

7.4.1 Repeatability, $\%FR = \frac{M}{2(S)} \times 100$

where; FR = full range

M = maximum output voltage difference between cycles,
at each calibration step for the given run.

S = sensitivity at the particular environmental calibration run.

7.5 To determine the thermal zero shift, calculate the average of the output voltages recorded at 0% input at each calibration temperature.

7.5.1 Thermal zero shift, $\%FR/^{\circ}F = \frac{V_{RT} - V_T}{S_{RT}(T_{RT} - T_T)} \times 100$

where; FR = full range.

V_{RT} = residual unbalance at room temperature.

V_T = residual unbalance at test temperature.

S_{RT} = sensitivity at room temperature.

T_{RT} = room temperature.

T_T = test temperature.

7.6 To determine the thermal sensitivity shift, calculate the sensitivity at each calibration temperature.

7.6.1 Thermal sensitivity shift, $\%/^{\circ}F = \frac{S_{RT} - S_T}{S_{RT}(T_{RT} - T_T)} \times 100$

where; S_{RT} = sensitivity at room temperature.

S_T = sensitivity at test temperature.

T_{RT} = room temperature

T_T = test temperature.

Figure I

Variable Reluctance or LVDT Type Pressure Transducers

Figure II

Strain Gage Type Pressure Transducer

WESTINGHOUSE FORM 59403A

NO.

MANUFACTURER

E-SPEC

RANGE

MANUFACTURER SERIAL NO.

MANUFACTURER MODEL NO.

DATE _____

WANL PART NO.

[illegible]S.G. ☐V.R. ☐

OTHER _____

CALIBRATION DATA

INPUT

OUTPUT

TEMP.

TEMP.

TEMP.

%FR

1

2

2

1

2

2

1

•

1

SAMPLE COPY

OUTPUT/INPUT IMPEDANCE

LINEARITY AND HYSTERESIS %FR

SENSITIVITY

RESIDUAL UNBALANCE

REPEATABILITY %FR

THERMAL ZERO SHIFT %/FR/°F

THERMAL SENSITIVITY SHIFT %/°F

TIME & ATMOS. PRESSURE

INSULATION TEST MEGOHMS

EXCITATION

VOLTS AC (RMS) OR DC

CPS

REMARKS:

STANDARDS ACCEPTANCE	DATE	QUALITY CONTROL ACCEPTANCE	DATE
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CALIBRATION DATA REPORT-TRANSDUCER, TYPE _____

WESTINGHOUSE FORM 59447

SHEET 2

NO.

MANUFACTURER		WANL E-SPEC NO.	
MANUFACTURER SERIAL NO.		MANUFACTURER MODEL NO.	DATE
WANL PART NO.			

A. INDICATE TYPE AND ACCURACY OF PHYSICAL TEST STIMULUS

HEISE GAGE ☐

PNEUMATIC DEAD WEIGHT TESTER ☐

(SPECIFY) OTHER _____

SERIAL NUMBER _____ ACCURACY _____ %

B. INDICATE TYPE AND ACCURACY OF TRANSDUCER OUTPUT READOUT INSTRUMENTATION

TYPE _____ SERIAL NUMBER _____ ACCURACY _____ %

C. INDICATE TYPE AND ACCURACY OF TRANSDUCER EXCITATION SOURCE

TYPE _____ SERIAL NUMBER _____ ACCURACY _____ %

D. INDICATE PRESSURE TRANSDUCER TYPE AND HOOK-UP

FIG. 1 ☐

STRAIN GAGE

FIG. 2 ☐

VARIABLE RELUCTANCE

FIG. 3 ☐

LVDT

FIG. 4 ☐

OTHER _____

E. INDICATE STRAIN GAGE TYPE AND HOOK-UP

FIG. 1 ☐

FULL BRIDGE

FIG. 2 ☐

HALF BRIDGE

FIG. 3 ☐

QUARTER BRIDGE

* NOTE: INDICATE WHICH IS ACTIVE AND DUMMY AND POLARITY OF EACH LEAD.

F. INDICATE ACCELEROMETER TYPE AND HOOK-UP

FIG. 1 ☐

PIEZOELECTRIC

FIG. 2 ☐

ELECTRO-MECHANICAL

G. DISPLACEMENT (LVDT) HOOK-UP

H. NOTES