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TITLE: ACCEPTANCE TEST SPECIFICATIONS FOR ACCELEROMETERS

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ACCEPTANCE TEST SPECIFICATIONS FOR ACCELEROMETERS

1.0 SCOPE

This document outlines the Westinghouse Astronuclear Laboratory (WANL) specifications and procedures for acceptance testing of accelerometers. All accelerometers that are to be used for reactor instrumentation shall meet the requirements of this specification before being accepted.

2.0 PERFORMANCE OF TESTS

- 2.1 The acceptance testing will be performed by the Standards Laboratory and/or Sensor Application Engineering, per the requirements of this specification.
- 2.2 All data taken shall be approved by Quality Control and kept as a permanent record for the transducer. A copy of the data sheet shall be dated, signed by the technician and forwarded to the responsible Sensor Application Engineer.
- 2.3 No deletions, changes or omission of tests covered by this specification shall be made without the approval of Sensor Application Engineering and Quality Control Engineering.
- 2.4 Since the requirements for acceptance testing and calibration testing overlap, the two tests may be performed simultaneously. However, this will require coordination and approval between Sensor Application Engineering and Quality Control Engineering as to specification limits, test equipment error, etc.

- 2.5 When out-of-spec readings occur, the transducer shall be sent to the ERB for disposition. All out-of-spec readings shall be circled on the data sheet.
- 2.6 Quality Control will instigate an RIR which will reflect any contractual information that is lacking and/or NMDR action required. Although the RIR is not completed at this time, a Xerox copy should accompany the units.

3.0 REFERENCE DOCUMENTS

The following documents per their latest revisions are a reference for this specification. In any conflict between this specification and those documents, paragraph 2.3 shall apply.

WANL-E-675453-A	Accelerometers, Variable Reluctance Type
WANL-E-675454	Transducer-Acceleration Linear Electro-Mechanical Servo Type
WANL-E-675397	Piezoelectric Accelerometers, Cold-Flow Test

4.0 TEST EQUIPMENT REQUIREMENTS

The following is a minimum list of test equipment needed to perform these tests. Additional and/or equivalent test equipment can be substituted if necessary.

Megohmmeter	test range, 50 V to 500 V DC
Impedance Bridge (RLC) (John Fluke)	

Charge Amplifier, Model 566
(Kistler, Inc.)

Visicorder Oscillograph (Minneapolis-Honeywell)

Power Supply, Model M-6.6-6.0
(Technipower, Inc.)

Cathode Follower, Type F460

Crescent-East Demodulator

Shaker Table and associated equipment

Power Supply, 28V DC
(Gulton Industries, Type LA64207)

± 2 volts at 2MA

AC Excitation Source

voltage stability better than 0.1%

frequency stability better than 1.0%

5.0 TEST PROCEDURE

The following procedure describes the sequence of operations necessary to perform the acceptance testing of accelerometers.

- 5.1 Record all preliminary data on applicable data form, i.e. manufacturer serial number, WANL part number, type of accelerometer, frequency range, acceleration range, etc.
- 5.2 Measure and record, with an impedance bridge, the input and output resistance/impedance of each transducer. Record on data sheet as $R + j X_L$. Check wire terminations with applicable specification control drawing. For piezoelectric type, measure and record output capacitance of accelerometer and test cable.

- 5.3 Measure and record the insulation resistance between all transducer leads or terminals in parallel and transducer case. It shall be 50 megohms minimum at 50V DC.
- 5.4 If applicable, install accelerometer in its associated mounting bracket.
- 5.5 Attach accelerometer to shaker test table with axis of accelerometer under test in line with axis of shaker table.
- 5.6 Electrically connect accelerometer to test system per attached block diagram, Fig. I, II or III.
- 5.7 Energize the test system, then set up the excitation voltage(s), where applicable, for the particular accelerometer being tested. Allow approximately thirty (30) minutes warmup, then reset any critical voltages.
 - 5.7.1 For variable reluctance type, setup the demodulator by peaking the phase and adjusting zero and/or operating range output(s).
 - 5.7.2 For piezoelectric type, adjust the associated amplifiers and readout equipment for operating range output.
 - 5.7.3 For strain gage type, adjust associated excitation and readout equipment for zero and operating range output.
- 5.8 Whenever possible, the accelerometer should be acceptance tested through the same type of leads, demodulators, amplifiers, test equipment, etc., that was used by the vendor.
- 5.9 For acceptance testing of accelerometers, the following definitions apply.
 - 5.9.1 Test step - each voltage measurement recorded at a given input of acceleration for a given frequency.

- 5.9.2 Test cycle - one operating range excursion of the accelerometer in the increasing and decreasing direction, consisting of all the calibration steps. The operating range shall be the assigned operational G-level for which the accelerometer will be used in a particular application as specified by the applicable drawing.
- 5.9.3 Test run - a minimum of three (3) cycles taken at a given environmental condition, i.e., temperature, radiation, etc.
- 5.10 Perform first test run - first test run shall always be performed at room temperature.
 - 5.10.1 With the accelerometer vibration at 40 ± 5 cps and at 100 ± 5 cps, perform test runs as follows:
 - 5.10.1.1 Measure and record at each frequency the output voltage at each step of each cycle. Each cycle of a test run for a particular accelerometer shall begin at 0% acceleration and increase to 100% of the operating range and return to 0%. Use 20% steps between 0% and 100% of the operating range.
 - 5.10.1.2 Repeat operations 5.10.1 and 5.10.1.1 at $+600^{\circ}\text{F}$ and -320°F , respectively.

6.0 PERFORMANCE REQUIREMENTS

- 6.1 RANGE: The nominal range of each type of accelerometer shall be in accordance with the applicable WANL specification control drawing.
- 6.2 LINEARITY AND HYSTERESIS: Calculate and record, for each run, the error resulting from the effects to linearity and hysteresis. These errors

shall be that percentage of variations of the full operating range output taken from a straight line drawn through the test points over the full test range.

NOTE: To calculate linearity and hysteresis:

- (a) Determine the average output at each step for each run.
- (b) Subtract algebraically, when applicable, the average outputs resulting from 0% and 100% inputs. This resultant is the operating range sensitivity.
- (c) Determine the linear change in output by dividing full operating range output by the number of increasing even test steps. This determines the straight line between the 0% and 100% operating range output.
- (d) Determine the worst case of linearity and hysteresis from the straight line between 0% and 100% operating 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, $\%OR = \frac{L}{2(S)} \times 100$
where; OR = operating range in volts, as determined at 6.2(b).
S = sensitivity at a particular environmental test run.

6.2.1 The combined error resulting from the effects of nonlinearity and hysteresis shall not exceed $\pm 1\%$ of peak-to-peak output over the operating temperature range.

6.3 SENSITIVITY: The sensitivity of each type of accelerometer shall be within the minimum and maximum limits specified on the applicable WANL specification control drawings and equipment specifications.

6.3.1 Determine the sensitivity by calculating and recording for each test run the average output observed from 100% input. (If applicable, subtract algebraically the average outputs for 0% and 100% inputs.)

6.3.1.1 For piezoelectric type, determine the sensitivity for each test cycle as follows:

$$E_x = E_{xc} \left(\frac{C_x + C_{xc}}{C_x} \right)$$

where; E_x = voltage output of accelerometer less test cable loading.

E_{xc} = voltage output of accelerometer including test cable loading.

C_x = capacitance of accelerometer.

C_{xc} = capacitance of accelerometer cable.

6.4 REPEATABILITY: The output shall be repeatable, within the limits specified in the applicable equipment specifications for three (3) consecutive operating range excursions performed under identical conditions over the operating temperature range.

6.4.1 Repeatability, $\%OR = \frac{M}{2S} \times 100$

where; OR = operating range in volts as determined at 6.2(b).

M = maximum output voltage difference between cycles at a calibration step for a given run.

S = sensitivity.

6.5 OPERATING TEMPERATURE RANGE: The accelerometer shall be operable within the limits of accuracy over its entire temperature range per their applicable equipment specifications.

6.6 THERMAL ZERO SHIFT: Measure and record the thermal zero shift of the accelerometer over its compensated temperature range. (See applicable E-Specification.) It shall not exceed 0.01% FR/°F.

$$6.6.1 \quad \text{Thermal zero shift, \%OR/°F} = \left| \frac{V_{T1} - V_{T2}}{S_{RT} (T_1 - T_2)} \right| \times 100$$

where; OR = operating range in volts as determined at 6.2 (b).

$V_{T1} - V_{T2}$ = difference in residual unbalance of the transducer at T_1 and T_2 .

$T_1 - T_2$ = the compensated temperature range of the transducer (°F).

S_{RT} = sensitivity at room temperature (volts).

6.7 THERMAL SENSITIVITY SHIFT: Measure and record the thermal coefficient of sensitivity of the accelerometer over its compensated temperature range. (See applicable E-Specification.) It shall not exceed 0.01% OR/°F.

$$6.7.1 \quad \text{Thermal sensitivity shift, \%°F} = \left| \frac{S_1 - S_2}{S_{RT} (T_1 - T_2)} \right| \times 100$$

where; S_1 = sensitivity at T_1 (volts).

S_2 = sensitivity at T_2 (volts).

S_{RT} = sensitivity at room temperature (volts).

$T_1 - T_2$ = the compensate range of the transducer (°F).

6.8 RESIDUAL UNBALANCE: When applicable, calculate and record for each run the average output observed at zero acceleration.

$$6.8.1 \quad \text{Residual unbalance, } \%OR = \frac{RU}{OR} \times 100$$

where; RU = residual unbalance in volts.

OR = operating range in volts as determined at 6.2.(b).

6.8.2 The residual unbalance shall not exceed $\pm 2\%$ of operating range output at zero acceleration.

6.9 FREQUENCY RESPONSE: Calculate and record at room temperature the per cent of output voltage variation over a given frequency range, at a given G-level.

6.9.1 The G-level and frequency range shall be determined by the particular transducer application (i.e. specification control drawing, equipment specification and measurements list).

$$6.9.2 \quad \text{Frequency response, } \% = \left| \frac{E_R - E_M}{E_R} \right| \times 100$$

where; E_R = the voltage output measured at 100 cps.

$E_R - E_M$ = the maximum voltage output difference measured above or below the E_R over the frequency range.

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

WESTINGHOUSE FORM 59446

NO.

CALIBRATION DATA

SAMPLE COPY

REMARKS:

STANDARDS ACCEPTANCE

DATE _____

QUALITY CONTROL ACCEPTANCE

DATE _____

FIG. I
VARIABLE RELUCTANCE TYPE

FIG. II
ELECTRO-MECHANICAL AND STRAIN GAGE TYPE

FIG. III
PIEZOELECTRIC TYPE