Attachment 17

Non-proprietary Ametek Report No. TR-1136, "Qualification Documentation Review Package for Ametek Aerospace Gulton-Statham Products Nuclear Qualified Pressure Transmitter Series Enveloping --- Gage Pressure Transmitter Series PG 3200, Differential Pressure Transmitter Series PO 3200 Differential High Pressure Transmitter Series PDH 3200, Draft Range Pressure Transmitter Series DR 3200, Remote Diaphragm Seal Differential Pressure Transmitter Series PO 3218, Remote Diaphragm Seal Differential High Pressure Transmitter Series PDH 3218," Revision C (Letter Item 5)

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

PREPARED ON BEHALF OF THE NUCLEAR INDUSTRY TO DEMONSTRATE EQUIPMENT QUALIFICATION TO 10CFR50.49, IEEE 323-1974, IEE 323-1983, IEEE 344-1975, IEEE 344-1987 & NUREG 0588, REVISION 1

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PACKAGE TITLE: QUALIFICATION DOCUMENTATION REVIEW PACKAGE FOR GULTON-STATHAM

NUCLEAR QUALIFIED PRESSURE TRANSMITTERS ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200,

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR3200,

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218,

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218.

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APPROVAL COVER PAGE:

This cover sheet shows the revision status of the other pages of the Qualification Documentation Review package. It is revised when any other sheet of the package is revised subsequent to first official issue.

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REFERENCED DOCUMENTS

This Qualification Documentation Review Package includes previously issued Equipment Qualification Reference(s) prepared by Gulton-Statham. These are described below:

- Gulton-Statham document Number PER 1005, Revision H, "Nuclear Qualification Report for Gulton-Statham Pressure Transmitter PG3200", dated December 6, 1984. (Including earlier revisions of this document).
- Gulton-Statham document Number PER 1006, Revision K, "PD/PDH3200, PD/PDH3218 Nuclear Qualification Report", dated December 6, 1984. (Including earlier revisions of this document).
- Gould, Inc., Measurement Systems Division Project Engineering Report PER 1003, "Functional Test Data Report for Gould Model PD3218-100 Pressure Transmitter Serial Number 6164 Exhibit II of NTS Report 528-00994-1," dated July 11, 1983.
- Gulton-Statham "Nuclear Qualification Test Project Engineering Test Report" Number PER 1029, Revision F, for Gulton Statham DR3200, Draft Range Differential Pressure Transmitter, dated January 18, 1985. (Including earlier revisions of this document).

All transmitters certified to the above documents are enveloped by this more comprehensive Qualification Documentation Review package.

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PART 1 - QUALIFICATION STATUS - ENVIRONMENTAL AND SEISMIC QUALIFICATION

This document package is an important collection of auditable data* which provides tangible evidence (using a systematic, auditable and thorough approach) that equipment qualification** (both environmental and seismic withstand) is demonstrated. This documentation package fulfills the requirements for documentation and verifies that the subject equipment, with reasonable assurance, is:

QUALIFIED TO THE REQUIREMENTS OF 10CFR50.49[(1)*], IEEE 323-1974[(2)], IEEE 323-1983[(3)], IEEE 344-1975[(4)] & NUREG 0588 REVISION 1[(6)]**

The equipment demonstrated qualified by this documentation package is the Gulton-Statham Nuclear Service Qualified Series PD 3200 (Differential Pressure), PG 3200 (Gage Pressure), PDH 3200 (High Differential Pressure), PD 3218 (Remote Diaphragm Seal Differential Pressure), PDH 3218 (Remote Diaphragm Seal High Differential Pressure), and DR3200 (Draft Range Pressure) Transmitters.

1A PURPOSE AND SCOPE

The purpose of this documentation package is to demonstrate the qualification of the subject equipment in a traceable and auditable manner. This Qualification Documentation Review (QDR) package is prepared to be a readily "reviewable" document which a competent individual can easily review and determine that qualification is demonstrated. This package is prepared recognizing that no standard test report and series of plans provided by a manufacturer or test lab has ever been acceptable without substantial packaging of data to make it readily "reviewable." Provision of this documentation package to Gulton-Statham's current and future customers is meant to ease the burden on the customer by providing readily reviewable data. Included is specific "parameter-by-parameter" review for parameters used by the NRC for review (based on original IEB 79-01B[(7)] format, e.g. Operating Time, Temperature, Radiation, Humidity, Aging, etc.)

For the reader's convenience, all referenced Figures and Tables for Section A are in Appendices directly following the text of Section A.

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*Auditable data is defined (Reference 22 in Section C) as, "Information which is documented and organized in a readily understandable and traceable manner that permits independent verification of inferences or conclusions based on the information."

** Equipment qualification is defined (Reference 2 in Section C) as, "The generation and maintenance of evidence to assure that the equipment will operate on demand to meet the system performance requirements." This documentation package is the Gulton-Statham means to provide the "generation and maintenance of evidence...to meet the system performance requirements."

***Refer to Section C for this and other references.

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Also included at the end of Section A text, is a checklist format previously used by the NRC in review of Qualification*. Completion of this checklist assures traceability to NRC requirements.

The documentation and analyses utilized in this package demonstrate the adequacy of the transmitters to meet typical harsh environment and seismic withstand qualification plant requirements with margin. This data is for a generic demonstration of qualification; consequently, the specific margin determination or enveloping of plant needs, is application-specific.

This package contains the most current revision of the environmental and seismic qualification documentation for this equipment. It supersedes and updates previous documentation as described in "Referenced Documentation," page A-4. Unique project documentation, rather than the generic documentation included in this report, is updated only to the extent that any such non-generic documentation uses the reports described in "Referenced Documentation" as its qualification basis. Unique project documentation under the control of a customer cannot be updated by this general qualification file.

1B APPLICATION DISCUSSION FOR DETERMINING BASIS OR QUALIFICATION ACCEPTABILITY

The Gulton-Statham PD 3200, PDH 3200, PD 3218, PDH 3218, DR 3200, and PG 3200 Transmitters enveloped by this documentation package (simply referred to as transmitters or transmitter when appropriate in this Qualification Documentation Review Package), are designed for installation in various locations within a nuclear power plant or other nuclear facilities. The level of qualification demonstrated should enable use in essential all areas outside Pressurized Water Reactor (PWR) containment or Boiling Water Reactor (BWR) drywell. Parameter review in Section D will allow the user or their Engineer to determine acceptability inside such areas as a containment building of a Pressurized Water Reactor, Candu Reactor, or steam tunnels for a Boiling Water Reactor.

During actual testing of several nuclear service transmitters (e.g. PD 3218 series), which had Neoprene gasketed terminal boxes and PVC lead wiring for the prototype test units, anomalies occurred (no such anomalies occurred with Viton□ gasketed and Kapton□lead wires used in actual current or post-qualification test unit manufacturing). These test anomalies, as well as others, are all evaluated and dispositioned in Section 2K. The transmitters actually type-tested are demonstrated representative of all the transmitter types** demonstrated qualified in similarity analysis of Section 2D (which also includes by reference, various other Sections of this package).

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*Reference 25 in Section C.

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**Although similarity is used for the PD/PDH3218 transmitters, prior to the anomalies (which occurred only during LOCA simulation) primarily traceable to the Neoprene gaskets and PVC wiring, the PD 3218 test units were demonstrated qualified by successful radiation exposure, SRV vibration, and seismic exposure. The DR3200 transmitters were not included in the original full qualification program; demonstration is by similarity analysis.

All units undergoing qualification testing by the qualification laboratory NTS (with reports described in Section 2E), are dispositioned in this package for traceability to the demonstrated qualified equipment. Specific sample traceability and anomaly review is found in Sections 2E and 2K or this report, respectively.

The safety function of a transmitter* is the sensing of a process or atmospheric pressure with the conversion of that pressure to a standard transmission signal of 4-20 mA dc output to represent the value of the sensed variable (i.e. pressure). The plant instrumentation and control system (or operator) monitors the value of transmission signal and performs a safety function or other action dependent upon the milliampere signal value which represents the pressure value. The specific plant safety analysis allows for an instrument accuracy derived from analysis or based on allowance for all the devices in the instrument loop. The performance characteristic of most interest is therefore the inaccuracy of the transmitter during normal, accident, and seismic conditions. Consistent with industry standard terminology, this inaccuracy is expressed as an accuracy number. Note that measured accuracy** values have been as poor as ±20% of Upper Range Limit*** and been acceptable in certain applications (e.g. post-accident monitoring). This Qualification Documentation Review Package and the Gulton-Statham generic acceptability was conservatively based on the performance requirements of Tables A9 and A10. The Gulton-Statham-established acceptance values are substantially more severe than specified by the Nuclear Steam Supply Vendor for the original supply of Gulton-Statham transmitters, found in practice, or used by other transmitter suppliers.****

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*Transmitter is defined (Reference 8) as, "A transducer which responds to a measured variable by means of a sensing element, and converts it to a standardized transmission signal which is a function only of the measured variable." Gulton-Statham note: The standardized transmission signal for Gulton-Statham is the traditional standard 4-20 mA dc signal of the power industry. A 10-50 mA dc signal output is also used in the power industry, although less frequently than 4-20 mA dc. Section F includes design change evaluations which validate acceptability of qualification for such units traceable to the original qualification.

**Accuracy, measured is defined (Reference 8) as, "The maximum positive and negative deviation observed in testing a device under specified conditions and by a specified procedure. Note 1: It is usually measured as an inaccuracy and expressed as accuracy. Note 2: It is typically expressed in terms of the measured variable, percent of span, percent of upper range value, percent of scale length or percent of actual output reading."

***Gulton-Statham Note: The standard measure used in this qualification is Upper Range Limit (URL) which is (per Reference 8), "The highest value of the measured variable that a device can be adjusted to measure."

****Reference 36 is original General Electric Specification which allows 5% of maximum range value for less severe exposure than the Gulton- Statham instrument, are qualified to with less inaccuracy. In worst cast instrument accuracy determinations, the inaccuracies for PWR service has been shown acceptable with loop accuracies of 17-30% or more, for steam generator low-low level, pressurizer pressure low-low level, steam generator narrow range level, pressurizer level, main steam flow, cold leg safety injection flow, etc. The other transmitter suppliers with poorer accuracy performance necessitated a much more complex set point analysis than would be necessary for the more accurate Gulton-Statham transmitters.

The discussion of similarity between the tested equipment and the Gulton-Statham standard equipment is provided throughout this section.

For completeness, available qualification data was reviewed for all nuclear qualification tests prior to the formal test program forming the basis of the P3200 series qualification. The first development of a nuclear qualified transmitter was to meet equipment Specification definitions[45-53] for General Electric to a qualification level lower than demonstrated in this file. The qualification efforts began with an investigation of the commercial P3000 series (primarily PD 3018 unit), which included various tests, analyses, design reviews and component changes (e.g. removal of Teflon□ sleeving, utilization of radiation-resistant fill fluid, etc.)[54-57]. These tests and analysis included irradiation to 30 Megarads, 250□F ambient service, and other parameters. Subsequent to design change and review from the P3000 series, the model series became the P3200 series[50,57].

Prior to the full type testing program, used as the primary means of equipment qualification demonstrated in this file, a "Nuclear Scope Test Report"[50] was prepared which included a combination of qualification methods for scoping or screening prior to the full qualification test program. Included was testing of PDH 3200-030 units with irradiation to a nominal 33 Megarads, thermal aging (221□F for 12.8 days), ambient (dry heat) of 265□F, and seismic simulation. This report, "does not completely duplicate the 'Formal Qualification Test Program.' The data obtained defines the accuracy, thermal, and radiation performance characteristics of the P3200 Series Pressure Transmitter." The scoping effort was instituted as a cost-effective initial qualification effort prior to the more costly formal qualification program. No specific qualification credit is taken for the scoping test reports or the earlier tests, as a true HELB environment was not included, nor was the appropriate IEEE 323-1974 test sequence. However, as these tests were qualification efforts for completeness, they are included. The screening tests demonstrated the units (within the test scope that did not include LOCA, MSLB, or HELB wet/pressure environments), would meet specifications for the test exposures previously described. The earlier tests were used as a means to determine candidate subcomponent changes from the P3000 series necessary to meet severe environmental conditions as nuclear qualified components. As part of the qualification review effort leading to this current report, the Gulton-Statham Quality Assurance group verified past shipping records and confirmed only the P3200 series was shipped as nuclear safety-related.

Other Gulton-Statham transmitter model series such as the P3000 series, which are the commercial grade model of the P3200 series, exist. The P3000 series may be functionally suitable for certain mild or moderately harsh nuclear plant environments, but they are not controlled under the current Gulton-Statham Nuclear Quality Assurance Program and do *not* include nuclear qualified materials (e.g. elastomers and cable), as does the P3200 series. Consequently, the P3000 series is not enveloped under this documentation package.

In addition, a P3100 designation was temporarily used for units with a planned capability somewhat less than the P3200 series. No P3100 units were ever released for production. A P3300 series was developed as a designation for P3200 Series Transmitters planned to be marketed through a Nuclear Steam System Supplier based on the standard P3200 series; and a worst case PWR environment to be supported by a model designation of P3400 with a completely new qualification program. No P3300 or P3400 units were ever shipped. Additional generic qualification tests (beyond the P3200 series tests described on this Qualification Report, was attempted for P3200 use in worst case PWR environments; however, this testing[61] while successful for irradiation and seismic withstand, was not successful in regards to meeting MSLB/LOCA qualification withstand at the extreme levels (e.g. greater than 425□F). Although much research and development or testing has occurred beyond the original test program forming the basis of qualification (often for research on other products or different aspects of unit performance), there is no known generic test result which will invalidate the level of qualification demonstrated.

1C VERY CONSERVATIVE QUALIFICATION MEANS

The requirement of this qualification documentation is to provide reasonable assurance (Refer to Paragraph 2Q for an explanation of this concept), that the Gulton-Statham transmitters will not degrade plant safety, and will perform their safety function in a harsh environment or for a worst case series of seismic events. This is done primarily by proving the adequacy of the equipment to successfully meet its performance requirements during a harsh environment exposure and severe seismic exposure. As this qualification demonstration is generic, it must support the licensing commitments of various plants. Representative, but conservative generic data, is used in this documentation package to allow the user to easily modify the analysis to make it unique for a specific application.

The Gulton-Statham Transmitters were type-tested to a designated worst case enveloping environment using the methodology of IEEE 323-1974 and IEEE 344-1975, which meet 10CFR50.49, IEEE 323-1983, IEEE 344-1987, IEEE 627-1980, and NUREG 0588 Revision 1 requirements. The review of the different requirements that follow illustrate how the transmitters meet all of the aforementioned requirements.

1C.1 ENVIRONMENTAL QUALIFICATION MEETING BOTH IEEE 323-1974 AND IEEE 323-1983 REQUIREMENTS TO MAXIMIZE USER FLEXIBILITY.

The NRC staff position found in USNRC Regulatory Guide 1.89 Revision 1[18], June 1984, Paragraph B, second subparagraph, describes the basis for environmental qualification quite well, as follows:

"For the purpose of this guide, 'qualification' is a verification of design limited to demonstrating that the electric equipment is capable of performing its safety function under significant environmental stresses resulting from design-basis accidents in order to avoid common-cause failures."

The qualification means for acceptability in the U.S., must meet the definition of the qualification requirements outlined in 10CFR50.49(f) [6][1], which includes the following four (4) acceptable qualification methods:

"(1) Testing an identical item of equipment under identical conditions or similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable."

"(2) Testing a similar item of equipment with a supporting analysis to show that the equipment to be qualified is acceptable."

"(3) Experience with identical or similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable."

"(4) Analysis in combination with partial type test data that support the analytical assumptions and conclusions."

The primary method of qualification for the Transmitters are methods (1) and (2) above or Type Testing. Although the EQ rule (10CFR50.49) does not differentiate the methods by showing a preference, the NRC staff does by its endorsement of IEEE 323-1974[2] in USNRC Regulatory Guide 1.89[18] in lieu of IEEE 323-1983[3] or IEEE 627-1980[11]. Whereas the 1983 version of IEEE 323, the 1980 version of IEEE 627, and the Rule has no preference for Type Testing, the NRC staff endorsed IEEE 323-1974 which includes the following in Paragraph 5, "Principles of Qualification."

"It is preferred that the demonstration be done by Type Tests on actual equipment."

The Gulton-Statham transmitters are type tested and meet the most stringent industry requirements of IEEE 323-1974. Therefore, this qualification demonstration meets or exceeds the 10CFR50.49, IEEE 323-1983, IEEE 627-1980, and NUREG 0588 Revision 1 requirements that remove very conservative and industry standard consensus determined as unnecessary practices of IEEE 323-1974.

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1C.2 SEISMIC WITHSTAND QUALIFICATION MEETING BOTH IEEE 344-1975 AND IEEE 344-1987 REQUIREMENTS TO MAXIMIZE USER FLEXIBILITY

For Seismic Withstand Testing, the methodology used was traceable to IEEE 344-1975 (as shown in the Qualification Reports and procedure described in Section 2E and found in Sections G.1 and G.2). This methodology remains essentially unchanged by IEEE 344-1987, the current version of the standard, as illustrated below.

The significant differences between the two (2) versions of the IEEE 344 standard, is that the later version includes a whole new Section, (Section 9), allowing for seismic qualification for experience and various non-binding additional guidelines and clarifications in the Appendices of the standard. The NTS testing is consistent with testing allowed in both issues of the standard (Paragraph 7 of the 1987 version and Paragraph 6 of the 1975 version). For example, review of Paragraph 6.6.1 of IEEE 344-1975 and Paragraph 7.6.1 of IEEE 344-1987, indicates essentially the same requirements. Subparagraph (a) below, is the exact words of the 1975 standard (Paragraph 6.6.1), while sub-paragraph (b) is that from the 1987 (Paragraph 7.6.1) standard:

(a) From IEEE-344-1975: "6.6.1 INTRODUCTION: Present test methods generally fall into two major categories: proof testing (Section 6.2), and fragility testing (Section 6.3). The choice of the type of motion to best simulate the postulated seismic environment is difficult, but the methods available also fall into two categories; single frequency and multiple frequency. The choice of method will depend upon the nature of the equipment and the expected vibration environment. The various technical requirements appropriate to each test method may provide extra benefits for specific applications. However, such consideration should not preclude the legitimate use of any of the methods specified, all of which can be justified as meeting some basic seismic criterion level."

In general, the proof test seismic simulation waveforms should:

(1) Produce a TRS which closely envelops the RRS or the applicable portions thereof, using single or multiple frequency as required, to provide a conservative (but not overly conservative) test table motion.

(2) Have a peak amplitude equal to or greater than the ZPA, except at low frequencies where the value of the RRS decreases below and stays below the ZPA.

(3) Not include frequencies above the ZPA asymptote.

(4) Have a duration in accordance with the requirements of Section 6.6.5.

As a further complication, consideration must be given to the choice of single-axis or multiple-axis testing as described in Section 6.6.6.

(b) From IEEE 344-1987: "7.6.1 INTRODUCTION: Present test methods generally fall into three major categories. They are proof-testing or generic testing (7.2), and fragility testing (7.3). The types of motion available to best simulate the postulated seismic environment fall into two categories; single frequency and multiple frequency. The method chosen will depend upon the nature of the expected vibration environment and also somewhat on the nature of the equipment. The various technical requirements appropriate to each test method may provide extra benefits for specific applications.

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In general, the proof or generic test seismic simulation waveforms, or both, should:

(1) Produce a TRS which closely envelopes the RRS or the applicable portions thereof, using single or multiple frequency input as required to provide a conservative (but not overly conservative) test-table motion.

(2) have a peak acceleration equal to, or greater than, the RRS ZPA.

(3) Not include frequency content above the ZPA asymptote.

(4) Have a duration in accordance with the requirements of Section 7.6.5.

Consideration must also be given to the choice of single-axis or multiple-axis testing as described in Section 6.6.6.

It is quite obvious from a review of the basic requirements that the methodology and criterion used in both standards is the same for the seismic testing. The differences are essentially editorial. The testing by NTS met the four (4) basic requirements stated in both standards by test.

1C.3 SELECTION OF ENVIRONMENTAL QUALIFICATION AND VIBRATION PARAMETERS

The aging requirements, harsh environmental exposure, vibration, and seismic simulation selected for qualification is shown in Section B and discussed in this Section. During the determination of the generic conditions for testing in the early 1980's when the units were tested, the industry attempted to establish generic requirements (i.e. the generic profiles of the non-binding appendices of IEEE 323-1974 were not included in the IEEE 323-1983 revision), and a series of generic cases for inside containment, inside drywell, outside containment, etc., was being discussed. The only available generic profiles now supported by the IEEE appeared two (2) years later in IEEE 382-1985*. Gulton-Statham, in support of industry needs, established a series of requirements reflected in Section B data that meets the majority of all know applications and was consistent with the conservative determination of appropriate parameters at the time of test plan preparation. Certain aspects of qualification far exceed industry "standard" methods such as (1) assurance of electronics adequacy by initial high dose rate exposure (e.g. 3 Megarads/hour), since electronic radiation susceptibility is much greater at high rates for electronics; (2) testing for Steam Relief Valve (SRV) induced vibration when such testing is rare, and (3) running the required seismic simulations twice for different mounting brackets on the same differential pressure transmitters.

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*Reference 22, Section C. NOTE: More than ten (10) years after issuance of IEEE 382-1985, these generic environmental profiles are the only industry-wide guidance.

PART 2 - EQUIPMENT DESCRIPTION AND EQUIPMENT ANALYSIS

This part of the summary section of the QDR (Section A, Part 2) includes equipment description, traceability, performance review, and other aspects of qualification demonstration. Detailed parameter by parameter reviews (e.g. temperature, pressure, radiation, etc.) are found in Section D.

2A GENERAL EQUIPMENT DESCRIPTION

The Transmitters subject to this documentation package are the PD 3200, PDH 3200, PD 3218, PDH 3218, DR 3200 and PG 3200 Series. The units provided as nuclear safety-related have always been manufactured under a nuclear quality program to 10CFR50, Appendix B(16). Currently, the manufacture is under both 10CFR50, Appendix B and the International Standard ISO 9001(17). Both these quality management systems require design control, configuration control, test control, change control, and quality control to assure that the equipment supplied meets the design and test configuration for that equipment. Paragraphs 2D and 2K provide more detail regarding original test configurations and traceability from the test units to the production units shipped to industry. Paragraph 2P describes the change control process.

2A.1 THE PD 3200 AND PDH 3200 SERIES TRANSMITTERS

The P3200 Series Differential Pressure Transmitter are units designed to provide accurate and reliable pressure measurements in level and flow applications. The transmitter features non-interacting zero (0) and span adjustments, simple dc electronics and thin film strain gage technology. The transmitters provide industry standard 4-20 mA* output with a power supply voltage at the transmitter of 12-55 VDC. The difference between the PD 3200 and PDH 3200 is simply the pressure range of the units, with the PDH unit having a higher pressure range and corresponding greater pressure diaphragm thickness. All design stresses and margins (electronics, seals, configuration), are identical between the PD 3200 and PDH 3200, with the simple difference of the previously described adjustment in diaphragm dimension to correspond to the process pressure. Qualification of the PDH 3200 equipment based on PD 3200 testing is clearly enveloped under the guidance of IEEE-323-1983 for Extrapolation and Interpolation which describes sound, "analytical techniques which may be used to qualify equipment by extending the application of test data"**. The unit specifications are provided in Table A1. Various model number code designations are described in Table A2, indicating different pressure ranges, junction box codes, and other available features. A more complete series of model numbers are reflected in Table A15 that includes past configuration designations and current configuration designations (e.g. Seismic Mounting Bracket).

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*As described under Section F, an alternate design has been evaluated under the design and configuration control systems at Gulton-Statham which allows use of an alternate industry standard signal level of 10-50 mA dc.

**Extrapolation and Interpolation methods of IEEE 323-1983 (Reference 3), Paragraph 6.5.3, describes acceptability of similarity approaches based on considering (1) Material, (2) Size, (3) Shape, and (4) Stress which are all met between the PD 3200 and PDH 3200 transmitters.

Paragraph 2D describes the basis for similarity analysis, while Paragraph 2K describes the samples tested. Performance under accident and seismic conditions is shown in Table A9. The actual environmental worst case exposure conditions are shown in the detailed parameter reviews of Section D.

The transmitters are relatively small, includes hermetically sealed electronics in a stainless steel housing, utilizes a unique field calibration technique by use of magnetically coupled external adjustment screws for span and zero adjustment (calibration), not requiring an opening of the unit (see Figure A3), and are based on decades of use in industry (more than a decade for the nuclear units and several decades for the P3000 Series commercial units).

2A1.1 TRANSMITTER PHYSICAL OUTLINE

A cross-sectional view of the basic unit is shown in Figure A1. The outline dimensions of a unit is shown in Figure A2. Figure A3 indicates the mechanism of field calibration which does not require any disturbance of the hermetically-sealed enclosure. The original unit used in qualification or type testing is reflected in Drawing 70006-000-001 (Reference 14 contained in Section F).

The ability to verify calibration without physically opening the unit (by use of magnetically coupled external adjustment screws for span and zero adjustment), allows the transmitter used in pipe break areas without special additional conduit seal assemblies or disconnect assemblies.

2A1.2 BRIEF DESCRIPTION OF OPERATING PRINCIPLES OF SENSING CIRCUIT

The design is based on proven thin film strain gage technology in which the gage is strained (e.g. force causes a deformation), leading to a change in electrical resistance of the strain gage. The strain gage* is a passive transducer that converts a mechanical displacement (based on pressure input in a pressure transmitter), into a change in resistance. The strain gage is a thin wafer-like device usually provided as a thin film strain gage (as it is in the Gulton-Statham transmitter), which is bonded to an element that deforms (metallic bending beam at Gulton-Statham). The strain gage is used in a Wheatstone Bridge circuit (see Figures A4A and A4B), which does not require alternating current as do other technologies based on capacitive measuring techniques. Consequently, the number of components is reduced resulting in increased reliability, lack of concern for ac to dc conversion and transformers and an ability to provide all this capability in a relatively small enclosure. The bending beam is acted upon by a combination of hydraulic and mechanical forces. Process pressure, applied to the isolation diaphragms on the sensor case outside is transmitted hydraulically by the silicone fill fluid to the internal force-sensing diaphragm (Figure A4C).

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*Brief description of strain gage derived from References 37-39. Reference 37 is provided in Section G.5, and it describes the non-nuclear version of the Gulton-Statham Transmitters. The principles and advantages of the superior design concepts are in the commercial as well as nuclear units (although the commercial unit uses less capable lead wires, less quality screening in manufacture, etc.)

The strain gage resistance change, changes the Wheatstone Bridge resistance balance with a resultant output voltage change proportional to the applied pressure. A relatively simple (in number of components and proven technology), dc amplifier provides the excitation voltage to the Wheatstone Bridge which converts the output of the bridge to a current and provides the 4-20 mA output signal on the two-wire dc power input cabling. The deflection of the sensing diaphragm, which is mechanically coupled to the bending beam, causes a strain on the strain gage with a resulting resistance change.

2A2 THE PD 3218 AND PDH 3218 REMOTE DIAPHRAGM SEAL SERIES TRANSMITTERS

The P3218 Series PD and PDH Differential Pressure Transmitters are essentially the same as the PD 3200 and PDH 3200 transmitters except for the addition of the remote capillary sensing diaphragm capillary assemblies.

2A2.1 TRANSMITTER PHYSICAL OUTLINE

Non-Proprietary Version

Figures A5A, A5B, A5C, and A5D illustrate the similarity between the PD/PDH 3200 and PD/PDH 3218 units. The electronics, potentially aging and environmentally-sensitive components, are the same between units. The capillary attachments are 316 stainless steel. The hydraulic media is DC-702 silicone oil which is identical to that used in the sensor cavity of the PD/PDH 3200 (and all nuclear) units. The Remote Sensing Assembly (paddles and capillary) comprise a separate hydraulic system outside the sensor - the physical integrity of the sealed electronic transmitter is not violated (see Figure A6). Process pressure applied to the remote diaphragm is transferred hydraulically to the transmitter sensors by the silicone oil in the capillary tubing. The capillary does not add in any additional environmentally-sensitive components. Essentially all performance testing, design, and quality is the same.

The only differences are as follow:

- The PD/PDH 3218 has welded-on pressure caps (where the capillaries meet the main body), while the PD/PDH 3200 has the standard bolted-on pressure caps.
- The PD/PDH 3218 has a different and more extensive mounting bracket due to its shape.
- The PD/PDH 3218 has a slightly different lower body to accommodate the pressure cap welds.

The difference in application is in the simple accounting for the change in response time* for sensing of the pressure changes which must be transmitted through the capillary, and the potential differences in fluid pressures for mounting the remote paddles at different temperatures, which is all accounted for in the installation design by the user. (Also see Section E)

Figure A5 is generated to illustrate the discussions above. Figure A5A is a model PD/PDH 3200 transmitter with bolt-on pressure flanges fitted to the sealed electronic transmitter housing. Figure A5B is a model PD/PDH 3200 transmitter with bolt-on pressure flanges removed from the sealed electronic transmitter housing. Figure A5C is a model PD/PDH 3218 which is essentially the PD/PDH 3200 electronic transmitter with welded pressure caps and capillary attachments. Figure A5D summarizes the above discussion. Note: These units which have only a mechanical change external to the electronic housing, have been fully vibration and seismically qualified, as described later.

As with the PD/PDH 3200 units, the transmitter features non-interacting zero and span adjustments, simple dc electronics and thin film strain gage technology. The transmitters provide industry standard 4-20 mA** output with a power supply voltage at the transmitter of 12-55 VDC. Unit specifications are provided in Table A3. Various model number code designations are described in Table A4 indicating different pressure ranges, junction box codes, and other available features. A more complete series of model numbers are reflected in Table A15 that includes past configuration designations and current configuration designations (e.g. Seismic Mounting Bracket). Paragraph 2K describes the samples tested and Paragraph 2D describes the basis to envelop the available units. Performance under accident and seismic conditions is shown in table A9 based on both testing of these units and by similarity to the PD/PDH 3200 units for the complete type test program.

The actual environmental worst case exposure conditions are shown in the detailed parameter reviews of Section D.

The outline dimensions of a unit are shown in Figure A6. Figure A3 (as for the PD and PDH 3200 Series), indicates the mechanism of field calibration which does not require any disturbance of the hermetically sealed enclosure.

2A2.2 BRIEF DESCRIPTION OF OPERATING PRINCIPLES OF SENSING CIRCUIT

The unit principles of operation is the same as in Section 2A1.2.

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*As the response time is a function of capillary length, contact the factory for necessary information appropriate to the subject capillary length.

**See footnote on page A18 regarding use of alternate 10-50 mA dc signal level.

Non-Proprietary

2A3 THE DR3200 DRAFT RANGE PRESSURE TRANSMITTERS

The DR 3200 Series Draft Range Differential Pressure Transmitters are essentially the same as the PD 3200 Transmitters, except for insignificance to the environmental qualification minor changes described in this section. The DR 3200 is designed to measure very small differential pressure; as low as 0 to 1" H_2O full scale. The only changes are the small changes necessary to achieve the higher sensitivity, and sensing diaphragm stiffness reduction gain over the PD 3200 unit.

The electronics, potentially aging and environmentally-sensitive components are essentially the same between units. Essentially, all performance testing, design, and quality is the same (except as necessary to test for different pressure ranges).

The only differences are as follows:

- The DR 3200 amplifier design is identical to the PD 3200 amplifier with the exception that two (2) resistors have a change in value to increase gain for the lower value transmitter pressure. This is not a significant design change between units as the electrical component physical configuration is unchanged, number of components are unchanged; just a resistance value change.
- The DR 3200 Sensing Diaphragm (see Figure A7) is thinner to result in less stiffness than the PD 3200 Transmitter and to be more sensitive to the lower external process pressure of the draft transmitter. Note that both sensing elements are fabricated of the same metallic material (stainless steel) and are not sensitive to thermal or radiation aging or accident-induced degradation effects due to temperature, radiation, etc.

2A3.1 TRANSMITTER PHYSICAL OUTLINE

A cross-sectional view of the basic unit is shown in Figure A7. The figure is identical to the PD/PDH 3200 cross-section (other than figure legend) shown in Figure A1. The outline dimensions of a unit is shown in Figure A8. Figure A3 from the PD/PDH 3200 unit indicates the mechanism of field calibration which does not require any disturbance of the hermetically sealed enclosure.

The ability to verify calibration without physically opening the unit (by use of magnetically coupled external adjustment screws for span and zero adjustment), allows transmitter use in pipe break areas without special additional conduit seal assemblies or disconnect assemblies.

Non-Proprietary Version

As with the PD/PDH 3200 units, the transmitter features non-interacting zero and span adjustments, simple dc electronics and thin film strain gage technology. The transmitters provide industry standard 4-20 mA* output, with a power supply voltage at the transmitter of 12-55 VDC. Unit specifications are provided in Table A5. Various model number code designations are described in Table A6, indicating different pressure ranges, junction box codes, and other available features. A more complete series of model numbers are reflected in Table A15, and includes past configuration designations and current configuration designations (e.g. Seismic mounting bracket). Paragraph 2D and 2K describes the basis to envelop the available units and samples tested, respectively. Performance under accident and seismic conditions is shown in Table A9, based on similarity to the PD/PDH 3200 units for the complete type test program.

The actual environmental worst case exposure conditions are shown in the detailed parameter reviews of Section D.

2A3.2 BRIEF DESCRIPTION OF OPERATING PRINCIPLES OF SENSING CIRCUIT

The unit principles of operation is the same as Section 2A.1.2.

2A4 THE PG 3200 SERIES TRANSMITTERS

The PG 3200 Series Gage Pressure Transmitters are units designed to provide accurate and reliable gage pressure measurements. The transmitter features non-interacting zero and span adjustments, simple dc electronics and thin film strain gage technology. The transmitters provide industry standard 4-20 mA* output with a power supply voltage at the transmitter of 12-55 VDC. Unit specifications are provided in Table A7. Various model number code designations are described in Table A8, indicating different pressure ranges, junction box codes, and other available features. A more complete series of model numbers are reflected in Table A15, that includes past configuration designations and current configuration designations (e.g. Seismic mounting bracket). Paragraphs 2D and 2K describe the basis to envelop the available units and samples tested, respectively. Performance under accident and seismic conditions are shown in Table A10. The actual environmental worst case exposure conditions are shown in the detailed parameter reviews of Section D.

2A4.1 TRANSMITTER PHYSICAL OUTLINE

The unit is relatively small, includes hermetically sealed electronics in a stainless steel housing, utilizes a unique field calibration technique by use of magnetically-coupled external adjustment screws for span and zero adjustment (calibration) not requiring an opening of the unit, and is based on decades of use in industry (more than a decade for the nuclear units and several decades for the P3000 Series commercial unit).

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*See footnote on page A18 regarding use of alternate 10-50 mA dc signal level.

Non-Proprietary Version

A cross-sectional view of the basic unit is shown in Figure A9. The outline dimensions of a unit is shown in Figure A10. Figure A3 (as for the PD and PDH 3200 Series) indicates the mechanism of field calibration which does not require any disturbance of the hermetically sealed enclosure.

2A4.2 BRIEF DESCRIPTION OF OPERATING PRINCIPLES OF SENSING CIRCUIT

The unit principles of operation is the same as in Section 2A1.2.

2B SEISMIC WITHSTAND CAPABILITY VERSUS ENVIRONMENTAL QUALIFICATION COVERAGE

The generation of a Qualification Documentation Review Package, such as this package, is usually provided only to demonstrate environmental qualification to documents such as 10CFR50.49.

Seismic Withstand Capability is not within the specific scope of 10CFR50.49, IEB 79-01B, and NUREG 0588 (References 1, 7 and 6). This is confirmed by the NRC, as stated in the "Statements of Consideration to 10CFR50.49" (Federal Register, Vol. 48, No. 15, Friday, January 21, 1983). This documentation package addresses Environmental Qualification in Section D, consistent with the parameter by parameter review successfully used for Environmental Qualification demonstration in the past.

However, for completeness in coverage, this package addresses both Environmental and Seismic Qualification.

Specifically, Section 2H addresses Seismic Withstand capability, which is very substantial, providing margin over every known application.

2C PHYSICAL LOCATION AND CUSTOMIZATION FOR GULTON-STATHAM CUSTOMERS

As indicated earlier, this is a generic qualification document. However, this document can be modified to specifically add reference to a User Location, Instrument Tag Numbers, detailed comparison between unique plant requirements and transmitter capability. Such an arrangement would be established as part of the contract details and scope of related services for Gulton-Statham's supply of equipment to customers.

The unique modification described above can be provided for previously supplied instrumentation as well as for new orders. The data presented herein is primarily driven towards IEEE standards, USNRC documentation preferences, and light water reactors. However, qualification demonstration to other international standards, such as IEC 780[26] as well as other reactor design requirements such as Canadian designed reactors [27-28] would be provided to satisfy the specific needs of a user application.

Proprietary Version

2D SIMILARITY/TRACEABILITY OF TESTED AND SUPPLIED TRANSMITTERS

The purpose of this discussion is to demonstrate that the various transmitter configurations which underwent type testing (described earlier in Section A, part 2, sub-paragraphs), are similar and therefore representative of the entire Gulton-Statham Nuclear Safety-Related equipment supply to industry. The specific test samples that underwent the type test program is described in Paragraph 2K. A series of model numbers are reflected in Table A15 that includes past configuration designations and current configuration designations (e.g. Seismic Mounting Bracket).

Supplied or Available Transmitter to Test Specimen Traceability includes consideration of similar or the same materials, similar or the same components, similar or the same ratings, similar or the same construction, etc. The following considerations are used to establish adequate traceability or similarity:

- Component physical arrangement; size, mounting features, interconnections, stresses, heat generation/dissipation, and other susceptibility.
- Aging effects.
- Environmental effects.
- Performance requirements.

As Gulton-Statham has maintained a full Nuclear Quality Assurance Program (meeting 10CFR50, Appendix B), throughout the original manufacturing, testing, and current manufacturing period that includes Design, Configuration, Procurement, Test and Quality Control, the units tested are representative of the entire series of PD 3200, PDH 3200, PD 3218, PDH 3218, DR 3200 and PG 3200 series transmitters. As described in Section F, Paragraph 3, certain control changes or improvements have occurred which does not invalidate the qualification or testing (e.g. exclusion of Neoprene gasketing and substitution of Viton □ which have passed qualification testing).

The similarity and Gulton-Statham controls clearly meet the Extrapolation and Interpolation methods of IEEE 323-1983 (Reference 3), Paragraph 6.5.3, which describes acceptability of similarity approaches based on considering (1) Material, (2) Size, (3) Shape, and (4) Stress.

The degree of similarity was and remained very substantial between test units, between test units and supplied units, and between test units and present production. The guidance found in accepted practice of valve actuators, modules, cable, seismic qualification, and generic qualification* all allow far more liberal or less conservative extrapolation than the degree of Gulton-Statham similarity. The Gulton-Statham transmitters clearly meet conditions of 10CFR50.49, sub-paragraph 6.f(1) and f(2) quoted in Section 1.C.1 of this document. Specific test unit overview which correlates the various samples is found in Section 2K as a clarification of units tested.

Non-proprietary version

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*Guidance for allowable extrapolation of similarity well beyond that necessary for Gulton-Statham is found in IEEE 323, 344, 381, 382 and 383 (References 2, 3, 4, 5, 22, 23, 41).

2E QUALIFICATION DOCUMENTATION APPLICABILITY

Qualification of the transmitters is primarily based on testing conducted by National Technical Systems (NTS) as described in NTS Test Report Number 528-0994, Revision B (Reference 9) to the NTS Procedure Number 528-0994, Revision C (Reference 10). Other initial and related developmental qualification efforts are described in Paragraph 1B for completeness. None of these efforts provided results for the qualification parameters (described in Section B) that invalidate the qualification demonstrated. Additional review of the original data** and presentation of the LOCA exposure*** has been generated by Gulton-Statham as part of this documentation package update. Such data, under the Quality Assurance Program at Gulton-Statham is found in Sections D (Figure DT1) and F.

Note that, "Summary information in and of itself is not to substantiate qualification of equipment because the licensee must examine the referenced document from which the data was extracted and certify that the data is fully applicable and valid for qualifying the specific component." pursuant to the enclosure to Generic Letter 81-15(13). Therefore, this section provides more than simple summary data and is supported by the complete test reports in Section G, the additional analysis within this section, and the additional analysis of Section D.

2F REPORT COMPLETENESS AND SUPPLEMENTARY DATA

Included in the Test Report are various photographs, Tables, and Data Sheets all providing reasonable assurance of an auditable, thorough, and complete test. The following highlights and examples are pertinent:

- Photographs of test set-ups for SRV Vibration, for Seismic Vibration, for LOCA Testing.
- Model description and serial numbers for test units. Additional amplification by reference to Tables A1-A8, Table A15, Figure A1-A10, and Section F drawings contained in this Qualification Report add clarity to the audit trail from the test units to the current production units.
- Seismic Withstand Testing Plots as well as SRV Vibration Aging Plots in Section B (Figures B2 and B3) and Section G.1 (NTS Report 528-0994, Appendices B and C).
- Illustrations of Test Set-ups. Additional amplification by reference to Figures A11-A13, A15, A20-A24, and A-26 contained in this Qualification Report add clarity to the functional and performance testing.

**Reference 42
***Reference 43

- Comprehensive Test Procedure. Additional amplification by reference to the test descriptions described in this package add clarity to the actual procedures used.
- Careful control of testing by controlled use of Change of Procedure and Notice of Deviations under a 10CFR50, Appendix B program.

Non-Proprietary Version

In addition, the original lab notebooks, tapes of High Energy Line Break (HELB) exposure from NTS testing, and raw functional test data was reviewed for this document package. The specific inaccuracy values derived from raw functional test data remain unchanged. Included was additional description of the functional tests performed, determination of the disposition of all planned test samples, and similar activities to assure (under a Nuclear Quality Program), that the basis for qualification demonstrated in this documentation package is provided with reasonable assurance. This documentation package includes all the pertinent data necessary for qualification demonstration (e.g. Application Discussion in Section 1B, Review of Anomalies in Section 2K, Reasonable Assurance in Section 2Q, etc.).

2G DESCRIPTION OF FUNCTIONAL TESTS FOR ACCURACY DETERMINATION AND DEMONSTRATION THAT QUALIFICATION PERFORMANCE REQUIREMENTS ARE MET

In 10CFR50.49[(1)], sub-paragraph (j), it is required that the "record of qualification including documentation...to permit verification that...each item (1) is qualified for its application; and (2) Meets its specified performance requirements when it is subjected to the conditions predicted to represent when it must perform its safety function up to the end of its qualified life."

As previously described in Section 1B, the true critical characteristic or performance requirement of a transmitter (which is a measuring sensor first as well as a signal converter), is the correctness or accuracy of the measurement.

Consequently, special attention to this measurement was established as the basis of qualification. This subsection describes these functional tests and the results of testing, "to permit verification that...specified performance requirements" are met, with reasonable assurance. Section D describes the demonstration of qualification.

Section 2H addresses Seismic and vibration testing not included in the EQ Rule (10CFR50.49).

Non-Proprietary Version

The functional tests consists of determining and assessing for acceptability five steps of transmitter output signals based on pressure input as follows:

1. **INITIAL ZERO (0) OUTPUT**
2. **UPSCALE 50% OUTPUT**
3. **FULL SCALE OUTPUT**
4. **DOWNSCALE 50% OUTPUT**
5. **FINAL ZERO (0) OUTPUT**

2G.1 FUNCTIONAL TEST SET-UP

Figure A11 describes the Functional Test Set-up for the PG 3200 Transmitter. This test is used for baseline testing and after or during each significant environmental or seismic exposure to determine instrument accuracy. All test equipment used was under the Gulton-Statham (formerly Gould) Quality Assurance Control, including traceability of calibration to the National Bureau of Standards (now the National Institute of Standards and Technology). A list of instruments (Measuring & Test Equipment) used for functional testing is provided in Section F (the NTS instruments used during environmental, vibration, and seismic test measurement and test are in the NTS documentation in Section G).

2G.2 ELECTRICAL CONNECTIONS FOR FUNCTIONAL TEST

The power supply is adjusted to provide 24 VDC to the transmitter. The transmitter senses the pressure and converts the measurement to a corresponding 4 to20 mA signal. The passage of the 4 to20 mA signal ($I_{TRANSMITTER}$), through the precision 250 ohm resistor (R_L) develops a voltage drop (V_{DROP}) by Ohms' Law ($V_{DROP} = I_{TRANSMITTER} \times R_L$), which is directly proportional to the signal current ($I_{TRANSMITTER}$) magnitude. The voltage drop is measured by a precision digital voltmeter (DVM) to three decimal places with a range of voltage from 1 to 5 volts corresponding respectively to the 4 to20 mA signal:

Non-Proprietary Version

V_{DROP} @ Lower Range Limit (4 mA) $= I_{TRANSMITTER} \times R_L$ = 4 mA dc X 250 ohms = 1 volt

V_{DROP} @ Upper Range Limit (20 mA) $= I_{TRANSMITTER} \times R_L$ = 20 mA dc X 250 ohms = 5 volts

This method is consistent with the standard and a rather simple method recommended to validate or perform instrument calibration by essentially all pressure transmitter manufacturers. Similar circuits have been used in research prepared for the USNRC for "Assessment of Class 1E Pressure Transmitter Response When Subjected to Harsh Environment Screening Tests," (Reference 44).

2G.3 MECHANICAL CONNECTIONS FOR FUNCTIONAL TEST

The pressure connections are by standard 1/4 inch NPT stainless steel tubing and related fittings to the threaded female connection on the PG 3200 Transmitter (Refer to Outline Figure A10 for connection detail).

2G.4 TEST AMBIENT CONDITIONS SURROUNDING TRANSMITTERS DURING TEST

The ambient test conditions were either the normal baseline (or post-exposure test) conditions defined below or those about the instruments in their test chambers. The normal ambient conditions were within the limits established in the NTS procedure, Paragraph 4[10] as:

- AMBIENT TEMPERATURE 73°F ± 18°F
- RELATIVE HUMIDITY 50% ± 30%
- ATMOSPHERIC PRESSURE 28.5 + 2.0, -3.0 inches Mercury absolute

2G.5 TEST PROCEDURE FOR FUNCTIONAL SAFETY CRITICAL ACCURACY DETERMINATIONS

2G.5.1 GAUGE PRESSURE TRANSMITTER (PG 3200) FUNCTIONAL TESTING

- Set-up per Figure A11 was assured. Vent Valve (Valve 2 for PG 3200 test set-up) was opened and pressure source valve (Valve 1 for PG 3200 test set-up) was closed such that no process or input pressure was provided to the transmitter which is the 0% pressure input. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 1, as transmitter output in volts as the 0% FS pressure input.

  With the vent pressure source at minimum pressure, the pressure source valve of Figure A11 (Valve 1 for PG 3200 test set-up), was opened and vent valve closed (Valve 2 for PG 3200 test set-up), and the pressure source slowly increased in pressure and stopped at 50% (with care taken not to overshoot the 50% point to negatively impact hysteresis* determination) of full scale range (i.e. mid-span**).

Non-Proprietary Version

The voltage drop across the precision 250 ohm resistor (R_L) was recorded which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 2, as transmitter output in volts as the 50% FS pressure input.

- The next step was to increase the pressure source slowly and stop at 100% (with care not to overshoot the 100% point). The voltage drop across the precision 250 ohm resistor (R_L) was recorded which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 3, as transmitter output in volts as the 100% FS pressure input.

- The next step was to decrease the pressure source slowly and stop at 50% (with care taken not to overshoot or go beyond the 50% point to negatively impact hysteresis determination). The voltage drop across the precision 250 ohm resistor (R_L) was recorded which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 4, as transmitter output in volts as the 50% FS pressure input.

- The next step was to decrease the pressure source slowly to 0% and open the Vent Valve (Valve 2 for PG 3200 test set-up), and close the pressure source valve (Valve 1 for PG 3200 test set-up), such that no process or input pressure was provided to the transmitter. The voltage drop across the precision 250 ohm resistor (R_L) was recorded which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 5, as transmitter output in volts as the 0% FS pressure input.

The next step was to calculate the Full Scale Sensitivity by taking the Transmitter Output at full scale (100%) from box 3 of Figure A12 and subtracting the Transmitter Output at zero input (0%) from box 1 of Figure A12. This is mathematically simply expressed as:

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*Hysteresis is defined (Reference 8) as, "That property of an element evidenced by the dependence of the value of the output, for a given excursion of the input, upon the history of prior excursions and the direction of the current traverse." A means to determine the separation of measured values between the upscale going and downscale going value of the measured variable which includes a full scale traverse (0% to 100%) of input. Errors are reported in absolute value and as a percent of either full scale (Upper Range Limit) or span.

**Span is defined (Reference 8) as, "The algebraic difference between the upper and lower range values." Equated in the signal parameter, this would be 16 mA dc based on subtracting the lower range limit value of 4 mA from the upper range value of 20 mA. Expressed in the derived voltage drop for the test set-up, this is four (4) volts span.
($V = I_S \times R_L$ = 16 mA X 250 ohms = 4 volts); whereas values expressed in relationship to Upper Range Limit (URL) of 20 mA is compared (as an absolute value) to 5 volts ($V_{DROP} = I_{URL} \times R_L$ = 20 mA X 250 ohms = 5 volts).

FULL SCALE SENSITIVITY = BOX 3 - BOX 1

This value in volts was recorded on the representative form shown as Figure A12, box 6.

- The next step was calculation of the Ideal Line Range Mid-Point Value by taking the Transmitter Full Scale Sensitivity value from box 6 of Figure 12 and dividing by 2; add the Transmitter Output at 0% of process input from Box 1 of Figure A12. This is mathematically simply expressed as:

IDEAL LINE MID-POINT = (BOX 6 / 2) + BOX 1

This value in volts was recorded on the representative form shown as Figure A12 in box 7.

- The next step was calculation of the Non-Linearity by taking the Transmitter Output (in volts) at 50% process input from box 2 of Figure A12 and subtracting the Transmitter Determined Ideal Line Range Mid-Point Value from the previous step from box 7 of Figure A12. This is mathematically simply expressed as:

NON-LINEARITY = BOX 2 - BOX 7

This value in volts was recorded on the representative form shown as Figure A12 in box 8.

- The next step was calculation of the Linearity Error as measured and determined at 100% Full Scale by taking the previously determined Non-Linearity from box 8 of Figure A12 and dividing by Full Scale Sensitivity (in volts) from box 6 of Figure A12 then multiplying by 100% to represent the data as a percentage of Full Scale. This is mathematically simply expressed as:

LINEARITY ERROR (PERCENT OF FS) = (BOX 8/ BOX 6) X 100%

This value in percent of Full Scale was recorded on the representative form shown as Figure A12, box 9.

- The next step was calculation of the Hysteresis by taking the Transmitter Output (in volts) at the second determined value of 50% process (approached from the 100% or Full Scale input end) from box 4 of Figure A12 and subtracting the Transmitter output (in volts) at the first determined value of 50% process (approached from the 0% of Full Scale input) from box 2 of Figure A12. This is mathematically simply expressed as:

HYSTERESIS = BOX 4 - BOX 2

This value in volts was recorded on the representative form shown as Figure A12, box 10.

Non-Proprietary Version

- The next step was calculation of the Hysteresis Error as measured and determined at 100% Full Scale by taking the previously determined Hysteresis from box 10 of Figure A12 and dividing by Full Scale Sensitivity (in volts) from box 6 of Figure A12 then multiplying by 100% to represent the data as a percentage of Full Scale. This is mathematically simply expressed as:

  HYSTERESIS ERROR (PERCENT OF FS) = (BOX 10/ BOX 6) X 100%

  This value in percent of full Scale was recorded on the representative form shown as Figure A12, box 11.

2G.5.2 DIFFERENTIAL PRESSURE TRANSMITTER (e.g. PD 3200) FUNCTIONAL TESTING

This description is representative of the testing for all the differential pressure transmitter units. The basis for differential transmitter qualification is the PD 3200 unit which used the test circuit of Figure A13. The PD 3200 unit (as well as PG 3200 units) which went through LOCA "A" form the basis of the Gulton-Statham Pressure Series qualification.

However, for completeness, the actual test circuits used for the Testing of the PD 3218 unit is shown in Figure A15. As previously described in the description for the PD 3218 units, this series of transmitters are qualified by similarity analysis. Since some physical changes from the PD 3200 series exists, the validation that the physical change will not degrade transmitter function is supported by actual, very severe, Seismic Withstand Testing described in NTS testing in reports of Section G.

Figure A15 for the PD 3218 Series, shows the capillary and paddle system used for this series of transmitters. Note that the illustration shows the small junction box used only for this transmitter series during type testing, which used Neoprene gaskets in lieu of Viton □ O-rings found in all other junction boxes as well as PVC lead wire in lieu of Kapton □ used in other transmitters. The anomalies with this transmitter with the Neoprene/PVC combination are dispositioned in Section 2K demonstrating that the PD/PDH 3218 units remain qualified with use of the Viton™/Kapton™ combination found in the successfully tested units. Section F illustrates the changes that precluded use of Neoprene in the units shipped for nuclear safety-related service as well as the steps used to appropriately preclude PVC use.

The following is the test process for the PD 3200 Series Transmitters used to demonstrate qualification:

Non-Proprietary Version

- Set-up per Figure A13 was assured. Vent Valve (Valve 2 for PD 3200 test set-up) was opened and pressure source valve (Valve 1 for PD 3200 test set-up) was closed such that no process or input pressure was provided to the transmitter high pressure port which is the 0% pressure input. The low pressure port is vented. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 1, as transmitter output in volts as the 0% FS pressure input.

- With the vent pressure source at minimum pressure, the pressure source valve of Figure A13 (Valve 1 for PD 3200 test set-up) was opened and vent valve closed (Valve 2 for PD 3200 test set-up) and the pressure source slowly increased in pressure and stopped at 50% (with care taken not to overshoot the 50% point to negatively impact hysteresis determination) of full scale range (i.e. mid-span). The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 2, as transmitter output in volts as the 50% FS pressure input.

- The next step was to increase the pressure source slowly and stop at 100% (with care taken not to overshoot the 100% point). The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 3, as transmitter output in volts as the 100% FS pressure input.

- The next step was to decrease the pressure source slowly and stop at 50% (with care taken not to overshoot or go beyond the 50% point to negatively impact hysteresis determination). The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 4, as transmitter output in volts as the 50% FS pressure input.

- The next step was to decrease the pressure source slowly to 0% and open the Vent Valve (Valve 2 for PD 3200 test set-up) and close the Pressure Source Valve (Valve 1 for PD 3200 test set-up), such that no process or input pressure is provided to the transmitter which is the 0% pressure input. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded on the representative form shown as Figure A12, box 5, as transmitter output in volts as the 0% FS pressure input.

- The next step was to calculate the Full Scale Sensitivity by taking the Transmitter Output at full scale (100%) from box 3 of Figure A12 and subtracting the Transmitter Output at zero input (0%) from box 1 of Figure A12. This is mathematically simply expressed as:

FULL SCALE SENSITIVITY = BOX 3 - BOX 1

Non-Proprietary Version

This value in volts was recorded on the representative form shown as Figure A12, box 6.

- The next step was calculation of the Ideal Line Range Mid-Point Value by taking the Transmitter Full Scale Sensitivity Value from box 6 of Figure A12 and dividing by 2, then adding the Transmitter Output at 0% of process input from Box 1 of Figure A12. This is mathematically simply expressed as:

IDEAL LINE MID-POINT = (BOX 6 / 2) + BOX 1

This value in volts was recorded on the representative form shown as Figure A12, box 7.

- The next step was calculation of the Non-Linearity by taking the Transmitter Output (in volts) at 50% process input from box 2 of Figure A12 and subtracting the Transmitter-determined Ideal Line Range Mid-Point Value from the previous step from box 7 of Figure A12. This is mathematically simply expressed as:

NON-LINEARITY = BOX 2 - BOX 7

This value in volts was recorded on the representative form shown as Figure A12, box 8.

- The next step was calculation of the Linearity Error as measured and determined at 100% Full Scale by taking the previously determined Non-Linearity from box 8 of Figure A12 and dividing by full Scale Sensitivity (in volts) from box 6 of Figure A12, then multiplying by 100% to represent the data as a percentage of Full Scale. This is mathematically simply expressed as:

LINEARITY ERROR (PERCENT OF FS) = (BOX 8/ BOX 6) X 100%

This value in percent of Full Scale was recorded on the representative form shown as Figure A12, box 9.

- The next step was calculation of the Hysteresis by taking the Transmitter output (in volts) at the second determined value of 50% process (approached from the 100% or Full Scale input end shown (or from) box 4 of Figure A12 and subtracting the Transmitter Output (in volts) at the first determined value of 50% process (approached from the 0% of Full Scale input), from box 2 of Figure A12. This is mathematically simply expressed as:

HYSTERESIS = BOX 4 - BOX 2

This value in volts was recorded on the representative form shown as Figure A12, box 10.

- The next step was calculation of the Hysteresis Error as measured and determined at 100% Full Scale by taking the previously determined Hysteresis from box 10 of Figure A12 and dividing by Full Scale Sensitivity (in volts) from box 6 of Figure A12, then multiplying by 100% to represent the data as a percentage of Full Scale. This is mathematically simply expressed as:

Non-Proprietary Version

HYSTERESIS ERROR (PERCENT OF FS) = (BOX 10/ BOX 6) X 100%

This value in percent of Full Scale was recorded on the representative form shown as Figure A12, box 11.

2G.5.3 TEST BASIS AND ADDITIONAL DISCUSSION

The above tests were first performed as a baseline (as well as additional data-gathering for Engineering research information, such as load effects testing as described in Section 2J), to verify the unit are well within the Specification limits. The Gulton-Statham requirement is an accuracy equal to or less than 0.25% accuracy as a percentage of span. This is a more conservative level of acceptability than comparison to the test circuit absolute voltage drop corresponding to the full scale value or upper range limit (using maximum span or upper range value less the lower range value or 20 mA - 4 mA is only 16 mA or 4 volts drop through a 250 ohm resistor equivalent in lieu of the upper range limit absolute value of 20 mA or 5 volts drop through a 250 ohm resistor equivalent).

2G.6 DETERMINATION OF ENVIRONMENTAL, VIBRATION, AND SEISMIC EXPOSURE

The maximum transmitter change in accuracy (known in the standards as, "error, environmental*"), due to the influence of the Environmental, Vibration, and Seismic Exposure, is defined as the greatest deviation of any of the five (5) data points from their initial or baseline value prior to the start of each Environmental, Vibration, and Seismic Exposure.

The maximum transmitter change in accuracy or "error, environmental" due to the influence of the Environmental, Vibration, and Seismic exposure is expressed by Gulton-Statham as a percent of full load or Upper Range Limit (URL) and includes Linearity and Hysteresis errors.

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*Error, Environmental is defined (Reference 8) as, "Error caused by a change in a specified operating condition from reference-operating conditions." See "Operating Influence." Operating Influence is defined (Reference 8) as, "The change in a performance characteristic caused by a change in a specified operating condition from reference operation condition, all other conditions being held within the limits of reference-operating conditions.

NOTE: The specified operating conditions are usually the limits of the normal operating conditions.

Non-Proprietary Version

Use of the Upper Range Limit or Full Scale Value is the appropriate method of expressing the accuracy consequences of the environmental influences, which is the basis of NRC research into transmitter behavior. As stated in NUREG/CR-3863, "Assessment of Class 1E Pressure Transmitter Response When Subjected to Harsh Environment Screening Tests" (Reference 44) Paragraph 6.3.5, "Comment on Error Calculation Method."

> "The method used for calculating error percentage has a dramatic effect on the shape of the functional test error curves. The data and curves presented in this report show error as a percentage of full scale (FS) readings. This is the same basis used by transmitter manufacturers for specifying transmitter performance. Specifying error by this method allows constant amount of actual error over the instrument's calibrated range."

At Gulton-Statham, this maximum transmitter change in accuracy is appropriately and conservatively calculated by dividing the maximum output change, in volts, by the voltage value corresponding to Span or 4 volts nominal for the Full Scale Sensitivity. As described in the previous procedures (e.g. Paragraph 2G.5.1), the maximum span value (Full Scale Sensitivity) is determined for each transmitter.

Non-Proprietary Version

2G.7 TRANSMITTER SAFETY SIGNIFICANT FUNCTIONAL PERFORMANCE

The performance data reported herein is for the full type test units forming the basis of qualification. All test results for the functional testing of all units is available at Gulton-Statham.

2G.7.1 BASELINE FUNCTIONAL PERFORMANCE

The baseline functional performance* for the accuracy, use as a reference or baseline for changes due to environmental impact throughout qualification was as follows for units going through complete qualification (i.e. through Section B HELB defined exposure, including "LOCA A"):

*Based on RSS calculation method, with 0.1% accuracy of Heise Pressure Standard Instrument, the worst case acceptance measurement is below 0.25% ($\sqrt{(0.225\%)^2 + (0.1\%)^2} = 0.246\%$)

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN)	±0.25%	XXXXX

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN)	±0.25%	XXXXX

PG 3200-200 XXXXX

ACCURACY (Calibrated at 200"$H_2$0)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN)	±0.25%	XXXXX

PG 3200-200 XXXXX

ACCURACY (Calibrated at 200"$H_2$0)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN)	±0.25%	XXXXX

The transmitters were within Specification requirements.

2G.7.2 QUALIFIED LIFE* (AGING) SIMULATION EXPOSURE FUNCTIONAL PERFORMANCE

The functional performance for the critical qualification parameter (i.e. accuracy) was monitored during the Thermal Aging (i.e. 221°F exposure for 16.25 days as described in Section D, subsection DA, *"Aging"*). In addition, the cyclical exposure (pneumatic cycling for 1000 cycles as described in Section D, subsection DA, *"Aging"*) was done during thermal exposure. The value during thermal aging (i.e. 221°F) is for information only, as it does not reflect the accuracy during normal operation prior to the onset of design-basis accident conditions. Qualified Life (Thermal Aging and Cyclical Aging) has a criterion of Maximum Inaccuracy (accuracy) XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX as shown in Tables A9 and A10. The results were as follows:

Non-Proprietary Version

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*Qualified Life is defined (Reference 3) as, The period of time, prior to the start of a design basis event, for which equipment was demonstrated to meet the design requirements for the specified service conditions.

NOTE: At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required for the postulated design basis and post-design basis events." Qualified Life includes both radiation and cyclic exposure. However, it is generally or commonly associated with thermal aging to simulate calendar time; especially due to the irradiation exposure almost always enveloping a full 40-year typical nuclear plant license duration as it does for the Gulton-Statham transmitters.

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN) DURING (221°F EXPOSURE) IMMEDIATELY AFTER AGING	±1.125%	XXXXX XXXXX

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN) DURING (221°F EXPOSURE) IMMEDIATELY AFTER AGING	±1.125%	XXXXX XXXXX

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PD 3200-200 XXXXX

ACCURACY (Calibrated at 200"H_20)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN) DURING (221°F EXPOSURE) IMMEDIATELY AFTER AGING	±1.250%	XXXXX XXXXX

PD 3200-200 XXXXX

ACCURACY (Calibrated at 200"H_20)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN) DURING (221°F EXPOSURE) IMMEDIATELY AFTER AGING	±1.250%	XXXXX XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Note that the combination of cycling at temperature and performance of an accuracy check at the thermal oven exposure temperature, is conservative as the transmitters will (for their qualified life period), normally be at normal ambient (perhaps 40°F-120°F, dependent on the plant and specific location). In addition, for the equivalent time period (ten or more years as described in Section D, Subsection DA, "Aging"), the transmitters were not recalibrated at all.

The transmitters were within specification requirements.

2G.7.3 RADIATION EXPOSURE* (AGING AND ACCIDENT) SIMULATION EXPOSURE FUNCTIONAL PERFORMANCE

The functional performance for the critical qualification parameter (i.e. accuracy) was monitored during the radiation exposure which included the full irradiation exposure to simulate 40 or more years of expected exposure normally and a post-accident qualification exposure. In addition, the exposure was at a dose rate initially higher than the industry norm** of a Megarad an hour to be conservative.

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*<u>Qualified Life</u> is defined (Reference 3) as: The period of time, prior to the start of a design basis event, for which equipment was demonstrated to meet the design requirements for the specified service conditions.

NOTE: At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required for the postulated design basis and post-design basis events." Qualified Life includes both radiation and cyclic exposure. However, it is generally or commonly associated with thermal aging to simulate calendar time; especially due to the irradiation exposure almost always enveloping a full 40-year typical nuclear plant license duration as it does for the Gulton-Statham transmitters.

**The <u>dose rate</u> requirements are not contained in detail in either the 1974 or 1983 versions of IEEE 323 (References 2 and 3). However, the dose rate has been limited by the defacto misinterpretation of IEEE 383 (Reference 23, Paragraph 2.3.3.3) for cables that limit the dose rate to "Not greater than 1 X 10^6 rd per hour." Actually, the NRC staff position of USNRC Regulatory Guide 1.89, Revision 1 (Reference 18) position C.2.C.5 is the correct technical requirement adhered to by Gulton-Statham when it takes the position that, "Electric equipment that could be exposed to radiation should be environmentally qualified to a radiation dose that simulates the calculated radiation environment (normal and accident) that the equipment should withstand prior to completion of its required safety functions."

Non-Proprietary Version

Electronics are known to have a transient effect as a consequence of dose rate such that the Gulton-Statham exposure of up to four (4) Megarads per hour for initial exposure (similar to and enveloping actual worst case, real nuclear accidents as described in Section D, Subsection DR), is both prudent and conservative, especially for outside containment areas.

As explained in Section D, Subsection DR, a total integrated dose of 20 Megarads is generally acceptable and reasonable value, even for in-containment locations at both old and new plants by the NRC [values that exist up to an order of magnitude greater are derived from very conservative IEEE guidance in various standards (e.g. IEEE 383-1974, Reference 23 - total of Paragraphs 2.3.3.3 and 2.4.2), has 200 Megarads].

Radiation has a criterion of maximum inaccuracy (accuracy) for two levels of integrated dose as follows:

RADIATION (33 MRADS T.I.D.) (NOMINAL ± 10%)	**MAXIMUM INACCURACY (ACCURACY) OF 3% OF UPPER RANGE LIMIT**
RADIATION (55 MRADS T.I.D.) (NOMINAL ± 10%)	**MAXIMUM INACCURACY (ACCURACY) OF 5.5% UPPER RANGE LIMIT**

The results were as follows:

PG 3200-100 (S/N C4864)

ACCURACY (Calibrated at 100 psig)
(EXPRESSED AS PERCENT OF SPAN)

SPECIFICATION
± 5.5% FOR 55 MRADS T.I.D.

DOSE RATE MRAD/HR	T.I.D. DOSE	MEASURED VALUE
2.12	9.25	XXXXX
2.12	17.56	XXXXX
2.12	27.98	XXXXX
0.00*	28.34	XXXXX
2.12	42.26	XXXXX
2.12	43.43	XXXXX
0.00*	44.70	XXXXX
2.12	48.17	XXXXX
2.12	49.58	XXXXX
2.12	53.40	XXXXX
2.12	55.03	XXXXX
0.00	55.28	XXXXX

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*Radiation field was down during this measurement of inaccuracy.

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy), based on use of the actual baseline performance value are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXThe functional performance was well within requirements.

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)
(EXPRESSED AS PERCENT OF SPAN)

SPECIFICATION
± 3% FOR 33 MRADS T.I.D.

DOSE RATE MRAD/HR	T.I.D. DOSE	MEASURED VALUE
3.10	1.19	XXXXX
2.12	7.85	XXXXX
0.00*	16.75	XXXXX
1.22	28.94	XXXXX
0.00	33.74	XXXXX

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy), based on use of the actual baseline performance value are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

The functional performance was well within requirements.

Non-Proprietary Version

*Radiation field was down during this measurement of inaccuracy.

PD 3200-200 XXXXX

ACCURACY (Calibrated at 40" H_20)
(EXPRESSED AS PERCENT OF SPAN)

SPECIFICATION
± 3% FOR 33 MRADS T.I.D.

DOSE RATE MRAD/HR	T.I.D. DOSE	MEASURED VALUE	CALCULATED MAX SPAN ERROR
4.40	2.56	XXXXX	XXXXX
4.40	8.21	XXXXX	XXXXX
2.03	11.67	XXXXX	XXXXX
2.03	22.17	XXXXX	XXXXX
1.25	23.45	XXXXX	XXXXX
1.25	33.83	XXXXX	XXXXX
0.00*	34.90	XXXXX	XXXXX

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

These values were derived from the min span values (which had an amplification of 5) found in the original PER1006 report, Table 6-5A and corrected to the common full scale span reference (which had an amplification of 1).

The functional performance was well within requirements.

Non-Proprietary Version

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*Radiation field was down during this measurement of inaccuracy.

PD 3200-100 XXXXX

ACCURACY (Calibrated at 40" H_20)
(EXPRESSED AS PERCENT OF SPAN)

SPECIFICATION
± 5.5% FOR 55 MRADS T.I.D.

DOSE RATE MRAD/HR	T.I.D. DOSE	MEASURED VALUE	CALCULATED MAX SPAN ERROR
4.40	2.27	XXXXX	XXXXX
4.40	8.14	XXXXX	XXXXX
2.03	9.51	XXXXX	XXXXX
2.03	27.56	XXXXX	XXXXX
2.03	30.17	XXXXX	XXXXX
2.03	38.39	XXXXX	XXXXX
2.03	43.64	XXXXX	XXXXX
2.03	50.17	XXXXX	XXXXX
2.03	52.20	XXXXX	XXXXX
2.03	54.27	XXXXX	XXXXX
2.03	55.15	XXXXX	XXXXX
0.00*	55.52	XXXXX	XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXX

These values were derived from the min span values (which had an amplification of 5) found in the original PER1006 Report, Table 6-5C and corrected to the common full scale span reference (which had an amplification of 1).

The functional performance was well within requirements.

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*Radiation field was used during this measurement of inaccuracy.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX

2G.7.4 STEAM RELIEF VALVE (SRV) VIBRATION SIMULATION EXPOSURE* FUNCTIONAL PERFORMANCE

SRV Vibration exposure is a rather severe vibration to simulate the vibration anticipated due to the dynamic loads associated with steam relief valve discharge and hydrodynamic loads. Significant concern for this phenomena only exists in BWRs and is very location-dependent (the Gulton-Statham transmitters are unlikely to be exposed to the vibratory forces for which it was tested). The requirement was that transmitters be exposed for fifteen (15) minutes in each of two (2) biaxial horizontal axis orientations and simultaneously with the vertical axis to the severe exposure represented by Figure B3, "Vibration Withstand Requirements Definition and Typical Actual Spectrum Tested for Steam Relief Valve (SRV) Discharge, RRS for SRV Aging**". The biaxial axis used for vibratory exposure is defined in Section B, Figure B4 and Figure 1, "Axes Definition for SRV Aging and Seismic Testing," found in Report 528-0994 (Section C, Reference 9) page 17 (complete report found in Section G.1). The exposure requirement at a conservative 5% damping and vibratory motion to 100 Hertz with peak g values above 6g is rather severe. Actual data from the exposure clearly indicates exposure levels well over 10g's for a very broad frequency band. This is found in Section B, Figure B3.

SRV Vibration Aging has a criterion of Maximum Inaccuracy (accuracy) of 2% of Upper Range Limit. The results were as follows:

	PG 3200-100-XXXXX
ACCURACY *(Calibrated at 100 psig)*	**SPECIFICATION**
(EXPRESSED AS PERCENT OF SPAN)	**±2%**
AFTER SRV EXPOSURE, AXIS	**MEASURED VALUE**
YZ	**XXXXX**
XY	**XXXXX**

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above. XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX The functional performance was well within requirements.

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*Qualified Life is defined (Reference 3) as, the period of time, prior to the start of design basis event, for which equipment was demonstrated to meet the design requirements for the specified service conditions. NOTE: At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required for postulated design basis and post-design basis events." Qualified Life includes both radiation and cyclic exposure. However, it is generally or commonly associated with thermal aging to simulate calendar time; especially due to the irradiation exposure almost always enveloping a full 40-year typical nuclear plant license duration as it does for the Gulton-Statham Transmitters.

**The Required Response Spectrum for SRV Aging is shown in the NTS Report (528-0994 in Section G.1 NTS page 19) as Figure 3, "Required Response Spectrum."

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig)	**SPECIFICATION**
(EXPRESSED AS PERCENT OF SPAN)	**± 2%**
AFTER SRV EXPOSURE, AXIS	**MEASURED VALUE**
YZ	**XXXXX**
XY	**XXXXX**

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

The functional performance was well within requirements.

PD 3200-200 XXXXX

ACCURACY (Calibrated at 40" H_2O)	**SPECIFICATION**
(EXPRESSED AS PERCENT OF SPAN)	**±2%**

AFTER SRV EXPOSURE, AXIS	**MEASURED VALUE**	**CALCULATED MAX SPAN ERROR**
XY	**XXXXX**	**XXXXX**
YZ	**XXXXX**	**XXXXX**

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

These values were derived from the min span values (which had an amplification of 5) found in the original PER 1006 Report, Tables 6-9 and corrected to the common full scale span reference (which had an amplification of 1).

The functional performance was well within requirements.

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*The data is recorded by data logger at 0 pressure after YZ Axes and SRV Exposure.

Non-Proprietary Version

PD 3200-200 XXXXX

ACCURACY (Calibrated at 40" H_2O) **(EXPRESSED AS PERCENT OF SPAN)**	**SPECIFICATION** **±2%**	
AFTER SRV EXPOSURE, AXIS	**MEASURED VALUE**	**CALCULATED MAX SPAN ERROR**
XY	**XXXXX**	**XXXXX**
YZ	**XXXXX**	**XXXXX**

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX

Non-Proprietary Version

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*The data is recorded by data logger at 0 pressure recorded after YZ Axes SRV Exposure.

2H SEISMIC WITHSTAND TESTING EXPOSURE* FUNCTION PERFORMANCE

Seismic Withstand Testing was in accord with IEEE 344 requirements (as described in Section 1.C.2. The requirements for testing are technically the same for the IEEE 344-1975 and IEEE 344-1987 standard). Included was Resonance Survey performance as described in the NTS Report, Section G.1, NTS Paragraph 5.3.3.2, with Figures 9 and 10 and photographs 5, 6, and 7 showing the set-ups. No resonance below 10 Hertz was found.

Note: If qualification for Seismic Withstand is by test, as is the case for this qualification, the Resonance Search primarily performed to establish whether static or dynamic analysis should be used, is unnecessary**

Consequently, the performance of a vibratory exposure for resonance determination is conservative.

The Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) testing was performed to the very severe profiles shown by Figures B2A and B2B "Seismic Withstand Requirements Definition, and Typical Actual Spectrum Tested, RRS for OBE and SSE"***. This exposure requirement at a conservative 5% damping and vibratory motion peak values of 7.5 and 15g (ZPA**** values of 4g and 6g) respectively, for OBE and SSE. Actual data from the exposure clearly indicates exposure levels of peak exposures (and ZPA equivalents) of 10g to 20g's or greater, for a very broad frequency band in Appendices C and D of the NTS Report.

2H.1 SEISMIC TESTING - GENERAL COMMENTS ON CONSERVATISM

The test levels, methods, durations, in this qualification effort are considered very conservative, as they exceed the general guidance of the industry standard IEEE 344 (both 1975 and 1987) in the following regards:

- Actual earthquake strong motion is 10 to 15 seconds, while the Gulton-Statham requirement is twice this duration, or thirty (30) seconds (actual exposure to facilitate accuracy measurements was a approximately forty (40) seconds).
- There is no known application with seismic levels in a nuclear plant approaching the demonstrated Gulton-Statham qualification levels.

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*Designated as Seismic Proof Testing in NTS Report (528-0994, Section G.1, NTS Paragraph 5.3)

**Refer to Reference 4 (Paragraph 6.13) or Reference 5 (Paragraph 7.1.4).

*** The Required Response Spectrum for OBE and SSE is shown in the NTS Report (528-0994, Section G.1, NTS page 20) as Figure 4, "Required Response Spectrum."

****Zero Period Acceleration, as defined in Reference 5 is, "The acceleration level of the high frequency, non-amplified portion of the response spectrum. This acceleration corresponds to the maximum peak acceleration of the time history used to derive the spectrum."

- To simulate all potential operating modes, and include different mounting brackets, PD 3200 transmitters were exposed to two sets of resonant, OBE, and SSE exposures as described in NTS Change of Procedure No. 7 and NTS Report Table II*.

- Gulton-Statham utilized 5% for damping in testing (for Test Response Spectra) in lieu of less severe, 1, 2, or 3% damping allowed by other requirements (e.g. USNRC Regulatory Guide 1.61**, or typical plant seismic response curves), in Required Response Spectra.

- Seismic excitation is conducted biaxially. Each horizontal axis is excited separately, but simultaneously with the vertical axis. The independent signal sources for the horizontal and vertical axis provide random phasing of input motion. The biaxial axis used for vibratory exposure is defined in Section B, Figure B4 "Axes Definition for SRV Aging and Seismic Testing" and Figure 1 found in Report 528-0994 (Section C, Reference 9) page 17 (complete report found in Section G.1).

  The transmitters are installed in a test fixture and rigidly bolted to the biaxial seismic simulator. The fixture is rotated ninety degrees (90°) about its vertical axis on completion of the testing in the initial axis configuration. The vibratory motion for this method of qualification meets the IEEE 344 requirements and the total duration of vibration with this method of testing is far more exposure than the actual earthquake exposure.

2H.2 ACTUAL ACCURACY RESULTS FOR TRANSMITTER ACCURACY RELATING TO SEISMIC QUALIFICATION

The response to seismic simulation for the differential pressure and gage pressure units are different due to the physical orientation of the strain-gage beam versus the diaphragm sensor and impulse sensor lines. As shown in cross-section (Figures A1 and A5), the differential pressure units (i.e. PD, PDH, and DR transmitters) can have additional mass adding to the process pressures in a manner greater than the PG units. The undamped, very fast response Gulton-Statham Differential Pressure units (30 millisecond response time), will respond during seismic simulation at a level much greater than a damped unit. The worst case inaccuracy during seismic events should not be a problem in most applications. Should a problem exist, a damped unit can be configured and verified for much less inaccuracy during seismic events.

The OBE and SSE vibration has a criterion of Maximum Inaccuracy (accuracy) of XXX of Upper Range Limit, post-event and XXX during the event. The biaxial axis used for vibratory exposure is defined in Figure B4, "Axes Definition for SRV Aging and Seismic Testing."

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*NTS Report (528-0994), Section G.1, NTS COP 7) and Table II, NTS Report (528-0994, Section G.1, NTS page 16.

**Reference 24

2H.2.1 SEISMIC RESPONSE FOR PG 3200 PRESSURE TRANSMITTERS

The results for the PG 3200 Transmitters was as follows:

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig) (EXPRESSED AS PERCENT OF SPAN)	**SPECIFICATION**	**MEASURED VALUE**
AFTER SSE & OBE EXPOSURE (WORST CASE)	**XXX% POST-EVENT**	**XXXXX**
(EXPRESSED AS PERCENT OF SPAN)	**XXX% DURING EVENT**	**SEE TABLE**

DURING SSE, AXIS	ELAPSED TIME, SEC	MEASURED VALUE
XY	4	XXXXX
XY	9	XXXXX
XY	13	XXXXX
XY	18	XXXXX
XY	22	XXXXX
XY	26	XXXXX
XY	31	XXXXX
XY	35	XXXXX
XY	40	XXXXX
YZ	4	XXXXX
YZ	9	XXXXX
YZ	13	XXXXX
YZ	18	XXXXX
YZ	22	XXXXX
YZ	27	XXXXX
YZ	31	XXXXX
YZ	36	XXXXX
YZ	40	XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX.

PG 3200-100 XXXXX

ACCURACY (Calibrated at 100 psig) (EXPRESSED AS PERCENT OF SPAN)	SPECIFICATION	MEASURED VALUE
AFTER SSE & OBE EXPOSURE (WORST CASE)	XXX% POST-EVENT	XXXX%
(EXPRESSED AS PERCENT OF SPAN)	XXX% DURING EVENT	SEE TABLE

DURING SSE, AXIS	ELAPSED TIME, SEC	MEASURED VALUE
XY	4	XXXXX
XY	9	XXXXX
XY	13	XXXXX
XY	18	XXXXX
XY	22	XXXXX
XY	26	XXXXX
XY	31	XXXXX
XY	35	XXXXX
XY	40	XXXXX
YZ	4	XXXXX
YZ	9	XXXXX
YZ	13	XXXXX
YZ	18	XXXXX
YZ	22	XXXXX
YZ	27	XXXXX
YZ	31	XXXXX
YZ	36	XXXXX
YZ	40	XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXX

The functional performance was well within requirements for the PG units.

2H.2.2 SEISMIC RESPONSE FOR PD 3200 PRESSURE TRANSMITTERS

The results for the PD 3200 Pressure Transmitters were as follows:

PD 3200-200 XXXXX

ACCURACY (Calibrated at 40" H_20)	SPECIFICATION	MEASURED VALUE
(EXPRESSED AS PERCENT OF SPAN)	XXX% POST-EVENT	XXXXX
AFTER SSE & OBE EXPOSURE		CALC MAX SPAN ERR
(WORST CASE)		XXXXX%
(EXPRESED AS PERCENT OF SPAN)	XXX% DURING EVENT	SEE TABLE

DURING SSE, AXIS	ELAPSED TIME, SEC	MEASURED VALUE	CALCULATED MAX SPAN ERROR
XY	4	XXXXX	XXXXX
XY	9	XXXXX	XXXXX
XY	13	XXXXX	XXXXX
XY	18	XXXXX	XXXXX
XY	22	XXXXX	XXXXX
XY	27	XXXXX	XXXXX
XY	31	XXXXX	XXXXX
YZ	5	XXXXX	XXXXX
YZ	9	XXXXX	XXXXX
YZ	14	XXXXX	XXXXX
YZ	18	XXXXX	XXXXX
YZ	23	XXXXX	XXXXX
YZ	27	XXXXX	XXXXX
YZ	32	XXXXX	XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above during the seismic event XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXX

These values were derived from the min span values (which had an amplification of 5) found in the original test data and corrected to the common full scale span reference (which had an amplification of 1).

The functional performance was within requirements. Unit was first tested with junction box, Rosemount mounting bracket, and then retested for second SSE with Gulton-Statham (type B4) mounting bracket, and junction box. The seismic results of the first test was representative and enveloping of second test.

Note: The current bracket numbers and older bracket numbers are described in Table A15. The Gulton-Statham design control process envelops the change in descriptions for the seismic mounting bracket.

PD 3200-200 XXXXX

ACCURACY (Calibrated at 40" $H_2 0$)	**SPECIFICATION**	**MEASURED VALUE**
(EXPRESSED AS PERCENT OF SPAN)	**±XXX% POST-EVENT**	**XXXX%**
AFTER SSE & OBE EXPOSURE		**CALC MAX SPAN ERR**
(WORST CASE)		**XXX%**
(EXPRESSED AS PERCENT OF SPAN)	**±XXX% DURING EVENT**	**SEE TABLE**

DURING SSE, AXIS	ELAPSED TIME, SEC	MEASURED VALUE	CALCULATED MAX SPAN ERROR
XY	4	XXXXX	XXXXX
XY	9	XXXXX	XXXXX
XY	13	XXXXX	XXXXX
XY	18	XXXXX	XXXXX
XY	22	XXXXX	XXXXX
XY	27	XXXXX	XXXXX
XY	31	XXXXX	XXXXX
YZ	5	XXXXX	XXXXX
YZ	10	XXXXX	XXXXX
YZ	14	XXXXX	XXXXX
YZ	19	XXXXX	XXXXX
YZ	23	XXXXX	XXXXX
YZ	28	XXXXX	XXXXX
YZ	32	XXXXX	XXXXX

Non-Proprietary Version

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value, are added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
These values were derived from the min span values (which had an amplification of 5) found in the original data and corrected to the common full scale span reference (which had an amplification of 1).

To clarify the seismic testing performed, Table A16 provides a cross-reference of plots, model numbers, and transmitter serial numbers.

2I HIGH ENERGY LINE BREAK (HELB) EXPOSURE* (AGING AND ACCIDENT) SIMULATION EXPOSURE FUNCTIONAL PERFORMANCE

The functional performance for the critical qualification parameter (i.e. accuracy), was monitored during the HELB exposure. Specific qualification review, including post-accident transient is covered in depth in Section D. Actual exposure extremes exceed the generic requirements curves (e.g. over 300°F transient in lieu of 260°F requirement of Figure B1). (see Figure A16, Figure DT1 and Table DT1 for detail). This section covers the performance characteristics. The HELB exposure is expected to envelop all application locations, except for certain in-containment applications at certain plants.

HELB Exposure has a criterion of Maximum Inaccuracy (accuracy) of 4.5% and 5% of Upper Range Limit, respectively, for PG and PD units (Reference Tables A9 and A10).

2I.1 HELB EXPOSURE PG TRANSMITTER RESPONSE

The results for the PG Transmitters were plotted as well as the requirements curve as follows:

PG 3200-100 XXXXXXXXX(Calibrated at 100 PSIG) FIGURE A17

PG 3200-100 XXXXXXXXX(Calibrated at 100 PSIG) FIGURE A17

During the measurements, the deviations from the baseline, or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy) based on use of the actual baseline performance value were added to the data taken by Gulton-Statham above.

The worst case value is the worst case deviation above from Figure A17
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXX

The functional performance was well within requirements.

Non-Proprietary Version

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*Accident Exposure as defined in Figure B1 and designated LOCA "A"

2I.2 HELB EXPOSURE PD TRANSMITTER RESPONSE

The results for the PD Transmitters were plotted as well as the requirements curve as follows:

PD 3200-200 (XXXXXXX) (Calibrated at 200" H_20) FIGURE A18
PD 3200-200 (XXXXXXX) (Calibrated at 200" H_20) FIGURE A19

Note: The transmitter serial number XXXXX had worse than expected performance which led to an assessment of the uniqueness of this unit, which led to such performance. A detailed analysis is provided in Section 2.K.2, determined the basis for the sub-optimal performance and led to a correction in a screening criteria to assure no production unit would exhibit such performance.

The analysis was supported by tests to validate the problem discovered during prototype testing and was corrected.

The qualification of the Differential Pressure Transmitters remains as demonstrated in this qualification file on the basis that no unit in the field will experience the problem determined during prototype testing.

Prior to HELB exposure, the PD transmitters were adjusted to assure they were set for the criteria for acceptance, which is an inaccuracy value expressed at Upper Range Limit (URL).

During the measurements, the deviations from the baseline or before exposure values (the previously defined Error, Environmental), were taken such that the total inaccuracy (expressed as accuracy), based on use of the actual baseline performance value are added to the data taken by Gulton-Statham above.

The worst case value is the worst case value deviation shown in Figure A19, XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXX Values shown are conservative as they are based on maximum span and not Upper Range value.

The functional performance was within requirements. The deviation in performance for the transmitter serial number XXXXX, is shown in detailed analysis supported by confirmatory test data in Section 2.K, not to impact acceptable qualification.

Non-Proprietary Version

2J GULTON-STATHAM TESTING FOR ENGINEERING INFORMATION

As previously described in Sections 1B, 2G, 2H, and 2I, the true critical characteristic or performance requirement of the transmitter (which is a measuring sensor first as well as a signal converter), is the correctness or accuracy of the measurement.

However, throughout the test program, Gulton-Statham performed many additional tests which were used to gather Engineering Information or confirm instrument characteristics. These tests are described herein for completeness.
No transmitter rating throughout the complete cycle of initial baseline testing through HELB exposure failed to meet requirements for the units qualified in this documentation package. Data on this testing, treated as Engineering Information Only, is available at Gulton-Statham.

2J.1 REPEATABILITY* BASELINE AND ACCURACY ENGINEERING INFORMATION DETERMINATION

This determination is essentially the same as that performed for the Functional Test described in detail previously using the test set-up of Figures A11 and A13. The difference is that two (2), 11-point checks are run consecutively under the same reference conditions and information on repeatability is sought, while hysteresis is specifically excluded. The data collected is sufficient to confirm repeatability is within specifications.

Tables A11 and A12 provide representative data collected from the first and last baseline checks of the PG units. Tables A13 and A14 provide representative data collected from the first and last baseline checks of the PD units. The signal output is checked to see the agreement of repeatability between readings. Review of the data presented (in the format of the voltage drop across the precision resistor), indicates the significant "Closeness of agreement among a number of consecutive measurements of the output for the same value of input under the same operating conditions, approaching from the same direction, for full range traverses."

Non-Proprietary Version

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*Repeatability is defined (Reference 8) as, The closeness of agreement among a number of consecutive measurements of the output for the same value of input under the same operating conditions, approaching from the same direction, for full range traverses."

"NOTE: It is usually measured as non-repeatability and expresses as repeatability in percent of span. It does not include hysteresis."

2J.2 POWER SUPPLY EFFECTS TEST

This determination is performed with essentially the same set-up as the Functional Test set-up of figures A11 and A13. The difference is that a power supply with a voltage minimum of 19 volts dc or less, and maximum of 60 volts dc or more, is used to determine two characteristics. These are the Lift-off Voltage* (validating the load limitation charts of the transmitter, e.g. as shown in Table A3), and showing the transmitter can withstand a voltage in excess of rating.

The following describes the procedure:

- Set-up per Figure A11 or A13 dependent on use of PG or PD transmitter. Set variable power supply to 19 volts dc.
- Adjust valves as previously performed in Functional Test.
- Starting at 0% pressure input, increase input to 100% to transmitter. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the 100% FS pressure input. A representative value from PD 3200-200, XXXXXXXXX was determined tXXXXXXXXXXXXXXX (Measurement 1).
- Slowly decrease the power supply voltage until there is a 10 mV drop across the dropping resistor. Record power input voltage to transmitter which is the Lift-Off Voltage. This was recorded; a representative value for PD 3200-200, XXXXXXXXX was determined XXXXXXXXXXXXXXXX(Measurement 2).
- Increase power supply voltage to 60 volts dc and measure voltage drop across the precision 250 ohm resistor (R_L) which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts at the 100% FS pressure input and intentional overvoltage. A representative value from PD3200-200, XXXXXXXX was determined XXXXXXXXXXXXXX(Measurement 3).
- Determine power supply effect which is the transmitter output with power input beyond the maximum voltage rating (corresponding to 60 volt input), less the output with the 19 volt input. Divide this value by the Voltage Difference between the maximum input voltage (60 volts), less the 19 volt input (or 41 volts - Measurement 4).

POWER SUPPLY EFFECT = (MEASUREMENT 3 - MEASUREMENT 1)
MEASUREMENT 4
POWER SUPPLY EFFECT = (XXXXX VDC XXXXX VDC)/XX VDC
POWER SUPPLY EFFECT = XXXXXXX V OUT/V POWER SUPPLY

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX

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*Lift-Off Voltage is the minimum dc voltage for which the transmitter will operate within specification. This voltage is dependent upon the load or resistance in the instrument loop and is based on determining a distinct drop in transmitter full scale output when compared to full scale output at a nominal power supply input of 19 volts with use of the 250 ohm-dropping resistor.

2J.3 TURN-DOWN* RATIO TEST

This determination is performed with essentially the same set-up as the Functional Test set-up of Figures A11 and A13. This test is used to verify the turn-down ratio or suppression which is the range of adjustability of the lower range value to the span.

The following describes the procedure:

- Set-up per Figure A11 or A13, dependent on use of PG or PD transmitter. Set variable power supply to 19 volts dc.
- Adjust valves as previously performed in functional Test for zero (0) process input pressure.
- Adjust zero (0) pot (Figure 3) counter-clockwise in the decreasing output direction until the transmitter output stops decreasing regardless of continued counter-clockwise adjustment, but not more than two (2) turns beyond the point where output decrease has stopped. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the Lower Cut-Off Voltage. A representative value from PD 3200-200, XXXXXXX, was determined XXXXXXXXXXXXXX (Measurement 1).
- Adjust zero (0) pot (Figure A3) clockwise in the increasing output direction until the transmitter output is 1.000 ±.005 volts. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as zero (0) pressure value. A representative value from PD 3200-200, XXXXXXXXX was determined XXXXXXXXX(Measurement 2).
- Close Vent Valve (Valve 2) and open valve from pressure source (Valve 1) at low or zero (0) pressure and apply to input port (high port on PD units). Increase pressure input until the full scale input is applied to the transmitter.

Non-Proprietary Version

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*Turn-Down Ratio is the amplified gain value for span suppression. For example, the maximum turn-down ratio of 5:1 results in min-span of 20% of full max span.

- Adjust span pot (Figure A3) clockwise in the increasing output direction until the transmitter output stops increasing regardless of continued clockwise adjustment, but no more than two turns beyond the point where output increase has stopped. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the Upper Cut-Off Voltage. A representative value from PD 3200-200, XXXXX, was determined XX XX XXXX XXXXX (Measurement 3).

- Adjust span pot (Figure A3) clockwise in the decreasing output direction until the transmitter output is 5.000 ± .005 volts. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the 100% full scale pressure value. A representative value from PD 3200-200, XXXXX, was determined XXXXXXXXXXXXXX (Measurement 4).

- Decrease input pressure; open Vent Valve 2. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the 0% full scale pressure value. A representative value from PD 3200-200, XXXXX, was determined XXXXXXXXXXXXX (Measurement 5).

- Close Vent Valve 2 and increase pressure standard such that 20% (1/5) of the full scale pressure value for the transmitter is applied.

- Adjust span pot (Figure A3) clockwise in the increasing output direction until the transmitter output stops increasing (thereby increasing amplifier gain, which should be five (5) or more), regardless of continued clockwise adjustment, but not more than two turns beyond the point where output increase has stopped.

- Decrease pressure standard to zero (0) pressure input, 0 PSIG. Open Vent Valve 2. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as "Post-Maximum Span Adjustment @ 0 PSID," with transmitter output in volts recorded. A representative value from PD 3200-200, XXXXX, was determined XXXXXXXXXXXXX(Measurement 6).

- Determine zero (0) interaction (Derived Measurement 7) as Measurement 6, less Measurement 5. This was recorded as "Interaction," with the value in volts recorded. A representative value from PD 3200-200, XXXXX, was determined XXXXXXX(Derived Measurement 7).

- Readjust the zero (0) pot (Figure A3) to obtain a voltage drop across the precision 250 ohm resistor (R_L) of 1.000 ± 0.010 volts. This was recorded as transmitter output in volts as the "Readjusted Zero (0 PSID)." A representative value from PD 3200-200, XXXXXX, was determined XXXXXXXXXXXXX(Measurement 8).

- Close Vent Valve 2 and increase pressure standard such that 20% (1/5) of the full scale pressure value for the transmitter is applied. The voltage drop across the precision 250 ohm resistor (R_L) was recorded, which is directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as “Maximum Gain,” with transmitter output in volts recorded. A representative value from PD 3200-200, XXXXX, was determined XXXXXXXXXXXX (Measurement 9).

- Turn Span pot clockwise until transmitter output reads 1.800 ± 0.010 volts.

- Open Vent Valve 2. Readjust the zero (0) pot (Figure A3) to obtain a voltage drop across the precision 250 ohm resistor (R_L) of 1.000 ± 0.010 volts. This was recorded as transmitter output in volts as the “Readjusted Zero (0) PSID.” A representative value from PD3200-200, XXXXX, was determined XXXXXXXXXXXXXX (Measurement 10).

- Close Vent Valve (Valve 2) and apply pressure source at low or zero (0) pressure and apply to input port (high port on PD units). Increase pressure input until the full scale input is applied to the transmitter.

- Readjust the Span pot (Figure A3) as necessary to obtain a voltage drop across the precision 250 ohm resistor (R_L) of 5.000 ± 0.010 volts. This was recorded as transmitter output in volts as the “100% Full Scale.” A representative value from PD3200-200, XXXXX, was determined XXXXXXXXXXXXX (Measurement 11).

Data gathered indicated that upper and lower cut-off exceeds the span with margin. The Turn-down ratio is five (5) or more, and little interaction exists between zero (0) and span.

2J.4 LOAD EFFECTS TEST

This test is performed to verify that there is essentially no effect (i.e. no measurable deviation beyond the accuracy limits of the measuring instruments and dropping resistors), with a change instrument loop load (test includes a load doubling), within rated load-limited operating region (see Table A3). Any value less than 0.00 V/ohm is acceptable. See representative set-up Figures A20 and A21.

The following describes the procedure:

- Set-up per representative Figure A20 or A 21 (similar set-up for PD and PG units, except for the need to adjust for different number of pressure ports - (See difference between Figures A11 and A13). Only place R_{L1} in circuit assuring continuous loop (i.e. circuit equal to Figures A11 or A13, as applicable).

- Start with open Vent Valve 2 and close.

- Starting at 0% pressure input, increase input to 100% to transmitter. The voltage drop across the precision 250 ohm resistor (R_{L1}) was recorded, which was directly proportional to the signal current by reading the value to three decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the 250 ohm load reading at 100% FS pressure input. A representative value from PD 3200-200, XXXXX, was determined XXXXXXXXXXXXXX(Measurement 1).

- Open Vent Valve 2; shut down circuit. Set-up per representative Figures A20 or A21 (similar set-up for PD and PG units, except for the need to adjust for different number of pressure ports - see difference between Figures A11 and A13). Add R_{L2} into R_{L1}, assuring continuous loop. Close circuit electrically and Vent Valve 2.

Non-Proprietary Version

Starting at zero percent (0%) pressure input, increase input to 100% to transmitter. The voltage drop across the precision 250 ohm resistor (R_{L1}) was recorded, which was directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). This was recorded as transmitter output in volts as the 500 ohm load reading at
100% FS pressure input. A representative value from PD 3200-200,
XXXXX, was determinedXXXXXXXXXXXX (Measurement 2).

- Determine load effect, which is the Transmitter output with 200% increase in loading. This is calculated as follows:

LOAD EFFECT = (MEASUREMENT 2 - MEASUREMENT 1)/250 OHMS

LOAD EFFECT = (XXXXX V - X.XXXV)/250 OHMS

LOAD EFFECT = XXXXXXX V/OHM

- In this example, the change is negligible (within the uncertainty of the measurement set-up), and well below 0.00 V/ohm. No load effects problems were reported in any tests from initial to final baseline.

2J.5 OTHER GULTON-STATHAM TESTING FOR ENGINEERING INFORMATION AND PERFORMANCE CONFIRMATION

Many other tests were performed to obtain Engineering information and performance confirmation. No test problems were reported in any tests from initial to final baseline for this series of tests. The following summarizes these tests (specific details of procedure are available at Gulton-Statham).

Non-Proprietary Version

2J.5.1 TIME CONSTANT TESTS

These tests are performed to measure the response time to a full scale step change in pressure. This is an important characteristic with the need for fast response. The Gulton-Statham Transmitter is typically 5 to10 times (or more), responsive to change than traditional industry transmitters. The acceptance criteria was to have a time-constant change of less than 10 milliseconds (for the PG units) and time-constant of less than 30 milliseconds for the PG and Differential Pressure* units (PD/PDH and DR), respectively. The PD/PDH 3218 units, due to the time necessary to transmit the pressure change through the silicone fluid filled capillary length, does not have an absolute time-constant acceptance value. The PD/PDH 3218 unit will have a time constant equal to the PD/PDH 3200 units plus that for signal transmission through the sealed diaphragm and capillary. This installation dependent value is addressed in Section F, Paragraph 4, with a recommendation that the user contact Gulton-Statham for specific data which relates to capillary length and other installation parameters.

- Most sensitive (undamped or unfiltered) configuration will be sensitive to rapid acceleration changes during vibration testing or pressure changes.
- Electronic component potential changes due to thermal or radiation transients will be most susceptible in an undamped circuit.
- Rather unique ability for rapid response even after simulating severe aging, may be of value to Gulton-Statham customers such that test data in support of this would be desirable**.

2J.5.1.1 SET-UP

Figures A22 and A23 represent the test set-up for the Time Constant Test. The configuration is similar to the functional tests; Figures A11 and A13 with the addition of instrumentation to accomplish measurements to determine the time constant. A dual trace oscilloscope is used with trace 2 configured or placed across the precision dropping resistor to measure voltage. The Vent Valve is a solenoid-operated valve. A reference transducer with a time-constant of less than one (1) millisecond (more than 5 to 30 times faster than the transmitter under test, to preclude significantly affecting measurement results), is used to monitor the input pressure to the transmitter. The output of the reference transducer is connected to oscilloscope trace 1, and the oscilloscope external trigger input. A Polaroid™ camera was fitted to the oscilloscope face to record trace results.

Non-Proprietary Version

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*NOTE: Some adjustment for capillary is necessary in the PD/PDH units dependent on capillary length. Contact the factory for data on time-constant adjustment

**Contact the factory for specific application data, if necessary, beyond the fact that all units meet the established criteria.

2J.5.1.2 TEST METHOD

The transmitter is pressurized to its full scale pressure. The solenoid vent valve is opened resulting in quick venting and step change output of the reference transducer triggering the oscilloscope sweep. The response of the transmitter output will decrease from the full scale or URL limit of 20 mA through the 250 ohm precision resistor (i.e. 5 volts = 20 mA X 250 ohms) to the zero (0) pressure value for 4 mA through the 250 ohm precision resistor (i.e. 1 volt = 4 mA X 250 ohms). The time response or Time-Constant being the time necessary for a 63.2% change (decrease in this test) due to a step change in forcing function. The magnitude of the nominal time-constant change would be the span or full scale (URL) less the zero (0) or 4 volts X 0.63 which is 2.52 volts. The determination of time constant is performed graphically as shown in Figure A24.

All time constants measured were faster than required and met the acceptance values. (see Typical Results in Figure A25).

2J.5.2 OVERLOAD/TOGGLE TESTS

These tests are performed to verify the transmitter's ability to withstand an overpressure on both the high port or low port due to an error in operation that applies the over-pressure to the low pressure port.

2J.5.2.1 SET-UP

Figure A26 is a representative the test set-up for the Test. The configuration is similar to the functional tests, but is designed to allow overpressure on both the high and low ports of a PD unit. The process medium for this test is distilled water to protect personnel should a component burst.

2J.5.2.2 TEST METHOD/PROCEDURE

The following describes the procedure:

- Obtain a full scale sensitivity from previous testing (see box 6 of the Test Form on Figure A12). A representative value from PD-3200-100, XXXXX, was determined XXXXXXXXXXXXXXXX(Measurement 1).

- Set-up per representative Figure A26. With Vent Valves 1 and 2 open (to atmosphere), and Valves 3, 4, and 5 closed, record the voltage reading across the precision 250 ohm resistor which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD 3200-100, XXXXX, was determined XXXXXXXXXXXXXXXX (Measurement 2).

Non-Proprietary Version

- Set Pressure Source to required Pressure Value; 4000 ± 40 PSIG for the PD 3200-100 unit being reviewed by example (which has a rated Static Pressure Limit of 3000 PSIG per Table A1 being used as an example).

- Close Valve 1; open Valve 3. Quickly open Valve 5 for a step change pressure input to the high pressure port. Hold pressure of 4000 ± 40 PSIG for one (1) minute. Check for leaks.

- Close Valve 5; close Valve 3; open Vent Valve 1 to establish 0% process input to both ports. Record the 0% process input voltage reading across the precision 250 ohm resistor which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD 3200-100, XXXXX, was determined XXXXXXXXXXXXXXX(Measurement 3).

- Close Valve 2; open Valve 4; open Vent Valve 1. Quickly open Valve 5 for a step change pressure input to the low pressure port. Hold pressure of 4000 ± 40 PSIG for one (1) minute. Check for leaks.

- Close Valve 5; close Valve 4; open Vent Valve 2 to establish 0% process input to the pressure ports. Record the 0% process input voltage reading across the precision 250 ohm resistor which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD 3200-100, XXXXX, was determined XXXXXXXXXXXX (Measurement 4).

- Set Pressure Source to 4000 ± 40 PSIG. Actual pressure depends on the rating of the units.

- Close Valve 1; open Valve 3. Quickly open Valve 5 for a step change pressure input to the high pressure port. Hold pressure of 4000 ± 40 PSIG for one (1). Check for leaks.

- Close Valve 5; close Valve 3; open Vent Valve 1 to establish 0% process to both ports as input. Record the 0% process input voltage reading across the precision 250 ohm resistor which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD 3200-100, XXX XXXXX was determined XXXXXXXXXXXXXX (Measurement 5).

- Determine the overload error as follows:

$$\textbf{OVERLOAD ERROR} = \left[\frac{(\textbf{MEASUREMENT 3} - \textbf{MEASUREMENT 2})}{\textbf{MEASUREMENT 1}}\right] \times 100\%$$

OVERLOAD ERROR = [(X.XXX – X.XXX)/X.XXX] X 100%

OVERLOAD ERROR = X.XXX% FS SENSITIVITY

Record this determination as derived Measurement 6.

Non-Proprietary Version

- Determine Toggle error as follows:

TOGGLE ERROR =[(MEASUREMENT 5-MEASUREMENT 4)] X 100%
MEASUREMENT 1

TOGGLE ERROR = [(X.XXX – X.XXX)/X.XXX] X 100%

TOGGLE ERROR = -X.XXX% FS SENSITIVITY

In this example, the change is relatively small compared to the ratings XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX Test pressure was 1000 PSIG greater than stated rating of 3000 PSIG.
No problems with this testing were reported in any tests from initial to final baseline.

2J.5.3 LINE PRESSURE COEFFICIENT (LPC) AND HYDROSTATIC TESTS

The Line Pressure Coefficient (LPC) test is preformed to determine the change in transmitter output as the pressure applied to both ports simultaneously increase from zero (0) to 2000 PSIG. The rating is expressed as the Static Pressure Effect (e.g. Table A1) with a value of ± XXX% of URL/1000 PSI.

The hydrostatic test is performed to verify the transmitter pressure integrity to withstand an overpressure on both the high port or due to an error in operation, that applies the overpressure to the low pressure report.

2J.5.3.1 SET-UP

Figure A26 is a representative the test set-up for the test. The configuration is the same as the Overload/Toggle Tests. The process medium for this test is distilled water to protect personnel, should a component burst.

2J.5.3.2 TEST METHOD / PROCEDURE

The following describes the procedure:

- Obtain the full scale sensitivity from previous testing (see box 6 of the Test Form on Figure A12). A representative value from PD 3200-200, XXXXXXXXX, was determined XXXXXXXXXXXXXXXX (Measurement 1).

- Set-up per representative Figure A26. With Vent Valves 1 and 2 open (to atmosphere) and Valves 3, 4, and 5 closed, record the voltage reading (for 0% input) across the precision 250 ohm resistor which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD3200-200,XXXXX, was determined XXXXXXXXXXXXXXXX (Measurement 2).

Non-Proprietary Version

- Set Pressure source to Pressure Valve of 1000 ±10 PSIG. Close Vent Valves 1 and 2; open valves 3 and 4. Slowly open Valve 5 for pressure input to the high and low pressure port. Record the voltage reading (at 1000 PSIG) across the precision 250 ohm resistor, which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative valve from PD 3200-200, XXXXX, was determined XXXXXXXXXXXXXXXX (Measurement 3).

- Increase line pressure to 2000 ±20 PSIG line pressure. Record the voltage reading (at 2000 PSIG) across the precision 250 ohm resistor, which is directly proportional to the signal current by reading the value to three (3) decimal places from the digital voltmeter (DVM). A representative value from PD 3200-200, XXXXXXXXXX was determined XXXXXXXXXXXXXXXX (Measurement 4).

- For PD 3200-200 XXXXX, Increase line pressure to 6000 ± PSIG and hold for two (2) minutes; check for leaks. Record acceptable hydrostatic check as Measurement 5. Remove overpressure condition from transmitter by lowering pressures and venting.

- Determine the Line Pressure Coefficient (LPC) per 1000 PSI as follows:

LINE PRESSURE COEFFICIENT=[(MEASUREMENT 4-MEASUREMENT 2)/2] X 100%
(MEASUREMENT1)

LINE PRESSURE COEFFICIENT = [(X.XXX – X.XXX)/2]/(X.XXX) X 100%

LINE PRESSURE COEFFICIENT = XX.XXX% FS SENSITIVITY/1000 PSI

Record this determination as derived Measurement 6.

No problems with this testing were reported in any tests from initial to final baseline.

Non Proprietary Version

2K CLARIFICATIONS AND REVIEW OF ANOMALIES IN TEST DATA

This section provides clarifications of equipment tested and other areas where the existing test documentation does not provide sufficient clarity. The specific parameter-by-parameter reviews of Section D demonstrate environmental qualification while the substantive coverage in earlier paragraphs of this section deal with performance issues, methods of test, and seismic qualification overview.

In addition, as the Qualification must address all anomalies to the extent necessary to preclude concern that the units are not qualified this section summarizes the dispositioning. Included is the review of the NTS Notice of Deficiencies and Change of Procedures in the NTS Report (Reference 9), as well as an integrated review of the raw data available from the lab notebooks and functional tests at Gulton-Statham.

Note: Typically many anomalies are laboratory caused, which actually overstresses the equipment, as it did in the great majority of the cases reviewed herein. Such overstressing adds to the confidence in the Gulton-Statham units.

The presentation of information is not necessarily in the order of importance, but rather it reflects a systematic review of the available data.

Non-Proprietary Version

1 TEST UNIT TRACEABILITY

Table 1 of Report 528-0994, page 14 (Section G-1 of this document) lists various transmitters and the tests which they were to have undergone. All units performed as required without any anomalies unless reported in this section. The following clarifies or corrects this data based on review of the complete EQ file.

PG 3200 TRANSMITTERS: MODEL PG 3200-100, URL 100 PSI (BY SERIAL NUMBERS)

S/N XXXXX and S/N XXXXX - underwent full qualification and are demonstrated qualified throughout this qualification package.

S/N XXXXX - was a control* unit that was aged and underwent EMI testing. Refer to Change of Procedure 9 (Report page 44) in the NTS Report. EMI testing is not traditionally part of EQ testing. However, it is evaluated in this section.

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*In the various NTS Reports of Section G, "Control Unit" refers to transmitter units used for reference only, or not intended to be exposed to the full compliment of qualification tests.

S/N XXXXX and S/N XXXX - was exposed to the full sequence of testing up through LOCA "B"." Performance of unit was satisfactory in functional testing up to time of severe LOCA "B" exposure. Such test data is available at Gulton-Statham. As described in Change in Procedures L-3 and L-1 (Report pages 49 and 52), LOCA "B" was added late in the program. Actual LOCA "B" exposure was well beyond anticipated with exposure greater than 500□F, with many uncontrolled exposures XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX. Although testing on transmitter continued, the planned higher qualification level for LOCA "B" was not achieved. Failure of XXXXX was catastrophic, while that of XXXXX was reflected in worst case inaccuracy[60] of approximately 10-12%. As reported by the Engineer responsible for testing [65],, "Steam penetrated termination wire conduit probably causing isolation resistance failure." Qualification to LOCA "A" is demonstrated in this qualification document.

PD 3200 TRANSMITTERS: MODEL PD 3200-200, URL 200" H_20 (BY SERIAL NUMBER)

XXXXXXXXX - underwent full qualification testing. This unit is demonstrated qualified by test data throughout this qualification package.

XXXXXXXXX - underwent full qualification and is demonstrated qualified throughout this qualification package. However, the accuracy during LOCA exposure was beyond expected levels. This is reviewed in depth and shown not be significant to qualification, as the cause has been isolated (as shown in 2K.2), and prevented from occurring in units shipped for use.

XXXXXXXXX - underwent full qualification and preformed successfully, even through the very severe LOCA "B" exposure. Conservatively, Gulton-Statham takes no credit for this successful performance, as the majority of transmitters exposed to the poorly controlled LOCA "B" were not successful. Data is available on the functional tests for this unit at Gulton-Statham.

XXXXXXXXXXXXXXXXXXXXXXX - was exposed to the full sequence of testing up through LOCA "B." Performance of unit was satisfactory in functional testing up to time of severe LOCA "B" exposure. Such test data is available at Gulton-Statham. As described in Change in Procedures, L-3 and L-1 (Report pages 49 and 52), LOCA "B" was added late in the program. Actual LOCA "B" exposure was well beyond anticipated, with exposure greater than 500°F, with many uncontrolled exposures. XXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX. Although testing on transmitter continued, the planned higher qualification level for LOCA "B" was not achieved. Qualification to LOCA "A" is demonstrated in this qualification document.

Non-Proprietary Version

XXXXXXXXX- was a control unit that was aged and underwent EMI testing. Refer to Change of Procedure 9 (Report page 44) in the NTS Report. EMI testing is not traditionally part of EQ testing. However, it is evaluated in this section.

XXXXXXXXX - was exposed to the full sequence of testing up through LOCA "B." Performance of unit was satisfactory in functional testing up to time of severe LOCA "B" exposure. Such test data is available at Gulton-Statham. As described in Change in Procedures L-3 and L-1 (Report pages 49 and 52), LOCA "B" was added late in the program. Actual LOCA "B" exposure was well beyond anticipated with exposure greater than 500□F, with many uncontrolled exposures XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX Although testing on transmitter continued, the planned higher qualification level for LOCA "B" was not achieved. As reported by the engineer responsible for testing[65] "Steam penetrated termination wire conduit probably causing isolation resistance failure." Qualification to LOCA "A" is demonstrated in this qualification document.

PD 3218 TRANSMITTERS: MODEL PD 3218-100, URL 100" H_20 (BY SERIAL NUMBER)

XXXXXXXXX - was a control unit held in spare and not exposed to EQ simulations.

XXXXXXXXX - underwent thermal aging and was a spare control unit. It was not exposed to other EQ simulations.

XXXXXXXXX - was discussed rather briefly in the NTS report, Reference 9 (in Section G.2 of this document), as it underwent accelerated thermal aging, SRV and Seismic Exposure, Irradiation and 7-day only LOCA exposure to obtain a preliminary assessment of transmitter performance. A separate report by both Gould[58] and NTS[59] reported on the results. The Gould Report Summary Data is included as Exhibit II to the NTS Report in Section G.2.

Non-Proprietary Version

The particular test unit exhibited full scale changes from baseline XXXXXXXXXXXXXXXXX exceeding the acceptance criteria. The test during LOCA was short and this series of test units with PVC lead wiring and Neoprene junction box gasketing performed poorly during longer term LOCA events. Consequently, no credit is taken for the somewhat reasonable performance of this unit. Discussion and dispositioning of the PVC wire and Neoprene gasketing is described in Paragraph 2.K.1 and the Paragraph immediately below for XXXXXXXXX. The NTS report [9] included various Change of Procedures (Report pages 19-24), approved by Gould and not consequential to the level of qualification reached. Change of Procedure #4 (Report Pages 21 and 22), provides the 7-day LOCA Simulation. Various Notices of Deviation (S-1, S-2, S-3, S-4) dealt with vibratory motion. XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXX

Note: Paragraph 5.2.1.3 indicates that the units were exposed to 16.25 days of aging temperature per Notice of Deviation 1 Report page 30, is in error.

The PD 3218 units are not included in the phase of testing described (Notice is for PG 3200 and PD 3200 units for a period after the P3218 units were aged). A Notice of Deviation (LOCA #4) occurred post-accident simulation in final baseline testing after an overload pressure of 2000 PSIG. This is not considered serious as it occurred after the accident simulation for effecting an engineering information test that is beyond the expected accident conditions.

Non-Proprietary Version

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXX"

XXXXXXX had very poor performance during LOCA "B" exposure. The PD 3218 unit was thermally aged less, did not include SRV testing, and had an open circuit. This unit, as well as every PD 3218 unit, had PVC lead wires and Neoprene gaskets, and a smaller terminal* box than other units. PVC is a thermoplastic that is recognized to have synergistic effects, has a low temperature rating for long-term service, and has an electrical volume resistivity, two (2) or more orders lower than other industry-successful lead wires (including the successful use of Kapton□ on all transmitters other than the PD 3218 units which used PVC lead wires). Additional coverage of the PD 3218 units is provided in this section. It is demonstrated that the change to the same Viton□ gaskets, Kapton□leadwires, and successful junction box of other units allows qualification by similarity for the PD 3218 unit.

DR 3200 TRANSMITTERS:
The DR 3200 transmitters were not part of the original qualification effort. Qualification is by the substantial similarity described in Paragraph 2A3 to the qualified PD units.

2 NOTICE OF DEVIATION 1
REPORT 528-0994, PAGE 56 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to lab failure to terminate aging exposure when planned for PD and PG units. Lab error provided more severe test and results in better qualified life.

3 NOTICE OF DEVIATION S-1
REPORT 528-0994, PAGE 57 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to performing resonance search without transmitters in operation. This is acceptable as, (1) transmitter is essentially a static device with little deviation in a vibration-susceptible mode, if energized, and (2) resonance search is not actually required by IEEE 344-1975 or IEEE 344-1987, if complete seismic testing is performed. The resonance search is inherently conservative as it is an additional vibratory exposure beyond seismic exposure. Furthermore, many Gulton-Statham units were exposed to seismic events twice to show that different mounting bracket would not invalidate qualification. A resonance is import in use of analytical techniques of vibration/seismic testing which is not the case for Gulton-Statham.

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*Industry common usage for a terminal or termination box (which contain termination provisions), is a junction box that may or may not use termination. Consequently, Gulton-Statham has adopted this terminology.

Non-Proprietary Version

4 **NOTICE OF DEVIATION S-2**
REPORT 528-0994, PAGE 58 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to performing resonance at levels that deviated from specification. Not significant as described in paragraph immediately above.

5 **NOTICE OF DEVIATION S-3**
REPORT 528-0994, PAGE 59 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to performing resonance at levels that deviated from specification. Not significant as described in sub-paragraph 3 above.

6 **NOTICE OF DEVIATION S-4**
REPORT 528-0994, PAGE 60 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to performing seismic exposures not in accord with standard practice. Units were actually vibration tested repeatedly, as indicated OBEs and SSEs were repeated. All this vibratory exposure demonstrates that the Gulton-Statham units are very sound.

7 **NOTICE OF DEVIATION L1 to L6, and L10**
REPORT 528-0994, PAGES 61 to 66, & 70 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to many stressful thermal cycles during LOCA exposure. The units were tested or continued to be tested with this unplanned stress. Included in Section F and the temperature analysis of Section DT, is a plot of the actual thermal behavior of the chambers. LOCA simulation was very severe for the transmitters -- well in excess of expected actual plant exposure.

8 **NOTICE OF DEVIATIONS - L7, L8, L9, L11 TO L15**
REPORT 528-0994, PAGES 67-69, 71-76 - (SECTION G1 OF THIS DOCUMENT)
Deviation is related to many stressful thermal cycles during LOCA exposure. This is LOCA "B" with no credit taken for this test. Stresses were even greater than described in subparagraph 6 above. Inability to pass LOCA "B" may be due to test lab failure.

9 **POOR CONDUIT/JUNCTION BOX INTERFACE FAILURE**
REPORT 528-0994, PAGE 11 - (SECTION G1 OF THIS DOCUMENT), PARAGRAPH 5.4.4
A poor connection was noted prior to LOCA exposure of PD 3218, XXXXXXXX. The unit later failed with steam coming out of the wiring. Such a failure clearly appears to be human error.

Note: This is a PD 3218 unit with Neoprene gasket, PVC wiring and small junction box, that may have further contributed to failure.

Non-Proprietary Version

10 EMI TESTING

EMI is not usually considered an EQ item for qualification. The original testing shows an EMI failure during conducted RF EMI testing (see NTS Report 528-0994, Exhibit II, SEA TEST Report TRS 11050, Appendix D, Test Data Sheets D-2 and D-7 for details). This test is an RF transient test. The transmitter utilizes a 2-wire circuit design. When exposed to RF transient, the output will have a momentary shift. After removing the RF transient, the transmitter will recover and there will be no permanent damage to the transmitter. Furthermore, current test methods to international standards IEC 801-2, IEC 801-3 and 1000-4 validate Gulton-Statham transmitters are acceptable from an EMI perspective. There is no known failure reported for Gulton-Statham transmitters due to EMI-induced failure.

2K.1 EVALUATION OF NEOPRENE GASKETED AND PVC WIRED TRANSMITTERS

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XXXXXXXXXXXXxxIt is a recognized fact that PVC has synergistic effects and is essentially precluded from use as primary insulation in containment in today's plants. Survival of PVC during LOCA is doubtful. Likewise, the use of another relatively low temperature material, Neoprene for high temperature LOCA exposure, is also another potential failure point. All these factors lead to a very probable failure mechanism.

The detailed similarity analysis earlier in this Part A, Paragraphs 2A2.1 and 2D of the qualification documentation, demonstrates qualification by similarity with use of the same material of construction. As shown in the various figures and specifications, the qualified transmitters actually shipped, using Viton™ elastomers, the same junction box, and Kapton™ pigtails. Theses are traceable under controlled configurations to the successful qualification.

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XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

2K.2 EVALUATION OF ANOMALY DUE TO LOW STRAIN GAGE BEAM INSULATION RESISTANCE AND PROGRAM TO PRECLUDE REOCCURRENCE

Subsequent to LOCA testing the PD 3200 unit XXXXXXXXX which had inaccuracy beyond the specification limits (see Figure A18), and the other units that did not meet specification requirements (e.g. XXXXX) were analyzed.

Figure A4C indicated the block diagram of the Differential Pressure Transmitters. A Wheatstone Bridge is sputtered onto the previously described sensing beam. The sensing diaphragm is linked to the beam to affect beam displacement and a resistance change of the strain gage bonded to the beam. The resistance change leads to an output from the Wheatstone Bridge ultimately being converted to the traditional 4-20 mA dc instrument loop signal. A block diagram of the transmitter circuit is shown in Figure A4B.

The unit electronics were exposed to a 290°F ambient and the change in accuracy was recorded. The amplifier output change was not drastic XXXXX. The assemblies were further broken down systematically and potential error causes eliminated. Ultimately, the error was determined to be within the strain gage beam. The strain gage beam consists of XXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX necessary to form a Wheatstone Bridge.

The insulation resistance between the strain gage and the metal beam was determined for the unit with larger inaccuracy with measurements at high temperature. It was determined that the beams with lower insulation resistance or shunt paths have the greatest error. This is analogous to other current-sensing instrumentation in nuclear plants where low insulation resistance caused leakage paths (due to cables, terminal blocks, etc.), have been an EQ concern(64). Whereas, Figure A4A indicates the normal Wheatstone Bridge configuration; Figure A27 indicates the low insulation resistance leakage paths which cause errors.

Various beams of different insulation resistance were exposed to high ambient temperatures and it was verified, as shown in Figure A28, that a high insulation resistance would minimize error. An insulation resistance of XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX, with an error in accordance with the following equation:

E = 4.5E06/IR IN PERCENT

WHERE:
IR = INSULATION RESISTANCE IN OHMS
E = OUTPUT ERROR IN PERCENT

To assure that all production transmitter would not experience significant low insulation resistance induced error, Gulton-Statham established a requirement that all beams for nuclear plants be screened to assure high insulation resistance XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.

Non-Proprietary Version

Gulton-Statham has a specific procedure, APS 1406 "Beam Selection Procedure for Nuclear Products," which requires an insulation resistance greater than XXXX ohms at room temperature. Even more significant is the requirement that every beam in nuclear transmitters be exposed to a stabilized temperature ofXXXXXXXX, with an insulation resistance of XXXX, or greater ohms, at this screening temperature. This testing is under a quality program and uniquely logged by serial number, actual resistance reading, pass/fail indications and other data.

Gulton-Statham has performed various tests to validate that the high initial IR results in acceptable performance under nuclear events. Figure A29 indicates results of verification testing XXXXX that shows that our screening criteria results in continuing high insulation resistance at XXXXX, even after XXXXX temperature and XXX Megarad radiation exposure.

Based on all of the above Gulton-Statham has established a controlled process to assure all production units will utilize strain gage beams that will not exhibit poor performance due to low insulation resistance.

2L MOUNTING/ORIENTATION

No special mounting or orientation of the equipment is necessary on the basis of environmental qualification requirements other than installation enveloped by testing.

The flexibility for the ultimate user is based on successful seismic qualification use of junction boxes as well as pigtails*. Also included, was the standard Gulton-Statham mounting bracket as well as a Rosemount Mounting Bracket. The test configuration and use of less massive transmitter than available from others, was established to facilitate user flexibility to replace competitive units. No special installation requirements, beyond the typical transmitter application has been identified by the qualification documentation found in QDR Section G.1, or any other data available (e.g. original lab notebook from the testing).

The torque values for bolting during test (described in lab testing notebook), was 65 ± 5 inch pounds, consistent with transmitter instruction manual.

2M INTERFACES

The equipment are subject to moisture exposure and high humidity conditions following a Design Basis Accident. However, the accident simulation included direct steam exposure without use of any special seals such that conductor seals are not necessary. However, pigtails must be in conduit or junction boxes and not directly exposed to the environment. No special interface requirements exist other than standard instrument practice as shown in the transmitter instruction manuals.

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*For installation in a pipe break area, refer to Section E.

Non-Proprietary Version

2N REVIEW OF NRC POTENTIALLY PERTINENT INFORMATION NOTICES / BULLETINS

Preparation of this qualification document included review of various information notices and correspondence pertaining to potential NRC concerns regarding transmitters. No specific information, notice, or area of concern was identified for the Gulton-Statham Transmitters. However, review for commonality with other transmitters was included for completeness, and as an aid to Gulton-Statham Transmitter users. USNRC Inspection and Enforcement Notice 89-42[19] and USNRC Bulletin No. 90-1[20] describe the concerns with Rosemount 1153 and 1154 transmitters that have a failure mechanism due to loss of fill oil in the sensing module.

As described in the section entitled "Increased Safety and Reliability," for the standard for the Gulton-Statham Transmitters[37], pages 8 and 9 (found in Section G.5), the Gulton-Statham configuration essentially precludes the concern for a Rosemount type fill oil leak concern. Figure A14 provides the details of the configuration that essentially precludes the pressure transmitter failure (due to feed through pin design in the units subject to the aforementioned NRC notice and bulletin.

2O SYNERGISTIC EFFECTS AND DOSE RATE EFFECTS

As stated in 10CFR50.49, "Synergistic effects must be considered, when these effects are believed to have a significant effect on equipment performance." Consideration of such state-of-the-art issues as synergistic effects or dose rate effect, is based on study of research findings of EPRI and Sandia Laboratories. At this time, significant dose rate and synergistic effects are limited to a small number of materials (e.g. Polyethylene, PVC, Teflon □), which do not constitute the elements of current construction of the transmitters.

2P DESIGN CHANGE CONTROL-RETAINING QUALIFICATION

As previously indicated, Gulton-Statham has in effect, a full 10CFR50, Appendix B, as well as an ISO 9001 Quality Management System that assure proper attention to design change control. Contained in Section F, is additional discussion of design change reviews which assure retention of transmitter qualification.

2Q REASONABLE ASSURANCE OF EQ

The demonstration of adequacy in equipment qualification is not completely absolute, but rather relates to the "reasonable" concepts established in Title 10 of the code of Federal Regulations and NRC staff guidance in such appropriate document as the DOR guidelines (Enclosure 4, IEB 79-01B[7], "Environmental Qualification of Class 1E Equipment," January 14, 1980). For example, 10CFR50, Appendix B, "Quality Assurance Criteria For Nuclear Power Plants and Fuel reprocessing Plants," the Introduction Paragraph establishes requirements, "...necessary to provide **adequate confidence..**" 10CFR50 Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 1, "Quality Standards and Records," requires Quality Assurance to be, "established and implemented in order to provide **adequate assurance....**" Finally, the DOR Guidelines, "Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors," Paragraph 1.0, Introduction, concerns itself with, "Class 1E equipment whose documentation does not provide reasonable assurance of environmental qualification."

On the basis of the regulations and NRC staff guidance, the requirements establish "reasonable assurance" or provide " adequate assurance" or "adequate confidence" that environmental qualification is established.

The transmitters are clearly qualified and provides "reasonable or adequate assurance" such that "adequate confidence" in environmental and seismic qualification exists.

2R ADDITIONAL ASSURANCE OF QUALIFICATION BY USE OF NRC CHECKLIST

To ensure that all pertinent issues regarding the environmental qualification of the subject equipment has been addressed in accordance with NRC's requirements or recommendations, the preparer of this documentation file has completed an overview *"checklist"* which is attached to this section. This checklist is derived from the NRC's Inspection Module "Temporary Instruction 2515, Evaluation of Licensee's Program for Qualification of Electrical Equipment Located in Harsh Environments," which is also used by the NRC auditors and inspectors.

The supplemental checklist is included as a means of demonstrating completeness in qualification and also serves as a summary, indicating where in the documentation file each parameter/concern is addressed.

Non-Proprietary Version

2S RESPONSIBLE ORGANIZATION (COMPANY / DIVISION) DESIGNATION

During the evolution and production of the nuclear safety-related transmitter product line the responsible organization designations have changed from Gould Electronics; Gould Inc., Measurement System Division; Schlumberger Industries, Statham Transducer Division; Statham; Gulton-Statham, a Mark IV Company; and Ametek Aerospace and Power Instruments, Gulton-Statham Products. Throughout that time period, configuration control under 10CFR50, Appendix B, was applied such that the basis for qualification demonstrated in this qualification file remains valid to all enveloped transmitter models. An illustration of traceability that the name changes did not impact configuration control is the drawing first produced during the period of qualification testing for the PD 3200 and PDH 3200 transmitters Drawing 70006-000-001 (Reference 14), found in Section F. As indicated in Revision E of this Drawing, the revision was issued in 1987, to reflect a logo change from Gould to Schlumberger.

NRC CHECKLIST

CRITERIA:

Meets 10CFR50.49; exceeds DOR Guidelines

COVERED IN EQ DOCUMENTATION: EQ ISSUE

1. Positive statement in QDR Section A, that the equipment is qualified for its application.
2. Full description of the equipment in QDR Section A.
3. If qualification sample is not identical to the installed device, a similarity analysis has been provided in QDR Section A.
4. Allowed mounting methods and orientations in QDR Section A.
5. Interfaces -- conduit, housing seal, etc., addressed in QDR Section A Seal, etc.
6. A qualified life has been established based upon accelerated aging-thermal, radiation, cyclic, as appropriate in QDR Sections DR and DA.
7. All type tests performed on the same specimen, as described in Section DA.
8. Performance /acceptance individual criteria (operating time, Parameter Reviews, such as transmitter accuracy, etc.), addressed in Sections A and G.
9. Test sequence conforms to IEEE 323-74 or individual justification has been Parameter Reviews provided in Section A.
10. Radiation dose covers accident and normal service in Section DR.
11. DBE exposure simulation meets plant requirements:

STEAM EXPOSURE	SECTION DT
TEMPERATURE	SECTION DT
PRESSURE	SECTION DP
HUMIDITY	SECTION DH

12. De-mineralized water spray simulation performed when required per QDR Section DC.
13. Accident environment margins: (See review for each parameter) in Section D.
14. Submergence Test (if required for application) Section DS.
15. Test anomalies resolved in QDR Section A.
16. Applicable IENs, etc., resolved in QDR Section F.
17. Maintenance/Surveillance Criteria and Life defined in QDR sections DA, and E.

Non-Proprietary Version

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

Non-Proprietary Version

SECTION A

TABLES

TABLE A1
PD 3200 & PDH 3200 SPECIFICATIONS

3200 SERIES

SPECIFICATIONS

Functional Specifications

Service	Liquid, gas or vapor
Range Limits - Adjustable	PD3200 0-20 to 0-100" H_2O 0-40 to 0-200" H_2O 0-80 to 0-400" H_2O PDH3200 0-6 to 0-30 psid 0-20 to 0-100 psid 0-60 to 0-300 psid 0-200 to 0-1000 psid
Output	4-20 mA, maximum 30 mA (limited)
Power Required	12 to 55V DC as measured at transmitter (reverse polarity protected)
Enclosure Classification	NEMA 3, 4, 6, 7, 9
Temperature Limits	
- Storage	- 65° to +200°F (-54° to +93°C)
- Operation, Electronics	+40° to +180°F (+5° to +82°C)
- DBE, Electronics	+40° to +250°F (+5° to +122°C)
- Maximum Process	+40° to +250°F (+5° to +122°C)
Static Pressure Limits	3000 psig (20.7 MPa) at either connection without damage to transmitter system for all ranges 100" H_2O, (2000 psig)
Humidity	0-100% RH
Zero Elevation	100% of upper range limit
Zero Suppression	+80% of upper range limit

NOTE: Sum of span and elevation or suppression cannot exceed the upper or lower range limit.

Performance Specifications

(% of Upper Range Limit)

NOTE: Performance is based on PD/PDH3200 with 316-SS diaphragms, silicone oil DC-702, reference conditions.

Accuracy	< ±0.25% of calibrated span, including linearity, hysteresis and repeatability
Stability	< ±0.25% of upper range limit/6 months
Dead Band	None
Temperature Effect	< ±1.5% between 40° and 250°F (+5° to +122°C) at max span
Static Pressure Effect	
- Zero Error	< ±0.5% of upper range limit/ 1000 psi (6.9 MPa)
- Span Error	< ±0.2% of calibrated span (both zero and span errors can be corrected for a particular line pressure)
Overpressure Effect	< ±2% of the upper range limit for overpressure events less than the static pressure rating of the transmitter
Power Supply Effect	0.01%/V of power supply variation
Load Effect	No effect if power supply voltage remains in operating region
Mounting Position Effect	Up to 2" H_2O (0.5 kPa) zero shift perpendicular to diaphragms (corrected by zero adjustment). No effect in plane of diaphragms; no span effect

Physical Specifications

Materials of Construction	
- Pressure Retaining Components	316SS
- Process Connections	1/4"- NPT on 2-1/8" centers
- O-Rings	Viton A
- Fill Fluid	Silicone oil DC-702
- Electronics Housing	316SS
- Electrical Termination Leads	Kapton insulated 16-gage stranded, Polyurethane potting. Yellow/white = negative; Black = positive; Green = ground
- Junction Box	Epoxy coated aluminum
Electrical Connections	3/4" NPT

NOTE: Consult factory for additional options

Weight	
- PD/PDH3200	11.1 lbs (5.1 kg)
- Mounting Bracket	2.0 lbs (0.9 kg)
- Junction Box	2.3 lbs (1.1 kg)

Calibration

Transmitters are factory-calibrated from zero to the maximum range unless specified otherwise when order is placed.

Tagging

Transmitters will be identified in accordance with customer requirements (15 character maximum). Stamped on calibration cover. OPTIONAL: 316SS tag wired to transmitter.

TABLE A2
PD 3200 & PDH 3200 MODEL CODE
(AS OF MAY 1996 - CONSULT FACTORY FOR CURRENT MODEL CODE)

3200 SERIES

ORDERING

Code Description

Model PD3200/PDH3200
Nuclear Service Qualified
Differential Pressure Transmitter

Range

PD3200

100	0-20 to 0-100" H_2O
200	0-40 to 0-200" H_2O
400	0-80 to 0-400" H_2O

PDH3200

030	0-6 to 0-30 psid
100	0-20 to 0-100 psid
300	0-60 to 0-300 psid
01M	0-200 to 0-1000 psid

Pressure Flange Configuration

5	3000 psi SWP with open ports
6	3000 psi SWP with 316SS plugs
7	3000 psi SWP with 316SS drain/vent valves
M	3000 psi SWP with Swagelok™ (Welded)

Electrical Termination

2	3 leads, 36" long, 3rd wire ground
8	Factory mounting of electrical accessory (e.g. Nuclear Junction Box)

Pressure Retaining Parts

	Pressure Flanges	Plugs or Vent/Drain	Diaphragms
22	316SS	316SS	316SS
	Bolts	**Fill Fluid**	
	316SS	Silicone Oil DC-702	

Accessories (Mounted) Electrical

XX	None
36	Nuclear Junction Box

Accessories (Unmounted) Mechanical

XX	None
	Seismic Mounting Bracket N2, order separately

PD3200 - 100 - 5 8 - 22 - 36 - XX
(Typical Model Number)

Non-Proprietary Version

TABLE A3
PD/PDH 3218 SPECIFICATIONS

3200 SERIES

SPECIFICATIONS

Functional Specifications

Service	Liquid, gas or vapor
Range Limits - Adjustable	**PD3218** 0-20 to 0-100" H_2O 0-40 to 0-200" H_2O 0-80 to 0-400" H_2O **PDH3218** 0-6 to 0-30 psid 0-20 to 0-100 psid 0-60 to 0-300 psid 0-200 to 0-1000 psid
Output	4-20 mA, maximum 30 mA (limited)
Power Required	12 to 55V DC as measured at transmitter (reverse polarity protected)
Load Limitations	See specification chart
Enclosure Classification	NEMA 3, 4, 6, 7, 9
Zero Elevation	-100% of upper range limit
Zero Suppression	+80% of upper range limit

NOTE: Sum of span and elevation or suppression cannot exceed the upper or lower range limit.

Temperature Limits - Transmitter	
- Storage	- 65° to +200°F (-54° to +93°C)
- Operation, Electronics	+40° to +180°F (+5° to +82°C) +40° to +250°F (+5° to +122°C)
- Maximum Process	+40° to +600°F (+5° to +315°C)
Static Pressure Limits	2000 psig (13.8 MPa) at 100°F, at either connection without damage to transmitter system. System limited by flange rating (i.e. 150, 300 or 600 psig)

NOTE: All systems tested to 1.5 times static pressure limit.

Humidity	0-100% RH

Performance Specifications
(% of Upper Range Limit)

NOTE: Performance is based on PD/PDH3218 with 316SS diaphragms, silicone oil DC-702 reference conditions.

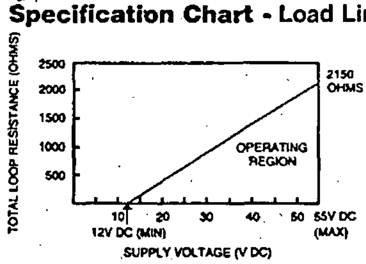
Accuracy	< ±0.25% of calibrated span, including linearity, hysteresis and repeatability
Repeatability	< ±0.1% at maximum span
Stability	< ±0.25% of upper range limit/6 months
Dead Band	None
Temperature Effect	< ±1.5% from 40° to 250°F (+5° to +122°C) at max span
Static Pressure Effect	
- Zero Error	< ±1.0% at max span/1000 psi (6.9 MPa)
- Span Error	< ±0.2% of calibrated span (both span and zero errors can be corrected for a particular line pressure)
Power Supply Effect	< 0.01%/V of power supply variation
Load Effect	No effect if power supply voltage remains in operating region

Physical Specifications

Materials of Construction

Transmitter		
- Wetted Parts	Paddle 316SS Inconel	Diaphragm 316SS Inconel
- Fill Fluid	Silicone oil DC-702, 45 CST Specific gravity = 1.07	
- Electronics Housing	316SS	
- Electrical Termination Leads	Kapton insulated 16-gage stranded, Polyurethane potting. Yellow/white = negative; Black = positive; Green = ground	
- Junction Box	Epoxy coated aluminum	
Electrical Connections	3/4" NPT	
Weight		
- PD/PDH3218	5.7 lbs (2.6 kg)	
- Mounting Bracket	3.5 lbs (1.6 kg)	
- Junction Box	2.3 lbs (1.2 kg)	
- Remote Seals	4.1 lbs each (1.9 kg)	
- Capillary Tubing	0.6 lb (.3 kg) per 5 ft. increment	

Specification Chart - Load Limitation



Calibration
Transmitters are factory-calibrated from zero to the maximum range unless specified otherwise when order is placed.

Tagging
Transmitters will be identified in accordance with customer requirements (15 character maximum). Stamped on calibration cover. OPTIONAL: 316SS tag wired to transmitter.

Non-Proprietary Version

TABLE A4
PD/PDH 3218 MODEL CODE
(AS OF MAY 1996 - CONSULT FACTORY FOR CURRENT MODEL CODE)

3200 SERIES

ORDERING

Code Description

Model PD3218/PDH3218
Nuclear Service Qualified
Differential Pressure Transmitter with Remote Diaphragm Seals

Range

PD3218

100	0-20 to 0-100" H_2O
200	0-40 to 0-200" H_2O
400	0-80 to 0-400" H_2O

PDH3218

030	0-6 to 0-30 psid
100	0-20 to 0-100 psid
300	0-60 to 0-300 psid
01M	0-200 to 0-1000 psid

Connection Size (Pressure Rating)

3	3", 150, 300 & 600 class ANSI

Electrical Termination

2	3 leads, 36" long, 3rd wire ground
8	Factory mounting of electrical accessory (e.g. Nuclear Junction Box)

Pressure Retaining Parts

	Paddle	Diaphragm
1	316SS	316SS
2	Inconel	Inconel

Fill Fluid

2	Silicone Oil DC-702

Accessories (Mounted) Electrical

XX	None
36	Nuclear Junction Box

Accessories (Unmounted) Mechanical

XX	None
	Seismic Mounting Bracket N3, order separately

Capillary Length

05	5' (standard) In 5' increments (maximum 40' each side) NOTE: Both sides must be equal length

PD3218 - 100 - 3 8 - 1 2 - 36 - XX - 05

(Typical Model Number)

Non-Proprietary Version

TABLE A5
DR 3200 SPECIFICATIONS

3200 SERIES

SPECIFICATIONS

Functional Specifications

Service	Liquid, gas or vapor
Range Limits - adjustable	DR3200 0-1" to 0-5" H_2O
Output	4-20 mA, maximum 30 mA (limited)
Power Required	12 to 55V DC as measured at transmitter (reverse polarity protected)
Load Limitations	See specification chart
Enclosure Classification	NEMA 3, 4, 6, 7, 9
Temperature Limits	
- Storage	- 65° to +200°F (-54° to +93°C)
- Operation, Electronics	+40° to +180°F (+5° to +82°C)
- DBE, Electronics	+40° to +155°F (+5° to +68°C)
- Maximum Process	+40° to +250°F (+5° to +122°C)
Static Pressure Limits	10 psig (0.07 MPa) at either connection without damage to transmitter system
Humidity	0-100% RH
Zero Elevation	-60% of upper range limit
Zero Suppression	+60% of upper range limit

NOTE: Sum of span and elevation or suppression cannot exceed the upper or lower range limit.

Performance Specifications
(% of Upper Range Limit)
NOTE: Performance is based on DR3200 with 316SS diaphragms, silicone oil of DC-702, reference conditions

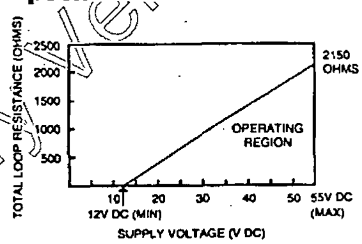
Accuracy	< ±0.25% of calibrated span, including linearity, hysteresis and repeatability
Repeatability	< ±0.1% at maximum span
Stability	< ±0.5% of upper range limit/6 months
Dead Band	None
Temperature Effect	< ±2% from 75° to 155°F (+24° to +68° C) at max span
Power Supply Effect	< 0.01%/V of power supply variation
Load Effect	No effect if power supply voltage remains in operating region
Mounting Position Effect	Up to 1.5" H_2O (0.4 kPa) zero shift perpendicular to diaphragms (corrected by zero adjustment). No effect in plane of diaphragms; no span effect

Physical Specifications

Materials of Construction

- Pressure Retaining Components	316SS
- Process Connections	1/4"- NPT on 2-1/8" centers
- O-Rings	Viton A
- Fill Fluid	Silicone oil DC-702
- Electronics Housing	316SS
- Electrical Termination Leads	Kapton insulated 16-gage stranded, Polyurethane potting. Yellow/white = negative; Black = positive; Green = ground
- Junction Box	Epoxy coated aluminum
Electrical Connections	3/4" NPT
Weight	
- DR3200	11.1 lbs (5.1 kg)
- Mounting Bracket	2.0 lbs (0.9 kg)
- Junction Box	2.3 lbs (1.1 kg)

Specification Chart - Load Limitation



Calibration
Transmitters are factory-calibrated from zero to the maximum range unless specified otherwise when order is placed.

Tagging
Transmitters will be identified in accordance with customer requirements (15 characters maximum). Stamped on calibration cover. OPTIONAL: 316SS tag wired to transmitter.

Non-Proprietary Version

TABLE A6
DR 3200 MODEL CODE
(AS OF MAY 1996 - CONSULT FACTORY FOR CURRENT MODEL CODE)

3200 SERIES

ORDERING

Code Description

Model DR3200
Nuclear Service Qualified
Draft Range Pressure Transmitter

Range

DR3200	
005	0-1 to 0-5" H_2O

Pressure Flange Configuration

0	Open ports
1	316SS plugs
2	316SS drain/vent valves

Electrical Termination

8	Factory mounting of electrical accessory (e.g. Nuclear Junction Box)

Pressure Retaining Parts

	Pressure Flanges	Plugs or Vent/Drain	Diaphragms
22	316SS	316SS	316SS
	Bolts	**Fill Fluid**	
	316SS	Silicone Oil DC-702	

Accessories (Mounted) Electrical

36	Nuclear Junction Box

Accessories (Unmounted) Mechanical

XX	None
	Seismic Mounting Bracket N2, order separately

DR3200 – 005 – 1 8 – 22 – 36 – XX
(Typical Model Number)

Non-Proprietary Version

TABLE A7
PG 3200 SPECIFICATIONS

3200 SERIES

SPECIFICATIONS

Functional Specifications

Service	Liquid, gas or vapor
Range Limits - Adjustable	**PG3200** 0-20 to 0-100 psi 0-40 to 0-200 psi 0-100 to 0-500 psi 0-200 to 0-1000 psi 0-400 to 0-2000 psi 0-1000 to 0-5000 psi
Output	4-20 mA, maximum 30 mA (limited)
Power Required	12 to 55V DC as measured at transmitter (reverse polarity protected)
Load Limitations	See specification chart
Enclosure Classification	NEMA 3, 4, 6, 7, 9
Temperature Limits	
- Storage	-65° to +200°F (-54° to +93°C)
- Operation, Electronics	+40° to +180°F (+5° to +82°C)
- DBE, Electronics	+40° to +250°F (+5° to +122°C)
- Maximum Process	+40° to +250°F (+5° to +122°C)
Overpressure	1.5 times upper range limit
Humidity	0-100% RH
Volumetric Displacement	Less than 0.001 in³ (0.0164 cc)
Zero Elevation	To full vacuum
Zero Suppression	+80% of full range

NOTE: Sum of span and suppression cannot exceed the upper range limit.

Performance Specifications
(% of Full Range)

Accuracy	< ±0.25% of calibrated span, including linearity, hysteresis and repeatability
Stability	< ±0.25% per 6 months
Temperature Effects	< ±1.5% between 40° and 250°F (+5° to +122°C) at max span
Power Supply Effect	< 0.01%/V of power supply variation
Load Effect	No effect if power supply voltage remains in operating region
Overpressure Effect	< ±0.25% after overpressure

Physical Specifications

Materials of Construction

- Diaphragm	316SS
- Fill Fluid	Silicone oil DC-702
- Pressure Retaining Components	316SS
- Process Connections	1/4" NPT
- Electronics Housing	316SS
- Electrical Termination Leads	Kapton insulated 16-gage stranded, Polyurethane potting. Yellow/white = negative; Black = positive; Green = ground
- Junction Box	Epoxy coated aluminum

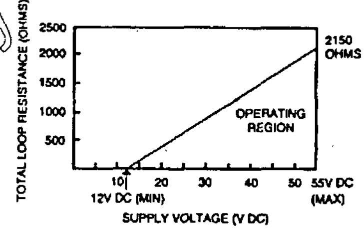
Electrical Connections 3/4" NPT

NOTE: Consult factory for additional options

Weight

- PG3200	4.4 lbs (1.8 kg)
- Mounting Bracket	2.0 lbs (1.0 kg)
- Junction Box	2.3 lbs (1.1 kg)

Specification Chart - Load Limitation



Calibration
Transmitters may be calibrated with absolute (psia) or gage (psig) reference. If calibration is not specified when order is placed, transmitters will be calibrated for maximum span with gage reference (psig).

Tagging
Transmitters will be identified in accordance with customer requirements (15 character maximum). Stamped on calibration cover. OPTIONAL: 316SS tag wired to transmitter.

Non Proprietary Version

TABLE A8
PG 3200 MODEL CODE
(AS OF MAY 1996 - CONSULT FACTORY FOR CURRENT MODEL CODE)

3200 SERIES

ORDERING

Code Description

Model PG3200
Nuclear Service Qualified
Sealed Gage Pressure Transmitter

Range

PG3200	
100	0-20 to 0-100 psi
200	0-40 to 0-200 psi
500	0-100 to 0-500 psi
01M	0-200 to 0-1000 psi
02M	0-400 to 0-2000 psi
05M	0-1000 to 0-5000 psi

Pressure Port Configuration

7	Open ports
8	With Swagelok™ (Welded)

Electrical Termination

2	3 leads, 36" long, 3rd wire ground
8	Factory mounting of electrical accessory (e.g. Nuclear Junction Box)

◇ **Pressure Retaining Parts**

	Pressure Cap	**Diaphragm**	**Fill Fluid**
12	316SS	316SS	Silicone Oil DC-702

Accessories (Mounted) Electrical

XX	None
36	Nuclear Junction Box

Accessories (Unmounted) Mechanical

XX	None
	Seismic Mounting Bracket N1, order separately

PG3200 - 100 - 7 8 - 12 - 36 - XX
(Typical Model Number)

Non-Proprietary Version

TABLE A9
PD/PDH 3200, PD/PDH 3218*, DR 3200* TRANSMITTER SUMMARY OF ACCURACY DEMONSTRATED FOR ENVIRONMENTAL QUALIFICATION SEISMIC QUALIFICATION

ENVIRONMENT / INFLUENCE	FUNCTIONAL PERFORMANCE
QUALIFIED LIFE (THERMAL AGING AND CYCLE AGING)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX
RADIATION (33 MRADS T.I.D.)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT (SEE NOTE 3)
RADIATION (55 MRADS T.I.D)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT (SEE NOTE 3)
SRV VIBRATION AGING	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT.
OBE EXPOSURE (DURING EXPOSURE)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT. FOR DR 3200, CONSULT FACTORY
OBE EXPOSURE (POST-VIBRATION)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT.
SSE EXPOSURE (DURING EXPOSURE)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT. FOR DR 3200, FOR THE MAXIMUM INACCURACY CONSULT FACTORY
SSE EXPOSURE (POST-VIBRATION)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT.
HELB EXPOSURE**	MAXIMUM INACCURACY (*ACCURACY*) OF XXX OF UPPER RANGE LIMIT.

Non-Proprietary

NOTE:

(1) All percentage values are calculated in percent of maximum span in lieu of less conservative maximum absolute URL or FS value.

(2) Refer to Section B for summary of Qualification exposure required (i.e. values of temperature, radiation, pressure, etc.) and details of Section D for Qualification Demonstrated.

(3) All test data available indicates an inaccuracy of less than XXX% even at total dose rate exposure up to XXX Mrads/hour. However, for dose rates above XXX Mrads/hour to XX Mrads/hour, the inaccuracy is considered to be up to ± XXX% to reflect worst case error of XXX% error reported in Reference 60.

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*Primary basis of qualification is the complete sequence of testing for the PD 3200 model.

**Designated as LOCA "A" in the qualification plan, but intending to meet a high energy line break event which may include a LOCA event, but is expected to envelop all outside drywell and PWR containment events at a representative plant.

TABLE A10
PG 3200 TRANSMITTER SUMMARY OF ACCURACY DEMONSTRATED FOR ENVIRONMENTAL QUALIFICATION & SEISMIC QUALIFICATION

ENVIRONMENT / INFLUENCE	FUNCTIONAL PERFORMANCE
QUALIFIED LIFE (THERMAL AGING AND CYCLE AGING)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
RADIATION (33 MRADS T.I.D.)	MAXIMUM INACCURACY (*ACCURACY*) OF XX% OF UPPER RANGE LIMIT (SEE NOTE 3)
RADIATION (55 MRADS T.I.D)	MAXIMUM INACCURACY (*ACCURACY*) OF XX% OF UPPER RANGE LIMIT (SEE NOTE 3)
SRV VIBRATION AGING	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
OBE EXPOSURE (DURING EXPOSURE)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
OBE EXPOSURE (POST-VIBRATION)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
SSE EXPOSURE (DURING VIBRATION)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
SSE EXPOSURE (POST-VIBRATION)	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT
HELB EXPOSURE**	MAXIMUM INACCURACY (*ACCURACY*) OF XXX% OF UPPER RANGE LIMIT

Non-Proprietary Version

NOTE:

(1) All percentage values are calculated in percent of maximum span in lieu of less conservative maximum absolute URL or FS value.

(2) Refer to Section B for summary of Qualification exposure required (i.e. values of temperature, radiation, pressure, etc.) and details of Section D for Qualification Demonstrated.

(3) All test data available indicates an inaccuracy of less than XXX% even at total dose rate exposure up to XXX Mrads/hour. However, for dose rates above XXX Mrads/hour to XXX Mrads/hour, the inaccuracy is considered to be up to ± XXX% to reflect worst case error of XXX% error reported in Reference 60.

**Designated as LOCA "A" in the qualification plan, but intending to meet a high energy line break event which may include a LOCA event, but is expected to envelop all outside drywell and PWR containment events at a representative plant.

TABLE A11
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- INITIAL BASELINE

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

Non-Proprietary Version

TABLE A11
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- INITIAL BASELINE
(Continued)

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

Non-Proprietary Version

TABLE A12
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- FINAL BASELINE

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

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TABLE A12
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- FINAL BASELINE
(Continued)

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

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TABLE A13
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- INITIAL BASELINE

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILIT Y
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

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TABLE A13
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- INITIAL BASELINE
(Continued)

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

Non-Proprietary Version

TABLE A14
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY
ENGINEERING INFORMATION -- FINAL BASELINE

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

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TABLE A14
REPRESENTATIVE DATA FOR PG3200 TRANSMITTER REPEATABILITY ENGINEERING INFORMATION -- FINAL BASELINE
(Continued)

TRANSMITTER OUTPUT -- VOLTS

PRESSURE INPUT, %FS	S/N XXXXX			
1ST RUN	S/N XXXXX	LINEARITY	HYSTERESIS	REPEATABILITY
0	X.XXX	X.XXX%	X.XXX%	X.XXX%
20	X.XXX	X.XXX%	X.XXX%	X.XXX%
40	X.XXX	X.XXX%	X.XXX%	X.XXX%
60	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX	X.XXX%	X.XXX%	X.XXX%
100	X.XXX	X.XXX%	X.XXX%	X.XXX%
80	X.XXX			X.XXX%
60	X.XXX			X.XXX%
40	X.XXX			X.XXX%
20	X.XXX			X.XXX%
0	X.XXX			X.XXX%
2ND RUN				
0	X.XXX	X.XXX%	X.XXX%	
20	X.XXX	X.XXX%	X.XXX%	
40	X.XXX	X.XXX%	X.XXX%	
60	X.XXX	X.XXX%	X.XXX%	
80	X.XXX	X.XXX%	X.XXX%	
100	X.XXX	X.XXX%	X.XXX%	
80	X.XXX			
60	X.XXX			
40	X.XXX			
20	X.XXX			
0	X.XXX			

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TABLE A15
P3200 MODEL CODE DESIGNATIONS USED DURING SUPPLY OF NUCLEAR SAFETY-RELATED P3200 SERIES TRANSMITTERS

PD/PDH 3200 TRANSMITTER SERIES *(Supplementing Table A2)*
PD/PDH 3200 *AA-- BC-- DD-- EE-- XX*

AA	**=**	**RANGE CODES; same as in original units provided**
B	**=**	**PRESSURE PORTS; included:**
		-0 2000 PSI SWP with open ports
		-1 2000 PSI SWP with 316SS plugs
		-2 2000 PSI SWP with 316SS drain/vent valves
		-3 4000 PSI SWP with open ports
		-4 4000 PSI SWP with open ports
		-5 4000 PSI SWP with 316SS plugs
		-7 4000 PSI SWP with 316SS drain/vent valves
C	**=**	**ELECTRICAL TERMINATION; same as in original units**
DD	**=**	**PRESSURE RETAINING PARTS; included:**
		-12 316SS caps, 316SS plugs, 316SS diaphragms, C.S. bolts
		-22 316SS caps, 316SS plugs, 316SS diaphragms, 316SS bolts
EE	**=**	**ELECTRICAL ACCESSORIES; same as in original units provided**
XX	**=**	**MECHANICAL ACCESSORIES; included:**
		-N2 Seismic Mounting Bracket (same bracket)
		-B4 Seismic Mounting Bracket (same bracket)
		-59 Seismic Mounting Bracket (same bracket)

Non-Proprietary Version

PD/PDH 3218 TRANSMITTERS SERIES *(Supplementing Table A4)*
PD/PDH 3218 *AA-- BC-- DD-- EE-- XX-- YY*

AA	**=**	**RANGE CODES; same as in original units provided**
B	**=**	**CONNECTION SIZE; same as in original units provided**
C	**=**	**ELECTRICAL TERMINATION; same as in original units provided**
DD	**=**	**PRESSURE RETAINING PARTS; same as in original units provided**
EE	**=**	**ELECTRICAL ACCESSORIES; included**
		-36 MA123-3 Nuclear Junction Box
		-36 MA136N Nuclear Junction Box
XX	**=**	**MECHANICAL ACCESSORIES; included**
		-N3 Seismic Mounting Bracket (same bracket)
		-B5 Seismic Mounting Bracket (same bracket)
		-56 Seismic Mounting Bracket (same bracket)
		-99 Seismic Mounting Bracket (same bracket)
YY	**=**	**CAPILLARY LENGTH; same as original unit**

TABLE A15
(Continued)
P3200 MODEL CODE DESIGNATIONS USED DURING SUPPLY OF NUCLEAR SAFETY-RELATED P3200 SERIES TRANSMITTERS

PG 3200 TRANSMITTER SERIES ***(Supplementing Table A8)***
PG 3200 ***AA-- BC-- DD-- EE-- XX***

AA	**=**	**RANGE CODES; same as in original units provided**
B	**=**	**PRESSURE PORTS; included:**
		-4 open ports
		-7 open ports
		-8 with Swagelok (welded)
C	**=**	**ELECTRICAL TERMINATION; same as in original units**
DD	**=**	**PRESSURE RETAINING PARTS; included:**
		-12 316SS caps, 316SS plugs, 316SS diaphragms, C.S. bolts
		-22 316SS caps, 316SS plugs, 316SS diaphragms, 316SS bolts
EE	**=**	**ELECTRICAL ACCESSORIES; same as in original units provided**
XX	**=**	**MECHANICAL ACCESSORIES; included:**
		-N1 Seismic Mounting Bracket (same bracket)
		-B6 Seismic Mounting Bracket (same bracket)
		-60 Seismic Mounting Bracket (same bracket)

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TABLE A16
THE SEQUENCE OF SAFE SHUTDOWN EARTHQUAKE (SSE) TESTING FOR ALL TRANSMITTER MODELS

PLOT	MODEL	SERIAL NUMBER	HORIZONTAL OR VERTICAL SPECTRUM	AXIS
1	PD 3218	XXXXX	H	X-Y
2			V	X-Y
3			H	X-Z
4			V	X-Z
5	PD 3218	XXXXX	H	X-Z
6			V	X-Z
7			H	X-Y
8			V	X-Y
9	PG 3200	XXXXX, XXXXX XXXXX, XXXXX	V	Y-Z
10			H	Y-Z
11			H	X-Y
12			V	X-Y
13	PD 3200	SET 2A XXXXX, XXXXX XXXXX, XXXXX	H	X-Y
14			V	X-Y
15			H	Y-Z
16			V	Y-Z
(CHANGE BRACKETS)				
17	PD 3200	SET 2B XXXXX, XXXXX XXXXX, XXXXX	H	Y-Z
18			V	Y-Z
19			V	X-Y
20			H	X-Y

The Operating Base Earthquake (OBE) testing for Model # PG 3200 was listed as SET #1 (as opposed to individual serial numbers). Set #1 included Serial Numbers XXXXX, XXXXX, XXXXX, and XXXXX.

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REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

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SECTION A

FIGURES

FIGURE A1
PD 3200 & PDH 3200 CROSS-SECTION

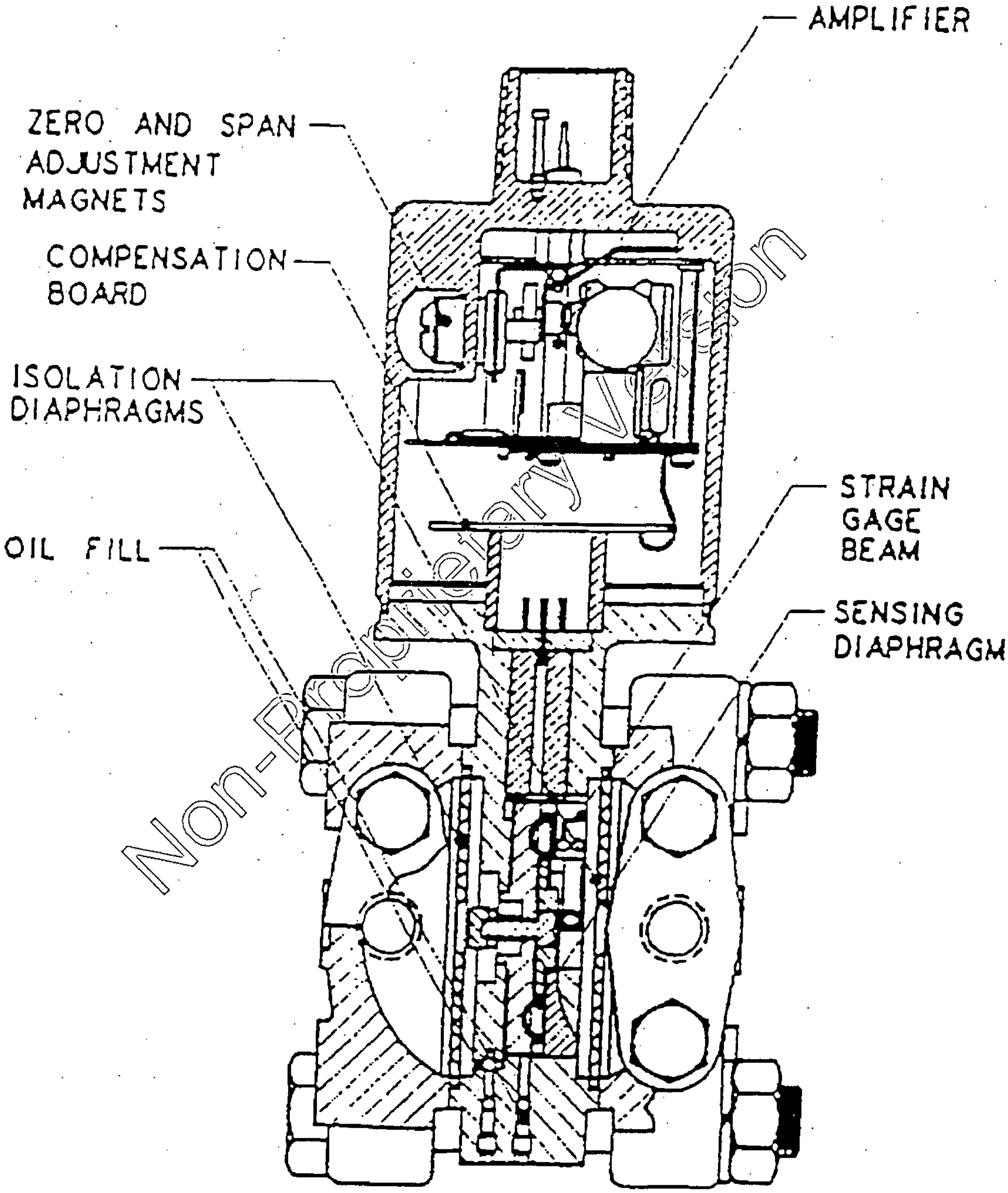

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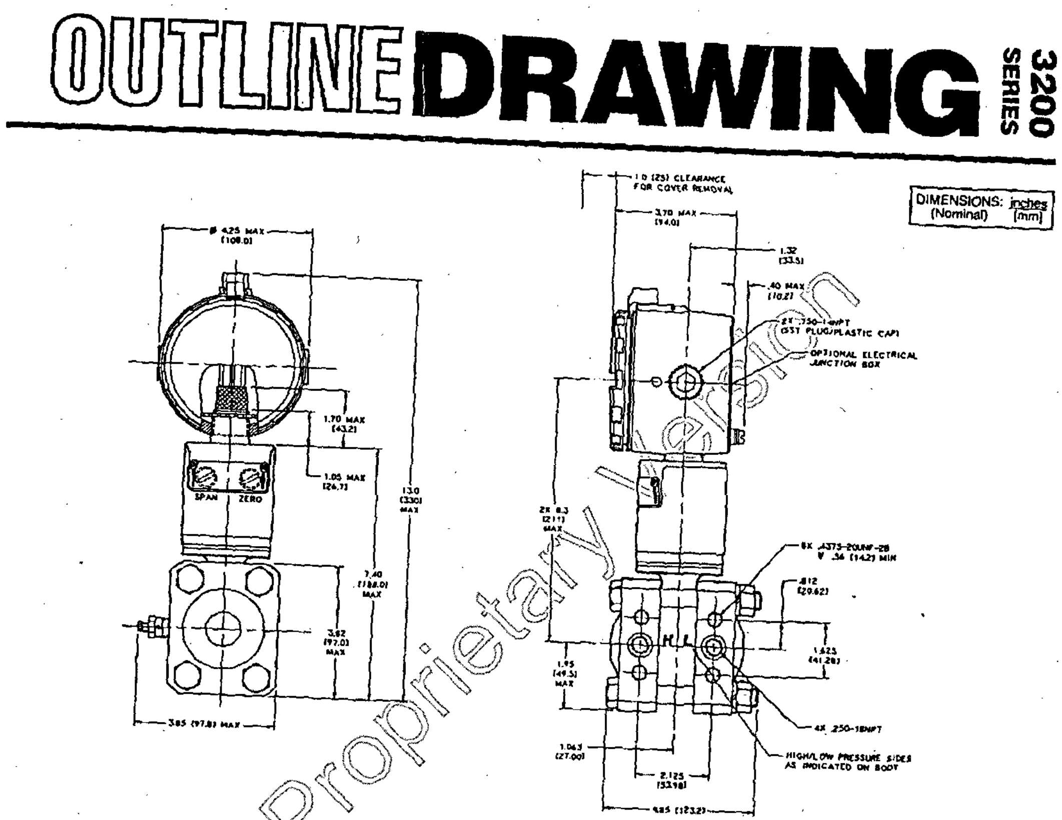
FIGURE A2
PD 3200 & PDH 3200 TYPICAL OUTLINE



Non-Proprietary Version

FIGURE A3
PD/PDH 3200, PD/PDH 3218, DR 3200 & PG 3200
FIELD CALIBRATION

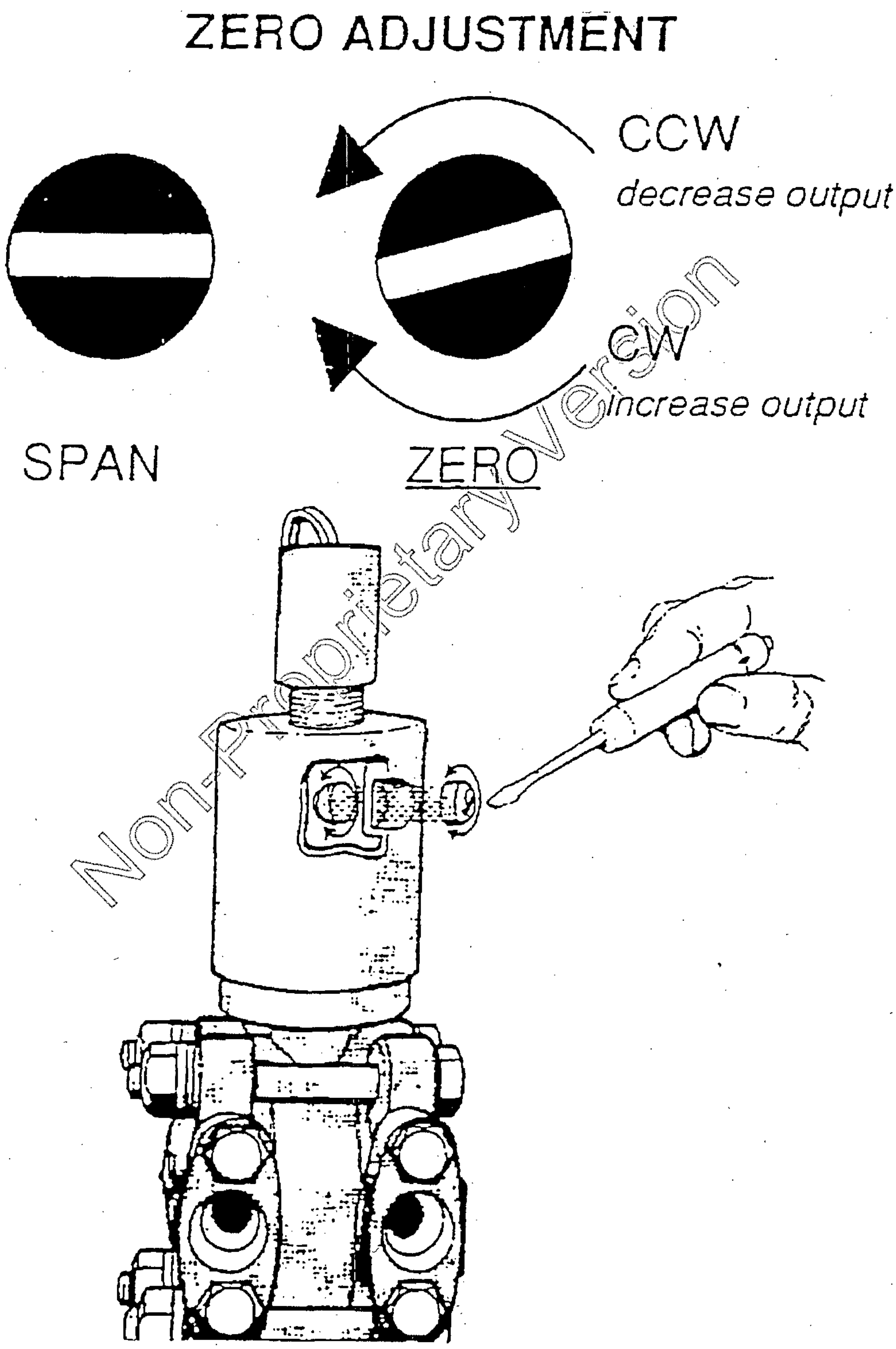


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FIGURE A4A
STRAIN GAGE WHEATSTONE BRIDGE CONFIGURATION

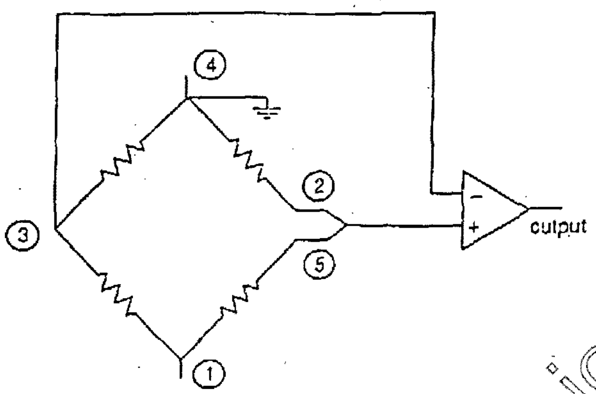

FIGURE A4B
TRANSMITTER CIRCUITRY

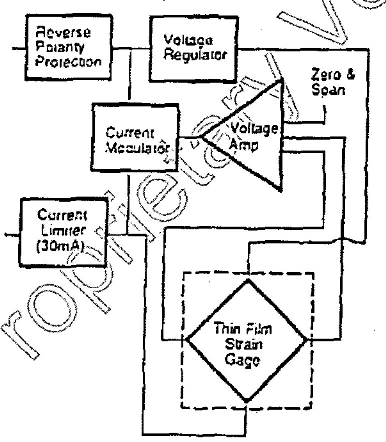

FIGURE A4C
BEAM SENSOR AND DIAPHRAGM CONFIGURATION

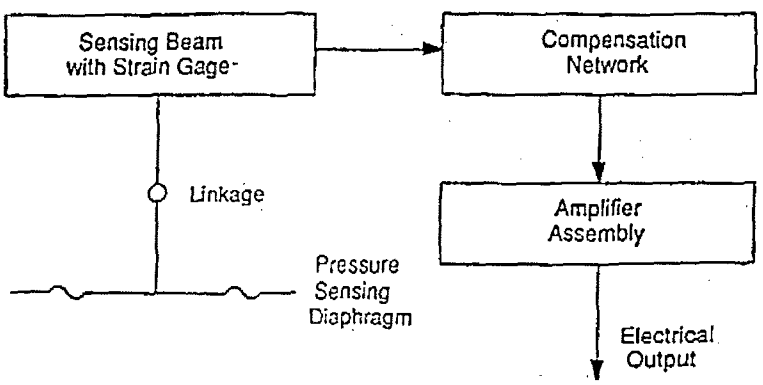

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FIGURE A5A
PD/PDH 3200 WITH BOLT-ON PRESSURE FLANGES

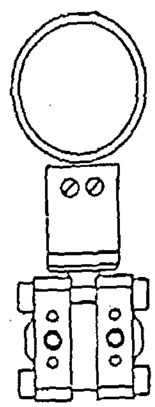

FIGURE A5B
PD/PDH 3200 WITH PRESSURE FLANGES REMOVED

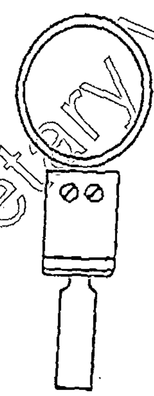

FIGURE A5C
PD/PDH 3218 WITH CAPILLARY/REMOTE DIAPHRAGM
ATTACHED TO ELECTRONIC TRANSMITTER

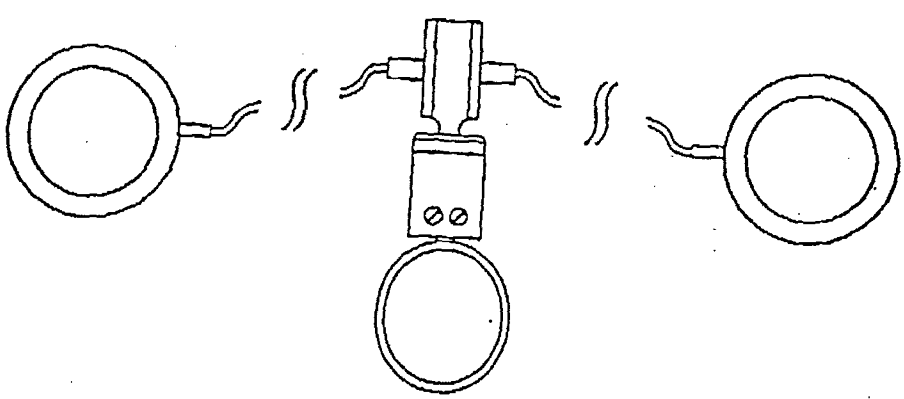

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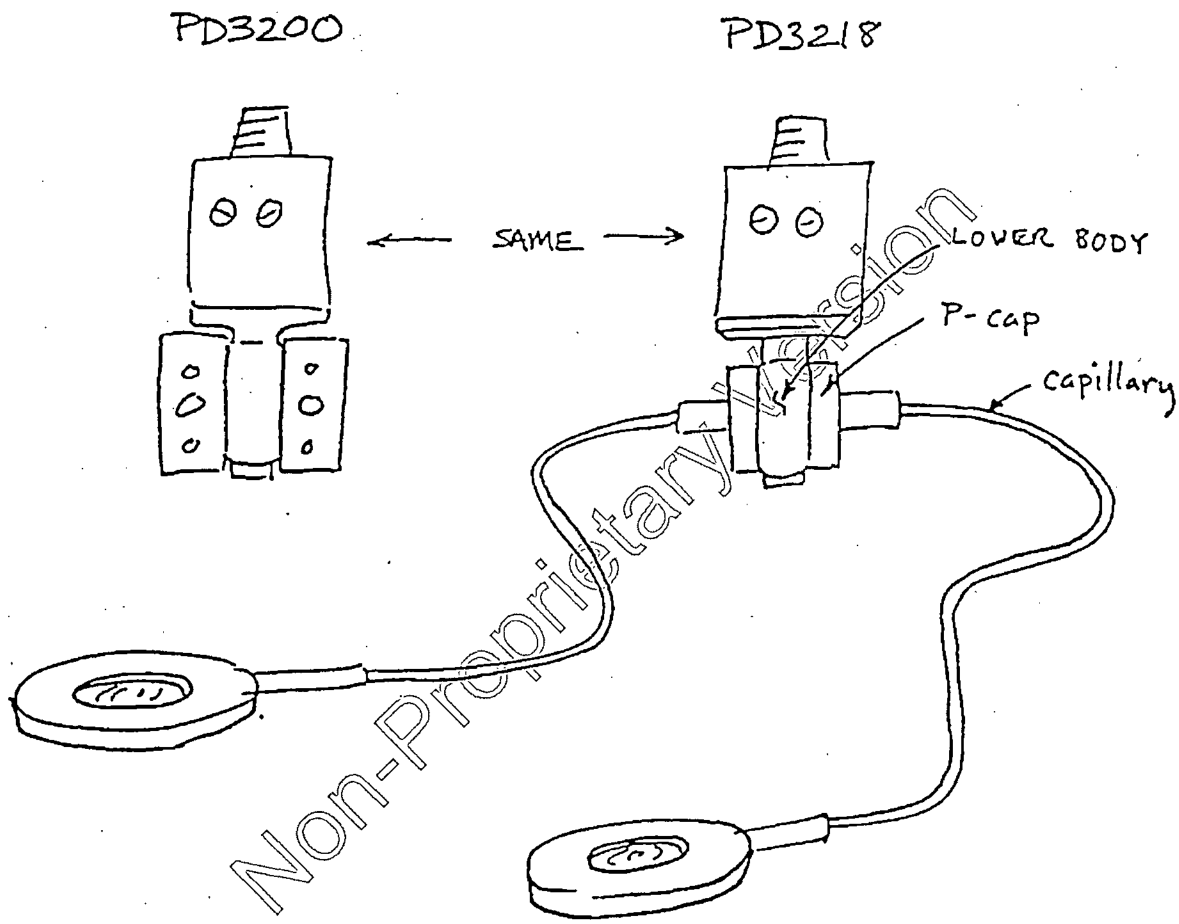
FIGURE A5D
EQUIVALENCY/SIMILARITY BETWEEN THE PD/PDH 3218
& PD/PDH 3200 TRANSMITTERS



Non-Proprietary Version

FIGURE A6
PD/PDH 3218 TYPICAL OUTLINE

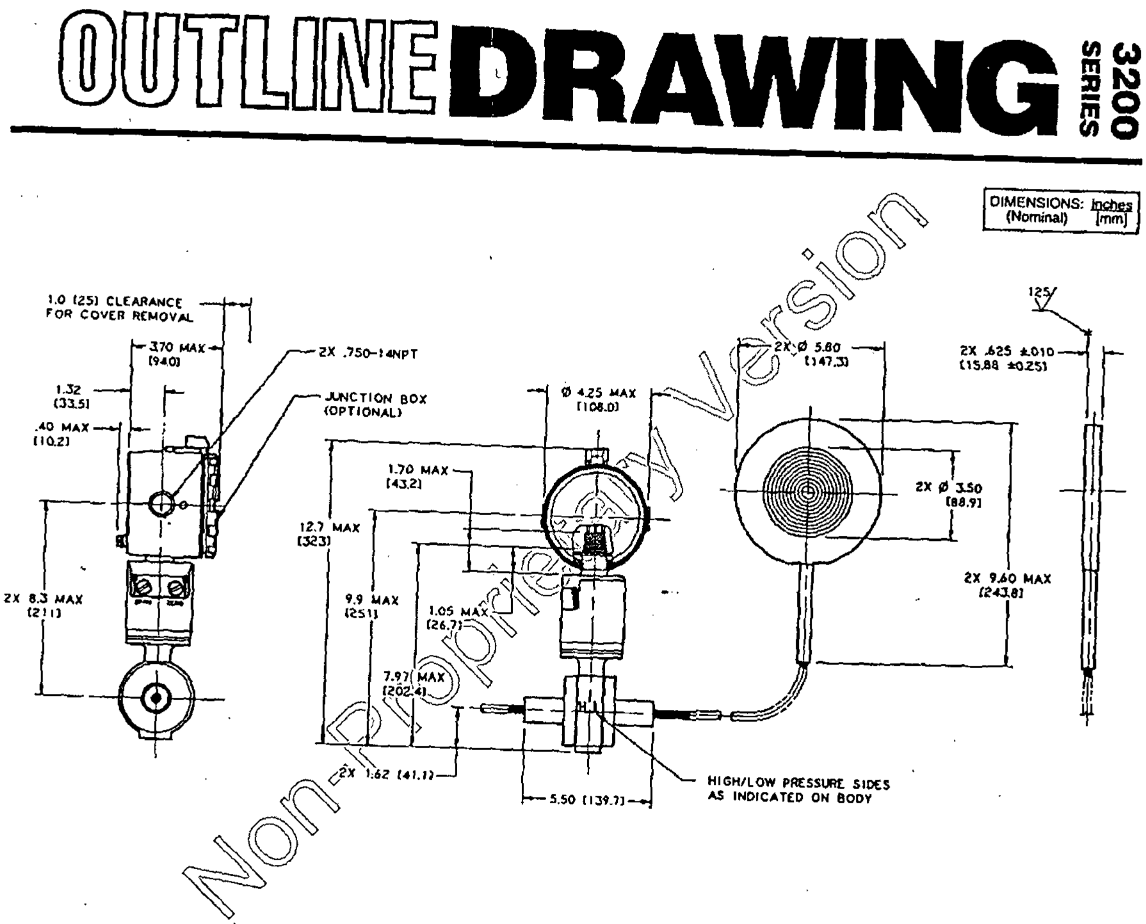


FIGURE A7
DR 3200 CROSS-SECTION

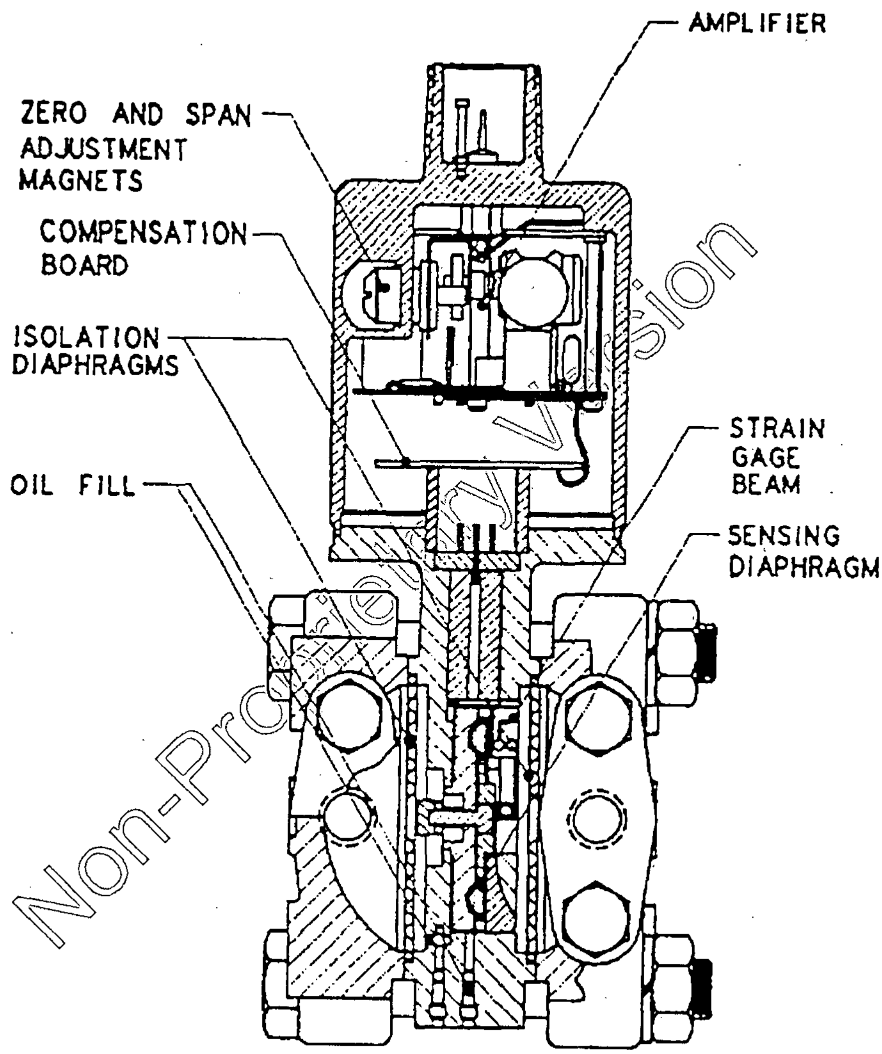


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FIGURE A8
DR 3200 TYPICAL OUTLINE

OUTLINE DRAWING 3200 SERIES

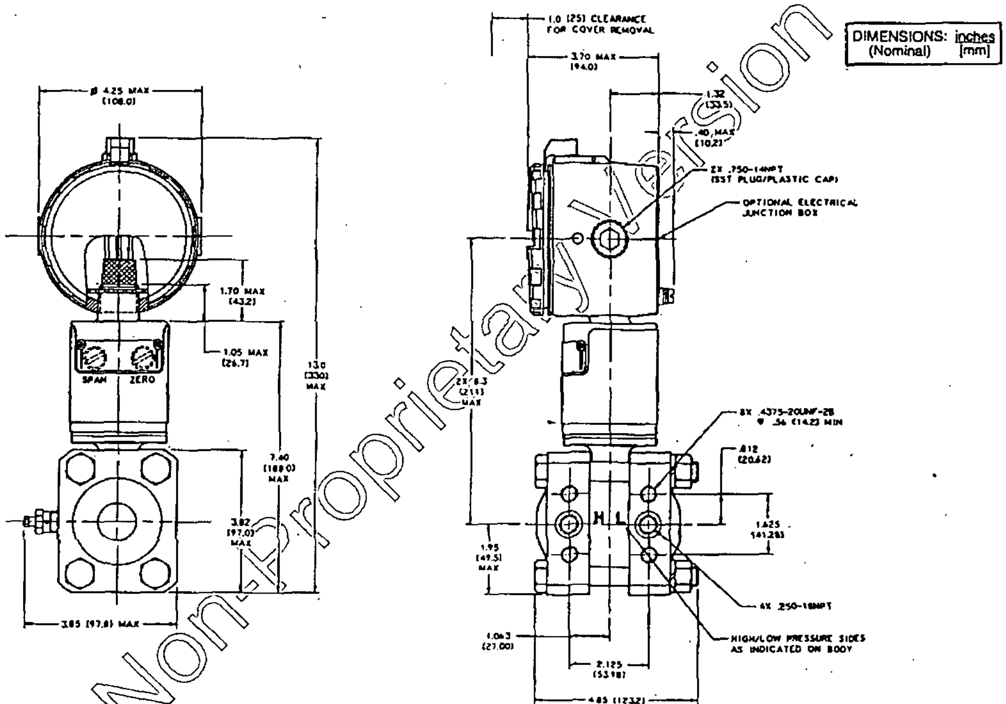

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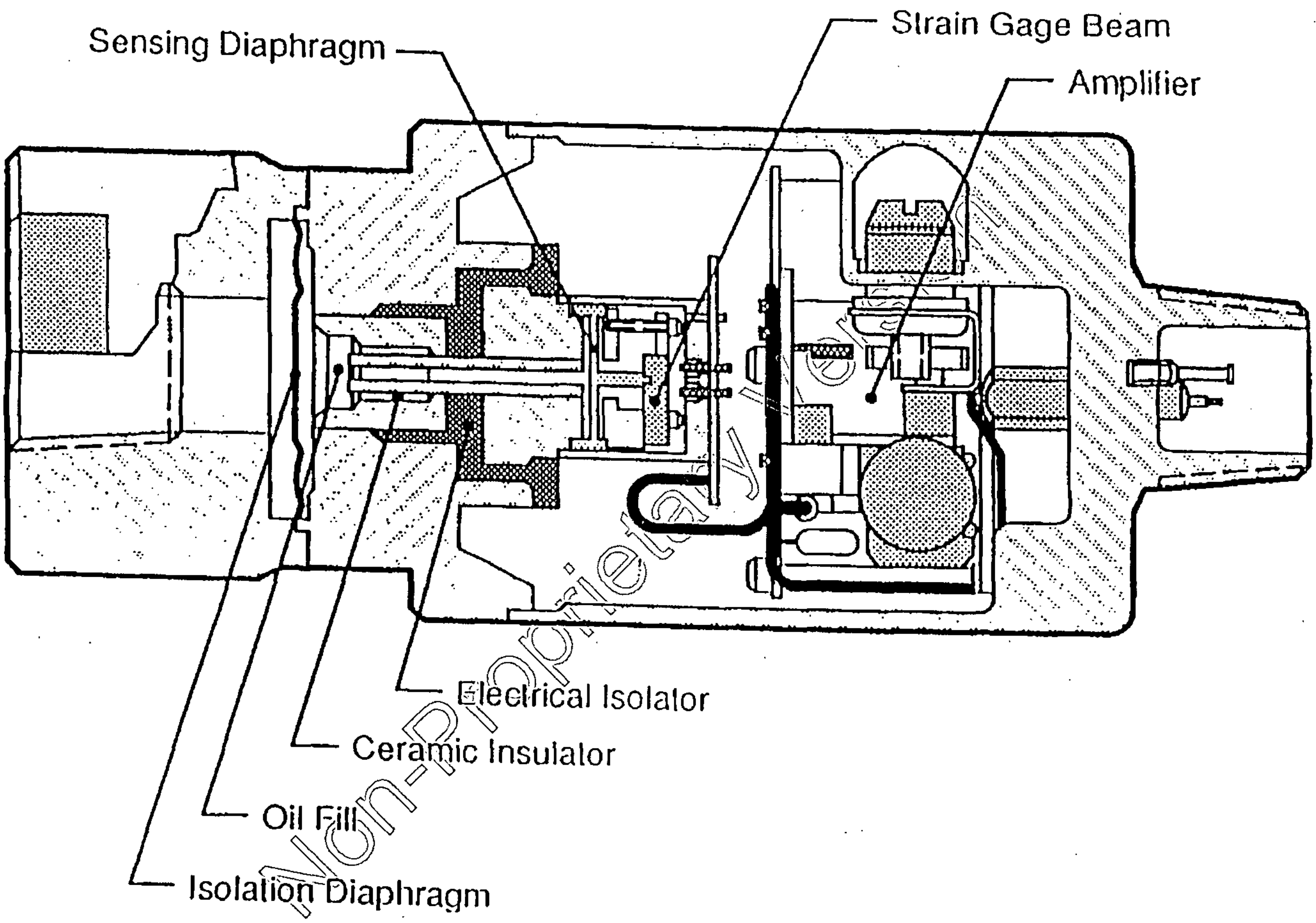
FIGURE A9
PG 3200 CROSS-SECTION

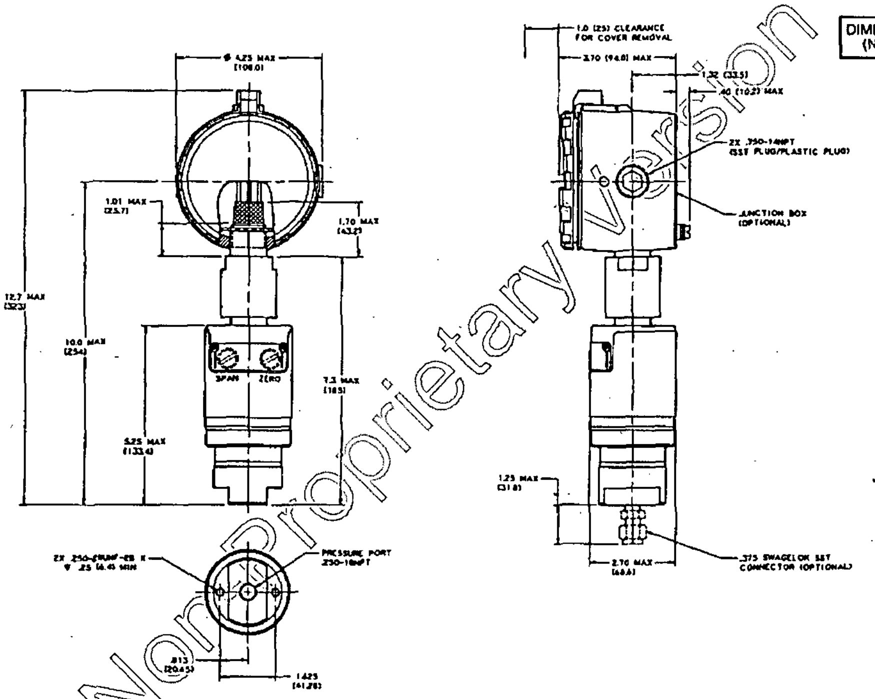


Non-Proprietary Version

FIGURE A10
PG 3200 TYPICAL OUTLINE

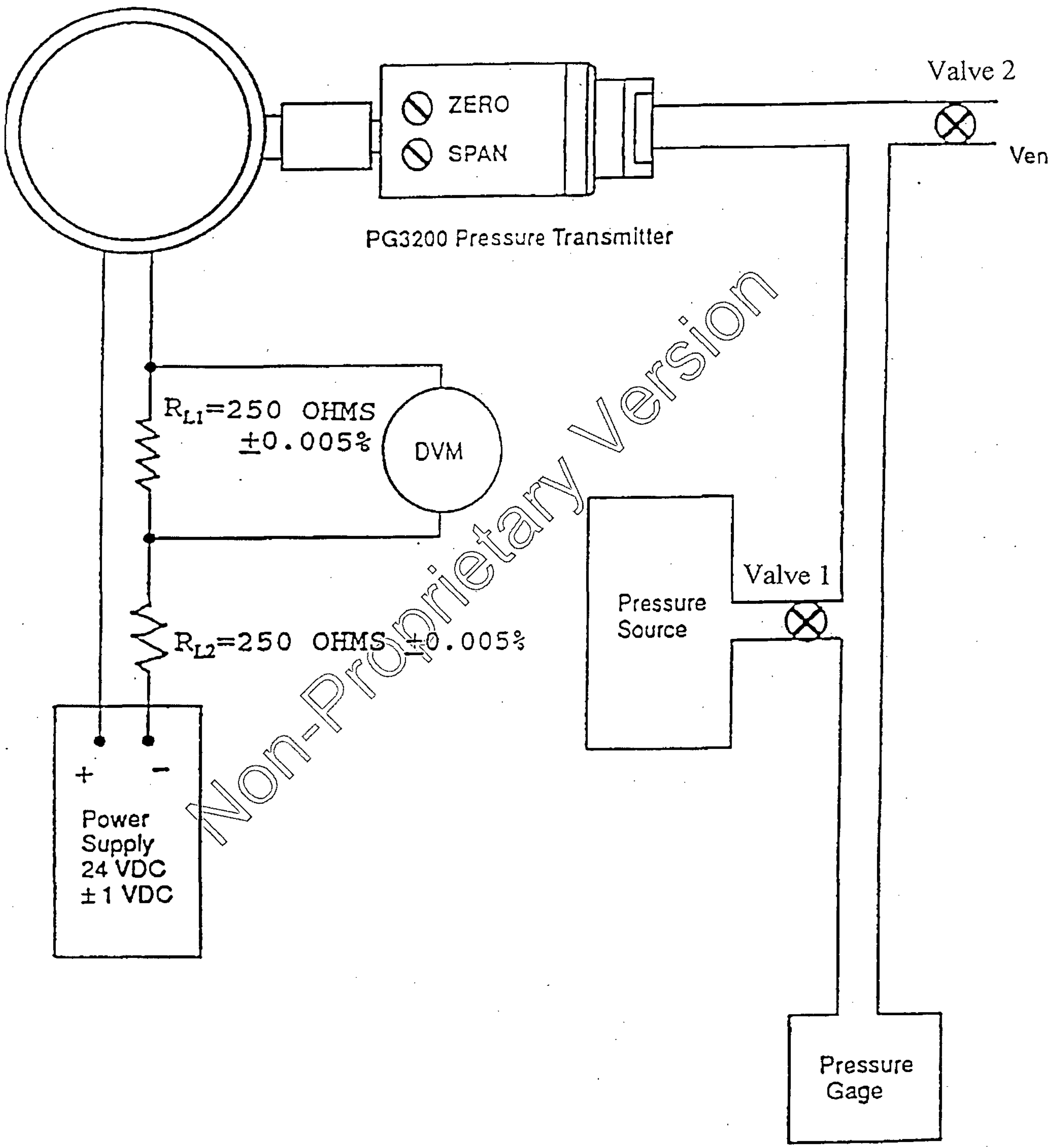
OUTLINE DRAWING 3200 SERIES

DIMENSIONS: Inches (Nominal) (mm)



Non-Proprietary Version

FIGURE A11
PG 3200 FUNCTIONAL TEST SET-UP



Non-Proprietary Version

FIGURE A12
FUNCTIONAL TEST DATA RECORDING SHEET

PRESSURE (%FS)	PSID	TRANSMITTER OUTPUT (V)	IDEAL LINE MID-POINT	NON-LINEARITY (V)	LINEARITY ERROR (%FS)	HYSTERESIS (V)	HYSTERESIS ERROR (%FS)
(0%)		1					
(50%)		2	7	8 V	9 %FS		
(100%)		3					
(50%)		4				10 V	%FS
(0%)		5					
FULL SCALE SENSITIVITY (FS)		6					

DATE: ______________ TEMPERATURE: ______________ °F

MODEL: ______________

SERIAL NO: ______________

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FIGURE A13
DIFFERENTIAL PRESSURE TRANSMITTER FUNCTIONAL TEST SET-UP

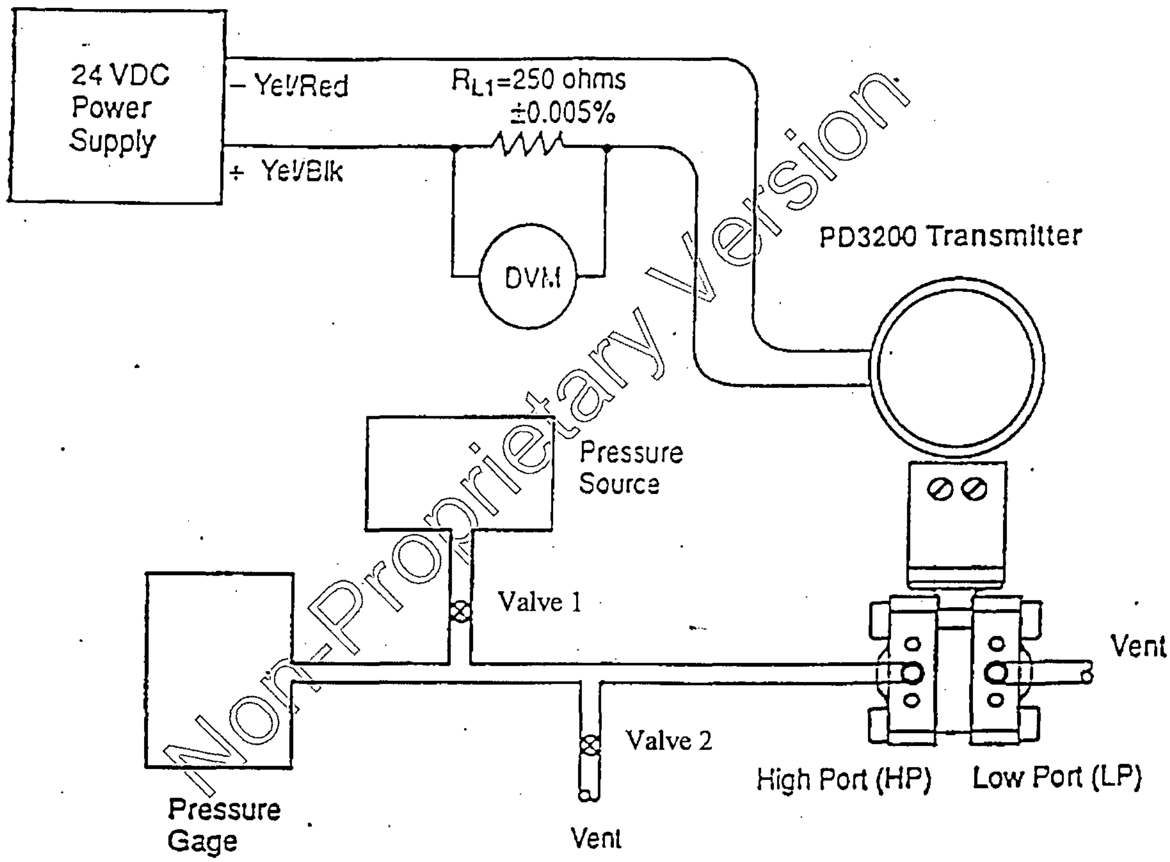

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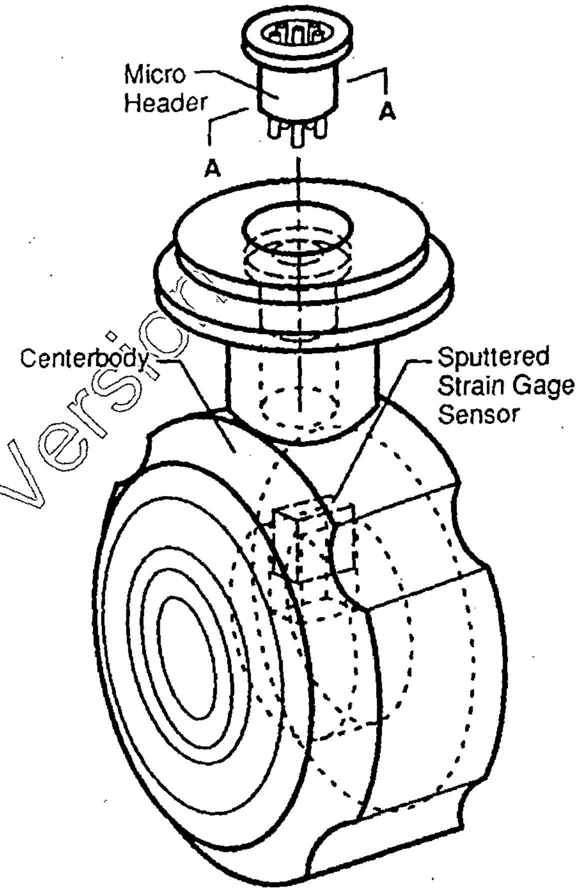
FIGURE A14
MODIFICATION TO PRECLUDE OIL LOSS SYNDROME IN TRANSMITTER

TRANSMITTER CENTERBODY AND HEADER ASSEMBLY ILLUSTRATION



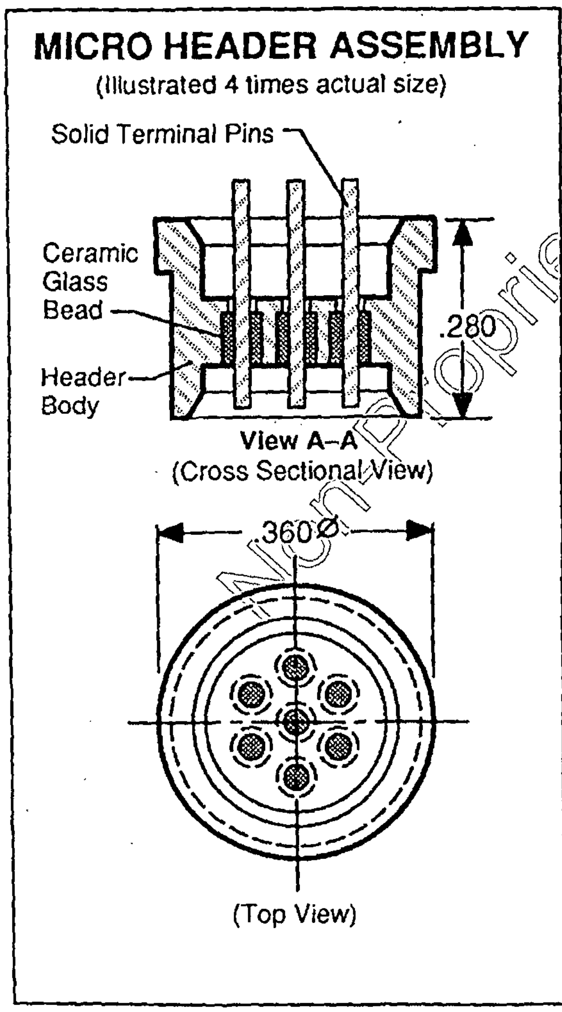


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FIGURE A15
REMOTE DIAPHRAGM DIFFERENTIAL PRESSURE TRANSMITTER FUNCTIONAL TEST SET-UP

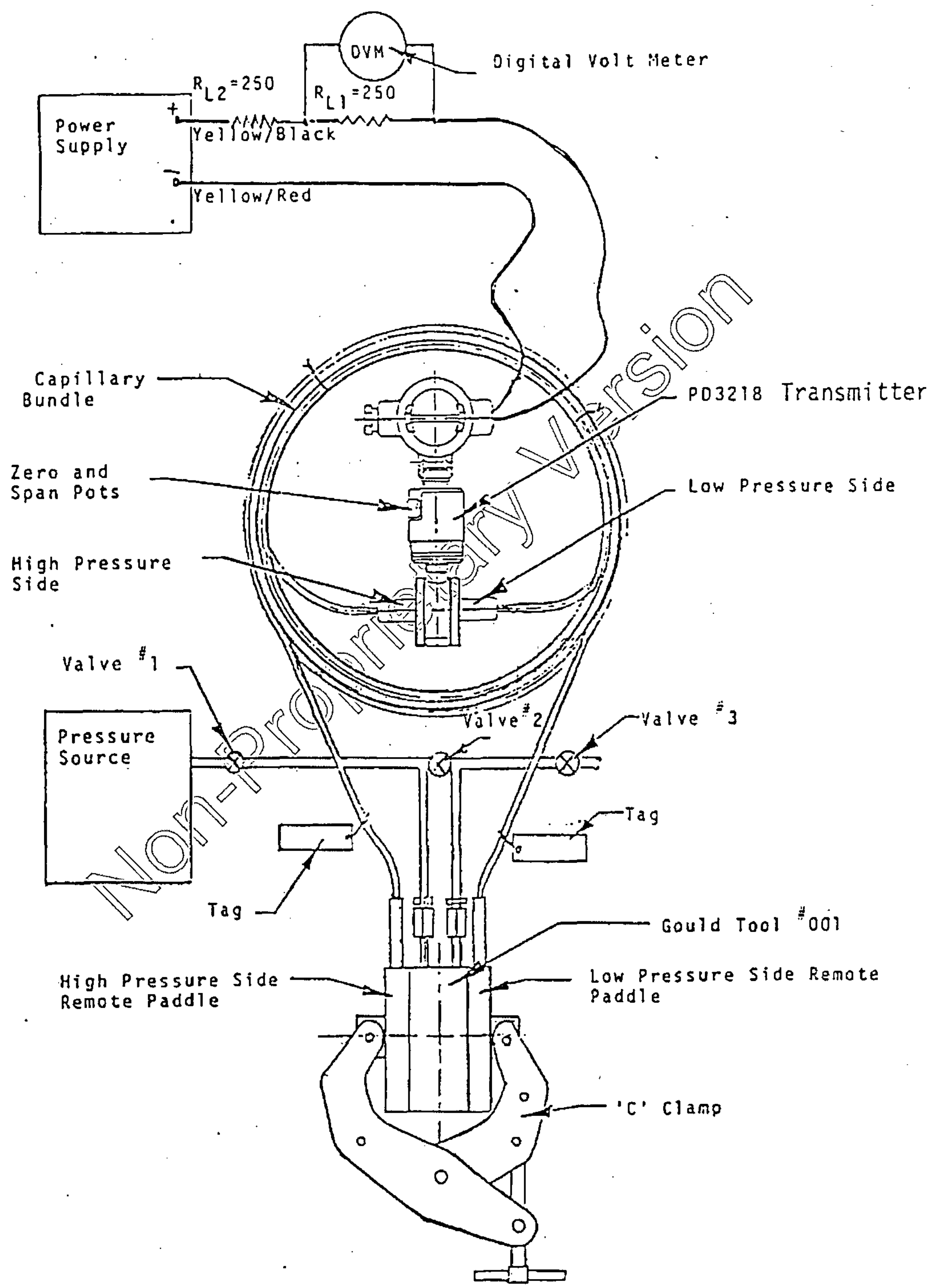

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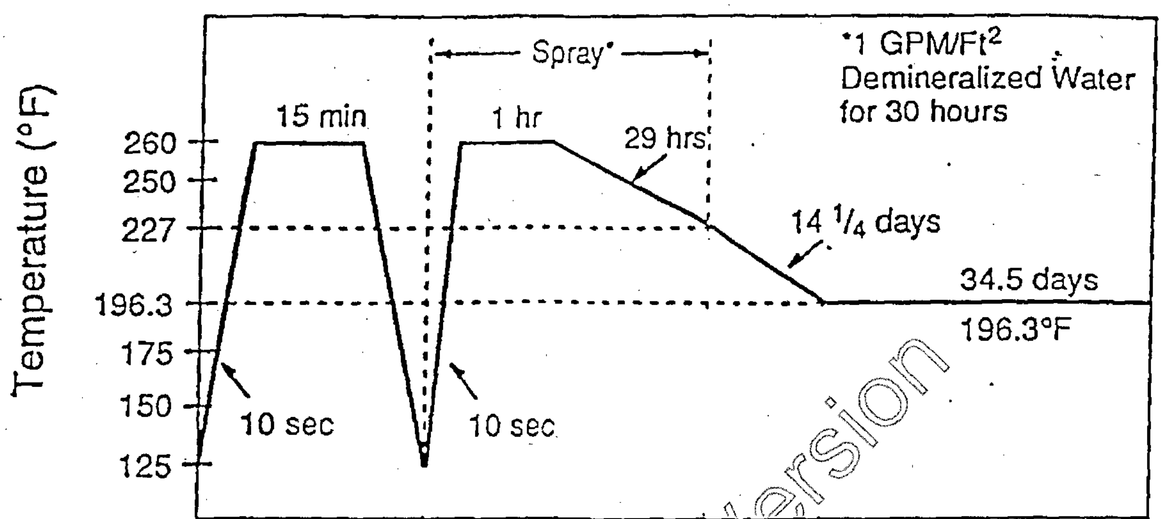
FIGURE A16
HELB-LOCA "A" TEMPERATURE PROFILE AND ACTUAL EXPOSURE*



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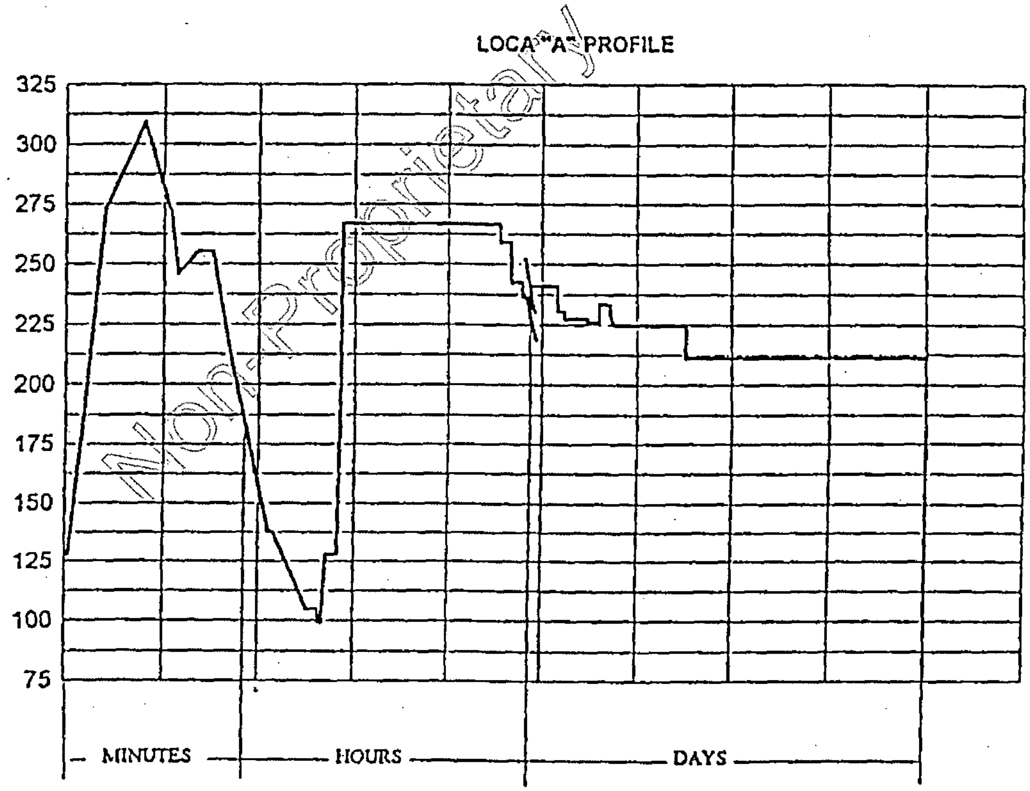

**Details are discussed in Section D, subsection DT - Parameter Temperature.*

FIGURE A17
HELB-INDUCED ERROR (DEVIATION)* FOR PG 3200-100, S/N XXXXX and XXXXX

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PROPRIETARY DATA
FIGURE REMOVED

**The error or deviation reflects change from before exposure values measured at 125°C.*

FIGURE A18
HELB-INDUCED ERROR (DEVIATION)* FOR PD 3200-200, S/N XXXXX

Non-Proprietary Version

PROPRIETARY DATA
FIGURE REMOVED

**The error or deviation reflects change from before exposure values measured at 125°C.*

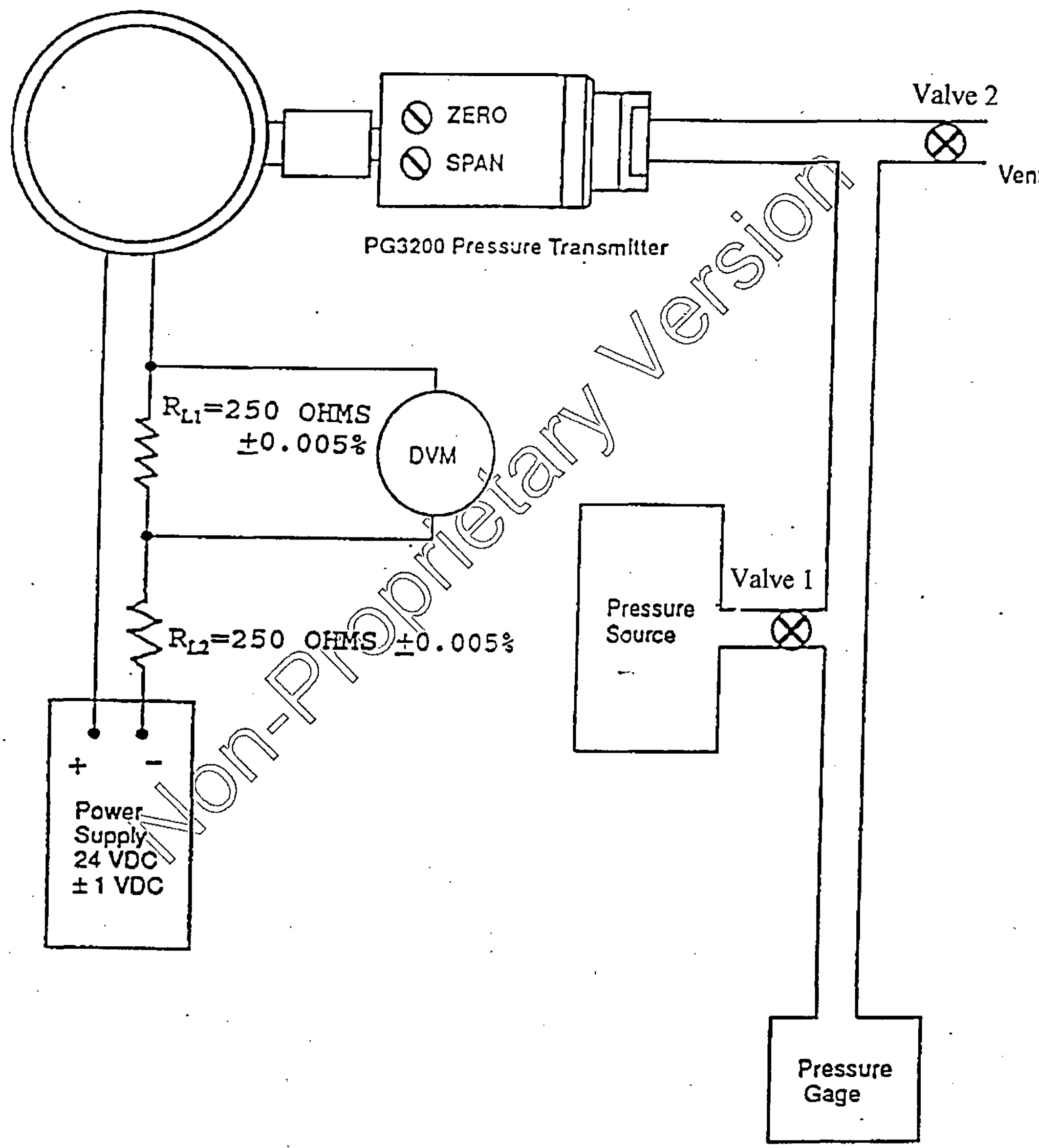
FIGURE A19
HELB-INDUCED ERROR (DEVIATION)* FOR PD 3200-200, S/N XXXXX

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

The error or deviation reflects change from before exposure values measured at 125°C.

FIGURE A20
PG 3200 LOAD EFFECTS TEST



Non-Proprietary Version

FIGURE A21
DIFFERENTIAL PRESSURE TRANSMITTER LOAD EFFECTS TEST

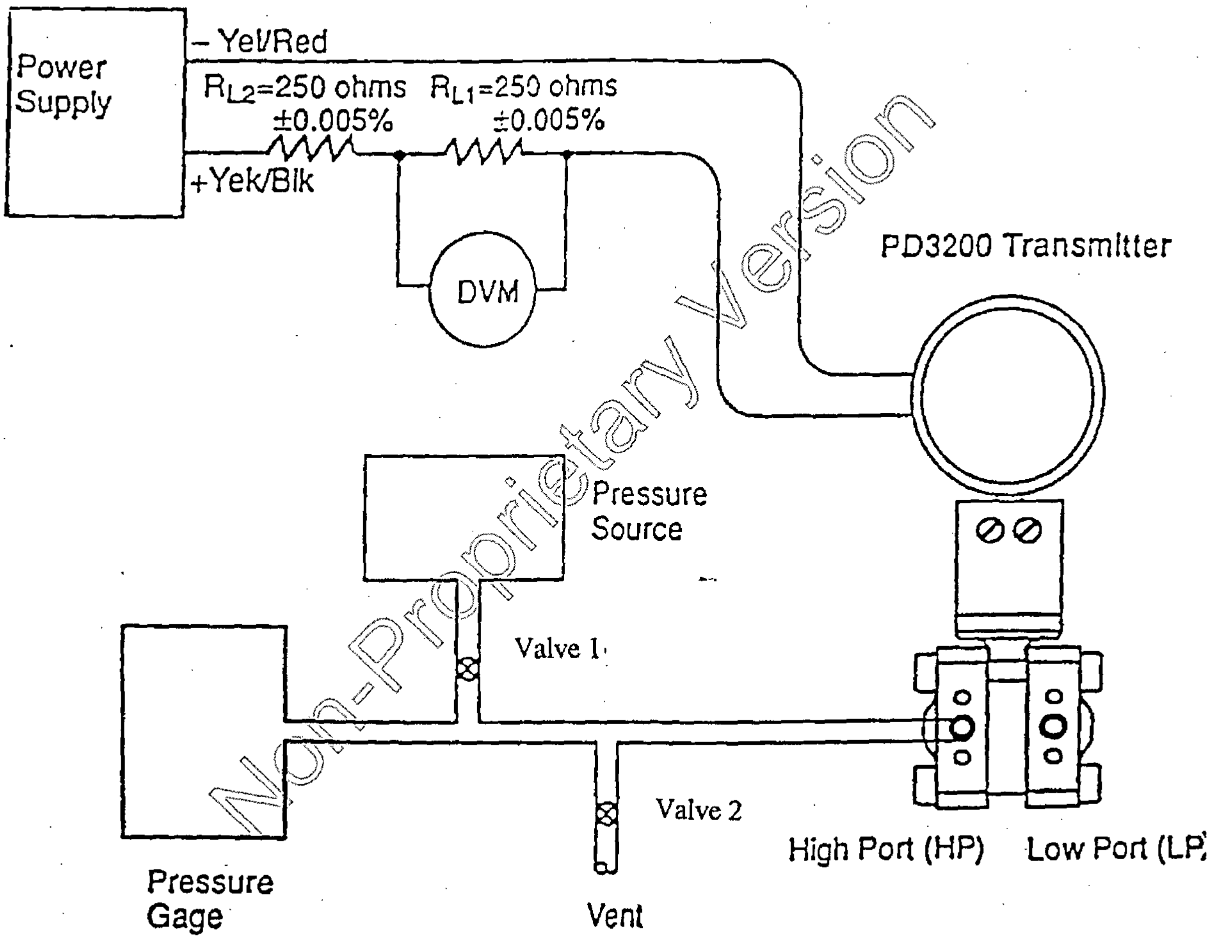
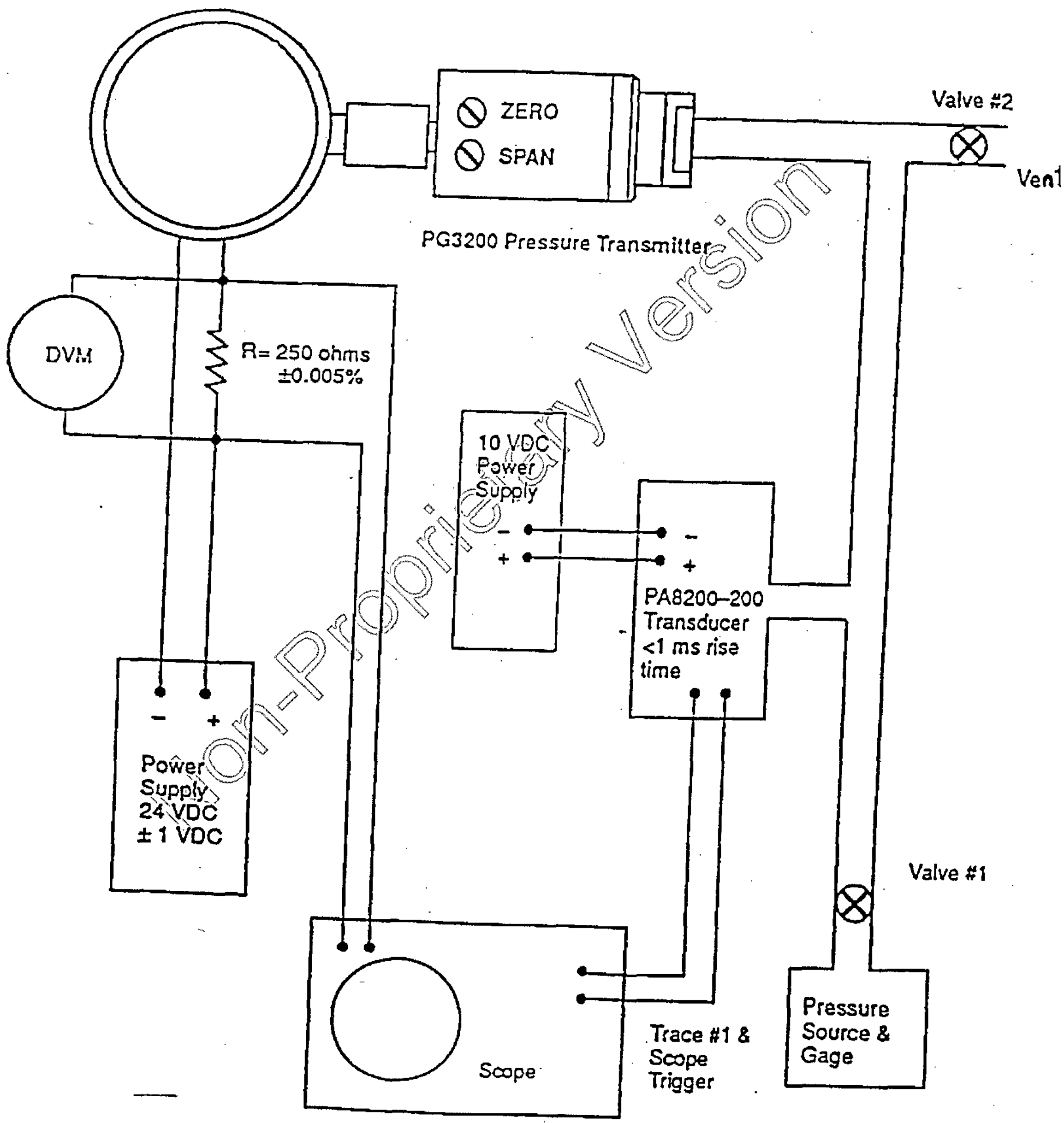


FIGURE A22
PG 3200 TIME-CONSTANT TEST SET-UP



Non-Proprietary Version

FIGURE A23
DIFFERENTIAL PRESSURE TRANSMITTER
TIME-CONSTANT TEST SET-UP

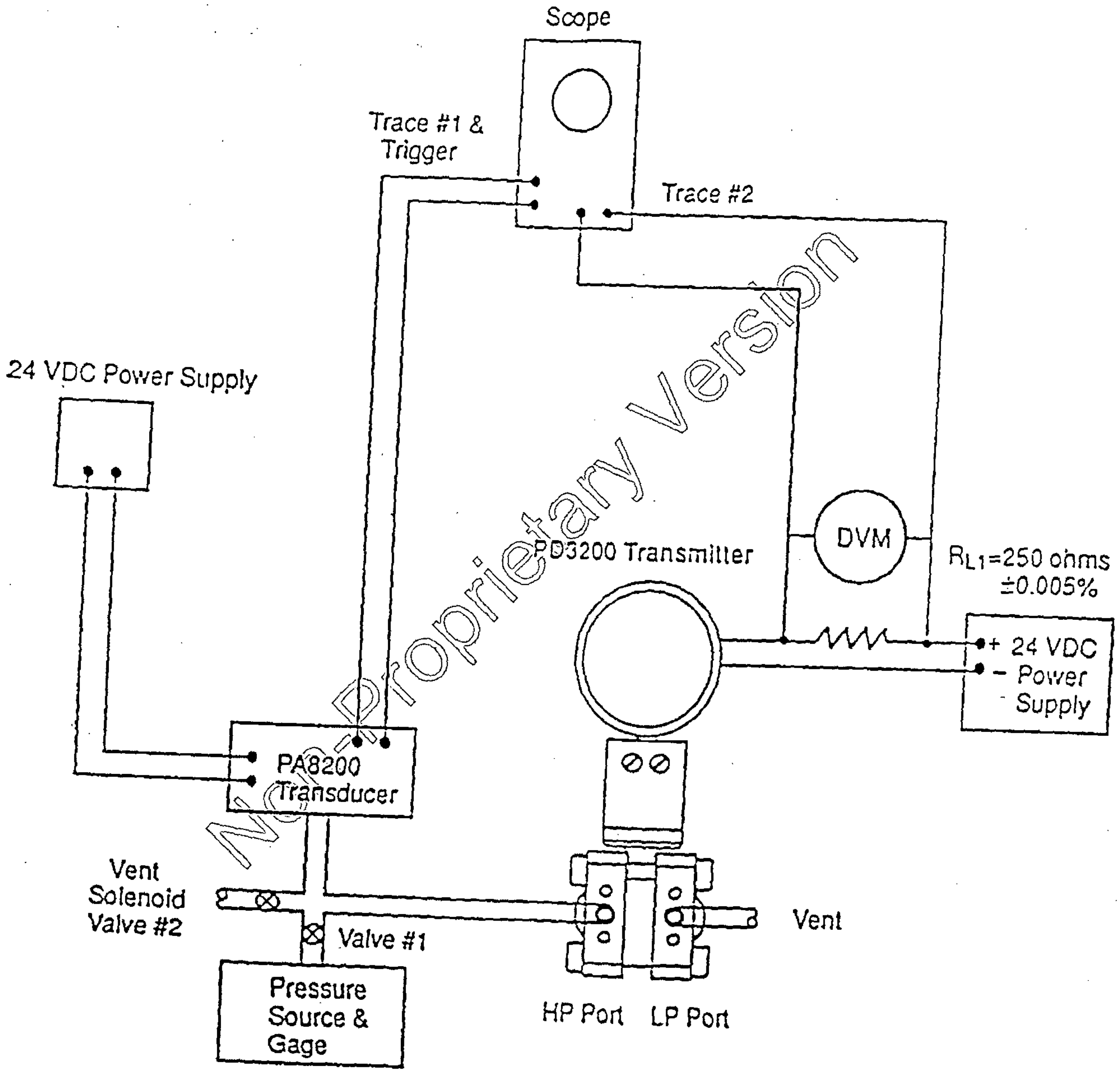


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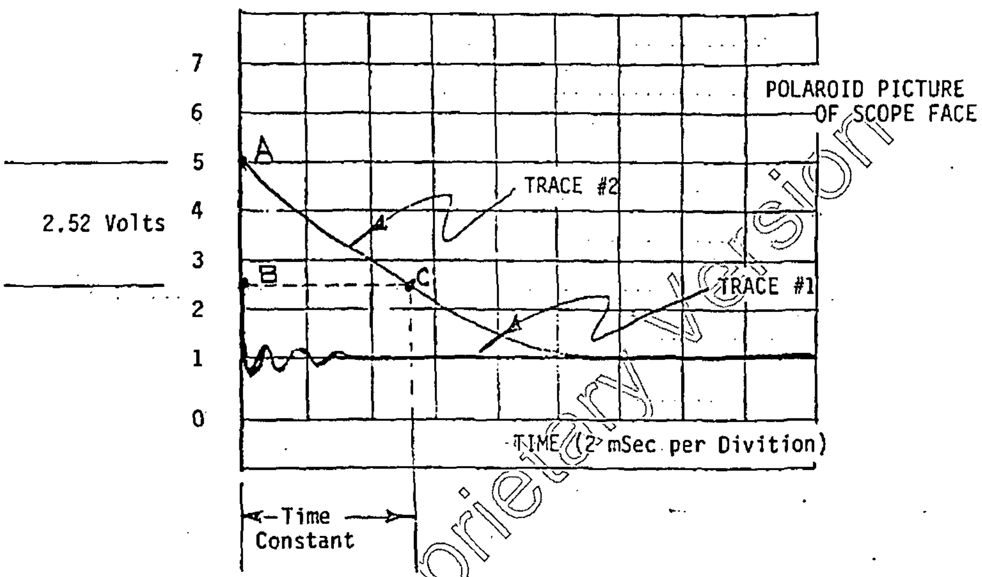
FIGURE A24
REPRESENTATION OF TIME-CONSTANT PLOTTING METHOD

Calculate 0 to 63% time constant as follows:



A. Subtract 2.52 volts from Point A pictured above (i.e. 2.52 divisions). This point is pictured as Point B above.

B. Draw line parallel to the horizontal division lines and find the intersection of that line and Tract number 2. This intersection is Point C.

C. Count the number of divisions between Point B and Point C and multiply this number of 2 mSec/division to obtain 0 to 63% time constant for the test transmitter.

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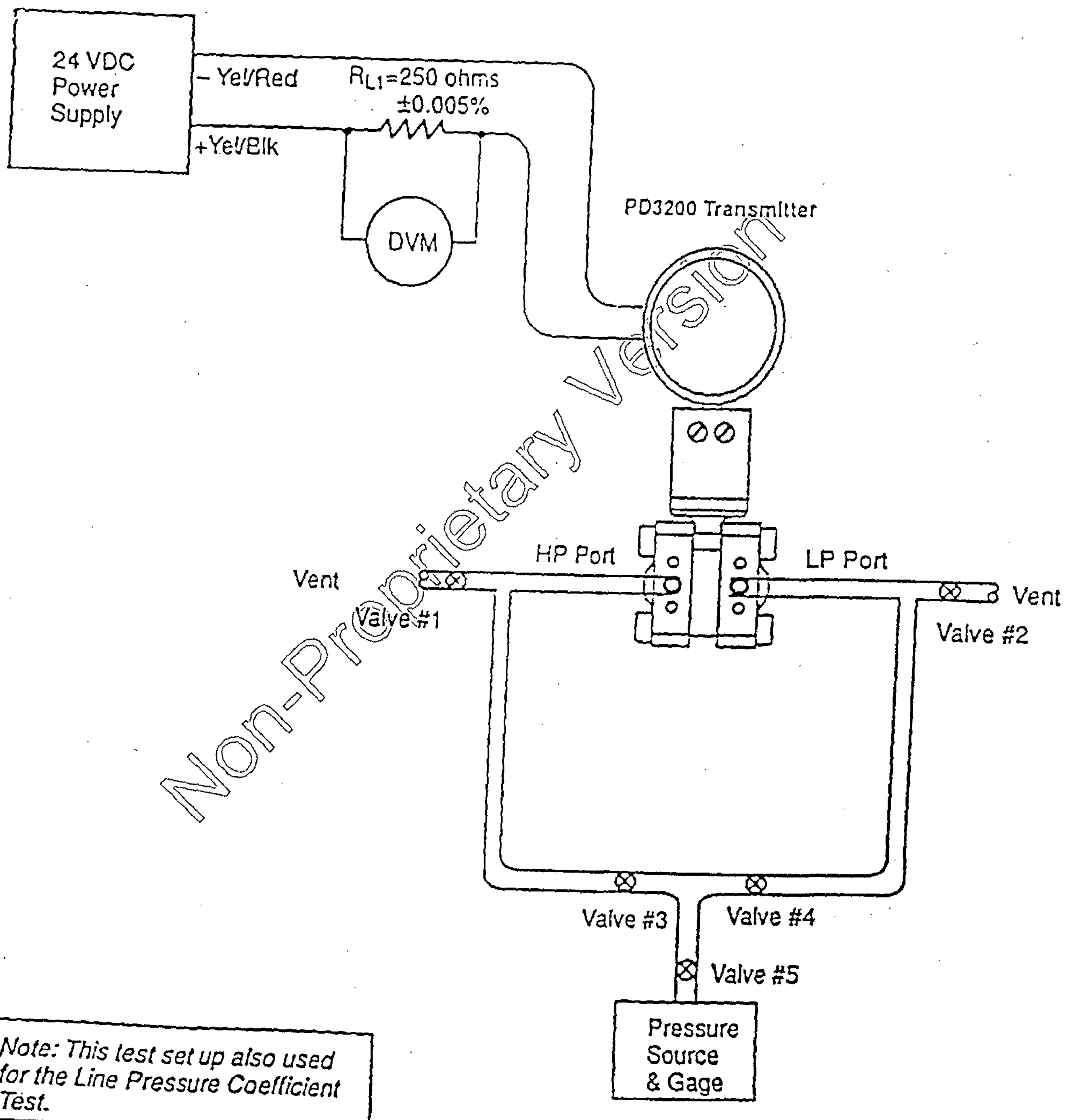
FIGURE A25
ACTUAL POST-RADIATION TIME-CONSTANT RESULTS

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE A26
REPRESENTATIVE OVERLOAD, LINE PRESSURE COEFFICIENT (LPC)
& HYDROSTATIC TEST SET-UP



Non-Proprietary Version

Note: This test set up also used for the Line Pressure Coefficient Test.

FIGURE A27
LOW INSULATION RESISTANCE LEAKAGE PATHS RESULTING IN INSTRUMENT INACCURACY

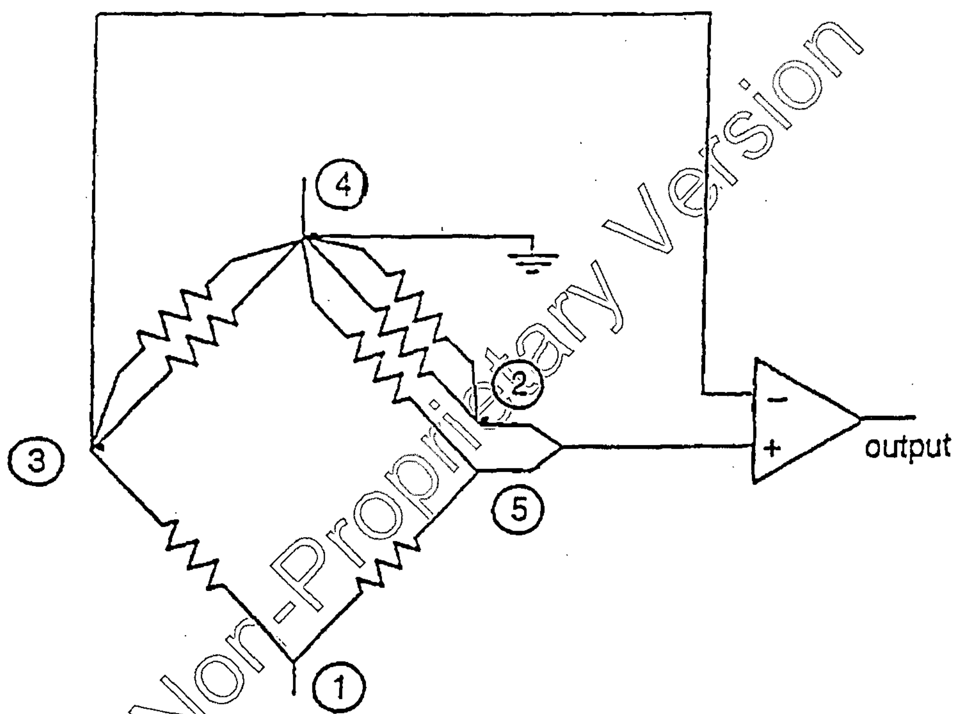


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FIGURE A28
INSULATION RESISTANCE VERSUS BEAM ERROR

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE A29
VALIDATION TEST CONFIRMING CONTINUED HIGH INSULATION RESISTANCE FOR STRAIN GAGE BEAMS

PROPRIETARY DATA
FIGURE REMOVED

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FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

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SECTION B

ENVIRONMENTAL QUALIFICATION, VIBRATION & SEISMIC QUALIFICATION REQUIREMENTS DEFINITION AND SUMMARY

This Qualification Documentation Review Section provides the definition of Environmental, Vibration and Seismic requirements established by Gulton-Statham for conservative enveloping of the majority of plant locations for the use of PD/PDH 3200, PD/PDH 3218, PG 3200 and DR 3200 Transmitters.

The service conditions considered in the environmental qualification of equipment within the scope of 10CFR50.49, include both normal conditions (as it relates to potential age degradation) and Design Basis Accident conditions. "Normal Conditions" are defined as "Those plant conditions that are expected to occur regularly, including anticipated operational occurrences (e.g. loss of off-site power), for which plant equipment is expected to perform the safety functions on a continuous and steady state basis."

The term "Abnormal Conditions" is sometimes used to include deviations from Normal Conditions anticipated to occur often enough at which plate equipment is designed to operate for a period of time without operational impairment and without exceeding the specified design limits. This is in fact the conditions enveloped by "Anticipated Operational Occurrences."

"Design Basis Accident Conditions" refers to an operating limit to which the equipment may be subjected without impairment of its safety functions and operational characteristics.

This Section defines the worst case parameters for qualification during normal and accident conditions. The traditional eight (8) parameters of the IEB 79-01B format of operating time, temperature, pressure, relative humidity, chemical spray, radiation, submergence and aging are individually analyzed in Sections DO, DT, DP, DH, DC, DR, DS, and DA, respectively.

Note: Parameters such as aging (or defined qualified life) are derived from specific plant conditions, (e.g. ambient temperature) such that plots of various life or aging conditions are presented in Section DA

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TABLE B1
QUALIFICATION PARAMETER SUMMARY

PARAMETER DESCRIPTION	REQUIREMENT MET	SECTION
POST-ACCIDENT OPERATING TIME	≥360 DAYS	DO
ACCIDENT TEMPERATURE	SEE FIGURE B1 (LOCA "A")	DT
ACCIDENT PRESSURE	SEE FIGURE B1 (LOCA "A")	DP
ACCIDENT HUMIDITY	100%	DH
CHEMICAL SPRAY	WATER SPRAY	DC
RADIATION	≥2E07 RADS	DR
SUBMERGENCE	POST-ACCIDENT SUBMERGENCE	DS
AGING	≥20 YEARS @ 100°F	DA
VIBRATORY QUALIFICATION SEISMIC SRV	 FIGURE B2 FIGURE B3	 A A

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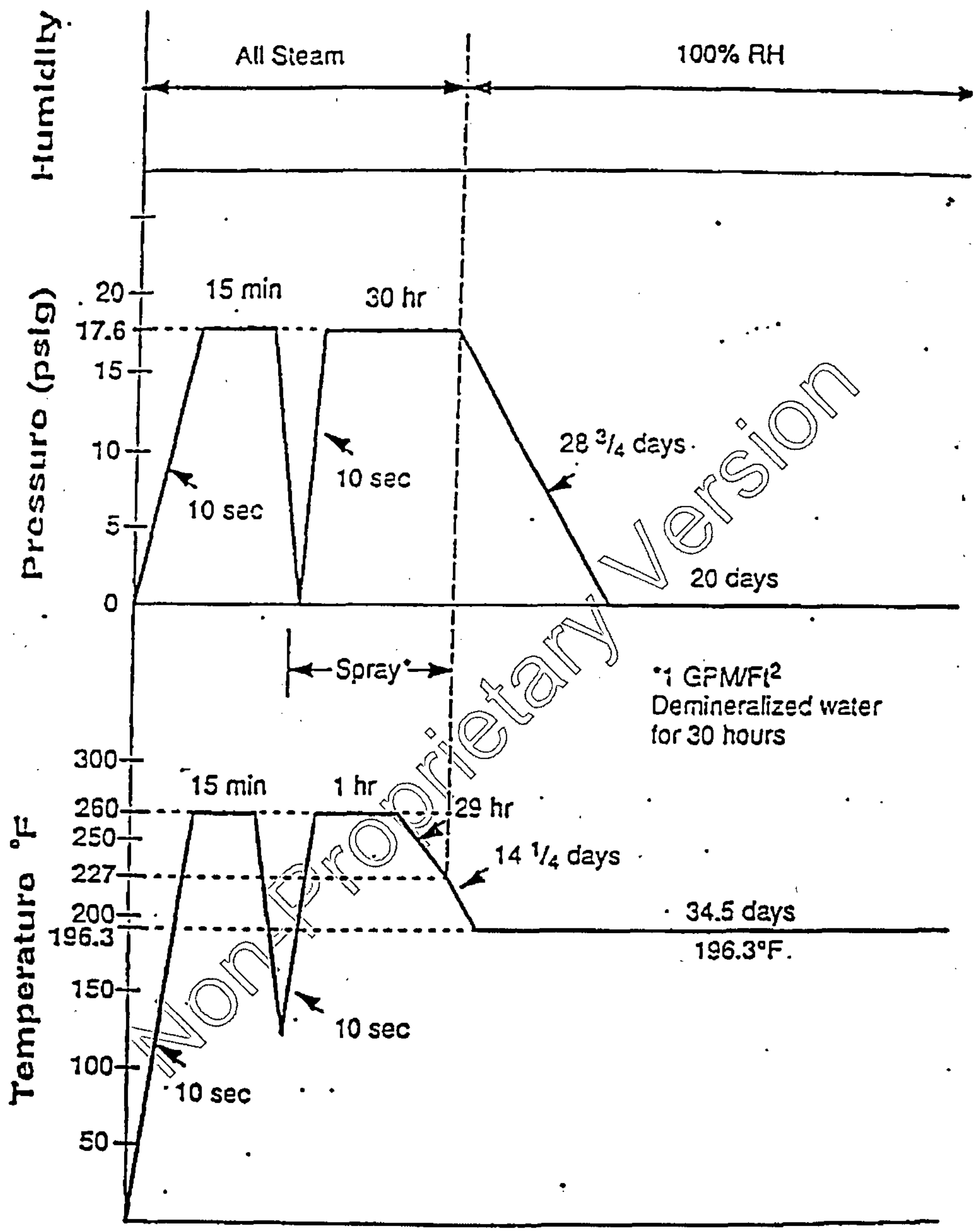
NOTES:

- A comprehensive series of capability curves is presented in Sections DT and DA for time-temperature capability at different ambient conditions.
- Refer to Tables A9 and A10 for Accuracy Performance of Transmitters.
- As indicated in referenced sections above, all parameters are met with margin.

FIGURE B1
HIGH ENERGY LINE BREAK REQUIREMENTS DEFINITION*



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*The High energy Line Break is mislabeled in the NTS Procedure (528-0994, Section G.1, NTS page 18), as Figure 3, "NTS Loss of Coolant Accident Simulation System," rather than Figure 4 "LOCA Profile" as currently defined in the NTS Procedure (528-0994, Section G.1, NTS page V), Table of Contents. Gulton-Statham attempted to further extend the qualification level during the actual period of test performance as defined in "Change in Procedure Number L-3," (NTS Report 528-0994, Section G.1, pages 52 and 53), leading to redefining the profiles to LOCA "A" and LOCA "B" (Accelerated) as shown in Figures 5 and ^ in NTS Report 528-0994, Section G.1 NTS, pages 21 and 22. The level of qualification required and demonstrated in this package is that of Figure B1 (LOCA "A"); the extended and rushed LOCA "B" test, introduced after testing began, had various anomalies (described and evaluated as not detrimental to demonstrated qualification in Section A, Paragraph 2K), precluding use of LOCA "B" data.

FIGURE B2A
SEISMIC WITHSTAND REQUIREMENTS DEFINITION
AND TYPICAL +ACTUAL SPECTRUM TESTED, RRS FOR OBE**

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

**The Required Response Spectrum for OBE and SSE is shown in the NTS Report (528-0994, Section G.1 NTS, page 20) as Figure 4, "Required Response Spectrum." The actual spectrums are shown in NTS Report 528-0994, Appendix C.

FIGURE B2B
SEISMIC WITHSTAND REQUIREMENTS DEFINITION AND TYPICAL ACTUAL SPECTRUM TESTED, RRS FOR SSE**

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

**The Required Response Spectrum for OBE and SSE is shown in the NTS Report (528-0994, Section G.1 NTS, page 20) as Figure 4, "Required Response spectrum." The actual Spectrums are shown in NTS Report 528-0994, Appendix C.

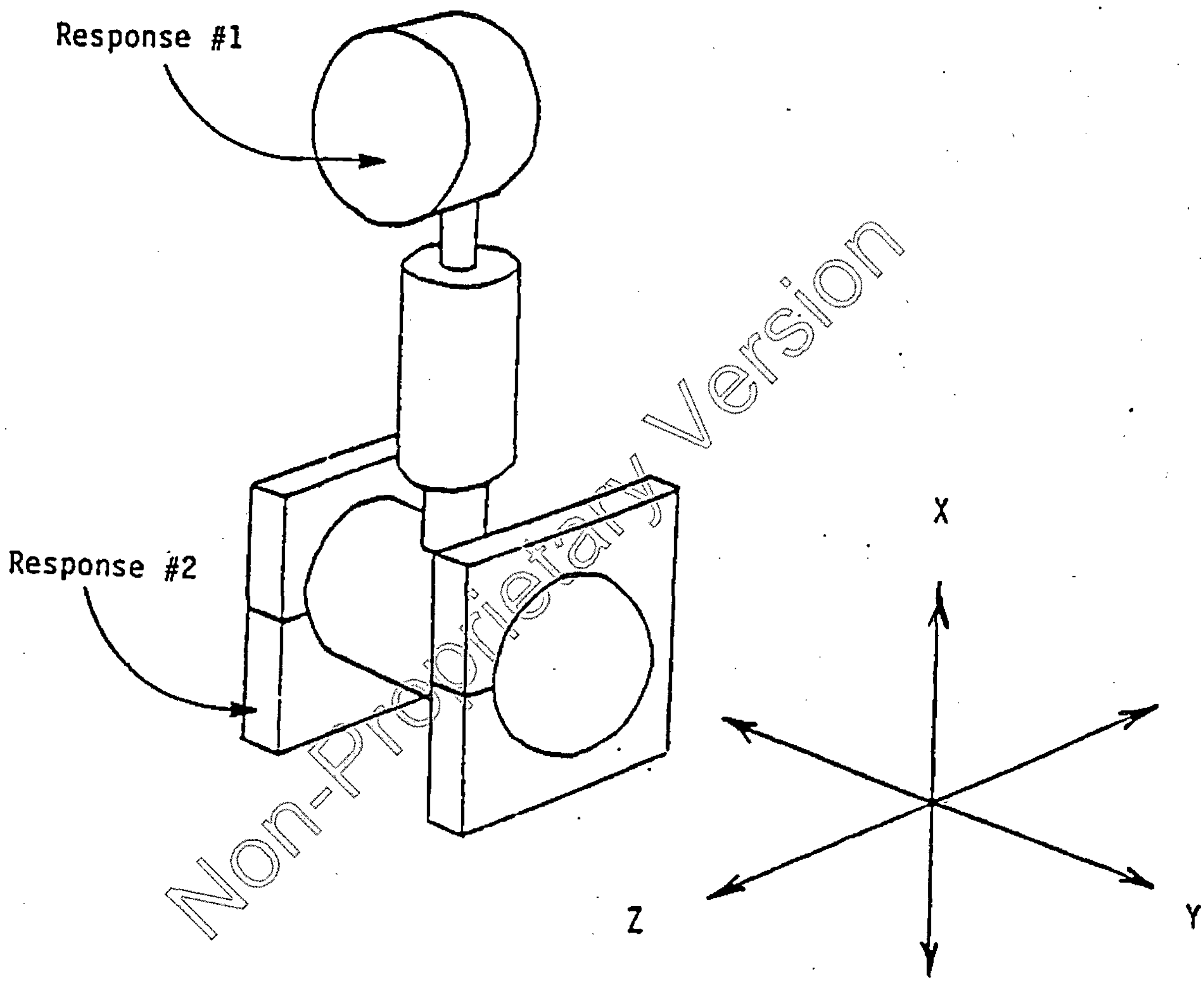
FIGURE B3
VIBRATION WITHSTAND REQUIREMENTS DEFINITION AND TYPICAL ACTUAL SPECTRUM TESTED FOR STEAM RELIEF VALVE (SRV) DISCHARGE RRS, FOR SRV AGING***

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

***The Required Response Spectrum for SRV Aging is shown in the NTS Report (528-0994, Section G.1 NTS, page 19) as Figure 3, "Required Response Spectrum." The actual spectrums are shown in NTS Report 528-0944, Appendix B.

FIGURE B4
AXES DEFINITION FOR SRV AGING AND SEISMIC TESTING



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REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

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SECTION C

REFERENCES

REFERENCES

1	10CRF50.49	"Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plant"
2	IEEE STANDARD 323-1974	"IEEE Standard for Qualified Class 1E Equipment for Nuclear Power Generation Stations"
3	IEEE 323-1983	"IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations"
4	IEEE 344-1975	"IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations"
5	IEEE 344-1987	"IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations"
6	NUREG 0588, REVISION 1	"Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment"
7	IEB-79-01B	"Environmental Qualification of Class 1E Equipment, January 14, 1980"
8	INSTRUMENT ENGINEERS' HANDBOOK, REVISED EDITION SECTION 1.1	"Instrument Terminology and Performance," pages 3-41, Copyright 1982, Chilton Book Company, Radnor, Pennsylvania
9	NATIONAL TECHNICAL SYSTEMS TEST REPORT NUMBER 528-0994, REVISION B	"Qualification Tests on Pressure Transmitters - Part Numbers: PD 3218, PD 3200, PG 3200, dated December 19, 1984 (Section G.1)
10	NATIONAL TECHNICAL SYSTEMS PROCEDURE NUMBER 528-0994, REVISION C	"Nuclear Qualification Tests of Pressure Transmitter Assemblies," dated May 1, 1983 (Section G.1)
11	IEEE 627-1980	"IEEE Standard for Design Qualification of Safety System Equipment Used in Nuclear Power Generating Stations"
12	GULTON-STATHAM DOCUMENT NUMBER 1006, REVISION G	"PD/PDH 3200, PD/PDH 3218 Nuclear Qualification Report", dated December 6, 1984
13	USNRC GENERIC LETTER 81-15	"Environmental Qualification of Class 1E Electrical Equipment - Clarification of Staff's Handling of Proprietary Information," dated March 13, 1981
14	SCHLUMBERGER INDUSTRIES DRAWING STATHAM DIVISION OF SOLARTRON TRANSDUCERS 70006-000-001	"Pressure Transmitter - Installation PD 3200, PDH 3200" (Current version of Drawing in Section F of this document)
15	DELETED	

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16	10CFR50 APPENDIX B	Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"
17	ISO 9001-1987	Quality Systems - "Model for Quality Assurance in Design/Development, Production, Installation and Servicing"
18	USNRC REGULATORY GUIDE 1.89, REVISION 1	"Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants"
19	USNRC INSPECTION AND ENFORCEMENT NOTICE 89-42	"Failure of Rosemount Models 1153 and 1154 Transmitters," dated April 21, 1989
20	USNRC BULLETIN 90-01	"Loss of Fill Oil in Transmitters Manufactured by Rosemount," dated March 9, 1990
21	IEEE 603-1980	"IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations"
22	IEEE 382-1985	"IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants"
23	IEEE 383-1974	"IEEE Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations"
24	USNRC REGULATORY GUIDE 1.61	"Damping Values for Seismic Design of Nuclear Power Plants"
25	TEMPORARY INSTRUCTION 2515	"Evaluation of Licensee's Program for Qualification of Electrical Equipment Located in Harsh Environments"
26	IEC 780	"Qualification of Electrical Items of the Safety Systems for Nuclear Power Generating Stations," published 1983
27	ATOMIC ENERGY OF CANADA LIMITED, TECHNICAL SPECIFICATION 86-30060-TS-001	"Environmental Qualification of Equipment"
28	ATOMIC ENERGY OF CANADA LIMITED, TECHNICAL SPECIFICATION TS-XX-30000-5	"Seismic Qualification of Equipment"
29	ATOMIC INDUSTRIAL FORUM LETTER, R.M. ECKERT TO R.H. VOLLMER, DATED AUGUST 24, 1982 TRANSMITTING	"A Nuclear Industry Position Paper on System Operating Times" (Position Paper in Section D, Subsection DA)
30	IEB-79-01B, SUPPLEMENT 2	"Environmental Qualification of Class 1E Equipment" dated September 30, 1980
31	ANSI/ANS 4.5-1980	"Criteria for Accident Monitoring Functions in Light-Water-Cooled Reactors"

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32	USNRC REGULATORY GUIDE 1.97, REVISION 3	"Instrumentation for Light-Water-cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident"
33	IEEE-317-1983	"IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations"
34	USNRC REGULATORY GUIDE 1.63, REVISION 3	"Electric Penetration Assemblies in Containment Structures for Nuclear Power Plant," dated February, 1987
35	EPRI NP-1558	"Review of Equipment Aging Theory and Technology"
36	GENERAL ELECTRIC NUCLEAR ENERGY DIVISION SPECIFICATION 21A3145	"Electronic Level Transmitter with Remote Seals," Revision 3, dated November 13, 1984
37	GULTON-STATHAM BROCHURE	"The Benefits of Statham 3000 Series Transmitters for Process Control," dated May 1, 1992 (found in Section G.5)
38	ELECTRONIC INSTRUMENTATION AND MEASUREMENT TECHNIQUES, THIRD EDITION CHAPTER 11 ,	"Transducers as Input Elements to Instrumentation Systems," William David Cooper and Albert D. Helfrick, Prentice-Hall, Copyright 1985
39	APPLICATION NOTE 290-1	"Practical Strain Gage Measurements" Hewlett-Packard Company. Palo Alto, California
40	GOULD INC. MEASUREMENT SYSTEMS DIVISION DRAWING 68997-000-001	"Differential Pressure Transmitter PD 3218" (Current version of Drawing in Section F of this document)
41	IEEE 381-1977	"IEEE Standard Criteria for Type Tests of Class IE Modules Used in Nuclear Power Generating Stations"
42	GULTON-STATHAM (KEVIN KLEM) LETTER TO QUAL-TEK (L.P. GRADIN)	"Follow-up to Your Request for the Pages Missing from the NTS Report #528-0994, Revision B Sent to You," dated November 13, 1995 (Found in Section F)
43	GULTON-STATHAM PREPARED LOCA "A" PROFILE (GRAPH INFORMATION)	Prepared and Approved November 28, 1995 (Found in Section F)
44	NUREG/CR-3863	"Assessment of Class 1E Pressure Transmitter Response when Subjected to harsh Environment Screening Tests," prepared by Sandia National Laboratory for USNRC, Printed March, 1985
45	GOULD INC. MEASUREMENT SYSTEMS DIVISION DRAWING 68803-000-(TAB)	"Differential Pressure Transmitter PD 3218 Special for General Electric (San Jose)" (Current version of Drawing in Section F of this document)
46	GULTON-STATHAM ENVELOPE/INSTALLATION DRAWING 32DP00X	"Nuclear Transmitter Assy (Differential)" (Current version of Drawing under configuration control at Gulton-Statham for transmitter models PD 3200 and PDH 3200)

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47	GULTON-STATHAM ENVELOPE/INSTALLATION DRAWING 32GP000,001,002	"Pressure Transmitter Nuclear (Gage)" (Current version of Drawing under configuration control at Gulton-Statham for transmitter model PG 3200)
48	GULTON-STATHAM ENVELOPE/INSTALLATION DRAWING 32DC000CAT	"Pressure Transmitter Nuclear (Remote Seal Differential)" (Current version of Drawing under configuration control at Gulton-Statham for transmitter model PD 3218)
49	GULTON-STATHAM ENVELOPE/INSTALLATION DRAWING 32DR000CAT	"Pressure Transmitter Nuclear (Draft Range)" (Current version of Drawing under configuration control at Gulton-Statham for transmitter model DR 3200)
50	GOULD INC. MEASUREMENT SYSTEMS DIVISION, PROJECT ENGINEERING REPORT 1002	"Nuclear Scope Test Report," dated May 18, 1983.
51	GENERAL ELECTRIC NUCLEAR ENERGY DIVISION SPECIFICATION 23A1226	"Class 1E Electronic Pressure Transmitter (IEEE 323-1974)," Revision 0, dated May 10, 1982
52	GENERAL ELECTRIC NUCLEAR ENERGY DIVISION	"Engineering Change Notice NJ37863," dated July 23, 1982
53	GENERAL ELECTRIC NUCLEAR ENERGY DIVISION DRAWING 184C4775	"Purchase Part Level Transmitter with Pressure Sealed Sys" Revision 1, dated July 22, 1982
54	GOULD INTEROFFICE MEMORANDUM L. GARNETT TO D. BAKER	"General Electric PD 3018's - December 31 Delivery," memo dated October 22, 1982.
55	GOULD INTEROFFICE MEMORANDUM L. GARNETT TO D. BAKER	"Nuclear Qualified Transmitter for General Electric Design Review Meeting," memo dated November 29, 1982.
56	GOULD INTEROFFICE MEMORANDUM L. GARNETT TO FILE	"Design Report - 30 Megarad PD 3018," dated January 18, 1983
57	GOULD INTEROFFICE MEMORANDUM P. MULLER TO D. BAKER	"NTS Report 528-0994/General Electric Qualification," dated February 14, 1983
58	GOULD INC. MEASUREMENT SYSTEMS DIVISION PROJECT ENGINEERING REPORT 1003	"Functional Test Data Report for Gould Model PD 3218-100 Pressure Transmitter Serial Number C6164 Exhibit II of NTS Report 528-0994-1," dated July 11, 1983
59	NATIONAL TECHNICAL SYSTEMS TEST REPORT NUMBER 528-0994-1	"Qualification Tests on Pressure Transducer Part Number PD 3218," dated July 5, 1983 (Section G.2)
60	GOULD INC. MEASUREMENT SYSTEMS DIVISION PROJECT ENGINEERING REPORT 1030 ADDENDUM 1	To Project Engineering Report 1005, REVISION B, dated January 21, 1985

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61	NATIONAL TECHNICAL SYSTEMS TEST REPORT NUMBER 528-1840	"Seismic and LOCA Testing of Pressure Transmitter Assemblies Part Numbers PD 3200 and PG 3200," dated February 7, 1985
62	SCHLUMBERGER INDUSTRIES STATHAM DIVISION OF SOLARTRON TRANSDUCERS DRAWING 70017-000-001	"Pressure Transmitter Installation - Isolated, PG 3200" (Current version of Drawing in Section F of this document)
63	GOULD INC. MEASUREMENT SYSTEMS DIVISION, BULLETIN 201	"Differential Pressure Transmitters Nuclear Qualified Model PD/PDH 3200 Series," dated May, 1983
64	USNRC INFORMATION NOTICE 92-12	"Effects of Cable Leakage Current on Instrument Settings and Indications," dated February 10, 1992
65	GOULD INC. MEASUREMENT SYSTEMS DIVISION, INTERNAL STATUS H. ALBAUGH TO D. KREEGER	"Status of Nuclear Test Program," dated August 23, 1983
66	GULTON-STATHAM PER-1176	"P3200 Baseline and Engineering Changes" as of June 1992
67	GULTON-STATHAM DOCUMENT NO N00182	"P3200 Baseline and Engineering Changes" (Current version of document under configuration control at Gulton-Statham)

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SECTION D

ENVIRONMENTAL QUALIFICATION

PARAMETER-BY-PARAMETER REVIEW

SUBSECTION DO -- PARAMETER: OPERATING TIME

REVIEW

The operability of the Gulton-Statham Transmitters is based on its conservatively assumed continuous operation, taking no credit for unavailability due to the performance of surveillance testing, maintenance, or disconnection of instrument loop equipment.

The transmitters are conservatively assumed to operate for the full duration from installation to plant retirement plus the post-DBE requirement.

It is recognized that the Gulton-Statham Transmitters may be installed as replacement equipment to the original plant transmitters. However for conservatism, the transformers will continue to be analyzed as requiring continuous 40-year operation plus long-term post-operation in the Aging Parameter Review Section DA.

NORMAL OPERATING TIME

The transmitters "operate" continuously for the 40-year period from installation to plant license termination, plus the post-accident period. As a potential part of the "Sense and Command Features"* the transmitters operational availability must be assumed for this EQ effort to be continuous.

For the transmitters, the qualification (in Aging Parameter Review Section), includes cycling.

POST-ACCIDENT OPERATION OR LONG-TERM POST-ACCIDENT OPERATION

The required post-accident operating time is a function of the safety function required, the accident duration, and conservatism in plant design.

Typical values found in various plants for transmitters vary from seven (7) days; thirty (30) days; sixty (60) days; ninety (90) days; one hundred-twenty (120) days; one hundred eighty (180) days or even a three hundred-sixty (360) days duration. Actual values found in use often significantly and conservatively exceeds the generic industry operability guidance including "long-term requirements." In 1982, the Atomic Industrial Forum[29] (with the position paper following the text of this subsection) defined, "Systems required during the long-term mode of operation..." to those limited to (a) decay heat removal, (b) post-accident monitoring, and (c) electrical power distribution and cooling systems supporting (a) and (b) as previously described. The long-term period extended for twenty-four (24) hours to fifteen (15) days on the basis of a careful and reasonable analysis of requirements.

*As defined in IEEE 603[21] sense and command features are the electrical and mechanical components and interconnections involved in generating those signals associated directly with safety functions. The scope of The sense and command features extends from the measured process variables into an electric or pneumatic signal.

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The NRC also previously recognized that the definition of "Long-Term" is variable, being accident scenario and equipment dependent. In question, Response 23 to IEB-79-01B, Supplement 2[30], the NRC stated:

Q.23 How long should "Long-Term" equipment be qualified for environmental qualification?

A.23 "Long-term" for the purpose of qualifying equipment for a harsh environment is variable. A determination of "long-term" for qualification of equipment should be based on the considerations listed below for each postulated accident scenario. Justification for the value used should be provided with the equipment qualification documentation.

1. The time period over which the equipment is required to bring the plant to cold shutdown and to mitigate the consequences of the accident.
2. The ability to change, modify or add equipment during the course of the accident or in mitigating its effects which will provide the same safety-related function.

For conservatism to envelop most applications, a time period of one hundred eighty (180) days post-accident duration may be used in an analysis enveloping plant needs. Conservatively, we have used three hundred-sixty (360) days in the temperature qualification in Section D, subsection DT. In addition, the qualification data presented is sufficiently complete to allow the user to adjust the analysis (if necessary) to meet unique requirements. Data is presented for post-accident ambients of 90°F - 145°F.

The present "standard" for even post-accident monitoring is a maximum of one hundred (100) days in ANSI/ANS 4.5-1980[31], Paragraph 6.1.2.3, which is addressed by NRC Regulatory Guide 1.97[32], indicates a one hundred (100) day post-accident monitoring duration.

It is worth noting that the Qualification demonstration provided in this QDR is based on a combination of very severe temperature, humidity, radiation, and post-accident duration which will not occur concurrently. For example, the LOCA event which can result in the harsh radiation exposure and long-term post-operability requirements, results in rather benign changes in temperature or humidity in the outside containment locations where most transmitters are expected to be found in.

CONCLUSION

Use of these conservative operating durations (40 years normally, and up to 360 days post-accident), and consideration of cycling in other parameter reviews, (e.g. Temperature - Subsection DT, Aging- Subsection DA), demonstrates qualification.

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Industry Position on System Operating Times

Prepared, based on input received at a workshop sponsored by the NSAC, attended by those listed below; and reviewed and approved by members of the E.O. Subcommittee, Utility Equipment Qualification Advisory Group Members, and the AIF Licensing Steering Group.

P. Jacobsen	- Consumers Power Co. – Chairman
S. Kasturi	- EDS Nuclear – Moderator
S. Masenheimer	- Duke Power
H. Shaffer	- YAEC
G. Langford	- Bechtel Power Corp.
M. Horrel	- Ebasco Services Inc.
JE Metcalf	- Stone & Webster Inc.
L. Casella	- Florida Power & Light Co.
L. Stalter	- Toledo Edison Co.
NB Le	- USNRC
TJ Delgaizo	- WESTEC Services Inc. RVRC/FRC/Consultant

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Issue Record

No.	Description	Date
1.	Comment issue to participants in the workshop	11/13/81
2.	Comment Issue – AIF EQ Subcommittee and EPRI/owner's group	03/05/82
3.	Issued to AIF Steering Group after incorporating corporating comments from AIR-EQ Subcommittee and Owner's Group	03/24/82
4.	Forwarded to the USNRC by AIF letter dated8/24/82 from Mr. Richard M. Eckert to Mr. Richard H. Vollmer	08/24/82

Industry Position on System Operating Times

1.0 INTRODUCTION

NRC Memorandum and Order CLI-80-21 endorsed the DOR Guidelines and NUREG-0588, both of which require that qualification times be established for each piece of safety-related Class 1E equipment. This qualification time is based on an evaluation of the equipment's safety function for the various design basis events and its associated required operating time while being subjected to the harsh environment.

The AIF committee on power plant design, construction and operation (Subcommittee on Equipment Qualification) has reviewed the industry practices involved in establishing the qualification times, as well as the available regulatory guides, industry standards, and operating experience pertaining thereto. In this position paper, the nuclear industry offers a set of guidelines for establishing the minimum required safety system operating times which could be used in determining appropriate equipment qualification times. The time frames proposed in this position paper represent those which envelope the various plant configurations, and design basis events. However, lower times than those suggested may be used for specific plants with appropriate justification.

2.0 DEFINITIONS

For purposes of this paper, the following definitions apply.

2.1 Qualification Time

The minimum period of time for which qualification tests in simulated DBE environments shall be conducted to adequately demonstrate equipment qualification.

Generally, qualification time is conservatively established based upon the minimum required operating time in severe environmental conditions. However, if failure of a piece of equipment due to severe environmental conditions, subsequent to performing its safety function, could affect accident mitigation efforts (e.g., failure of interlocking instrumentation isolates a required safety system), this should be considered in establishing the qualification time.

2.2 Operating Time

Operating time is defined as the minimum time period required for the system/equipment to accomplish its intended safety functions. This period is the time interval (Fig. 1) between the start of the event to the time the required safety function is accomplished. If an equipment is required to be cycled (e.g.; valve open/close) several times to accomplish a given safety function, then the total real time period over which such cycling is required to be accomplished Including the cumulative cycle times constitute the system operating time.

2.3 Safety System

Safety system is defined as an assembly of components or equipment required to perform a safety function such as reactor trip, core cooling, or containment isolation.

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Industry Position on System Operating Times

2.4 Hot Shutdown

A condition in which the reactor is subcritical typically by 1% K/K, but the RCS temperatures are still at or greater than 200 degrees Fahrenheit. The reactor is under control and capable of being maintained in this condition.

3.0 Position

The operating times for equipment qualification can be separated into four categories. These categories are:

Short term:

Functional Scope: reactor shutdown, initiation of accident mitigation, initiation of containment isolation.

Duration: 0 to 20 minutes.

Intermediate term:

Functional Scope: accident mitigation, accident monitoring.

Duration: 20 minutes to 24 hours.

Long term:

Functional Scope: decay heat removal, post accident monitoring.

Duration: 24 hours to 15 days.

Extended term:

Functional Scope: inaccessibly decay heat removal, inaccessible post accident.

Duration: 15 days to 1 year.

When equipment is properly assigned to one of these categories, the maximum duration for that category can be used as the operating time for that equipment for qualification. The effects of equipment failure beyond these operating times must be considered and shorter operating times may be used if justified.

The use of these guidelines will result in the adequate, consistent, and cost effective equipment qualification programs required to assure plant safety and the protection of the health and safety of the public.

The rationale for the proposed operating time guidelines are presented in Section4.0

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Industry Position on System Operating Times

4.0 DISCUSSION

Safety-related equipment must be capable of performing their design safety functions and/or maintain system integrity under the worst postulated environmental conditions prevailing after the accident during which the equipment is required to perform its safety function. Accident conditions may involve exposure of the equipment to elevated temperatures, pressures, relative humidity, radiation, and in some cases chemical spray and submergence. The damage caused by these environmental factors can be cumulative in nature. For example, a material property such as tensile strength, insulation resistance, or viscosity could continue to degrade or corrosion could be enhanced while exposed to the adverse environmental condition(s). Equipment may be capable of performing its intended safety functions after a short exposure period because the reduction of the affected material property was covered by a safety factor in the design. However, continued exposure to these environmental extremes could cause significant reduction of the material properties to the point where the equipment cannot function. Therefore, it is import to define not only the accident environmental conditions, but also to define the duration of such equipment exposure to these conditions. After this period, equipment must remain functional, and/or maintain its physical integrity so as to assure that subsequent to performing its safety function, it will not fail in a manner detrimental to plant safety.

Evaluation of the range of variations in nuclear power plant designs relative to DBE/HELB analysis, containment structures, safety systems, equipment functions, NSSS designs, etc., indicates that all such system/equipment performance requirements fall into one or more of the following time categories:

- Short term functional requirements such as containment isolation, reactor trip, actuation of emergency core cooling,
- Intermediate functional requirements such as achieving hot shutdown conditions.
- Long term functional requirements such as those involving returning the plant to pre-accident conditions, except for radiation levels, when access to repair and replace equipment is possible.
- Extended term functional requirements such as long term decay heat removal or post accident monitoring where access may not be available.

It should be noted that the time categories proposed above present a set of enveloping time requirements applicable generically to all nuclear power plants. In specific plants, when required, times shorter than those proposed in this guideline may be used when appropriate.

Industry Position on System Operating Times

These time categories are described in detail below.

4.1 Short Term Requirement

Systems required during the short term are those required to establish control of the accident situation. These include:

A. Reactor protection systems

B. Actuation systems required to initiate accident mitigation systems (i.e.: safety injection, containment isolation, containment cooling).

C. Containment isolation systems, provided subsequent failures of those valves have been analyzed to ensure that the accident mitigation efforts will not be affected.

Time requirements for the short term system operability category is defined as up to twenty (20) minutes from accident initiation. A review of the various plant PSAR, FSAR, and IEB 79-01B submittals and plant unique load definition documents will show that the majority of system operability requirements for design basis events (DBE), including high energy line breaks (HELB), are totally bounded by a time envelope of sixty (60) seconds (see Figure 2). This 60 second envelope is considered to be conservative with respect to those events such as LOCA, MSLB< etc. which result in automatic actuation.

However, the 20 minute duration criteria proposed above is necessitated by the less severe but more time limited accident scenarios of small OOCA, HELB and the like. For these events, system equipment may be subjected to environmental conditions in excess of their normal design values, not necessarily the peak values resulting from the worst case DBE, but rather for an extended period of time before automatic action or operator intervention will occur. For determination of this required time frame, in lieu of analysis of the possible accident scenarios which would fall into this category, industry believes that 20 minutes represents adequate time for operator identification, evaluation and initiation of appropriate safety action. (1)

We believe, based on a qualitative evaluation of available data on small break or leak induced less severe accidents, as well as the available instrumentation and other Control Room information systems, that the 20 minute time could be shown to be a very conservative time frame for operator assessment of the situation, identification of the type of incident, and initiation of appropriate protective actions, including, if required, mitigation systems such as containment or other system isolation and core cooling.

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(1) ANS 58.5 (March, 1981), NUREG-0700, etc.

Industry Position on System Operating Times

4.2 Intermediate Term Requirements

Systems required during intermediate term are those required to achieve a hot standby of shutdown condition of the reactor and primary systems. Depending upon the accident, these include systems such as:

A. Active and passive core cooling systems
B. Secondary heat removal systems in a PWR
C. Containment spray and cooling systems
D. Containment isolation systems
E. A minimum set of auxiliary support systems required to support functioning of the primary safety systems listed in a, b, c, and d above. These include on-site power systems, cooling water systems etc.
F. Accident monitoring instrumentation systems.

The intermediate time frame from <u>20 minutes to 24 hours</u> is the time postulated to get to a hot shutdown condition with the plant operators in control of the situation. At the end of the 24 hour period, the injection and spray modes would have been completed and the plant would be in a position to proceed in a time is believed to be conservative since it provides for ample time to call in additional personnel or expertise to assess the situation and take any necessary corrective action. Design Basis Accident and HELB pressure and temperature profiles for various BWR and PWR plants are documented in the PSAR, and PSARs, and IEB 79-01B submittals. These profiles were developed with a set of very conservative assumptions including concurrent single failures, consistent with all the applicable regulatory requirements, and the "defense in depth" philosophy. Evaluation of this data would show that within about 20 hours following any event, stable, and in most instances decreasing trends of the pressure and temperature conditions within the reactor coolant systems, secondary heat removal systems, and the affected area in containment or other plant areas are achieved (see Figure 2).

4.3 Long Term Requirements

Systems required during the long term mode of operation are those installed to provide long term decay heat removal, and post accident monitoring. These are limited to the:

A. Decay heat removal system
B. Instrumentation required to monitor containment pressure and radiation, Secondary heat removal system (i.e., Auxiliary Feedwater) operational monitoring and decay heat removal system operational monitoring.
C. Electrical power distribution and cooling systems required for support of those systems in (A) and (B) above to continue functioning.

Non-Proprietary

Industry Position on System Operating Times

The long term time period extends from 24 hours to 15 days. This is the period of time required to bring the plant, which is under control and stabilized, to the point where systems are accessible for adjustment, preventive maintenance, calibration, repair, and alterations. During this period the plant is in a long term cooling configuration that can be maintained indefinitely with access to equipment. The plant either enters this period in long term cooling, or is placed in it near the beginning of the interval.

It is judged that 15 days represents an adequate amount of time for plant staff and all those who would become involved after a DBE/HELB to determine the actions needed to maintain the long term cooling mode, make the needed preparations, and to begin to take appropriate action. Those actions required at the end of the 15 days to sustain systems will be known from the system design, but depending on the type of events, some time will have to be spent reviewing the options available at the time.

4.4 Extended Term Requirements

It is recognized that there is another category of systems, which must be designed for a much longer period of operability in a harsh environment without access. These systems include Post Accident Monitoring of radioactivity release to the environment and long term heat removal, where by the particular plant design they may not be accessible due, usually, to high radiation conditions. Examples of this would be RHR equipment, and Reactor Coolant System pressure instrumentation for a PWR located inside primary containment. They must be designed for a period of time consistent with the scenarios and calculated environments. It is believed that in all cases, one year would represent an adequate time period to seek alternative solutions and/or terminate the conditions of inaccessibility. By that time, the radiation sources will have been dealt with sufficiently to allow access to the equipment, or alternate systems/equipment required to perform the same safety function could be installed. Experience in Three Mile Island (MI) verifies this capability.

5.0 CONCLUSION

We believe that the four categories of time frames, i.e., short, intermediate, long and extended term, represents an enveloping set for all the DBE's and HELB's postulated and analyzed as part of nuclear power plant design. These guidelines, if used by the industry and adopted by the NRC, would result in an adequate, conservative, consistent and cost effective program to address equipment qualification. We recommend that the NRC adopt these guidelines in the ongoing development or the rules of other regulatory documents.

Industry Position on System Operating Times

6.0 REFERENCES

CLI-80-21, Commission memorandum and order dated May 20, 1980.

DOR Guidelines, Enclosure 4 to the IE Bulletin 79-01B.

NUREG-0588, "Interim staff position on environmental qualification of safety-related electrical equipment".

ANSI/ANS 4-6, Draft No. 7, proposed standard, "Functional criteria for on-line monitoring in light water reactors".

ANSI/ANS 4-5 – 1980, "Criteria for accident monitoring functions in in light-water-cooled reactors".

Regulatory Guide 1.7, "control of combustible gas concentration in containment following a LOCA".

Branch technical position ASB 2, "Residual decay energy for light-water reactors for long term cooling".

Regulatory Guide 1.97, Rev. 2, December, 1980, "Instrumentation for light-water-cooled nuclear power plants to assess plant and evnirons conditions during and following an accident.

Regulatory Guide 1.89.

10 CRF 50, Appendix A, "General design criteria for nuclear power plants", criteria 4, 13, 19 and 64.

Regulatory Guide 1.62.

NUREG-0800, SRP 9.5.1, Fire Protection Program and attached BTP CHEB 9.5-1, Guidelines for ire protection for nuclear power plants.

Non-Proprietary Version

Industry Position on System Operating Times

FIGURE 1

t_0 = 0	EVENT START, development of an abnormal event
t_1	Detection of an event by sensor or identification of the same by an operator
t_2	Initiation of a trip or protective actuation function (i.e., initiate rod drop, valve close, pump start)
t_3	Completion of protective action (i.e. rods in, valve closed, pump started in delivering the flow)
t_4 = 20 minutes	Reactor plant and containment condition stable
t_5 => 24 hours	Reactor plant in a hot shutdown condition, and the abnormal environmental conditions stabilized (i.e., worsening trend arrested and possibly reversed)
t_6 = 15 days up to 1 year for specific system / equipment	Plant under cold shutdown conditions. Environmental conditions in affected areas returned to pre-event conditions except radiation.

Non-Proprietary Version

Industry Position on System Operating Times

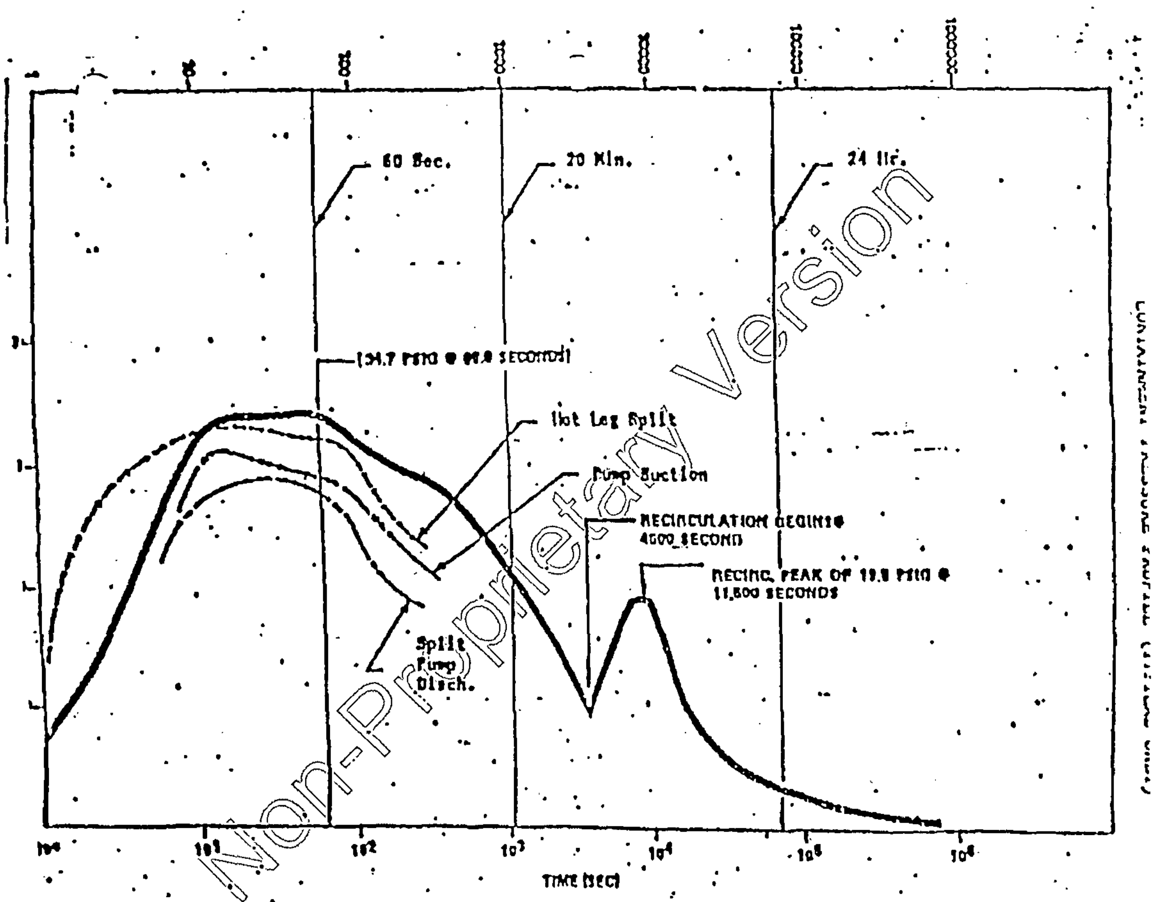


FIGURE 2

Non-Proprietary Version

SUBSECTION DT -- PARAMETER: TEMPERATURE

NORMAL TEMPERATURES

As indicated in the QDR Section A, the transmitters may be located in various plant areas. Transmitters, due to their need for calibration checks and the ease with which the pressure connections can be tubed out from the process connection points, are located in areas designed to allow reasonable access to plant personnel. Consequently, they are not located right next to such thermally (and radiation) hot spots similar to the reactor coolant loop or other usually inaccessible worst case locations.

Furthermore, the normal ambient temperatures, and the proportion of plant life at those temperatures, are usually very conservatively expressed.

Within Section D, Subsection DA, data is presented to allow determination of qualified life at various temperatures.

The aging data in Section D, Subsection DA, provides information on Qualified Life in one degree F (1°F) increment from 70°F* to 145°F which will facilitate convenient adjustment and should exceed all application needs.

EVALUATING TEMPERATURE RISE DUE TO ENERGIZATION

The subject equipment under evaluation are Gulton-Statham Transmitter assemblies. These instruments operate with low level voltage and current; 12- 55 VDC and 4-20 mA dc (*see* Specifications of Tables A1, A3, A5, and A7 in Section A). Internal heat rise due to continuous energization is therefore considered insignificant.

EVALUATING TEMPERATURE RISE DUE TO PROCESS

The process connection for the transmitters are completely isolated from the electronics housing (see Figures A1, A5, A7, and A9 in QDR Section A). The process fluid that reaches the process side of the transmitter is separated by an isolating diaphragm and ceramic insulators. Furthermore, the instrument-sensing lines bring the process effluent to the transmitter, which is typically remote from a hot process. Therefore, it is reasonably concluded that the subject transmitters will experience negligible heat due to process fluids.

Note: Data provided on the substantial thermal capability of these transmitters in this subsection and Subsection DA, will allow the user to adjust the analysis should the process condition provide heat transfer to the transmitter or be other than insignificant.

*Even though a plant location may be less than 70°F during periods of the transmitters' installed life, the data below 70°F is not provided as the qualified life at 70°F is well beyond plant license duration. See Section DA.

ACCIDENT TEMPERATURES

As the transmitters may be located in various areas of the plant, qualification is demonstrated to the worst case expected temperature conditions postulated for the typical installation. Section B includes as Figure B1 the High Energy Line Break Definition. Although certain data exists for performance to even a higher level (designated as the extended LOCA "B" as explained in the footnote to Figure B1), anomalies and equipment failures to this test level (which included temperature spikes above 500°F), conservatively precludes its use.

The Qualification testing of the transmitters was to temperature greater than the generic Figure B1, the High Energy Line Break Definition requirement, as described in Table DT1 of this subsection.

TRANSMITTER EVALUATION

As indicated in Table I, of the NTS Report[9], NTS page 15, as well as the Specimen Location Drawing (Figure 7 of this report, NTS page 23), the qualification testing included the following:

TRANSMITTER TYPE	SERIAL NUMBER*
PD 3200	XXXXX
PD 3200	XXXXX
PG 3200	XXXXX
PG 3200	XXXXX
PD 3218	XXXXX

The data of profile of Figure B1, Section B, is the definition document --not the plot of achieved accident temperature simulation. Figure DT1 which is provided at the end of this subsection, provides a plot of actual achieved Temperature Exposure. This data was derived from the data logger information from the chamber monitoring instrumentation. In general, the actual exposure is far more severe than the original Specification (e.g. approximately 41 days at 211°F in lieu of planned 34.5 days at 196.3°F). This data is used in the conservative Post-Accident Analysis at the end of this section. By "Similarity Analysis" in QDR Section A, Paragraphs 2A3 and 2D, the Draft Range (DR) and PD/PDH 3218 Series is enveloped in this qualification.

*All serial numbers proceeded by a "C", although for convenience, the "C" prefix was not stated, as in Figure 7 of NTS Report[9] (NTS page 23).

**Failures/anomalies dispositioned as not detrimental to qualification as described in this QDR, Section A, Paragraph 2K.

Non-Proprietary Version

The required plant profile is obviously plant dependent. Actual transient period is usually rather short with a return to normal temperature conditions in 3-24 hours for outside containment events, and within 2-7 days for inside containment limiting LOCA-type events. This analysis will assume the post-transient temperature is 120°F for all areas.

A detailed Long-Term Post-Accident capability demonstration at the end of this section, demonstrates with margin, transmitter capability for these reasonably conservative conditions. Data is presented in such a manner that the analysis can be easily modified for user analysis if the unique user requirements are not enveloped.

The data provided includes information on post-accident capability in one degree F (1°F) increments from 90°F* to 145°F which will facilitate convenient adjustment and should exceed all application needs.

If there is no HELB transient, the user may consider this data to further extend Qualified Life beyond that established in subsection D.A, using accepted principles of aging analysis.

Non-Proprietary Version

CONCLUSION

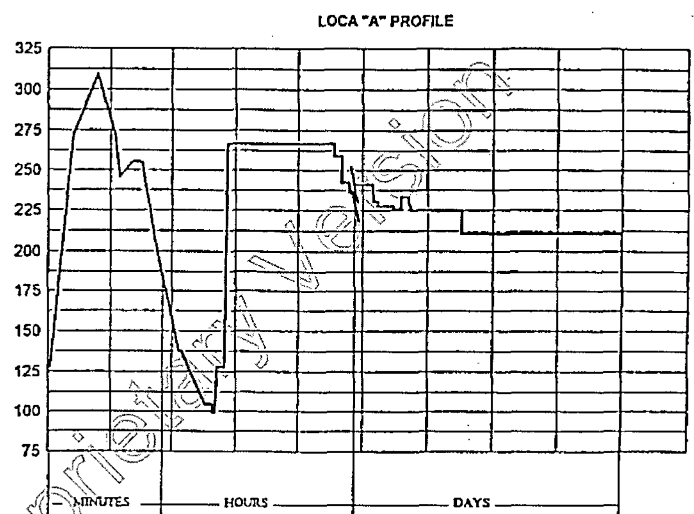
The transmitters are qualified with significant margin for the reasonable postulated accident temperatures.

*Even though a plant location may be less than 90°F during periods of the transmitters' post-accident operation, the data below 90°F is not provided as the capability at 90°F, is well beyond plant requirements. See analysis in this subsection.

*FIGURE DT1 -- HIGH ENERGY LINE BREAK PROFILE FROM ACTUAL TEST DATA**

LOCA "A" PROFILE (Graph Information)

DATE	RECORDED TIME	TEMP. (Deg. F)	
8/9/83	09:15.03	128.2	
	09:24.51	272.6	
	09:34.33	309.6	
	09:41.54	271.7	
	09:43.13	246	
	09:48.37	255	
	09:52.01	255	
	09:57.02	209.8	Minutes
	11:37.32	138	Hours
	11:48.03	138	
	13:06.15	104.7	
	13:21.36	104.7	
	13:29.21	99.3	
	13:33.46	99.3	
	13:38.46	128.2	
	14:07.37	128.2	
	14:10.05	266.7	
		266.7	
	21:11.36	259	
		259	Hours
8/10/83	09:06.50	242.6	Days
		242.6	
	23:12.50	236.4	
		236.4	Break in Testing
8/11/83	06:14.42	241	
8/12/83	12:06.13	241	
8/13/83	13:06.13	230.5	
		230.5	
	20:06.58	227.5	
		227.5	
8/14/83	18:06.35	225.8	
		225.8	
8/15/83	08:24.16	233.5	
		233.5	
	20:17.12	229.6	
8/16/83	00:17.12	225	
		225	
8/19/83	07:40.37	211	
8/29/83	17:05.14	211	
			End of Testing



Non-Proprietary Version

*The level of qualification required and demonstrated in this package is that of Figure B1 (LOCA "A"); this plot reflects actual conditions measured during testing. Table DT1 shows the actual data points used for this plot.

TABLE DT1

HIGH ENERGY LINE BREAK DATA FOR TEMPERATURE PROFILE PLOT*

DATE	TIME (HR., MIN., SEC.)	TEMPERATURE (°F)	INTERVAL**
START OF MINUTES PLOT			
8/09/83	9:15:03	128.2	----
8/09/83	9:24:51	272.6	9:48
8/09/83	9:34:33	309.6	19:30
8/09/83	9:41:54	271.7	26:48
8/09/83	9:43:13	246.0	28:01
8/09/83	9:48:37	255.0	33:34
8/09/83	9:52:01	255.0	36:58
8/09/83	9:57:02	209.8	41:59
START OF HOURS PLOT			
8/09/83	11:37:32	138.0	2:22:29
8/09/83	11:48:03	138.0	2:33:00
8/09/83	13:08:15	104.7	3:53:12
8/09/83	13:21:36	104.7	4:06:33
8/09/83	13:29:21	99.3	4:14:18
8/09/83	13:33:46	99.3	4:18:43
8/09/83	13:38:46	128.2	4:23:43
8/09/83	14:07:37	128.2	4:52:34
8/09/83	14:10:05	266.7	4:55:02
8/09/83	21:11:38	259.0	11:56:35
START OF DAYS PLOT			
8/10/83	9:06:50	242.6	23:51:47
8/10/83	23:12:50	236.4	37:57:47
8/11/83	6:14:42	241.0	53:59:39
8/12/83	12:06:13	241.0	74:51:10
8/13/83	12:06:13	230.5	98:51:10
8/13/83	20:17:12	227.5	107:02:09
8/14/83	8:06:35	225.8	128:51:32
8/15/83	08:47:16	233.5	143:32:13
8/15/83	20:17:12	229.6	155:02:09
8/16/83	20:17:12	225.0***	179:02:09
8/19/83	7:40:37	211.0****	238:25:34
9/29/83	17:05:14	211.0	1231:50:11

Non-Proprietary Version

END OF TESTING PERIOD

*The level of qualification required and demonstrated in this package is that of Figure B1 (LOCA "A"); this data reflects actual conditions measured during testing. Table DT1 shows the actual data points plotted as a temperature profile in Figure DT1. Plot points are for changes; values were relatively stable at the tail of the accident exposure; values are conservative averages of the variation. For conservatism, the post-accident analysis uses values 5°F lower than plotted to account for minor inaccuracies which may exist.

**Interval from start of exposure expressed in hours, minutes and seconds.

***Temperature plateau at 225°F until next data point change (8/19/83 at 07:40:37).

****Temperature plateau at 211°F until Test Termination (9/29/83 at 17:05:14)

LONG-TERM POST-ACCIDENT OPERABILITY ANALYSIS FOR TRANSMITTERS

Purpose: To verify that the DBA testing of NTS Report[9] and Figure DT1 and Table DT1 of this subsection, envelop the conservatively assumed post-accident period of 360 days, post-DBA operability requirements (conservatively developed in subsection DO).

Reference: Generic Plant Requirements developed earlier in subsection DT and Test Data (Figure DT1 and Table DT1).

Basis: The accident ambient temperature following a DBA reduces to 120°F or less, as defined earlier in this subsection.

The basis for the analysis is the Arrhenius equation which is defined as:

$$t_1 = t_2 \, e^{\,phi/k \, (1/T1 \,-\, 1/T2)}$$

Where:

t_1	=	Equivalent time at service temperature T_1
t_2	=	Time at temperature T_2
T_1	=	Service Temperature (in °K) corresponding to t_1
T_2	=	Temperature (in °K) corresponding to t_2
phi	=	Activation energy (in electron volts)
k	=	Boltzmann constant, 8.617×10^{-5} eV/°K

An activation energy of 0.96 eV was identified in the aging analysis based on NTS materials breakdown review (as described in Subsection DA) for the weak-link component used in the qualified Gulton-Statham transmitters and the footnote below*.

The traditional and technically correct method of addressing temperature transient periods is a physical review of the demonstrated accident profile against the plant requirements and assuring that the test is enveloping.

Non-Proprietary Version

*The worst case activation energy was provided for a Neoprene gasket ("O"-ring) not used in these transmitters; Viton™ is utilized. The 0.96 eV value is for the next lowest activation energy item, Silicon solid-state components. Refer to NTS Plots from Figures 1 and 2 of Exhibit I to the NTS Procedure[10] (Analysis Report pages 45 and 46).

- **NOTE 1:** A nuclear accident will not have two (2) accident transients. Consequently, the first transient may be considered additional margin. (see Figure DT2).

- **NOTE 2:** Very short duration accident exposures at high temperature conditions (especially superheat), may not impact the qualification due to thermal lag. Should concern exist for short transients (approximately five (5) minutes or less) above the qualification level, please contact Gulton-Statham to discuss possible thermal lag analysis to demonstrate qualification by methods previously accepted by the regulatory agency.

The Gulton-Statham analysis is in keeping with the intent of such standards as IEEE 317-1983[33] where it is stated in Paragraph 6.3.3(b):

(b) Accelerated Thermal Testing may be used to simulate the temperature-time profile following the major temperature transient(s) of the most severe DBE environmental conditions[8]."

Superscript 8 of the quotation states, "[8] In IEEE Std 323-1983, see time T_4 of Figure 1," where the T_4 point refers to the plateau endpoint of the peak transient (Figure 1 of IEEE 323-2983 is included as Figure DT2 in this subsection). the T_4 point corresponds to the T_N designation on Figure DT2.

The NRC has accepted the IEEE 317-1983 methodology in the post-10CFR50.49 environment as endorsed by USNRC Regulatory Guide 1.63, Revision 3, dated February 1987[34].

For the subject transmitters, the operability analysis using accelerated aging techniques will begin at the time equal to approximately 7.5 days (the beginning of the 211°F plateau very conservatively after more than 238 hours of accident exposure) on August 19, 1983, per Table DT1.

Non-Proprietary Version

DEMONSTRATED CAPABILITY VS. REQUIREMENTS

As discussed above, the transient peaks are enveloped by test. For outside containment events, the seven (7) day accident transient period is very conservative. For further conservatism we will assume that the long-term stable period is the full 360-day period (in reality, the total period would include the transient period such that a 360-day duration for our example would be approximately seven (7) days of transient and 353 days of long-term stable operation -- not 360 days).

The accident exposure plateau (see Table DT1) of 211°F begins at 238 hours, 25 minutes, and 34 seconds and ends at 1231 hours, 50 minutes, and 11 seconds for a duration of 993 hours, 24 minutes, and 37 seconds determined below.

TOTAL STABLE PLATEAU PERIOD = PLATEAU END TIME - PLATEAU BEGIN TIME START

TOTAL STABLE PLATEAU PERIOD = 1231:50:11 - 238:25:34

TOTAL STABLE PLATEAU PERIOD = 993:24:37

For conservatism we use 993 hours in the analysis.

CASE 1: 180 DAYS AT 120°F

Where:

t_1 = Equivalent time at service temperature T_1 (120°F in this case)

t_2 = Time at temperature T_2
t_2 = 993 hours @ 211°F less 5°F margin
t_2 = 993 hours @ 206°F

T_1 = Service temperature (in °K) corresponding to t_1
T_1 = Service temperature of 120°F = 322.04(°K) corresponding to t_1

T_2 = Temperature (in °K) corresponding to t_2
T_2 = Test temperature of 211°F less 5°F margin = 369.82 (°K) corresponding to t_2

phi = Activation energy (in electron volts)
phi = 0.96 eV s previously determined (also see Section DA)

k = Boltzmann constant, 8.617×10^{-5} eV/°K

t_1 = $t_2 e^{\text{phi/k}\ (1/T1 - 1/T2)}$
t_1 = 993 hours x $e^{(0.96/8.617 \times 10\text{-}5\ \text{eV/}^\circ\text{K})(1/322.04 - 1/369.82)}$
t_1 = 8.145 E04 hours
t_1 = 9.29 years

Non-Proprietary Version

CONSERVATIVE CAPABILITY VS REQUIREMENTS MARGIN

The requirement was previously determined to be 360 days (or 24 hours/day x 360 days = 8640 hours) at 120°F. The demonstrated capability of 8.145 E04 hours at 120°F.

Therefore, the transmitters envelop the requirement with the following substantial margin:

$$\text{PERCENT MARGIN} = \frac{\text{CAPABILITY - REQUIREMENT}}{\text{REQUIREMENT}} \times 100\%$$

$$= \frac{8.145\text{ E04} - 8640}{8640} \times 100\%$$

$$= 843\%$$

This margin is almost two (2) orders of magnitude greater than the suggested margin factor for consideration in IEEE 323[2,3].

The Gulton-Statham Transmitters are demonstrated qualified for a very conservative post-accident operability requirement of 360 days with significant margin.

For convenience, the post-operating time is provided in 1 degree F (1°F) increments from 90°F to an extremely conservative 145°F in Figures and Tables located at the end of this subsection.

Non-Proprietary Version

CONCLUSION

Transmitters are qualified for post-accident operability with substantial margin.

*FIGURE DT2 -- IEEE METHOD TO EXTRAPOLATE HELB/LOCA TAIL FOR LONG-TERM POST-ACCIDENT ANALYSIS**

FOR NUCLEAR POWER GENERATING STATIONS

IEEE
Std 323-1983

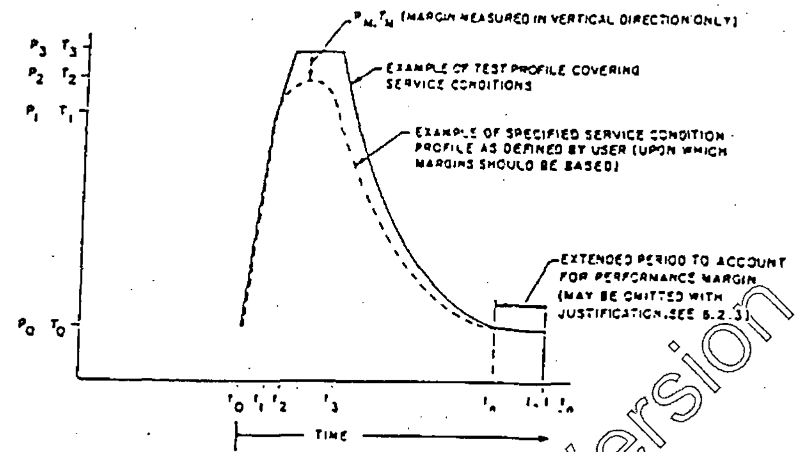


Fig 1
Typical LOCA/HELB Temperature and Pressure Illustrating
Application of Time, Temperature, and Pressure Margins

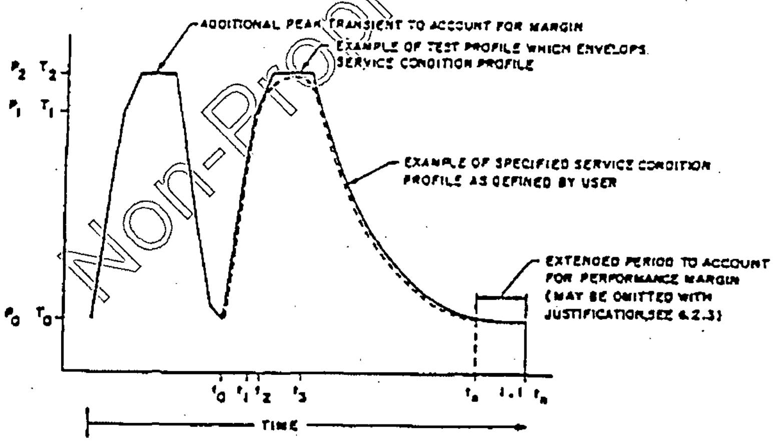


Fig 2
Typical LOCA/HELB Temperature and Pressure Illustrating
Additional Peak Transient to Account for Margin

Non-Proprietary Version

*Please see previous discussion of NRC acceptance of approach first officially documented in USNRC Regulatory Guide 1.63, Revision 3 [34]. Figure taken from IEEE 323-1983[3], Figures 1 and 2.

FIGURE DT3
POST-ACCIDENT OPERATION vs TEMPERATURE 130°F - 145°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE DT4
POST-ACCIDENT OPERATION vs TEMPERATURE 115°F - 130°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE DT5
POST-ACCIDENT OPERATION vs TEMPERATURE 100°F - 115°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE DT6
POST-ACCIDENT OPERATION vs TEMPERATURE 90°F - 100°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

TABLE DT2
POST-ACCIDENT OPERATION vs TEMPERATURE DATA

PROPRIETARY DATA
TABLE REMOVED

Non-Proprietary Version

TABLE DT2
POST ACCIDENT OPERATION vs TEMPERATURE DATA
(Continued)

PROPRIETARY DATA
TABLE REMOVED

Non-Proprietary Version

SUBSECTION DP - PARAMETER PRESSURE

The transmitters are assumed to be installed throughout the plant. As such, they are expected to experience the nominal atmospheric conditions (14.7 PSIA) during normal operation.

OUTSIDE CONTAINMENT AND DRYWELL

During accident conditions for essentially all areas outside containment or drywell, the accident pressure from a pipe break environment is typically less than 5 PSIG.*

As indicated in the data in Section B, Figure B1, the specified pressure was 17.6 PSIG during accident simulation. Furthermore, consistent with the margin guidance of IEEE 323[2, 3], there was a requirement for a 15 PSIG margin for a total required pressure test of 32 PSIG. This is confirmed in the "Change in Procedure" (C.O.P.) form NTS (Report[9] page 54) for C.O.P. L-4 where the needs to complete functional testing led to extending the exposure beyond the original planned period of time.

The actual qualification tests were at saturated conditions as described in "Change in Procedure" (C.O.P.) from NTS (Report[9] page 55) for C.O.P. L-5. As the peak temperatures of the Qualification Test described in subsection DT were at 270°F or higher (309°F peak) for fifteen (15) minutes, the testing pressure is compatible with an actual LOCA (30-50 PSIG).

All conditions outside drywell or containment should be enveloped with substantial margin on the basis of a 32 PSIG qualification, even when using the conservative 15 PSIG values suggested by IEEE 323[2, 3].

INSIDE CONTAINMENT AND DRYWELL

For In-Containment or Drywell-type accidents, the pressure can be appreciably higher than other plant areas. Values suggested by IEEE 382[22] are as high as 70 PSIG for a PWR and 30 PSIG for a BWR (Mark III) in Figures B1-B3 of the standard. Actual plant pressure conditions, worst case, relate to the saturated steam condition associated with their accident event. Typical plants having performed detailed accident analysis usually have a worst case environment of less than 50 PSIG, which corresponds to worst case LOCA events with approximately 300°F peak temperatures. Main Steam Line Breaks usually result in superheat conditions with an accident pressure well below LOCA. The actual qualification tests were at saturated conditions as described in "Change in Procedure" (C.O.P.) form NTS (Report[9] page 55) for C.O.P. L-5. As the peak temperatures of the qualification Test described in subsection DT were at 270°F or higher (309°F) for fifteen (15) minutes, the testing pressure is compatible with an actual LOCA.

*NOTE: IEEE 382[22] includes a Figure B4, "Reference Service Conditions Line-Break Parameters Outside Containment (BWR and PWR)" that indicates atmospheric pressure which may not be conservative.

Non-Proprietary

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Should a user require specific pressure qualification above the 32 PSIG level used in the LOCA "A" Report (which was exceeded by this test), Gulton-Statham should be contacted as other data is, or may be available to meet a unique application need which is not "generically" provided.

CONCLUSION

The transmitters are considered qualified for this parameter, with substantial margin for typical areas outside containment or drywell.

The transmitters (on a generic basis) may not be qualified for this parameter, with requisite expected margin for worse case accidents inside containment or drywell.

Contact Gulton-Statham for assistance for a unique application.

Non-Proprietary Version

SUBSECTION DH -- PARAMETER: RELATIVE HUMIDITY

NORMAL OPERATION

The effects of humidity during normal operation are not considered to be degrading. The NRC has reached the same conclusion as industry that, "It has not been demonstrated that the time dependent variation in humidity will produce any differences in degradation of electric equipment," as stated in comments to 10CFR50.49 (Federal Register, Vol 48, No. 15, page 2732, "Comments"). The normal relative humidity conditions specified for normal plant operation are almost always less than 95%.

Note: The Gulton-Statham Transmitters are designed for normal operation at 100% humidity and are designed for submersible service*.

ACCIDENT

As an accident for an HELB event includes a pipe break, as does the requirements for qualifying the Gulton-Statham Transmitters (see Figure B1 of Section B), the units are qualified for 100% humidity.

The subsections DT and DP described the accident LOCA "A" simulation. This was a saturated steam qualification. Saturated steam, by definition, represents 100% relative humidity at its saturation condition. This was the condition of testing which started out as all steam and was maintained at 100% RH as described in Figure B1.

Non-Proprietary Version

CONCLUSION

The transmitters are demonstrated qualified for this parameter.

*The nuclear transmitters are based on the commercial 3000 Series Transmitters which are used as submersible industrial transmitters to measure reservoir/dam levels, sub-sea wellhead pressure, waste water, and other applications that take advantage of the welded sealed construction.

NOTE: The present qualification test program did not include complete submergence under LOCA in the sequence of testing such that a claim for nuclear submersion qualification after LOCA is not being made. Unique application support is, however, available for many applications. Additional data is found in Subsection DS.

SUBSECTION DC -- PARAMETER: CHEMICAL SPRAY

OUTSIDE CONTAINMENT AND DRYWELL

During accident conditions essentially all areas outside containment or drywell are not subject to Chemical Spray. This parameter is therefore not applicable for the majority of applications.

However, these units have been subjected to pipe break simulation and an accidental spray of deionized water, as described in Figure B1, modified by Change in Procedure (C.O.P.) form NTS (Report[9] page 51) for C.O.P. L-2 where deionized water was substituted for demineralized water.

INSIDE CONTAINMENT AND DRYWELL

Inside drywell requirements of BWRs differ in their use of spray systems. BWRs have been designed to include such sprays while others do not have such spray systems. As described in the previous paragraph, deionized spray was used which may envelop BWR applications where spray is used.

For In-Containment of a PWR which uses a borated chemical spray, the application has not been specifically enveloped in the LOCA "A" test being used for qualification. Gulton-Statham testing for LOCA "B" added after the qualification program started as described in Change in Procedure (C.O.P.) form NTS (Report[9] pages 52 and 53) for C.O.P. L-2 would generally be enveloping. Specifically, Gulton-Statham added a PWR Chemical Spray requirement as part of its LOCA "B" test as described in Change in Procedure (C.O.P.) form NTS (Report[9] pages 49 and 50) for C.O.P. L-1. However, due to anomalies experienced during this test, no credit is being taken generically for this test data.

Should a user require specific Chemical Spray qualification for in-containment use, Gulton-Statham should be contacted as other data is or may be available to meet a unique application need which is not being "generically" provided*.

Non-Proprietary Version

*The nuclear transmitters are based on the commercial 3000 Series Transmitters which are used as submersible industrial transmitters to measure reservoir/dam levels, subsea wellhead pressure, waste water, and other applications that take advantage of the welded sealed construction.

NOTE: The present qualification test program did not include PWR chemical spray testing such that a claim for nuclear qualification during LOCA is not being made. Unique application support is however, available for many applications which would provide qualification by analysis supported by test data.

CONCLUSION

The transmitters are considered qualified for this parameter, with margin for typical areas outside containment or drywell as they have been exposed to a spray environment, and these areas do not see such an environment.

The transmitters require user review for qualification for this parameter, with requisite expected margin for worst case accidents inside drywell or equivalent BWR environments where spray is used.

Note: The LOCA "A" environment was originally developed to meet the accident definition of a BWR (Reference 2.2.7 of NTS Procedure[10]).Contact Gulton-Statham for assistance for a unique application.

The transmitters (on a generic basis) may not be qualified for this parameter, with requisite expected margin for worst case accidents inside PWR containment. Contact Gulton-Statham for assistance for a unique application.

Non-Proprietary Version

SUBSECTION DR -- PARAMETER: RADIATION

The purpose of this review is to demonstrate that the Gulton-Statham Transmitters are qualified for all reasonably expected plant environments, including worst case generic radiation.

The review is therefore generic. Radiation degradation of a material's properties is the result of its exposure to ionizing radiation. The amount of this degradation will depend on the cumulative amount of radiation, the radiation sensitivity of the various materials used in the item, and the function or required properties of the individual components needed to prevent failure of the item. For environmental qualification purpose, only Neutron, Beta and Gamma radiation doses are of concern. The three (3) radiation types have different physical interactions, but the total radiation dose is generally the controlling mechanism.

The general considerations concerning radiation types are summarized below:

- Gamma radiation, due to its penetrating power, is important for both airborne and contained sources and is used in vendor qualification tests and is acceptable to the NRC.

- Beta radiation is usually important only for airborne sources, but, due to its low penetration power, its effect is attenuated by a thin covering of metal or insulation. The basic design of the Gulton-Statham Transmitter with its sealed construction and metal encasement of vital susceptible organic, essentially precludes Beta concern.

- Neutrons are important only inside the reactor cavity. The transmitters are obviously not subject to neutron radiation.

Radiation degradation or Aging, if it is significant, is generally proportional to the total radiation dose the equipment has received in its lifetime. This is often called "Total Integrated Dose" or T.I.D.

The unit of radiation normally used to measure doses to materials is the RAD. It represents an absorbed dose (i.e. energy deposited in the material) of 100 ergs/g. Dose from any type of radiation (Neutron, Beta, Gamma) can be expressed in Rads.

Radiation effects or material changes can be positive or negative. Negative changes are the primary concern for EQ due to its significance to qualification. But, a definition of negative is application-dependent. For example, the cross-linking of polyethylene under radiation causes significant reduction in elongation and increase in hardness and tensile strength. For a specific application, the radiation-changed material may be preferred. This is often the case for cross-linked polyethylene (e.g. cross-linked polyethylene used in SIS wire, Firewall III, etc.)

Non-Proprietary Version

Electronics have a transient radiation effect, as explained in Section A, and NTS Analysis Report (Exhibit I to NTS Procedure[10], Paragraph 5.5.4). Gulton-Statham exposed the units to high dose rates and monitored results during exposure for conservatism. Actual accuracy results are shown in Section A. All were satisfactory.

GENERIC REASONABLE RADIATION VALUES

The total integrated dose of 20 Megarads is generically acceptable and reasonable value, even for containment established for both old and new plants by the NRC [values that exist up to an order of magnitude greater are derived from very conservative IEEE guidance in various standards, e.g. IEEE 383-1974, Reference 23 (Paragraphs 2.3.3.3 and 2.4.2), has 200 Megarads].

There are no known pressure transmitters in any drywell of any BWR in the United States. Consequently the limiting condition for generic selection of a radiation value is PWRs, which do contain pressure transmitters. Use of the PWR in-containment value is considering enveloping for the entire plant (although a unique application may exist).

Prior to the issuance of the EQ Rule[1] during the late 1970s, much discussion occurred to establish a bounding radiation value that was both realistic and conservative, without adoption of the believed unrealistic values in the aforementioned IEEE standard. When the NRC undertook the task of reviewing every operating reactor in the late 1970s and early 1980s (approximately seventy units), they established an acceptable screening criteria in their Bulletin to the Industry[7], Enclosure 4, DOR Guidelines, Section 4.1, "Service Conditions Inside Containment for a Loss of Coolant Accident LOCA" which was as follows:

"Gamma Radiation Doses -- A total Gamma dose radiation condition of 2×10^7 rads is acceptable for Class 1E Equipment located in general areas inside containment for PWRs for dry type containments."

The USNRC current Regulatory Guide for EQ, RG 1.89, Revision 1[18] (NRC staff expectation for all recent or new plants in US), contains an Appendix D, "Methodology and Sample Calculation for Qualification Radiation Dose" that addresses the issue. This document is meant to envelop the largest nuclear plants (volume up to 2.5 million cubic feet and 4100 MW thermal rating) and contains the following in Paragraph 5, "Conclusion:"

"The values given in Table D-1 and Table D-2 and Figure D-1 for the various locations in the containment provide an estimate of expected radiation qualification for a 4100 MWt PWR design."

The total one (1) year Gamma dose from an accident is given as 1.54 E07 Rads. Even if an incredible 10 Rads an hour was at the transmitter location, normally, this only becomes 0.35 E07 Rads in forty (40) years (3.5 E05 hours x 10 Rads/hr) such that a 2 E07 Rad value is clearly a reasonable generic value.

Consequently, for our review, we use this radiation value.

CAPABILITY DEMONSTRATED BY QUALIFICATION TEST

As indicated in the NTS Report[9], Paragraph 5.2.3, NTS Report pages 5 and 6, the transmitters were irradiated by a Cobalt 60 source. As indicated in NUREG 0588[6] for the most stringent qualification requirements (NRC designated NUREG 0588, Category 1 equipment) Paragraph 2.2, "Qualification by Test," subparagraph (12), "Cobalt 60 is an acceptable Gamma radiation source for environmental qualification."

The NTS Change in Procedure (C.O.P.) form NTS (Report[9] page 47) or C.O.P. 13 identifies eight (8) transmitters for irradiation at a T.I.D. of 33 and 55 Megarads, nominal for the PD 3200 and PG 3200 transmitter units. All of these units (two of each type), were exposed to either the LOCA "A" or LOCA "B" accident profiles (see Figures 7 and 8 of NTS Report[9], NTS pages 23 and 24).

Specific Data (August 9, 1983 certification) provided by the irradiation facility found in Exhibit 1 of the NTS Report, indicate the following for the transmitters of interest (those which went on to Seismic Qualification and LOCA "A" Qualification):

PG 3200-100 XXXXX

2 hours @ 3.10 Megarads/Hr	=	6.2 Megarads
23.17 hours @ 2.12 Megarads/Hr	=	49.01 Megarads
T.I.D.	=	**55.21 Megarads**

PG 3200-100 XXXXX

2.52 hours @ 3.10 Megarads/Hr	=	7.812 Megarads
4.18 hours @ 2.12 Megarads/Hr	=	8.862 Megarads
14.18 hours @ 1.22 Megarads/Hr	=	17.3 Megarads
T.I.D.	=	**33.974 Megarads**

Non-Proprietary Version

PD 3200-200 XXXXX

2 hours @ 4.4 Megarads/Hr	=	8.8 Megarads
7 hours @ 2.03 Megarads/Hr	=	14.21 Megarads
9.5 hours @ 1.25 Megarads/Hr	=	11.875 Megarads
T.I.D.	=	**34.885 Megarads**

PD 3200-200 XXXXX

2 hours @ 4.4 Megarads/Hr	=	8.8 Megarads
23 hours @ 2.03 Megarads/Hr	=	46.59 Megarads
T.I.D.	=	**55.49 Megarads**

Non-Proprietary Version

The data presented does not account for dosimetry potential uncertainty. Radiation data provided with the NTS Report[9], Exhibit 1, includes a review of the dosimetry used against NBS measurements with a worst case percent (%) difference shown of -6.08%. To be conservative, we will increase that worst case uncertainty by more than 130% to a worst case uncertainty of -8% of recorded or stated dose.

CASE 1 - LOWER BOUNDARY OF DEMONSTRATED QUALIFICATION

The least radiation dose received for any transmitter was for transmitter PG 3200-100 XXXXX with a T.I.D. of 33.974 Megarads. Applying the worst case uncertainty of -8% results in a conservative assumed radiation of 31.26 Megarads (0.92 x 33.974 = 31.26).

CASE 2 - UPPER BOUNDARY OF DEMONSTRATED QUALIFICATION

The greatest radiation dose received for any transmitter was for transmitter PD 3200-200 XXXXX with a T.I.D. of 55.49 Megarads. Applying the worst case uncertainty of -8% results in a conservative assumed radiation of 51.05 Megarads (0.92 x 55.49 = 51.05).

Every transmitter functioned properly, as described in Section A, such that it is reasonable to claim a nominal radiation capability up to 51 Megarads.

MARGIN IN QUALIFICATION OVER GENERIC WORST CASE ENVELOPING VALUE

As demonstrated previously, a reasonable radiation requirement for nuclear power plants is 2E07 Rads, T.I.D. Margin in Qualification is compared to this number.

CASE 1 - LOWER BOUNDARY OF DEMONSTRATED QUALIFICATION

MARGIN = (CAPABILITY - REQUIREMENT)/(REQUIREMENT) X 100%

MARGIN = (31.26 E06 - 20 E06)/(20 E06) X 100%

MARGIN = 56.3%

CASE 2 - UPPER BOUNDARY OF DEMONSTRATED QUALIFICATION

MARGIN = (CAPABILITY - REQUIREMENT)/(REQUIREMENT) X 100%

MARGIN = (51.05 E06 - 20 E06)/(20 E06) X 100%

MARGIN = 155.25%

These margin values are significantly greater than the 10% suggested margin factor for consideration in IEEE 323[2, 3].

The Gulton-Statham transmitters are demonstrated qualified for a very conservative radiation levels, up to 51 Megarads.

Non-Proprietary Version

CONCLUSION

Transmitters are qualified for radiation to worst case industry generic values with substantial margin.

SUBSECTION DA - AGING

The purpose of this review is to establish a qualified life for the transmitters and which may be installed in various plant areas.

For maximum usefulness, this Section provides data to allow determination of qualified at various temperatures.

The aging data (Figures DA1-DA4 and Table DA1) provides information on Qualified Life in one degree F (1°F) increments from 70°F* to 130°F, which will facilitate convenient adjustment and should exceed all application needs.

As indicated in QDR Section D, subsection DT, temperature rise due to operation of the low level current-carrying transmitters is negligible. Therefore the temperature rise does not need to be considered when establishing the qualified life for these instruments.

The following analyses and calculation is provided to determine the qualified life for the transmitters based on the pre-aging testing by Gulton-Statham as summarized below.

Non-Proprietary Version

TRANSMITTER EVALUATION

The transmitters were type-tested as described in the NTS Report[9] in QDR Section G.1. As part of the type-testing, the transmitters were thermally aged as stated in Section 5.2.1 of the NTS Report[9] (NTS Report page 4). the original basis for thermal aging was a 221°F exposure for 11.9 days for the transmitters, which was extended by an error by NTS leading to an exposure period of 16 days and 6 hours (total of 390 hours), as documented in NTS Notice of Deviation #1 (on page 56 of the NTS Report). Review of the NTS procedures and report (References 9 and 10) and the various data sheets, confirms the following:

1. Initial analysis by NTS was based on aging the transmitters for the least capable organic material used (Neoprene O-Rings), which have an activation energy of 0.87 eV, followed by Silicone solid-state components, with activation energy of 0.96 eV. Time temperature curves with these activation energies are presented in Figures 1 and 2 of the Analysis Report (NTS page number 45 and 46), forming a part of the NTS Procedure[10]. The actual time temperature analysis based on Arrhenius aging theory is presented in the analysis in Paragraphs 5.3.2.5 and 5.3.2.6. The PD 3218 units contained the Neoprene O-rings in the "smaller junction boxes" described in the NTS Procedure[10], Paragraph 3.2.1 and were aged separately and earlier than the PD 3200 and PG 3200 units demonstrated qualified in this QDR (e.g. only the total of eight (8) PG 3200 and PD 3200 units planned for LOCA "A" and LOCA "B" exposure were exposed to the 16-day and 6-hour aging of subject to aforementioned Notice of Deviation #1).

*Even though a plant location may be less than 70°F during periods of the transmitters' installed life, the data below 70°F is not provided as the qualified life at 70°F is well beyond plant license duration. See Figure DA1.

2. The PD 3200 and PG 3200 units were mechanically cycled for 1000 cycles in lieu of original plan for 572 cycles (Change of Procedure 2 in NTS Report[9], page 39), which was accomplished by cycling from 25% of the maximum pressure value (URL) to 75% of this value then back to the 25% pressure value. This is very severe as the cycle rate is high to accomplish the cycling during thermal aging and cycling is occurring while the units are being stressed in the thermal oven.

3. As the transmitters were in the oven and the only means of calibration adjustment is with the magnetically-coupled adjustment screws shown in Figure A3, the units were functional throughout their demonstrated qualified life without calibration adjustment. Accuracy checks during the aging exposure and post-aging confirmed operability within qualification acceptance values established in Section A (e.g. Tables A9 and A10).

Non-Proprietary Version

The determination of qualified life is therefore based on the testing of the transmitters based on the weak link, lowest activation energy component. This is the Silicone solid-state components with an activation energy as previously determined of 0.96 eV. Using Arrhenius methodology and the "weakest link" component argument, the above thermal aging test data was converted to a qualified life line equation for the complete unit.

The following calculations are performed to determine the actual qualified life of the transmitters based on Gulton-Statham thermal aging data and an assumed conservative ambient temperature of 100°F. This is an example of the approach, as this QDR is providing Figures DA1 through DA4, as well as Table DA1 for user access to results from sixty-one (61) calculation (in 1°F increments) of qualified life from 70°F through 130°F. Table DA1 provides input data for easy user checking.

EXAMPLE QUALIFIED LIFE ANALYSIS FOR TRANSMITTERS

PURPOSE: To determine the Qualified Life by use of one (1) example demonstrating the approach used to provide qualified life for ambients of 70°F to 130°F. The analysis is based on 100°F for convenience (mid-range of provided data to the user).

REFERENCE: Generic Plant Requirements developed earlier in subsection DT and Test Data (see previous review of Type-Test Data presented in Figure DT1 and Table DT1).

BASIS: The continuous ambient temperature is assumed (for this illustrative calculation) to be 100°F.

The basis for this analysis is the Arrhenius* equation which is defined as follows:

$$t_1 = t_2\, e^{phi/k\,(1/T1 - 1/T2)}$$

Where:

t_1 = Equivalent time at service temperature T_1

t_2 = Time at temperature T_2

T_1 = Service temperature (in °K) corresponding to t_1

T_2 = Temperature (in °K) corresponding to t_2

phi = Activation energy (in electron volts)

k = Boltzmann constant, 8.617×10^{-5} eV/°K

An activation energy of 0.96 eV was identified in the aging analysis based on NTS materials breakdown review (as described in this subsection DA) for the weak-link component used in the qualified Gulton-Statham Transmitters and the footnote below**.

QUALIFIED LIFE DEMONSTRATION

Sample Case: Continuous 100°F

Where:

t_1 = Equivalent time at service temperature T_1 (100°F in this case)

t_2 = Time and temperature T_2

t_2 = 360 hours @ 221°F

T_1 = Service temperature (in °K) corresponding to t_1

T_1 = Service temperature of 100°F = 310.93°K corresponding to t_1

T_2 = Temperature (in °K) corresponding to t_2

*Use of Arrhenius methodology is the NRC accepted method as stated in NUREG 0588[6] where it states in Section 4 (for the most stringent NUREG 0588 Category 1), subparagraph (4) The Arrhenius methodology is considered an acceptable method for addressing accelerating aging." An excellent text on the approach and its "limits" is EPRI NP 1558[35].

**The worst case activation energy was provided for a Neoprene gasket ("O"-Ring) not used in these transmitters; Viton™ is utilized. The 0.96 eV value is for the next lowest activation energy item, Silicon solid-state components. Refer to NTS plots from Figures 1 and 2 of Exhibit I to the NTS Procedure [10] (Analysis Report pages 45 and 46).

Non-Proprietary Version

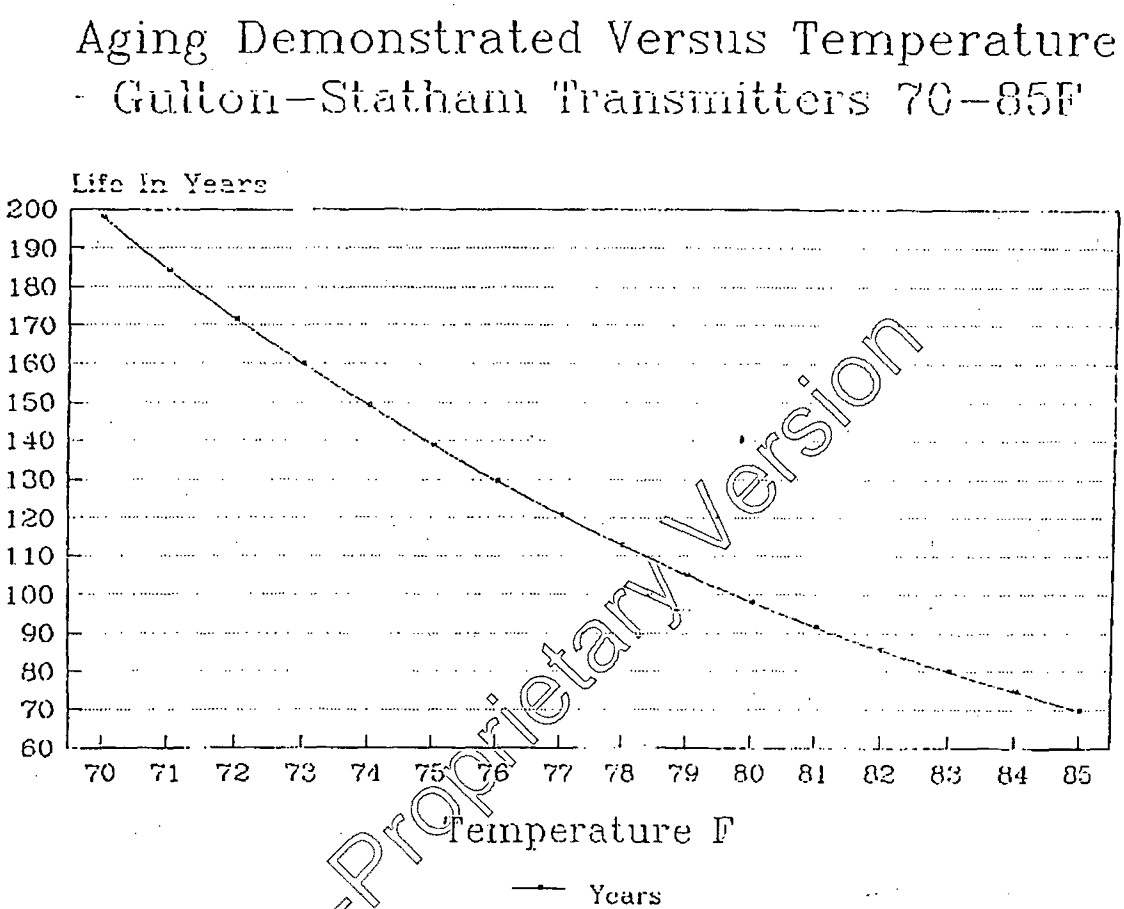
T_2	=	Test temperature of 221°F = 378.15°K corresponding to t_2
phi	=	Activation energy (in electron volts)
phi	=	0.96 eV as previously determined
k	=	Boltzmann constant, 8.617 x 10^{-5} eV/°K
t_1	=	$t_2 \, e^{phi/k \, (1/T1 - 1/T2)}$
t_1	=	390 hours x $e^{(0.96/8.617 \times 10^{-5} eV/°K)(1/310.93 - 1/378.15)}$
t_1	=	2.277 E05 hours
t_1	=	25.99 years

Non-Proprietary Version

DATA FOR QUALIFIED THERMAL LIFE BASED ON 70°F TO 130°F AMBIENTS

Data presented in Figures DA1 through DA4 and Table DA1 provide readily useful qualified life data for the user. The results are based on thermal degradation concepts using Regulatory Agency accepted approaches. Obviously, qualified life for transmitters of hundreds of years does not account for obsolescence or other aspects which would limit life. (Likewise, this data should not be misconstrued to imply that transmitters do not belong under a prudent calibration, plant surveillance and maintenance program). This data is presented to illustrate the substantial margin which exists at moderate ambient temperatures and allows easy user use of Gulton-Statham data.

FIGURE DA1
QUALIFIED LIFE vs TEMPERATURE 70°F - 85°F



Non-Proprietary Version

FIGURE DA2
QUALIFIED LIFE vs TEMPERATURE 85°F - 100°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE DA3
QUALIFIED LIFE vs TEMPERATURE 100°F - 115°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

FIGURE DA4
QUALIFIED LIFE vs TEMPERATURE 115°F - 130°F

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

TABLE DA1
QUALIFIED LIFE vs TEMPERATURE DATA

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

TABLE DA1
QUALIFIED LIFE vs TEMPERATURE DATA
(Continued)

PROPRIETARY DATA
FIGURE REMOVED

Non-Proprietary Version

SUBSECTION DS -- SUBMERGENCE

SUBMERGENCE GENERALLY NOT REQUIRED

Pressure Transmitters are generally not located in an area in which post-accident submergence is necessary in a nuclear power plant or similar regulated nuclear facility. Consequently, the comprehensive test program instituted for the nuclear qualified Gulton-Statham Transmitters did not include submergence in the initial phase of qualification.

GULTON-STATHAM SUBMERGENCE QUALIFIED TRANSMITTERS

However, the Gulton-Statham Transmitters are rather unique in the industry, as they are based on the Gulton-Statham 3000 Series (with enhanced radiation-hardened or temperature-capable materials), within the Gulton-Statham hermetically-designed enclosure. Gulton-Statham Transmitters are found in submerged service to measure reservoir/dam level, sub-sea well head pressure, shipboard ballast control, in-ground tank level, as well as wastewater applications.

Subsequent to completion of the initial testing for LOCA qualification, Gulton-Statham provided submergence testing. This is documented in Project Engineering Report 0648-84-200-NUC-0711, "3200 Series Nuclear Qualified Pressure Transmitters Submergence Test Report," dated September 9, 1985.

Using one each of the "controlled" units from the qualification testing (PD 3200-200 XXXXX and PG 3200-100 XXXXX), which is shown traceable to the original qualification program in Section 2K of Part A of this Qualification file and the junction box which went through LOCA testing (PD 3200-200 XXXXX and PG 3200-100 XXXXX), a very conservative test configuration was established.

Using a test set-up consistent with that described in Section A and the same five (5) point function test method, the units were submergence tested for fourteen (14) days in five (5) feet of enhanced conductivity water. The units performed satisfactorily.

Note: The testing was not done under an external pressure condition. However, it does demonstrate submergibility in situations enveloped by the testing. Furthermore, it validates the integrity of the Viton™ gasketed Gulton-Statham junction boxes and further enhances the demonstration of the overall integrity of Gulton-Statham Transmitters.

Non-Proprietary Version

CONCLUSION

1. Submergence capability demonstrated within the limits of Project Engineering Report 0648-84-200-NUC-0711, "3200 Series Nuclear Qualified Pressure Transmitters Submergence Test Report" after severe harsh environment exposure.

2. The scope of this qualification file is demonstration of a completely qualified transmitter for all events associated with worst case accident exposure. Most often submergence service is for a unit which does not see the very harsh level of qualification in this program. Therefore, for most applications, a far more comprehensive level of submergence (in harsh fluids, under pressure, etc.) is available.

Non-Proprietary Version

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

Non-Proprietary Version

SECTION E

INSTALLATION AND MAINTENANCE REQUIREMENTS

1. MAINTENANCE REQUIREMENTS / INTERVALS

This equipment does not require special maintenance/surveillance as the basis for continued qualification. Furthermore, no maintenance or surveillance requirements have been established as a result of this qualification review.

Maintenance which would be identified herein if it was necessary, is that which is required to ensure continued environmental and seismic qualification.

The user is expected to evaluate and justify deviations from recommendations in the Gulton-Statham instruction manuals in compliance with the appropriate quality requirements (e.g. 10CFR50 Appendix b, ASME NQA-1) in effect at the user installations.

For transmitters in a pipe break environment or submerged service where the integrity of the junction box seal relates to retention of qualification, Gulton-Statham instruction manual recommendations for replacement of the Junction box O-rings after O-Ring disturbance. In addition, the customer who procures units without Gulton-Statham's junction box (Code 2 designation on Tables A2, A4, A8), in pipe break areas must use metallic conduit/flex conduit with metallic core to the NPT connection on the transmitter.

2. REPLACEMENT REQUIREMENTS

NONE. As discussed above, equipment qualification does not rely upon replacement intervals. For harsh environment transmitters, the Qualified Life demonstrated (Section D, Subsection DA) should be considered.

3. STORAGE REQUIREMENTS

No special requirements are contained in the qualification documentation. Storage requirements are not applicable for installed transmitters. Spare parts are stored in accordance with ANSI N45.2.2, Level B.

4. INSTALLATION REQUIREMENTS

No special EQ provisions are necessary other than installation in accordance with the installation instructions, or user-evaluated alternate demonstrating equivalent installation quality. Installation that deviates from test configuration should be evaluated by user to assure the qualification envelops user configuration.

Replacement and spare parts should be maintained consistent with the present qualified configuration. Note that the requirement for adequate attention to quality and surveillance is the cornerstone to assurance of adequacy of Class 1E Equipment.

The installation of all Gulton-Statham Transmitters should be in accord with the recommendations of the Gulton-Statham instruction manuals.

The response time for the PD/PDH 3218 units with remote diaphragm seal, is a function of the capillary length. contact the factory for expected response time. In addition, placement of the Remote Low Pressure and High Pressure Seal, if in different ambient temperatures, will cause an offset which should be compensated for. Contact the factory for the expected correction to apply.

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

Non-Proprietary Version

SECTION F

QUALITY ASSURANCE ASPECTS IN SUPPORT OF QUALIFICATION

1. TRACEABILITY OF TRAINING ORIENTATION AND QUALITY ASSURANCE DOCUMENTATION

Each preparer and reviewer of this documentation package has been specifically trained and oriented to assure that their technical efforts are based on a familiarization to the EQ requirements. Actual signed-off training/orientation is available in Quality Assurance Records.

2. REVIEW OF NRC OR REGULATORY AGENCY DOCUMENTS PERTAINING TO QUALITY ASPECTS OF GULTON-STATHAM EQ

No specific NRC Notice or Bulletin exists relating to Gulton-Statham Transmitters. Other transmitter industry concerns, such as the loss of oil fill in capacitance-type transmitters are not applicable to Gulton-Statham.

Discussion of the method used by Gulton-Statham to preclude concern for the oil fill problems of other vendors [19,20] is provided in Figure A14 and Section A, Paragraph 2N.

3. DESIGN CHANGE SUMMARY AND EVALUATIONS DEMONSTRATING THAT CHANGES TO GULTON-STATHAM CONFIGURATIONS SINCE QUALIFICATION TESTING DOES NOT DEGRADE QUALIFICATION

Gulton-Statham has a controlled system for design changes and evaluation of configurations which assure continued qualification. Gulton-Statham Report PER-1176 [66] and document number N00182 [67] document all of the changes. Typical design changes include the enhancement to preclude oil loss problems exhibited by others (see Figure A14), and the ability to support an instrument loop of 10-50 mA.

Also included are the change control revising the PD 3218 units to change from Neoprene to Viton™ O-Rings and lead wire from PVC to Kapton™.

Drawings following this section reflect the general configurations of transmitters at time of initial qualification test. Comparison to the same transmitters in Section A figures as well as the design control at Gulton-Statham assures production transmitters are traceable to qualified transmitters. The original Gould Inc. drawings included are:

68803-000-(TAB)
68997-000-001
70006-000-001
70017-000-001

4. QUALITY ASSURANCE RECORDS OF SPECIFIC UPDATES OR MODIFICATION TO EQ TEST REPORTS FORMING BASIS FOR TRANSMITTER QUALIFICATION

During the evolution of the use of the original qualification reports, the following specific modifications or updates were necessary:

- An Examination, Tabulation, and Plotting of the actual LOCA "A" Profile from the data log of testing. Prepared by Kevin Klem (Gulton-Statham Product Manager), and Verified by Paul Mesmer, Vice President of Quality Assurance), dated November 28, 1995 (Enclosure F1).

- Examination and Reconciliation of Missing Pages for NTS Report #528-0994. Letter from Gulton-Statham (Kevin Klem) to QUAL-TEK (Lawrence Gradin), "Follow-up to your request for the pages missing from the NTS #528-0994, Revision B sent to you," dated November 13, 1995 (Enclosure F2).

Non-Proprietary Version

TABLE F1

LIST OF MEASUREMENT & TEST EQUIPMENT USED FOR FUNCTIONAL TESTING OF PD 3200 TRANSMITTERS

(Derived from original Gould Project Engineering Report 1006). Other Measurement & Test Equipment used by Test Lab is found in reports located in Section G.

TEST MEASUREMENT EQUIPMENT SPECIFICATIONS

INSTRUMENT:	**PRESSURE STANDARD, OPTICAL PRESSURE SENSOR WITH PRESSURE SOURCE DRY NITROGEN**
MANUFACTURER:	Heise
MODEL:	Digital Pressure Standard
SERIAL NUMBER:	0001/201/066
RANGE:	0 - 100 PSIG
ACCURACY:	0.1% of reading
CALIBRATION DAY:	June 14, 1983
CALIBRATION DUE:	October 14, 1983

INSTRUMENT:	**DIGITAL MULTIMETER**
MANUFACTURER:	Fluke
MODEL:	8800A
SERIAL NUMBER:	00001/504/224 and 00001/504/151
RANGE:	Used 200 VDC Range
ACCURACY:	0.01% of Input
CALIBRATION DAY:	March 24, 1983
CALIBRATION DUE:	September 24, 1983

INSTRUMENT:	**DATA LOGGER**
MANUFACTURER:	Fluke
MODEL:	2240B
SERIAL NUMBER:	E14735 (NTS)
RANGE:	Used 40 VDC Range
ACCURACY:	Output Verified by Calibrated Digital Multimeter

INSTRUMENT:	**POWER SUPPLY**
MANUFACTURER:	Power Design Inc.
MODEL:	4005R
SERIAL NUMBER:	0002/510/010
RANGE:	0 - 50 VDC
ACCURACY:	Output Verified by Calibrated Digital Multimeter

Non-Proprietary Version

INSTRUMENT:	**PRESSURE TRANSDUCER**
MANUFACTURER:	Gulton-Statham
MODEL:	PA8200-200
SERIAL NUMBER:	30
RANGE:	0 - 200 PSIA
ACCURACY:	0.25% of range

INSTRUMENT:	**PRESSURE CALIBRATOR**
MANUFACTURER:	Gilmore
MODEL:	289
SERIAL NUMBER:	3553
RANGE:	0 - 6000 PSI
ACCURACY:	Calibrated against Dial Pressure Gage

INSTRUMENT:	**DIAL PRESSURE GAGE, BOURDON TUBE WITH PRESSURE SOURCE WATER**
MANUFACTURER:	Heise
MODEL:	H12064
SERIAL NUMBER:	00001-201-128
RANGE:	0 - 5000 PSI
CALIBRATION DAY:	July 7, 1983
CALIBRATION DUE:	November 7, 1983

INSTRUMENT:	**DATA LOGGER**
MANUFACTURER:	Kay
MODEL:	8000
SERIAL NUMBER:	23454
RANGE:	Multiple
ACCURACY:	Output Verified by Calibrated Digital Multimeter

INSTRUMENT:	**POWER SUPPLY**
MANUFACTURER:	Harrison
MODEL:	6205B
SERIAL NUMBER:	6K0814
RANGE:	0 - 80 VDC
ACCURACY:	Output Verified by Calibrated Digital Multimeter

INSTRUMENT:	**OSCILLOSCOPE**
MANUFACTURER:	Tektronix
MODEL:	7603N
SERIAL NUMBER:	1/501/048
RANGE:	5mV & 50mV/cm-Voltage/2msec/cm-Time
ACCURACY:	3% of indicated value
CALIBRATION DAY:	March 2, 1983
CALIBRATION DUE:	September 2, 1983

Non-Proprietary Version

TABLE F2

LIST OF MEASUREMENT & TEST EQUIPMENT USED FOR FUNCTIONAL TESTING OF PG 3200 TRANSMITTERS

(Derived from original Gould Project Engineering Report 1005). Other Measurement & Test Equipment used by Test Lab is found in reports located in Section G.

TEST MEASUREMENT EQUIPMENT SPECIFICATIONS

INSTRUMENT:	**PRESSURE STANDARD, OPTICAL PRESSURE SENSOR WITH PRESSURE SOURCE DRY NITROGEN**
MANUFACTURER:	Heise
MODEL:	Digital Pressure Standard
SERIAL NUMBER:	0001/201/066
RANGE:	0 - 100 PSIG
ACCURACY:	0.1% of reading
CALIBRATION DAY:	June 14, 1983
CALIBRATION DUE:	October 14, 1983

INSTRUMENT:	**DIGITAL MULTIMETER**
MANUFACTURER:	Fluke
MODEL:	8800A
SERIAL NUMBER:	00001/504/224 and 00001/504/151
RANGE:	Used 200 VDC Range
ACCURACY:	0.01% of Input
CALIBRATION DAY:	March 24, 1983
CALIBRATION DUE:	September 24, 1983

INSTRUMENT:	**DATA LOGGER**
MANUFACTURER:	Fluke
MODEL:	2240B
SERIAL NUMBER:	E14735 (NTS)
RANGE:	Used 40 VDC Range
ACCURACY:	Output Verified by Calibrated Digital Multimeter

INSTRUMENT:	**DATA LOGGER**
MANUFACTURER:	Kay
MODEL:	8000
SERIAL NUMBER:	23454
RANGE:	Multiple
ACCURACY:	Output Verified by Calibrated Digital Multimeter

Non-Proprietary Version

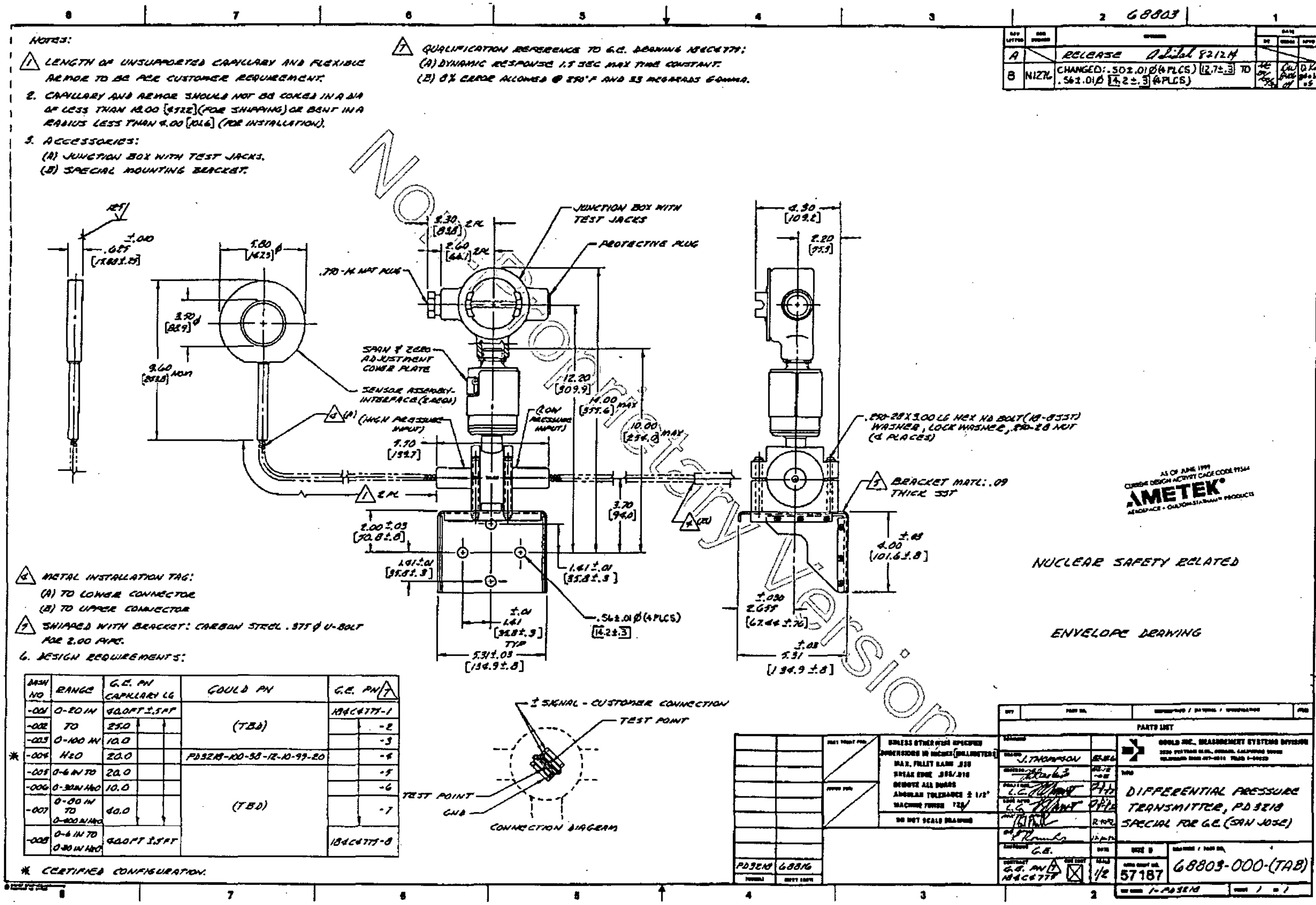
INSTRUMENT:	**POWER SUPPLY**
MANUFACTURER:	Harrison
MODEL:	6205B
SERIAL NUMBER:	6K0814
RANGE:	0 - 80 VDC
ACCURACY:	Output Verified by Calibrated Digital Multimeter

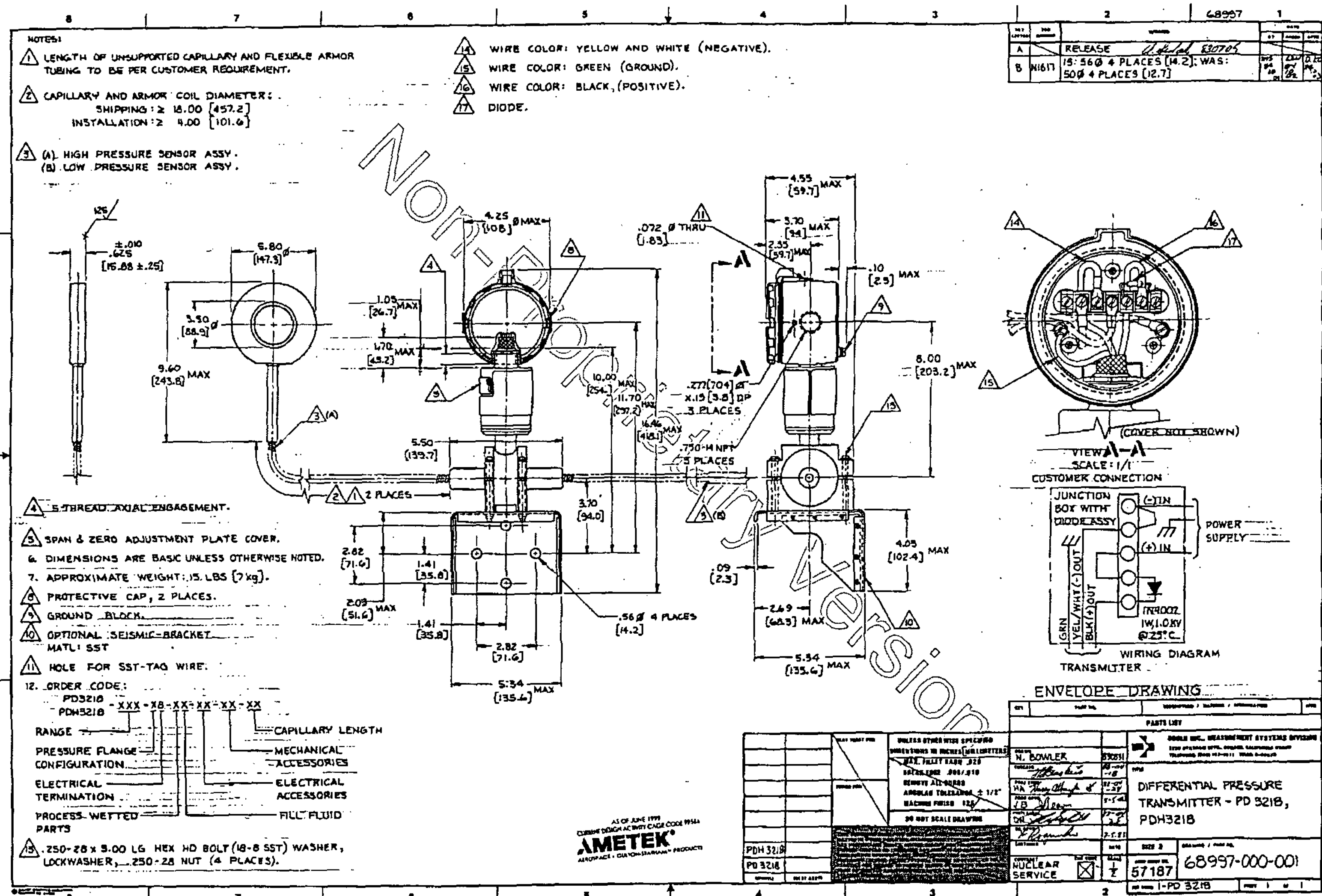
INSTRUMENT:	**POWER SUPPLY**
MANUFACTURER:	Power Design Inc.
MODEL:	4005R
SERIAL NUMBER:	0002/510/010
RANGE:	0 - 50 VDC
ACCURACY:	Output Verified by Calibrated Dial Pressure Gage

INSTRUMENT:	**PRESSURE TRANSDUCER**
MANUFACTURER:	Gulton-Statham
MODEL:	PA8200-200
SERIAL NUMBER:	30
RANGE:	0 - 200 PSIA
ACCURACY:	0.25% of range

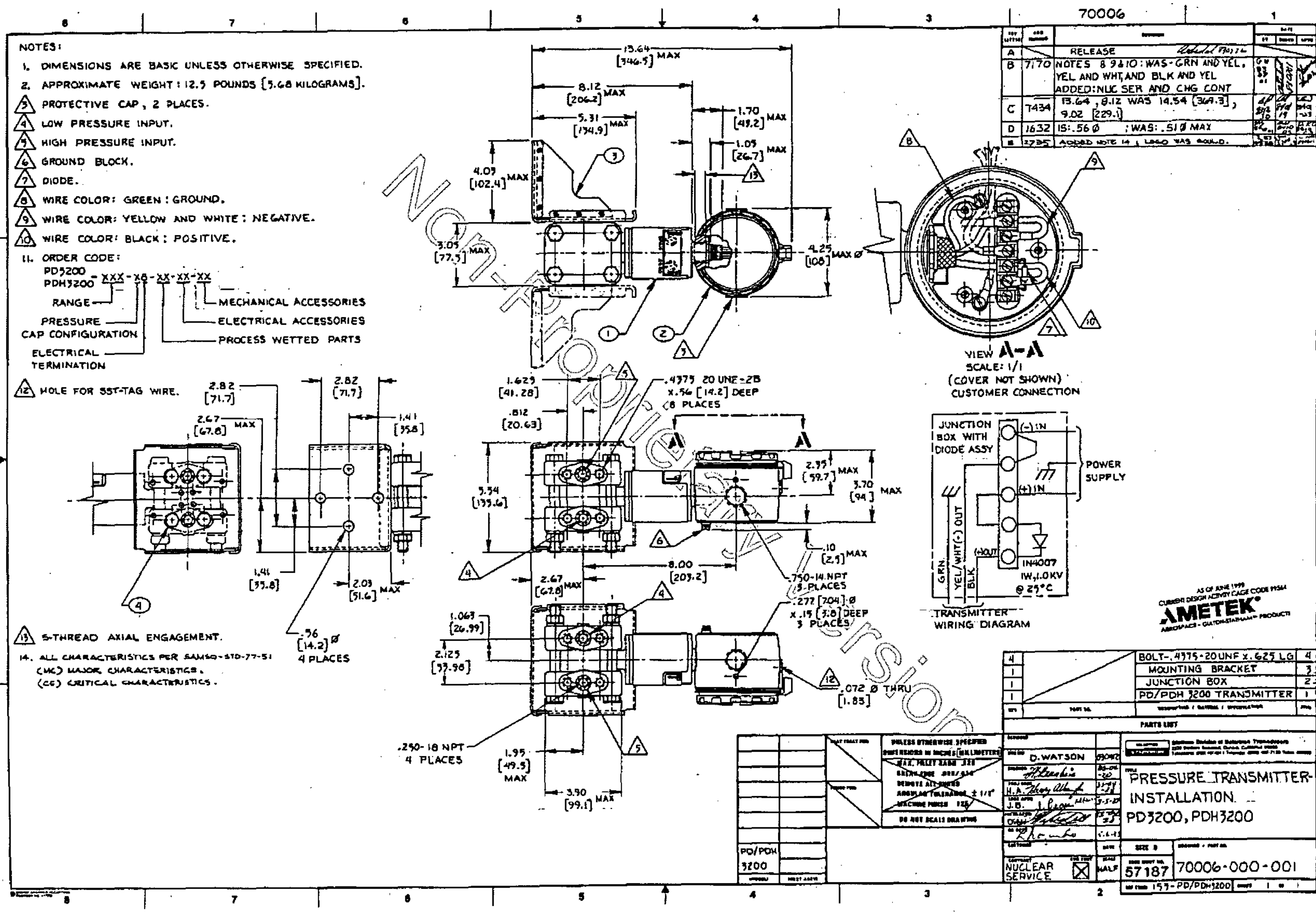
INSTRUMENT:	**OSCILLOSCOPE**
MANUFACTURER:	Tektronix
MODEL:	7603N
SERIAL NUMBER:	1/501/048
RANGE:	5mV & 50mV/cm-Voltage/2msec/cm-Time
ACCURACY:	3% of indicated value
CALIBRATION DAY:	March 2, 1983
CALIBRATION DUE:	September 2, 1983

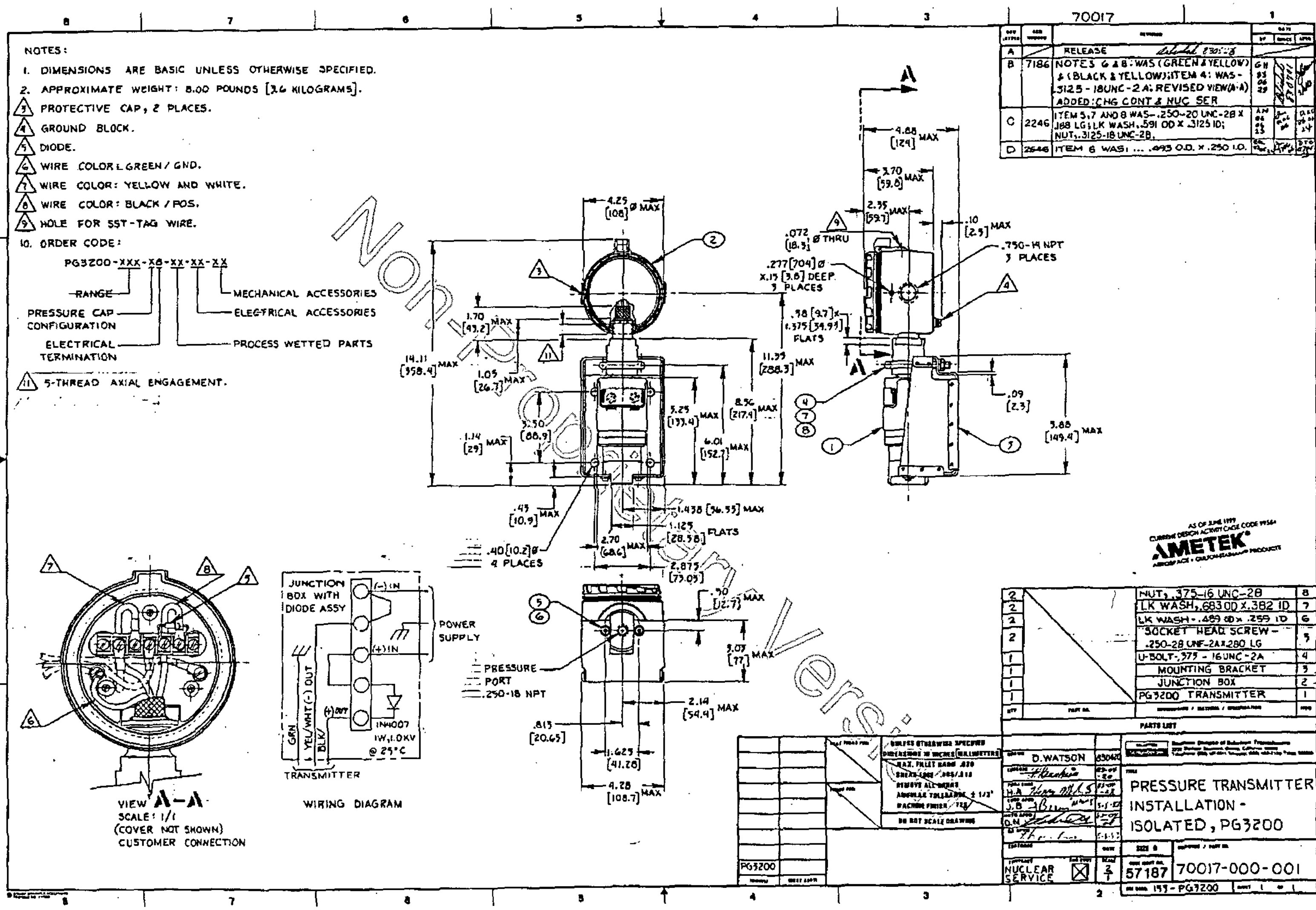
Non-Proprietary Version


68803
NOTES:
1. LENGTH OF UNSUPPORTED CAPILLARY AND FLEXIBLE ARMOR TO BE PER CUSTOMER REQUIREMENT.
2. CAPILLARY AND ARMOR SHOULD NOT BE COILED IN A DIA OF LESS THAN 18.00 [457.2] (FOR SHIPPING) OR BENT IN A RADIUS LESS THAN 4.00 [101.6] (FOR INSTALLATION).
3. ACCESSORIES:
(A) JUNCTION BOX WITH TEST JACKS.
(B) SPECIAL MOUNTING BRACKET.
4. METAL INSTALLATION TAG:
(A) TO LOWER CONNECTOR
(B) TO UPPER CONNECTOR
5. SHIPPED WITH BRACKET: CARBON STEEL .375 Ø U-BOLT FOR 2.00 PIPE.
6. DESIGN REQUIREMENTS:
7. QUALIFICATION REFERENCE TO G.E. DRAWING 184C4779:
(A) DYNAMIC RESPONSE 1.5 SEC MAX TIME CONSTANT.
(B) 8% ERROR ALLOWED @ 250°F AND 33 MEGARADS GAMMA.
A RELEASE 8212H
B N1276 CHANGED: .502.01Ø (4 PLCS) [12.7±.3] TO .562.01Ø [14.2±.3] (4 PLCS)
JUNCTION BOX WITH TEST JACKS
PROTECTIVE PLUG
.75-14 NPT PLUG
SPAN & ZERO ADJUSTMENT COVER PLATE
SENSOR ASSEMBLY-INTERFACE (2 REQD)
(HIGH PRESSURE INPUT)
(LOW PRESSURE INPUT)
.250-28 X 3.00 LG HEX HD BOLT (18-8 SST) WASHER, LOCK WASHER, .250-28 NUT (4 PLACES)
BRACKET MATL: .09 THICK SST
.562.01Ø (4 PLCS) [14.2±.3]
NUCLEAR SAFETY RELATED
ENVELOPE DRAWING
± SIGNAL - CUSTOMER CONNECTION
TEST POINT
GND
CONNECTION DIAGRAM
DASH NO | RANGE | G.E. PN CAPILLARY LG | GOULD PN | G.E. PN
-001 | 0-20 IN H2O | 40.0FT ±.5FT | (TBD) | 184C4779-1
-002 | TO | 25.0 | | -2
-003 | 0-100 IN | 10.0 | | -3
* -004 | H2O | 20.0 | PD3218-100-38-12-10-99-20 | -4
-005 | 0-6 IN TO | 20.0 | | -5
-006 | 0-30 IN H2O | 10.0 | | -6
-007 | 0-80 IN TO 0-400 IN H2O | 40.0 | (TBD) | -7
-008 | 0-6 IN TO 0-30 IN H2O | 40.0FT ±.5FT | | 184C4779-8
* CERTIFIED CONFIGURATION.
AS OF JUNE 1999 CURRENT DESIGN ACTIVITY CAGE CODE 99364
AMETEK
AEROSPACE - GULTON-STATHAM PRODUCTS
DIFFERENTIAL PRESSURE TRANSMITTER, PD3218 SPECIAL FOR G.E. (SAN JOSE)
57187
68803-000-(TAB)
PD3218 68816
Non-Proprietary Version



Non-Proprietary Version


70006
NOTES:
1. DIMENSIONS ARE BASIC UNLESS OTHERWISE SPECIFIED.
2. APPROXIMATE WEIGHT: 12.5 POUNDS [5.68 KILOGRAMS].
3 PROTECTIVE CAP, 2 PLACES.
4 LOW PRESSURE INPUT.
5 HIGH PRESSURE INPUT.
6 GROUND BLOCK.
7 DIODE.
8 WIRE COLOR: GREEN: GROUND.
9 WIRE COLOR: YELLOW AND WHITE: NEGATIVE.
10 WIRE COLOR: BLACK: POSITIVE.
11. ORDER CODE:
PD3200 - XXX - X8 - XX - XX - XX
PDH3200
RANGE
PRESSURE CAP CONFIGURATION
ELECTRICAL TERMINATION
MECHANICAL ACCESSORIES
ELECTRICAL ACCESSORIES
PROCESS WETTED PARTS
12 HOLE FOR SST-TAG WIRE.
13 5-THREAD AXIAL ENGAGEMENT.
14. ALL CHARACTERISTICS PER SAMSO-STD-77-51
(MC) MAJOR CHARACTERISTICS.
(CC) CRITICAL CHARACTERISTICS.
RELEASE
NOTES 8 9 & 10: WAS-GRN AND YEL, YEL AND WHT, AND BLK AND YEL
ADDED: NUC SER AND CHG CONT
13.64, 8.12 WAS 14.54 [369.3], 9.02 [229.1]
15: .56 Ø : WAS: .51 Ø MAX
VIEW A-A
SCALE: 1/1
(COVER NOT SHOWN)
CUSTOMER CONNECTION
JUNCTION BOX WITH DIODE ASSY
POWER SUPPLY
(-) IN
(+) IN
(+) OUT
GRN.
YEL/WHT(-) OUT
BLK.
IN4007
1W, 1.0KV
@ 25°C
TRANSMITTER WIRING DIAGRAM
.4375 20 UNF-2B x .56 [14.2] DEEP 8 PLACES
.750-14 NPT 3-PLACES
.277 [7.04] Ø x .15 [3.8] DEEP 3 PLACES
.250-18 NPT 4 PLACES
.072 Ø THRU [1.83]
.56 [14.2] Ø 4 PLACES
AMETEK
BOLT-.4375-20UNF x .625 LG
MOUNTING BRACKET
JUNCTION BOX
PD/PDH 3200 TRANSMITTER
PARTS LIST
D. WATSON
PRESSURE TRANSMITTER-INSTALLATION
PD3200, PDH3200
NUCLEAR SERVICE
57187
70006-000-001
PD/PDH 3200



Non-Proprietary Version

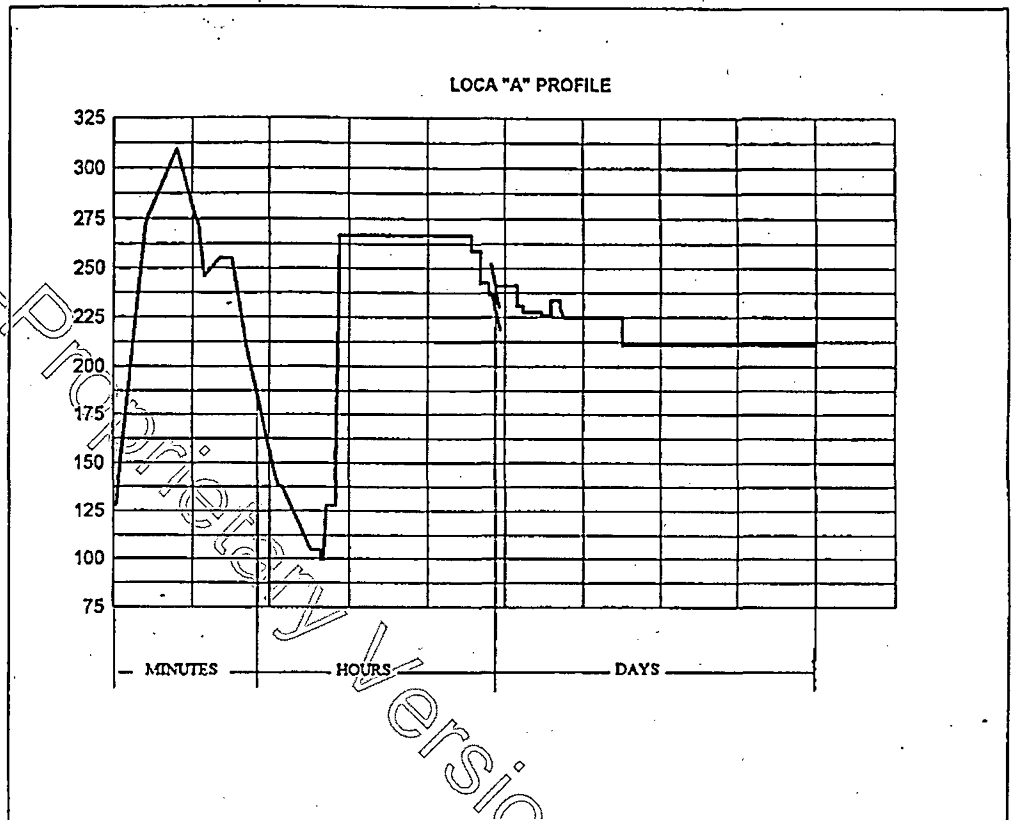
Non-Proprietary Version

ENCLOSURE

F1

LOCA "A" PROFILE (Graph Information)

DATE	RECORDED TIME	TEMP. (Deg. F)	
8/9/83	09:15.03	128.2	
	09:24.51	272.8	
	09:34.33	309.8	
	09:41.54	271.7	
	09:43.13	248	
	09:48.37	255	
	09:52.01	255	
	09:57.02	209.8	Minutes
	11:37.32	138	Hours
	11:48.03	138	
	13:08.15	104.7	
	13:21.38	104.7	
	13:29.21	99.3	
	13:33.46	99.3	
	13:38.46	128.2	
	14:07.37	128.2	
	14:10.05	266.7	
		266.7	
	21:11.38	259	
		259	Hours
8/10/83	09:06.50	242.6	Days
		242.6	
	23:12.50	236.4	
		236.4	Break In Testing
8/11/83	06:14.42	241	
8/12/83	12:06.13	241	
8/13/83	13:06.13	230.5	
		230.5	
	20:08.58	227.5	
		227.5	
8/14/83	18:06.35	225.8	
		225.8	
8/15/83	08:24.18	233.5	
		233.5	
	20:17.12	229.6	
8/16/83	00:17.12	225	
		225	
8/19/83	07:40.37	211	
9/29/83	17:05.14	211	
			End of Testing



Non-Proprietary Version

NOTE:

1) THE LOCA "A" PROFILE IS BASED ON THE GRAPH INFORMATION PRESENTED. THIS DATA WAS DERIVED FROM THE ACTUAL STRIP RECORDER DATA TAKEN DURING THE LOCA "A" TESTING
2) THE ORIGINAL RAW DATA IS AVAILABLE FOR REVIEW AT THE FACTORY.
3) THE PROFILE AND GRAPH INFORMATION PRESENTED WERE PREPARED BY KEVIN KLEM, PRODUCT MANAGER AND WAS VERIFIED BY PAUL MESMER, V.P. of QUALITY ASSURANCE.

Prepared By: *[signature]* Dated: 11/28/95

Kevin Klem
Product Manager

Verified By: *[signature]* Dated: 11-28-95

Paul Mesmer
V.P. of Quality Assurance

Non-Proprietary Version

ENCLOSURE

F2

Gulton Statham
A MARK IV COMPANY

November 13, 1995

Lawrence P. Gradin
Director of Engineering
QUAL-TEK Inc.
127 Cabot Street
West Babylon, NY 11704

SUBJECT: Follow up to your request for the pages missing from the NTS Report, #528-0994, Revision B sent to you.

Reference: Our telecon of November 3, 1995.

Non-Proprietary Version

Dear Larry,

As I stated in our discussion, it appears that pages 1-9 of the NTS Report #528-0994, Revision B have been separated from the rest of the report and cannot be located. I have located a copy of pages 1-9 from the original NTS Report, at the no revision level.

Looking at the Revision A & B Summary pages, the only missing pages affected by these revisions were pages 8 & 9. We have looked at no revision copies of the pages and correspondence that occurred later with regard to this program. It appears that the revisions on pages 8 & 9 were related to clarifications of particular portions of the testing. I have provided a description of the clarifications below:

<u>Revision A changes</u>

The changes made by this revision to paragraph 5.3.3.2 appear to be addressing two items of interest. The first is the addition of Figures 9 & 10 to show the placement of accelerometers for each part during resonance search. The second is a statement to define resonance by a Q of 2 or greater.

The changes made by this revision to paragraph 5.3.4.4 clarify the location of the accelerometers. The first sentence changed from "... on the seismic simulator in two ..." to "... on the transmitter in two ...".

GS

Revision B changes

You will notice that paragraph 5.3.4.3 was omitted from the no revision copy of page 8. It appears that Revision B inserted the missing paragraph. The paragraph made clarification of the fact that no testing below 1 Hz is required due to no resonance being found for frequencies less than 10 Hz as mentioned in paragraph 5.3.3.2.

Thank you for your consideration of this matter. If you have any further questions or require any additional information, please do not hesitate to contact me.

Sincerely,

Kevin Klem
Regional Sales Manager

Non-Proprietary Version

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

Non-Proprietary Version

SECTION G

POST TEST AND ANALYSIS FOR LONGER TIME CONSTANT

SECTION G

1. POST TEST AND ANALYSIS FOR LONGER TIME CONSTANT

See Engineering Report ER-1331 for Time Constant Variation and Appendix B for Additional Increase in Time Constant

Non-Proprietary Version

REPORT NO. TR-1136

QUALIFICATION DOCUMENTATION

REVIEW PACKAGE

FOR

AMETEK AEROSPACE GULTON-STATHAM PRODUCTS

NUCLEAR QUALIFIED
PRESSURE TRANSMITTER SERIES ENVELOPING ---

GAGE PRESSURE TRANSMITTER SERIES PG 3200

DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3200

DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3200

DRAFT RANGE PRESSURE TRANSMITTER SERIES DR 3200

REMOTE DIAPHRAGM SEAL DIFFERENTIAL PRESSURE TRANSMITTER SERIES PD 3218

REMOTE DIAPHRAGM SEAL DIFFERENTIAL HIGH PRESSURE TRANSMITTER SERIES PDH 3218

Non-Proprietary Version

SECTION H

VALIDATION TESTING – BOURNS WIREWOUND TRIMMING POTENTIOMETERS

SECTION H

1. INTRODUCTION

This section summarizes the testing performed to qualify the Bourns 3250 Series wirewound potentiometer for use in AMETEK nuclear qualified P32XX Series pressure transmitters.

The P32XX Series pressure transmitters are constructed with two (2) sub-assemblies: the Case and Electronics Assembly and the Transducer Sub-Assembly. With the exception of several select resistors for temperature compensation and capacitors for response time adjustment, all P32XX Series pressure transmitters use the same electronic assembly onto which the trimming potentiometers are installed. Based on this, testing was performed on two models: PG3200-200 and PD3200-100. All other models in the P32XX Series are qualified based on similarity.

Non-Proprietary Version

2. THERMAL AGING

The pressure transmitters are rated to operate up to +250°F [121.1°C] without damage. This temperature was used as the aging temperature during testing. During the lifetime of the pressure transmitters, the service temperature is rated at +104°F [+40°C]. The accelerated aging test will also take into account a power plant upset which would result in an elevated temperature exposure of +150°F [+66°C] for a total of 320 hours during a 40-year span.

The accelerated thermal aging duration for the pressure transmitters, based on the lowest activation energy of the silicon transistor, is calculated by implementing the Arrhenius Equation as follows:

$$t_1 = t_a \exp[(E_a/k)(1/T_1 - 1/T_a)] + t_b \exp[(E_a/k)(1/T_1 - 1/T_b)]$$

where:

- t_1 = aging duration at accelerated temperature T_1 (hours)
- t_a = simulated 40-year lifetime at service temperature T_a (350400 hours)
- t_b = simulated duration at power plant upset temperature T_b (320 hours)
- E_a = energy of activation (0.96 eV)
- T_1 = aging temperature (250 °F [394.3 °K])
- T_a = service temperature (104 °F [313.2 °K])
- T_b = power plant upset temperature (150 °F [338.7 °K])
- k = Boltzmann's Constant (8.617E-5 eV/°K)

The aging time at 250°F [121°C] is 236 hours or 9.83 days to simulate 40 years of thermal aging at a maximum service temperature of 104°F [40°C] including 320 hours of plant upset at 150°F [66°C].

Testing was performed on two (2) PD3200-100 transmitters and one (1) PG3200-200 transmitter. Testing was allowed to continue for a total of 22 days or 528 hours. This simulates 92 years of thermal aging at a maximum service temperature of 104°F [40°C] including 320 hours of plant upset at 150°F [66°C]. Test data are as follows:

	PG3200-200	PD3200-100	PD3200-100
	S/N: XXXXX	S/N: XXXXX	S/N: XXXXX
Error* after 3 day	X.XX%	X.XX%	X.XX%
Error* after 5 day	X.XX%	X.XX%	X.XX%
Error* after 10 day	X.XX%	X.XX%	X.XX%
Error* after 17 day	X.XX%	X.XX%	X.XX%
Error* after 22 day	X.XX%	X.XX%	X.XX%

*NOTE: Error is expressed as a percentage of Upper Range Limit (URL)

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Non-Proprietary Version

3.0 *RADIATION AGING*

Testing was performed to compare the performance of the transmitters employing the Bourns wirewound trimming potentiometers to transmitters employing the Spectrol wirewound potentiometers originally qualified in 1983.

Five (5) PG3200-200 were subjected to Radiation Aging testing with a dose rate of XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Model Number	Serial Number	Potentiometer
PG3200-200	XXXXX	Spectrol wirewound
PG3200-200	XXXXX	Spectrol wirewound
PG3200-200	XXXXX	Spectrol wirewound
PG3200-200	XXXXX	Bourns wirewound
PG3200-200	XXXXX	Bourns wirewound

During testing, the transmitters' outputs were measure and record. These were compared with the baseline outputs or the outputs prior to exposure. Errors are expressed as a percentage of URL.

Hour	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
1	X.XX	X.XX	X.XX	X.XX	X.XX
2	X.XX	X.XX	X.XX	X.XX	X.XX
3	X.XX	X.XX	X.XX	X.XX	X.XX
4	X.XX	X.XX	X.XX	X.XX	X.XX
5	X.XX	X.XX	X.XX	X.XX	X.XX
6	X.XX	X.XX	X.XX	X.XX	X.XX
7	X.XX	X.XX	X.XX	X.XX	X.XX
8	X.XX	X.XX	X.XX	X.XX	X.XX
9	X.XX	X.XX	X.XX	X.XX	X.XX
10	X.XX	X.XX	X.XX	X.XX	X.XX

Non-Proprietary Version

Testing showed that the performance of the Bourns wirewound trimming potentiometers is similar to that of the Spectrol wirewound potentiometers under the same irradiation condition.

4.0 *CONCLUSION*

THE BOURNS WIREWOUND POTENTIOMETERS ARE CONSIDERED QUALIFIED FOR USE IN P32XX SERIES PRESSURE TRANSMITTERS