| Eskom | SPECIFICATION | NUCLEAR ENGINEERING |
|---|---|---|

Title: **Procurement Specification for Safety Class 1E Absolute, Differential and Relative Pressure Transmitters (Outside Containment)**

| | |
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|---|---|
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## Content



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# 1. Introduction

This specification lists the minimum requirements for the procurement of Class 1E absolute, differential and relative pressure transmitters, for use in harsh and mild environments outside containment at Eskom's Koeberg Operating Unit (KOU).

If any conflict arises between this specification and other referenced documents, the Manufacturer / Vendor / Supplier shall not proceed, but shall request clarification, in writing, from the approved Eskom buyer.

# 2. Supporting Clauses

## 2.1 Scope

The supply shall consist of the following equipment:

- Absolute pressure transmitters
- Relative pressure transmitters
- Differential pressure transmitters

Each transmitter shall be supplied with the OEM's dedicated bracket and mounting hardware for pipe or wall mounting, as well as accessories required for connection to the existing process piping.

Where indicated, the transmitter must be supplied with a separator and capillary to separate the transmitter from the main fluid.

The manufacturer and/or supplier shall be responsible for:

- Manufacture;
- Testing;
- Environmental and seismic qualification;
- Documentation,
- Packaging, storage and transport,
- Technical support; and
- Customs formalities for export purposes.

### 2.1.1 Purpose

This specification lists the minimum requirements for the procurement of Class 1E absolute, differential and relative pressure transmitters, to be qualified for seismic, harsh and mild environmental conditions outside containment.

### 2.1.2 Applicability

This specification is applicable to Nuclear Engineering.

### 2.1.3 Effective date

This document is effective from the authorisation date.

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## 2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

### 2.2.1 Normative

[1] ASME NQA-1: Quality Assurance Requirements for Nuclear Facilities

[2] IEEE 323: Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

[3] IEEE 344: Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

[4] ISO 9000 including ISO 9001:2008: Quality Management Systems

[5] KBA 12 22 E02 008: Qualification of Safety-related Electrical Equipment (Class 1E) – General Seismic Specification

### 2.2.2 Informative

[6] DSG-317-094 – Specification for Chemical Products and Materials used at KNPS

[7] KBA 0022E00 065 - Process Instrumentation System (S.I.P) Relative Pressure Transmitters

[8] KBA 0022E00 068 – Process Instrumentation System (S.I.P) Differential Pressure Transmitters

[9] KBA 0022E00 069 - Process Instrumentation System (S.I.P) Absolute Pressure Transmitters

[10] KBA 0022E00 077 - Process Instrumentation System (S.I.P) Local Instrument Specification

[11] KBA 0022E01 005 - Prescriptions Relative to Nuclear Cleanliness During Manufacture of Equipment used in the Nuclear Island

[12] RCC-E – Design and Construction Rules for Electrical Equipment of Nuclear Islands

## 2.3 Definitions

**2.3.1 Class 1E:** The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment (Reference [2]).

**2.3.2 Harsh Environment:** An environment expected as the result of the postulated service conditions appropriate for the design basis and beyond design basis accidents of the station. Harsh environments are the result of a loss of coolant accident (LOCA) or high energy line breaks (HELB) inside the containment and post-LOCA or HELB outside the containment.

**2.3.3 Mild environment:** An environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences.

**Note:** Environmental Qualification of equipment at KOU shall be in accordance with IEEE 323 and IEEE 344. However, equipment qualified in accordance with RCCE, KTA or other recognized standards shall be evaluated for acceptability on case-by-case basis.

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## 2.4 Abbreviations

| Abbreviation | Description |
|---|---|
| **ANSI** | American National Standards Institute |
| **ASME** | American Society of Mechanical Engineers |
| **EOMR** | End of Manufacture Report |
| **EQ** | Environmental Qualification |
| **HELB** | High Energy Line Breaks |
| **IEEE** | The Institute of Electrical and Electronics Engineers, Inc. |
| **LOCA** | Loss of Coolant Accident |
| **NPT** | National Pipe Thread |
| **NQA** | Nuclear Quality Assurance |
| **OD** | Outside Diameter |
| **OEM** | Original Equipment Manufacturer |
| **QADP** | Quality Assurance Data Package |
| **QCP** | Quality Control Plan |
| **RCC-E** | Design and Conception Rules for Electrical Equipment of Nuclear Islands |
| **RRS** | Required Response Spectra |
| **SSE** | Safe Shutdown Earthquake |
| **URL** | Upper Range Limit |

## 2.5 Roles and Responsibilities

Not applicable.

## 2.6 Process for Monitoring

Not applicable.

## 2.7 Related/Supporting Documents

Not applicable.

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# 3. Requirements

The pressure transmitters must comply with all the requirements listed below.

## 3.1 Design Requirements

### 3.1.1 Service Conditions

**Normal Environmental Conditions:**

| | | |
|---|---|---|
| Temperature | : | 4°C to 50ºC |
| Pressure | : | Below atmospheric |
| Relative humidity | : | 15 to 95% |
| Radiation | : | Background |

**Accident Conditions:**

| | | |
|---|---|---|
| Qualification | : | IEEE 323 and IEEE 344 |
| Temperature | : | 4°C to 50ºC |
| Pressure | : | Below atmospheric |
| Radiation (max) | : | Red zone (≥ 10 000 µSv/h) |
| Seismic | : | Safe Shutdown Earthquake (SSE) |

**Seismic Resistance:**

The Class 1E equipment shall withstand earthquakes in accordance with the specifications given in Appendix A.

### 3.1.2 Functional Requirements

| | | |
|---|---|---|
| Power supply | : | 30 Vdc ± 10% |
| Residual Ripple | : | 5% peak to peak |
| Output Signal | : | Two-wire system using 4-20 mA.<br>The output current increases linearly with increasing value or variation of measured quantity (i.e. no signal conversion inside transmitter. A filter is allowed if it can be preset to zero filtering). |
| Load Limitations | : | 0 to 700Ω for a 30 V supply voltage |
| Measurement range | : | Specific transmitter range requirements will be specified to the OEM on relevant Koeberg Purchase Orders. |

***Note:*** *The instrument shall withstand a system hydrostatic test of 1.5 × system design pressure.*

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### 3.1.3 Physical Requirements

**Electrical connection:**

- Shielded, twisted twin cable (the method of terminating the cable must be qualified for Accident Conditions);
- ½ -14 NPT conduit with screw terminals;
- M20-1.5.

***Note:*** *electrical connection for each transmitter shall be specified in the purchase order.*

**Process connections:**

- ½ - 14 NPT or ¼ - 18 NPT threaded connection with no welded vent/drain valves (for absolute and differential pressure transmitters);
- ½" R. for relative pressure transmitters;
- ⅜" threaded compression fitting (for some absolute pressure transmitters).

***Note:*** *process connections for each transmitter shall be specified in the purchase order.*

**Installation:**

- Mounting on 2" OD vertical or horizontal pipe;
- Wall or panel mounting (with supplied mounting bracket).

**Separators:**

The purchase order shall specify transmitters requiring separators;

The material of the separators must comply with that specified in Section 3.2.1;

Process connection - ½" NPT,

The level of cleanness must be the same as the transmitters,

The separator must be provided with a vent drain port - ¼".

**Capillary:**

Length shall be specified in the purchase order.

Filling Fluid: silicone oil.

The filling operation (separator and capillary) shall be possible on site. A filling procedure shall be provided.

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**Measurement chambers:**

There shall be no detectable leakage during the hydro tests at 1.5 times the design pressure. The pressure rise shall occur:

- Quickly up to working pressure;
- In steps of a few bars up to test pressure.

The test pressure shall be maintained for at least 30 minutes.

The differential pressure transmitters shall withstand a unilateral pressure 1.5 times the design static pressure without damage.

### 3.1.4 Performance Characteristics

***Note:*** *The values of the various errors quoted in this paragraph are expressed as a percentage of the specified measurement range.*

**Accuracy:**

The intrinsic accuracy for each transmitter shall be 0.5% or better.

The overall accuracy for each transmitter shall be 2.1% or better.

**Stability:**

| | | |
|---|---|---|
| Temperature | : | ≤ 0.06%/°C URL (upper range limit) |
| Time | : | Drift ≤ 0.5%/year |
| Vibration | : | All transmitters are subject to the particular operational requirements in the event of an earthquake; see Appendix A, which must not affect their performance. |
| Supply Voltage | : | ≤ 0.008%/V |
| Overpressure | : | 1.5 times the design pressure, < 1% (absolute and relative only)<br>1.5 times the maximum static operating pressure (differential only) |

Allowable errors of output signal when conditions have returned to normal (after possible zero or end of scale resetting):

- 0.25% per 100 bars of overpressure (within instrument accuracy limit);
- 0.25% for transmitters whose static pressure is less than 100 bars;
- The influence of maximum static operating pressure on the output signal shall not exceed 1.5%.

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**Response time (Fixed time constant at 63%):**

≤ 0.4 s or better

Equipment provided with a Separator Capillary Unit: < 0.25 s + X s/capillary meter

*Number X depends on measurement range and filling fluid and the various options must be stated in tender documents.*

**Transient response:**

| | | |
|---|---|---|
| Hysteresis | : | < 0.5% |
| Deviation from characteristic | : | < 0.5% (Fixed point adjustment) |

## 3.2 Manufacturing Requirements

### 3.2.1 Materials

The material selection is done by Koeberg. This will be reflected by the item part number on the purchase order.

Parts in contact with the fluid shall be austenitic stainless steel AISI 316 or better.

### 3.2.2 Casing

Minimum environmental rating IP 65.

Stainless steel components shall not be painted.

If painting is required, painting procedure and paint specifications shall be approved by Koeberg.

Controls must be easily accessible.

### 3.2.3 Marking and identification

Each instrument shall be clearly and permanently identified (e.g. an engraved metal plate) indicating:

- The manufacturer's name;
- The instrument type;
- The serial number and / or part number;
- The measurement range.

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### 3.2.4 Verification and Tests

The manufacturer shall ensure that sub-contractors comply with the requirements in this section.

The manufacturer shall perform all inspections, tests, aging or other services necessary to **guarantee the performance stated in his technical sheets**.

The manufacturer shall supply a production file, consisting of:

#### 3.2.4.1 The Manufacturing, Inspection and Test Plan (MITP):

These lists shall be prepared for each type of equipment. Each manufacturing operation or test shall be clearly specified in the M.I.T.P. Each operation mentioned shall be given a document reference which specifies the operation.

#### 3.2.4.2 The Manufacturing and Testing Procedures

These procedures shall correspond to the main operations mentioned in the MITPs.

These procedures shall indicate, in particular:

- The welding and weld inspection methods;
- The methods used to obtain and keep the required degree of cleanness;
- The acceptance criteria for testing.

#### 3.2.4.3 The Test Reports Certificates or Test

These documents correspond to the main manufacturing or testing operations and should be available for perusal:

- The weld examination certificates;
- Liquid penetrant testing (all the welds which cannot be checked by ultrasonic or radiographic testing);
- The compliance certificates for seals;
- The hydrotest certificates;
- The cleanness certificates;
- The calibration certificates.

Results of tests shall be submitted as part of the Quality Assurance Data Package (QADP).

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## 3.3 Engineering quality requirements

### 3.3.1 Qualification Requirements

The pressure transmitters used outside the reactor containment must pass or have successfully passed tests to prove their ability to perform their specified functions under normal ambient conditions, harsh environments, and under seismic loading, as well as accidental ambient conditions specified for certain materials. It must be demonstrated that if past test results are used, the test conditions must envelope the qualification requirements for Koeberg Operating Unit.

### 3.3.2 Class of Nuclear Cleanness

Requirements associated with the cleanness of the transmitters are specified in ASME NQA-1.

**NOTE:** To facilitate manufacturing, the manufacturer may use a single class of cleanness, but it must comply with the requirements of the highest class.

### 3.3.3 Quality Assurance

- The pressure transmitters shall be qualified in accordance with IEEE-323-1974 or latest standard, and IEEE-344-1975 (Alternative qualification standard, i.e. RCC-E code or KTA standard are acceptable and must be evaluated on a case-by-case basis).
- The manufacturer or supplier is required to implement a quality assurance program which is consistent with, and meets those requirements of TITLE 10 CODE OF FEDERAL REGULATIONS 50 (10 CFR 50), APPENDIX B and ANSI or ASME NQA1 which are applicable to the scope of work performed under this specification. ESKOM, Koeberg must be advised of any significant changes in the supplier's quality assurance programme.
- ESKOM approval is required for the dispositioning of any non-conformances to procurement requirements or to ESKOM-approved documents, except where the item can be re-worked to full compliance. Proposed dispositions for repair or "use-as-is" shall be identified on an APPLICATION FOR CONCESSION or PRODUCTION PERMIT FORMAT or equivalent, and submitted to ESKOM, Koeberg Operating Unit for approval.
- ESKOM reserves the right of access to supplier or sub-supplier facilities and records for the purpose of inspection or audit.

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### 3.4 Documentation

#### 3.4.1 Documents to be submitted with quote

Quality Control Plan (QCP)

#### 3.4.2 Documents to be submitted on delivery of equipment

A comprehensive Quality Assurance Data Package (QADP) shall be supplied with the following included as a minimum:

- Statement of conformity
- Test reports
- Material certificates
- End of Manufacturing Report (EOMR)
- Certificate of Conformance (C.O.C)
- Lists of spare parts recommended to comply with the operating conditions

#### 3.4.3 Documents to be submitted on initial purchase of equipment

In addition to the documentation listed above, when the equipment is procured for the first time, or either the part number or component has changed, the manufacturer / supplier shall provide the following documentation:

- Environmental Qualification (EQ) test report (or summary of qualification); and
- Seismic test report.

### 3.5 Packaging and shipment

The supplier is responsible for packaging in accordance with ASME NQA-1 Sub-part 2.2 for transportation to South Africa and for the transportation to a mutually agreed port of shipment.

## 4. Acceptance

This document has been seen and accepted by:

| Name | Designation |
|---|---|
| A Stephanus | Manager (Acting) – Specification Engineering Group |
| MV Phalane | Engineer - Specification Engineering Group |
| K Moroka | Senior Engineer – Engineering Programmes Group |

## 5. Revisions

| Date | Rev. | Compiler | Remarks |
|---|---|---|---|
| May 2017 | 1 | X Booi | Original |
| | | | |

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## 6. Development Team

Not applicable.

## 7. Acknowledgements

Not applicable.

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# Appendix A – Seismic Specification

## A.1 Seismic requirements

### AIM

The aim of this appendix is to define the safe shutdown earthquake (SSE) applicable to allow testing according to the guidelines of IEEE 344, and not to define the test method.

### 1.0 SAFE SHUTDOWN EARTHQUAKE INTRODUCTION

### Vibration Specifications

In the event of an earthquake, the floors upon which the various pieces of electrical equipment are installed are subjected to vibratory waves. These waves are transmitted by the structural elements of the buildings, which serve to filter out some of the waves. If time line history (actually recorded or theoretical) is available, the waveforms of these vibrations can be studied and understood.

The effects of the vibratory waves can be predicted from the behaviour of dummy oscillators anchored to the floors. This behaviour is transformed into floor oscillator response or floor response spectra. Such spectra are generally of the acceleration response type.

The spectrum for a given floor consists of a family of parametric curves, which vary from the oscillator reduced damping factor.

Seismic floor motion occurs simultaneously in all directions, but it can be broken down into three fundamental axes. Response spectra are generally established for one random horizontal axis and the vertical direction as well.

### Required Response Spectra (RRS)

By joining together the response spectra for the various floors of the building, one horizontal envelope spectrum and one vertical envelope spectrum can be determined. Such spectra represent the sum of seismic phenomena that will take place at equipment anchoring points. This constitutes the required response spectra (RRS) for qualification purposes.

In determining envelope spectra, it is preferable to select those curves which correspond to the assumed damping level for the piece of equipment to be qualified.

In most cases, however, this value can be assumed to be 5%.

### 1.2 Test Principle

These tests shall be run by subjecting the equipment to a vibratory motion that conservatively simulates the vibration expected to occur at the equipment anchoring point in the event of a SSE.

Consequently, motion observed on the shake table shall produce effects identical or superior to those specified by the reference spectra.

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### 1.3 Mounting of Equipment on Shake Table

Equipment shall be mounted on the shake table so as to simulate actual intended on-site mounting. The orientation of the equipment shall be identical to its location on site, as the effect of gravity is of particular importance.

Connections shall be identical to those used in actual installation (bolting, welding, etc.). The effect of electrical connections, conduits and sensing lines shall be taken into account.

## 2.0 TEST REPORT

This document shall contain all data necessary to show that the equipment has been properly qualified.

The following items shall be included:

- Equipment specification;
- Test facility description;
- Test method description;
- Test data (including proof of performance);
- Test results and conclusions (comparison of the test response spectrum and the RRS);
- Date and approved signature.

## 3.0 REQUIRED Response SPECTRA (RRS)

### 3.1 Electrical Control and Instrumentation Assemblies

Two envelope spectra have been drawn up (one vertical and one horizontal), with 5% damping factor.

These spectra are representative of severity levels determined for the Koeberg Nuclear Power Station plant. They are represented in figures 1 and 2 respectively, by solid lines.

**Qualified Equipment shall meet seismic conditions defined by these spectra.**

**NOTE:**

There exists a critical point on the horizontal spectrum at 1 Hz (high acceleration). If this low frequency service cannot be simulated at the test facility (shake table travel and velocity are usually limited), **it must be shown that the equipment subjected to testing does not carry any natural frequency in the 1 Hz range.**

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## A.2 Horizontal SSE Spectra - 5% Damping

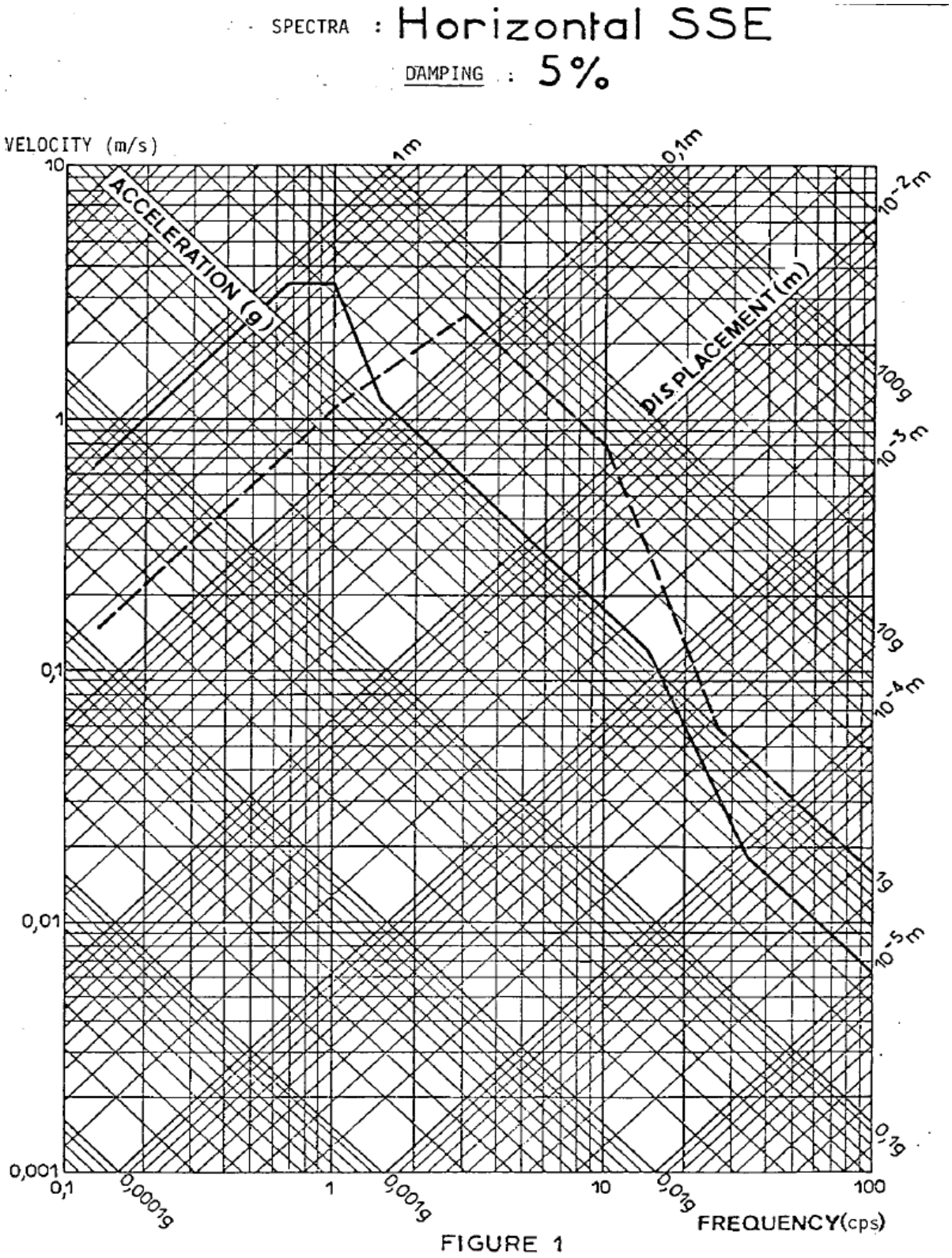


FIGURE 1

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## A.3 Vertical SSE Spectra - 5% Damping

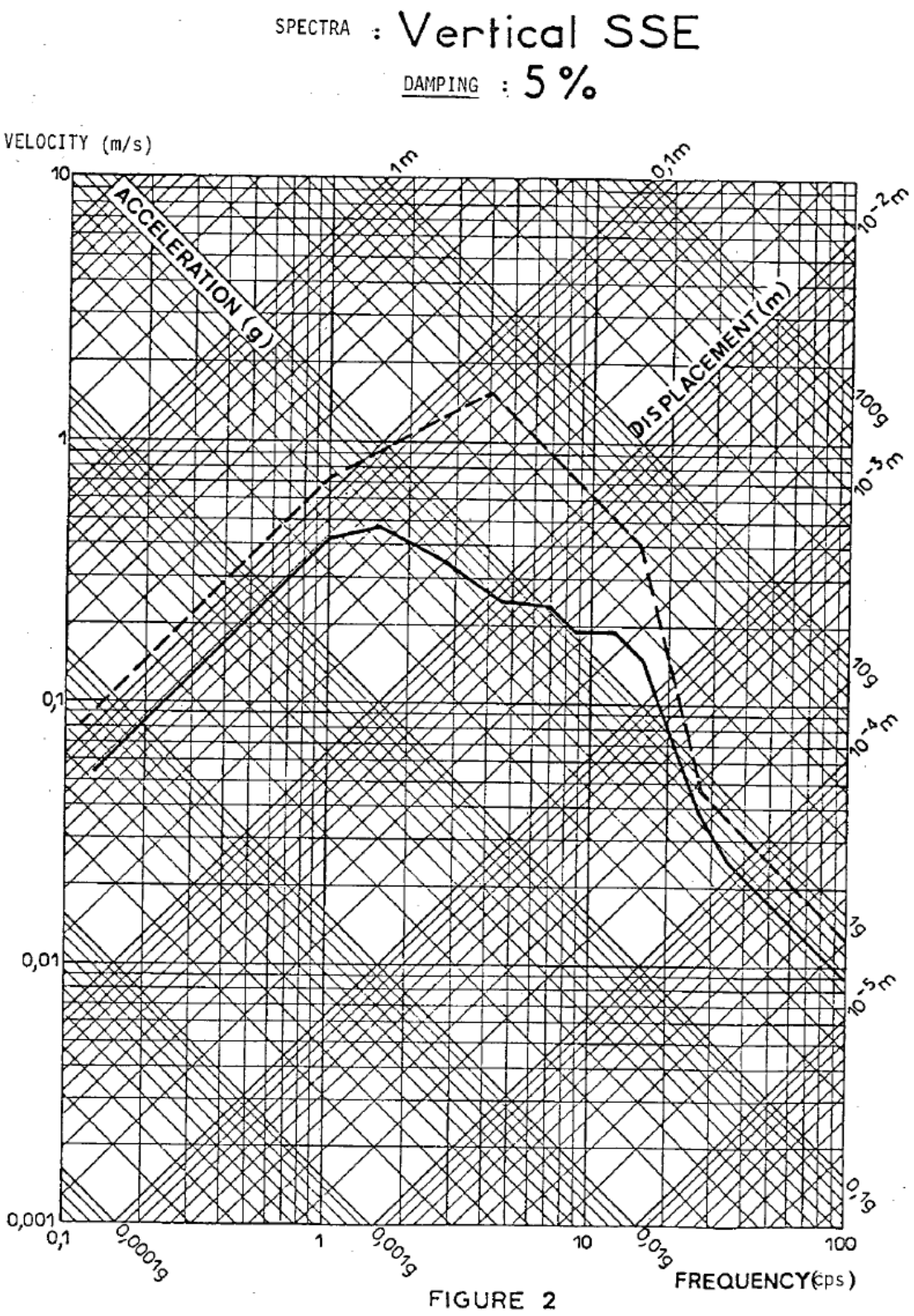


FIGURE 2

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