

Accelerometer-Based Vibration Monitoring System

API STANDARD 678
FIRST EDITION, MAY 1981
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American Petroleum Institute
1220 L Street, Northwest
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Refining Department

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FOREWORD

This standard is based on the accumulated knowledge and experience of manufacturers and users of monitoring systems. The objective of this publication is to provide a purchase specification for machinery monitoring systems using piezoelectric vibratory acceleration transducers.

This standard requires the purchaser to specify certain details and features. Also, it is recognized that the purchaser may wish to modify, delete, or amplify sections of the standard. It is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard rather than by rewriting or by incorporating sections into another complete standard.

Suggested revisions are invited and should be submitted to the director of the Refining Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Accelerometer-Based Vibration Monitoring System

SECTION 1—GENERAL

1.1 Scope

This specification covers the minimum requirements for machinery monitoring systems using piezoelectric vibratory acceleration transducers. It outlines a standardized system covering hardware (sensors and instruments) requirements, installation, and arrangement. This system may be used separately or in conjunction with noncontacting, eddy current proximity devices as described in API Standard 670. Accelerometer-based vibration monitoring systems are generally used for machinery having high shaft-to-bearing transmissibility, such as with rolling element bearings; for speed changers to monitor gear mesh condition; and for other turbomachinery to monitor such high frequency phenomena as blade rate, blade passing, and rubs, as well as such low frequency phenomena as cavitation and reciprocating compressor forces.

1.2 Alternative Designs

The vendor may offer alternative designs (see 6.1 for proposal requirements). Equivalent metric dimensions, fasteners, and flanges may be substituted as mutually agreed upon between purchaser and vendor.

1.3 Conflicting Requirements

In case of conflict between this standard and the inquiry or order, the information included in the order shall govern.

1.4 Definition of Terms

The terms used in this standard are defined as follows:

A *vibration transducer* is a device which converts mechanical vibration into an electrical signal proportional to that vibration.

A *piezoelectric accelerometer* is a transducer that translates vibratory acceleration to an electrical charge.

An *electrically isolated accelerometer* is one in which both signal leads are electrically separated from the accelerometer case.

The *charge amplifier cable* is the interconnection between the piezoelectric accelerometer and an external charge amplifier.

The *extension cable* is the interconnection between an accelerometer having an integral impedance matching device and a junction box.

The *charge amplifier* is a conditioning device which converts the charge signal generated by the piezoelectric accelerometer and provides an output voltage signal proportional to the accelerometer's electrical charge. (The charge amplifier must be powered by a direct current sufficient to provide the dynamic range required from the system.)

An *accelerometer with an integral impedance matching device* is a piezoelectric accelerometer with a built-in miniaturized charge amplifier. (This design eliminates the need for an external charge amplifier.)

Linear frequency response range is the portion of the transducer's voltage output versus frequency curve, between the lower and upper frequency limits, where the response is within a specified tolerance.

Operating frequency range is the frequency range specified by the user for a particular type of machinery.

A *channel* is a transducer and the hardware required to monitor its output signal.

The term *field changeable* describes a required equipment feature the function of which may be changed after installation of the monitoring system. This change may be accomplished by (1) soldering jumper leads to terminal pins especially provided for this purpose, (2) employing circuit board-mounted switches or potentiometers, (3) using a shorting or diode pin-type matrix board, or (4) using prewired shorting plugs.

The term *field alterable* describes a required equipment feature the function of which may be altered after installation. This alteration may be accomplished by (1) making any changes in field changeable functions or (2) inserting or replacing plug-in modules or circuit boards in the monitor housing.

An *anticipatory alarm (alert)* is a device that indicates whether the transducer output signal has exceeded a pre-established value (first stage of alarm).

A *shutdown (danger)* is a device that indicates whether the transducer output signal has exceeded the anticipatory alarm value by a pre-established value (second or final stage of alarm).

A *filter* is an electrical device which suppresses signals outside the frequency range of interest.

Signal suppression is a scheme for altering the vibration

monitor's reading by subtracting (suppressing) mechanical runout, electrical noise, and so forth.

Root mean square (rms) is the square root of the mean of the square of the signal (voltage, acceleration, current) taken during a complete cycle.

The *machinery vendor* is the agency that designs, fabricates, and tests machines. The machinery vendor may purchase a monitoring system and may install transducers on machines.

The *instrument manufacturer* is the agency that designs, fabricates, and tests monitoring system components.

The *construction contractor* is the agency that installs the machinery train and installs monitors and connects them to transducers.

The *owner* is the final recipient of the machinery train; he may purchase the monitoring system.

G is a unit of acceleration equal to 386.4 inches per second squared (9.81 meters per second squared).

IPS is a unit of velocity equal to 1 inch per second (25.4 millimeters per second).

The *blade passing frequency* is calculated by multiplying the number of rotating blades times the rotational speed of the shaft.

The *blade rate frequency* is calculated by multiplying the blade passing frequency by the number of stationary blades, diffuser vanes, or volute tongues and dividing this number by the largest integer which is a common factor in the numbers of rotating blades and stationary blades, diffuser vanes, or volute tongues.

1.5 Referenced Publications

1.5.1 The latest edition of the following standards, codes, or specifications shall form to the extent specified

herein a part of this standard.

IPCEA¹

S-61-402

Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

ISO²

Requirements for Instruments for Measuring Vibration Severity

NFPA³

Bulletin
No. 70

National Electrical Code, Article 725, "Class 1, Class 2, and Class 3, Remote-Control, Signaling, and Power Limiting Circuits"

496

Purged and Pressurized Enclosure for Electrical Equipment in Hazardous Locations

NEMA⁴

ICS 1-110

Enclosures

ANSI⁵

Y-14.2

Line Conventions and Lettering

1.5.2 The applicability of any federal, state, or local codes, regulations, ordinances, or rules shall be mutually agreed upon by the purchaser and the vendor.

¹ Insulated Power Cable Engineers Association, 283 Valley Road, Montclair, New Jersey 07042.

² International Standards Organization, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

³ National Fire Protection Association, 470 Atlantic Avenue, Boston, Massachusetts 02210.

⁴ National Electrical Manufacturer's Association, 2101 L Street, N.W., Washington, D.C. 20037.

⁵ American National Standards Institute, 1430 Broadway, New York, New York 10018.

SECTION 2—GENERAL DESIGN SPECIFICATIONS

2.1 Linearity Requirements

The minimum linearity requirements of the system, including the transducer, the power supply, and the monitor, as calibrated on a bench test, shall be as described in 2.1.1 and 2.1.2 unless otherwise specified by the purchaser.

2.1.1 Accelerometer linearity shall be ± 5 percent of 100 millivolts per *G* (or 10 pico coulombs per *G* for accelerometers without integral impedance matching devices) sensitivity over a minimum operating range of 0.1 to 75 *G* peak and over the frequency range of 5 hertz to 10 kilohertz.

2.1.2 Channel linearity shall be 10 percent of specified

full scale acceleration display range over a frequency range of 5 hertz to 10 kilohertz.

2.2 Environmental Requirements

2.2.1 TEMPERATURE

The linearity requirements of 2.1 shall apply over the temperature ranges and temperature transients described in 2.2.1.1 through 2.2.1.6.

2.2.1.1 Piezoelectric accelerometer without integral impedance matching device and charge amplifier cable: -65 to $+450$ F (-54 to $+232$ C) and a temperature transient of 5 F (2.8 C) per second.