

Machinery Protection Systems

API STANDARD 670
SIXTH EDITION, JULY 2025



American
Petroleum
Institute

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

Users of this standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to ensure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Copyright © 2025 American Petroleum Institute

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

The verbal forms used to express the provisions in this document are as follows.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Contents

	Page
1	Scope 1
1.1	General 1
2	Normative References 1
3	Terms, Definitions, Acronyms, and Abbreviations 2
3.1	Terms and Definitions 2
3.2	Acronyms and Abbreviations 14
4	Scope of Supply and Responsibility 17
4.1	Purchaser 17
4.2	Details 7
5	Requirements 7
5.1	Units of Measure 17
5.2	Statutory Requirements 17
5.3	Documentation Requirements 17
6	General Design Specifications 17
6.1	Temperature Ranges 17
6.2	Humidity 17
6.3	Shock 17
6.4	Chemical Resistance 18
6.5	Accuracy 18
6.6	Interchangeability 22
6.7	Segregation 22
6.8	System Enclosures and Environmental Requirements 25
6.9	Power Supplies 25
6.10	MPS Features/Functions 26
6.11	System Output Relays 28
6.12	Digital Communication Links 29
6.13	System Wiring and Conduits 29
6.14	Grounding of the MPS 32
6.15	System Security, Safeguards, Self-tests, and Diagnostics 33
6.16	Reliability 33
6.17	Sensors and Transducers 34
6.18	Sensor and Transducer Arrangements 43
7	Monitoring and Protection Systems 55
7.1	Vibration, Position, and Temperature Monitoring Systems (VMSs) 55
7.2	Electronic ODS 64
7.3	Surge Detection Systems (SDSs) 68
7.4	Trip Systems 72
8	Inspection, Testing, and Preparation for Shipment 80
8.1	General 80
8.2	Inspection 80
8.3	Testing 80
8.4	Preparation for Shipment 81
8.5	Mechanical Running Test 81
8.6	Field Testing 81
9	Vendor's Data 86
9.1	General 86
9.2	Proposals 87

Annex A (informative) Machinery Protection System Datasheets.....	89
Annex B (informative) Typical Responsibility Matrix Worksheet	110
Annex C (normative) Accelerometer Mounting.....	111
Annex D (normative) Signal Cable	116
Annex E (normative) Gearbox Casing Vibration Detection Requirements	119
Annex F (normative) Field Testing and Documentation Requirements	121
Annex G (informative) Vendor Data and Drawing Requirements	124
Annex H (informative) Typical VMS Arrangement Plans	131
Annex I (informative) VMS Setpoint Multiplier Considerations.....	143
Annex J (normative) Electronic Overspeed Detection System Considerations.....	147
Annex K (informative) Surge Detection and Anti-surge Control.....	153
Annex L (informative) Functional Safety Methodology	158
Annex M (informative) The Use of Functional Safety Methodology to reduce Economic Losses and Redundancy to Avoid Spurious Shutdowns	183
Annex N (informative) Torsional Vibration Monitoring	189
Annex O (normative) Calculation of the Maximum Rotor Speed During an Overspeed Trip.....	201
Annex P (normative) Reciprocating Compressor Monitoring	211
Bibliography	215

Figures

1 Typical Curves Showing Accuracy of 8 mm Proximity Probe System	21
2 Typical Conduit Cable Arrangement	30
3 Typical Armored Cable Arrangement	31
4 Typical Instrument Grounding.....	33
5 Standard 8 mm Radial Vibration and Axial Proximity Probe System	34
6 Other Standard Options for Radial Vibration and Axial Proximity Probes	36
7 Standard 11 mm Proximity Probe System.....	37
8 Standard Magnetic Shear Sensor with Removable (Nonintegral) Cable and Connector	39
9 Side Clearance for Radial Vibration Probes	44
10 Standard Axial Probe Arrangement	45
11 Piston Rod Monitoring Probe Sideview Clearance.....	46
12 Typical Piston Rod Monitoring Probe(s) Arrangement	47
13 Typical Installations of Radial Load on Pad Bearing Temperature Sensors	51
14 Standard Installation of Radial Load Between Pad Bearing Temperature Sensors.....	52
15 Typical Installation of Thrust Bearing Temperature Sensors.....	52
16 Piston Rod Drop Calculations.....	60
17 Piston Rod Drop Measurement Using Crank Angle Reference Probe for Triggered Mode	61
18 2oo3 Voting as Part of Logic Solver.....	66
19 2oo3 Voting as Part of Hydraulic Circuit	66
20 Surge Detection and Anti-surge Control Systems.....	69
21 Surge Detection with Compressor Inlet Temperature.....	71
22 Typical System Arrangement Using Distributed System Architecture	76
23 Typical System Arrangement Using Integrated System Architecture.....	77

24	Calibration of Radial Monitor and Setpoint for Alarm and Shutdown	82
25	Calibration of Axial Position (Thrust) Monitor.....	83
26	Typical Field Calibration Graph for Radial and Axial Position (Gap).....	84
A.1	Machinery Protection System Datasheets (USC).....	89
A.2	Machinery Protection System Datasheets (SI).....	99
C.1	Typical Flush-mounted Accelerometer Details	112
C.2	Typical Nonflush-mounted Arrangement Details for Integral Stud Accelerometer.....	113
C.3	Typical Nonflush-mounted Arrangement for Integral Stud Accelerometer with Protection Housing	113
H.1	Typical System Arrangement for a Turbine with Hydrodynamic Bearings	131
H.2	Typical System Arrangement for Double-helical Gear (See Table H.4, Note 2)	133
H.3	Typical System Arrangement for a Centrifugal Compressor or a Pump with Hydrodynamic Bearings	135
H.4	Typical System Arrangement for an Electric Motor with Sleeve Bearings	137
H.5	Typical System Arrangement for a Pump or Motor with Rolling Element Bearings	139
H.6	Typical System Arrangement for a Reciprocating Compressor.....	140
I.1	Setpoint Multiplication Example	143
J.1	Overspeed Protection System	146
J.2	Relevant Dimensions for Overspeed Sensor and Multi-tooth Speed Sensing Surface Application Considerations (See Table J.1)	147
J.3	Precision-machined Overspeed Sensing Surface (See Table J.1)	150
K.1	Compressor Performance Limitations	153
K.2	Pressure and Flow Variations During a Typical Surge Cycle.....	153
L.1	Risk Graph as per VDMA 4315-1	161
L.2	Risk Graph as per ISO 13849.....	165
L.3	Perfect Proof Test.....	170
L.4	Non-perfect Proof Test.....	171
L.5	Relationship Between Categories, DCavg, MTTFd of Each Channel, and PL.....	173
L.6	Functional Block Diagram of Typical Protection Loop with a Single Solenoid Valve.....	175
L.7	Functional Block Diagram of Typical Protection Loop with a Dual Solenoid Valve.....	175
M.1	Risk Graph for Asset Losses	184
M.2	Protection/Availability Matrix	186
M.3	Process Block Diagram	187
N.1	Wireless Strain Gauge System	190
N.2	Magnetostrictive System	191
N.3	Multi-tooth Phase Shift Systems.....	192
N.4	Mode Shape for Motor-gearbox-compressor	194
N.5	Mode Shape for Reciprocating Engine Driving a Reciprocating Compressor	195
N.6	Strain Gauge Installation Arrangement.....	196
N.7	Magnetostrictive System Installation Arrangement	197
N.8	Multi-tooth Phase Shift System Installation Arrangement.....	198
C.1	The Peak Kinetic Energy of the Rotor	201
Tables		
1	MPS Accuracy Requirements.....	19
2	Summary of Allowable Usage of Wireless Technology for MPSs.....	23

3	Minimum Separation Between Installed Signal and Power Cables	32
4	Accelerometer and Piezo-velocity Transducer Test Points (SI)	85
5	Accelerometer and Piezo-velocity Transducer Test Points (USC Units)	85
D.1	Color Coding for Single-circuit Thermocouple Signal Cable	117
F.1	Tools and Instruments Needed to Verify and Test MPSs	120
F.2	Data, Drawing, and Test Worksheet	121
G.1	Typical Milestone Timeline	125
G.2	Sample Distribution Record (Schedule)	127
H.1	Probe Nomenclatures	132
H.2	Key and Notes for Figure H.1	132
H.3	Probe Nomenclatures	134
H.4	Key and Notes for Figure H.2	134
H.5	Probe Nomenclatures	136
H.6	Key and Notes for Figure H.3	136
H.7	Probe Nomenclatures	138
H.8	Key and Notes for Figure H.4	138
H.9	Vibration Monitor	139
H.10	Key and Notes for Figure H.5	139
H.11	Key and Notes for Figure H.6	141
J.1	Recommended Dimensions for Speed Sensing Surface when Magnetic Speed Sensors Are Used	150
J.2	Recommended Dimensions for Nonprecision Speed Sensing Surface when 8 mm Proximity Probe Speed Sensors Are Used	151
J.3	Recommended Dimensions for Precision-machined Speed Sensing Surface when 8 mm Proximity Probe Speed Sensors Are Used	151
L.1	Safety Integrity Levels and Probability of Failure	158
L.2	Performance Level as per ISO 13849 and Safety Integrity Level as per IEC 61508/61511	160
L.3	Definition of the Range of the Parameter Severity, S	161
L.4	Definition of the Range of the Parameter Probability of Presence in the Hazardous Zone—F	162
L.5	Definition of Vulnerability and Unavoidability A	163
L.6	Definition of the Range of the Parameter AV (Unavoidability Considering the Vulnerability)	163
L.7	Definition of the Range of the Parameter W (Probability of the Occurrence of the Unwanted Event)	164
L.8	Examples of Risk Targets	166
L.9	Examples of Turbomachinery Initiating Causes	167
L.10	Examples of Turbomachinery IPLs	167
L.11	Examples of Turbomachinery Conditional Modifiers	168
L.12	Table of Calculated PFD _{avg} for Example of L.8.2.2	177
L.13	Mean Time to Dangerous Failure of Each Channel (MTTFd)	179
L.14	Diagnostic Coverage	179
L.15	Table of Calculated PFD _{avg} for Example in L.8.5	180
L.16	Typical Torsional Vibration Monitoring System Accuracy Requirements	189

Currently in preview, click buy full version

Machinery Protection Systems

1 Scope

1.1 General

This standard covers the minimum requirements for a machinery protection system (MPS) measuring radial shaft vibration, casing vibration, shaft axial position, shaft rotational speed, crosshead vibration, piston rod monitoring, phase reference, crank angle reference, overspeed, surge detection, and critical machinery temperatures (such as bearing metal and motor windings). It covers requirements for hardware (transducers and monitor systems), installation, documentation, and testing.

NOTE A bullet [•] at the beginning of a subsection or paragraph indicates that either a decision is required or further information is to be provided by the purchaser.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Standard 612, *Petroleum, Petrochemical, and Natural Gas Industries—Steam Turbines—Special-purpose Applications*

API 618, *Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services*

API Technical Report 684-1, *API Standard Paragraphs Recurdynamic Tutorial: Lateral Critical Speeds, Unbalance Response, Stability, Train Torsionals, and Rotor Balancing*

ASTM E230/E230M-23a¹, *Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

NEMA WC 57²/ICEA S-73-532-2021³, *Standard for Control, Thermocouple Extension, and Instrumentation Cables*

IEC 60079⁴, (all parts) *Explosive atmospheres*

IEC 60259, *Degrees of protection provided by enclosures (IP Code)*

IEC 60584-1, *Thermocouples—Part 1: EMF specifications and tolerances*

IEC 61000-6-2, *Electromagnetic compatibility (EMC)—Part 6-2: Generic standards—Immunity standard for industrial environments*

IEC 61508, (all parts) *Electronic functional safety package*

IEC 61511, (all parts) *Functional safety—Safety instrumented systems for the process industry sector*

IEC 62061, *Safety of machinery—Functional safety of safety-related control systems*

¹ ASTM International, PO Box C700, 100 Barr Harbor Drive, West Conshohocken, PA 19428, www.astm.org.

² National Electrical Manufacturers Association, 1812 N. Moore Street, Arlington, VA 22209, www.nema.org.

³ Insulated Cable Engineers Association, P.O. Box 493, Miamitown, OH 45041, www.icea.net.

⁴ International Electrotechnical Commission, 3 rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.