

Pipeline SCADA Alarm Management

API RECOMMENDED PRACTICE 1167
SECOND EDITION, JUNE 2016

REAFFIRMED, OCTOBER 2021



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.

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, Washington, DC 20001.

Copyright © 2016 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.

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

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, 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, Washington, DC 20001.

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

Contents

1	Scope	1
2	Normative References	1
3	Terms, Definitions, and Abbreviations	2
3.1	Definitions	2
3.2	Abbreviations	5
4	Alarm Management Plan	6
5	Alarm Philosophy	6
5.1	Alarm Philosophy Purpose	6
5.2	Alarm Philosophy Use and Contents	7
6	Alarm Application and Determination	8
6.1	General Considerations	8
6.2	Alarm Determination	9
6.3	Purpose and Use of Alarm Priority	9
6.4	Diagnostic Alarm Priority	10
6.5	Safety-related Alarms	10
6.6	Other Uses of the Alarm System	11
7	Alarm Documentation and Rationalization	11
7.1	General	11
7.2	Documentation & Rationalization Process	11
7.3	Documentation & Rationalization Methodology	11
7.4	Documentation & Rationalization Preparation	12
7.5	Determination and Assignment of Alarm Priority	13
7.6	Determination of Alarm Setpoint	13
7.7	Staged Approaches to Alarm Rationalization	14
7.8	Recommended Storage of Documentation & Rationalization Information	14
8	SCADA System Alarm Functionality and Alarm Design	14
8.1	General	14
8.2	Point Types and Alarm Types	15
8.3	Alarm Priority	16
8.4	Alarm Settings and Alarm Occurrences	16
8.5	Other Alarm-related Electronic Records	17
8.6	Alarm Logs/Alarm Summaries	17
8.7	Event Logs/Event Summaries	17
8.8	Alarm Summary Display	18
8.9	Alarm Deadband	18
8.10	Alarm On-Delay and Off-Delay	18
8.11	Alarm Suppression and Alarm Shelving	19
8.12	Alarm System Reliability	19
8.13	Defined Alarm Design Cases	20
9	Roles and Responsibilities	21
9.1	Overview and Introduction	21
9.2	Management	21
9.3	Technical	21
9.4	Operations	21

Contents

10	Alarm Handling	22
10.1	General	22
10.2	Nuisance Alarms	22
10.3	Alarm Shelving	22
10.4	Designed Alarm Suppression	23
10.5	State-based or State-dependent Alarms	23
10.6	Alarm Flood Suppression	23
10.7	Alarm Audit and Enforcement	24
10.8	Special-purpose Priorities and Alarm Routing	24
10.9	Controller-adjustable Alarms	24
11	Controller Alert Systems	25
12	Nonannunciated Events	25
13	Alarm Audits and Performance Monitoring	26
13.1	Overview and Introduction	26
13.2	Audits of Managerial and Work Practices	26
13.3	Alarm System Performance Metrics	27
13.4	Alarm System Key Performance Indicators	27
13.5	Reporting of Alarm System Analyses	29
13.6	Regulatory Requirements for Alarm System Monitoring	30
14	Management of Change	30
14.1	Purpose and Use	30
14.2	Testing	30
14.3	Documentation	30
14.4	Notification and Training	31
14.5	Emergency Management of Change	31
14.6	Temporary Management of Change	31
14.7	Regulatory Requirements for Management of Change	31
Annex A (informative) Determination of Alarm Priority		32
Annex B (informative) Priority Distribution for Alarm Configuration and Occurrence		36
Annex C (informative) Guidelines for Determining Possible Alarm System Key Performance Indicators		37
Bibliography		39
Tables		
A.1	EXAMPLE Areas of Impact and Severity of Consequences Grid	33
A.2	EXAMPLE Maximum Time Available for Response and Correction Grid	34
A.3	EXAMPLE Severity of Consequences and Time to Respond Grid for Alarm Priority Determination	34
B.1	Recommended Priority Distribution for Alarm Configuration and Occurrence	36
C.1	Alarm KPI Summary	38

Introduction

This publication was created by an API subcommittee. The members of this subcommittee were predominantly pipeline operators of liquid pipelines, but included participation from pipeline operators of gas pipelines, as well as members from the alarm management and control systems communities and U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration representatives.

With the technological advances of SCADA systems within the pipeline industry over the past two decades, it has become relatively simple to supply pipeline controllers with a wealth of information regarding the pipeline systems that they are operating. As the amount of information available to a controller increases, the importance of having a program in place to manage this information also increases. Alarm information should be presented to the controller in a manner that allows for easy identification and clear expectations as to the response required.

Pipeline SCADA Alarm Management

1 Scope

This document is intended to provide pipeline operators with recommended industry practices in the development, implementation, and maintenance of an alarm management program. It provides guidance on elements that include, but are not limited to, alarm definition, philosophy, documentation, management of change, and auditing.

This document is not intended to be a step-by-step set of instructions on how to build an alarm management system. Each pipeline operator has a unique operating philosophy and will therefore have a unique alarm philosophy as well. This document is intended to outline key elements for review when building an alarm management system.

SCADA systems used within the pipeline industry vary in their alarm-related capabilities. There are also many different software systems available to aid in alarm management. It is the responsibility of the pipeline operator to determine the best method to achieve their alarm management goals.

This document uses industry best practices to help to illustrate aspects of alarm management. The scope is intended to be broad. There are several publications and standards listed in Section 2 and the Bibliography that provide greater detail on the various elements of alarm management. Pipeline operators are encouraged to consult these publications.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 1165, *Recommended Practice for Pipeline SCADA Displays*

ANSI/ISA¹ 18.2-2009, *Management of Alarm Systems for the Process Industries*

49 CFR Part 192², *Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standards*

49 CFR Part 195, *Transportation of Hazardous Liquids by Pipeline*

¹The Instrumentation, Systems, and Automation Society, 67 Alexander Drive, Research Triangle Park, North Carolina, 22709, www.isa.org

²U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, East Building, 2nd Floor, 1200 New Jersey Ave., SE, Washington, DC 20590, www.phmsa.dot.gov

3 Terms, Definitions, and Abbreviations

3.1 Definitions

For the purposes of this document, the following definitions apply.

3.1.1

alarm

Visible and/or audible means of indicating to the controller an equipment malfunction, an analog or accumulation process deviation, or other condition requiring a controller's response.

3.1.2

alarm configuration

(alarm attributes, alarm settings)

Setup of individual alarms (such as their setpoints, priorities, deadbands, delay times, etc.) produced by SCADA systems.

3.1.3

alarm flood

Condition determined by the operator, during which the alarm rate is greater than the controller can effectively manage.

3.1.4

alarm management

Processes and practices for determining, documenting, designing, operating, monitoring, and maintaining alarm systems.

3.1.5

alarm objective analysis

AOA

See definition of "rationalization."

3.1.6

alarm occurrence

Audible and/or visible indication of the alarm, along with a time-stamped electronic record containing information about the particular alarm generated when the conditions of the alarm configuration are met (such as an analog value exceeding a high alarm setpoint).

NOTE Different alarm analyses can be made of both alarm configuration and alarm occurrences.

3.1.7

alarm philosophy

Document that establishes the basic definitions, principles, and processes to determine, design, document, implement, operate, monitor, and maintain an alarm system.

3.1.8

alarm priority

Relative importance assigned to each alarm indicating the urgency of response, typically using an allowable response time and consequence severity.

3.1.9

alarm setpoint

(alarm limit, alarm trip point)

Threshold value of an analog or discrete state or logic condition that triggers the alarm indication.

3.1.10 alarm system

Collection of hardware and software that detects a change in an operating condition, communicates the indication of that state to the controller either through an alarm or an alert, and records changes of the operating condition.

3.1.11 alert

Visible and/or audible means of notifying the controller when a controller-predefined operating condition has attained a certain value.

NOTE These notifications are used to drive controller awareness.

3.1.12 control system

See definition of “SCADA.”

NOTE This recommended practice uses the term “SCADA” as generic and inclusive of a variety of control system types.

3.1.13 diagnostic alarm

Alarm indicating sensor or hardware malfunction.

NOTE Controller’s reactions to diagnostic alarms may be limited to notification of the maintenance function.

3.1.14 human-machine interface HMI

Collection of screens, displays, keyboards, switches, and other technologies used by the controller to monitor and interact with the SCADA system.

3.1.15 management of change MOC

Process used by pipeline operators to manage changes to their facilities and processes, organizations, and documents to ensure that changes are adequately identified, evaluated, planned, controlled, and communicated.

NOTE “Change management” and “management of change” are interchangeable throughout this document.

3.1.16 master alarm database

Approved list of all rationalized alarms for a SCADA control system and their correct attributes and settings.

NOTE This information can be gathered, stored, and maintained using a variety of formats or methods.

3.1.17 nonannunciated event

An event occurrence that is not annunciated to the controller, does not impose a load on the controller, and is therefore not considered when determining controller alarm rates.

NOTE Some SCADA systems have the ability to route some event occurrences directly to electronic storage, without any indication to the controller, or to other functions (such as maintenance). Such nonannunciated events do not meet the general definition of an alarm used in this recommended practice.

3.1.18**nuisance alarm**

Alarm that annunciates excessively or unnecessarily or does not return to normal after the correct response is taken (e.g. chattering, fleeting, false, or stale alarms).

3.1.19**operating position**

Span of control and alarm responsibility of a single pipeline controller, generally involving computer consoles, graphical displays, and communication equipment enabling a controller to interact with the SCADA system.

NOTE A pipeline control room can have multiple operating positions.

3.1.20**pipeline control room**

Operations center staffed by personnel charged with responsibility for remotely monitoring and/or controlling entire or multiple sections of pipeline systems.

NOTE For the purposes of this document, “pipeline control room” and “control room” are synonymous.

3.1.21**pipeline controller**

Qualified individual whose function is to remotely monitor and/or control the operations of the entire or multiple sections of pipeline systems via a SCADA system from a pipeline control room and who has operational authority and accountability for the daily remote operational functions of pipeline systems as defined by the pipeline operator.

NOTE For the purposes of this document, “pipeline controller” and “controller” are synonymous.

3.1.22**pipeline controller response**

Action that extends beyond the mental notation, visual recognition, or electronic acknowledgment of an alarm occurrence.

NOTE An action may include, but is not limited to, a change to operating parameters, modification to alarm limits, internal or external notifications, increased or more frequent monitoring of an operation, recording of process or operating data, or other specific action as defined by an alarm’s design.

3.1.23**pipeline operator**

Entity that owns or operates pipeline facilities.

NOTE For the purposes of this document, “pipeline operator” and “operator” are synonymous.

3.1.24**rationalization****(alarm objective analysis [AOA])**

Process to determine and ensure that alarms are selected, designed, prioritized, and documented in accordance with the principles of the pipeline operator’s alarm philosophy.

3.1.25**safety-related alarms**

Alarms that specifically indicate that equipment, systems, or processes are outside operator-defined safety-related parameters.

3.1.26 shelve

Mechanism, typically initiated by the controller, to temporarily suppress an alarm, following proper administrative and functional requirements.

3.1.27 Supervisory Control and Data Acquisition SCADA

Computer-based system that collects information about a pipeline facility, generates alarms, and provides a structured view of the pipeline system with the capability to control the pipeline operation.

NOTE 1 This is a generic definition of SCADA.

NOTE 2 The use of the term “SCADA” in this document is intended to be inclusive of industry-specific use of the term SCADA as well as including distributed control systems (DCSs) or systems that utilize programmable logic controllers (PLCs), remote terminal units (RTUs), or similar technologies. Commonly used terms such as “basic process control system” (BPCS) and “process control system” (PCS) are also synonyms for the purposes of this recommended practice.

3.1.28 suppress

Any mechanism to prevent the indication of a configured alarm to the controller when the alarm condition is present.

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

ACK	acknowledgment [event]
AMP	alarm management plan
AOA	alarm objective analysis
API	American Petroleum Institute
BPCS	basic process control system
CFR	<i>Code of Federal Regulations</i>
CTA	common trouble alarm
D&R	documentation and rationalization
DI	digital input
DO	digital output
ESD	emergency shutdown
HAZOP	hazard and operability
HH	HI-HI or high-high
HMI	human-machine interface
KPI	key performance indicator
LASD	local area shutdown
LL	LO-LO or low-low
MOC	management of change

PFD	process flow diagram
PHA	process hazard analysis
P&ID	piping and instrumentation diagram
PID	proportional-integral-derivative
PLC	programmable logic controller
RTU	remote terminal unit
SCADA	Supervisory Control and Data Acquisition
UPS	uninterruptible power supply

4 Alarm Management Plan

The purpose of the alarm management plan (AMP) is to establish alarm management effectiveness criteria and to evaluate the effectiveness of such criteria. Additionally, the AMP addresses how the alarm philosophy is utilized.

The AMP, intended to meet the requirements of 49 CFR 192 and 195, should include the following:

- alarm maintenance,
- identification of factors and criteria to measure alarm management effectiveness,
- governance items involving alarm setpoints and limits.

The AMP encompasses:

- alarm standardization and aligns with SCADA system design,
- best practices where applicable,
- well-defined and rationalized alarms.

It is recommended that the AMP contain:

- description of procedures and how they are implemented,
- planned alarm management effort for the year,
- project target to improve the alarm rates.

Control center personnel receive and are trained on this AMP as part of the overall control room management plan (refer to API RP 1168). Others with identified responsibilities within this plan also are provided access to this document and appropriate training.

5 Alarm Philosophy

5.1 Alarm Philosophy Purpose

An alarm philosophy is a comprehensive document that covers the proper ways to define, design, implement, maintain, monitor, and test an alarm system. It establishes the pipeline operator's criteria, definitions, and principles for effective alarm management, including the required procedures or work processes, and metrics used to identify, classify, rationalize, prioritize, document, and manage alarms. All pipeline operators should develop, document, and follow their own comprehensive alarm philosophy.

A documented alarm philosophy helps to ensure:

- consistency of alarm design and presentation,
- consistency of alarms with the pipeline operator's risk management goals/objectives,
- agreement with good engineering practices,
- effective controller response to alarms.

The alarm philosophy should be designed to meet the federal regulation requirements of 49 CFR 192 and 195 and for having a written AMP to provide for effective controller response to alarms.

5.2 Alarm Philosophy Use and Contents

The philosophy document covers both new SCADA systems and existing systems. It is for both in-house use and contractor use during projects. Due to the wide variety of equipment used within the pipeline industry, the detailed contents of the alarm philosophy may vary from one location to another. However, alarms should be implemented consistently within a single SCADA system and across operating positions.

The philosophy document should provide a consistent and optimum basis for the following topics:

- alarm definition and principles;
- alarm selection and configuration;
- alarm system performance monitoring;
- procedures or work processes for resolution of alarm problems;
- methods for alarm rationalization and priority determination;
- alarm detection, presentation, annunciation, navigation, and controller interface;
- alarm documentation, including controller response to alarms;
- considerations for alarms routed to multiple controllers/locations;
- alarm handling methods;
- defined alarm design topics that are “up-front” decisions regarding the consistent implementation practices to be followed for the configuration of certain types of alarms;
- alarm system maintenance and testing;
- alarm system management of change (MOC);
- alarm system training;
- alarm system improvement process;
- alarm system roles and responsibilities;

- alarm system audit;
- definitions (not included in “alarm definition and principles” above) and references;
- alarm system training for noncontrol center personnel (e.g. staff, control system technicians, etc.).

The alarm philosophy should be based on several key principles as follows:

- The alarm system is to be designed to notify the controller of events requiring a response. Alarms are not a substitute for the controller’s routine monitoring of a pipeline or facility operation.
- Controllers are trained on the alarm management strategy.
- Proper alarm management enhances the controller’s ability to make a decision using experience, skill, and available information.
- Alarm priorities define the order of the controller’s response.
- The alarm system is routinely maintained.
- Controllers respond to all alarms, regardless of priority.
- The system design, therefore, should not produce more alarms than those to which the controller can respond.
- Alarms are not created solely upon the assumption that the controller will fail to respond to a different alarm.

NOTE Some of these may also be addressed in other company documents, such as operating procedures or engineering standards.

An alarm philosophy document need not be specific to a particular type of SCADA system as the principles and concepts are system independent. It is common to have SCADA system-specific appendices to the philosophy (or separate documents) that translate the principles to the particular features, capabilities, and limitations of a particular SCADA system.

Consideration should be given to each of the mentioned topics when preparing an alarm philosophy document.

6 Alarm Application and Determination

6.1 General Considerations

SCADA systems are structured to manage more than just alarms. A typical SCADA system structure may consist of alarms, alerts, and nonannunciated events. The primary focus of this document is on alarms because alarms have a significant importance in safely and effectively operating the pipeline. Alerts are used to drive awareness. The pipeline operator may choose to present alerts on a separate display or on the same display as alarms but with a lower priority. Nonannunciated events are configured similarly to an alarm, yet are not annunciated to the controller.

Properly implemented alarm systems play a key role in safe and effective pipeline operations. Improperly implemented, maintained, or overloaded alarm systems can significantly detract from the controller’s ability to accomplish effective operations and handle nonnormal conditions.

Alarms are used to indicate the need for controller action to return the pipeline to normal and safe operation or to avoid automated shutdowns. Alarms may also indicate the need for controller action in response to operational changes in hydraulics, volume measurement, or product quality operating situations.