Pipeline SCADA Displays

API RECOMMENDED PRACTICE 1165
SECOND EDITION, DECEMBER 2022



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 © 2022 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
2	Normative References	1
3	Terms, Definitions, and Abbreviations	2
3.1	Terms and Definitions	2
3.2	Abbreviations	6
4	Human Factors Engineering (HFE) Considerations in Display Design	7
4.1	General	7
4.2	Short-term Memory	13
4.3	Signal-to-Noise Ratio	14
4.4	Eye Scan Pattern	15
4.5	Consistency	17
4.6	Coding	18
5	Display Hardware	19
5.1	General Considerations	19
5.2	Display Devices	19
5.3	Display Response	20
5.4	Controller Input Devices	21
6	Display Layout and Organization	21
6.1	General Considerations	21
6.2	Display Hierarchy	22
6.3	Window Management Considerations	28
7	Display Navigation	31
7.1	General Considerations	31
7.2	Navigation Techniques	31
8	Object Characteristics	35
8.1	General Considerations	35
8.2	Color	36
8.3	Symbols	37
8.4	Animation	39
8.5	Text	40
9	Object Dynamics	42
9.1	General Considerations	42
9.2	Data Values	42
9.3	Data Attributes	48
10	Control and Selection Techniques	51
10.1	Object Selection	51
10.2	Command Execution	54
10.3	Error Management	54
11	Administration	55
11.1	General	55
11.2	Consistency Within a Company	55
11.3	Documentation	56
11.4	Consistency Between Control Centers and Remote Locations	56
11.5	Management of Change	57
12	Display Determination	58

Contents

Page

Annex A (informative) **Example Annexes for SCADA Displays** 59

Bibliography 137

Figures

1 Endsley Situation Awareness Model 8
2 Proximity Example 1: Pipeline Example Where Proximity (a) Has Not Been Applied and (b) Has Been Applied 10
3 Proximity Example 2: Table Example Where Proximity (a) Has Not Been Applied and (b) Has Been Applied 10
4 Similarity Example: All Valves Are Recognized as Valves Because of the Similar “Butterfly” Property 11
5 Closure Example: Line Breaks Are Closed Visually when Scanning a Given Pipeline with thte Break 12
6 Balance Example: Line Breaks Are Closed Visually when Scanning a Given Pipeline with the Break 12
7 Figure/Ground Example: Salience Coding of Data Elements 13
8 Figure/Ground Example: Figure/Ground Examples for Different Potential Conditions Based on the Salience Coding Shown in the Example Above 13
9 Example Flow and Volume Information 14
10 Example Tabular Data Display 15
11 Example Graphic Display 16
12 Example Console Layout 16
13 Example Static Object Consistency 17
14 Example Static Text Consistency 18
15 Coding for Object Traits 19
16 Example Level 1 System Overview A 23
17 Example Level 1 System Overview B 23
18 Example Level 1 Trend Display 24
19 Example Level 2 Tabular Display A 25
20 Example Level 2 Tabular Display B 25
21 Example Level 3 Display 26
22 Example Level 4 Predetermined Control Display 27
23 Example Level 4 Pop-up 27
24 Example Tabbed Control Panel 32
25 Example Navigation Menu 33
26 Example Ribbon Bar 33
27 Example Valve Symbol Legend 38
28 Example Piping Shown with Additional HMI Elements 39
29 Example Piping Legend 39
30 Serif vs Sans Serif Fonts 40
31 Object Characteristics of Fill and Tilt 42
32 Object Characteristics of Shading 43
33 Persistent Variable Single Line of Text 44
34 Example Numeric Value 45
35 Example Combination Visual and Numeric Indicator 45
36 Example Visual Indicator 46
37 Example of Data Attribute Placement 48
38 Example of Consistent Attributes for Devices, Text States, and Analogs 49
39 Example Communication Failure Indicator 50
A.1 Example Valve Symbols Indicating States 63
A.2 Example Pump Symbols Indicating States 63
A.3 Example Analog Indicator 63

Contents

Page

A.4 Example Complex Analog Indicator with Trend and Bar 64
A.5 Example State Indicator with Text 64
A.6 Example of Unique Symbols and Indicators with Data Attributes 64
A.7 Example of Complex Analog with Rate of Change Indicator 65
A.8 Example Level 1 Overview Display 66
A.9 Example Hydraulic Profile 66
A.10 Example Level 2 Pipeline Display 67
A.11 Example Level 2 Terminal Display 68
A.12 Example Level 3 Pipeline Display 68
A.13 Example Level 3 Terminal Display 69
A.14 Example Level 4 Display 69
A.15 Example Pop-up Controls 70
A.16 Example Console Layout 70
A.17 Color Palette 72
A.18 Example Object Legend 73
A.19 Level 1 Navigation Bars 74
A.20 Example Level 2 Contract Monitor 75
A.21 Example Level 2 Pipeline Station Overview 75
A.22 Example Level 2 Linepack Overview 76
A.23 Example Level 2 Odorization Monitor 77
A.24 Example Level 3 Station Display 78
A.25 Example Pop-up Controls 78
A.26 Example Trend 79
A.27 Example Five-panel SCADA Display 81
A.28 Example Valve Object Library 84
A.29 Example Pump Object Library 84
A.30 Example Analog Indicator (Part 1) 85
A.31 Example Analog Indicator (Part 2) 85
A.32 Example Analog Indicator 86
A.33 Example Limit Indicators 87
A.34 Example Analyzer Value Indicator 87
A.35 Example Flow Indicator 88
A.36 Example Level Indicator 88
A.37 Example Pressure Indicator 88
A.38 Example Pipeline Pressure Indicator 89
A.39 Example Temperature Indicator 89
A.40 Example Vibration Indicator 90
A.41 Example Volume Indicator 90
A.42 Example Analog with Trend Tail 90
A.43 Example State Text 91
A.44 Example Data Attributes 91
A.45 Example Symbols with Alarm Indicators 91
A.46 Example Analogs with Alarm Indicators 92
A.47 Example Complex Analogs with Alarm Indicators 92
A.48 Example of a Disabled Alarm 93
A.49 Example of Complex Analog with Rate of Change Indicator 93
A.50 Example Level 1 Overview 94
A.51 Example Level 2 Display 95
A.52 Example Level 3 Display 96
A.53 Example Level 4 Display 97
A.54 Level 4 Diagnostic Overview 97
A.55 Example Level 4 Leak Detection Display 98
A.56 Example Analog Faceplate with Setpoint (Part 1) 99

Contents

Page

A.57 Example Analog Faceplate with Setpoint (Part 2) 99
A.58 Example Valve Faceplate with Control (Part 1) 100
A.59 Example Valve Faceplate with Control (Part 2) 100
A.60 Example Valve Faceplate with Control (Part 3) 100
A.61 Example Pump Faceplate with Control (Part 1) 101
A.62 Example Pump Faceplate with Control (Part 2) 101
A.63 Example Pump Faceplate with Control (Part 3) 101
A.64 Tabbed Navigation Pop-up Panel 102
A.65 Navigation Button/Poke Point 102
A.66 Example Color Palette 106
A.67 Example Valve Objects 108
A.68 Example Pump Objects 109
A.69 Example Basic Analogs 109
A.70 Example Tank Symbol Design 109
A.71 Example Data Attributes of Alarms 110
A.72 Example Analog Objects 110
A.73 Point Label/State Symbol Design 110
A.74 Valve Controllable Symbol Design 110
A.75 Valve Manual Symbol Design 111
A.76 Valve Setpoint Symbol Design 111
A.77 Pump Controllable Symbol Design 112
A.78 Example Symbol of a Manual Pump 114
A.79 Example Alarm Function 114
A.80 Branch System Information Display (Zone Map) 115
A.81 System Alarm Summary 115
A.82 Example Alarm Tool Icons 116
A.83 System Event Summary 116
A.84 Facility Manager Summary 117
A.85 Example Level 3 Display 117
A.86 Example Facility Schematic Display 118
A.87 Example Device Detail Display 118
A.88 Point Pop-ups 119
A.89 Setpoint Symbol Design 119
A.90 Example Toolbars 120
A.91 Example Color Palette 123
A.92 Example Basic Analog 126
A.93 Example Complex Analog 126
A.94 Example State Text 126
A.95 Example State Text with Control and Redundant Coding 126
A.96 Example Valve Object Data Attributes 127
A.97 Example Basic Analog 127
A.98 Example Basic Analog with Control 127
A.99 Example Pump Object Components 128
A.100 Example Tank Object Components 128
A.101 Example Standard Display Layout 130
A.102 Example Level 1 Alarm Display 130
A.103 Example Level 1 Event Summary Display 131
A.104 Example Level 3 Flow Path Display 132
A.105 Example Level 4 Control Panel 133
A.106 Example Control Panel for a Valve 134
A.107 Example Navigation Tab Area (Maximum Possible) 134
A.108 Example Console Layout 136

Contents

Page

Tables

A.1 Example Alarm Color Legend 60
A.2 Example Non-alarm Data Attribute Color Legend 61
A.3 Example Text-based Color Legend 61
A.4 Example Text Legend 62
A.5 Example Color Palette 83
A.6 Example Text Specifications 83
A.7 Example Text Specification 107
A.8 Example Line Width Schema 108
A.9 Pump Controllable Control Flag 112
A.10 Pump Controllable Quality Flag 113
A.11 Example Text Specifications 124
A.12 Example Valve State and Redundant Coding 125
A.13 Example Pump State and Redunant Coding 125
A.14 Example Data Attribute Legend 129
A.15 Toolbar Legend 135

Pipeline SCADA Displays

1 Scope

This recommended practice (RP) focuses on the design and implementation of displays used for the display, monitoring, and control of information on pipeline supervisory control and data acquisition (SCADA) systems. The primary purpose is to promote the success of the controller to safely operate pipeline systems and to document industry practices that provide guidance to a pipeline company or operator who wants to select a new SCADA system, or update or expand an existing SCADA system, and for guidance throughout the SCADA system display lifecycle. The pipeline industry and stakeholders have determined that well-designed displays can contribute to safe operations and prevent or mitigate pipeline incidents. Using established human factors considerations in display design can promote the safety performance of a pipeline operator.

This RP assists pipeline companies and SCADA system developers in identifying items that are considered best practices when developing human-machine interfaces (HMIs). Design elements that are discussed include, but are not limited to, hardware, navigation, colors, fonts, symbols, data entry, and control/selection techniques.

A secondary purpose is to provide guidance to SCADA display designers and developers to use industry experience to promote safety, efficiency, and reliability during the display lifecycle.

It is recognized that each operator has unique philosophies and SCADA systems; therefore, not all elements of this RP may be applicable.

For example:

— some pipeline control centers are a combination of several different SCADA systems;

— some of these SCADA systems may not have the developer tools necessary to implement the RPs;

— some operators may have existing display techniques that utilize unique operating philosophies.

This RP is not all-inclusive. It is intended to cover best practices and provide examples for display techniques only, not dictate operational control philosophy or overall SCADA system functionality. Examples included in this RP are not prescriptive and are provided to illustrate representative practices.

This RP complements but does not replace other procedures and effective display techniques or industry standards that are used for software development and implementation. Regulatory and individual company standards are not addressed in this publication.

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 1168*, Pipeline Control Room Management*, Second Edition, 2015

Endsley, M.R. and Jones, D.G. (2016). *Designing for Situation Awareness: An Approach to User-Centered Design*, Second Edition. Boca Raton, FL: CRC Press.

McCormick, E.J. and Sanders, M.S. (1993). *Human Factors in Engineering and Design*. Seventh Edition. New York; London; McGraw-Hill

ISO 11604-4 1, *Ergonomic design of control centres—Part 4: Layout and dimensions of workstations*, 2019

[1] International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.