

# Table of Contents

|          |                                                                     |           |
|----------|---------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction .....</b>                                           | <b>7</b>  |
| 1.1      | Purpose.....                                                        | 7         |
| 1.2      | Scope.....                                                          | 7         |
| 1.3      | Benefits.....                                                       | 7         |
| 1.4      | Objectives .....                                                    | 8         |
| 1.5      | Key Concepts.....                                                   | 8         |
| 1.6      | Structure of this Guide .....                                       | 11        |
| <b>2</b> | <b>Development of the User Requirements Documentation .....</b>     | <b>13</b> |
| 2.1      | Introduction .....                                                  | 13        |
| 2.2      | Process Requirements.....                                           | 13        |
| 2.3      | Defining User Requirements for a Process Gas System .....           | 15        |
| 2.4      | Equipment Performance/Operational and Maintenance Requirements..... | 16        |
| 2.5      | Control/Monitoring System Requirements .....                        | 17        |
| 2.6      | Facility.....                                                       | 17        |
| 2.7      | Reference Documents .....                                           | 18        |
| 2.8      | Roles and Responsibilities.....                                     | 18        |
| <b>3</b> | <b>Design Options – Process Gas Generation/Supply Systems.....</b>  | <b>21</b> |
| 3.1      | Introduction .....                                                  | 21        |
| 3.2      | Process Gases: Descriptions and Properties .....                    | 22        |
| 3.3      | Process Gases: Typical Applications .....                           | 24        |
| 3.4      | Applicable Regulations, Standards, and Codes.....                   | 25        |
| 3.5      | Safe Handling and Storage of Gases .....                            | 27        |
| 3.6      | User Requirements Considerations for Process Gases .....            | 33        |
| <b>4</b> | <b>Design Options – Compressed Air Systems.....</b>                 | <b>37</b> |
| 4.1      | Design of Generation of Compressed Air Systems.....                 | 37        |
| 4.2      | Equipment Selection .....                                           | 38        |
| 4.3      | Compressors.....                                                    | 38        |
| 4.4      | Compressed Air System Controls .....                                | 42        |
| 4.5      | Air Treatment .....                                                 | 43        |
| 4.6      | Dryers .....                                                        | 44        |
| 4.7      | Compressed Air Filters.....                                         | 48        |
| 4.8      | Air Receivers.....                                                  | 49        |
| 4.9      | Traps and Drains .....                                              | 50        |
| 4.10     | Designing for Redundancy.....                                       | 51        |
| <b>5</b> | <b>Design Options – Distribution Systems .....</b>                  | <b>53</b> |
| 5.1      | Concepts.....                                                       | 53        |
| 5.2      | Non-Return or Check Valves .....                                    | 57        |
| 5.3      | Pressure Reducing Valves.....                                       | 57        |
| 5.4      | Mixing Valves .....                                                 | 58        |
| 5.5      | Filtration .....                                                    | 59        |
| 5.6      | Filters in Compressed Air Systems.....                              | 62        |
| 5.7      | Material Selection .....                                            | 63        |
| <b>6</b> | <b>Design Options – Control and Monitoring Systems.....</b>         | <b>69</b> |
| 6.1      | Introduction .....                                                  | 69        |
| 6.2      | Control Systems.....                                                | 69        |
| 6.3      | Monitoring .....                                                    | 70        |

|           |                                                                                                       |            |
|-----------|-------------------------------------------------------------------------------------------------------|------------|
| <b>7</b>  | <b>Risk Assessment .....</b>                                                                          | <b>81</b>  |
| 7.1       | Introduction .....                                                                                    | 81         |
| 7.2       | Quality Risk Management for Process Gas Systems .....                                                 | 82         |
| 7.3       | Risk Assessment Process.....                                                                          | 83         |
| 7.4       | Risk Control .....                                                                                    | 85         |
| 7.5       | Risk Assessment Communication.....                                                                    | 86         |
| 7.6       | Risk Review .....                                                                                     | 86         |
| <b>8</b>  | <b>Final Design.....</b>                                                                              | <b>89</b>  |
| 8.1       | Introduction .....                                                                                    | 89         |
| 8.2       | Engineering Turnover Package.....                                                                     | 89         |
| 8.3       | Commissioning .....                                                                                   | 91         |
| 8.4       | Installation and Operational Tests .....                                                              | 93         |
| 8.5       | Performance Testing .....                                                                             | 94         |
| 8.6       | Acceptance and Release .....                                                                          | 94         |
| <b>9</b>  | <b>Operation and Maintenance.....</b>                                                                 | <b>97</b>  |
| 9.1       | Maintenance .....                                                                                     | 97         |
| 9.2       | Calibration.....                                                                                      | 98         |
| <b>10</b> | <b>Appendix 1 – Example of the Development of a Sampling Strategy Based on a Risk Assessment.....</b> | <b>99</b>  |
| 10.1      | System Description .....                                                                              | 100        |
| 10.2      | Control Strategy .....                                                                                | 100        |
| 10.3      | Moisture Content.....                                                                                 | 102        |
| 10.4      | Hydrocarbons/Oil .....                                                                                | 102        |
| 10.5      | Viable and Non-Viable Particulate .....                                                               | 103        |
| 10.6      | Microbial Levels .....                                                                                | 103        |
| <b>11</b> | <b>Appendix 2 – Risk Assessment Examples .....</b>                                                    | <b>109</b> |
| <b>12</b> | <b>Appendix 3 – Calibration Strategies .....</b>                                                      | <b>113</b> |
| <b>13</b> | <b>Appendix 4 – Sample User Requirement Specifications .....</b>                                      | <b>117</b> |
| <b>14</b> | <b>Appendix 5 – The Effect of System Leakage .....</b>                                                | <b>121</b> |
| 14.1      | Minimize Leaks .....                                                                                  | 122        |
| 14.2      | Pressure/Flow Controllers.....                                                                        | 122        |
| <b>15</b> | <b>Appendix 6 – Nitrogen Gas Generation Systems .....</b>                                             | <b>125</b> |
| <b>16</b> | <b>Appendix 7 – Miscellaneous Information .....</b>                                                   | <b>129</b> |
| <b>17</b> | <b>Appendix 8 – References .....</b>                                                                  | <b>135</b> |
| <b>18</b> | <b>Appendix 9 – Glossary .....</b>                                                                    | <b>139</b> |
| 18.1      | Abbreviations and Acronyms .....                                                                      | 140        |
| 18.2      | Definitions .....                                                                                     | 141        |