

ISO 80601-2-84:2020-07 (E)

Medical electrical equipment - Part 2-84: Particular requirements for the basic safety and essential performance of ventilators for the emergency medical services environment

| Contents | Page |
|---|------|
| Foreword | xxii |
| Introduction..... | xxiv |
| 1 Scope of the integrated model and fundamental principles | 1 |
| 1.1 Contents of this document | 1 |
| 1.2 Scope of the QIF Version 3.0 information model..... | 1 |
| 1.3 Conformance | 3 |
| 2 Normative references | 4 |
| 3 Terms and definitions | 6 |
| 3.1 Terms defined in ISO 22093:2011 and ANSI/DMIS 105.3-2016, Part 1 | 6 |
| 3.1.1 actual..... | 6 |
| 3.1.2 dimensional measuring equipment (DME) | 6 |
| 3.1.3 nominal..... | 6 |
| 3.1.4 measurement..... | 6 |
| 3.1.5 part coordinate system (PCS)..... | 6 |
| 3.2 Terms defined in XML Schema Part 0: Primer Second Edition, W3C Recommendation 28 October 2004 | 6 |
| 3.2.1 attribute | 6 |
| 3.2.2 complexType | 6 |
| 3.2.3 element..... | 6 |
| 3.2.4 instance file | 7 |
| 3.3 Terms defined in XML Schema Part 1: Structures Second Edition, W3C Recommendation 28 October 2004 | 7 |
| 3.3.1 attribute information item | 7 |
| 3.3.2 element information item | 7 |
| 3.3.3 enumeration | 7 |
| 3.3.4 extension | 7 |
| 3.3.5 key..... | 7 |
| 3.3.6 keyref | 7 |

| | | |
|--------|---|----|
| 3.3.7 | schema (or XML schema)..... | 7 |
| 3.3.8 | schema document (or schema file)..... | 7 |
| 3.3.9 | simple type | 8 |
| 3.3.10 | string | 8 |
| 3.3.11 | token | 8 |
| 3.4 | Terms defined in the QIF standard | 8 |
| 3.4.1 | accuracy test | 8 |
| 3.4.2 | action..... | 8 |
| 3.4.3 | action group..... | 8 |
| 3.4.4 | action method | 8 |
| 3.4.5 | actual component | 8 |
| 3.4.6 | actual component set..... | 8 |
| 3.4.7 | application area | 9 |
| 3.4.8 | articulating arm CMM..... | 9 |
| 3.4.9 | aspect..... | 9 |
| 3.4.10 | definition aspect..... | 9 |
| 3.4.11 | nominal aspect | 9 |
| 3.4.12 | item aspect | 9 |
| 3.4.13 | measured aspect | 9 |
| 3.4.14 | assembly | 9 |
| 3.4.15 | assembly path | 9 |
| 3.4.16 | assignable cause..... | 9 |
| 3.4.17 | attribute characteristic..... | 9 |
| 3.4.18 | attribute data | 10 |
| 3.4.19 | autocollimator | 10 |
| 3.4.20 | bias..... | 10 |
| 3.4.21 | bill of characteristics (BoC) | 10 |
| 3.4.22 | boolean condition | 10 |
| 3.4.23 | calibration | 10 |
| 3.4.24 | caliper..... | 10 |
| 3.4.25 | capability | 10 |
| 3.4.26 | capacitive sensor..... | 10 |
| 3.4.27 | carriage | 10 |
| 3.4.28 | Cartesian CMM..... | 10 |
| 3.4.29 | characteristic | 10 |
| 3.4.30 | characteristic item..... | 11 |
| 3.4.31 | charge coupled device camera sensor | 11 |
| 3.4.32 | checked..... | 11 |
| 3.4.33 | clipping plane | 11 |

| | | |
|--------|---|----|
| 3.4.34 | complex tactile probe sensor | 11 |
| 3.4.35 | component..... | 11 |
| 3.4.36 | composite feature | 11 |
| 3.4.37 | computed tomography | 11 |
| 3.4.38 | confocal chromatic sensor | 11 |
| 3.4.39 | constructed feature..... | 11 |
| 3.4.40 | control limits | 11 |
| 3.4.41 | control points | 11 |
| 3.4.42 | coordinate measuring machine..... | 12 |
| 3.4.43 | control polygon | 12 |
| 3.4.44 | corrective action | 12 |
| 3.4.45 | corrective action plan..... | 12 |
| 3.4.46 | data/information quality..... | 12 |
| 3.4.47 | datum definition | 12 |
| 3.4.48 | datum reference frame | 12 |
| 3.4.49 | dial caliper | 12 |
| 3.4.50 | digital caliper | 12 |
| 3.4.51 | digital micrometer | 12 |
| 3.4.52 | draw wire sensor | 12 |
| 3.4.53 | DVRT sensor..... | 12 |
| 3.4.54 | eddy current sensor..... | 13 |
| 3.4.55 | entity..... | 13 |
| 3.4.56 | evaluation | 13 |
| 3.4.57 | event | 13 |
| 3.4.58 | external product definition..... | 13 |
| 3.4.59 | feature..... | 13 |
| 3.4.60 | file unit..... | 13 |
| 3.4.61 | fixture | 13 |
| 3.4.62 | gage | 13 |
| 3.4.63 | gage repeatability and reproduceability (gage R&R)..... | 14 |
| 3.4.64 | generatrix | 14 |
| 3.4.65 | generic feature..... | 14 |
| 3.4.66 | geometric..... | 14 |
| 3.4.67 | geometric characteristic..... | 14 |
| 3.4.68 | inspection | 14 |
| 3.4.69 | inspection traceability | 14 |

| | | |
|---------|--|----|
| 3.4.70 | internal product definition..... | 14 |
| 3.4.71 | item | 14 |
| 3.4.72 | key characteristic..... | 15 |
| 3.4.73 | knot vector..... | 15 |
| 3.4.74 | laser radar | 15 |
| 3.4.75 | laser tracker..... | 15 |
| 3.4.76 | laser triangulation sensor..... | 15 |
| 3.4.77 | light pen CMM | 15 |
| 3.4.78 | linearity | 15 |
| 3.4.79 | Long Term Archiving and Retrieval..... | 15 |
| 3.4.80 | LVDT sensor | 15 |
| 3.4.81 | magneto-inductive sensor..... | 15 |
| 3.4.82 | manufacturing traceability..... | 16 |
| 3.4.83 | measurand | 16 |
| 3.4.84 | measure feature method..... | 16 |
| 3.4.85 | measurement..... | 16 |
| 3.4.86 | measurement device | 16 |
| 3.4.87 | measurement plan..... | 16 |
| 3.4.88 | measurement resource..... | 16 |
| 3.4.89 | measurement result..... | 16 |
| 3.4.90 | measurement room | 16 |
| 3.4.91 | mesh | 16 |
| 3.4.92 | micrometer | 17 |
| 3.4.93 | microscope | 17 |
| 3.4.94 | multiple carriage CMM..... | 17 |
| 3.4.95 | non-dimensional quality data | 17 |
| 3.4.96 | normal | 17 |
| 3.4.97 | normal vector..... | 17 |
| 3.4.98 | notable event..... | 17 |
| 3.4.99 | note | 17 |
| 3.4.100 | noted event | 17 |
| 3.4.101 | optical comparator..... | 17 |
| 3.4.102 | parallel link CMM | 17 |
| 3.4.103 | part | 17 |
| 3.4.104 | persistent identifier | 18 |

| | | |
|---------|--|----|
| 3.4.105 | plan element | 18 |
| 3.4.106 | plan note | 18 |
| 3.4.107 | plan root..... | 18 |
| 3.4.108 | point sampling strategy | 18 |
| 3.4.109 | process variation..... | 18 |
| 3.4.110 | product..... | 18 |
| 3.4.111 | product and manufacturing information (PMI)..... | 18 |
| 3.4.112 | production | 18 |
| 3.4.113 | QIF persistent identifier (QPIId)..... | 18 |
| 3.4.114 | qualification | 18 |
| 3.4.115 | rule..... | 19 |
| 3.4.116 | sampling category | 19 |
| 3.4.117 | sampling method..... | 19 |
| 3.4.118 | sensor | 19 |
| 3.4.119 | sensor qualification | 19 |
| 3.4.120 | set..... | 19 |
| 3.4.121 | simple tactile probe | 19 |
| 3.4.122 | sine bar | 19 |
| 3.4.123 | stability | 19 |
| 3.4.124 | standard deviation..... | 19 |
| 3.4.125 | statistical study plan | 20 |
| 3.4.126 | statistical study results | 20 |
| 3.4.127 | structured light sensor..... | 20 |
| 3.4.128 | tactile probe sensor..... | 20 |
| 3.4.129 | theodolite | 20 |
| 3.4.130 | thread specification | 20 |
| 3.4.131 | tolerance | 20 |
| 3.4.132 | tool..... | 20 |
| 3.4.133 | touch probe | 20 |
| 3.4.134 | traceability..... | 21 |
| 3.4.135 | trimming contour | 21 |
| 3.4.136 | ultrasonic sensor | 21 |
| 3.4.137 | universal length measuring machine | 21 |
| 3.4.138 | version | 21 |
| 3.4.139 | weld characteristic..... | 21 |
| 3.4.140 | weld symbol | 21 |

| | | |
|---------|---|----|
| 3.4.141 | wire-frame | 21 |
| 3.4.142 | work instruction | 21 |
| 3.4.143 | workpiece..... | 21 |
| 4 | Symbols and abbreviated terms..... | 22 |
| 5 | Overview of the Quality Information Framework (QIF) information model | 24 |
| 5.1 | Purpose | 24 |
| 5.2 | Model based definition manufacturing quality workflow..... | 24 |
| 5.3 | QIF design requirements | 27 |
| 5.4 | QIF Data Quality..... | 28 |
| 5.4.1 | XML implementation | 28 |
| 5.4.2 | Redundancy Checks..... | 31 |
| 5.4.3 | Product Data Quality..... | 31 |
| 5.4.4 | Digital Signature | 31 |
| 5.4.5 | Long Term Archiving and Retrieval..... | 32 |
| 5.5 | QIF manufacturing functional requirements | 33 |
| 5.6 | QIF and STEP | 33 |
| 5.7 | QIF information model design guidelines | 34 |
| 5.8 | Overview of XML schema file modularity | 34 |
| 5.9 | Data structures | 35 |
| 5.9.1 | The QIFDocument element..... | 35 |
| 5.9.2 | Four aspects of features data | 40 |
| 5.9.3 | Four aspects of characteristics | 45 |
| 5.9.4 | Default tolerances and characteristics | 48 |
| 5.9.5 | Relationships between the aspects..... | 50 |
| 5.10 | Hierarchy of required information..... | 55 |
| 5.10.1 | QIF use of optional elements | 55 |
| 5.10.2 | Example: diameter characteristic..... | 55 |
| 5.10.3 | ScaleCoefficient..... | 58 |
| 5.11 | Actual parts and assemblies | 58 |
| 5.12 | Checking connections between data objects | 60 |
| 5.13 | Tracking information through the product lifecycle | 63 |
| 5.13.1 | Persistent Identifiers | 63 |

| | | |
|--------|---|----|
| 5.13.2 | UUIDs and QPIDs | 63 |
| 5.13.3 | External File References | 64 |
| 5.13.4 | QIF data flow | 65 |
| 5.13.5 | Using QPIDs in QIF..... | 66 |
| 5.14 | Linking PMI information to product shape models..... | 69 |
| 5.15 | Welding Characteristics and Symbols..... | 71 |
| 5.15.1 | Base parameters | 72 |
| 5.15.2 | Location Significance parameter..... | 72 |
| 5.15.3 | Weld Characteristic parameters..... | 72 |
| 5.15.4 | Supplementary parameters..... | 75 |
| 5.15.5 | Non-Destructive Testing types..... | 75 |
| 5.15.6 | Compound Welds | 75 |
| 5.16 | QIF handling of transforms, transformations, and coordinate systems | 76 |
| 5.16.1 | Coordinate Spaces | 76 |
| 5.16.2 | Transformation matrix..... | 76 |
| 5.16.3 | Transforms | 82 |
| 5.16.4 | Coordinate systems..... | 82 |
| 5.16.5 | CAD coordinate systems | 85 |
| 5.16.6 | Coordinate system lists..... | 85 |
| 5.17 | Feature control frames..... | 86 |
| 5.17.1 | Geometric tolerance characteristic types | 86 |
| 5.17.2 | Tolerance zone size..... | 87 |
| 5.17.3 | Zone shape | 88 |
| 5.17.4 | Zone extents..... | 88 |
| 5.17.5 | Other zone modifiers | 89 |
| 5.17.6 | Datum reference frames | 89 |
| 5.18 | QIF handling of units..... | 91 |
| 5.18.1 | Introduction..... | 91 |
| 5.18.2 | PMI units | 92 |
| 5.18.3 | Default units | 93 |
| 5.18.4 | Other units..... | 93 |
| 5.19 | Modeling slots in QIF | 94 |
| 5.19.1 | Introduction..... | 94 |
| 5.19.2 | Internal and external..... | 94 |

| | | |
|--------|---|-----|
| 5.19.3 | Location and size..... | 94 |
| 5.19.4 | End types | 96 |
| 5.19.5 | Bottom types | 99 |
| 5.19.6 | Taper..... | 99 |
| 5.19.7 | Draft | 99 |
| 5.19.8 | Feature measurement | 100 |
| 5.20 | Modeling cones and conical segments in QIF | 100 |
| 5.20.1 | Introduction..... | 100 |
| 5.20.2 | Location, orientation and angle..... | 101 |
| 5.20.3 | Linear extents..... | 102 |
| 5.21 | Modeling pattern features in QIF..... | 105 |
| 5.21.1 | Circular pattern feature | 106 |
| 5.21.2 | Circular arc pattern feature | 107 |
| 5.21.3 | Linear pattern feature | 108 |
| 5.21.4 | Parallelogram pattern feature | 109 |
| 5.22 | Modeling threads in QIF | 109 |
| 5.22.1 | Thread specification types | 110 |
| 5.23 | Feature measurement determination | 110 |
| 5.23.1 | Checked and set features..... | 110 |
| 5.23.2 | Measurement and construction..... | 111 |
| 5.23.3 | Measurement points | 111 |
| 5.23.4 | Construction methods..... | 111 |
| 5.24 | CharacteristicDesignators - encoding "balloon" numbers in QIF | 113 |
| 5.25 | Attributes and Part Notes..... | 114 |
| 5.26 | Detailed requirements..... | 116 |
| 5.26.1 | XML naming and design rules (NDR) | 116 |
| 5.26.2 | Annotation conventions | 118 |
| 6 | QIF Library..... | 120 |
| 6.1 | Introduction..... | 120 |
| 6.1.1 | Changes in the QIF Library from QIF Version 2.1 | 121 |
| 6.2 | Auxiliary.xsd | 121 |
| 6.3 | Characteristics.xsd | 122 |
| 6.3.1 | Characteristics <i>element</i> | 122 |

| | | |
|--------|---|-----|
| 6.3.2 | Characteristic definitions, nominals, items, and measurements | 122 |
| 6.3.3 | DefaultCharacteristicDefinitions | 126 |
| 6.3.4 | DefaultToleranceDefinitions | 126 |
| 6.3.5 | CharacteristicGroups | 126 |
| 6.3.6 | Constraint checking for characteristics | 126 |
| 6.3.7 | ToleranceZones | 127 |
| 6.3.8 | Substitution groups in Characteristics.xsd | 127 |
| 6.4 | Expressions.xsd | 127 |
| 6.4.1 | Types Defined in Expressions.xsd | 128 |
| 6.4.2 | Substitution groups in Expressions.xsd | 128 |
| 6.5 | Features.xsd | 128 |
| 6.5.1 | Features <i>element</i> | 128 |
| 6.5.2 | Feature types | 129 |
| 6.5.3 | Constraint checking for features | 132 |
| 6.5.4 | Feature construction methods | 132 |
| 6.5.5 | Substitution groups for features | 133 |
| 6.6 | GenericExpressions.xsd | 133 |
| 6.6.1 | Arithmetic Expressions | 133 |
| 6.6.2 | String Expressions | 133 |
| 6.6.3 | Boolean Expressions | 134 |
| 6.7 | Geometry.xsd | 134 |
| 6.8 | IntermediatesPMI.xsd | 136 |
| 6.9 | Primitives.xsd | 137 |
| 6.10 | PrimitivesPD.xsd | 138 |
| 6.11 | PrimitivesPMI.xsd | 138 |
| 6.12 | Statistics.xsd | 138 |
| 6.12.1 | Basic Statistics Types | 138 |
| 6.12.2 | Characteristic Statistics Evaluation Types | 140 |
| 6.13 | Topology.xsd | 142 |
| 6.14 | Traceability.xsd | 143 |
| 6.14.1 | <i>InspectionTraceabilityType</i> | 144 |
| 6.14.2 | <i>PreInspectionTraceabilityType</i> | 144 |
| 6.14.3 | <i>ProductTraceabilityType</i> | 145 |

| | | |
|--------|---|-----|
| 6.14.4 | <i>ActualProductTraceabilityType</i> | 145 |
| 6.14.5 | <i>ManufacturingProcessTraceabilityType</i> | 146 |
| 6.15 | Units.xsd..... | 147 |
| 6.15.1 | FileUnits | 147 |
| 6.15.2 | Conversions | 148 |
| 6.15.3 | FileUnitsExample..... | 149 |
| 6.15.4 | Instance File Example Using Units | 150 |
| 6.16 | Visualization.xsd..... | 151 |
| 7 | QIF Model Based Definition (MBD) information model..... | 154 |
| 7.1 | Foreword | 154 |
| 7.2 | Introduction..... | 154 |
| 7.3 | Scope | 154 |
| 7.3.1 | Contents of this clause | 154 |
| 7.3.2 | QIF MBD Information Model Application Architecture | 155 |
| 7.4 | QIF MBD information model requirements..... | 157 |
| 7.5 | Overview of the product data model | 157 |
| 7.5.1 | Design principles | 157 |
| 7.5.2 | Geometry..... | 166 |
| 7.5.3 | Topology..... | 243 |
| 7.5.4 | Product structure | 272 |
| 7.5.5 | Transformations..... | 287 |
| 7.5.6 | Auxiliary data..... | 288 |
| 7.5.7 | Visualization data | 293 |
| 7.5.8 | Validation properties..... | 338 |
| 7.5.9 | High level description of the product data | 343 |
| 8 | QIF Plans information model..... | 345 |
| 8.1 | Foreword | 345 |
| 8.2 | Introduction..... | 346 |
| 8.3 | Scope | 347 |
| 8.3.1 | Contents of this clause | 347 |
| 8.3.2 | Workflow of QIF Plans data for manufacturing quality..... | 347 |
| 8.3.3 | QIF Plans information model | 348 |

| | | |
|--------|--|-----|
| 8.3.4 | QIF Plans scope | 348 |
| 8.3.5 | QIF Plans use cases..... | 349 |
| 8.3.6 | QIF Plans product definition support..... | 351 |
| 8.4 | Data types and <i>elements</i> of the QIF Plans information model..... | 351 |
| 8.4.1 | Plan | 351 |
| 8.4.2 | PlanElement | 351 |
| 8.4.3 | Action | 351 |
| 8.4.4 | Action Groups..... | 352 |
| 8.4.5 | Nesting of Action Groups..... | 353 |
| 8.4.6 | Action Group Functions | 353 |
| 8.4.7 | Measurand | 354 |
| 8.4.8 | Action Method..... | 354 |
| 8.4.9 | Measure Feature Method | 354 |
| 8.4.10 | Work Instruction..... | 355 |
| 8.5 | Tracking information through the product lifecycle | 355 |
| 8.6 | QIF Plans data flow to results | 355 |
| 8.7 | QIF Results reference to QIF Plans | 355 |
| 8.8 | Item tracking and persistence between QIF Plans and QIF Results..... | 355 |
| 8.9 | High level description of QIF Plans.xsd..... | 356 |
| 8.9.1 | High level structure of the QIF Plans schema | 356 |
| 8.9.2 | Major <i>elements</i> | 358 |
| 8.9.3 | Simplified relationships <i>elements</i> | 359 |
| 8.9.4 | Conditional Action Groups | 359 |
| 8.9.5 | Plan Variables | 360 |
| 9 | QIF Resources information model | 361 |
| 9.1 | Foreword | 361 |
| 9.2 | Introduction..... | 361 |
| 9.3 | Scope | 362 |
| 9.3.1 | Contents of this clause | 362 |
| 9.4 | QIF Resources Requirements | 362 |
| 9.5 | The QIF Resources data model..... | 363 |
| 9.5.1 | QIF Resources Instance Data..... | 363 |
| 9.5.2 | <i>MeasurementResourceBaseType</i> | 364 |

| | | |
|--------|--|-----|
| 9.5.3 | Measurement Devices | 367 |
| 9.5.4 | Coordinate Measuring Machine (CMM) | 370 |
| 9.5.5 | Sensors and Tools..... | 373 |
| 9.5.6 | Rotary Table..... | 375 |
| 9.5.7 | Resolution Types..... | 375 |
| 9.5.8 | Working Volumes | 375 |
| 9.5.9 | Axis Types..... | 375 |
| 9.5.10 | Environmental Data | 375 |
| 9.5.11 | Calibrations | 376 |
| 9.5.12 | <i>MeasurementRoomType</i> | 376 |
| 10 | QIF Rules information model | 377 |
| 10.1 | Introduction..... | 377 |
| 10.1.1 | Why..... | 377 |
| 10.1.2 | What..... | 377 |
| 10.1.3 | How | 378 |
| 10.1.4 | Changes from QIF 2.1 | 379 |
| 10.2 | Design principles of QIF Rules | 379 |
| 10.2.1 | Structure of a Rule..... | 379 |
| 10.2.2 | Feature Rules | 380 |
| 10.2.3 | DME Selection Rules..... | 381 |
| 10.3 | QIF Rules schema files..... | 382 |
| 10.4 | QIF Rules <i>elements</i> and data types..... | 382 |
| 10.4.1 | QIF Rules top level | 382 |
| 10.4.2 | Feature Rules | 383 |
| 10.4.3 | DME Selection Rules..... | 386 |
| 11 | QIF Results information model..... | 392 |
| 11.1 | Foreword | 392 |
| 11.2 | Introduction..... | 392 |
| 11.3 | Scope | 392 |
| 11.3.1 | Workflow of QIF Results data for manufacturing quality..... | 392 |
| 11.3.2 | Design guidelines for the QIF Results information model..... | 393 |
| 11.4 | The QIFResults.xsd schema file | 394 |
| 11.4.1 | High level structure of the QIF Results schema | 394 |

| | | |
|--------------|---|-----|
| 11.5 | Data dictionary: QIFResults.xsd..... | 398 |
| 12 | QIF Statistics information model | 399 |
| 12.1 | Foreword | 399 |
| 12.2 | Introduction..... | 399 |
| 12.3 | Scope | 400 |
| 12.3.1 | Contents of this clause | 400 |
| 12.4 | Requirements | 400 |
| 12.4.1 | QIF Statistics quality metrology activity diagram | 401 |
| 12.5 | The QIF Statistics data model..... | 403 |
| 12.5.1 | Design principles of QIF Statistics | 403 |
| 12.5.2 | QIF Statistics data sets..... | 404 |
| 12.5.3 | Statistical and summary values | 406 |
| 12.5.4 | Statistical study criteria | 413 |
| 12.5.5 | Data groups and subgroups..... | 414 |
| 12.5.6 | High level structure of the QIF Statistics schema..... | 419 |
| 12.5.7 | Referencing measurement results | 420 |
| 12.6 | QIF Statistics samples | 421 |
| 12.6.1 | Typical quality data examples..... | 421 |
| 12.6.2 | Typical quality study type examples..... | 427 |
| Annex A | – Graphical conventions of the data dictionary | 455 |
| Annex B | – Sample QIF instance files..... | 458 |
| Annex C | – ISO GPS support in QIF 3.0 | 493 |
| Annex D | – DMSC Volunteer Agreement | 497 |
| Bibliography | | 498 |

Figures

| | | |
|----------|---|----|
| Figure 1 | – QIF version 3.0 information architecture | 2 |
| Figure 2 | – QIF Model-Based Quality Workflow | 25 |
| Figure 3 | – QIF XML schema directory structure..... | 35 |
| Figure 4 | – Structure of the QIFDocument <i>element</i> | 37 |
| Figure 5 | – Reference connections among feature data objects in a QIF XML instance file | 40 |
| Figure 6 | – A plate with four holes..... | 40 |
| Figure 7 | – A plate with four holes and GD&T | 41 |

| | |
|--|-----|
| Figure 8 – A plate with four holes with names..... | 42 |
| Figure 9 – References among characteristic data objects in a QIF XML instance file..... | 46 |
| Figure 10 – A plate with ballooned tolerances..... | 46 |
| Figure 11 – Connections at the PMI Stage..... | 53 |
| Figure 12 – Connections at the Planning Stage | 54 |
| Figure 13 – Connections at the post-measurement stage | 54 |
| Figure 14 – QIF id and reference types..... | 60 |
| Figure 15 – QPidType elements..... | 67 |
| Figure 16 – QPidFullReferenceType elements | 68 |
| Figure 17 – Weld Characteristics Hierarchy | 71 |
| Figure 18 – Location Significance | 72 |
| Figure 19 – Weld Characteristic Parameters Hierarchy..... | 73 |
| Figure 20 – Weld Characteristic Parameters..... | 73 |
| Figure 21 – Melt Through..... | 75 |
| Figure 22 – Non-Destructive Testing with Multiple Reference Lines..... | 75 |
| Figure 23 – Compound Weld | 76 |
| Figure 24 – Transformation matrix example..... | 81 |
| Figure 25 – An opposite parallel lines feature with round closed ends | 95 |
| Figure 26 – An opposite parallel planes feature with flat closed ends | 96 |
| Figure 27 – A slot with non-tangent round ends..... | 97 |
| Figure 28 – A flat-ended slot with rounded corners | 98 |
| Figure 29 – Opposite planes features with open ends | 98 |
| Figure 30 – A tapered slot (opposite angled lines) | 99 |
| Figure 31 – A slot with draft (opposite angled plane feature)..... | 100 |
| Figure 32 – An unbounded cone located at a reference diameter and defined by its half angle..... | 101 |
| Figure 33 – An unbounded cone located at its vertex and defined by its full angle..... | 102 |
| Figure 34 – A bounded, truncated cone located at a reference diameter | 103 |
| Figure 35 – A bounded, truncated cone located at a virtual reference diameter | 103 |
| Figure 36 – A bounded, truncated cone located at its small end | 104 |
| Figure 37 – A bounded, truncated cone located at its large end..... | 104 |
| Figure 38 – A bounded pointed cone located at its vertex..... | 105 |
| Figure 39 – A bounded truncated cone located at its vertex..... | 105 |
| Figure 40 – PatternFeatureCircle with FeatureDirection omitted..... | 106 |
| Figure 41 – PatternFeatureCircle with FeatureDirection | 107 |
| Figure 42 – PatternFeatureCircularArc | 108 |
| Figure 43 – PatternFeatureLinear | 108 |
| Figure 44 – PatternFeatureParallelogram | 109 |
| Figure 45 – Threaded features..... | 110 |
| Figure 46 – Attributes element names and types | 114 |
| Figure 47 – Types with Attributes element | 115 |
| Figure 48 – Characteristics element | 122 |
| Figure 49 – Characteristic types | 126 |
| Figure 50 – Tolerance zone types..... | 127 |
| Figure 51 – Features element | 129 |
| Figure 52 – Feature Types (below) | 130 |
| Figure 53 – Comparison of feature definitions in QIF and DMIS | 131 |
| Figure 54 – Individual geometry types | 135 |

| | |
|--|-----|
| Figure 55 – Geometry set types | 135 |
| Figure 56 – Alignment operations | 136 |
| Figure 57 – Datums and datum reference frames | 136 |
| Figure 58 – ISO-specific types | 137 |
| Figure 59 – Types with enumeration or user definition | 138 |
| Figure 60 – Basic Statistics Types | 139 |
| Figure 61 – CharacteristicStatsEval types (continued on next page)..... | 140 |
| Figure 62 – Criterion Types | 142 |
| Figure 63 – Summary Statistics Types..... | 142 |
| Figure 64 – Individual topology types..... | 143 |
| Figure 65 – Topology set types..... | 143 |
| Figure 66 – Elements of InspectionTraceabilityType | 144 |
| Figure 67 – Elements of PreInspectionTraceabilityType | 145 |
| Figure 68 – Elements of ProductTraceabilityType | 145 |
| Figure 69 – Elements of ActualProductTraceabilityType | 146 |
| Figure 70 – Elements of ManufacturingProcessTraceabilityType | 146 |
| Figure 71 – FileUnits element | 147 |
| Figure 72 – Derivation hierarchy of values with units | 148 |
| Figure 73 – Conversion of units | 149 |
| Figure 74 – FileUnits snippet | 150 |
| Figure 75 – Instance file snippets using units..... | 151 |
| Figure 76 – VisualizationSet <i>element</i> | 152 |
| Figure 77 – ViewSetType | 153 |
| Figure 78 – Workflow of QIF MBD Information..... | 156 |
| Figure 79 – Entity attributes | 162 |
| Figure 80 – Geometry Types | 167 |
| Figure 81 – Point | 168 |
| Figure 82 – 2D Parametric Curve | 169 |
| Figure 83 – 2D Curves Types | 169 |
| Figure 84 – 2D Segment..... | 170 |
| Figure 85 – 2D Polyline..... | 171 |
| Figure 86 – 2D Circular Arc | 172 |
| Figure 87 – 2D Circular Arc (turned) | 172 |
| Figure 88 – 2D Conic Arc (form = PARABOLA) | 173 |
| Figure 89 – 2D Conic Arc (form = PARABOLA, turned = true) | 174 |
| Figure 90 – 2D Conic Arc (form = ELLIPSE) | 174 |
| Figure 91 – 2D Conic Arc (form = ELLIPSE, turned = true)..... | 174 |
| Figure 92 – 2D Conic Arc (form = HYPERBOLA)..... | 175 |
| Figure 93 – 2D Conic Arc (form = HYPERBOLA, turned = true)..... | 175 |
| Figure 94 – 2D Spline Curve..... | 178 |
| Figure 95 – 2D NURBS Curve | 180 |
| Figure 96 – 2D Aggregate Curve | 182 |
| Figure 97 – 3D Parametric Curve | 184 |
| Figure 98 – 3D Curve Types..... | 184 |
| Figure 99 – 3D Segment..... | 186 |
| Figure 100 – 3D Polyline..... | 186 |
| Figure 101 – 3D Circular Arc..... | 187 |
| Figure 102 – 3D Conic Arc (form = PARABOLA) | 189 |

| | |
|--|-----|
| Figure 103 – 3D Conic Arc (form = ELLIPSE) | 189 |
| Figure 104 – 3D Conic Arc (form = HYPERBOLA) | 190 |
| Figure 105 – 3D Spline Curve | 192 |
| Figure 106 – 3D NURBS Curve | 194 |
| Figure 107 – 3D Aggregate Curve | 196 |
| Figure 108 – Parametric Surface | 198 |
| Figure 109 – Parametric Surface Types | 199 |
| Figure 110 – Scaling coefficient | 200 |
| Figure 111 – Plane | 201 |
| Figure 112 – Plane (Parameter Space) | 201 |
| Figure 113 – Cylinder | 203 |
| Figure 114 – Cylinder (turnedV = true) | 204 |
| Figure 115 – Cylinder (Parametric Space) | 204 |
| Figure 116 – Cone | 206 |
| Figure 117 – Cone (turnedV = true) | 207 |
| Figure 118 – Cone (Parametric Space) | 207 |
| Figure 119 – Sphere | 209 |
| Figure 120 – Sphere (turnedV = true) | 210 |
| Figure 121 – Sphere (Parametric Space) | 210 |
| Figure 122 – Torus | 213 |
| Figure 123 – Torus (turnedV = true) | 214 |
| Figure 124 – Torus (Parametric Space) | 214 |
| Figure 125 – Extrude Surface | 217 |
| Figure 126 – Extrude Surface (Parametric Space) | 217 |
| Figure 127 – Ruled Surface | 219 |
| Figure 128 – Ruled Surface (turnedSecondCurve = true) | 220 |
| Figure 129 – Ruled Surface (Parametric Space) | 220 |
| Figure 130 – Surface Of Revolution | 222 |
| Figure 131 – Surface Of Revolution (turned Generatrix) | 223 |
| Figure 132 – Surface Of Revolution (Parametric Space) | 223 |
| Figure 133 – Spline Surface | 225 |
| Figure 134 – Spline Surface (Parameter Space) | 225 |
| Figure 135 – NURBS Surface | 229 |
| Figure 136 – NURBS Surface (Parameter Space) | 229 |
| Figure 137 – Offset Surface | 232 |
| Figure 138 – Offset Surface (Parametric Space) | 232 |
| Figure 139 – The edge 'w' of triangle 't' | 235 |
| Figure 140 – Triangulation Path | 236 |
| Figure 141 – Two sewn triangles | 238 |
| Figure 142 – Triangle Mesh | 239 |
| Figure 143 – Triangle Mesh with special normals | 240 |
| Figure 144 – Topology Types | 243 |
| Figure 145 – Boundary Representation | 244 |
| Figure 146 – Vertex | 245 |
| Figure 147 – Edge | 246 |
| Figure 148 – Loop | 248 |
| Figure 149 – Co-Edge | 250 |

| | |
|---|-----|
| Figure 150 – Outer Loop..... | 251 |
| Figure 151 – Inner Loop..... | 252 |
| Figure 152 – Slit Loop..... | 253 |
| Figure 153 – Vertex Loop | 254 |
| Figure 154 – Mesh Loop | 255 |
| Figure 155 – Mesh Co-Edge..... | 257 |
| Figure 156 – Face..... | 258 |
| Figure 157 – Mesh Face | 259 |
| Figure 158 – Mesh Face (Triangle Visibility and Color) | 260 |
| Figure 159 – Shell..... | 262 |
| Figure 160 – Shell Faces | 263 |
| Figure 161 – Body | 264 |
| Figure 162 – Cloud of Points..... | 266 |
| Figure 163 – Cloud of Point with Defined Normals..... | 266 |
| Figure 164 – Point Cloud (Point Visibility and Color) | 267 |
| Figure 165 – Sewn Faces (normals of the underlying surfaces are conformed: Turned ₀ = Turned ₁ , FALSE)..... | 269 |
| Figure 166 – Sewn Faces (normals of the underlying surfaces are not conformed: Turned ₀ (FALSE) ≠ Turned ₁ (TRUE))..... | 270 |
| Figure 167 – Tolerant Edges and Vertices | 271 |
| Figure 168 – Product directed acyclic graph | 272 |
| Figure 169 – Unfolded product tree..... | 274 |
| Figure 170 – Reference of a part entity within an assembly | 276 |
| Figure 171 – Multiple representations for parts and assemblies..... | 279 |
| Figure 172 – Point | 288 |
| Figure 173 – Line..... | 289 |
| Figure 174 – Reference Plane | 290 |
| Figure 175 – Coordinate System | 291 |
| Figure 176 – Annotation View | 298 |
| Figure 177 – Text..... | 299 |
| Figure 178 – Balloons | 299 |
| Figure 179 – Leader | 301 |
| Figure 180 – Double head leader..... | 303 |
| Figure 181 – Extended leader | 304 |
| Figure 182 – Double head extended leader | 305 |
| Figure 183 – Circular leader..... | 306 |
| Figure 184 – Double head circular leader | 307 |
| Figure 185 – Witness Lines | 308 |
| Figure 186 – Circular Witness Line | 309 |
| Figure 187 – Rectangular frame | 310 |
| Figure 188 – Circular frame | 311 |
| Figure 189 – Flag frame..... | 312 |
| Figure 190 – Triangular form frame..... | 313 |
| Figure 191 – Pentagonal form frame..... | 313 |
| Figure 192 – Hexagonal form frame..... | 314 |
| Figure 193 – Octagonal form frame | 315 |
| Figure 194 – Weld Symbol frame..... | 316 |
| Figure 195 – Irregular form frame | 317 |

| | |
|---|-----|
| Figure 196 – Graphic presentation..... | 318 |
| Figure 197 – Saved view | 320 |
| Figure 198 – Simplified Representation | 322 |
| Figure 199 – Exploded View | 323 |
| Figure 200 – Display Style | 325 |
| Figure 201 – Zone Section with one section plane..... | 327 |
| Figure 202 – Zone Section with three section planes..... | 327 |
| Figure 203 – Positions of the section planes..... | 328 |
| Figure 204 – The result of Section Plane 1 AND Section Plane 2 | 328 |
| Figure 205 – The result of (Section Plane 1 AND Section Plane 2) OR Section Plane 3..... | 329 |
| Figure 206 – Logical operations tree..... | 329 |
| Figure 207 – Sections of wire, sheet and solid bodies..... | 330 |
| Figure 208 – Hatching Pattern | 333 |
| Figure 209 – Combination of patterns | 334 |
| Figure 210 – Orthographic Camera..... | 336 |
| Figure 211 – Perspective Camera | 337 |
| Figure 212 – High level view of QIF MBD highest level <i>elements</i> | 344 |
| Figure 213 – Measurement Scope (e.g., Bill of Characteristics) with QIF Plans | 350 |
| Figure 214 – Inspection Process Planning with QIF Plans | 351 |
| Figure 215 – Sub- <i>elements</i> of the Plan data type | 357 |
| Figure 216 – QIF Plans Major <i>Elements</i> with Simplified Relations | 358 |
| Figure 217 – QIF Resources instance data high level view..... | 363 |
| Figure 218 – MeasurementResourceBaseType | 365 |
| Figure 219 – MeasurementResourceBaseType | 366 |
| Figure 220 – MeasurementResourceBaseType derived type inheritance diagram: tool with integrated sensor close-up..... | 367 |
| Figure 221 – MeasurementDeviceType overview | 368 |
| Figure 222 – CMM type inheritance diagram | 371 |
| Figure 223 – Cartesian CMM geometry types..... | 372 |
| Figure 224 – Method 1 for mounting a sensor on a universal device..... | 373 |
| Figure 225 – Method 2 for mounting a sensor on a universal device..... | 373 |
| Figure 226 – Rules <i>element</i> and QIFRulesType | 382 |
| Figure 227 – FeatureRules <i>element</i> and FeatureRulesType | 383 |
| Figure 228 – DMESelectionRules <i>element</i> and DMESelectionRulesType | 386 |
| Figure 229 – DMEMThen <i>element</i> and DMEMThenType | 387 |
| Figure 230 – DMEDecisionClass <i>element</i> and DMEDecisionClassType | 388 |
| Figure 231 – DMEDecisionId <i>element</i> and DMEDecisionIdType | 390 |
| Figure 232 – DMEDecisionMakeModel <i>element</i> | 391 |
| Figure 233 – Example of QIF Results information flow..... | 393 |
| Figure 234 – The Results <i>element</i> | 394 |
| Figure 235 – High level view of the MeasurementResults <i>element</i> | 396 |
| Figure 236 – The ActualComponentType data type | 398 |
| Figure 237 – QIF Statistics workflow..... | 401 |
| Figure 238 – Highest level QIF Statistics elements..... | 420 |
| Figure 239 – Sample QIF widget | 421 |

TABLES

| | |
|---|-----|
| Table 1 – XSLT Checks | 29 |
| Table 2 – Weld Parameters | 74 |
| Table 3 – Material Condition Values | 87 |
| Table 4 – Binary Arrays | 159 |
| Table 5 – Binary Representation..... | 160 |
| Table 6 – Line Styles | 293 |
| Table 7 – Special Symbols | 297 |
| Table 8 – Leader Head Types..... | 303 |
| Table 9 – Statistical values and their associated mnemonics..... | 409 |
| Table 10 – Statistical summary values and their associated mnemonics. | 411 |
| Table 11 – Subgroup statistical values and their associated mnemonics. | 417 |