

# PART 2 – INSPECTION

## PART 2 – TABLE OF CONTENTS

PART 2 – INSPECTION .....	i
CHAPTER 2.1 – GENERAL .....	2-1
2.1.1 GENERAL .....	2-1
CHAPTER 2.2 - TYPES AND SCOPES OF INSPECTION.....	2-2
2.2.1 TYPES AND SCOPES OF INSPECTION .....	2-2
2.2.2 ROUTINE INSPECTION .....	2-2
2.2.3 IN-DEPTH INSPECTIONS .....	2-3
2.2.4 SPECIAL INSPECTIONS .....	2-4
CHAPTER 2.3 – FREQUENCY .....	2-5
CHAPTER 2.4 – INSPECTOR QUALIFICATIONS .....	2-6
CHAPTER 2.5 – SAFETY.....	2-8
2.5.1 HEALTH & SAFETY PLAN .....	2-8
2.5.2 PERSONNEL SAFETY .....	2-8
2.5.2.1 OSHA and Standard Requirements .....	2-9
2.5.2.2 Hazard Assessment And Elimination of Personnel Hazards .....	2-9
2.5.2.3 Personnel Training Programs.....	2-11
2.5.3 PUBLIC SAFETY .....	2-11
2.5.3.1 Pedestrian and Vehicular Safety .....	2-11
2.5.3.2 Navigational Safety Practices .....	2-13
2.5.4 BRIDGE-SPECIFIC SAFETY PLAN .....	2-13
CHAPTER 2.6 – PLANNING, SCHEDULING, EQUIPMENT, AND MOBILIZATION.....	2-15
2.6.1 PLANNING .....	2-15
2.6.1.1 Data Collection and Review .....	2-15
2.6.1.2 Identification of Site Specific Conditions .....	2-17
2.6.1.3 Preparation of the Inspection Schedule and Sequence .....	2-18
2.6.2 MOBILIZATION .....	2-19
2.6.2.1 Preparation of Inspection Notes .....	2-20
2.6.2.2 Inspection Equipment .....	2-28
2.6.2.3 Special Notifications .....	2-29
CHAPTER 2.7 – INSPECTION FORMS AND REPORTS .....	2-30
2.7.1 GENERAL .....	2-30
2.7.2 INSPECTION FORMS.....	2-31
2.7.2.1 Condition Rating Summary.....	2-31
2.7.2.2 Component Inspection Forms .....	2-31
2.7.2.3 Deficiency Reports .....	2-32
2.7.3 REPORT .....	2-32
2.7.4 REPORT FORMAT .....	2-32
2.7.5 SAMPLE FORMS .....	2-33
CHAPTER 2.8 – PROCEDURES .....	2-34
2.8.1 STRUCTURAL INSPECTION PROCEDURES.....	2-34
2.8.1.1 Substructure .....	2-35
2.8.1.2 Superstructure .....	2-36
2.8.1.3 Shipladders, Walkways, and Platforms .....	2-36
2.8.1.4 Counterweights and Counterweight Pits .....	2-37
2.8.1.5 Pier Protection System and Other Waterway Protective Devices.....	2-37
2.8.1.5.1 Protrusion or Pile Clusters on the Side of Pier Protection Devices .....	2-38
2.8.1.5.2 Bolts, Washers, Steel Corner Plates .....	2-38
2.8.1.5.3 Debris Collection.....	2-39
2.8.1.5.4 Dolphins and Pier Protection Cells .....	2-39
2.8.1.5.5 Kinematic Pier Protection Systems .....	2-44

## PART 2 – INSPECTION

2.8.1.5.6 Clearance Gauge Inspection .....	2-44
2.8.1.6 Operator's (Tender's) House .....	2-46
2.8.1.7 Traffic Signs and Signalizations .....	2-47
2.8.1.7.1 Resistance Gates .....	2-47
2.8.2 MECHANICAL INSPECTION PROCEDURES .....	2-48
2.8.2.1 Open Gearing .....	2-48
2.8.2.1.1 Gear Alignment.....	2-49
2.8.2.1.1.1 Spur Gears .....	2-50
2.8.2.1.1.2 Bevel Gears .....	2-53
2.8.2.1.2 Gear Tooth Wear Measurements .....	2-54
2.8.2.1.2.1 Measuring Gear Teeth.....	2-54
2.8.2.1.3 Appearance and Identification of Gear Tooth Wear and Destruction.....	2-56
2.8.2.1.3.1 Wear .....	2-56
2.8.2.1.3.1.1 Polishing .....	2-57
2.8.2.1.3.1.2 Abrasive and Corrosive Wear .....	2-57
2.8.2.1.3.1.3 Tip and Root Interference.....	2-58
2.8.2.1.3.1.4 Scuffing.....	2-58
2.8.2.1.3.2 Surface Fatigue .....	2-58
2.8.2.1.3.2.1 Pitting.....	2-59
2.8.2.1.3.2.2 Spalling.....	2-59
2.8.2.1.3.3 Plastic Flow.....	2-59
2.8.2.1.3.4 Tooth Breakage .....	2-60
2.8.2.1.3.5 Gear Tooth Wear Observations and Inspections .....	2-60
2.8.2.2 Enclosed Gearing .....	2-61
2.8.2.2.1 Parallel Shaft Reducers .....	2-64
2.8.2.2.2 Right-angle Reducers.....	2-65
2.8.2.2.3 Differential Reducers .....	2-66
2.8.2.2.4 Inspection .....	2-67
2.8.2.2.4.1 External Inspection .....	2-68
2.8.2.2.4.2 Operational Inspection.....	2-69
2.8.2.2.4.3 Internal Inspection .....	2-69
2.8.2.3 Bearings.....	2-70
2.8.2.3.1 Sleeve Bearings.....	2-71
2.8.2.3.1.1 Inspection .....	2-73
2.8.2.3.2 Anti-friction Bearings.....	2-75
2.8.2.3.2.1 Inspection .....	2-77
2.8.2.3.3 Trunnion Bearings .....	2-78
2.8.2.3.3.1 Inspection .....	2-80
2.8.2.4 SHAFTS AND COUPLINGS.....	2-80
2.8.2.4.1 Shafts.....	2-80
2.8.2.4.1.1 Inspection .....	2-81
2.8.2.4.2 Couplings .....	2-82
2.8.2.4.2.1 Rigid Couplings.....	2-82
2.8.2.4.2.1.1 Inspection .....	2-82
2.8.2.4.2.2 Flexible Couplings .....	2-83
2.8.2.4.2.2.1 Gear Couplings.....	2-83
2.8.2.4.2.2.2 Grid Couplings.....	2-84
2.8.2.4.2.2.3 Chain Couplings .....	2-85
2.8.2.4.2.2.4 Insert Couplings.....	2-86
2.8.2.4.2.2.5 Jaw Type Couplings .....	2-87
2.8.2.4.2.2.6 Inspection of Flexible Couplings.....	2-87
2.8.2.5 Buffer Cylinders .....	2-89
2.8.2.5.1 Inspection .....	2-91
2.8.2.6 Live Load Shoes .....	2-93
2.8.2.6.1 Inspection .....	2-94
2.8.2.7 Threaded Fasteners .....	2-94

## PART 2 – INSPECTION

2.8.2.7.1 Anchor Bolts .....	2-95
2.8.2.7.2 Turned Bolts .....	2-96
2.8.2.7.3 Inspection .....	2-97
2.8.2.8 Emergency and Manual Drives .....	2-97
2.8.2.8.1 Emergency Drive Engines .....	2-97
2.8.2.8.2 Manual Drives .....	2-98
2.8.2.8.3 Inspection .....	2-98
2.8.2.8.4 Air Motors .....	2-99
2.8.2.8.4.1 Inspection .....	2-100
2.8.2.9 Shrink Fits With and Without Clamping Sleeves .....	2-101
2.8.2.10 Machinery Coding Recommendations .....	2-101
2.8.2.11 Special Machinery .....	2-104
2.8.2.11.1 Bascule Bridges .....	2-104
2.8.2.11.1.1 Trunnions .....	2-104
2.8.2.11.1.1.1 Inspection .....	2-106
2.8.2.11.1.2 Segmental Girders and Tread Plates .....	2-107
2.8.2.11.1.2.1 Inspection .....	2-108
2.8.2.11.1.3 Bascule Centering Devices .....	2-109
2.8.2.11.1.3.1 Inspection .....	2-110
2.8.2.11.1.4 Span Locks .....	2-110
2.8.2.11.1.4.1 Inspection .....	2-113
2.8.2.11.1.5 Hopkins Frame .....	2-113
2.8.2.11.2 Swing Span Bridges .....	2-115
2.8.2.11.2.1 Center Bearings .....	2-115
2.8.2.11.2.1.1 Inspection .....	2-116
2.8.2.11.2.2 Balance Wheels and Track .....	2-118
2.8.2.11.2.2.1 Inspection .....	2-119
2.8.2.11.2.3 Tapered Rollers .....	2-120
2.8.2.11.2.3.1 Inspection .....	2-121
2.8.2.11.2.4 Wedges, End-lift Jacks, and Shoes .....	2-122
2.8.2.11.2.4.1 Inspection .....	2-127
2.8.2.11.2.5 Swing Span Centering Latches .....	2-129
2.8.2.11.2.5.1 Inspection .....	2-129
2.8.2.11.2.6 Drum Girder .....	2-130
2.8.2.11.3 Vertical Lift Bridges .....	2-131
2.8.2.11.3.1 Wire Ropes and Sockets .....	2-131
2.8.2.11.3.1.1 Inspection .....	2-133
2.8.2.11.3.2 Sheaves and Drums .....	2-134
2.8.2.11.3.2.1 Inspection .....	2-135
2.8.2.11.3.3 Trunnions .....	2-135
2.8.2.11.3.4 Tension Adjusting Devices .....	2-136
2.8.2.11.3.4.1 Inspection .....	2-136
2.8.2.11.3.5 Span Guides .....	2-136
2.8.2.11.3.5.1 Inspection .....	2-137
2.8.2.11.3.6 Balance Chains .....	2-137
2.8.2.11.3.6.1 Inspection .....	2-138
2.8.2.11.3.7 Span Leveling Devices .....	2-139
2.8.2.11.3.7.1 Inspection .....	2-140
2.8.2.11.3.8 Lift Span Centering Devices .....	2-140
2.8.2.11.3.8.1 Inspection .....	2-140
2.8.2.11.3.9 Span Locks .....	2-141
2.8.2.11.3.9.1 Inspection .....	2-142
2.8.2.11.4 Special Machinery Component Coding Guidelines .....	2-142
2.8.2.11.4.1 Bascule Components .....	2-142
2.8.2.11.4.2 Swing Components .....	2-144
2.8.2.11.4.3 Lift Span Components .....	2-146

## PART 2 – INSPECTION

2.8.2.12 Hydraulic Components .....	2-147
2.8.2.12.1 Hydraulic System Basic Principles .....	2-148
2.8.2.12.2 Hydraulic Components on Movable Bridges .....	2-149
2.8.2.12.3 Accumulators .....	2-150
2.8.2.12.4 Valves .....	2-152
2.8.2.12.5 Hydraulic Cylinders.....	2-155
2.8.2.12.6 Hydraulic Pumps.....	2-157
2.8.2.12.7 Hydraulic Motors or Rotary Actuators.....	2-160
2.8.2.12.9 Rigid Hydraulic Piping and Tubing .....	2-162
2.8.2.12.10 Hydraulic Hose .....	2-163
2.8.2.12.11 Reservoirs.....	2-163
2.8.2.12.12 Hydraulic Fluid .....	2-164
2.8.2.12.13 Hydraulic Systems Interlocking Sensors and Controls.....	2-166
2.8.2.12.14 Hydraulic Machinery Coding Recommendations .....	2-166
2.8.3 ELECTRICAL INSPECTION PROCEDURES.....	2-168
2.8.3.1 Electrical Systems for Movable Bridges .....	2-169
2.8.3.1.1 Bascule Bridges.....	2-169
2.8.3.1.2 Swing Bridges.....	2-170
2.8.3.1.3 Vertical Lift Bridges.....	2-170
2.8.3.1.3 Other Movable Bridge Types.....	2-170
2.8.3.1.4 Basic Electrical Equipment .....	2-171
2.8.3.2 Inspection Scope .....	2-171
2.8.3.2.1 Routine Inspections .....	2-171
2.8.3.2.2 In-Depth Inspections.....	2-172
2.8.3.2.3 Inspector Safety.....	2-174
2.8.3.3 Motors .....	2-174
2.8.3.3.1 AC Squirrel Cage Induction Motors .....	2-175
2.8.3.3.1.1 Inspection .....	2-176
2.8.3.3.2 AC Wound-Rotor Induction Motors.....	2-176
2.8.3.3.2.1 Inspection .....	2-178
2.8.3.3.3 DC Motors.....	2-180
2.8.3.3.3.1 Inspection .....	2-181
2.8.3.3.4 Synchronous Motors.....	2-181
2.8.3.3.4.1 Inspection .....	2-182
2.8.3.4 Motor Controls and Motor Control Centers .....	2-182
2.8.3.5 Brakes.....	2-185
2.8.3.5.1 Thruster Brakes .....	2-185
2.8.3.5.2 Dual Magnet Clapper and Solenoid Brakes .....	2-186
2.8.3.5.3 Disc Brakes.....	2-187
2.8.3.5.4 Brake Inspection .....	2-187
2.8.3.6 Electric Cables .....	2-188
2.8.3.6.1 Cable Insulation Inspection .....	2-189
2.8.3.6.2 Terminal Connections of Wires and Cables .....	2-191
2.8.3.6.2.1 Inspection .....	2-191
2.8.3.7 POWER SOURCE.....	2-192
2.8.3.7.1 Inspection (Incoming Power) .....	2-193
2.8.3.7.2 Generators .....	2-193
2.8.3.7.2.1 Inspection .....	2-194
2.8.3.7.3 Transformers .....	2-195
2.8.3.7.3.1 Dry Transformers.....	2-195
2.8.3.7.3.1.1 Inspection .....	2-196
2.8.3.7.3.2 Liquid-filled Transformers .....	2-197
2.8.3.7.3.2.1 Inspection .....	2-197
2.8.3.8 CIRCUIT BREAKERS .....	2-198
2.8.3.8.1 Air Circuit Breakers.....	2-199
2.8.3.8.2 Molded Case Circuit Breakers.....	2-200

## PART 2 – INSPECTION

2.8.3.8.3 Oil Circuit Breakers.....	2-201
2.8.3.8.4 Inspection .....	2-201
2.8.3.9 TRAFFIC CONTROL.....	2-202
2.8.3.9.1 Warning Lights and Signals.....	2-202
2.8.3.9.2 Traffic Signals.....	2-203
2.8.3.9.3 Traffic and Resistance Gates .....	2-203
2.8.3.10 NAVIGATIONAL LIGHTS.....	2-204
2.8.3.11 LIGHTNING PROTECTION SYSTEM .....	2-204
2.8.3.12 ELECTRICAL COMPONENT CODING GUIDELINES .....	2-205
2.8.3.13 Controls and Interlocking.....	2-206
2.8.3.13.1 General .....	2-206
2.8.3.13.2 Bridge Operating Sequence .....	2-207
2.8.3.13.3 Discrete Control System Component Inspection.....	2-207
2.8.3.13.3.1 Limit Switches.....	2-208
2.8.3.13.3.2 Selsyn Transmitters .....	2-211
2.8.3.13.3.3 Resolvers and Optical Encoders .....	2-212
2.8.3.13.4 Control Console .....	2-213
2.8.3.13.4.1 Metering Equipment.....	2-215
2.8.3.13.4.2 External Inspection of Control Console .....	2-215
2.8.3.13.4.3 Internal Inspection of Control Console .....	2-215
2.8.3.13.4.3.1 Component Inspection.....	2-215
2.8.3.13.4.4 Bridge Control Interlocking .....	2-216
2.8.3.13.4.4.1 Bridge Control Interlocking Tests .....	2-216
2.8.3.13.5 Programmable Logic Controllers (PLC's).....	2-217
2.8.3.13.6 Drum and Relay Logic Controllers.....	2-219
2.8.3.13.6.1 Drum Controllers.....	2-219
2.8.3.13.6.2 Relay Logic Controllers.....	2-222
2.8.3.13.7 Main and Motor Speed Controls.....	2-225
2.8.3.13.7.1 AC Wound Rotor Manual Control .....	2-225
2.8.3.13.7.2 Variable Speed Controllers.....	2-226
2.8.3.13.7.3 AC Adjustable Voltage Controller .....	2-226
2.8.3.13.7.4 AC Adjustable Frequency Controllers .....	2-227
2.8.3.13.7.5 AC Flux Vector Controller .....	2-228
2.8.3.13.7.6 DC Static Drive Controllers.....	2-228
2.8.3.13.8 Surge Protection.....	2-229
2.8.3.13.8.1 Inspection .....	2-230
2.8.3.13.9 Controls and Interlocking Coding Guidelines .....	2-232
CHAPTER 2.9 – PREDICTED COMPONENTS LIFE .....	2-249
2.9.1 PREDICTED COMPONENT LIFE FOR HYDRAULIC AND ELECTRICAL COMPONENTS .....	2-249
CHAPTER 2.10 – TESTING AND ADVANCED INSPECTION METHODS .....	2-252
2.10.1 GENERAL .....	2-252
2.10.2 ULTRASONIC INSPECTION OF SHAFTS AND GEARS.....	2-252
2.10.3 INTERNAL INSPECTION OF COMPONENTS.....	2-256
2.10.4 APPLIED AND RESIDUAL STRESS MONITORING.....	2-256
2.10.5 LEAF OR SPAN BALANCE .....	2-257
2.10.5.1 Checking Static Balance.....	2-257
2.10.5.2 Checking Balance by Motor Current Measurement .....	2-258
2.10.5.3 Strain Gauge Balancing.....	2-259
2.10.6 VIBRATION MEASUREMENT .....	2-260
2.10.7 LUBRICATING OIL ANALYSIS .....	2-261
2.10.8 ELECTRICAL MEASUREMENT .....	2-262
2.10.9 ELECTRICAL INSULATION RESISTANCE TESTING.....	2-263
2.10.10 TESTING TRANSFORMER INSULATING OIL .....	2-268
2.10.11 HYDRAULIC SYSTEM TESTING .....	2-270
2.10.11.1 Hydraulic Oil Sampling .....	2-270
2.10.11.2 Analysis of Filter Elements .....	2-271

**PART 2 – INSPECTION**

- 2.10.11.3 Operating Pressures / Cycle Testing..... 2-271
- 2.10.11.4 Leakage Testing ..... 2-271
- 2.10.11.5 Case Drain Flow Analysis..... 2-272
- 2.10.11.6 Temperature Analysis..... 2-272
- 2.10.12 DIAGNOSTIC MONITORING SYSTEMS ..... 2-272
  - 2.10.12.1 Gearbox Vibration..... 2-273
  - 2.10.12.2 Open Gear ..... 2-273
  - 2.10.12.3 Span Lock Pressure ..... 2-273
  - 2.10.12.4 Advanced Statistical Methods for Mechanical Components ..... 2-274