

## Table of Contents

<b>1. Introduction</b> .....	<b>1</b>
<b>2. Scope</b> .....	<b>3</b>
<b>3. Guidance</b> .....	<b>5</b>
3.1 Introduction .....	5
3.2 Mechanical deterioration mechanisms .....	5
3.2.1 External corrosion .....	5
3.2.2 Internal corrosion .....	6
3.2.3 Stress Corrosion Cracking (SCC) .....	7
3.2.4 Fretting corrosion .....	8
3.2.5 Erosion .....	8
3.2.6 Fatigue .....	9
3.2.7 Creep .....	11
3.2.8 Stress relaxation .....	12
3.2.9 Hydrogen embrittlement .....	12
3.2.10 Liquid Metal Embrittlement (LME) .....	12
3.2.11 Brittle fracture .....	13
3.2.12 Excessive external loads .....	13
3.2.13 Failure of supports .....	13
3.2.14 Accidental damage .....	14
3.2.15 Internal wear .....	14
3.3 General deterioration mechanisms & factors requiring equipment change .	14
3.3.1 Machine instrumentation control/monitoring system obsolescence.....	14
3.3.2 Plant instrumentation control/monitoring system changes .....	15
3.3.3 Instrumented protective system upgrade .....	15
3.3.4 Efficiency re-rate .....	15
3.3.5 Capacity re-rate to cope with plant capacity increase .....	16
3.3.6 Capacity re-rate to cope with equipment duty point changing .....	16
3.3.7 Reliability upgrade .....	16
3.3.8 Regulatory driven change .....	17
3.3.9 Management Of Change (MOC) .....	17
3.3.10 Original Equipment Manufacturer (OEM) spares/support .....	17
3.3.11 Increase in plant turnaround interval .....	18
3.4 Specific deterioration modes by types of machine .....	19
3.5 Reasons for machine internal component replacement .....	24
3.6 Reasons for complete machine replacement .....	24
3.7 How long can a machine operate? .....	25
3.8 Machine overhauls for older equipment .....	25
<b>References</b> .....	<b>26</b>
<b>Bibliography</b> .....	<b>26</b>
<b>Appendix A Illustrations of long term machinery degradation</b> .....	<b>27</b>

## List of Figures

Figure 1 Steam turbine blade corrosion .....	27
Figure 2 Steam turbine casing creep analysis .....	27
Figure 3 Steam turbine split line machining to correct casing distortion.....	28
Figure 4 Steam turbine blade root cracking .....	28
Figure 5 Centrifugal compressor vane leading edge erosion.....	29
Figure 6 Centrifugal compressor impeller corrosion .....	29
Figure 7 Centrifugal compressor low temperature (-90°C) fatigue cracking.....	30
Figure 8 Centrifugal compressor efficiency/capacity rerate .....	30
Figure 9 Centrifugal compressor impeller erosion due to internal fouling .....	31
Figure 10 Centrifugal compressor bearing fatigue failure.....	31
Figure 11 Reciprocating compressor HVOF coating build-up of bearing areas ....	32
Figure 12 Reciprocating compressor foundation removal and replacement.....	32
Figure 13 Reciprocating compressor motor torsional fatigue failure.....	33
Figure 14 Centrifugal pump impeller measurement and modelling .....	33
Figure 15 Centrifugal pump casing erosion.....	34
Figure 16 Centrifugal pump impeller corrosion.....	34

## List of Tables

Table 1 Long term deterioration mechanisms for different types of machinery...	20
Table 2 Key to deterioration mechanisms .....	24