
TABLE OF CONTENTS

CHAPTER 1

MICROBES IN THE PAPER MACHINE ENVIRONMENT	1
INTRODUCTION	1
Biofilms and Biofouling	1
Deposits	2
Spoilage.....	2
MICROBES.....	3
BACTERIA	3
Aerobes.....	3
Facultative anaerobes.....	5
Anaerobes	5
FUNGI	6
ALGAE	6
INVERTEBRATES	7
THE PAPER MACHINE ENVIRONMENT	8
pH	8
Water Activity/Moisture Content	9
Temperature.....	10
MACHINE SYSTEM	10
Fresh Water.....	10
Fibers.....	12
Virgin Fiber	13
Dry Lap	13
Wet Lap	13
Recycled Fiber.....	13
Broke	13
HIGH DENSITY STORAGE TOWERS.....	14
WHITE WATER	14
SAVEALL	16
MACHINE CHESTS AND HEADBOX	16
MACHINE FRAME.....	16
ADDITIVES.....	16

AIR	18
BOILOUTS	18
SUMMARY	19
BIBLIOGRAPHY.....	19

CHAPTER 2

BIOCORROSION IN THE PULP AND PAPER INDUSTRY.....	21
CORROSION IN GENERAL	21
MICROBIAALLY INFLUENCED CORROSION	21
MECHANISMS	21
Active Corrosion	22
Passive Corrosion	24
Differences Between Active and Passive Corrosion	24
MICROORGANISMS INVOLVED IN MIC.....	24
Sulfate-Reducing Bacteria	24
Acid Producers	25
Metal Depositors	26
Slime-Forming Bacteria.....	28
PROOFS OF MIC.....	29
IDENTIFICATION OF ACTIVE CORROSION	29
MONITORING AND TREATMENTS	31
Monitoring.....	31
Treatments	33
SUMMARY	35
LITERATURE CITED	35

CHAPTER 3

CONTROL OF MICROORGANISMS IN PAPERMAKING SYSTEMS.....	37
INTRODUCTION.....	37
ENGINEERING SURVEY	37
Tank Capacities, Tank Working Volumes and Tank Flows.....	38
Presence or Absence of Tank Agitation	38
Position of Sampling Points.....	38
Existence of Recycle Lines.....	38
Sources of Fresh and Dilution Water	38
Ventilation	38
Solids Content of All Streams.....	38
Temperature and pH	38
Performance Additives	38
Current Biocide Program	39
Production.....	39

Intermittent Flows or “Dead Legs”	39
MICROBIOLOGICAL SURVEY	39
General Machine Biological Survey.....	39
Microscopic Survey.....	40
Survey of the Numbers and Types of Microorganisms.....	40
PRODUCT SELECTION AND MICROORGANISM CONTROL	41
Regulations	42
Safety.....	42
Chemicals.....	43
New and Emerging Technologies	44
PRODUCT EVALUATION.....	46
Laboratory Evaluation	46
Field Evaluation	47
MONITORING AND FOLLOW-UP	49
SUMMARY	51
APPENDIX A.....	52
Understanding the Relationship Between Growth Rate, Retention Time and Washout.....	52
Determination of Bacterial Growth Rate	52
Calculating the Specific Growth Rate	52
Determining Tank Retention Time.....	53
Effect of Tank Retention Time on Bacterial Accumulation	54
Poorly Mixed Tanks.....	54

CHAPTER 4

MICROBIOLOGICAL CONTROL IN KAOLIN AND CALCIUM CARBONATE SLURRY	56
PIGMENTS AND ADDITIVES	56
Introduction.....	56
Pigment Processing.....	56
Microorganisms	57
Control Methodologies	58
HEALTH, SAFETY, HANDLING ISSUES	61
FACTORS AFFECTING MICROBIOLOGICAL PRESERVATION OF PIGMENT SLURRIES	
AT PAPER MILLS	61
Unloading/Storage Facilities/Tank Design	61
PCC-Contamination From Water/CO ₂	62
Water Quality.....	62
Transportation/Storage.....	63
Temperature.....	63
pH	63
Reduced Susceptibility/Selection/Tolerance/Resistance	63
MONITORING THE EFFECTIVENESS OF A PRESERVATIVE TREATMENT	
PROGRAM IN A PIGMENT SLURRY.....	64

Enumeration Methods.....	64
Monitoring Frequency.....	65
Measurement of Residual Biocide.....	65
PROGRAM MONITORING.....	66
Visual Inspection.....	66
Water Quality.....	66
Biocide Application.....	66
Sampling.....	66
Success Criteria.....	66
TRAINING.....	67
MICROORGANISM IDENTIFICATION.....	67
SUPPLIER - CUSTOMER UNDERSTANDING/ KNOWLEDGE BASE.....	67
SUMMARY.....	69

CHAPTER 5

THE EFFECT OF WATER RECOVERY AND REUSE ON MICROBIAL ACTIVITY.....	70
INTRODUCTION.....	70
DEFINING CLOSURE.....	70
POTENTIAL PROBLEMS.....	71
OXIDATIVE-REDUCTIVE POTENTIAL (ORP).....	73
CASE STUDY: CLASSIC VOLATILE FATTY ACID ODOR PROBLEM.....	74
CASE STUDY FOR IMPEDING CLOSURE PROJECT.....	75
BIOCIDES AND CLOSURE.....	76
WATER SOURCES.....	78
SUMMARY.....	78
REFERENCES.....	79

CHAPTER 6

BOILOUTS - CHEMICAL CLEANING PROGRAMS.....	80
INTRODUCTION.....	80
BOILOUT EVALUATION.....	81
Prevention of Premature Slime Accumulation.....	81
Prevention of Corrosion Pitting.....	81
Prevention of Scale Formation.....	81
Removal of Organic Deposits.....	81
FORMULATION OF CHEMICAL BOILOUT SOLUTIONS.....	82
“Caustic” (Sodium Hydroxide).....	82
Organic Penetrants and Dispersants.....	82
Inorganic Dispersing Agents and Chelants.....	82
Foaming Agents.....	83
Acid.....	83

BOILOUT PROCEDURES.....	83
Guidelines for a Successful Caustic Boilout Program	84
Achieving and Maintaining The Desired Alkalinity	84
Thorough Post-Boilout Washup	84
ALTERNATE SYSTEM BOILOUTS	85
SUMMARY	85

CHAPTER 7

MICROBIOLOGICAL QUALITY ASSURANCE OF WET WIPE PAPER PRODUCTS.....	86
INTRODUCTION	86
RAW MATERIALS	87
Paper	88
Water	88
Wet Wipe Solution Chemicals.....	88
CONTAINER TESTING.....	89
FINISHED PRODUCT MICROBIOLOGICAL TESTING.....	89
MANUFACTURING ENVIRONMENT TESTING	90
PRESERVATIVE EFFICACY	90
SUMMARY	91
REFERENCES	91

CHAPTER 8

PAPERMAKING MICROBIOLOGY FUNDAMENTALS	92
GENERAL OVERVIEW AND CLASSIFICATION	92
Overview	92
Classification.....	92
MICROORGANISMS AND THEIR ENVIRONMENT	94
Nutritional Requirements.....	95
Carbon	95
Nitrogen.....	95
Other Nutrients	95
Water	95
Physical Requirements.....	96
<i>Temperature</i>	96
<i>Gases</i>	97
<i>Acidity and Alkalinity (pH)</i>	97
<i>Energy</i>	98
DESCRIPTION OF MICROORGANISMS	98
Invertebrates.....	98
Protozoa	99
Algae.....	100
Fungi.....	101

Fungi and the Papermaking Process	102
Bacteria	103
BACTERIA AND THE PAPERMAKING PROCESS	105
SUMMARY.....	107
ACKNOWLEDGEMENTS	107
SUGGESTED READING.....	107
TAPPI MICROBIOLOGY AND MICROBIAL TECHNICAL COMMITTEE	108
APPENDIX I	
TAPPI METHODS USED IN PAPER MACHINE MICROBIOLOGY	115
OFFICIAL METHOD.....	115
PROVISIONAL METHOD	116
STANDARD PRACTICE	116
CLASSICAL METHOD	116
WITHDRAWN METHODS.....	116
USEFUL METHOD	117
WHAT DO THE NUMBERS AND THE SUFFIXES IN TAPPI TEST METHOD NUMBERS MEAN?	117
APPENDIX II	
GLOSSARY OF MICROBIOLOGICAL TERMS	119
APPENDIX III	
GENERAL MICROBIOLOGICAL SAFETY	125
TEXTBOOKS	125
ADDITIONAL INFORMATION.....	126
APPENDIX IV	
DEVELOPMENT OF MICROBIOLOGICAL GUIDELINES FOR FOOD-GRADE PAPERBOARD: A HISTORICAL PERSPECTIVE	127
THE “DAIRYMAN’S STANDARD”	128
HISTORICAL BACKGROUND.....	128
DISCUSSION.....	130
LITERATURE CITED	130
SUBJECT INDEX.....	132
