

BAB 4 - MAINTENANCE & TROUBLESHOOTING

4.1 Preventive Maintenance

Program preventive maintenance dirancang untuk mempertahankan reliability dan accuracy sistem monitoring dissolved oxygen melalui maintenance schedule yang terstruktur dan task-based maintenance procedures.

4.1.1 Schedule Maintenance Berkala

Schedule maintenance dibagi berdasarkan frekuensi dan criticality komponen untuk optimasi resource maintenance dan minimize system downtime.

Daily Maintenance (Shift Check):

- Visual inspection kondisi fisik enclosure dan kabel
- Verifikasi pembacaan sensor dalam range normal
- Check alarm status dan clear acknowledged alarms
- Record daily reading untuk trending analysis
- Backup configuration parameters (weekly)

Weekly Maintenance:

- Cleaning sensor probe dari algae atau debris
- Inspection koneksi kabel untuk signs of corrosion
- Verifikasi accuracy sensor dengan grab sample comparison
- Check tightness terminal connections
- Update maintenance log dan performance tracking

Monthly Maintenance:

- Comprehensive sensor calibration check
- Cleaning dan inspection semua electrical connections
- Verification communication performance (error rates)
- EEPROM health check dan write count monitoring
- System performance analysis dan tuning review

Quarterly Maintenance:

- Full system calibration dengan certified reference
- Replacement consumable items (jika applicable)
- Software backup dan configuration documentation
- Comprehensive system testing all functions
- Engineering review performance trends dan recommendations

4.1.2 Sensor Maintenance Procedures

Sensor dissolved oxygen memerlukan maintenance regular untuk maintain accuracy dan extend operational life dalam lingkungan wastewater yang challenging.

Sensor Cleaning Procedure:

1. Preparation

- Set sistem ke manual mode untuk prevent control fluctuation
- Prepare cleaning solution (mild detergent atau specialized sensor cleaner)
- Document current sensor reading untuk comparison

2. Physical Cleaning

- Remove sensor dari mounting bracket dengan careful handling
- Gently brush sensor probe dengan soft bristle brush
- Rinse dengan clean water untuk remove cleaning solution residue
- Inspect sensor membrane untuk damage atau heavy fouling

3. Reinstallation

- Mount sensor kembali pada position yang sama
- Verify secure mechanical connection
- Allow stabilization time (5-10 minutes) sebelum measurement
- Compare reading dengan pre-cleaning value untuk significant changes

Sensor Inspection Checklist:

- ☐ Probe surface free from heavy deposits atau biofilm
- ☐ Cable jacket intact tanpa cuts atau abrasion
- ☐ Connector seals dry dan properly seated
- ☐ Mounting hardware secure dan corrosion-free
- ☐ Reading stable dan within expected range

4.1.3 Electrical System Maintenance

Electrical system maintenance focus pada prevention of connection degradation dan early detection of component aging yang dapat affect system reliability.

Power Supply Inspection:

- Verify input voltage stability ($220V \pm 10\%$)
- Check output voltage regulation ($24V \pm 5\%$, $5V \pm 5\%$)
- Inspect cooling fan operation (jika equipped)
- Check for signs of overheating atau component stress
- Verify protection circuits function (overcurrent, overvoltage)

Communication System Check:

- Test RS485 communication integrity (error rate $<0.1\%$)
- Verify cable shielding effectiveness
- Check termination resistor values (120Ω)
- Inspect connector contacts untuk corrosion atau looseness
- Validate Modbus timing parameters

Control Output Verification:

- Calibrate PWM to 0-10V converter accuracy
- Test output linearity across full range (0-100%)
- Verify load impedance compatibility dengan VFD input
- Check signal isolation effectiveness
- Validate control response timing

4.1.4 Software dan Configuration Maintenance

Software maintenance memastikan system configuration remain optimal dan provide backup untuk quick recovery dari potential failures.

Firmware Maintenance:

- Monitor firmware stability (reboot frequency, error logs)
- Backup firmware binary dan source code
- Document any custom modifications atau parameter changes
- Verify EEPROM data integrity dan backup critical parameters
- Update firmware version control documentation

HMI Application Maintenance:

- Backup HMI project files dan screen layouts
- Verify operator interface responsiveness
- Check data logging functionality dan storage capacity
- Test alarm notification system
- Update operator training materials jika ada interface changes

Configuration Documentation:

- Maintain current copy of all system parameters
- Document any changes dengan justification dan approval
- Backup calibration data dan certificates
- Record maintenance activities dan findings
- Update system documentation untuk configuration changes

4.2 Troubleshooting Guide

Troubleshooting guide menyediakan systematic approach untuk diagnosis dan resolution masalah umum yang mungkin terjadi selama operasi sistem.

4.2.1 System Communication Issues

Communication problems antara ESP8266 dan HMI adalah salah satu failure mode yang paling common dan dapat significantly impact system operation.

Symptom: HMI Displays "Communication Error"

Diagnostic Steps:

1. Verify Physical Connections

- Check RS485 cable continuity dengan multimeter

- Inspect connector pins untuk corrosion atau damage
- Verify proper shield grounding pada both ends
- Confirm wiring sesuai dengan pinout diagram

2. Test Communication Parameters

- Verify Modbus settings match pada ESP8266 dan HMI:
 - Baud rate: 9600 bps
 - Data bits: 8
 - Parity: None
 - Stop bits: 1
 - Slave address: 1

3. ESP8266 Status Check

- Connect serial monitor untuk check firmware operation
- Verify firmware boot sequence normal
- Check untuk error messages dalam serial output
- Confirm ESP8266 responding to serial commands

4. Troubleshooting Actions

- Restart HMI dan observe communication restoration
- Power cycle ESP8266 dengan unplug/replug power
- Check termination resistors (120Ω at each end)
- Replace RS485 cable jika suspected damage

Expected Resolution Time: 15-30 minutes

4.2.2 Sensor Reading Issues

Sensor problems dapat manifest sebagai erratic readings, stuck values, atau readings yang clearly unrealistic untuk operating conditions.

Symptom: DO Reading Stuck at Zero atau Maximum

Diagnostic Steps:

1. Sensor Physical Inspection

- Remove sensor untuk visual inspection
- Check untuk heavy fouling, damage, atau obstruction
- Verify sensor cable integrity
- Inspect connector untuk moisture atau corrosion

2. Electrical Testing

- Measure sensor output voltage dengan multimeter
- Expected range: 0-3.3V corresponding to 0-20 ppm
- Check ADC input pada ESP8266 dengan voltmeter
- Verify analog ground reference

3. Calibration Verification

- Perform quick calibration check dengan known reference

- Compare reading dengan handheld DO meter
- Check calibration factor dalam system parameters
- Verify sensor response dalam different DO concentrations

Troubleshooting Actions:

- Clean sensor thoroughly dengan appropriate solution
- Re-calibrate sensor dengan fresh reference solutions
- Replace sensor cable jika electrical problem detected
- Update calibration factors jika systematic offset observed

Expected Resolution Time: 30-60 minutes

4.2.3 Control Output Problems

Control output issues affect kemampuan sistem untuk properly adjust motor frequency dalam response ke DO measurements.

Symptom: Motor Frequency Not Responding to DO Changes

Diagnostic Steps:

1. Control Logic Verification

- Check sistem dalam auto mode (not manual)
- Verify PID parameters reasonable (not zero atau extreme values)
- Confirm setpoint value appropriate untuk current conditions
- Check untuk alarm conditions yang disable control

2. Output Signal Testing

- Measure PWM output dari ESP8266 dengan oscilloscope
- Verify PWM to 0-10V converter output voltage
- Check 0-10V signal reaching VFD input terminals
- Confirm VFD configured untuk 0-10V analog input

3. PID Controller Analysis

- Monitor PID error calculation (setpoint - measured value)
- Check integral windup atau derivative spikes
- Verify output limits not constraining control action
- Analyze control stability dengan trend data

Troubleshooting Actions:

- Reset PID controller integral term
- Adjust PID parameters untuk better response
- Verify VFD analog input configuration
- Check PWM to voltage converter calibration
- Replace converter module jika output incorrect

Expected Resolution Time: 45-90 minutes

4.2.4 Power Supply dan Hardware Failures

Hardware failures dapat range dari component aging hingga environmental damage yang require component replacement.

Symptom: System Intermittent Operation atau Random Resets

Diagnostic Steps:

1. Power Supply Analysis

- Measure input voltage stability dengan recording voltmeter
- Check output voltage regulation under load
- Verify adequate current capacity untuk all connected loads
- Inspect untuk signs of overheating atau component stress

2. Environmental Factors

- Check enclosure sealing untuk moisture intrusion
- Verify operating temperature within specification
- Look untuk signs of corrosion pada connections
- Check untuk electromagnetic interference sources

3. Component Testing

- Test ESP8266 operation dengan separate power supply
- Verify HMI operation independent dari control system
- Check MAX485 module functionality
- Test sensor dengan different controller

Troubleshooting Actions:

- Replace suspected power supply components
- Improve enclosure sealing jika moisture detected
- Add filtering untuk power supply atau communication lines
- Replace elektronik modules showing signs of failure
- Implement better grounding jika EMI suspected

Expected Resolution Time: 1-4 hours depending on component availability

4.3 Spare Parts dan Documentation

Comprehensive spare parts inventory dan documentation management essential untuk minimize downtime dan ensure quick restoration of system operation.

4.3.1 Recommended Spare Parts Inventory

Spare parts selection based pada failure frequency, criticality, dan lead time untuk replacement parts dari suppliers.

Critical Spare Parts (Stock Level: 2 units):

- ESP8266 Wemos D1 R1 Uno microcontroller board
- MAX485 RS485 transceiver module

- PWM to 0-10V converter module
- LM2596 DC-DC stepdown converter
- Power supply 24V 10A industrial grade

Important Spare Parts (Stock Level: 1 unit):

- DFRobot SEN0237 dissolved oxygen sensor
- HMI Wecon PI3070ie touchscreen panel
- RS485 communication cable (25 meter)
- Sensor mounting bracket dan hardware
- Electrical enclosure IP65 rated

Consumable Items (Stock Level: As Needed):

- Terminal blocks dan connectors
- Cable glands dan sealing materials
- Sensor cleaning solution dan brush kit
- Calibration standard solutions
- Backup batteries untuk real-time clock

Part Numbers dan Supplier Information:

Component	Part Number	Supplier
ESP8266 Wemos D1 R1	WEM-D1R1-UNO	Local Electronics
MAX485 Module	MAX485-TTL-5V	Electronics Supply
PWM-Voltage Converter	PWM-0-10V-ISO	Industrial Automation
DO Sensor DFRobot	SEN0237-A	DFRobot Distributor
HMI Wecon 7"	PI3070ie	Wecon Indonesia
PSU 24V 10A	PSU-24V-10A-DIN	Power Supply Specialist

4.3.2 Documentation Management

Proper documentation management ensures all technical information readily available untuk maintenance personnel dan supports knowledge transfer.

Technical Documentation Library:

- System installation drawings dan wiring diagrams
- Component datasheets dan technical specifications
- Firmware source code dan compilation instructions
- HMI application project files dan screen layouts
- Commissioning test results dan acceptance certificates

Maintenance Documentation:

- Preventive maintenance procedures dan checklists
- Calibration procedures dan standards
- Troubleshooting guides dengan historical solutions
- Spare parts catalog dengan supplier contacts

- Training materials untuk operators dan technicians

Configuration Management:

- Current system configuration parameters
- Change control procedures dan approval matrix
- Version control untuk firmware dan HMI applications
- Backup procedures untuk configuration data
- Recovery procedures untuk system restoration

4.3.3 Technical Support Resources

Established support resources provide access ke expert assistance ketika local troubleshooting insufficient untuk problem resolution.

Internal Support Structure:

- **Level 1:** Plant operators (basic troubleshooting, routine maintenance)
- **Level 2:** Maintenance technicians (component replacement, advanced diagnostics)
- **Level 3:** Engineering support (system design changes, complex problems)
- **Level 4:** External vendor support (specialized component issues)

External Support Contacts:

Support Type	Contact Information
ESP8266/Arduino Support	Arduino Community Forum
HMI Technical Support	Wecon Indonesia: +62-21-xxxx-xxxx
Sensor Technical Support	DFRobot: sensor-support@dfrobot.com
System Integration	Engineering Consultant: consultant@email.com
Emergency Service	24/7 Hotline: +62-xxx-xxxx-xxxx

Documentation Access:

- Technical library maintained in engineering office
- Digital copies stored pada network drive dengan backup
- Mobile access via tablet untuk field maintenance
- Version control dan update notification system
- Regular review dan update schedule quarterly

4.3.4 Training dan Knowledge Transfer

Comprehensive training program ensures maintenance personnel have necessary skills untuk effective system maintenance dan troubleshooting.

Training Modules:

1. **System Overview** - Architecture, components, operation principles
2. **HMI Operation** - Screen navigation, parameter setting, alarm handling
3. **Sensor Maintenance** - Cleaning, calibration, replacement procedures
4. **Troubleshooting** - Systematic diagnosis approach, common problems

5. **Safety Procedures** - Electrical safety, lockout/tagout, emergency procedures

Training Schedule:

- Initial training: 16 hours over 2 days
- Refresher training: 4 hours quarterly
- Advanced troubleshooting: 8 hours annually
- New employee orientation: 8 hours
- Safety updates: 2 hours monthly

Training Documentation:

- Training manuals dengan hands-on exercises
- Video demonstrations of key procedures
- Competency assessment checklist
- Training records dan certification tracking
- Continuous improvement feedback dari trainees

Knowledge Retention:

- Regular knowledge sharing sessions
- Documentation of lessons learned dari maintenance activities
- Cross-training antara maintenance teams
- Mentoring program untuk new technicians
- Performance feedback dan improvement planning

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