CONTROL STRATEGY & CONTROL PHILOSOPHY

Flash Dryer System – Modified Starch

1. PURPOSE AND SCOPE

This document defines the **complete Control Strategy and Control Philosophy** for the Modified Starch Flash Dryer system, based on the approved **P&ID** (5204-PR-DW-0001-03).

, explosion protection layout, rotating equipment monitoring, and expert operational comments.

The philosophy covers:

- Process control
- Equipment protection
- Explosion and mechanical safety interfaces
- Startup, shutdown, and emergency logic
- Operator interaction philosophy
- Detailed control philosophy

2. OVERALL CONTROL OBJECTIVES

The primary control objectives of the Flash Dryer system are:

1. Maintain final product moisture within specification.
2. Prevent product overheating and degradation.
3. Ensure continuous, stable solids conveying through the dryer.
4. Protect rotating and pressurized equipment.
5. Provide immediate safe response to explosion or mechanical failure.
6. Ensure compliance with ATEX / EN 14491 explosion protection requirements.

3. CONTROL SYSTEM ARCHITECTURE

- Control platform: **PLC**
- Control layers:
    - Regulatory control (PID / PI)

  - Sequential control (step-based logic)
  - Interlock and trip layer
  - Operator HMI supervision
- Safety philosophy:
  - Hard interlocks in PLC
  - Fail-safe field devices
  - Interface with explosion protection devices

4. OPERATING MODES

Mode	Description
OFF	All equipment de-energized
START-UP	Manual controlled startup sequence
NORMAL OPERATION	Fully automatic cascade-controlled drying
SHUTDOWN	Controlled drying and cooldown Manually
EMERGENCY SHUTDOWN	Immediate protective shutdown
MAINTENANCE	Local / manual control with interlocks enforced

5. MAIN PROCESS CONTROL STRATEGY

5.1 Moisture-Based Cascade Control

The flash dryer operates under a **cascade control strategy**:

- **Master controller**: Online product moisture analyzer
- **Slave controller**: Exhaust air temperature controller
- **Manipulated variable**: Steam control valve to air heater

Control logic:

- The moisture controller adjusts the **setpoint of exhaust air temperature**.
- The temperature controller regulates steam flow to maintain that setpoint.

- If the moisture analyzer fails, the system automatically reverts to **temperature-only control**.

- If the deviation from the setpoint becomes significant or sudden changes occur in the conditions of the input cake to the dryer; at that point, the control of the dryer is assigned to **FEED RATE CONTROL BASED ON MOISTURE)** until conditions stabilize.

6. AIR SYSTEM AND FAN CONTROL

6.1 Dryer Fan Control (V6515)

Based on the P&ID, (5204-PR-DW-0001-03) the dryer fan is equipped with:

- VFD control
- Shaft speed measurement
- Bearing temperature monitoring
- Vibration monitoring
- Air velocity measurement at duct outlet

Control strategy:

- Fan speed is controlled to maintain required air velocity.
- Fan cannot start unless:
  - All downstream paths are open
  - Explosion vents are healthy
  - No active trip conditions exist

6.2 Fan Protection Interlocks

Protection	Action
High bearing temperature	Fan trip
High vibration	Fan trip

Overspeed	VFD trip
Loss of airflow	Heater trip ((TCV- S101)
Shaft speed mismatch	Alarm then trip

7. FEED SYSTEM CONTROL (STARCH CAKE FEEDER)

- Feed screw / feeder operates under mass measuring (WIC-B6200) control.
- Feed rate is interlocked with:
  - Fan running status
  - Heater availability
  - Cyclone and discharge readiness

If airflow or heating is lost:

- Feed is stopped immediately
- Purge sequence is initiated if allowed

8. HEATER AND STEAM CONTROL PHILOSOPHY

- Steam flow is modulated via control valve.
- Heater enable is permitted only if:
  - Fan is running
  - Minimum airflow is confirmed
  - No high temperature trip is active

Trips:

- High inlet air temperature (TIC-101) → Steam valve closed
- Fan trip → Steam valve closed (TCV- S101)
- Explosion signal → Steam valve closed

9. EXPLOSION PROTECTION AND BURST SENSOR LOGIC

9.1 Explosion Detection

The system includes multiple **Burst Sensors** XS-101 to XS-106 (Dryer Duct) + XS-F6506 to XS-F6511 (Cyclones) + XS-B6512 (Silo)) Installed on:

- Dryer duct
- Cyclone inlets
- Dry starch receiving silo

9.2 Explosion Response Strategy

Upon detection of burst / explosion signal:

Immediate actions:

1. Close steam control valve (TCV- S101& TCV- S102).
2. Stop product feed.
3. Maintain fan operation if mechanically allowed (post-explosion purge).
4. Generate latched alarm requiring manual reset.

Explosion events are treated as:

- **Non-auto-resettable trips**
- Root-cause investigation mandatory before restart

10. CYCLONE AND SOLIDS DISCHARGE CONTROL

- Cyclone discharge is via airlock/rotary valve.
- Rotary valves are interlocked with:
    - Fan operation
    - Cyclone pressure balance (controlled by level switches)
- Blockage detection results in:
    - Feed reduction
    - Alarm escalation
    - Controlled shutdown if unresolved

11. START-UP MANUAL SEQUENCE (SUMMARY)

1. Operator permissive check.
2. Start dryer fan and verify airflow.
3. Enable heater and warm-up.
4. Start feed at minimum rate.
5. Enable cascade moisture control.
6. Ramp to normal production.

12. NORMAL SHUTDOWN SEQUENCE

1. Operator Stop feed system) The **operator must shut down the cake feed system from the peeler centrifuge to the disintegrator in the correct sequence, starting from the beginning of the line all the way to the end, taking into account the delay time for the series equipment — which is also monitored by the operator)**
2. Continue drying until duct moisture clears.
3. Disable heater.
4. Cool-down with air.
5. Operator Stop fan.

13. EMERGENCY SHUTDOWN (ESD)

Triggers:

- Emergency stop
- Explosion signal
- Fan trip
- Critical temperature or vibration

Actions:

- Immediate steam isolation
- Immediate feed stops
- Fan logic based on structural integrity status

14. ALARM PHILOSOPHY

- First-out alarm logic applied
- Priority-based alarms:
    - High: Safety / equipment damage
    - Medium: Process deviation
    - Low: Advisory
- All trips require manual reset

15. INTERFACE WITH MECHANICAL DESIGN

The control philosophy is directly aligned with:

- Explosion vent sizing and location
- Vacuum design limits
- Mechanical stress limits of ducting and cyclones
- Fan operating envelope

No control action allows operation beyond mechanical design limits.

16. CAUSE & EFFECT MATRIX

16.1. PURPOSE OF CAUSE & EFFECT MATRIX

This Cause & Effect Matrix defines the **automatic protective and control responses** of the Flash Dryer system to abnormal process, mechanical, or safety events.

The matrix ensures:

- Consistent and predictable system behavior
- Protection of personnel and equipment
- Compliance with explosion safety standards
- Clear implementation guidance for PLC/DCS programming

16.2. PHILOSOPHY AND DESIGN BASIS

- All **Trips** are latched and require manual reset.
- Explosion-related causes have **highest priority**.
- Steam isolation is always **fail-safe closed**.

- Feed stoppage is **immediate** on loss of safe drying conditions.
- Fan operation after trip depends on **mechanical integrity and explosion logic**.

16.3. Cause & Effect Matrix

Symbol	Meaning	Description
✓	Action Executed	The specified action is automatically executed when the cause occurs
—	No Action	No automatic action is initiated
L	Latched Trip	A trip that remains active until manually reset by the operator after fault clearance and, where applicable, completion of maintenance or safety inspection
A	Alarm Only	An operator alarm without automatic shutdown or trip action; the process may continue to operate within safe limits

16.4. CAUSE & EFFECT MATRIX – MAIN PROCESS & SAFETY

16.4.1 Explosion & Fire Related Events

Cause	Feed Stop	Steam Valve Close	Fan Stop	Fan Continue (Purge)	Alarm	Trip
Burst Sensor – Dryer Duct	✓	✓	—	✓	✓	L
Burst Sensor – Cyclone Body	✓	✓	—	✓	✓	L
Burst Sensor – Exhaust Duct	✓	✓	—	✓	✓	L
Fire Detection (If Any)	✓	✓	✓	—	✓	L

Notes:

- Fan continues only if mechanical integrity is confirmed.
- Restart requires inspection and manual reset.

16.4.2 Air System & Fan Protection

Cause	Feed Stop	Steam Close	Fan Trip	Alarm	Trip
Fan Bearing High Temperature	✓	✓	✓	✓	L
Fan High Vibration	✓	✓	✓	✓	L
Fan Overspeed	✓	✓	✓	✓	L
Fan Motor Trip	✓	✓	✓	✓	L
Low Air Velocity in Duct	✓	✓	—	✓	A

16.4.3 Heater & Temperature Protection

Cause	Feed Stop	Steam Close	Fan Stop	Alarm	Trip
High Inlet Air Temperature	✓	✓	—	✓	L
High Exhaust Air Temperature	✓	✓	—	✓	L
Steam Supply Failure	✓	✓	—	✓	A
Condensate Backup High Level	✓	✓	—	✓	L

16.4.4 Feed System Abnormal Conditions

Cause	Feed Stop	Steam Close	Fan Stop	Alarm	Trip
Feeder Motor Trip	✓	—	—	✓	A
Feed Blockage	✓	—	—	✓	A
Loss of Airlock Rotation	✓	—	—	✓	L

16.4.5 Cyclone & Solids Discharge

Cause	Feed Stop	Steam Close	Fan Stop	Alarm	Trip
Cyclone High Differential Pressure	✓	—	—	✓	A
Rotary Valve Failure	✓	—	—	✓	L
Solids Backup High Level	✓	—	—	✓	L

16.4.6 Instrument & Control System Failures

Cause	Control Mode Change	Feed Stop	Alarm
Online Moisture Analyzer Failure	Temp Control Only	—	✓
Exhaust Temp Sensor Failure	Safe Steam Close	✓	✓
PLC / DCS CPU Fault	All Outputs Safe	✓	✓

17. INTERLOCK AND TRIP LOGIC (PSEUDO CODE)

17.1 Heater Enable Interlock

```
IF Fan Running = TRUE
AND Airflow_OK = TRUE
AND No_Active_Trips = TRUE
THEN
  Heater_Enable = TRUE
ELSE
  Heater_Enable = FALSE
END_IF
```

17.2 Feed Enable Interlock

```
IF Fan_Running = TRUE
AND Heater_Enabled = TRUE
AND Exhaust_Temp_Stable = TRUE
AND Explosion_OK = TRUE
THEN
  Feed_Enable = TRUE
ELSE
  Feed_Enable = FALSE
END_IF
```

17.3 Explosion Trip Logic

```
IF Burst_Sensor_Activated = TRUE
THEN
```

```
  Steam_Valve = CLOSE
  Feed_Enable = FALSE
  Explosion_Trip = TRUE
  Alarm_Latched = TRUE
END_IF
```

17.4 Fan Protection Logic

```
IF Bearing_Temp_High OR Vibration_High OR Overspeed
THEN
  Fan_Trip = TRUE
  Steam_Valve = CLOSE
  Feed_Enable = FALSE
END_IF
```

17.5 Moisture Analyzer Failure Logic

```
IF Moisture_Analyzer_Fault = TRUE
THEN
  Moisture_Control = DISABLED
  Exhaust_Temp_Control = ENABLED
  Alarm = TRUE
END_IF
```

18. ALARM, TRIP & OPERATOR ACTION PHILOSOPHY

18.1. PURPOSE OF THIS SECTION

This section defines the **alarm and trip philosophy** of the Flash Dryer system, including:

- Classification of alarms and trips

- Process rationale behind each protection
- Expected operator actions
- Clear distinction between alarms and shutdown events

The objective is to:

- Prevent unsafe operating conditions
- Protect equipment and product quality
- Avoid nuisance alarms
- Support efficient operator response

18.2. GENERAL ALARM PHILOSOPHY

18.2.1 Alarm Design Principles

- Alarms are generated only when **operator action is required**.
- Alarms are prioritized according to process risk.
- Alarms do **not automatically stop the plant**, unless escalated to a trip.
- Each alarm has:
  - Clear cause
  - Clear consequence
  - Defined operator response

18.2.2 Alarm Priority Classification

Priority	Description	Operator Response Time
High (H)	Immediate risk to safety or equipment	Immediate
Medium (M)	Risk to process stability or quality	Short term
Low (L)	Advisory or maintenance-related	When convenient

18.3. GENERAL TRIP PHILOSOPHY

- Trips result in **automatic shutdown actions**.
- Trips are **latched** and require manual reset.
- Trips override all operating modes.
- Explosion and fire-related trips have the **highest priority**.
- Trips always act in a **fail-safe manner**.

18.4. ALARM & TRIP CLASSIFICATION BY PROCESS AREA

18.4.1 Air System and Fan Protection

Alarms

Alarm	Priority	Process Meaning	Operator Action
Low Air Velocity	M	Risk of poor entrainment	Monitor, prepare for load reduction
Fan Bearing Temperature High	H	Mechanical degradation	Reduce load, prepare for shutdown
Fan Vibration High (Warning)	M	Early mechanical issue	Inform maintenance

Trips

Trip	Process Action
Fan Bearing Temperature High-High	Fan stop, steam close, feed stop
Fan Vibration High-High	Fan stop, steam close, feed stop
Fan Overspeed	Immediate fan trip

18.4.2 Heater and Thermal Protection

Alarms

Alarm	Priority	Meaning
Inlet Air Temperature High	H	Heater overload
Exhaust Air Temperature High	H	Product overheating risk
Condensate Level High	M	Heater efficiency loss

Trips

Trip	Process Action
Heater Overtemperature	Steam valve close
Condensate High-High	Steam valve close
Steam Supply Failure (Critical)	Controlled feed stop

18.4.3 Product Quality and Drying Performance

Alarms

Control Response (No Trip)

- Switch to exhaust temperature control
- Operator informed
- Production may continue at reduced performance

18.4.4 Feed System and Solids Handling

Alarms

Alarm	Priority	Meaning
Feed Blockage	M	Risk of unstable drying
Rotary Valve Speed Low	M	Solids backup risk
Cyclone Differential Pressure High	M	Fouling or overload

Trips

Trip	Process Action
Rotary Valve Failure	Feed stop
Solids High Level	Feed stop

18.4.5 Explosion and Fire Protection

Trips (Highest Priority)

Cause	Automatic Actions
Explosion / Burst Sensor Activation	Process steam close, feed stop, alarms latched
Fire Detection	Process steam close, feed stop, fan logic per design ,quench steam open if needed
Emergency Stop	Immediate ESD

Notes:

- Explosion-related trips are never bypassed.
- Restart requires mechanical inspection and management approval.

18.5. FIRST-OUT ALARM PHILOSOPHY

- The first detected trip or alarm is recorded as **First-Out**.
- Subsequent alarms are logged but do not mask the root cause.
- First-Out indication is clearly displayed to operators.

18.6. OPERATOR RESPONSE GUIDELINES

Alarm Response

Operators are expected to:

1. Identify alarm priority
2. Assess process trend
3. Take corrective action
4. Escalate to shut down if alarm persists

Trip Response

Operators must:

1. Acknowledge trip
2. Secure the system
3. Inform maintenance and supervision
4. Perform inspection
5. Reset only after clearance

18.7. ALARM RATIONALISATION PHILOSOPHY

- Each alarm is justified by a process risk.
- Duplicate alarms are avoided.
- Alarm limits are aligned with:
    - Equipment design limits
    - Product quality constraints
    - Safety margins

18.8. INTERFACE WITH FAT / SAT

During FAT and SAT:

- All alarms are tested for correct priority and message
- Trips are verified for correct actions
- Operator displays are validated for clarity

19. DETAILED CONTROL PHILOSEPHY

19.1. PRIMARY CONTROL LOOPS

19.1.1. MAIN MOISTURE CONTROL LOOP (Cascade Control)

Primary Loop - Moisture Control:

- **Sensor:** MT-101 (Moisture Transmitter, 0-50% range)
- **Controller:** MIC-101 (Moisture Indicating Controller)
- **Setpoint:** 12% moisture (adjustable based on product specification)
- **Output:** Setpoint to secondary temperature loop

Secondary Loop - Temperature Control:

- **Sensor:** TT-103 (Temperature Transmitter at Fan Inlet, 0-200°C)
- **Controller:** TIC-103 (Temperature Indicating Controller)
- **Setpoint:** Received from MIC-101 (typically 60-80°C)
- **Output:** 4-20mA to Steam Control Valve on Zone 3 Heater (TCV-101)

Control Algorithm:

```
IF MT-101 > Setpoint THEN
   Decrease TIC-103 Setpoint (reduce drying temperature)
ELSE IF MT-101 < Setpoint THEN
   Increase TIC-103 Setpoint (increase drying temperature)
ENDIF
```

19.1.2. FEED RATE CONTROL BASED ON MOISTURE

Control Logic: In normal operation, moisture control is performed by the **1.1. MAIN MOISTURE CONTROL LOOP (Cascade Control)**until the deviation from the setpoint becomes significant or sudden changes occur in the conditions of the input cake to the dryer; at that point, the control of the dryer is assigned to this loop **(1.2. FEED RATE CONTROL BASED ON MOISTURE)** until conditions stabilize.

- **Master:** MT-101 Moisture reading
- **Slave:** VFD-B6200 (Agitated Feed Vessel speed)
- **WT-B6200:** Weight measurement for feed rate calculation

Feed Rate Adjustment = f(MT-101, Product Throughput)

IF MT-101 > 15% THEN

  Reduce VFD-B6200 speed by 10%

ELSE IF MT-101 < 9% THEN

  Increase VFD-B6200 speed by 10%

ENDIF

19.1.3. SECONDARY TEMPERATURE CONTROL LOOP

After-Heater Temperature Control:

- **Sensor:** TT-101 (Temperature Transmitter in Dryer Duct, 0-200°C)
- **Controller:** TIC-101 (Temperature Controller)
- **Setpoint:** 170°C (adjustable)
- **Alarms:**
  - TAH-101: High Alarm at 180°C
  - TAL-101: Low Alarm at 150 ((variable based on capacity))
- **Output:** Trim adjustment to main steam valve **TCV/S101**

Safety Interlock:

IF TT-101 > 185°C THEN

  Close steam valve fully

Activate emergency stop sequence

ENDIF

19.1.4. SESSION TEMPERATURE CONTROL LOOP

- **Sensor:** TT-102 (Temperature Transmitter in heater inlet manifold , 0-200°C)
- **Controller:** TIC-102 (Temperature Controller)
- **Setpoint:** 15°C (adjustable)
- **Alarms:**
    - TAH-102: High Alarm at 15°C
    - TAL-101: Low Alarm at 0 °C
- **Output:** Trim adjustment to second steam control valve **TCV/S102**

Safety Interlock:

IF TT-102 > 20°C THEN

Close steam control valve **TCV/S102** fully

19.2. SAFETY INTERLOCKS & ESD SYSTEM

19.2.1. EXPLOSION PROTECTION SYSTEM

Sensors: XS-101 to XS-106 (Dryer Duct) + XS-F6506 to XS-F6511 (Cyclones) + XS-B6512 (Silo)

IF ANY explosion sensor activated THEN

IMMEDIATE:

1. Close all steam valves (FT-S101 related)

2. Stop ID fan (V6515)

3. Stop the starch cake feed system to the dryer, including screw conveyors M-1 to M-4 and the starch cake blower (H6204).

4. Activate quench steam suppression system

5. Isolate system from plant

6. Alarm to control room

ENDIF

19.2.2. HIGH TEMPERATURE PROTECTION

IF TT-101 > 180°C OR TT-102 > 185°C THEN

Close steam control valve

Reduce fan speed to 50%

Alarm: "HIGH TEMPERATURE - PROCESS INTERRUPTED"

ENDIF

19.2.3. PRESSURE SAFETY

IF PT-102 > 1.5 barg OR PT-103 < -0.5 barg THEN

Stop ID fan (V6515)

Open emergency vent

Activate suppression if needed and open steam quench valve HS/S-101 And HS/S-102 and Open steam control valve (**TCV/S103** &**TCV/S104) and gradually** Ramp to 100%

Alarm: "PRESSURE DEVIATION - SYSTEM STOPPED"

ENDIF

19.2.4. DOOR SAFETY INTERLOCKS

Sensors: GS-101 to GS-106 (Heater & Duct doors) + GS-B6200 to GS-H6512, GS-H6513 (Equipment access)

IF ANY door open during operation, THEN

Stop relevant equipment section

Prevent restart until door closed

Local indication + Control room alarm

ENDIF

19.3. SEQUENCE CONTROL

19.3.1. STARTUP SEQUENCE (MANUALY)

PHASE 1: PRE-START CHECKS

- All doors closed (GS-xxx verification)
- No active alarms

- Utilities available (steam, power, air)
- Safety systems armed

PHASE 2: COLD START

1. Start exhaust fan V6515 at 20% speed
2. Open steam valve gradually to reach TT-A102 = 50°C
3. Start feed system (B6200 → H6203 → H6204)
4. Ramp up fan speed to 50%
5. Increase temperature to setpoint (TT-102 = 170°C)

PHASE 3: NORMAL OPERATION

- Engage moisture control loop (MT-101 → TIC-103)
- Monitor all parameters
- Ramp to 100% capacity

19.3.2. NORMAL SHUTDOWN SEQUENCE (MANUALY)

STEP 1: Feed system stop

- Stop B6200 (Agitated feed vessel) after WT-B6200 tend to Zero
- Stop H6203 (feeder) +Delay Time (calculated in commissioning)
- Stop H6204 (wet blower) +Delay Time (calculated in commissioning)

STEP 2: Drying system cooldown

- Reduce steam valve to 10%
- Maintain fan at 30% for 10 minutes
- When TT-103 < 50°C, stop fan

STEP 3: Complete shutdown

- Close steam valve

- Isolate system
- Purge if necessary

19.3.3. EMERGENCY SHUTDOWN SEQUENCE

TRIGGERS:

- ESD button pressed
- Explosion detected (XS-xxx)
- Fire alarm
- Power failure
- Critical parameter deviation

ACTIONS:

IMMEDIATE (0-2 seconds):

1. Close all steam valves
2. Stop all rotating equipment
3. Activate suppression if needed

FOLLOW-UP (2-30 seconds):

4. Purge system with inert gas
5. Isolate from plant
6. Full system alarm

19.3.4. OPERATIONAL MODES

AUTO MODE:

- All control loops active
- All interlock activity

MANUAL MODE:

- Operator control of individual devices

- Override capability
- For maintenance/troubleshooting
- startup/shutdown

19.4. MONITORING & DATA ACQUISITION

19.4.1. CRITICAL PARAMETERS MONITORING

TEMPERATURES (All TT-xxx):

- TT-S101: Steam header (0-220°C)
- TT-101: Dryer inlet (0-200°C)
- TT-102: Dryer process (0-200°C)
- TT-103: Fan inlet (0-200°C)
- TT-C101-C104: Condensate temperatures

PRESSURES (All PT-xxx & PG-xxx):

- PT-S101: Steam pressure (0-16 barg)
- PT-102/103: Process pressures (0-2 barg)
- Trend analysis for filter clogging detection

FLOW:

- FT-S101: Steam flow (0-xxx kg/hr)
- FT-C101: Condensate flow

MOISTURE:

- MT-101: Product moisture (0-50%)

19.4.2. EQUIPMENT STATUS MONITORING

MOTOR STATUS:

- V6515: Fan status, speed, vibration (VT-V6515)

- Temperature monitoring: TT-V6515A/B (motor), TT-V6515C/D (bearings)

ROTATING EQUIPMENT:

- Speed sensors ST-M1 to ST-M7
- Vibration monitoring for predictive maintenance

LEVEL MONITORING:

- LSH-B6506 to LSH-B6512: Hopper/silo high level
- LSL-B6512: Silo low level
- LT-B6515: Condensate tank level

19.4.3. ALARM MANAGEMENT

Priority 1 (Critical - Red):

- Explosion sensor activation
- Temperature > 185°C
- Motor failure
- Safety system fault

Priority 2 (High - Orange):

- Temperature deviation > 10°C
- Pressure deviation > 20%
- Moisture out of spec
- Level alarms

Priority 3 (Medium - Yellow):

- Equipment warning
- Maintenance due
- Efficiency drop

19.5. ADDITIONAL CONTROL STRATEGIES

19.5.1. ENERGY OPTIMIZATION

text

IF Condensate temperature (TT-C104) < 85°C THEN

  Adjust steam trap operation

  Optimize heat recovery

ENDIF

Fan speed optimization based on:

- Pressure drop across system (PT-102 to PT-103)
- Product moisture content
- Energy consumption

19.5.2. PRODUCT QUALITY ASSURANCE

Continuous monitoring:

- Moisture consistency (MT-101 trend)
- Temperature profile (TT-101, TT-102, TT-103)
- Residence time calculation
- Product throughput rate

19.5.3. PREVENTIVE MAINTENANCE TRIGGERS

text

Vibration monitoring (VT-V6515):

  IF > 4.5 mm/s THEN Warning

  IF > 7.0 mm/s THEN Alarm + Schedule maintenance

Bearing temperature (TT-V6515C/D):

  IF > 85°C THEN Investigate

IF > 95°C THEN Schedule maintenance

19.6. CONTROL SYSTEM ARCHITECTURE

19.6.1. HARDWARE CONFIGURATION

PLC System:

- Distributed I/O stations
- Safety PLC for ESD functions

Field Devices:

- 4-20mA analog signals (majority)
- Digital inputs for status/interlocks

Human-Machine Interface:

- Engineering workstation
- Mobile access for maintenance

19.6.2. COMMUNICATION PROTOCOLS

- MODBUS TCP/IP for PLC to DCS(Optional)
- OPC UA for data historian
- Wireless for mobile devices (Optional)

19.7. IMPLEMENTATION PRIORITY

PHASE 1 (Immediate - Safety):

1. ESD system implementation
2. Temperature safety interlocks
3. Door safety interlocks

PHASE 2 (Short-term - Basic Control):

1. Moisture-temperature cascade control
2. Basic sequence control

3. Critical parameter monitoring

PHASE 3 (Medium-term - Optimization):

1. Advanced control algorithms
2. Energy optimization
3. Predictive maintenance

PHASE 4 (Long-term - Integration):

1. Full plant integration
2. Advanced analytics
3. Remote monitoring

19.8. KEY PERFORMANCE INDICATORS

1. Product Moisture Consistency: ±0.5%

2. Energy Consumption: ≤0.608 ton steam/ton product

3. System Availability: >98%

4. Safety Incident Rate: 0

5. Maintenance Cost: <2% of CAPEX annually

This comprehensive control strategy ensures safe, efficient, and reliable operation of your modified starch drying system while meeting all your specified requirements and incorporating industry best practices.