**Cement Factory Process Control & Dashboard Documentation (Extended Version)**

**1. Roles in the Organization**

**1.1 Operator**

* **Primary Responsibility:** Real-time monitoring of process parameters, equipment status, and alarms.
* **Access Rights:**
  + View dashboards, trends, alarms, and basic analytics.
  + Acknowledge alarms but cannot modify critical setpoints.
  + Report abnormal readings to Supervisors.
* **Restrictions:**
  + No access to parameter editing, system calibration, or emergency controls.

**1.2 Supervisor**

* **Primary Responsibility:** Approve and execute low-risk operational adjustments to maintain process stability.
* **Access Rights:**
  + Modify operational setpoints (within predefined safety limits).
  + Approve minor adjustments suggested by AI (e.g., blending ratios, mill speed, fan airflow).
  + Authorize planned stoppage or restart of non-critical equipment.
* **Restrictions:**
  + Cannot override safety interlocks or critical process shutdowns without Manager approval.

**1.3 Engineer / Maintenance Specialist**

* **Primary Responsibility:** Equipment health, diagnostics, and calibration.
* **Access Rights:**
  + Perform vibration analysis, bearing temperature checks, gearbox diagnostics.
  + Run maintenance overrides (e.g., feeder calibration, gearbox tuning).
  + Approve start-up after maintenance and report post-maintenance health status.
* **Restrictions:**
  + Cannot approve production parameter changes or AI-driven process optimization.

**1.4 Quality Analyst**

* **Primary Responsibility:** Laboratory analysis, material quality testing, and compliance assurance.
* **Access Rights:**
  + Access lab dashboards for XRF, XRD, fineness, and strength tests.
  + Initiate retesting and validate lab equipment readings.
  + Generate compliance reports for Managers.
* **Restrictions:**
  + Cannot modify production process parameters directly.

**1.5 Energy & Environment Officer**

* **Primary Responsibility:** Monitoring and controlling emissions, energy consumption, and sustainability measures.
* **Access Rights:**
  + View and approve corrective actions for NOx, SO₂, CO₂ deviations.
  + Authorize adjustments in fuel mix and cooling water usage for compliance.
  + Generate energy optimization and environmental compliance reports.
* **Restrictions:**
  + Cannot modify core production parameters unrelated to energy or emissions.

**1.6 Manager / Plant Head**

* **Primary Responsibility:** Oversight of all operations with approval rights for high-risk changes.
* **Access Rights:**
  + Approve emergency shutdown/start of critical units (kiln, burners, fans).
  + Authorize major AI-driven process changes.
  + Review and sign off on compliance reports and audit logs.
* **Restrictions:**
  + Cannot bypass system safety interlocks.

**1.7 Administrator (IT/SCADA)**

* **Primary Responsibility:** System security, RBAC enforcement, and audit management.
* **Access Rights:**
  + Manage user roles, permissions, and login policies.
  + Configure dashboards and ensure cyber-physical security (PLC/SCADA).
  + Maintain audit logs of every parameter change, alarm acknowledgment, and system override.
* **Restrictions:**
  + Cannot modify process parameters or intervene in production.

**2. Step-wise Control & Dashboard Operations**

**Step 1: Raw Material Extraction (Mining Center)**

* **Dashboard Components:**
  + Conveyor belt speedometer, tonnage graph, vibration health chart.
  + Hopper load gauge, moisture content indicator, equipment status panel.
* **Operations:**
  + Start/Stop conveyors (Supervisor+).
  + Hopper weight calibration (Engineer+).
  + Moisture threshold adjustment (Supervisor+).
* **Risk Levels:**
  + Low Risk: Adjust conveyor speed ±5%.
  + High Risk: Full conveyor shutdown/startup (Manager approval).

**Step 2–4: Crushing, Grinding & Homogenization**

* **Dashboard Components:**
  + Crusher motor current trends, mill power charts, separator performance index.
  + Blending silo level (radar/ultrasonic) and AI-optimized blend ratios.
* **Operations:**
  + Adjust feed rate and mill speed (Supervisor+).
  + Perform vibration diagnostics and separator calibration (Engineer+).
* **Risk Levels:**
  + Low Risk: Adjust blend ratio ±2% via AI.
  + High Risk: Emergency crusher stop (Manager approval).

**Step 5–7: Preheater, Kiln & Clinker Cooling (Pyroprocessing)**

* **Dashboard Components:**
  + IR-based kiln shell heatmap, fuel flow meters, O₂/CO₂/NOx gas analyzer.
  + Draft pressure gauges, fan vibration health panel.
* **Operations:**
  + Adjust kiln rotation speed and burner temperature (Supervisor+).
  + Perform fan diagnostics and shell scan validation (Engineer+).
* **Risk Levels:**
  + Low Risk: Temperature adjustment ±10°C.
  + High Risk: Kiln shutdown/start or fuel mix change (Manager approval).

**Step 8–10: Clinker Storage & Cement Grinding**

* **Dashboard Components:**
  + Silo stock levels, grinding mill vibration trends, particle size analyzer.
* **Operations:**
  + Adjust grinding load (Supervisor+).
  + Perform gearbox and separator calibration (Engineer+).
* **Risk Levels:**
  + Low Risk: Adjust mill feed rate ±5%.
  + High Risk: Mill shutdown/restart (Manager approval).

**Step 11: Packing & Dispatch**

* **Dashboard Components:**
  + Bag weight accuracy chart, packaging machine vibration monitor, RFID/Barcode logs.
* **Operations:**
  + Adjust packer speed (Supervisor+).
  + Calibrate load cells (Engineer+).
* **Risk Levels:**
  + Low Risk: Adjust packer speed ±2%.
  + High Risk: Stop/start of full dispatch line (Manager approval).

**Step 12: Quality Control**

* **Dashboard Components:**
  + Chemical composition analyzer (XRF/XRD), fineness graph, compressive strength data.
* **Operations:**
  + Initiate retesting (Quality Analyst+).
  + Update mix design recommendations (Manager+).
* **Risk Levels:**
  + Low Risk: Re-test specific batches.
  + High Risk: Adjust raw mix design for entire production.

**Step 13: Energy & Emission Monitoring**

* **Dashboard Components:**
  + CO₂, NOx, SO₂ levels with compliance thresholds.
  + Power consumption per ton of clinker.
* **Operations:**
  + Initiate emission control measures (Environment Officer+).
  + Approve long-term energy optimization strategies (Manager+).

**Step 14: Central Command & AI Insight**

* **Dashboard Components:**
  + AI-driven anomaly detection, efficiency scoring, predictive maintenance alerts.
* **Operations:**
  + Accept/reject AI suggestions (Supervisor+).
  + Execute AI-driven setpoint adjustments (Manager+).
* **Risk Levels:**
  + Low Risk: AI-assisted tuning of non-critical parameters.
  + High Risk: AI control of pyroprocessing units.

**3. Authorization Matrix**

|  |  |  |  |
| --- | --- | --- | --- |
| **Dashboard** | **View Access** | **Perform (Low Risk)** | **Perform (High Risk)** |
| Mining Center | Operator+ | Supervisor+ | Manager |
| Crushing & Grinding | Operator+ | Supervisor+ | Manager |
| Pyroprocessing & Kiln | Operator+ | Supervisor+ | Manager |
| Storage & Grinding | Operator+ | Supervisor+ | Manager |
| Packing & Dispatch | Operator+ | Supervisor+ | Manager |
| Quality Control | Analyst+ | Supervisor+ | Manager |
| Energy & Emission | Operator+ | Env. Officer+ | Manager |
| AI Command | Operator+ | Supervisor+ | Manager |

**4. Security Measures**

* **MFA + SSO** – Integration with Azure AD or Okta for secure authentication.
* **Digital Signatures** – Enforced for all critical changes (kiln temperature, fuel mix, emissions control).
* **Audit Trail** – Immutable log of all process parameter changes, alarms, and approvals.
* **Safety Interlocks** – Prevent unsafe operations, even with high-level authorization.
* **AI Decision Approval Workflow** – Supervisor reviews, Manager authorizes.

**5. Additional Considerations**

* **Fail-Safe Mode:** If RBAC service fails, system defaults to "View Only" mode.
* **Role Escalation Protocol:** Emergency override requires two-factor confirmation (Manager + Administrator).
* **Training Mode:** Simulated dashboards for training Operators and Supervisors without affecting real plant data.