TECPROMIN S. A.
TECNOLOGÍA EN PROCESAMIENTO DE MINERALES S.A.

PROJECT N° 8845-17

B2SG-4-0812-01

BHP FLUORSALFA

SGO WP2 CONCENTRATOR PROJECT

MILK OF LIME PLANT PACKAGE

SYSTEM FUNCTIONAL DESCRIPTION (CONTROL PHILOSOPHY)

4-V2-2270-IC-IPC-136001

4-0812-00061

(8845-17-ING-01-DOC-EL-01)

BHP
SGO WP2 CONCENTRATOR PROJECT
O/C: B2SG-4-0812-01
CERTIFIED DOCUMENT
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1.- INTRODUCTION

This document defines the control philosophy for the project "SGO WP2 CONCENTRATOR PROJECT MILK OF LIME PREPARATION PLANT – CAPACITY 16 tph".

In addition, this document was prepared using the following documents as a reference.

P & ID DIAGRAM	8845-17-ING-01-IN-01-01_D	4-V2-2270-PR-PID-136001-01
	8845-17-ING-01-IN-01-02_D	4-V2-2270-PR-PID-136001-02
	8845-17-ING-01-IN-01-03_D	4-V2-2270-PR-PID-136001-03
ELECTRIC SINGLE LINE DIAGRAM	8845-17-ING-01-PL-EL-01-01_D	4-V2-2270-EL-ESS-136001-01
	8845-17-ING-01-PL-EL-01-02_D	4-V2-2270-EL-ESS-136001-02
PROCESS FLOW DIAGRAM	8845-17-ING-01-DF-01_D	4-V2-2270-PR-PFD-136001
INSTRUMENT LIST	8847-17-ING-01-DOC-EL-04_D	4-V2-2270-IC-LOE-136001
INSTRUMENT INDEX	8845-17-ING-01-DOC-EL-04-01_C	4-V2-2270-IC-LOE-136002
INSTRUMENT DATA SHEETS	8845-17-ING-01-DOC-EL-04-03-01…18_C	4-V2-2270-IC-DAS-136004
ELECTRICAL LOAD LIST	8845-17-ING-01-DOC-EL-05_C	4-V2-2270-EL-LST-136002

The criteria adopted for the definition of the control system and the implementation of the Project, are based on technical documentation provided by Fluor-Salfa, these concepts are followed by current practices in plants with similar characteristics, in the experience of our engineers and the structure of the control system of the plant supplied.

2.- PLANT CONTROL SYSTEM

The control system for the milk of lime preparation plant will be controlled directly from DCS. This will control and visualize the motor states by PROFIBUS DP comunication protocol.

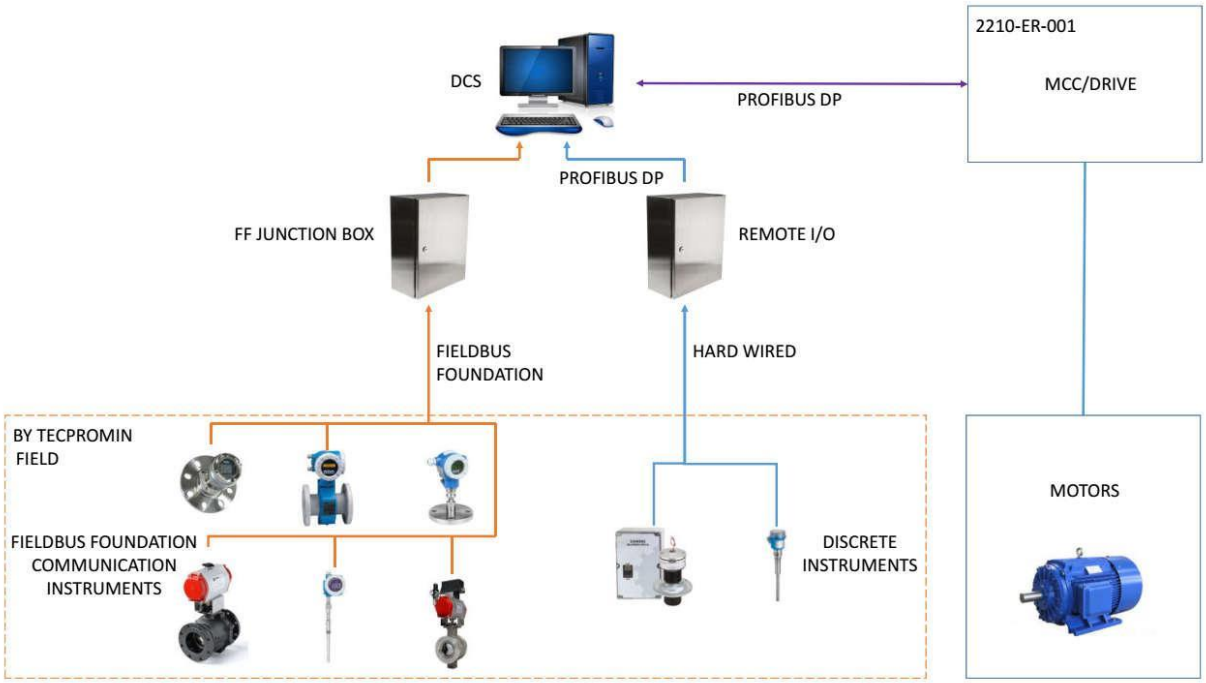
For the instrumentation there are two scenarios, the analog instrumentation will be controlled and monitored through the FIELDBUS FOUNDATION comunication protocol and for the instruments with discrete type signals, these will be controlled through hard wiring, in signals of 120 VAC conected to a Remote I/O.

In case of failure of the communications, the plant will not be able to continue operating, since constant monitoring of the signals and conditions associated with the process is required.

Located in field there will be two types panels (by others) that will concéntrate both analogue and discrete signals of the instrumentation, in order to interconnect these signals with the DCS, therefore, there will be FF junction boxes (by others) for the instruments with FIELDBUS FOUNDATION communication protocol and will be Remote IO Panel (by others) for instruments with digital inputs at 120 VAC.

For the operation of direct starting motors and adjustable frecuency drives (AFD), drives with PROFIBUS DP communication will be used. Each motor has a local station for maintenance purposes, which has a JOG button and E-stop.

2.1.- Plant control architecture:



3.- OPERATION MODES OF THE PLANT.

3.1.- Maintenance mode:

This operating mode can only be enabled, exclusively from DCS

The operation in manual operation will be used as a way to mantain equipment.

To Access to the maintenance mode the proccess must be stopped, if requires to return to automatic mode must be met security coditions and the plant must be stopped.

If “maintenance mode” operation is selected from DCS`s selector (2270-HS-11810), the start and stop commands of each motor are made through the locally located keypads. This operation is considered only for maintenance purposes without responding to sequences of interlocks or start / stop restrictions, except security interlock.

This operating mode must be indicated prominently in the DCS.

3.1. Automatic operation mode:

This operation mode will allow the operation of the elctrical equipment associated with the process according to the coditions and restrictions of operation and safety defined

If the automatic operation mode is required, depending on whether the safety conditions and interlocks are met, the process will star automatically.

Automatic operation mode will be the default mode of operation.
This operating mode must be indicated prominently in the DCS.

4.- ALARMS DESCRIPTION.

4.1.- Alarms maintenance mode:

The following table shows the stoppage by condition of emergency stops of the equipment involved.

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
E-STOP MAINTENANCE HOIST	2270-ZM-009-25A/B-HS-ES	EMERGENCY STOP	FAULT	CAUSE THE DETENTION OF THE INVOLVERD EQUIPMENT, DISPLAY ALARM IN DCS.
E-STOP LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14A-HS-ES			
E-STOP LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14B-HS-ES			
E-STOP LIME SLAKER SCREW FEEDER	2270-ZM-009-04A-HS-ES			
E-STOP LIME SEPARATING CHAMBER AGITATOR 1	2270-ZM-009-31A-HS-ES			
E-STOP LIME SEPARATING CHAMBER AGITATOR 2	2270-ZM-009-32A-HS-ES			
E-STOP LUBRICATION SYSTEM	2270-ZM-009-34A-HS-ES			
E-STOP LIME SCRUBBER EXHAUST FAN	2270-ZM-009-20A-HS-ES			
E-STOP LIME SCRUBBER EXHAUST FAN	2270-ZM-009-29A-HS-ES			
E-STOP LIME SLAKER DISCHANGE PUMPBOX AGITATOR	2270-ZM-009-23A-HS-ES			
E-STOP JIB CRANE	2270-ZM-009-33A-HS-ES			
E-STOP LIME UNLOADING COMPRESSOR	2270-ZM-009-02A-HS-ES			
E-STOP TOWER MILL	2270-ZM-009-06A-HS-ES			
E-STOP LIME RECYCLE PUMP	2270-ZM-009-08A-HS-ES			
E-STOP LIME RECYCLE PUMP	2270-ZM-009-09A-HS-ES			
E-STOP LIME SILO ROTARY VALVE	2270-ZM-009-21A-HS-ES			
E-STOP LIME TRANSFER PUMP	2270-ZM-009-12A-HS-ES			
E-STOP LIME TRANSFER PUMP	2270-ZM-009-13A-HS-ES			

NOTE: FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.

The following table shows the alarms for the stop condition due to overload or loss of the operating status of the equipment involved.

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
MAINTENANCE HOIST	2270-ZM-009-25A/B-OL	OVERLOAD; LOSS OF THE RUNNING STATUS	FAULT	CAUSE THE DETENTION OF THE INVOLVERD EQUIPMENT, DISPLAY ALARM IN DCS.
LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14A-OL			
LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14B-OL			
LIME SLAKER SCREW FEEDER	2270-ZM-009-04A-OL			
LIME SEPARATING CHAMBER AGITATOR 1	2270-ZM-009-31A-OL			
LIME SEPARATING CHAMBER AGITATOR 2	2270-ZM-009-32A-OL			
LUBRICATION SYSTEM	2270-ZM-009-34A-OL			
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-20A-OL			
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-29A-OL			
LIME SLAKER DISCHANGE PUMPBOX AGITATOR	2270-ZM-009-23A-OL			
JIB CRANE	2270-ZM-009-33A-OL			
LIME UNLOADING COMPRESSOR	2270-ZM-009-02A-OL			
TOWER MILL	2270-ZM-009-06A-OL			
LIME RECYCLE PUMP	2270-ZM-009-08A-OL			
LIME RECYCLE PUMP	2270-ZM-009-09A-OL			
LIME SILO ROTARY VALVE	2270-ZM-009-21A-OL			
LIME TRANSFER PUMP	2270-ZM-009-12A-OL			
LIME TRANSFER PUMP	2270-ZM-009-13A-OL			

NOTE: FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.

4.2.- Alarms automatic mode:

The following table shows the stoppage by condition of emergency stops of the equipment involved.

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
E-STOP LIME SILO BOTTOM BIN ACTIVATOR MOTOR	2270-ZM-009-14A-HS-ES	EMERGENCY STOP	FAULT	CAUSE THE DETENTION OF THE INVOLVERD EQUIPMENT, DISPLAY ALARM IN DCS.
E-STOP LIME SILO BOTTOM BIN ACTIVATOR MOTOR	2270-ZM-009-14B-HS-ES			
E-STOP LIME SILO ROTARY VALVE MOTOR	2270-ZM-009-21A-HS-ES			
E-STOP LIME SLAKER SCREW FEEDER MOTOR	2270-ZM-009-04A-HS-ES			
E-STOP TOWER MILL	2270-ZM-009-06A-HS-ES			
E-STOP MILL LUBRICATION SYSTEM MOTOR	2270-ZM-009-34PP1A-HS-ES			
E-STOP AIRCOOLER MILL LUBRICATION SYSTEM	2270-ZM-009-35A-HS-ES			
E-STOP LIME RECYCLE PUMP MOTOR	2270-ZM-009-08A-HS-ES			
E-STOP LIME RECYCLE PUMP MOTOR	2270-ZM-009-09A-HS-ES			
E-STOP LIME SEPARATING CHAMBER AGITATOR 1	2270-ZM-009-31A-HS-ES			
E-STOP LIME SEPARATING CHAMBER AGITATOR 2	2270-ZM-009-32A-HS-ES			
E-STOP LIME TRANSFER PUMP MOTOR	2270-ZM-009-12A-HS-ES			
E-STOP LIME TRANSFER PUMP MOTOR	2270-ZM-009-13A-HS-ES			
E-STOP LIME SLAKER DISCHANGE PUMPBOX AGITATOR MOTOR	2270-ZM-009-23A-HS-ES			
E-STOP LIME SCRUBBER EXHAUST FAN MOTOR	2270-ZM-009-20A-HS-ES			
E-STOP LIME SCRUBBER EXHAUST FAN MOTOR	2270-ZM-009-29A-HS-ES			

NOTE: FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.

The following table shows the alarms for the stop condition due to overload or loss of the operating status of the equipment involved.

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
MAINTENANCE HOIST	2270-ZM-009-25A/B-OL	OVERLOAD; LOSS OF THE RUNNING STATUS	FAULT	CAUSE THE DETENTION OF THE INVOLVERD EQUIPMENT, DISPLAY ALARM IN DCS.
LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14A-OL			
LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14B-OL			
LIME SLAKER SCREW FEEDER	2270-ZM-009-04A-OL			
LIME SEPARATING CHAMBER AGITATOR 1	2270-ZM-009-31A-OL			
LIME SEPARATING CHAMBER AGITATOR 2	2270-ZM-009-32A-OL			
LUBRICATION SYSTEM	2270-ZM-009-34A-OL			
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-20A-OL			
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-29A-OL			
LIME SLAKER DISCHANGE PUMPBOX AGITATOR	2270-ZM-009-23A-OL			
JIB CRANE	2270-ZM-009-33A-OL			
LIME UNLOADING COMPRESSOR	2270-ZM-009-02A-OL			
TOWER MILL	2270-ZM-009-06A-OL			
LIME RECYCLE PUMP	2270-ZM-009-08A-OL			
LIME RECYCLE PUMP	2270-ZM-009-09A-OL			
LIME SILO ROTARY VALVE	2270-ZM-009-21A-OL			
LIME TRANSFER PUMP	2270-ZM-009-12A-OL			
LIME TRANSFER PUMP	2270-ZM-009-13A-OL			

NOTE: FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.

The following table shows the alarms and stops of the equipments Lime silo (2270-ZM-009-01), Lime silo rotary valve (2270-ZM-009-21) and Lime slaker screw feeder (2270-ZM-009-04).

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SILO 2270-ZM-009-01	2270-LSHH-11826	2270-LAHH-11826 = 0	FAULT	WHEN LAHH-11826 = 0 THE SYSTEM SHOULD ALLOW LIME UNLOADING COMPRESSOR 2270-ZM-009-02 TO COMPLETE THE TRUCK UNLOADING, BLOCKING ONCE IT FINISHES OPERATING. DISPLAY ALARM IN DCS.
	2270-LSLL-11829	2270-LALL-11829 = 0	WARNING	DISPLAY ALARM IN DCS.
	2270-LIT-11825	2270-LAHH-11825 > 95%	FAULT	THE SYSTEM SHOULD ALLOW THE LIME UNLOADING COMPRESSOR 2270-ZM-009-02 TO END THE TRUCK DISCHARGE, BLOCKING ONCE IT FINISHES OPERATING. DISPLAY ALARM IN DCS.
		2270-LALL-11825 < 5%	WARNING	DISPLAY ALARM IN DCS.
LIME SILO ROTARY VALVE 2270-ZM-009-21	2270-SAL-11818	STATE = 0	WARNING	STOP LIME SILO ROTARY VALVE 2270-ZM-009-21. DISPLAY ALARM IN DCS.
LIME SLAKER SCREW FEEDER 2270-ZM-009-04	2270-SAL-11817	STATE = 0	WARNING	STOP LIME SLAKER SCREW FEEDER 2270-ZM-009-04. DISPLAY ALARM IN DCS.

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

IMPORTANT: IF THE ALARMS 2270-LALL-11829 AND 2270-LALL-11825 REMAIN DURING 8 HOURS FOLLOWED, THE SYSTEM WILL STOP AND CAN NOT OPERATE AGAIN UNTIL YOU ENSURE ITS CORRECT FUNCTIONING.

The following table shows the alarms and stops of the equipment Vortex pre-mixer (2270-ZM-009-30).

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
VORTEX PRE-MIXER 2270-ZM-009-30	2270-TIC-11801	2270-TAHH-11801 SP+10°C	FAULT	START STOP SEQUENCE. DISPLAY ALARM IN DCS.
		2270-TAH-11801 SP+5°C	FAULT	LIME SLAKER SCREW FEEDER 2270-ZM-009-04 STOP; IT KEEPS OPEN THE VALVE 2270-TV-11801; DISPLAY ALARM IN DCS.
		2270-TAL-11801 SP-5°C	WARNING	DISPLAY ALARM IN DCS.
	2270-PIT-11834	2270-PALL-11834 < 275,8 kPa	FAULT	START STOP SEQUENCE. DISPLAY ALARM IN DCS.
	2270-FIT-11801	FAL-11801 < 86.36 m3/h	FAULT	START STOP SEQUENCE. DISPLAY ALARM IN DCS.

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

The following table shows the alarms and stops of the equipments Lime separating chamber (2270-ZM-009-18) and Lime slaker pump box (2270-ZM-009-19).

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SEPARATING CHAMBER 2270-ZM-009-18	2270-LIT-11850	LALL-11850 < 5%	FAULT	CAN NOT OPERATE THE LIME SEPARATING CHAMBER AGITATOR 1/2 2270-ZM-009-31/32; LIME RECYCLE PUMP 2270-ZM-009-08/09; LIME TRANSFER PUMP 2270-ZM-009-12/13 DISPLAY ALARM IN DCS. IN CASE OF FAILURE OF THE LIME SEPARATING CHAMBER AGITATOR 1 & 2 2270-ZM-009-31/32, THE PROCESS MUST BE STOPPED IMMEDIATELY BECAUSE THEY CAN PRODUCE OBSTRUCTIONS IN THE DISCHARGE DUCTS IF THEY CONTINUE WITH THE WORK.
		LAL-11850 < 40%	FAULT	CAN NOT OPERATE THE LIME SEPARATING CHAMBER AGITATOR 1 & 2 2270-ZM-009-31/32 DISPLAY ALARM IN DCS.
		LAHH-11850 > 95%	FAULT	CLOSE VALVE 2270-TV-11801 CLOSE VALVE 2270-HV-11808 STOP LIME SLAKER SCREW FEEDER 2270-ZM-009-04; DISPLAY ALARM IN DCS.
LIME SLAKER DISCHARGE PUMP BOX 2270-ZM-009-19	2270-LIT-11845	LALL-11845 < 5%	FAULT	MILK OF LIME TANK FEED PUMP 2270-PP-208/209; DISPLAY ALARM IN DCS..
		LAL-11845 < 40%	FAULT	CAN NOT OPERATE THE LIME SLAKER DISCHARGE PUMPOX AGITATOR 2270-ZM-009-23. DISPLAY ALARM IN DCS..
		LAHH-11845 > 95%	FAULT	CAN NOT OPERATE THE LIME TRANSFER PUMP 2270-ZM-009-12/13; DISPLAY ALARM IN DCS.

NOTE: FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.

The following table shows the alarms and stops of the equipments Lime slaker (2270-ZM-009-06) and Lubrication system (2270-ZM-009-34).

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SLAKER 2270-ZM-009-06	2270-TT-11824A	TEMPERATURE BETWEEN 40°C AND 60°C	NORMAL OPERATION	-
		2270-TAH-11824A > 80°C	WARNING	DISPLAY ALARM IN DCS.
	2270-TT-11824B	TEMPERATURE < 65°C	NORMAL OPERATION	-
		2270-TAH-11824B > 80°C	WARNING	DISPLAY ALARM IN DCS.
		2270-TAH-11824B > 85°C	FAULT	START EMERGENCY STOP SEQUENCE OF LIME SLAKER 2270-ZM-009-06; DISPLAY ALARM IN DCS.
LUBRICATION SYSTEM 2270-ZM-009-34	2270-PIT-11892A	2270-PDIA-11892 = 70 kPa	WARNING	DISPLAY ALARM IN DCS.
	2270-PIT-11892B			
	2270-PIT-11895	PRESSURE 100 kPa	NORMAL OPERATION	-
		2270-PAL-11895 < 50 kPa	WARNING	DISPLAY ALARM IN DCS.
	2270-TIT-11893	TEMPERATURE < 65°C	NORMAL OPERATION	-
		2270-TAH-11893 > 80°C	WARNING	DISPLAY ALARM IN DCS..
		2270-TAHH-11893 > 85°C	FAULT	START EMERGENCY STOP SEQUENCE OF LIME SLAKER 2270-ZM-009-06; DISPLAY ALARM IN DCS.
	2270-TIT-118934	TEMPERATURE < 45°C	NORMAL OPERATION	-
		2270-TAH-11894 > 70°C	WARNING	DISPLAY ALARM IN DCS.
		2270-TAHH-11894 > 80°C	FAULT	START EMERGENCY STOP SEQUENCE OF LIME SLAKER 2270-ZM-009-06; DISPLAY ALARM IN DCS.
	2270-FSL-11896	FLOW 10 L/min	NORMAL OPERATION	-
		2270-FAL-11896 < 5L/min	WARNING	DISPLAY ALARM IN DCS.

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

5.- OPERATION OF THE PLANT.

5.1.- Automatic mode:

In this operation mode, the operator must check the general conditions of the plant before starting the process (opening of manual valves, visual inspection of the plant, etc.) and select in automatic mode. Once the selector has been positioned on the screen, it must be verified that the status of the plant indicates “Ready to Start”, if the conditions for the departure are not met, you must verify them. When the plant is ready to start preparing milk of lime, you must choose to start from DCS to begin the process.

To start automatically, the following conditions must be met.

- The operator must select automatic mode.
- The operator must apply all process setpoints.

DESIGNATION	VALUE	COMMENTS
SETPOINT NOMINAL TEMPERATURE	70° C +/-4° C	WORK TEMPERATURE
SETPOINT MASIC FLOW OF CAL PREPARED	16 tph	DESIGN FLOW
SETPOINT OF% SOLID DESIRED	15%	% DESIGN OF DESIRED SOLIDS
SETPOINT MINIMUM OPERATING PRESSURE	275,8 kPa	MINIMUM WORK PRESSURE
SETPOINT AGITATOR OPERATION 2270-ZM-009-31A	> 40%	LEVEL LIME SEPARATING CHAMBER 2270-ZM-009-18
SETPOINT AGITATOR OPERATION 2270-ZM-009-32A	> 40%	LEVEL LIME SEPARATING CHAMBER 2270-ZM-009-18
SETPOINT AGITATOR OPERATION 2270-ZM-009-23A	> 40%	LEVEL LIME SLAKER DISCHARGE 2270-ZM-009-19

The operator is responsible for verifying that the conditions are optimal to start the starting sequence.

Before starting the starting sequence, the operator should verify the following:

- Verify that the manual ball valves on the water line are open to the flowmeter (2270-FIT-11801), in the control valve for slaking water (2270-TV-11801), emergency water (HV-11808), and to the entrance of the sprinklers of the Vortex pre-mixer (2270-ZM-009-30).
- Verify that the levels of the Lime slaker dischage pump box (2270-ZM-009-19) and storage tank (2270-PP-208/209) (by others) have the capacity to receive lime. (> 70%).
- Check the opening or open the silo gate valve manually actuated (2270-ZM-009-36). This gate valve manually actuated must remain open throughout the process. It should only be closed for maintenance purposes.
- Check with the control room operator the status of the equipment for automatic start-up.

Before starting the preparation of milk of lime, through the automatic start sequence, the following conditions must be taken into account.

- The storage tank (2270-PP-208/209) (by others) should't check high level before starting the process.
- The Lime slaker discharge pumpbox (2270-ZM-009-19) must not mark less than 40% of its capacity before starting. If in the Lime slaker discharge pumpbox (2270-ZM-009-19) this condition of minimum level of filling is not met, the system will open the control valves (2270-TV-11801 and 2270-HV-11808) fully to reach that level.
- No equipment should mark a fault in the control system

- The pressure transmitter (2270-PIT-11834) should not signal the low pressure alarm lower than that set on DCS, (275.8 kPa) of the fresh water line.
- The Lime separating chamber agitators 1 & 2 (2270-ZM-009-31 / 32) belonging to the Lime separating chamber (2270-ZM-009-18), must start with a level equal to or greater than 40% the capacity of the tank, under no circumstances should they operate under 40% of the capacity of the tank since this can bring mechanical problems in the shafts of these agitators.

The preparation milk of lime plant will not initiate the preparation sequence if some of the aforementioned conditions are present.

When all the aforementioned conditions are met, the control system will allow the automatic start of the system. Before starting the automatic mode, the process setpoint must be entered.

DESIGNATION	VALUE	COMMENTS
SETPOINT NOMINAL TEMPERATURE	70° C +/-4° C	WORK TEMPERATURE
SETPOINT MASIC FLOW OF CAL PREPARED	16 tph	DESIGN FLOW
SETPOINT OF% SOLID DESIRED	15%	% DESIGN OF DESIRED SOLIDS
SETPOINT MINIMUM OPERATING PRESSURE	275,8 kPa	MINIMUM WORK PRESSURE
SETPOINT AGITATOR OPERATION 2270-ZM-009-31A	> 40%	LEVEL LIME SEPARATING CHAMBER 2270-ZM-009-18
SETPOINT AGITATOR OPERATION 2270-ZM-009-32A	> 40%	LEVEL LIME SEPARATING CHAMBER 2270-ZM-009-18
SETPOINT AGITATOR OPERATION 2270-ZM-009-23A	> 40%	LEVEL LIME SLAKER DISCHARGE 2270-ZM-009-19

Once the Setpoint values have been entered, it is possible to start the automatic mode through the automatic start button (2270-HS-11812).

The steps followed by control system to start the preparation of milk of lime are as follows.

1. Enter in the system the quantity of quicklime to be processed (*desing 16 tph*) and the % of the desired solid (*desing 15%*) described in the previous Setpoint table.

2. The slaking water cycle starts. The control valve (2270-TV-11801) is opened in a relation of 1:3 (CaO/H_2O) to the lime setpoint to feed and starts the following equipment:
   - Lime slaker dischange pumpbox agitator (2270-ZM-009-23A)
   - Transfer pump to storage tank (2270-PP-208/209 BY OTHERS)
   - Lime separating chamber agitators 1 & 2 (2270-ZM-009-31A/32A)
   - Lime scrubber exhaust fan (2270-ZM-009-20/29)
   - Opening of solenoid valves (2270-ZM-009-11801/80)
   - Lime slaker (2270-ZM-009-06)
   - Mill lubrication system for lime slaker (2270-ZM-009-34)

3. After 5 minutes or reached the desired level in the Lime slaker discharge pumpbox (2270-ZM-009-19) and storage tank (2270-PP-208/209 BY OTHERS) the following equipment is started:
   - Lime slaker screw feeder (2270-ZM-009-04)
   - Lime silo rotary valve (2270-ZM-009-21)
   - Pneumatic valve opening (2270-HV-11823)
   - Lime silo bottom bin activator (2270-ZM-009-14A/B)

4. When the slaking temperature reaches the Setpoint, temperature control is initiated. From now on the preparation is controlled automatically by the temperature of the chemical reaction acting on the control valve (2270-TV-11801).

5. When entering a value in the percentage of solid in the Lime slaker discharge pumpbox (2270-ZM-009-19) the dilution water valve (2270-FV-11808) should start to open or close to reach the % solid required.

5.1.2. Stop Sequence (washing).

When the plant is operating automatically and reaches the high level of milk of lime of the storage tank (by others), a stop sequence (washing) order is generated. In the same way when an excessive rise in temperature is generated (second alarm SP+10°C), the plant initiates a stop sequence (washing).

This sequence has the objective of washing, lowering the temperature of the system and stopping ir, in order to leave the equipment in conditions of a next automatic start. The steps that take place in the automatic stop are the following.

1. The Lime silo bottom bin activator (2270-ZM-009-14A/B) are stopped.
2. Pneumatic gate vale (2270-HV-11823) closed.
3. After one minute, stop rotary valve (2270-ZM-009-21).
4. Operate screw feeder (2270-ZM-009-04) for a period of 5 minutes to clean it and leave it unloaded. Then it stops.
5. Once the Lime slaker screw feeder (2270-ZM-009-04) is stopped, the Control Valves (2270-TV-11801 and 2270-HV-11808) are opened 100% for 15 minutes to lower the temperature and wash the system.
   (This washing time must be adjusted during start-up).
6. Lime slaker stops (2270-ZM-009-06), Mill lubrication system for lime slaker (2270-ZM-009-34), stops Lime separating chamber agitator 1 and 2 (2270-ZM-009 -31/32), the Lime slaker discharge pumpbox agitator is stopped (2270-ZM-009-23), the control valve (2270-HV-11808) and the control valve (2270-TV-11801) are closed.
7. After 20 minutes the Lime scrubber exhaust fan (2270-ZM-009-20 / 29) stops.
8. Once the Lime scrubber exhaust fan (2270-ZM-009-20 / 29) is stopped, the solenoid valves (2270-ZV-11852/80) are closed and the automatic stop is completed.
9. The system is able to operate again.

The plant also begins the detention sequence for the following:

- If the following equipment fails:
  - Lime silo rotary valve (2270-ZM-009-21).
  - Mill (2270-ZM-009-06).
  - If the Lime transfer pump (2270-ZM-009-12) fails and fails to split the Lime transfer pump (2270-ZM-009-13) after 10 sec. which is stand-by. (This time must be adjusted in the field).
- If there is low fresh water flow.
- For normal sequence stop when selecting stop from the DCS.
- If there is a change form manual to automatic and automatic to manual, without having stopped the plant first.

6.- DESCRIPTION AND INTERLOCKS

Next, we will define the interlocks, starting, stopping and operating conditions by functional systems.

- All signals will be represented in the DCS control system. Each of digital input signals must be configured as an alarm signal and / or event in the supervisor system database.

6.1.- Stage Loading lime silo.

Involved equipment:

Equipment and instruments	Tag
LIME SILO VENT	2270-ZM-009-22
LIME UNLOADING COMPRESSOR	2270-ZM-009-02
LIME SILO	2270-ZM-009-01
LIME SILO RADAR LEVEL SENSOR	2270-LIT-11825
HIGH LEVEL SWITCH LIME SILO	2270-LSHH-11826
LOW LEVEL SWITCH LIME SILO	2270-LSLL-11829

They are considered interlocks and indication of high high level (2270-LAHH-11825), low low level (2270-LSLL-11825) of the Lime silo (2270-ZM-009-01) respectively.
To load the Lime silo (2270-ZM-009-01), it must be at its level less than or equal to 69% of its capacity. If the high-level high alarm (2270-LAHH-11825) is displayed during loading, the system must allow the truck to be unloaded, blocking it once it has finished unloading. The truck unloading process is achieved through the Lime unloading compressor (2270-ZM-009-02), which injects air pressure by pushing the lime towards the Lime silo (2270-ZM-009-01). The Lime unloading compressor (2270-ZM-009-02) can not be operated again if this high level high alarm (2270-LAHH-11825) is present, it will be able to operate once the level of lime in the Lime silo (2270-ZM-009-01) is less than or equal to 70% of its capacity.

If the low low level alarm (2270-LALL-11829) is present, an alarm indication is sent, and does not affect the process in any way. But, if the alarm remains deployed 8 hours in a row, the plant stops.
(This time must be confirmed in the field)

The loading of the Lime silo (2270-ZM-009-01) is carried out by means of trucks loaded with CaO, which through the Lime unloading compressor equipment (2270-ZM-009-02) allow the unloading of said truck.

Prior to download they must be enabled:

Equipment	Tag
DCS	2270-HS-11826
LIME SILO VENT	2270-ZM-009-22
LIME UNLOADING COMPRESSOR	2270-ZM-009-02

The lime silo vent (2270-ZM-009-22) works autonomously when detecting a differential pressure, so if there is a pressure difference in the Lime Silo (2270-ZM-009-01) it will initiate ventilation.

Interlock table:

EQUIPMENT	TAG	CONDITION	DESCRIPTION
LIME SILO	2270-ZM-009-01	SI LI-11825 < 70%	CAN START THE LOADING PROCESS
LIME UNLOADING COMPRESSOR	2270-ZM-009-02A	SI LI-11825 ≥ 70%	COMPRESSOR CAN NOT OPERATE
		SI LI-11825 = 70%	COMPRESSOR WILL OPERATE UNTIL END OF TRUCK DOWNLOAD

Alarms table:

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SILO 2270-ZM-009-01	2270-LSHH-11826	2270-LAHH-11826 = 0 NOTE2	FAULT	WHEN LAHH-11826 = 0 THE SYSTEM SHOULD ALLOW THE LIME UNLOADING COMPRESSOR 2270-ZM-009-02 TO END THE TRUCK DISCHARGE, BLOCKING ONCE IT FINISHES OPERATING. DISPLAY ALARM IN DCS
	2270-LSLL-11829	2270-LALL-11829 = 0	WARNING	DISPLAY ALARM IN DCS
	2270-LIT-11825	2270-LAHH-11825 > 95%	FAULT	THE SYSTEM SHOULD ALLOW THE LIME UNLOADING COMPRESSOR 2270-ZM-009-02 TO END THE TRUCK DISCHARGE, BLOCKING ONCE IT FINISHES OPERATING. DISPLAY ALARM IN DCS.
		2270-LALL-11825 < 5%	WARNING	DISPLAY ALARM IN DCS
LIME SILO VENT 2270-ZM-009-22	2270-PDAH-11827	2270-PDAH-11827 = 0	WARNING	DISPLAY ALARM IN DCS
LIME UNLOADING COMPRESSOR 2260-ZM-009-02	2260-ZM-009-02	2270-YL-11826 = 1	WARNING	DISPLAY ALARM IN DCS

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

NOTE2 : - The level switch operates when the silo is at 70% capacity

6.2.- Stage of lime discharge from Lime Silo to Vortex pre-mixer:

Involved equipment:

Equipment	Tag
LIME SILO	2270-ZM-009-01
LIME SILO RADAR LEVEL SENSOR	2270-LIT-11825
HIGH LEVEL SWITCH LIME SILO	2270-LSHH-11826
LOW LEVEL SWITCH LIME SILO	2270-LSLL-11829
LIME SILO BOTTOM BIN ACTIVATOR	2270-ZM-009-14
GATE VALVE PNEUMATICALLY ACTUATED	2270-ZM-009-26
GATE VALVE MANUALLY ACTUATED	2270-ZM-009-24
LIME SILO ROTARY VALVE	2270-ZM-009-21
ZERO SPEED SENSOR ROTARY VALVE	2270-SE-11818
LIME SLAKER SCREW FEEDER	2270-ZM-009-04
ZERO SPEED SENSOR LIME SLAKER SCREW FEEDER	2270-SE-11817
VORTEX PRE-MIXER	2270-ZM-009-30

To discharge and dose the quicklime contained in the Lime silo (2270-ZM-009-01) the following sequence of departure must be considered.

NOTE: The gate valve manually (2270-ZM-009-24) must always be open. It is only closed for maintenance purposes.

1. Open control valve (2270-TV-11801)
2. Start Lime slaker screw feeder (2270-ZM-009-04)
3. Start Lime silo rotatory valve (2270-ZM-009-21)
4. Open gate valve pneumatically (2270-ZM-009-23)
5. Start Lime silo bottom bin activator (2270-ZM-009-14A/B)

The lime contained in the Lime silo (2270-ZM-009-01) is induced to exit through the lime silo bottom bin activator (2270-ZM-009-14), dosed by the Lime silo rotary valve (2270-ZM-009 -21) and transported by the Lime slaker screw feeder (2270-ZM-009-04) to the Vortex pre-mixer (2270-ZM-009-30).

The lime feed circuit has a Lime silo rotary valve (2270-ZM-009-21).
This Lime silo rotary valve (2270-ZM-009-21). It has a drive by means of a frequency inverter which allows to vary its operating speed from 25hz to 50hz and thereby regulate the mass flow delivered to the process.

This equipment will allow the operator to enter a weight adjustment point (16 tph design). The Lime silo rotary valve (2270-ZM-009-21) has a zero speed sensor (2270-SSL-11818) to indicate an alarm condition in case of starting this engine and not registering movement in the valve and / or in the case of blocking.

The Lime silo rotary valve (2270-ZM-009-21) unloads on the Lime slaker screw feeder (2270-ZM-009-04). It also has a zero speed sensor (2270-SSL-11817) to indicate alarm condition in case of engine split and no movement of the screw or in case of equipment blockage. The Lime slaker screw feeder (2270-ZM-009-04) feeds the Vortex pre-mixer (2270-ZM-009-30).

In the DCS operation screen, the instrument states and instrument measurements will be displayed. It should have a trend curve of the flows.

Interlock table:

EQUIPMENT	TAG	CONDITION	DESCRIPTION
LIME SLAKER DISCHARGE PUMPBOX	2270-ZM-009-19	2270-LI-11845 > 70 %	START PROCESS OF LOADING TO VORTEX PRE-MIXER 2270-ZM-009-30
LIME SILO ROTATORY VALVE	2270-ZM-009-21	MANUALLY GATE VALVE = OPEN LIME SILO BOTTOM BIN (2270-ZM-009-14A/B) = OFF PNEUMATICAL GATE VALVE = CLOSED	START LIME SILO ROTARY VALVE
LIME SLAKER SCREW FEEDER	2270-ZM-009-04	LIME SILO ROTARY VALVE = STOPPED	START LIME SLAKER SCREW FEEDER

Alarms table:

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SILO 2270-ZM-009-01	2270-LIT-11825	LALL-11825 < 5%	FAULT	CAN NOT START LOADING PROCESS TO VORTEX, DISPLAY ALARM IN DCS
LIME SILO ROTARY VALVE 2270-ZM-009-21	2270-SAL-11818	ESTATE = 0	FAULT	LIME SILO ROTARY VALVE STOPPED
LIME SLAKER SCREW FEEDER 2270-ZM-009-04	2270-SAL-11817	ESTATE = 0	FAULT	LIME SLAKER SCREW FEEDER STOPPED

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

6.3.- Stage of preparation of milk of lime:

Involved equipment:

Equipo	Tag
VORTEX PRE-MIXER	2270-ZM-009-14
LIME SLAKER	2270-ZM-009-06
TEMPERATURE SENSOR	2270-TE-11801A/B
LIME SEPARATING CHAMBER	2270-ZM-009-18
LIME SEPARATING CHAMBER AGITATORS 1 & 2	2270-ZM-009-31/32
LIME SEPARATING CHAMBER RADAR LEVEL SENSOR	2270-LIT-11850
LIME TRANSFER PUMP	2270-ZM-009-12/13
LIME RECYCLE PUMP	2270-ZM-009-08/09
FLOWMETER	2270-FIT-11801
CONTROL VALVES	2270-TV-11801/HV-11808
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-20/29
SOLENOID VALVES	2270-ZV-11852/80

The lime slaking process starts controlled by mass ratio and is fed in parallel quicklime from the Lime slaker screw feeder (2270-ZM-009-04) to the Vortex pre-mixer (2270-ZM-009-14) and water from the fresh water line in a 1:3 mass ratio complying with the Setpoint by design, 16 tph of quicklime and 48 m^3/h of water (2270-TV-11801). This mixture generates a solids concentration of approximately 33%.

For this to happen, the Lime silo rotary valve (2270-ZM-009-21) must turn at 20 RPM, 40 Hz. (It must be gauged on the ground).

At this point the lime is humid with two water circuits, one of these is slaking water that will regulate temperature through the control valve (2270-TV-11801), and the other water circuit feeds the Lime scrubber exhaust fan (2270-ZM-009-20) located at the top of the Vortex pre-mixer (2270-ZM-009-30). The Solenoid Valve (2270-ZV-11852) must remain open as this prevents the clogging of the washing equipment and the emission of dust into the environment.

The mixture prepared in the Vortex pre-mixer (2270-ZM-009-30) is delivered to the Lime slaker (2270-ZM-009-06).

Lime slaking is the transformation of quicklime (CaO, calcium oxide) into hydrated or quenched lime (Ca(OH)2, calcium hydroxide), this transformation is a highly hazardous exothermic reaction if not properly controlled, allowing generate the boiling of the water contained in the Lime slaker (2270-ZM-009-06) and cause pressure on the equipment and splashing with consequent damage to both people and facilities. It is important to remember that there must always be enough water for the correct slaking and thus avoid the mentioned risks. This is why an alarm is generated with a low-flow safety interlock given by:

(Nominal flow x 0.75 = Low flow alarm value), This low flow alarm value will depend on the weight setpoint entered into the preparation. For example:

SP Weight = 16 tph (design value)
Slaking water flow = 16 x 3 = 48 m^3/h

Once in operation and reached the Setpoint of temperature 70°C +/- 5°C, (Temperature Sensor 2270-TIT-11801A) the DCS begins to control by temperature slaking through a PID block that acts on the Valve control (2270-TV-11801) regulating the water input flow to the equipment to maintain the setpoint temperature. Since temperature control is the most critical process in the system, two high temperature alarm levels will be defined, these thresholds will be dependent on the Setpoint temperature. The first alarm level (5ºC over Setpoint temperature) will give the signal for the emergency water control valve (2270-HV-11808) to enter into operation, which will aim to lower the temperature to the Setpoint. The second alarm level (10ºC above the setpoint temperature) will stop the lime supply and keep the emergency water control valve (2270-HV-11808) open until the system temperature is 5ºC under the Setpoint.

For example:

- SP Temperature: 70ºC (Adjustable operating range in field)
- SPT + 5ºC first alarm (emergency water is opened): 75ºC
- SPT +10ºC Second alarm (maintains emergency water and stops lime feed): 80ºC

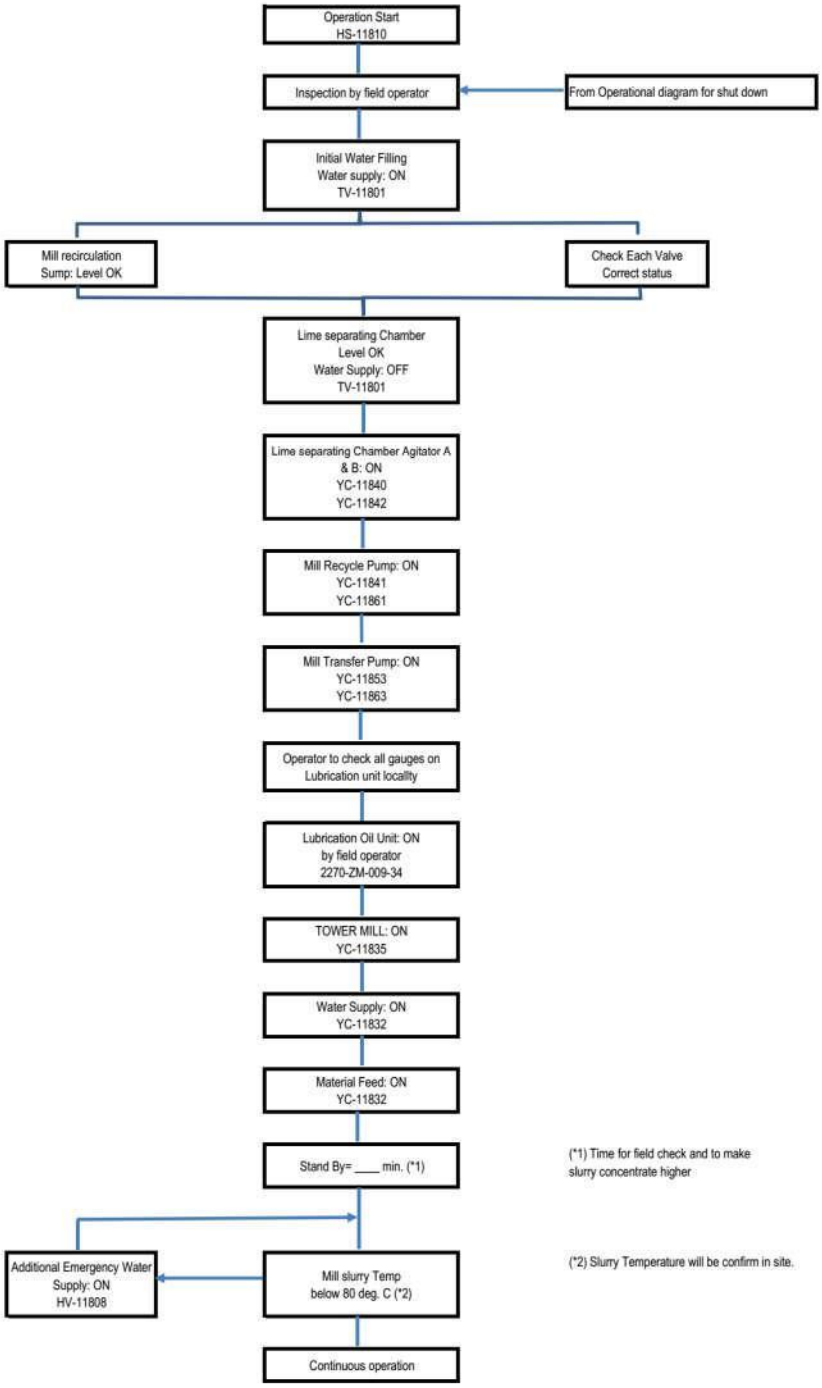
The optimum temperature of the slaking (Setpoint) depends on the type of lime that is used and will vary with time due to changes in the raw material. During the start up, the ideal value is chosen for the process conditions.

On the contrary, when the temperature decreases 10ºC with respect to the Setpoint the program will generate an alarm, being necessary to check in the field the correct operation of the Lime silo rotary valve (2270-ZM-009-21), the Lime slaker screw feeder (2270- ZM-009-04), the Silo bottom bin activator (2270-ZM-009-14A / B), the level of lime in the Lime silo (2270-ZM-009-01), etc.

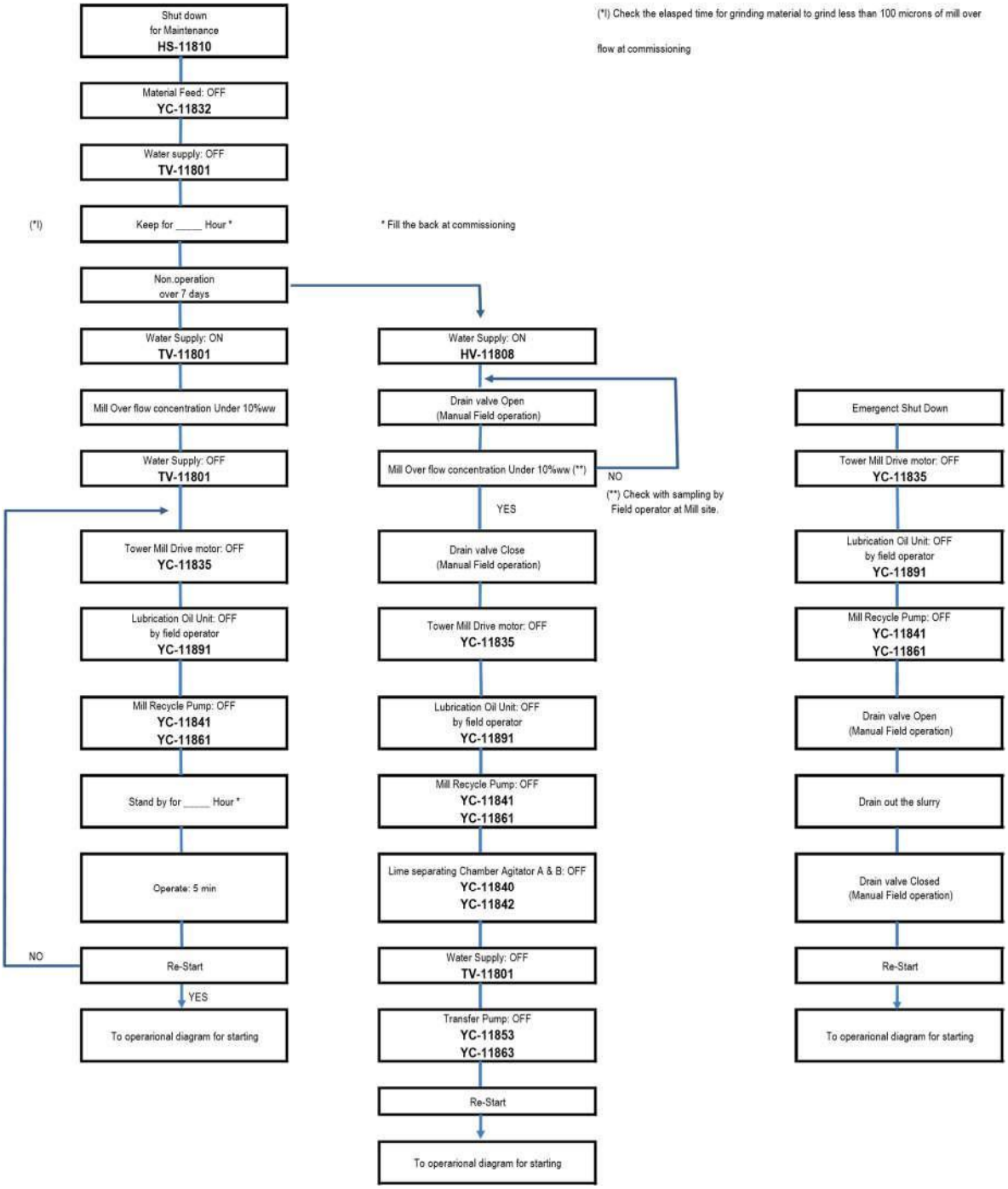
The Lime slaker (2270-ZM-009-06) unloads the milk of lime to the Lime separating chamber (2270-ZM-009-18) allowing the milk of lime with fine particles to discharge to the Lime slaker discharge pump box (2270-ZM) -009-19) and the larger particles are recirculated to the Lime slaker (2270-ZM-009-06).

The operation of the Lime slaker (2270-ZM-009-06) is explained in the following block diagrams.

- Block diagram of the lime slaker (2270-ZM-009-06) for the start of the operation.



- Block diagram of the Lime slaker (2270-ZM-009-06) for detention.



The Lime separating chamber (2270-ZM-009-18) has two Lime separating chamber agitators (2270-ZM-009-31 / 32) which keep the small particles in suspension and then be driven through the Lime transfer pumps (2270-ZM-009-12A/13A) to the Lime slaker discharge pumpbox (2270-ZM-009-19). Larger particles are returned through the Lime recycle pump (2270-ZM-009-08 / 09) to the Lime slaker (2270-ZM-009-06).

The Lime transfer pumps (2270-ZM-009-12A/13A) has a drive with frequency inverter which allows setting an operating height in the Lime slaker discharge pumpbox (2270-ZM-009-19). The frequency inverter will work between 30hz and 50hz.

The agitators can not operate in empty, therefore and given that it has a continuous level measurement, start, stop and operation levels will be set according to the level of the Lime slaker discharge pumpbox (2270-ZM-009-19).

- Low-low level:15% give stop order to the milk of lime tank feed pump (by others) (2270-PP-208/209)
- Low level: 40% it ives starting order to the agitator and the pumps of impulsión of hidrated lime. Under this level, the agitator is oredered to stop
- High level: 90% The lime feed is stopped, the system enters the washing stage and the pump that was in stand by is incorporated.
- High-high level: 100% Maximum level of the tank before its overflow, an alar mis generated.

The plant has a vahos aspiration system composed of Lime scrubber exhaust fan (2270-ZM-009-20/29), these equipments maintain a negative pressure inside the slaking lime system in order to prevent the escape of vapors and dust to the environment. These vapors are conducted to a vapor washing chamber, which allows clean air to be discharged into the environment.

The Lime slaker (2270-ZM-009-06) unloads on the Lime separating chamber (2270-ZM-009-18), which has 2 agitators (2270-ZM-009-31/32), these work in a way independent of each other, both in its departure and detention, the Lime separating chamber (2270-ZM-009-18) classifies the milk of lime returning the largest particles to the Lime slaker (2270-ZM-009-06) and ensuring the step of the milk of lime with the desired particle size, additionally ensures the shutdown of any remnant of quicklime that might remain. This agitation system prevents the sedimentation of the solid particles, therefore it must operate permanently and an alarm must be generated before its stop.

From the Lime separating chamber (2270-ZM-009-18) the milk of lime is transferred through the Lime transfer pump (2270-ZM-009-12A/13A) to the Lime slaker discherge pumpbox (2270-ZM-009-19).
The Lime slaker discherge pumpbox (2270-ZM-009-19) receives the final product from the Lime separating chamber (2270-ZM-009-18) by the Lime transfer pump (2270-ZM-009-12A / 13A).

Interlock table:

EQUIPMENT	TAG	CONDITION	DESCRIPTION
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-20	SOLENOID VALVE 2270-ZV-11852 MUST BE OPEN ONCE ENABLED THE STATE (2270-HS-11810) FROM THE DCS.	CAN START LIME SCRUBBER EXHAUST FAN
VORTEX PRE-MIXER	2270-ZM-009-30	LIME SCRUBBER EXHAUST FAN 2270-ZM-009-20 OPERATING. VALVE 2270-TV-11801 MUST BE OPEN LIME SLAKER SCREW FEEDER 2270-ZM-009-04 MUST BE OPERATING	CAN START VORTEX PRE-MIXER
VORTEX PRE-MIXER	2270-TV-11801/HV-11808	VALUE 2270-TIC-11801	CONTROL OPENING OF VALVES 2270-TV-11801 AND 2270-HV-11808
LIME SEPARATING CHAMBERS AGITATOR 1 & 2	2270-ZM-009-31A/32A	2270-LI-11850 > 40%	START LIME SEPARATING CHAMBERS AGITATOR 1 & 2 2270-ZM-009-31A/32A
LIME RECICLE PUMP	2270-ZM-009-08/09	AFTER 2 MINUTES OF OPERATION OF THE LIME SEPARATING CHAMBER AGITATOR 2270-ZM-009-31/32	START LIME RECICLE PUMP 2270-ZM-009-08 OR 2270-ZM-009-09
LIME TRANSFER PUMP	2270-ZM-009-12A/13A	40 % < 2270-LIT-11850 < 100 %	START LIME TRANSFER PUMP 2270-ZM-009-12 OR 2270-ZM-009-13

Alarms table:

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
VORTEX PRE-MIXER 2270-ZM-009-30	2270-TIC-11801	TEMPERATURE 2270-TAHH-11801 SP+10°C	FAULT	START STOP SEQUENCE. DISPLAY ALARM IN DCS.
		TEMPERATURA 2270-TAH-11801 SP+5°C	FAULT	STOP LIME SLAKER SCREW FEEDER 2270-ZM-009-04; IT KEEPS OPEN THE VALVE 2270-TV-11801; DISPLAY ALARM IN DCS.
		TEMPERATURA 2270-TAL-11801 SP-5°C	WARNING	DISPLAY ALARM IN DCS.
LIME SEPARATING CHAMBER 2270-ZM-009-18	LIT-11850	LALL-11850 < 5%	FAULT	CAN NOT OPERATE LIME SEPARATING CHAMBER AGITATOR 2270-ZM-009-31/32; LIME RECICLE PUMP 2270-ZM-009-08/09; LIME TRANSFER PUMP 2270-ZM-009-12/13; DISPLAY ALARM IN DCS.
		LAHH-11850 > 95%	FAULT	CLOSE VALVE 2270-TV-11801 CLOSE VALVE 2270-HV-11808 STOP LIME SLAKER SCREW FEEDER 2270-ZM-009-04; DISPLAY ALARM IN DCS.

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

6.4.- Dilution system.

Involved equipment:

Equipment	Tag
LIME SLAKER DISCHANGE PUMP BOX AGITATOR	2270-ZM-009-23
LIME SLAKER DISCHANGE PUMP BOX AGITADOR MOTOR	2270-ZM-009-23A
RADAR LEVEL TRANSMITTER LIME SLAKER DISCHANGE	2270-LIT-11845
CONTROL VALVE	2270-FV-11870
SCRUBBER	2270-ZM-009-11

In the Lime slaker discharge pumpbox (2270-ZM-009-19) the necessary water is incorporated to reach the% solids required in the process through the Control Valve (2270-FV-11870). This control is carried out by balancing in DCS between the weight of the Setpoint of lime to be slaking and the flow of water fed by the Flowmeters (2270-FIT-11801/11870), in this way the control valve opening is controlled (2270-FV-11870) of adition water to the Lime slaker discharge pumpbox (2270-ZM-009-19). The amount of dilution water is represented by the following formula.

$$\%\text{Sol} = \frac{\text{Ms} + \text{MH2O Rx}}{\text{Ms} + \text{MH2O Ap} + \text{MH2O D} + \text{MH2O Rx}}$$

$$\text{Ms} + \text{MH2O Ap} + \text{MH2O D} + \text{MH2O Rx} = \frac{\text{Ms} + [(\frac{18}{56}) * \text{Ms}]}{\%\text{Sol}} = \frac{\text{Ms}[1 + \frac{18}{56}]}{\%\text{Sol}}$$

$$\text{MH2O D} = \frac{\text{Ms} + \text{MH2O Rx}}{\%\text{Sol}} - (\text{Ms} + \text{MH2O Ap} + \text{MH2O Rx})$$

$$\text{MH2O D} = \frac{\text{Ms} + (\frac{18}{56} * \text{Ms})}{\%\text{Sol}} - (\text{Ms} + \text{n} * \text{Ms} + \frac{18}{56} * \text{Ms})$$

Where n = 3 or 4 adjustment in field

$$\text{MH2O D} = \frac{\text{Ms} * (1 + 0{,}32)}{\%\text{Sol}} - \text{Ms}(1 + \text{n} + 0{,}32)$$

For n=3

$$\text{MH2O D} = \frac{\text{Ms} * (1{,}32)}{\%\text{Sol}} - \text{Ms}(4{,}32)$$

For n=4

$$\text{MH2O D} = \frac{\text{Ms} * (1{,}32)}{\%\text{Sol}} - \text{Ms}(5{,}32)$$

With:

- Ms = Solid mass and/ or quicklime (Tons)
- M H2O Rx = Mass of reaction water (Amount of water that reacts to form hydrated lime) (Tons)
- M H2O Ap = Mass of hidration water (Tons)
- M H2O D = Mass of dilution water (Tons)
- % Sol = Solids %, expressed as a fraction, in other words 15% = 0.15
- n = number of times the mass of Cal (3 or 4)

Interlock table:

EQUIPMENT	TAG	CONDITION	DESCRIPTION
LIME SCRUBBER EXHAUST FAN	2270-ZM-009-29	THE SOLENOID VALVE 2270-ZV-11880 MUST BE OPEN ONCE ENABLED BY THE STATE (2270-HS-11810) FROM THE DCS.	CAN OPERATE SCRUBBER
LIME SLAKER DISCHANGE PUMPBOX	2270-ZM-009-12/13	LALL-11850 DEBE ESTAR PRESENTE	START LIME TRANSFER PUMP 2270-ZM-009-12 O 2270-ZM-009-13
	2270-ZM-009-2	LI-11845 ≥ 40 %	START LIME SLAKER DISCHANGE PUMPBOX AGITATOR (2270-ZM-009-23)

Alarms table:

EQUIPMENT	TAG	CONDITION	TYPE	DESCRIPTION
LIME SLAKER DISCHANGE PUMP BOX 2270-ZM-009-19	2270-LIT-11845	LALL-11845 < 40%	WARNING	CAN NOT OPERATE LIME SLAKER DISCHANGE PUMPBOX AGITATOR 2270-ZM-009-23; DISPLAY ALARM IN DCS.
		LAHH-11845 > 95%	FAULT	CAN NOT OPERATE LIME TRANSFER PUMP 2270-MZ-009-12/13; STOP THE PREPARATION ON MILK OF LIME. DISPLAY ALARM IN DCS.

NOTE: - FAULT, the involved equipment must be stopped and indicate an alarm display in the DCS.
- WARNING, display alarm in the DCS.

7.- ATTACHED (LIME SLAKER EIRICH OPERATION)

1.3. Preparation for MS seed slurry Operation

1) Fill with specified oil in the lubrication unit for gear reducer and the bearing box in the upper housing.
2) Fill with grease in the gear couplings and motor.

> **Note!**
> The bushing is made of oil-less metal.
> Therefore **NO** lubrication is required.

3) Check for oil leakage, bolt looseness, and other irregularities.
4) Open the suction valve of the recirculation pump.
5) Fill with initial water in the mill shell and cyclone feed tank until water overflows from overflow outlet of mill shell and until the water level exceeds the set point (low point) of the level sensor of Mill Recirculation Sump of cyclone feed tank.
6) Check the mill shell door, ball discharge cover and piping system, etc., for leakage.

> **Note!**
> The condition of each facility at site should be inspected according to the document No. J107028-003.
> Tower Mill should be started with a switch at the machine side control panel but not in the control room.

1.4. Start and Run

1) Open the discharge valve of the recirculation pump.
2) Start the recirculation pump.
3) Check the circulation of slurry or water between the mill shell and cyclone feed tank at field.
4) Supply cooling water to lubrication unit.
5) Start up the motor for oil pump.
6) Check the pressure gauges furnished on lubrication unit.

> **Note!**
> Confirm that the oil circulation is properly with the flow gauge of lubrication unit for gear reducer (oil flow rate is 10.5 L/min).

7) Start up the main drive motor.
8) Check the rotation direction of the main drive motor.
9) Start up the agitator motor. Check the direction of rotation.
10) Charge grinding balls into the mill shell through the ball charge nozzle with recording the load current of main drive motor at the each 1 ton charge.

> **Note!**
> Please keep empty ball drums for future use when balls will be discharge.

> **WARNING!!!**
> DON'T CHARGE BALLS WITHOUT RUNNING THE SCREW.

11) Check the load current just after the required amounts of balls have been charged into the mill shell.
12) Start feeding the water and material if the load current would satisfy the demanded value.
13) Check the particle size and concentrate with sampling cyclone over flow slurry.
14) Record the load current of the motor as a reference current when operation becomes steady at a specified density or particle size.

1.5. Stop

1.5.1 Short Time Stop

1) Stop feeding of material and water.
2) Keep running the Tower Mill, the gear reducer lubrication unit and the recirculation pump for about 60 minutes so as to grind the material in the mill under 100 micron meter.
3) Stop the motor and then the gear reducer lubrication unit.
4) Continue to run the recirculation pump.
5) Run the Tower Mill for 5 minutes at intervals of 4 hours.

1.5.2 Long Time Stop (Non-operation over 7 days)

1) Stop feeding of material.
2) Feed make-up water to the mill shell and dilution water to the bottom of mill shell for reducing the slurry density and replace slurry to water.
3) Stop main drive motor firstly.
4) Stop the gear reducer lubrication unit after the density in the circuit comes less than 10%.
5) Close the discharge valve of recirculation pump.
6) Stop the recirculation pump and agitator.
7) Flush the inside of the piping systems and the recirculation pump with water.
8) For the safety reason, run Tower Mill for several minutes once a day.

1.5.3 Emergency Stop

In case of emergency stop of the motor caused by electric trouble, etc.

1) Turn off the power supply, before check and investigation to avoid accident
2) Stop feeding material.
3) Open the drain valve of the mill lower port, and drain the slurry and flush all the piping and Tower Mill.
4) Disassemble the recirculation pump piping, and discharge the slurry from cyclone feed tank and pipe line and flush with water.
5) In case the long recovery is estimated for the investigation of the problem cause, discharge balls from the mill shell.

1.6. Re-Start

1) Make sure that slurry (or water) is filled in the mill shell and cyclone feed tank.
2) Start up the recirculation pump
3) Open discharge valve.
4) Check the circulation of slurry (or water) between the mill shell and the recirculation pump.
5) Start up the gear reducer lubrication unit and the main motor.
6) Start feeding of material and water.

WARNING!!!
DON'T START UP THE MAIN MOTOR (SCREW) WITHOUT FILLING WATER OR SLURRY IN THE MILL SHELL WHEN BALLS ARE FILLED IN THE MILL SHELL.

1.7. Additional Ball Charge

1) Add balls until the load current rises to the reference current if the load current is lower than the reference current.
2) Additional balls shall be charged into the mill shell to make up for worn-out balls at regular intervals. Record the weight of additional charged balls.

NOTE!
Record the weight of additional charged balls.

NOTE!
The amount of balls charged to make up for the fall of the load current increases gradually due to the worn out of the screw liners after long term operation.