



Acquisition Group  
Infrastructure Design Branch

## **DESIGN STANDARD DS 72-02**

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### **LIME STORAGE, MIXING & DOSING SYSTEM - Control Functional Specification**

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# DESIGN STANDARD DS 72-02

## LIME STORAGE, MIXING & DOSING SYSTEM

### - Control Functional Specification

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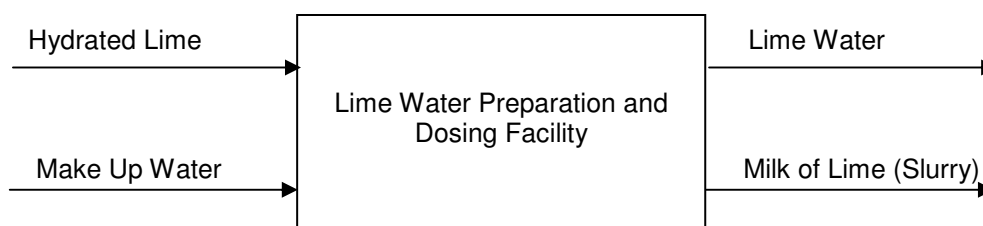
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# 1 System Overview

## 1.1 Process Description

Lime is used in the stabilisation process to increase the calcium, alkalinity and pH of the clear water produced by the treatment plant to protect downstream pipelines from corrosion. Hydrated lime is used to produce lime water with a calcium hydroxide concentration of typically 0.1% (1200mg/L) which is dosed into the clear water from the treatment plant.

The feed into the lime system is dry hydrated lime which is slurried with water to form a milk of lime suspension, this suspension is then diluted and clarified to produce the lime water solution that is used for dosing. The major input and output streams for the lime facility are shown in Figure 1.1.



**Figure 1.1 Main Input and Output Streams for Lime System**

The lime facility can be considered to comprise of four major sub-sections namely,

- Milk of lime Preparation System 1
- Milk of lime Preparation System 2
- Lime clarification system
- Lime water storage and dosing system

Each milk of lime system consists of a vertical silo for hydrated lime storage and a dry lime feeding system to introduce controlled quantities of lime into a milk of lime mixing tank. Duty and standby lime storage and milk of lime systems have been installed to give the system additional redundancy. Pumps operating on flow and level control loops control the throughput through the mixing system.

The lime clarification system receives the milk of lime suspension and mixes this with a controlled addition of dilution water to produce lime water at the required concentration. The lime water is produced in a reactor clarifier that overflows into a lime water storage tank. Unreacted solids in the clarifier are discharged to the sludge drying beds (or wastewater treatment facilities) by underflow pumps.

Lime water is pumped from the lime water storage tank by variable speed pumps that are flow paced to meet the process demand of the recipient clear water.

The operational strategy and control functionality are discussed in detail in later sections of this specification. An overview of the system is given below to give an appreciation of the operational philosophy and the interdependency between the four main process units.

The milk of lime systems, lime clarification system and the lime water storage and dosing system can be considered as independent systems, each with dedicated control sequences to maintain operational integrity. The first system to commence operation will be the lime water dosing facility; operation will be triggered by flow in the recipient clear water main. Operation of this system will then trigger the following,

- Operation of the lime clarification system to maintain a preset level in the lime water storage tank
- Operation of the duty milk of lime preparation system that will feed milk of lime into the clarification system

The inter-relationship with respect to start up and shutdown events is shown in the Table 1.1.

Process Unit	Start Up Initiation	Shut down Initiation	Abort Initiation
Milk of Lime System 1	System selected as duty system, and lime dosing system operating.	Lime Dosing System Shutdown. Failure of lime clarification system. Failure of lime dosing system.	Fault within system
Milk of Lime System 2	System selected as duty system, and lime dosing system operating.	Lime Dosing System Shutdown. Failure of lime clarification system. Failure of lime dosing system.	Fault within system
Lime Clarification	Lime dosing system operating.	Lime Dosing System Shutdown. Failure of lime dosing system. Failure of both milk of lime systems.	Fault within system
Lime Dosing	Pre-set flow registered by FIT 85216.	Pre-set flow registered by FIT 85216. Failure of lime clarification system. Failure of both milk of lime systems.	Fault within system

**Table 1.1 Inter-Relationship between the Four Main Process Units**

With this approach, the flow rate through the milk of lime preparation and clarification process will closely match the flow rate discharged out of the lime water storage tank into the recipient clear water main.



## 1.2 HMI Screens

The main process information that has to be entered on the HMI display by the Operator is given in Table 1.2 with typical values as shown. The values entered are used in the calculations that are embedded in the process control loops or timers that are initiated within sequences. Entering or changing these values shall only be accessible to key personnel with Supervisor and Engineer privilege levels.

Parameter		Tag Number	Typical Value
Desired lime dose rate of calcium hydroxide into recipient water main		HC85119	43 mg/L
Calcium hydroxide concentration in lime water		HC84115	1200mg/L
Reactive lime content in delivered hydrated lime		HC84113	92%
Bulk density of hydrated lime		HC84116	290 kg/m <sup>3</sup>
Clarifier operating efficiency		HC84114	95%
Lime silo fan overrun timer	System 1	-	15 mins
	System 2	-	15 mins
Clarifier underflow pump cyclic timer		-	1 hour
Clarifier underflow pump run timer		-	300 secs
Clarifier underflow pump flushing timer		-	300 secs
Milk of Lime pump flushing timer	System 1	-	30 secs
	System 2	-	30 secs
Lime Mixing Tank operating level set point	System 1	HC84312A	75%
	System 2	HC84412A	75%
Lime Mixing Tank level set point to initiate mixer operation	System 1	HC84312B	40%
	System 2	HC84412B	40%
Lime Water flow to Vortex Mixer set point	System 1	HC84306B	5 m <sup>3</sup> /h
	System 2	HC84406B	5 m <sup>3</sup> /h
Milk of Lime flow to Clarifier set point	System 1	HC84505B	15 m <sup>3</sup> /h
	System 2	HC84605B	15 m <sup>3</sup> /h
Lime Water Storage Tank level set point		HC85110	75%

**Table 1.2 Operational Parameters Configurable on HMI Display**

## 1.3 Group Controllers

To facilitate control, each of the four main process units associated with the lime system has its own control sequences. There is minimal interface between the four process units, the main interface points are listed in Table 1.1 and can be summarised as,

- Command to start operation
- Command to stop operation and undertake an orderly shutdown
- Advise other units that a fault has occurred and the process unit is ‘not available’.

To facilitate the control sequences within each process unit, the PLC controlled valves and drives associated with that unit are grouped together within the control system under a Group Controller. The purpose of the Group Controller is to,

1. Monitor the ‘Available’ (health) status of each of the valves and drives that will be controlled by the sequences,
2. Allow the operator to place all the affected controllable valves and drives into an ‘Automatic state’, thereby ensuring that the control sequences that will actuate these devices will succeed.

The control sequences that rely on the response of these devices is prevented or stopped from executing if the Group Controller does not have the required list of ‘Available’ devices. In the case of dual redundant plant devices configured as duty/standby, both items would need to be ‘Not Available’.

The Group Controller has two states that can be selected on the HMI screen,

- AUTO** This state prohibits the Operator from initiating individual drive or valve operation from the HMI screen.
- MANUAL** Control sequences cannot be initiated. The Operator has control access to the individual items of equipment controllable from the HMI display.

The Group Controller can only be selected to MANUAL when the system is in the ‘Stopped’ operational state or a sequence is locked in an invalid state due to a sequence not finishing.

The Group Controller references for the lime system are,

Milk of Lime Preparation System 1	POT_ML1_GC
Milk of Lime Preparation System 2	POT_ML2_GC
Lime Clarification System	POT_LC_GC
Lime Dosing System	POT_LD_GC

Individual devices associated with each group controller are discussed in the following sub sections. The processes covered by each group controller are shown in Figure 1.2.

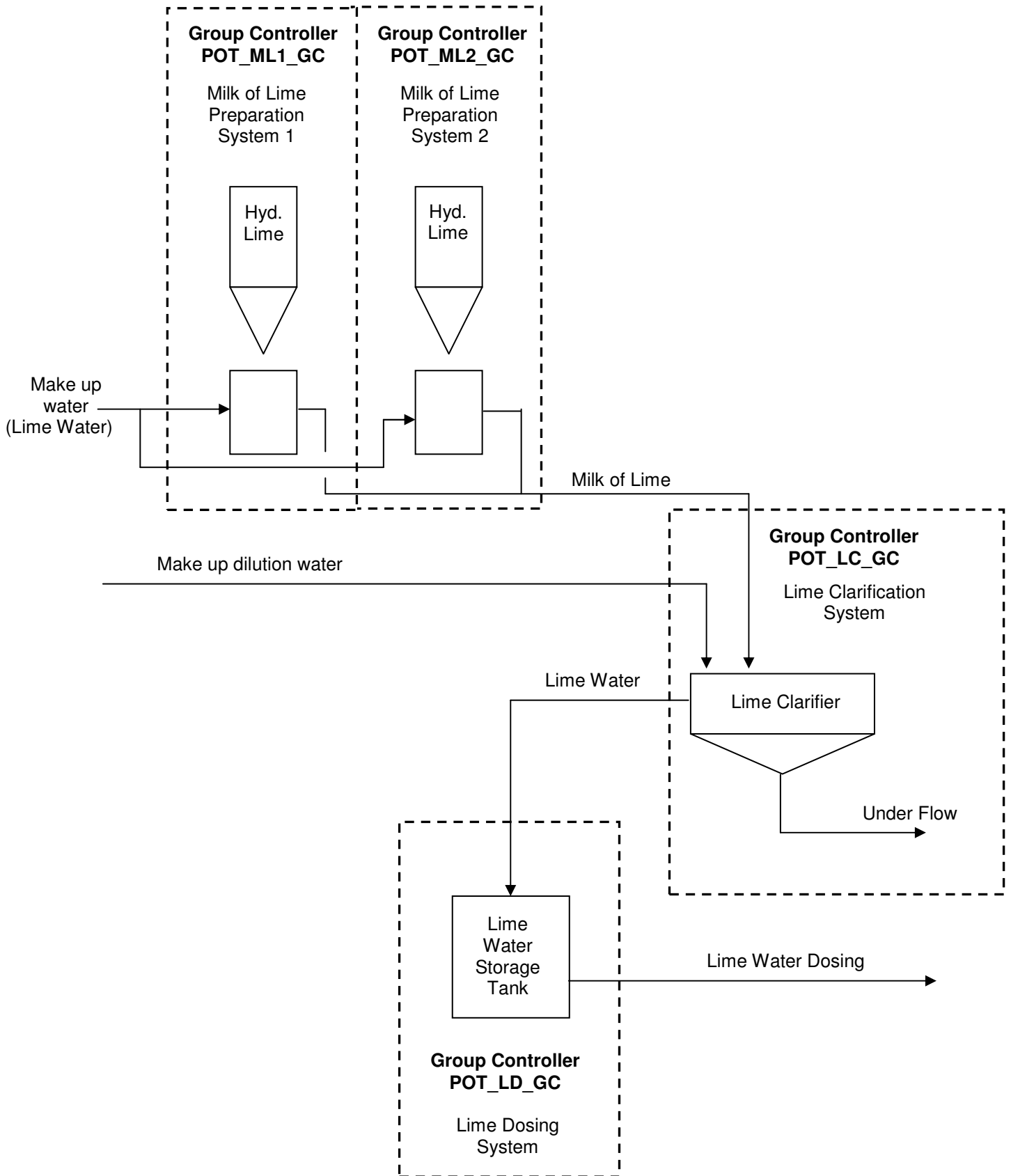


Figure 1.2 Process Unit Group Controllers

## 1.4 Milk of Lime Preparation Functionality

The lime facility incorporates two milk of lime preparation systems, operating in a duty/standby configuration. The operator is able to select the duty system on the HMI display. In the event that the duty system is ‘not available’ the standby system will commence operation. The two systems are referred to as,

- Milk of Lime Preparation System 1
- Milk of Lime Preparation System 2

The duty milk of lime preparation system is automatically initiated when the lime dosing system is operating. Each system incorporates a number of different operations and these are summarised in the Table 1.3.

Operation	Inter-relationship within Milk of Lime Preparation System
Dry hydrated lime loading	None – loading can take place at any time
Milk of lime preparation and pumping	Initiated when lime dosing system operating
Dry lime feeding into the weighing hopper	Separate sequence that runs when milk of lime preparation and pumping is operating

**Table 1.3 Inter-relationship of Operations within Milk of Lime Preparation System**

The control system enables both manual and automatic control capability of the milk of lime preparation systems. In the automatic mode of operation, the control system can be in any one of the following operational states.

- Running
- Ready
- Stopped

The milk of lime preparation system is moved between each of these operational states by executing sequences initiated from the commands on the Sequence Controls pop up panel on the HMI display, or by tripped interlocks and triggers.

The commands available on the Sequence Controls pop up panel are,

- Abort Running
- Goto Ready
- Goto Stopped

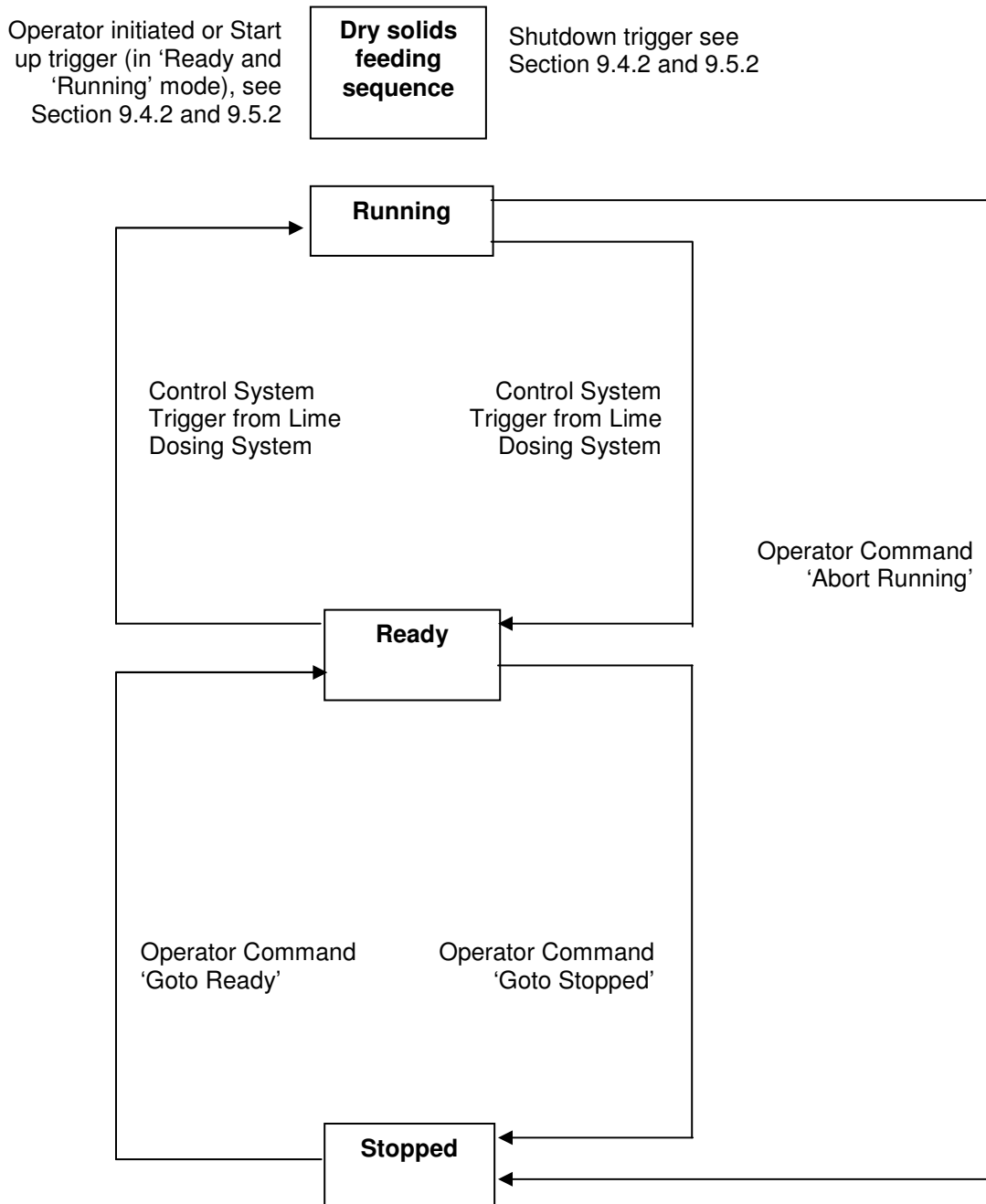
Transition to the ‘Running’ state can only occur when the system is in the ‘Ready’ operational state. The ‘Running’ mode is automatically initiated when any of the lime water dosing pumps commences operation. When the operation of the dosing pumps is terminated the system will return to the ‘Ready’ state.

Operator transition to the ‘Ready’ state can only occur from the ‘Stopped’ state, this is achieved by selecting ‘Goto Ready’ on the Sequence Controls pop up panel.

The system can transition to a ‘Stopped’ state by the Operator selecting any of the following commands from the Sequence Controls pop up panel,

- ‘Abort Running’
- Goto Stopped, only when the system is in the ‘Ready’ state

The inter-relationship between these operational states and the commands is shown in the Figure 1.3. The dry solids feeding sequence is an independent sequence associated with the milk of lime process that can be executed manually from the 'Ready' state or automatically from the 'Running' state.



**Figure 1.3 Operational States Associated with Milk of Lime System**

The devices within each milk of lime system are controlled by a group controller as discussed in Section 1.3. The devices associated with each Group Controller are shown in Table 1.4.

Group Controller	
POT_ML1_GC	POT_ML2_GC
System 1	System 2
Bin activator BA 84108	Bin activator BA 84208
Rotary valve RV 84111	Rotary valve RV 84211
Loss-in-weight feeder FD 84112	Loss-in-weight feeder FD 84212
Mixing tank agitator MX 84311	Mixing tank agitator MX 84411
Lime water (tank) valve VA 84305	Lime water (tank) valve VA 84711
Lime water (vortex) valve VA 84306	Lime water (vortex) valve VA 84406
Milk of lime valve VA 84501	Milk of lime valve VA 84601
Flushing valve VA 84502	Flushing valve VA 84602
Milk of lime dosing pump PU 84505	Milk of lime dosing pump PU 84605

**Table 1.4 Devices Associated with Group Controllers**

Individual valves, if faulted, alarmed, electrically isolated or tagged as ‘Out of Service’, will present their status on the HMI and to the Group Controller as ‘Not Available’.

The pre-requisites, triggers and interlocks for the control sequences are described in detail in Section 9.4 and Section 9.5.

## 1.5 Lime Water Clarification System Functionality

The operation of the lime clarification system is automatically initiated when the lime water dosing system is operating. It incorporates a number of different operations and these are summarised in the following Table 1.5.

Operation	Inter-relationship with Overall Lime system Operations
Rake and draft tube impeller operation	Operates continuously under control of a dedicated clarifier control system installed on the clarifier. An output is available from the clarifier control cubicle to advise the main control system that the rake and draft tube are ‘healthy’.
Lime water production	Initiated when the lime water dosing system operating
Lime clarifier underflow discharge	Separate sequence that runs when lime water production is operating

**Table 1.5 Inter-relationship of Operations within Lime Water Clarification System**

The control system enables both manual and automatic control capability of the lime water clarification system. In the automatic mode of operation, the control system can be in any one of the following operational states.

- Running
- Ready
- Stopped

The clarification system is moved between each of these operational states by executing sequences initiated from the commands on the Sequence Controls pop up panel on the HMI display, or by tripped interlocks and triggers.

The commands available on the Sequence Controls pop up panel are,

- Abort Running
- Goto Ready
- Goto Stopped

Transition to the ‘Running’ state can only occur when the system is in the ‘Ready’ operational state. The ‘Running’ mode is automatically initiated when any of the lime water dosing pumps commences operation. When the operation of the dosing pumps is terminated the system will return to the ‘Ready’ state.

Operator transition to the ‘Ready’ state can only occur from the ‘Stopped’ state, this is achieved by selecting ‘Goto Ready’ on the Sequence Controls pop up panel.

The clarification system can transition to a ‘Stopped’ state by the Operator selecting any of the following commands from the Sequence Controls pop up panel,

- ‘Abort Running’
- Goto Stopped, only when the system is in the ‘Ready’ state

The inter-relationship between these operational states and the commands is shown in the Figure 1.4. The underflow pumping sequence is an independent sequence associated with the lime clarification process that can be executed manually from the ‘Ready’ state or automatically from the ‘Running’ state.

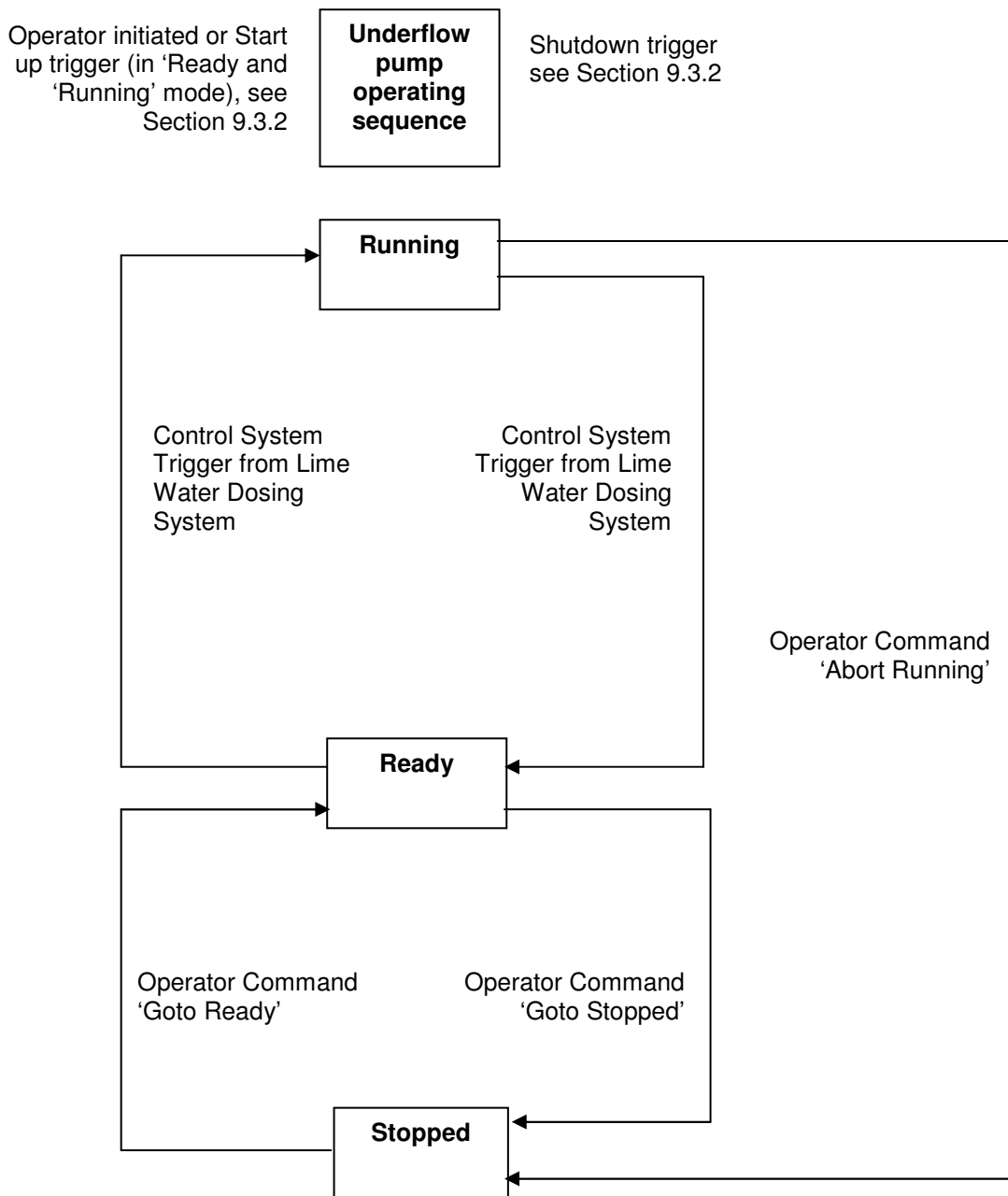
The devices within the lime water clarification system are controlled by a group controller as discussed in Section 1.3. The devices associated with the Group Controller are shown in Table 1.6.

Plant Device
Clarifier control system
Dilution water make up pump PU 84901
Dilution water make up pump PU 84902
Dilution water make up pump PU 84903
Dilution water valve VA 84917

**Table 1.6 Devices Associated with Group Controller**

Individual valves, if faulted, alarmed, electrically isolated or tagged as ‘Out of Service’, will present their status on the HMI and to the Group Controller as ‘Not Available’. All three dilution pumps have to be ‘Not Available’ for the Group Controller to be ‘Not Available’.

The pre-requisites, triggers and interlocks for the control sequences are described in detail in Section 9.3.



**Figure 1.4 Operational States Associated with Lime Clarification System**



## 1.6 Lime Water Dosing System Functionality

The operation of the lime water dosing system is automatically initiated when a preset flow rate is registered in the recipient clear water pipeline.

The control system enables both manual and automatic control capability of the lime water dosing system. In the automatic mode of operation, the control system can be in any one of the following operational states.

- Dosing
- Ready
- Stopped

The lime water dosing system is moved between each of these operational states by executing sequences initiated from the commands on the Sequence Controls pop up panel on the HMI display, or by tripped interlocks and triggers.

The commands available on the Sequence Controls pop up panel are,

- Abort Dosing
- Goto Ready
- Goto Stopped

Transition to the 'Dosing' state can only occur when the system is in the 'Ready' operational state. Operator transition to the 'Ready' state can only occur from the 'Stopped' state, this is achieved by selecting 'Goto Ready' on the Sequence Controls pop up panel.

The lime water dosing system can transition to a 'Stopped' state by the Operator selecting any of the following commands from the Sequence Controls pop up panel,

- 'Abort Dosing'
- Goto Stopped, only when the system is in the 'Ready' state

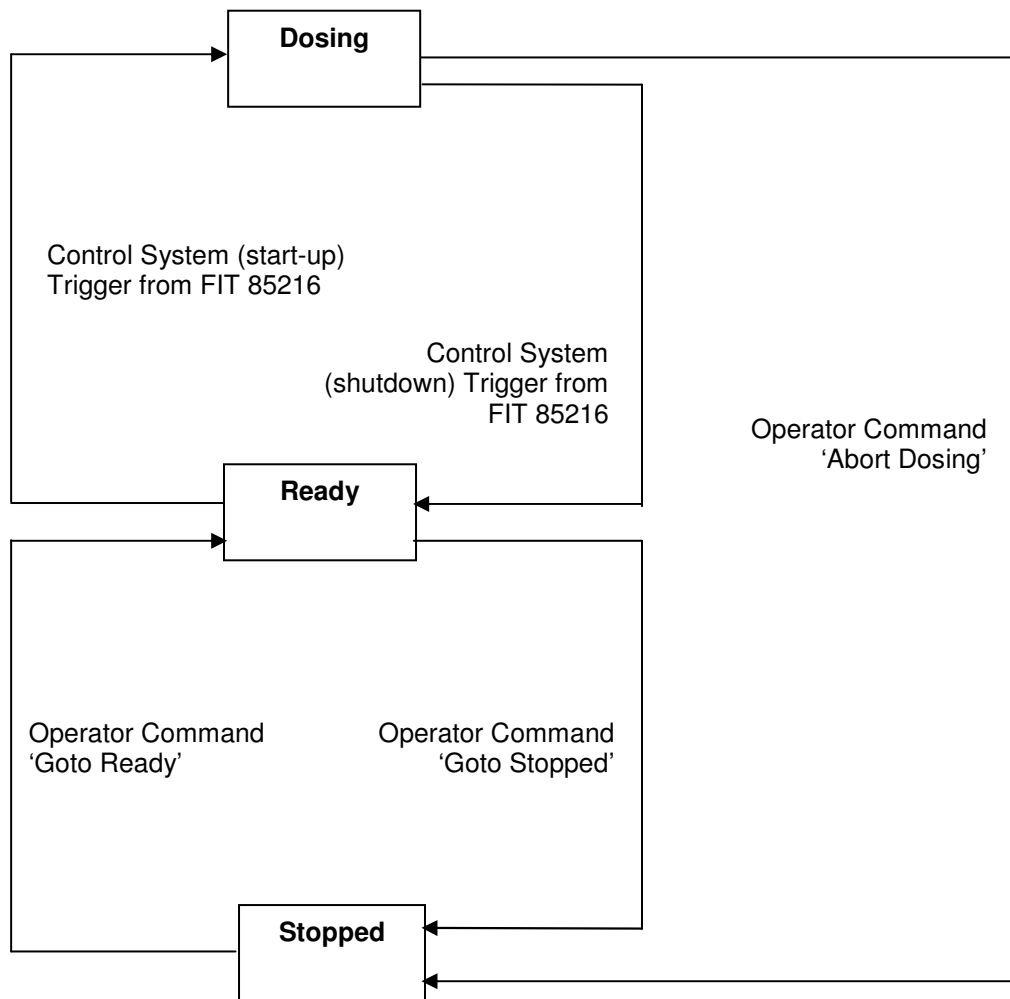
The inter-relationship between these operational states and the commands is shown in the Figure 1.5.

The devices within the lime water dosing system are controlled by a group controller as discussed in Section 1.3. The devices associated with the Group Controller are shown in Table 1.7.

Plant Device
Lime water dosing pump PU 85111
Lime water dosing pump PU 85112
Lime water dosing pump PU 85113
Lime dosing pump common delivery valve VA85121
Lime water mixing pump PU 85114
Lime water mixing pump PU 85115

**Table 1.7 Devices Associated with Group Controller**

Individual valves, if faulted, alarmed, electrically isolated or tagged as 'Out of Service', will present their status on the HMI and to the Group Controller as 'Not Available'. All three dosing pumps have to be 'Not Available' for the Group Controller to be 'Not Available'. Both lime water mixing pumps have to be 'Not Available' for the Group Controller to be 'Not Available'.



**Figure 1.5 Operational States Associated with Lime Water Dosing System**

Two lime water mixing pumps PU 85114 and PU 85115 are installed operating in a duty standby arrangement. The control system incorporates a toggle button on the HMI display to enable the Operator to manually select the duty pump. If the selected duty pump is ‘Not Available’ when required to operate then the standby pump will automatically commence operation. The failed pump will not be available for selection until the alarm condition is acknowledged and reset.

The pre-requisites, triggers and interlocks for the control sequences are described in detail in Section 9.2.

## 1.7 Operation of Lime Sump Pumps

The sumps in the lime building and under the lime clarifier can operate independently of the operation of the lime system.

The settings on the HMI display will allow a pumping system for a sump to operate in both an automatic mode through the level switches in the sump and for the Operator to manually intervene and initiate pump operation. This is achieved from a pop up display on the HMI screen for each sump pump that has the functionality shown in Figure 1.6. The selector can be moved from AUTO to MANUAL when a sump pump is operating.

If START is selected in manual mode the pump will continuously operate irrespective of the level in the sump. STOP will terminate the pump operation.

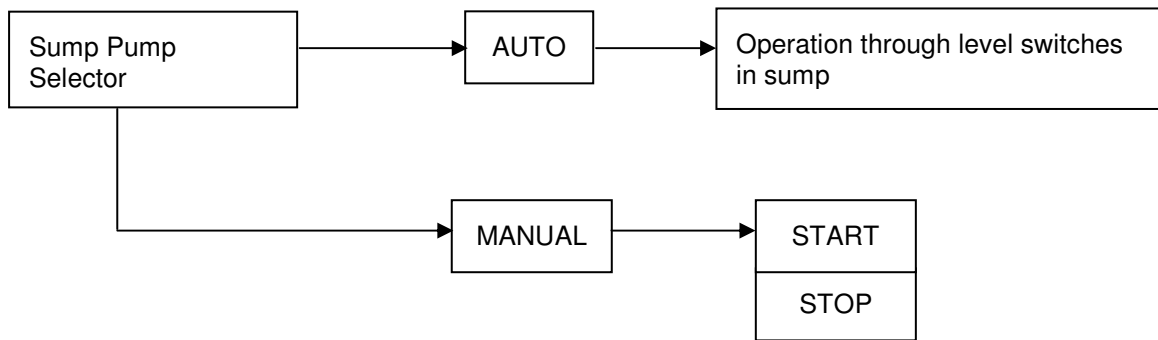


Figure 1.6 Sump Pump Operation

## 1.8 Control Sequences

The main control sequences associated with the lime load-in, preparation, clarification and dosing system are listed in Table 1.8.

Sequence No.	Sequence Description
POT_LL1_01	Hydrated Lime Load-in Sequence for System 1 Silo Filling Operation
POT_LL1_02	'Load-in Abort' Sequence for System 1 Silo Filling Operation
POT_LL2_01	Hydrated Lime Load-in Sequence for System 2 Silo Filling Operation
POT_LL2_02	'Load-in Abort' Sequence for System 2 Silo Filling Operation
POT_LD_01	'Goto Ready' Sequence for Lime Water Dosing
POT_LD_02	'Dosing Start Up' Sequence for Lime Water Dosing
POT_LD_03	'Dosing Abort' Sequence for Lime Water Dosing
POT_LD_04	'Dosing Shutdown' Sequence for Lime Water Dosing
POT_LD_05	'Goto Stop' Sequence for Lime Water Dosing
POT_LC_01	'Goto Ready' Sequence for Lime Clarification
POT_LC_02	'Clarification Start Up' Sequence for Lime Clarification
POT_LC_03	'Clarification Abort' Sequence for Lime Clarification
POT_LC_04	'Clarification Shutdown' Sequence for Lime Clarification
POT_LC_05	'Goto Stop' Sequence for Lime Clarification
POT_LC_06	'Underflow Pumping' Sequence
POT_ML1_01	'Goto Ready' Sequence for Milk of Lime Preparation System 1
POT_ML1_02	'Preparation Start Up' Sequence for MOL Preparation System 1
POT_ML1_03	'Preparation Abort' Sequence for MOL Preparation System 1
POT_ML1_04	'Preparation Shutdown' Sequence for MOL Preparation System 1
POT_ML1_05	'Goto Stop' Sequence for MOL Preparation System 1
POT_ML1_06	Hydrated Lime Feeding Sequence for MOL Preparation System 1
POT_ML2_01	'Goto Ready' Sequence for Milk of Lime Preparation System 2

POT_ML2_02	'Preparation Start Up' Sequence for MOL Preparation System 2
POT_ML2_03	'Preparation Abort' Sequence for MOL Preparation System 2
POT_ML2_04	'Preparation Shutdown' Sequence for MOL Preparation System 2
POT_ML2_05	'Goto Stop' Sequence for MOL Preparation System 2
POT_ML2_06	Hydrated Lime Feeding Sequence for MOL Preparation System 2

**Table 1.8 List of Main Control Sequences**

The step details and description of these control sequences are not included in this standard.

## 1.9 Interaction with Water Treatment Plant System

The status of the lime system is one of the pre-requisites for operation of the water treatment plant in automatic mode. The lime system is 'Available' if the conditions shown in Table 1.9 are current.

<b>Lime System Status for AUTO Operation of the Water Treatment Plant</b>
Lime Water Dosing system is in the 'Ready' operational state
<b>AND</b> Lime Clarification system is in the 'Ready' operational state
<b>AND</b> Milk of Lime System 1 is in the 'Ready' operational state <b>OR</b> Milk of Lime System 2 is in the 'Ready' operational state

**Table 1.9 Conditions for 'Availability' of Lime System**

The transition of the lime system operational state to a 'Stopped' condition will not terminate operation of the water treatment plant if it is operating.

If the lime water dosing system is transitioned to the 'Stopped' state from the 'Dosing' state by an abort interlock or trigger then the following alarm message is displayed on the HMI screen,

Alarm Message: *"Lime dosing system failure"*

## 1.10 Reference P&IDs, Tag Numbers & Values

The tag numbers used in this functional specification have been taken from the Water Corporation's Corrosive Chemical Standard Design for Lime Systems which includes the following drawing numbers:

- JD71-060-084.1 through to JD71-060-084.6 for Milk of Lime Preparation
- JD71-060-084.7 through to JD71-060-084.9 for Lime Clarification
- JD71-060-085.1 and JD71-060-085.2 for Lime Water Dosing

*All values used in this functional specification for set points, defaults, timers and alarms etc are typical values that have been provided for information only. These values will need to be revised by future designers and contractors to make them specific for each site.*

## 2 Milk of Lime Preparation System 1 Instrumentation

### 2.1 Hydrated Lime Storage System 1

The following drives, valves and instruments are associated with the hydrated lime loading and storage silo TA 84110.

#### 2.1.1 Drives

##### Lime Silo Dust Filter Extraction Fan FN 84106

Each silo has a filter to prevent lime dust escaping to the atmosphere during the load-in process. Air is drawn through the filter by the extraction fan which operates when the silo load-in valve VA 84101 is open. The operation of the fan is terminated 15 mins after VA 84101 closes.

Tag Number	Set Point	Functionality
IY 84106		Fan motor run activated
YS 84106A		Fan motor running
YA 84106	Motor Fault	Fan motor fault. Fan shuts down <ul style="list-style-type: none"> <li>• Interlock to close VA 84101</li> </ul>
KQI 84106	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

##### Bin Activator BA 84108

A bin activator located at the base of the lime storage silo prevents bridging in the silo and ensures a consistent flow of hydrated lime to the rotary valve. The operation of the bin activator is interlocked with the operation of the loss-in-weight feeder FD 84112. The signal to run BA 84108 is initiated when FD 84112 calls for hopper filling and stops when FD 84112 hopper is filled.

If BA 84108 fails during operation, an interlock will terminate operation of lime preparation System 1.

Tag Number	Set Point	Functionality
IY 84108		Activator run activated
YS 84108A		Activator running
YA 84108	Motor Fault	Activator fault. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of lime preparation system</li> </ul>
KQI 84108	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

#### 2.1.2 Valves

##### Load-in Valve VA 84101

This valve opens to allow a delivery of hydrated lime to be conveyed into the silo. In addition to the standard valve control from the PLC, this valve can be opened and closed by pushbuttons (HS 84101C & HS 84101D) on the load-in panel. The valve position is displayed on the load-in panel and the HMI screen.

A lime delivery normally takes 45 - 60 mins to unload, after the delivery is complete the driver will normally close this load-in valve from the load-in panel. This valve is programmed to close if it remains open for longer than 90 mins, unless the unloading is still taking place as indicated by a continuing increase in the lime silo weight. This valve shall automatically close when

there is a failure (fail-closed). Closing the valve also acts to prevent the dust filter extractor fan from overheating as the fan is programmed to stop 15 mins after the load-in valve closes.

Tag Number	Set Point	Functionality
ZSH 84101	Fully open	ZIH 84101 notifies the control system that the load-in valve is open including a light indication at the load-in panel to notify the operator/delivery driver.
ZSL 84101	Fully closed	ZIL 84101 notifies the control system that the load-in valve is closed including a light indication at the load-in panel to notify the operator/delivery driver.
ZA 84101	Valve Fault	HMI alarm displayed on HMI screen “VA 84101 failed” <ul style="list-style-type: none"> <li>No Interlock (Valve closed automatically)</li> </ul>

### 2.1.3 Instruments

#### Lime Silo Load Cells WIT 84102

The weight in the silo is measured by load cells WE 84102 using sensors located beneath the silo support legs. The load cell is calibrated in tonnes. The weight is displayed on the HMI panel, on the load-in panel and it also has a local display (typically mounted on the lime building wall at the mezzanine level).

Tag Number	Typical Set Point	Functionality
WI 84102		Weight in silo displayed on HMI display, load-in panel and locally.
WAHH 84102	100% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WAHH 84102 Lime Silo TA 84110 overfull” <ul style="list-style-type: none"> <li>Interlock to close VA 84101 after 1 minute</li> <li>“Silo Full Load-in Stopped” Alarm light illuminated on the load-in panel</li> </ul>
WAH 84102	93% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WAH 84102 Lime Silo TA 84210 full” <ul style="list-style-type: none"> <li>Load-in panel alarm light “Silo Full Stop Load-in” and audible alarm sounds to notify the operator to stop filling the silo.</li> </ul>
YSL 84102 (WAL 84102)	Calculated, see Section 8.5.1	Message displayed on HMI screen “WAL 84102 Lime Silo TA 84110 low weight, re-order lime” <ul style="list-style-type: none"> <li>Indicator light “OK to Fill Silo” illuminated on the load-in panel to notify operator that silo can be filled</li> </ul>
WALL 84102	3% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WALL 84102 Lime Silo TA 84110 empty” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Level Switch LSH 84103

A high level in the silo is registered by a vibrating fork level switch LSH 84103.

Tag Number	Typical Set Point	Functionality
LSH 84103	1.2m below top of silo	HMI alarm displayed on HMI screen “LAH 84103 Lime Silo TA 84110 level high” <ul style="list-style-type: none"> <li>Interlock to close VA 84101 after 10 seconds</li> <li>Alarm light “Silo High Level Load-in Stopped” illuminated on the load-in panel</li> </ul>

### Pressure Switch PSH 84104

A high pressure in the silo is registered by pressure switch PSH 84104.

Tag Number	Typical Set Point	Functionality
PSH 84104	10 kPa	HMI alarm displayed on HMI screen “PAH 84104 Lime Silo TA 84110 pressure high” <ul style="list-style-type: none"> <li>• Interlock to close VA 84101 after 10 seconds</li> <li>• Alarm light “Silo High Pressure Load-in Stopped” illuminated on the load-in panel</li> </ul>

### Access Hatch Switch YS 84105

Switch located in the access hatch to advise when the hatch is open.

Tag Number	Set Point	Functionality
YS 84105		HMI alarm displayed on HMI screen “YA 84105 Access Hatch open” <ul style="list-style-type: none"> <li>• Interlock to prevent VA84101 from being opened or trigger to close VA84101 if it is already open.</li> <li>• Interlock to prevent Milk of Lime Preparation System 1 from operating or trigger to shut it down.</li> </ul>

## 2.2 Lime Feeding & Mixing System 1

The following drives, valves and instruments are associated with the transfer of hydrated lime from the lime storage silo TA 84110 to the mixing tank TA 84310, producing a milk of lime suspension that is pumped to the clarifier.

### 2.2.1 Drives

#### Rotary valve RV 84111

A fixed speed rotary valve RV 84111 controls the discharge of hydrated lime from the silo into the hopper of the loss-in-weight feeder. The operation of the rotary valve is interlocked with the operation of the loss-in-weight feeder FD 84112. The signal to run RV 84111 is initiated when FD 84112 calls for hopper filling and stops when FD 84112 hopper is filled.

If RV 84111 fails during operation, an interlock will terminate operation of the milk of lime preparation system.

Tag Number	Set Point	Functionality
IY 84111		Run activated
YS 84111A		Rotary valve running
YA 84111	Motor Fault	Rotary valve fault. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
KQI 84111	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Loss-in-Weight Feeder FD 84112

The loss-in-weight feeder consists of a hopper with an agitator AG84112 and a metering screw feeder FD84112 and it controls the supply of hydrated lime into the mixing tank. If FD 84112 fails during operation, an interlock will terminate operation of the milk of lime preparation system.

Tag Number	Set Point	Functionality
IY 84112		Screw feeder activated
YS 84112A		Screw feeder running
SY 84112		Screw speed
YA 84112	Motor Fault	Screw feeder fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of the milk of lime preparation system</li> </ul>
KQI 84112	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Lime Mixing Tank Mixer MX 84311

The lime mixing tank is fitted with a fixed speed agitator to continuously maintain the lime in suspension. The operation of the mixer MX 84311 is interlocked with the level in the mix tank. The operation of MX 84311 is initiated by YSH 84312 and terminated by LAL 84312. In the event when the operation of the lime preparation system is terminated or when there is a power outage, the tank mixer shall be kept in operation to prevent the milk of lime suspension from settling unless there is a problem with the mixer itself. The mixer shall therefore be connected to backup power supply.

Tag Number	Set Point	Functionality
IY 84311	Run	Mixer activated
YS 84311A		Mixer running
YA 84311	Motor Fault	Mixer fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of the milk of lime preparation system</li> </ul>
KQI 84311	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Milk of Lime Dosing Pump PU 84505

This variable speed pump continuously transfers milk of lime slurry from the mix tank to the lime water clarifier when the lime preparation System 1 is running. The speed of this pump is automatically controlled to a set point using a feed back flow control loop FIC 84505. During shutdown or power outage this pump shall continue to operate for a period of time so that it can be flushed with lime water. The pump shall be connected to backup power supply.



Tag Number	Set Point	Functionality
IY 84505	Run	Pump motor activated
YS 84505A		Pump motor running
SY 84505		Pump motor speed
YA 84505	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>
KQI 84505	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

## 2.2.2 Valves

### Lime Mixing Tank Dilution Valve VA 84305

This flow control valve is modulated by level control loop LIC 84312 to control the flow rate of lime water into the mix tank.

Tag Number	Set Point	Functionality
ZI 84305	Valve Position	Indicates position (% open) of valve on HMI
ZA 84305	Valve Fault	HMI alarm displayed on HMI screen “VA 84305 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Vortex Mixer Lime Water Valve VA 84306

This flow control valve is modulated by flow control loop FIC 84306 to control the flow rate of lime water into the vortex mixer.

This valve must open before the loss-in-weight feeder starts to discharge and must close after the loss-in-weight feeder stops to ensure that hydrated lime is never introduced to the vortex mixer without lime water flowing.

Tag Number	Set Point	Functionality
ZI 84306	Valve Position	Indicates position (% open) of valve on HMI
ZA 84306	Valve Fault	HMI alarm displayed on HMI screen “VA 84306 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Milk of Lime Dosing Valve VA 84501

This valve opens as part of the start up sequence for the milk of lime dosing pump PU 84505. It closes when the operation of the pump is terminated.

Tag Number	Set Point	Functionality
ZSH 84501	Fully open	ZIH 84501 notifies the control system that the valve is open.
ZSL 84501	Fully closed	ZIL 84501 notifies the control system that the valve is closed.
ZA 84501	Valve Fault	HMI alarm displayed on HMI screen “VA 84501 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Milk of Lime Flushing Valve VA 84502

Every time the milk of lime dosing pump PU 84505 stops, faults, or the milk of lime preparation system is shutdown, this valve opens to flush the line for a period of 30 seconds with lime water

pumped from the lime water storage tank. The flushing time is configurable on the HMI display. This valve shall have backup power during outage.

Tag Number	Set Point	Functionality
ZSH 84502	Fully open	ZIH 84502 notifies the control system that the valve is open.
ZSL 84502	Fully closed	ZIL 84502 notifies the control system that the valve is closed.
ZA 84502	Valve Fault	HMI alarm displayed on HMI screen “VA 84502 failed” <ul style="list-style-type: none"> <li>• No Interlock</li> </ul>

## 2.2.3 Instruments

### Lime Mixing Tank Level Switch LSH 84313

A level switch mounted from the tank roof to provide back up to level transmitter LIT 84312 with the following alarms and interlocks.

Tag Number	Typical Set Point	Functionality
LSH 84313	High level set to 0.25 m below top of tank.	HMI alarm displayed on HMI screen “LAH 84313 mixing tank TA 84310 tank water level high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Lime Mixing Tank Level Switch LSL 84313

Level switch mounted on the tank wall to provide back up to level transmitter LIT 84312.

Tag Number	Typical Set Point	Functionality
LSL 84313	Low level set 0.25 m above base of tank.	HMI alarm displayed on HMI screen “LAL 84313 mixing tank TA 84310 tank water level low” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Vortex Mixer Level Switch LSH 84309

This level switch is present to notify the operator of a blockage in the cone or discharge chute of the vortex mixer.

Tag Number	Typical Set Point	Functionality
LSH 84309	High level set to 0.2m below top of vortex mixer	HMI alarm displayed on HMI screen “LAH 84309 vortex mixer water level high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Loss-in-Weight Feeder Load Cells WIT 84112

The loss-in-weight feeder is supplied with its own proprietary loss-in-weight control system (WKIC 84112), incorporating a speed sensor and load cells (WIT 84112). The control system will continuously take weight measurements and compare this to the actual feed rate. The speed of the screw feeder will be adjusted by a variable speed drive to correct any deviation from the required feed rate.

Tag Number	Typical Set Point	Functionality
WKI 84112		Displays lime feed rate (in kg/h) on HMI screen
WAHH 84112	100% of feeder weight (kg)	HMI alarm displayed on HMI screen “WAHH 84112 weigh feeder overfull” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>

WKAH 84112	50% greater than feed rate set point (kg/h)	HMI alarm displayed on HMI screen “WKAH 84112 feed rate has exceeded the set point by more than 50%.” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
YSH 84112	80% of feeder weight (kg)	Terminates operation of hydrated lime hopper filling sequence
YSL 84112	20% of feeder weight (kg)	Initiates operation of hydrated lime hopper filling sequence
WKAL 84112	50% less than feed rate set point (kg/h)	HMI alarm displayed on HMI screen “WKAL 84112 feed rate lower than the set point by more than 50%.” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
WALL 84112	10% of feeder weight (kg)	HMI alarm displayed on HMI screen “WALL 84112 weigh feeder failed to refill” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Lime Mixing Tank Level Transmitter LIT 84312

The level in the milk of lime mixing tank is registered by ultrasonic level transmitter LIT 84312 calibrated in metres. The level transmitter also provides feedback control to level control loop LIC 84312 that determines the degree of opening of flow control valve VA 84305.

Tag Number	Typical Set Point	Functionality
LI 84312		Displays tank level (in metres) on HMI screen
LAHH 84312	90% of max. level	HMI alarm displayed on HMI screen “LAHH 84312 mixing tank TA 84310 tank water level high high” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>
LAH 84312	80% of max. level	HMI alarm displayed on HMI screen “LAH 84312 mixing tank TA 84310 tank water level high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
YSH 84312	40% of max. level	Initiates operation of mixer MX 84311 (regardless of which system is selected for duty) when tank level rises above this set point.
LAL 84312	30% of max. level	HMI alarm displayed on HMI screen “LAL 84312 mixing tank TA 84310 tank water level low” This alarm only applies when the milk of lime preparation system is not in the ‘Stopped’ state <ul style="list-style-type: none"> <li>Interlock to stop mixer MX 84311 if alarm is registered for a continuous period of 2 minutes.</li> </ul>
LALL 84312	20% of max. level	HMI alarm displayed on HMI screen “LALL 84312 mixing tank TA 84310 tank water level low low” This alarm only applies when the milk of lime preparation system is not in the ‘Stopped’ state <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Mixing - Lime Water Flow Transmitter FIT 84307

The flow rate of lime water to the vortex mixer is registered by a magnetic flow meter transmitter FIT 84307. The flow transmitter also provides feedback control to flow control loop FIC 84306 that determines the degree of opening of flow control valve VA 84306.

Tag Number	Typical Set Point	Functionality
FI 84307		Displays flow rate (m <sup>3</sup> /h) on HMI screen
FAHH 84307	30% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAHH 84307 vortex mixer inlet water flow rate high high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
FAH 84307	10% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAH 84307 vortex mixer inlet water flow rate high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FAL 84307	10% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAL 84307 vortex mixer inlet water flow rate low” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FALL 84307	30% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FALL 84307 vortex mixer inlet water flow rate low low”. The low low condition shall be registered for a continuous period of 30 seconds before an alarm condition is active. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Milk of Lime Flow Transmitter FIT 84509

A magnetic flow meter is used to measure the flow of milk of lime into the clarifier. The flow transmitter also provides feedback control to flow control loop FIC 84505 that determines the speed of the milk of lime dosing pump PU 84505.

Tag Number	Typical Set Point	Functionality
FI 84509		Displays flow rate (m <sup>3</sup> /h) on HMI screen
FAHH 84509	75% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAHH 84509 milk of lime flow rate high high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FAH 84509	15% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAH 84509 milk of lime flow rate high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FAL 84509	15% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAL 84509 milk of lime flow rate low”. <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FALL 84509	75% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FALL 84509 milk of lime flow rate low low”. The low low condition has to be registered for a continuous period of 30 seconds before an alarm condition is active. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

### 3 Milk of Lime Preparation System 2 Instrumentation

#### 3.1 Hydrated Lime Storage System 2

The following drives, valves and instruments are associated with the hydrated lime loading and storage silo TA 84210.

##### 3.1.1 Drives

###### Lime Silo Dust Filter Extraction Fan FN 84206

Each silo has a filter to prevent lime dust escaping to the atmosphere during the load-in process. Air is drawn through the filter by the extraction fan which operates when the silo load-in valve VA 84201 is open. The operation of the fan is terminated 15 mins after VA 84201 closes

Tag Number	Set Point	Functionality
IY 84206		Fan motor run activated
YS 84206A		Fan motor running
YA 84206	Motor Fault	Fan motor fault. Fan shuts down <ul style="list-style-type: none"> <li>• Interlock to close VA 84201</li> </ul>
KQI 84206	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

###### Bin Activator BA 84208

A bin activator located at the base of the lime storage silo prevents bridging in the silo and ensures a consistent flow of hydrated lime to the rotary valve. The operation of the bin activator is interlocked with the operation of the loss-in-weight feeder FD 84212. The signal to run BA 84208 is initiated when FD 84212 calls for hopper filling and stops when FD 84212 hopper is filled.

If BA 84208 fails during operation, an interlock will terminate operation of milk of lime preparation System 1.

Tag Number	Set Point	Functionality
IY 84208		Activator run activated
YS 84208A		Activator running
YA 84208	Motor Fault	Activator fault. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
KQI 84208	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

##### 3.1.2 Valves

###### Load-in Valve VA 84201

This valve opens to allow a delivery of hydrated lime to be conveyed into the silo. In addition to the standard valve control from the PLC, this valve can be opened and closed by pushbuttons (HS 84201C & HS 84201D) on the load-in panel. The valve position is displayed on the load-in panel and the HMI screen.

A lime delivery normally takes 45 - 60 mins to unload, after the delivery is complete the driver will normally close this load-in valve from the load-in panel. This valve is programmed to close if it remains open for longer than 90 mins, unless the unloading is still taking place, as indicated by a continuing increase in the lime silo weight. This valve shall automatically close when

there is a failure (fail-closed). Closing the valve also acts to prevent the dust filter extractor fan from overheating as the fan is programmed to stop 15 mins after the load-in valve closes.

Tag Number	Set Point	Functionality
ZSH 84201	Fully open	ZIH 84201 notifies the control system that the load-in valve is open including a light indication at the load-in panel to notify the operator/delivery driver.
ZSL 84201	Fully closed	ZIL 84201 notifies the control system that the load-in valve is closed including a light indication at the load-in panel to notify the operator/delivery driver.
ZA 84201	Valve Fault	HMI alarm displayed on HMI screen “VA 84201 failed” <ul style="list-style-type: none"> <li>No Interlock (Valve closed automatically)</li> </ul>

### 3.1.3 Instruments

#### Lime Silo Load Cells WIT 84202

The weight in the silo is measured by load cells WE 84202 using sensors located beneath the silo support legs. The load cell is calibrated in tonnes. The weight is displayed on the HMI panel, on the load-in panel and it also has a local display (typically mounted on the lime building wall at the mezzanine level).

Tag Number	Typical Set Point	Functionality
WI 84202		Weight in silo displayed on HMI display, load-in panel and locally.
WAHH 84202	100% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WAHH 84202 Lime Silo TA 84210 overfull” <ul style="list-style-type: none"> <li>Interlock to close VA 84201 after 1 minute</li> <li>“Silo Full Load-in Stopped” Alarm light illuminated on the load-in panel</li> </ul>
WAH 84202	93% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WAH 84202 Lime Silo TA 84210 full” <ul style="list-style-type: none"> <li>Load-in panel alarm light “Silo Full Stop Load-in” and audible alarm sounds to notify the operator to stop filling the silo.</li> </ul>
YSL 84202 (WAL 84202)	Calculated, see Section 8.5.1	Message displayed on HMI screen “WAL 84202 Lime Silo TA 84210 low weight, re-order lime” <ul style="list-style-type: none"> <li>Indicator light “OK to Fill Silo” illuminated on the load-in panel to notify operator that silo can be filled</li> </ul>
WALL 84202	3% of silo capacity weight (tonnes)	HMI alarm displayed on HMI screen “WALL 84202 Lime Silo TA 84210 empty” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Level Switch LSH 84203

A high level in the silo is registered by a vibrating fork level switch LSH 84203.

Tag Number	Typical Set Point	Functionality
LSH 84203	1.2m below top of silo	HMI alarm displayed on HMI screen “LAH 84203 Lime Silo TA 84210 level high” <ul style="list-style-type: none"> <li>Interlock to close VA 84201 after 10 seconds</li> <li>Alarm light “Silo High Level Load-in Stopped” illuminated on the load-in panel</li> </ul>

### Pressure Switch PSH 84204

A high pressure in the silo is registered by pressure switch PSH 84204.

Tag Number	Typical Set Point	Functionality
PSH 84204	10 kPa	HMI alarm displayed on HMI screen “PAH 84204 Lime Silo TA 84210 pressure high” <ul style="list-style-type: none"> <li>• Interlock to close VA 84201 after 10 seconds</li> <li>• Alarm light “Silo High Pressure Load-in Stopped” illuminated on the load-in panel</li> </ul>

### Access Hatch Switch YS 84205

Switch located in the access hatch to advise when the hatch is open.

Tag Number	Set Point	Functionality
YS 84205		HMI alarm displayed on HMI screen “YA 84205 Access Hatch open” <ul style="list-style-type: none"> <li>• Interlock to prevent VA84201 from being opened or trigger to close VA84201 if it is already open</li> <li>• Interlock to prevent Milk of Lime Preparation System 2 from operating or trigger to shut it down.</li> </ul>

## 3.2 Lime Feeding & Mixing System 2

The following drives, valves and instruments are associated with the transfer of hydrated lime from the lime storage silo TA 84210 to the mixing tank TA 84410, producing a milk of lime suspension that is pumped to the clarifier.

### 3.2.1 Drives

#### Rotary valve RV 84211

A fixed speed rotary valve RV 84211 controls the discharge of hydrated lime from the silo into the hopper of the loss-in-weight feeder. The operation of the rotary valve is interlocked with the operation of the loss-in-weight feeder FD 84212. The signal to run RV 84211 is initiated when FD 84212 calls for hopper filling and stops when FD 84212 hopper is filled.

If RV 84211 fails during operation, an interlock will terminate operation of the milk of lime preparation system.

Tag Number	Set Point	Functionality
IY 84211		Run activated
YS 84211A		Rotary valve running
YA 84211	Motor Fault	Rotary valve fault. <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
KQI 84211	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Loss-in-Weight Feeder FD 84212

The loss-in-weight feeder consists of a hopper with an agitator AG84212 and a metering screw feeder FD84212 and it controls the supply of hydrated lime into the mixing tank. If FD 84212 fails during operation, an interlock will terminate operation of the milk of lime preparation system.

Tag Number	Set Point	Functionality
IY 84212		Screw feeder activated
YS 84212A		Screw feeder running
SY 84212		Screw speed
YA 84212	Motor Fault	Screw feeder fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of the milk of lime preparation system</li> </ul>
KQI 84212	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Lime Mixing Tank Mixer MX 84411

The lime mixing tank is fitted with a fixed speed agitator to continuously maintain the lime in suspension. The operation of the mixer MX 84411 is interlocked with the level in the mix tank. The operation of MX 84411 is initiated by YSH 84412 and terminated by LAL 84412. In the event when the operation of the lime preparation system is terminated or when there is a power outage, the tank mixer shall be kept in operation to prevent the milk of lime suspension from settling unless there is a problem with the mixer itself. The mixer shall therefore be connected to backup power supply.

Tag Number	Set Point	Functionality
IY 84411	Run	Mixer activated
YS 84411A		Mixer running
YA 84411	Motor Fault	Mixer fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of the milk of lime preparation system</li> </ul>
KQI 84411	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Milk of Lime Dosing Pump PU 84605

This variable speed pump continuously transfers milk of lime slurry from the mix tank to the lime water clarifier when the lime preparation System 2 is running. The speed of this pump is automatically controlled to a set point using a feed back flow control loop FIC 84605. During shutdown or power outage this pump shall continue to operate for a period of time so that it can be flushed with lime water. The pump shall be connected to backup power supply.

Tag Number	Set Point	Functionality
IY 84605	Run	Pump motor activated
YS 84605A		Pump motor running
SY 84605		Pump motor speed
YA 84605	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>



KQI 84605	Hours Run	Number of hours running will be totalised and displayed on the HMI screen
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### 3.2.2 Valves

#### Lime Mixing Tank Dilution Valve VA 84405

This flow control valve is modulated by level control loop LIC 84412 to control the flow rate of lime water into the mix tank.

Tag Number	Set Point	Functionality
ZI 84405	Valve Position	Indicates position (% open) of valve on HMI
ZA 84405	Valve Fault	HMI alarm displayed on HMI screen “VA 84405 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Vortex Mixer Water Valve VA 84406

This flow control valve is modulated by flow control loop FIC 84406 to control the flow rate of lime water into the vortex mixer.

This valve must open before the loss-in-weight feeder starts to discharge and must close after the loss-in-weight feeder stops to ensure that hydrated lime is never introduced to the vortex mixer without lime water flowing.

Tag Number	Set Point	Functionality
ZI 84406	Valve Position	Indicates position (% open) of valve on HMI
ZA 84406	Valve Fault	HMI alarm displayed on HMI screen “VA 84406 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Milk of Lime Dosing Valve VA 84601

This valve opens as part of the start up sequence for the milk of lime dosing pump PU 84605. It closes when the operation of the pump is terminated.

Tag Number	Set Point	Functionality
ZSH 84601	Fully open	ZIH 84601 notifies the control system that the valve is open.
ZSL 84601	Fully closed	ZIL 84601 notifies the control system that the valve is closed.
ZA 84601	Valve Fault	HMI alarm displayed on HMI screen “VA 84601 failed” <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Milk of Lime Flushing Valve VA 84602

Every time the milk of lime dosing pump PU 84605 stops, faults, or the milk of lime preparation system is shutdown, this valve opens to flush the line for a period of 30 seconds with lime water pumped from the lime water storage tank. The flushing time is configurable on the HMI display. This valve shall have backup power during outage.

Tag Number	Set Point	Functionality
ZSH 84602	Fully open	ZIH 84602 notifies the control system that the valve is open.
ZSL 84602	Fully closed	ZIL 84602 notifies the control system that the valve is closed.
ZA 84602	Valve Fault	HMI alarm displayed on HMI screen “VA 84602 failed” <ul style="list-style-type: none"> <li>No Interlock</li> </ul>

### 3.2.3 Instruments

#### Lime Mixing Tank Level Switch LSH 84413

Level switch mounted from the tank roof to provide back up to level transmitter LIT 84412 with the following alarms and interlocks.

Tag Number	Typical Set Point	Functionality
LSH 84413	High level set to 0.25 m below top of tank.	HMI alarm displayed on HMI screen “LAH 84413 mixing tank TA 84410 tank water level high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Lime Mixing Tank Level Switch LSL 84413

Level switch mounted on the tank wall to provide back up to level transmitter LIT 84412.

Tag Number	Typical Set Point	Functionality
LSL 84413	Low level set 0.25 m above base of tank.	HMI alarm displayed on HMI screen “LAL 84413 mixing tank TA 84410 tank water level low” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Vortex Mixer Level Switch LSH 84409

This level switch is present to notify the operator of a blockage in the cone or discharge chute of the vortex mixer.

Tag Number	Typical Set Point	Functionality
LSH 84409	High level set to 0.2m below top of vortex mixer	HMI alarm displayed on HMI screen “LAH 84409 vortex mixer water level high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

#### Loss-in-Weight Feeder Load Cells WIT 84212

The loss-in-weight feeder is supplied with its own proprietary loss-in-weight control system (WKIC 84212), incorporating a speed sensor and load cells (WIT 84212). The control system will continuously take weight measurements and compare this to the actual feed rate. The speed of the screw feeder will be adjusted by a variable speed drive to correct any deviation from the required feed rate.

Tag Number	Typical Set Point	Functionality
WKI 84212		Displays lime feed rate (in kg/h) on HMI screen
WAHH 84212	100% of feeder weight (kg)	HMI alarm displayed on HMI screen “WAHH 84212 weigh feeder overfull” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
WKAH 84212	50% greater than feed rate set point (kg/h)	HMI alarm displayed on HMI screen “WKAH 84212 feed rate has exceeded the set point by more than 50%.” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
YSH 84212	80% of feeder weight (kg)	Terminates operation of hydrated lime hopper filling sequence
YSL 84212	20% of feeder weight (kg)	Initiates operation of hydrated lime hopper filling sequence
WKAL 84212	50% less than feed rate set point (kg/h)	HMI alarm displayed on HMI screen “WKAL 84212 feed rate lower than the set point by more than 50%.” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>

WALL 84212	10% of feeder weight (kg)	HMI alarm displayed on HMI screen “WALL 84212 weigh feeder failed to refill” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
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### Lime Mixing Tank Level Transmitter LIT 84412

The level in the milk of lime mixing tank is registered by ultrasonic level transmitter LIT 84412 calibrated in metres. The level transmitter also provides feedback control to level control loop LIC 84412 that determines the degree of opening of flow control valve VA 84405.

Tag Number	Typical Set Point	Functionality
LI 84412		Displays flow rate (in metres) on HMI screen
LAHH 84412	90% of max. level	HMI alarm displayed on HMI screen “LAHH 84412 mixing tank TA 84410 tank water level high high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
LAH 84412	80% of max. level	HMI alarm displayed on HMI screen “LAH 84412 mixing tank TA 84410 tank water level high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
YSH 84412	40% of max. level	Initiates operation of mixer MX 84411 (regardless of which system is selected for duty) when tank level rises above this set point.
LAL 84412	30% of max. level	HMI alarm displayed on HMI screen “LAL 84412 mixing tank TA 84410 tank water level low” This alarm only applies when the milk of lime preparation system is not in the ‘Stopped’ state <ul style="list-style-type: none"> <li>• Interlock to stop mixer MX 84411 if alarm is registered for a continuous period of 2 minutes.</li> </ul>
LALL 84412	20% of max. level	HMI alarm displayed on HMI screen “LALL 84412 mixing tank TA 84410 tank water level low low” This alarm only applies when the milk of lime preparation system is not in the ‘Stopped’ state <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>

### Mixing - Lime Water Flow Transmitter FIT 84407

The flow rate of lime water to the vortex mixer is registered by magnetic flow meter transmitter FIT 84407. The flow transmitter also provides feedback control to flow control loop FIC 84406 that determines the degree of opening of level control valve VA 84406.

Tag Number	Typical Set Point	Functionality
FI 84407		Displays flow rate ( in m <sup>3</sup> /h) on HMI screen
FAHH 84407	30% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAHH 84407 vortex mixer inlet water flow rate high high” <ul style="list-style-type: none"> <li>• Interlock to terminate operation of milk of lime preparation system</li> </ul>
FAH 84407	10% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAH 84407 vortex mixer inlet water flow rate high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>

FAL 84407	10% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAL 84407 vortex mixer inlet water flow rate low” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FALL 84407	30% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FALL 84407 vortex mixer inlet water flow rate low low”. The low low condition has to be registered for a continuous period of 30 seconds before an alarm condition is active. <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

**Milk of Lime Flow Transmitter FIT84609**

A magnetic flow meter is used to measure the flow of milk of lime into the clarifier. The flow transmitter also provides feedback control to flow control loop FIC 84605 that determines the speed of the milk of lime dosing pump PU 84605.

Tag Number	Typical Set Point	Functionality
FI 84609		Displays flow rate (in m <sup>3</sup> /h) on HMI screen
FAHH 84609	75% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAHH 84609 milk of lime flow rate high high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FAH 84609	15% higher than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAH 84609 milk of lime flow rate high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FAL 84609	15% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FAL 84609 milk of lime flow rate low” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FALL 84609	75% lower than desired flow (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen “FALL 84609 milk of lime flow rate low low”. The low low condition has to be registered for a continuous period of 30 seconds before an alarm condition is active. <ul style="list-style-type: none"> <li>Interlock to terminate operation of milk of lime preparation system</li> </ul>

## 4 Lime Clarification Instrumentation

### 4.1 Lime Clarification

The milk of lime suspension from the lime preparation system is diluted with process water and introduced into the clarifier that produces lime water with a concentration of approximately 1200 mg/L. Underflow from the base of the clarifier is pumped away to the sludge drying beds (or waste treatment facility) section of the plant.

The clarifier components include local starting and stopping equipment, local status indication and alarms and a control system all housed in a control cabinet installed on the clarifier operating platform. The drives, valves and instruments associated with the clarifier are described below.

#### 4.1.1 Drives

##### Clarifier Dilution (Process Water) Pumps, PU 84901, PU 84902 and PU 84903

Two duty and one standby variable speed pumps are installed to supply process water to the clarifier for lime dilution.

The number of operating pumps and their speed is controlled by the level control loop that maintains a constant water level in the lime water storage tank. The loop and the method of synchronising the operating speed of the pumps is described in Section 8.2.

Information on the process water pumps is given below.

Pump Tag Number			Set Point	Functionality
PU 84901	PU 84902	PU 84903		
IY 84901	IY 84902	IY 84903		Pump motor activated
YS 84901A	YS 84902A	YS 84903A		Pump motor running
SY 84901	SY 84902	SY 84903		Pump motor speed
YA 84901	YA 84902	YA 84903	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of pump and initiate operation of standby pump</li> </ul>
KQI 84901	KQI 84902	KQI 84903	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

##### Lime Clarifier Underflow Pumps, PU 84805 and PU 84815

Duty and standby fixed speed progressive cavity pumps are installed to pump the clarifier underflow to the sludge drying beds (or the waste treatment facility). A toggle switch on the HMI screen allows the Operator to select the duty pump.

Information on the underflow pumps is given below.

Pump Tag Number		Set Point	Functionality
PU 84805	PU 84815		
IY 84805	IY 84815		Pump motor activated
YS 84805A	YS 84815A		Pump motor running
YA 84805	YA 84815	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of pump and initiate operation of standby pump</li> </ul>
KQI 84805	KQI 84815	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### Lime Clarifier Rake SS84724 and Rake Lift ME84725

The lime water clarifier is fitted with a rake which keeps sludge mobile and scrapes it towards the central discharge point for withdrawal. This rake is supplied with the clarifier and it has its own control system that lifts the rake in the event of a high torque before lowering it back gradually to its original position. **In the event when the operation of the lime clarification system is terminated or when there is a power outage, the clarifier rake shall be kept in operation to prevent the lime sludge from settling unless there is a problem with the rake itself. The rake drive shall therefore be connected to backup power supply.**

The clarifier rake and rake lifting mechanism shall have the following control functionality.

Tag Number	Set Point	Functionality
IY 84724	Run	Rake motor activated
YS 84724A		Rake motor running
SY 84724		Rake motor variable speed drive
YL 84724B	Forward Direction	Rake direction displayed on HMI display and local panel.
YL 84724C	Reverse Direction	Rake direction displayed on HMI display and local panel.
WAH 84724		Alarm displayed on local panel and HMI screen "WAH 84724 Clarifier Rake Torque High" <ul style="list-style-type: none"> <li>Interlock to lift rake after 30 seconds</li> </ul>
WAHH 84724		Alarm displayed on local panel and HMI screen "WAHH 84724 Clarifier Rake Torque High High" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime clarification system after 30 seconds</li> </ul>
YA 84724A	Motor Fault	Rake motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime clarification system</li> </ul>
YA 84724B	Gear Box Oil Level Low Alarm	Alarm displayed on local panel and HMI screen "YA 84724B Clarifier Rake Gear Box Oil Level Low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
KQI 84724	Hours Run	Number of hours running will be totalised and displayed on the HMI screen and local panel.

Tag Number	Set Point	Functionality
ZSH 84725	Fully raised	ZIH 84725 indicates on the HMI display and local panel that the rake is fully raised.
ZSL 84725	Fully lowered	ZIL 84725 indicates on the HMI display and local panel that the rake is fully lowered.
YA 84725	Motor Fault	Rake lift motor fault. <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
KQI 84725	Hours Run	Number of hours running will be totalised and displayed on the HMI screen and local panel.

### Lime Clarifier Draft Tube Recirculation Impeller MX84723

The clarifier is fitted with an impeller mounted in a draft tube to recirculate a portion of the lime sludge to ensure intimate mixing.

Tag Number	Set Point	Functionality
IY 84723	Run	Impeller motor activated
YS 84723A		Impeller motor running
SY 84723		Impeller motor variable speed drive
YA 84723	Motor Fault	Impeller motor fault. <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
KQI 84723	Hours Run	Number of hours running will be totalised and displayed on the HMI screen and local panel.

## 4.1.2 Valves

### Lime Clarifier Dilution Water Control Valve VA 84917

This flow control valve provides secondary control for the flow of process water into the clarifier. This valve is normally fully open, it only exhibits control action when a single process water pump is operating at minimum speed and the flow is in excess of that required to maintain the set point level in the lime water storage tank.

Tag Number	Set Point	Functionality
ZI 84917	Valve Position	ZI 84917 indicates position (% open) of valve on HMI <ul style="list-style-type: none"> <li>Partially close VA 84917 when dilution water flow from a single process water pump operating at minimum speed still exceeds the flow required</li> </ul>
ZA 84917	Valve Fault	HMI alarm displayed on HMI screen "VA 84917 failed" <ul style="list-style-type: none"> <li>No interlock.</li> </ul>

### Lime Clarifier Underflow Discharge Valve, VA 84712

This valve opens intermittently to bleed sludge from the base of the lime clarifier. The de-sludging operation is carried out on a timed basis with the time intervals configurable on the HMI screen.

In order to avoid draining the clarifier this valve must be able to automatically close upon failure (fail-closed) and when the operation of the clarification system is terminated. Automatic operation of the valve can be inhibited from the HMI screen.

Tag Number	Set Point	Functionality
ZSH 84712	Fully open	ZIH 84712 notifies the control system that the valve is open.
ZSL 84712	Fully closed	ZIL 84712 notifies the control system that the valve is closed.
ZA 84712	Valve Fault	HMI alarm displayed on HMI screen "VA 84712 failed" <ul style="list-style-type: none"> <li>No interlock (Valve closed automatically)</li> </ul>

### Lime Clarifier Underflow Flushing Valve, VA 84706

This valve opens after a de-sludging operation to introduce service water into the line to flush the underflow pumps and sludge line to the sludge drying beds or waste treatment facilities. The operation is carried out on a timed basis with the time intervals configurable on the HMI screen.

This valve must also automatically close when there is a failure (fail-closed).

Tag Number	Set Point	Functionality
ZSH 84706	Fully open	ZIH 84706 notifies the control system that the valve is open.
ZSL 84706	Fully closed	ZIL 84706 notifies the control system that the valve is closed.
ZA 84706	Valve Fault	HMI alarm displayed on HMI screen "VA 84706 failed" <ul style="list-style-type: none"> <li>No interlock (Valve closed automatically)</li> </ul>

### 4.1.3 Instruments

#### Lime Clarifier Dilution Water Flow Transmitter, FIT 84703

This magnetic flow meter monitors the flow of process water into the clarifier.

Tag Number	Typical Set Point	Functionality
FI 84703		Displays flow rate (in m <sup>3</sup> /h) on HMI screen
FAHH 84703	High high flow set to 150% of FI 85119	HMI alarm displayed on HMI screen "FAHH 84703 dilution water flow rate high high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FAH 84703	High flow set to 130% of FI 85119	HMI alarm displayed on HMI screen "FAH 84703 dilution water flow rate high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FAL 84703	Low flow set to 70% of FI 85119	HMI alarm displayed on HMI screen "FAL 84703 dilution water flow rate low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FALL 84703	5 m <sup>3</sup> /h	HMI alarm displayed on HMI screen "FALL 84703 dilution water flow rate low low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>

#### Lime Clarifier Sludge Level Transmitter, LIT 84719

The clarifier is fitted with an ultrasonic level transmitter LIT 84719 which monitors the sludge blanket / lime water interface level. It is calibrated in metres and has the following functionality

Tag Number	Typical Set Point	Functionality
LI 84719		Displays sludge blanket / lime water interface level (in metres) on local panel and HMI screen
LAHH 84719	60% higher than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAHH 84719 sludge level high high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAH 84719	35% higher than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAH 84719 sludge level high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAL 84719	35% lower than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAL 84719 sludge level low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LALL 84719	60% lower than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LALL 84719 sludge level low low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>



### Lime Clarifier Bed Mass Transmitter, LIT 84718

Transmitter LIT 84718 operates on the principle of differential pressure to indicate the bed mass (measured in metres). It has the following functionality.

Tag Number	Typical Set Point	Functionality
LI 84718		Displays bed mass (in metres) on local panel and HMI screen
LAHH 84718	60% higher than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAHH 84718 bed mass high high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAH 84718	35% higher than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAH 84718 bed mass high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAL 84718	35% lower than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LAL 84718 bed mass low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LALL 84718	60% lower than optimal blanket level (m)	Alarm displayed on local panel and HMI screen "LALL 84718 bed mass low low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>

### Lime Clarifier Water Turbidity Transmitter, AIT 84721

Turbidity transmitter AIT 84721 is installed near the clarifier weir box (but in the main tankage of the clarifier) to monitor lime water turbidity. This gives an indication of the suspended solids carry over from the clarifier and potential impact on the final water quality despatched from the plant. It has the following functionality.

Tag Number	Typical Set Point	Functionality
AAHH 84721	300 NTU	Alarm displayed on local panel and HMI screen "AAHH 84721 lime water turbidity high high" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime clarification system if AAHH 84721 registered for 10 minutes. Clarifier rake to be kept in operation.</li> </ul>
AAH 84721	100 NTU	Alarm displayed on local panel and HMI screen "AAH 84721 lime water turbidity high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>

### Lime Clarifier Water Conductivity Transmitter, AIT 84722

Conductivity transmitter AIT 84722 is installed near the clarifier weir box (but in the main tankage of the clarifier) to monitor lime water conductivity. This gives an indication of the lime water concentration being produced. It has the following functionality.

Tag Number	Typical Set Point	Functionality
AAHH 84722	900 mS/m (1,500 mg/L)	Alarm displayed on local panel and HMI screen "AAHH 84722 lime water concentration high high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
AAH 84722	800 mS/m (1,300 mg/L)	Alarm displayed on local panel and HMI screen "AAH 84722 lime water concentration high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
AAL 84722	500 mS/m (800 mg/L)	Alarm displayed on local panel and HMI screen "AAL 84722 lime water concentration low" <ul style="list-style-type: none"> <li>No interlock</li> </ul>

AALL 84722	400 mS/m (600 mg/L)	Alarm displayed on local panel and HMI screen “AALL 84722 lime water concentration low low” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
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### Underflow Pumps Discharge Pressure Transmitter, PIT 84809

Pressure transmitter PIT 84809 is located on the common discharge line from the sludge underflow pumps. The transmitter provides indication of line fouling and will highlight the requirement for pigging of the line. It has the following functionality.

Tag Number	Typical Set Point	Functionality
PAH 84809	500 kPa	HMI alarm displayed on HMI screen “PAH 84809 underflow line pressure high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
PAL 84809	100 kPa	HMI alarm displayed on HMI screen “PAL 84809 underflow line pressure low” <ul style="list-style-type: none"> <li>No interlock</li> </ul>

### Underflow Pumps Discharge Flow Transmitter, FIT 84811

This is a magnetic flow meter that is used to measure the flow of sludge or flushing water to the sludge drying beds (or waste treatment facility).

Tag Number	Typical Set Point	Functionality
FAHH 84811	40 m <sup>3</sup> /h	HMI alarm displayed on HMI screen “FAHH 84811 underflow line flow rate high high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>
FAH 84811	20 m <sup>3</sup> /h	HMI alarm displayed on HMI screen “FAH 84811 underflow line flow rate high” <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
FAL 84811	10 m <sup>3</sup> /h	HMI alarm displayed on HMI screen “FAL 84811 underflow line flow rate low” <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
FALL 84811	5 m <sup>3</sup> /h	HMI alarm displayed on HMI screen “FALL 84811 underflow line flow rate low low” <ul style="list-style-type: none"> <li>Interlock to terminate operation of PU 84805 and PU 84815</li> </ul>

### Underflow Pump 1 (PU 84805) Delivery Pressure Switch PSH 84807

This pressure switch is present to notify the operator of an unacceptable discharge pressure on the pump.

Tag Number	Typical Set Point	Functionality
PSH 84807	600 kPa	HMI alarm displayed on HMI screen “PAH 84807 pump PU 84805 discharge pressure high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>

### Underflow Pump 2 (PU 84815) Delivery Pressure Switch PSH 84817

This pressure switch is present to notify the operator of an unacceptable discharge pressure on the pump.

Tag Number	Typical Set Point	Functionality
PSH 84817	600 kPa	HMI alarm displayed on HMI screen “PAH 84817 pump PU 84815 discharge pressure high” <ul style="list-style-type: none"> <li>No interlock</li> </ul>

## 5 Lime Water Storage and Dosing Instrumentation

The lime water produced in the clarifier gravity flows to a covered lime water tank, where it is stored before being pumped to the stabilisation system.

The drives and instrumentation associated with the storage and pumping system are described below.

### 5.1 Lime Water Storage

#### Lime Water Storage Tank Level Transmitter LIT 85110

The level in the lime water tank TA 85110 is registered by an ultrasonic level transmitter LIT 85110 calibrated in metres. The level transmitter also provides feedback control to level control loop LIC 85110 that determines the flow rate into the clarifier.

Tag Number	Typical Set Point	Functionality
LI 85110		Displays tank level (in metres) on HMI screen
LAHH 85110	90% of max. level (m)	HMI alarm displayed on HMI screen "LAHH 85110 lime water tank level high high" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime clarification system. Clarifier rake to be kept in operation.</li> </ul>
LAH 85110	80% of max. level (m)	HMI alarm displayed on HMI screen "LAH 85110 lime water tank level high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAL 85110	30% of max. level (m)	HMI alarm displayed on HMI screen "LAL 85110 lime water tank level low" <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
LALL 85110	20% of max. level (m)	HMI alarm displayed on HMI screen "LALL 85110 lime water tank level low low" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime dosing system</li> </ul>

#### Lime Water Storage Tank Level Transmitter LIT 85103

This level transmitter provides a back up to level transmitter LIT 85110. It provides alarms and triggers interlocks but does not provide any feed back to the level control loop.

Tag Number	Typical Set Point	Functionality
LI 85103		Displays tank level (in metres) on HMI screen
LAHH 85103	90% of max. level (m)	HMI alarm displayed on HMI screen "LAHH 85103 lime water tank level high high" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime clarification system. Clarifier rake to be kept in operation.</li> </ul>
LAH 85103	80% of max. level (m)	HMI alarm displayed on HMI screen "LAH 85103 lime water tank level high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LAL 85103	30% of max. level (m)	HMI alarm displayed on HMI screen "LAL 85103 lime water tank level low" <ul style="list-style-type: none"> <li>No interlock.</li> </ul>
LALL 85103	20% of max. level (m)	HMI alarm displayed on HMI screen "LALL 85137 lime water tank level low low" <ul style="list-style-type: none"> <li>Interlock to terminate operation of lime dosing system</li> </ul>

## 5.2 Lime Water Dosing

### 5.2.1 Drives

#### Lime Water Dosing Pumps PU 85111, 85112 & 85113

Two duty and one standby variable speed pumps are installed to dose lime water into the recipient clear water.

The number of operating pumps and their speed are controlled by a flow control loop paced from flow meter FIT 85216 in the main pipeline. The loop and the method of synchronising the operating speed of the pumps are described in Section 8.1.

Information on the lime water dosing pumps is given below.

Pump Tag Number			Set Point	Functionality
PU 85111	PU 85112	PU 85113		
IY 85111	IY 85112	IY 85113		Pump motor activated
YS 85111A	YS 85112A	YS 85113A		Pump motor running
SY 85111	SY 85112	SY 85113		Pump motor speed
YA 85111	YA 85112	YA 85113	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of pump and initiate operation of standby pump</li> </ul>
KQI 85111	KQI 85112	KQI 85113	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

#### Lime Water Mixing Pumps, PU 85114 and PU 85115

Lime water is used for preparation of the milk of lime suspension and flushing of the milk of lime transfer pumps. The lime water for mixing and flushing is supplied from the limewater tank by fixed speed pumps operating in a duty/standby arrangement. A toggle switch on the HMI screen allows the Operator to select the duty pump. These pumps shall be connected to backup power supply to ensure flushing of milk of lime pump can take place during power outage.

Pump Tag Number		Set Point	Functionality
PU 85114	PU 85115		
IY 85114	IY 85115		Pump motor activated
YS 85114A	YS 85115A		Pump motor running
YA 85114	YA 85115	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of pump and initiate operation of standby pump</li> </ul>
KQI 85114	KQI 85115	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

### 5.2.2 Valves

#### Lime Water Dosing Pump Common Delivery Valve VA 85121

This valve opens as part of the start up sequence for the lime water dosing. It closes when the lime dosing system is terminated.

Tag Number	Set Point	Functionality
ZSH 85121	Fully open	ZIH 85121 notifies the control system that the valve is open.
ZSL 85121	Fully closed	ZIL 85121 notifies the control system that the valve is closed.
ZA 85121	Valve Fault	HMI alarm displayed on HMI screen "VA 85121 failed" <ul style="list-style-type: none"> <li>• Interlock to terminate operation of lime dosing system</li> </ul>

### 5.2.3 Instruments

#### Lime Water Flow Transmitter, FIT 85119

A magnetic flow meter is used to measure the flow of lime water to the stabilisation system. It also provides feedback into flow control loop FIC 85119.

Tag Number	Typical Set Point	Functionality
FAHH 85119	50% higher than FIC 85119 Set Point (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen "FAHH 85119 lime water dosing flow rate high high" <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
FAH 85119	30% higher than FIC 85119 Set Point (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen "FAH 85119 lime water dosing flow rate high" <ul style="list-style-type: none"> <li>• No interlock.</li> </ul>
FAL 85119	30% lower than FIC 85119 Set Point (m <sup>3</sup> /h)	HMI alarm displayed on HMI screen "FAL 85119 lime water dosing flow rate low" <ul style="list-style-type: none"> <li>• No interlock.</li> </ul>
FALL 85119	5 m <sup>3</sup> /h	HMI alarm displayed on HMI screen "FALL 85119 lime water dosing flow rate low low" <ul style="list-style-type: none"> <li>• Interlock to terminate operation of lime dosing system</li> </ul>

#### Flow Switch, FSL 85132

This flow switch is present to indicate a low flow situation and offer protection to lime water mixing pump PU 85114.

Tag Number	Typical Set Point	Functionality
FSL 85132	Low level set to 2 m <sup>3</sup> /h.	HMI alarm displayed on HMI screen "FAL 85132 lime water mixing flow rate low" <ul style="list-style-type: none"> <li>• Interlock to terminate operation of PU 85114 and initiate operate of standby pump PU 85115</li> </ul>

#### Flow Switch, FSL 85133

This flow switch is present to indicate a low flow situation and offer protection to lime water mixing pump PU 85115.

Tag Number	Typical Set Point	Functionality
FSL 85133	Low level set to 2 m <sup>3</sup> /h.	HMI alarm displayed on HMI screen "FAL 85133 lime water mixing flow rate low" <ul style="list-style-type: none"> <li>• Interlock to terminate operation of PU 85115 and initiate operate of standby pump PU 85114</li> </ul>

## 6 Lime Bund Sumps Instrumentation

### 6.1 Lime Building Bund Sump

The bund area in the lime building is capable of holding the contents of a lime mixing tank. The bund floor is graded to a sump which has two pumps. Level switches within the sump control pump operation to transfer the sump contents to the sludge drying beds (or waste treatment facilities).

#### Lime Building Sump Pumps PU 84610 & PU 84611

A toggle switch on the HMI screen allows the Operator to select the duty sump pump.

Pump Tag Number		Set Point	Functionality
PU 84610	PU 84611		
IY 84610	IY 84611		Pump motor activated
YS 84610A	YS 84611A		Pump motor running
YA 84610	YA 84611	Motor Fault	Pump motor fault. <ul style="list-style-type: none"> <li>Interlock to terminate operation of pump and initiate operation of standby pump</li> </ul>
KQI 84610	KQI 84611	Hours Run	Number of hours running will be totalised and displayed on the HMI screen

#### Sump Level Switches LSL, LSH, LSHH, LSHHH84617

The four switches in the sump have the have the following functionality.

Tag Number	Set Point	Functionality
LSHHH 84617		HMI alarm "LAHHH 84617 lime building sump level high high high" <ul style="list-style-type: none"> <li>No interlock</li> </ul>
LSHH 84617		HMI alarm "LAHH 84617 lime building sump level high high" <ul style="list-style-type: none"> <li>Trigger to start operation of standby sump pump, duty sump pump keeps operating</li> </ul>
LSH 84617		Trigger to start operation of duty sump pump
LSL 84617		Trigger to stop operation of duty and standby sump pump

### 6.2 Lime Clarifier Bund Sump

The lime clarifier and the underflow pumps are located on a concrete pad which grades to a sump. Depending on site layout, other bunds and tanks, such as the lime water pumps' bund and the lime water storage tank scour may also drain to this sump. This sump has a pump to transfer the contents to the sludge drying beds (or waste treatment facilities). Level switches within the sump control pump operation.

#### Lime Clarifier Sump Pump PU 84820

The lime clarifier sump pump has the following functionality.

Tag Number	Set Point	Functionality
IY 84820		Pump motor activated
YS 84820A		Pump motor running
YA 84820	Motor Fault	Pump motor fault.

KQI 84820	Hours Run	Number of hours running will be totalised and displayed on the HMI screen
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**Sump Level Switches LSL, LSH, LSHH84825**

The three switches in the sump have the following functionality.

Tag Number	Set Point	Functionality
LSHH 84825		HMI alarm “LAHH 84825 lime clarifier bund sump level high” <ul style="list-style-type: none"> <li>• No interlock</li> </ul>
LSH 84825		Trigger to start operation of sump pump PU 84820
LSL 84825		Trigger to stop operation of sump pump PU 84820

## 7 Lime System Operating Strategy

### 7.1 Hydrated Lime Loading Operation

Hydrated lime can be loaded into either silo irrespective of the operational status of the lime system. The only prerequisites are that there should be sufficient volume in the silo to receive a full delivery of lime and the access hatch on the silo roof is closed (no hatch open alarm is active). The weight of lime is registered by load cells on the silo, available volume is indicated by an “OK to fill silo” light on the load-in panel.

The operation is controlled in the field from the load-in panel which displays the weight of lime in the silo and any alarms registered by the pressure, weight and level sensors on the silo.

The operator has control of an automatic valve on the inlet to the silo which he opens to allow delivery of hydrated lime from the truck into the silo. If an alarm condition is registered then the control system will automatically close this valve. If there are no alarm conditions and the filling operation proceeds to completion, then the load-in operator will close the valve at the end of the delivery.

There are no alarm conditions pertinent to the load-in operation that will terminate operation of the lime system. With reference to the instrumentation on the silo, the only condition that would terminate operation of a milk of lime preparation system is an alarm low low weight registered by the load cells on the silo.

### 7.2 Lime Water Concentration

The concentration of calcium hydroxide in the lime water prepared in the clarification process can be selected by the Operator on the HMI screen. A typical range available to the Operator is shown in Table 7.1.

	Calcium Hydroxide Concentration in Lime Water
Maximum	1400mg/L (0.14%)
Recommended	1200mg/L (0.12%)
Minimum	900mg/L (0.09%)

**Table 7.1 Typical Selection range for Calcium Hydroxide Concentration in Lime Water**

The control loops will automatically control the mass flow of hydrated lime into the mixing tank and also the flow rate of dilution water to prepare the set concentration. Another factor that has to be considered is the concentration of reactive lime in the delivered hydrated lime. This concentration (in %) is selected by the operator on the HMI display.

The algorithm that calculates the hydrated lime addition also includes a factor for the clarifier operating efficiency, this accounts for un-reacted lime lost in the underflow and allows the Operator to balance the selected calcium hydroxide concentration with that achieved in practice.

The operational philosophy for the milk of lime preparation system is that there will be a constant throughput through the lime mixing tank. This throughput will not vary with the dosing rate of the lime water dosing pumps. The flow rate of dilution water to the clarifier will be controlled such that it essentially equals the flow rate of lime water pumped from the lime system. In this way, the system is hydraulically balanced with the water coming into the system equalling the flow rate of water discharged from the system.



The mass flow of lime in the form of calcium hydroxide leaving the system can be derived from the known flow rate of lime water dosed into the clear water and the calcium hydroxide concentration that has been entered by the Operator, typically 1200mg/L (0.12%). The reactivity of the commercial lime is then taken into account to calculate the mass flow of dry hydrated lime that has to be added to the mixing tank.

The concentration of lime coming out of the mixing tank will vary according to the dosing rate of lime water; the typical variation that might be expected is from 0.18% to 2% which is an acceptable range for milk of lime suspensions.

The milk of lime preparation system can be in one of three operating states, namely

- Running
- Ready
- Stopped

The conditions that enable transition between these states is discussed in Chapter 9. From an operational consideration, the 'Ready' state means that the system is immediately able to respond to a start command and produce milk of lime. Therefore in this state the mixing tank will contain an acceptable level of water for the mixer to operate. On shutdown, when the system returns to the 'Ready' state the mixer will continue to operate.

### 7.3 Lime Dose Rate

The lime dose rate is the amount of calcium hydroxide that is added to the recipient clear water. The calcium content is used in combination with carbon dioxide injection to stabilise the clear water produced by the water treatment plant.

The desired calcium hydroxide dose rate can be selected by the Operator on the HMI display. A typical range available to the Operator is shown in Table 7.2.

	Desired Lime (Calcium Hydroxide) Dose Rate
Maximum	45 mg/L
Recommended	43 mg/L
Minimum	35 mg/L

Table 7.2 Typical Selection range for Calcium Hydroxide Dose Rate Addition to Recipient Water

### 7.4 Clarifier Dilution Water Pump Selection

Three transfer pumps shall be installed to pump process water to the clarifier for dilution of the milk of lime. Two pumps will be assigned as duty pumps and the third pump will be a standby pump.

The tag numbers of the pumps are shown in Table 7.3.

Tag Number
PU 84901
PU 84902
PU 84903

Table 7.3 Tag Number of Process Water for Lime Dilution Pumps

To simplify the control logic, duty pump selection is not on a rotational basis. The Operator assigns a pump to a specific duty pump number. Pump assignment can only be made when the

lime clarification system is in the ‘Stopped’ operational state.

The control logic references a duty pump number, i.e. Duty Pump 1, and not the tag number. The ability to assign pumps to different duty positions enables the Operator to manage pump operational times.

When the lime system commences operation, Duty Pump 1 will initially commence operation and the control system for the pumps will select a second duty pump if the first is not capable of meeting the flow demand. Under the worst case scenario with a high dosing rate of calcium hydroxide and a low concentration in the lime water, two dilution pumps can still meet the process demands, thereby always allowing the third pump to provide a standby redundancy should one of the duty pumps fail.

The lowest required flow rate will occur at minimum plant flows. In this event only one duty pump will be operational. By controlling the flow control valve on the pump discharge while operating the duty pump at its minimum recommended speed, the required low flow rate can be achieved. The control loop is described in more detail in Section 8.2.

## 7.5 Lime Water Dosing Pump Selection

Three transfer pumps shall be installed to pump lime water from the lime water storage tank to the recipient water main. Two pumps will be assigned as duty pumps and the third pump will be a standby pump.

To simplify the control logic, duty pump selection is not on a rotational basis. The Operator assigns a pump to a specific duty pump number. Pump assignment can only be made when the lime dosing system is in the ‘Stopped’ operational state.

The tag numbers of the pumps are shown in Table 7.4.

Tag Number
PU 85111
PU 85112
PU 85113

**Table 7.4 Tag Number of Lime Water Dosing Pumps**

The operator can select any of these pumps to be a Duty Pump 1, Duty Pump 2 or the standby pump. The ability to assign pumps to different duty positions enables the Operator to manage pump operational times.

When the operation of the lime dosing system is initiated the control loop will initiate operation of Duty Pump 1. The control loop will then initiate operation of Duty Pump 2 if insufficient flow can be produced from Duty Pump 1. The operation of the control loop is described in detail in Section 8.1.

If a duty pump is ‘not available’ then the standby pump will automatically take over its operation and the failed duty pump will be unavailable for further operation until the fault is acknowledged and reset.

## 7.6 Operation of Lime Underflow Pumps

Un-reacted solids that are present in the hydrated lime and calcium carbonate that will be precipitated as part of the milk of lime preparation reaction will accumulate in the clarifier. These inert solids will settle to the bottom of the clarifier and require periodic removal.

With reference to the devices in the clarifier group controller, it can be seen that it is not a prerequisite for operation of the clarifier that the underflow pumps are available. This is

because the clarifier is protected by a torque alarm on the rake drive and the dosing system is protected from high turbidity in the overflow from the clarifier by the turbidity analyser. Alarm conditions associated with these parameters will terminate operation of the lime clarification system and thereby the overall lime water production and dosing facility. Sludge blanket instrumentation and its associated alarms will also advise the Operator of conditions that could possibly abort operation of the lime clarification process.

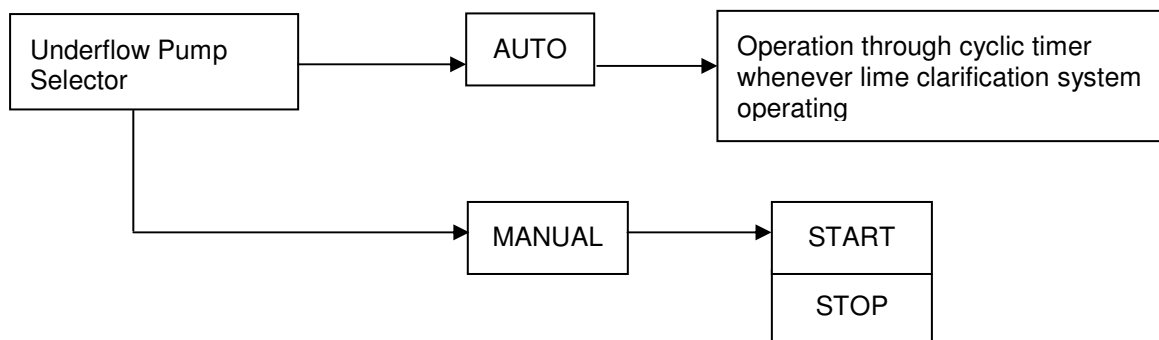
If the clarifier underflow is not simply directed to sludge drying beds, but a waste treatment facility then the operation of the underflow pumps should ideally take place when the waste treatment system is operating and able to accept and process underflow from the lime clarifier. The operation of the underflow pumps should therefore be interlocked with the operation of the waste treatment facility.

The underflow pumps will operate on a cyclic basis whenever the lime clarification process is operating. It is not desirable for lime slurry to remain in the underflow pump suction and discharge lines and therefore after every discharge operation the line is flushed out with service water to remove any residual solids.

The settings on the HMI display will allow the underflow pumps to operate in both an automatic mode through the cyclic timer and for the Operator to manually intervene and initiate pump operation. This is achieved from a pop up display on the HMI screen that has the following functionality shown in Figure 7.1. The selector can be moved from AUTO to MANUAL when the lime clarification system is operating. In the AUTO mode the underflow pumps operate on a cyclic time basis through a timer that is initiated as part of the start up sequence and stopped by the shutdown or abort sequence.

The MANUAL – START command can be issued when the system is in the ‘Ready’ or ‘Running’ state. If relevant, any interlocks with the waste treatment facility (being able to accept sludge) will apply.

If START is selected the duty underflow pump will operate for the duration of the ‘Pump Operation Timer’ setting, it will then proceed through a flushing operation. STOP will terminate the clarifier discharge, the sequence will then proceed through a flushing operation.



**Figure 7.1 Underflow Pump Operation**

The duration of the flushing operation can be selected by the operator on the HMI screen. Recommended timer settings for the operation of the clarifier underflow pumps are shown in Table 7.5.

Settings	Pump Interval Timer	Pump Operation Timer	Flushing Timer
Maximum	2 hours	1200 secs	1200 secs
Recommended	1 hour	300 secs	300 secs
Minimum	30 minutes	60 secs	60 secs

**Table 7.5 Underflow Timer Settings**

## 7.7 Operation of Sumps in Lime Facility

Sumps are installed in the milk of lime preparation building and under the lime clarifier. The former includes two sump pumps operating on a duty and duty assist basis. Only a single pump is installed in the sump under the clarifier.

The discharge from both sumps flows to the sludge drying beds (or waste treatment facility).

Operation of the pumps is independent of operation of the lime water preparation and dosing system. The control system for the pumps has an automatic and manual capability. Under automatic control the pumps operation will be initiated by level switches in the sump. Under manual control the pumps can run independently of the level switches.

## 8 Process Control Loops and Calculations

### 8.1 Lime Water Dosing Flow Rate Control

Control loop FIC 85119 associated with the lime water dosing system controls the introduction of lime water into the recipient clear water main. The control loop is activated during the start up sequence for the lime dosing system which is initiated by a preset flow registered by flow transmitter FIT 85216.

The control loop is flow paced from flow transmitter FIT 85216 located in the recipient clear water pipeline. The flow transmitter FIT 85216 is also used to flow pace the dosing of other chemicals into the recipient water such as chlorine and fluorosilicic acid (FSA).

The set point flow rate calculated by FY 85119 (in m<sup>3</sup>/h) is given by the following formula,

$$\frac{(Flow\ rate\ registered\ by\ FIT\ 85216\ in\ m^3/h) \times (Operator\ input\ for\ desired\ lime\ dose\ rate\ in\ mg/L)}{(Operator\ input\ for\ lime\ water\ concentration\ in\ mg/L)}$$

A schematic of the control loop is shown in Figure 8.1.

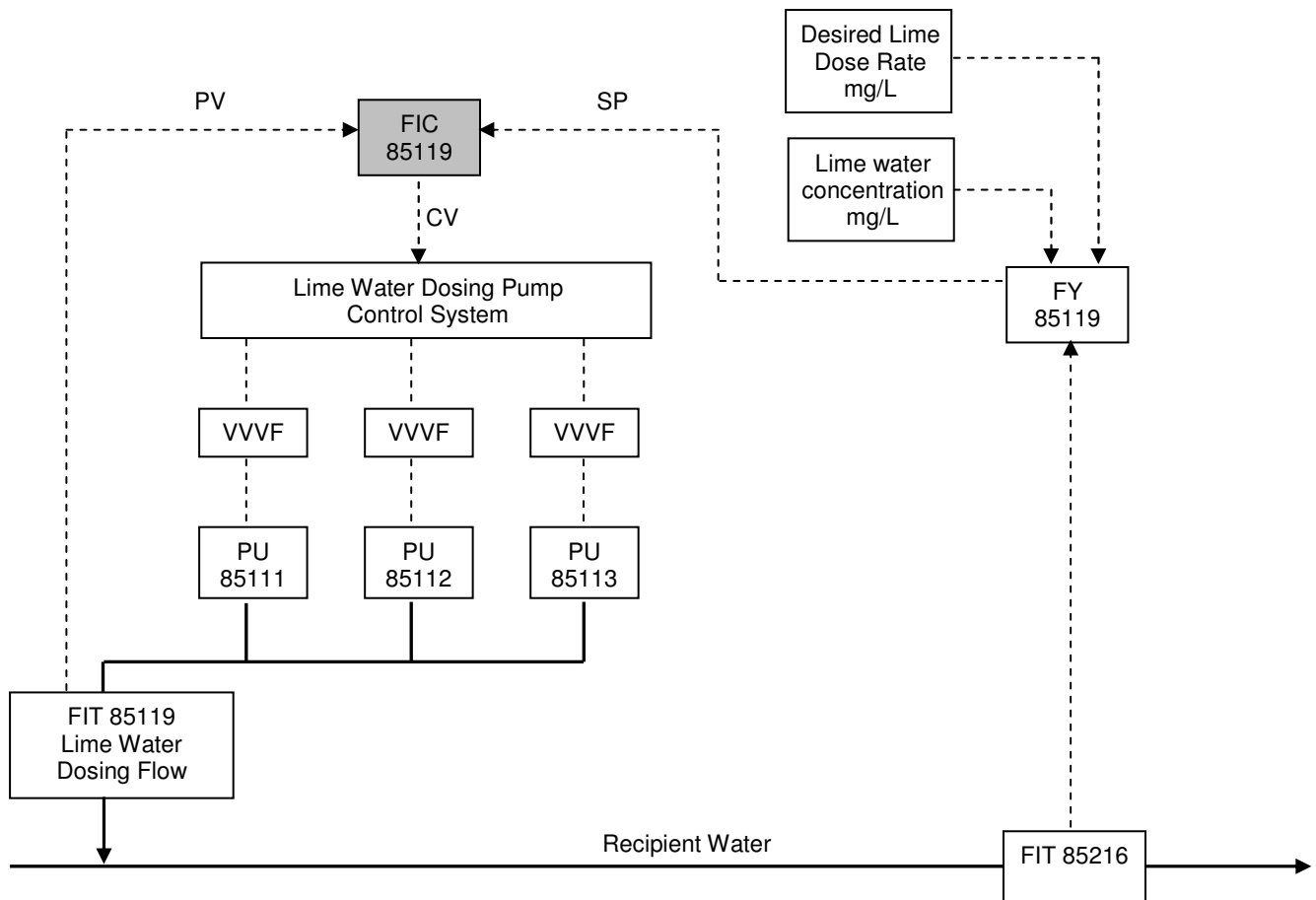


Figure 8.1 Lime Water Dosing Control Loop FIC 85119

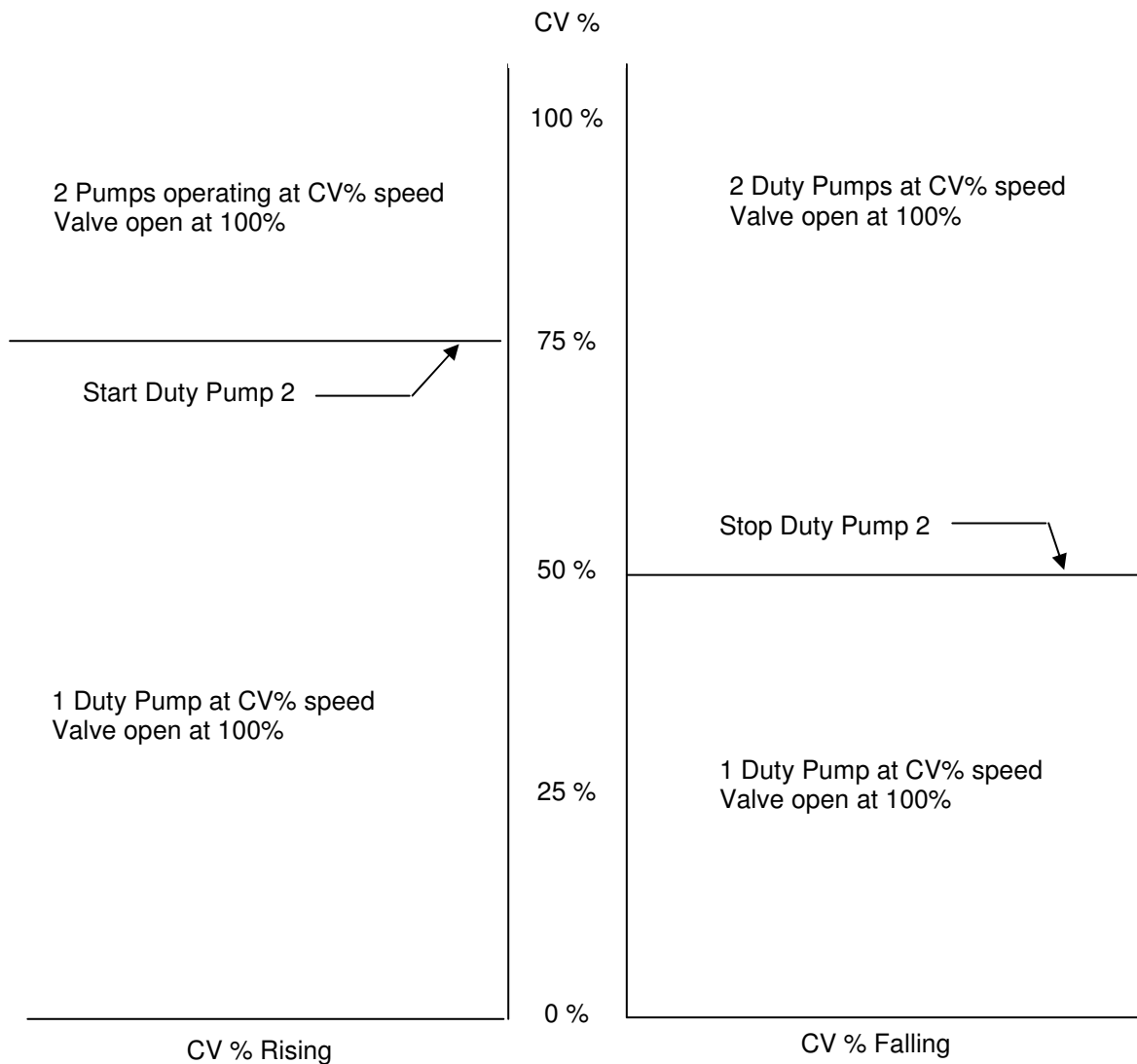
The lime dosing pumps have variable speed drives that enable the pump to operate between a maximum and minimum speed that is programmed into the PLC. The values corresponding to the output control variable are shown in the Table 8.1.

Control variable	Pump speed
100%	60 Hz
0%	20 Hz

**Table 8.1 Settings for Pump Variable Speed Drives**

The number of operating lime dosing pumps and their speed is determined by a pump controller that is based upon the algorithm shown diagrammatically in Figure 8.2. The control variable (CV %) is the percentage of the pump speed between the maximum and minimum values programmed into the variable speed drive units.

When the second duty pump commences operation on a rising CV output the speed will be the same as the operating pump. The flow controller will then reduce the speed of the two pumps until the set point value is registered by FIT 85119.



**Figure 8.2 Control Logic for Lime Water Dosing Pumps**

## 8.2 Clarifier Dilution Water Flow Rate Control

Control loop FIC 84900 associated with the process water dilution pumps to the clarification process is the most complex control loop associated with the lime system. It is used not only to balance the flow out of the lime water tank but also to rapidly respond in a stable manner to maintain a constant lime water level in the lime water tank

The control loop is activated during the start up sequence for the lime clarification system, which is initiated when any of the lime water dosing pumps is running.

The make up dilution pumps have variable speed drives that enable the pump to operate between a maximum and minimum speed that is programmed into the PLC. The values corresponding to the output control variable are shown in Table 8.2.

Control variable	Pump speed
100%	60 Hz
0%	10 Hz

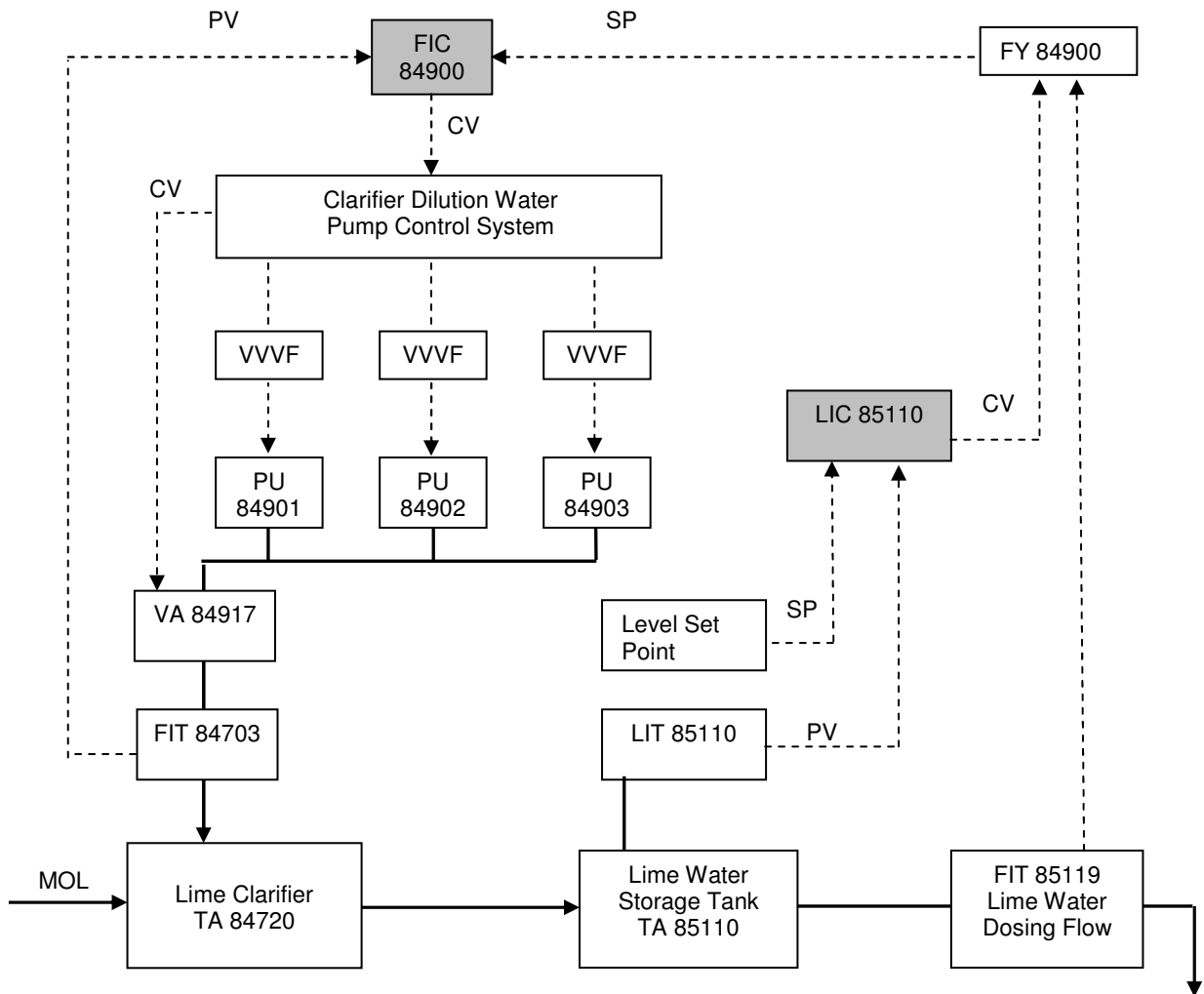
**Table 8.2 Settings for Pump Variable Speed Drives**

The control loop is flow paced from flow transmitter FIT 85119 located in the discharge pipeline from lime water dosing pumps. The control loop also incorporates a refinement that considers the lime water level in the lime water storage tank. This refinement uses the control variable for a conventional PID level control loop LIC 85110 operating on the lime water storage tank. The control variable from LIC 85110 is used in the following formula to calculate the set point flow for control loop FIC 84900. A schematic of the control loop is shown in Figure 8.3.

The set point flow rate calculated by FY 84900 (in m<sup>3</sup>/h) is given by the following formula,

$$(Flow\ rate\ registered\ by\ FIT\ 85119\ in\ m^3/h) \times (0.8 + (0.4 \times CV\% \text{ from LIC 85110}))$$

This effectively gives a  $\pm 20\%$  multiplier on the set point flow rate due to level variation in the lime water storage tank.



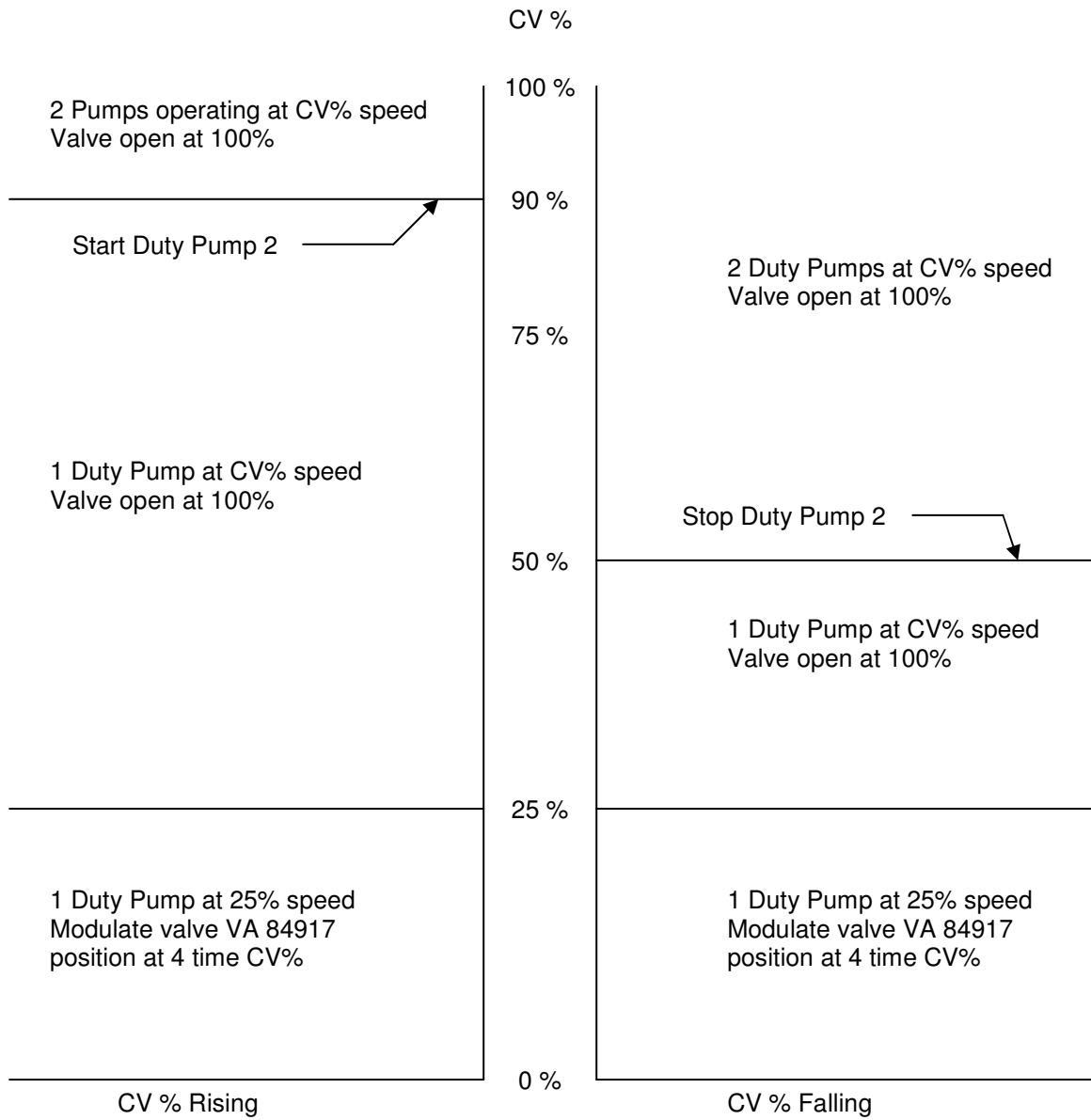
**Figure 8.3 Clarifier Dilution Control Loop FIC 84900**

The number of operating process water dilution water pumps and their speed is determined by a pump controller that is based upon the algorithm shown in Figure 8.4. The control variable (CV %) is the percentage of the pump speed between the maximum and minimum values programmed into the variable speed drive units.

When the second duty pump commences operation on a rising CV output the speed will be the same as the operating pump. The flow controller will then reduce the speed of the two pumps until the set point value is registered by FIT 84703.

It can be seen from the algorithm that flow control valve VA 84917 is used when one operating pump still provided more water than the set point value. In this event valve VA 84917 begins to close and throttle the pump discharge to reduce the flow rate. At a CV% of less than 25% the pump speed is maintained at 25% which corresponds to a speed of 22.5 Hz. When the CV value is greater than 25% the valve is fully open.





**Figure 8.4 Control Logic for Clarifier Dilution Water Pumps**

## 8.3 Milk of Lime Preparation System 1 Control

### 8.3.1 Control Loops

The milk of lime preparation system incorporates three control loops operating on mixing tank TA 84310. The control loops are shown schematically in Figure 8.5 and each is described in the following subsections.

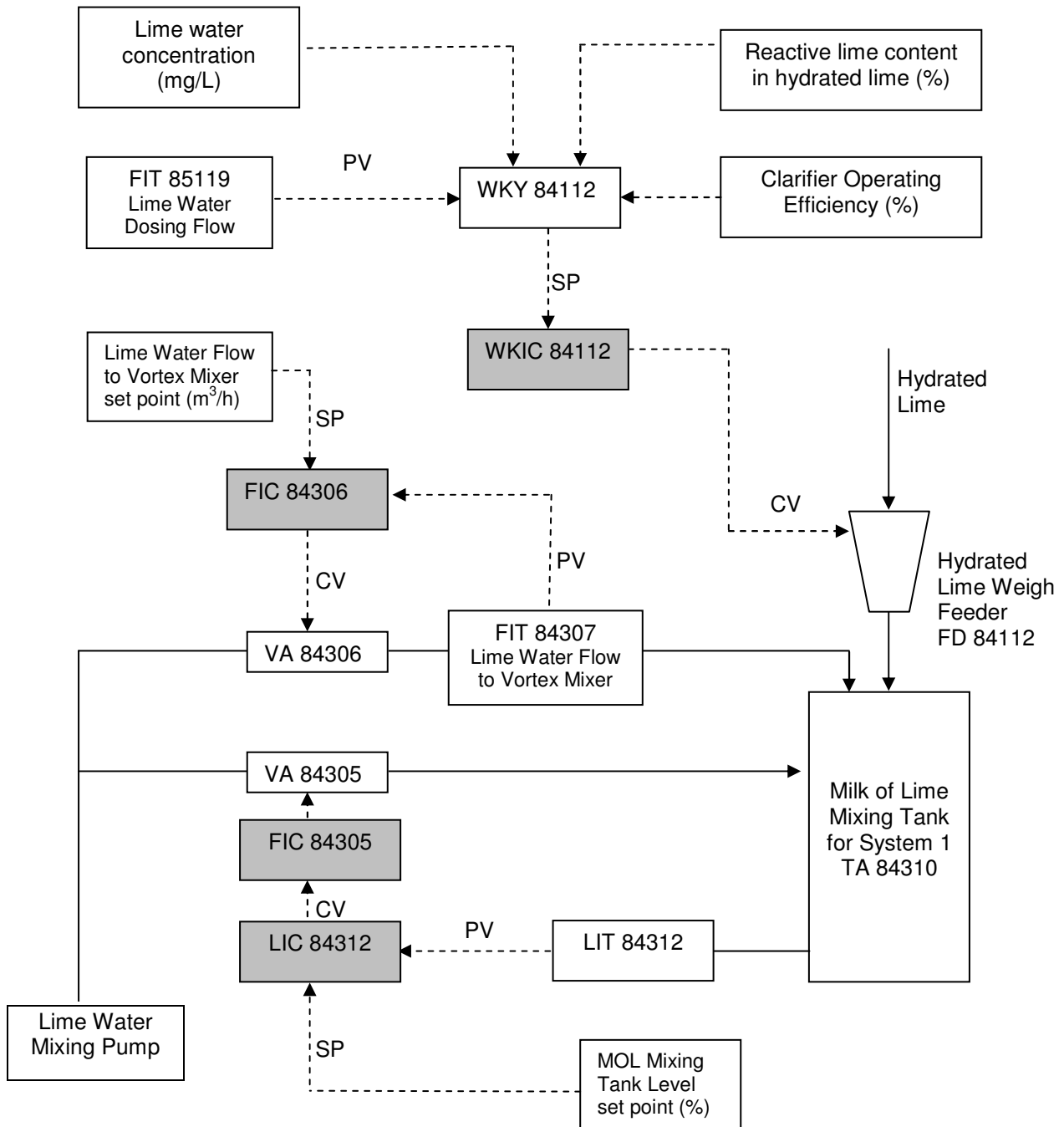


Figure 8.5 Control Loops for Milk of Lime Preparation System 1

### 8.3.2 Hydrated Lime Mass Flow Rate Control, WKIC 84112

Control loop WKIC 84112 controls the feed rate of hydrated lime into the lime mixing tank. The control loop is flow paced from flow transmitter FIT 85119 located on the discharge from the lime water pumps. From knowledge of the lime water flow rate and its concentration, the mass of lime lost from the overall lime facility can be calculated. This mass has to be fed into the mixing tank by the screw feeder FD 84112 controlled by control loop WKIC 84112.

The mass flow rate set point (in kg/h) from the screw feeder is given by the following formula,

$$\frac{(Lime\ Dose\ Flow\ rate\ registered\ by\ FIT\ 85119\ in\ m^3/h) \times (Lime\ water\ concentration\ in\ mg/L)}{(Reactive\ lime\ in\ the\ hydrated\ lime\ in\ \%) \times (Clarifier\ operating\ efficiency\ in\ \%) \times 1000}$$

The lime water concentration, the reactive lime content of the hydrated lime and the clarifier operating efficiency are parameters that can be changed on the HMI screen by personnel with designated log-on privileges.

### 8.3.3 Vortex Mixer Inlet Water Flow Rate Control, FIC 84306

Control loop FIC 84306 is responsible for the controlled flow of lime water into the vortex mixer. The control loop operates at a set flow rate that is registered by flow transmitter FIT 84307 which provides the process value to the control loop. The control value from the controller determines that position of flow control valve VA 84306. The flow rate set point can be configured on the HMI display.

### 8.3.4 Mixing Tank Level Control, LIC 84312

Control loop LIC 84312 is responsible for the maintaining a preset operating water level in the mixing tank. The control loop operates at a set water level that is registered by level transmitter LIT 84312 which provides the process value to the control loop. The control value from the controller determines that position of flow control valve VA 84305.

Typical set point level is 75%. The set point can be configured on the HMI display.

## 8.4 Milk of Lime Preparation System 2 Control

### 8.4.1 Control Loops

The milk of lime preparation system incorporates three control loops operating on mixing tank TA 84410. The control loops are shown schematically in Figure 8.6 and each is described in the following subsections.

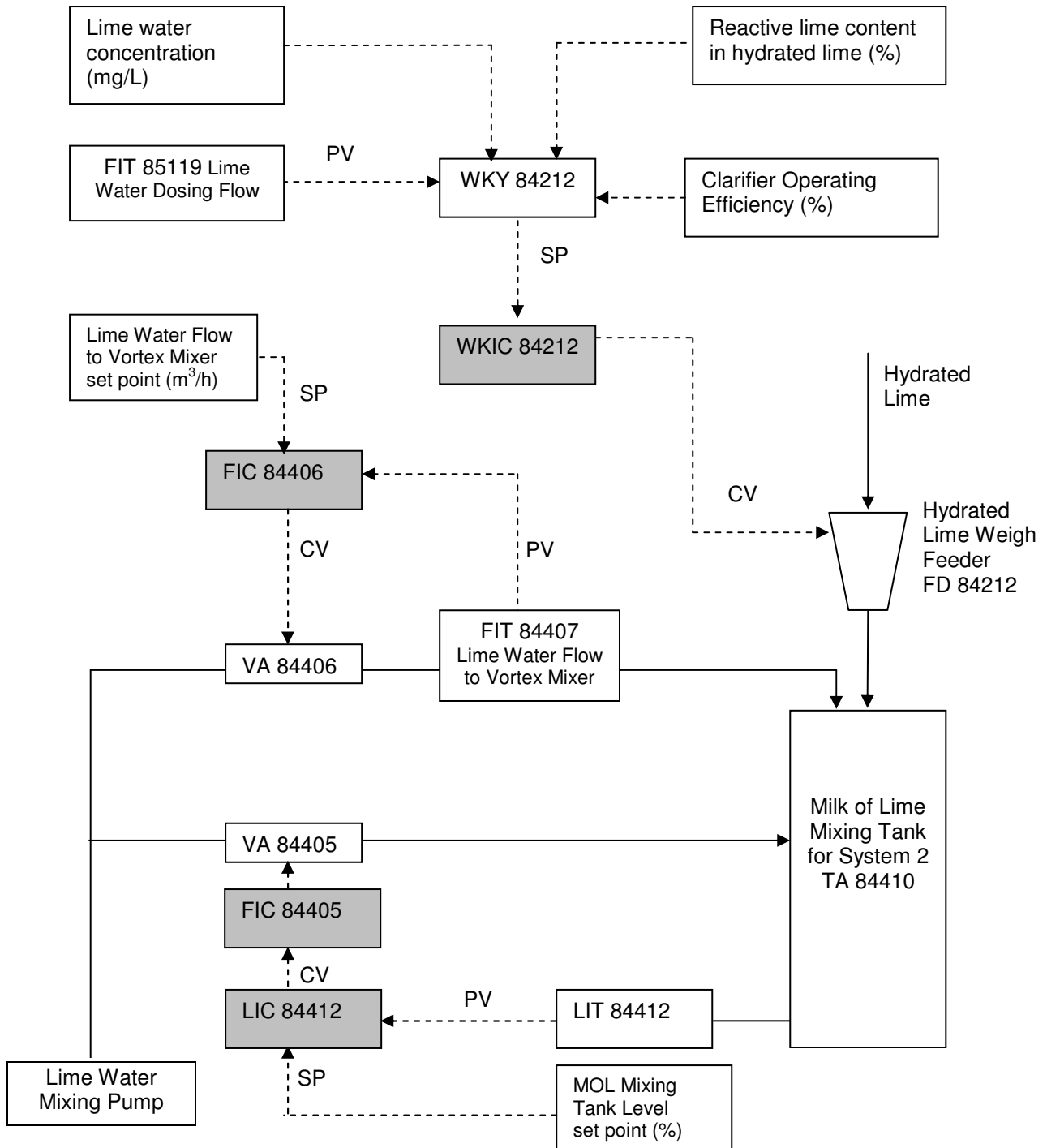


Figure 8.6 Control Loops for Milk of Lime Preparation System 2

## 8.4.2 Hydrated Lime Mass Flow Rate Control, WKIC 84212

Control loop WKIC 84212 controls the feed rate of hydrated lime into the lime mixing tank. The control loop is flow paced from flow transmitter FIT 85119 located on the discharge from the lime water pumps. From knowledge of the lime water flow rate and its concentration, the mass of lime lost from the overall lime facility can be calculated. This mass has to be fed into the mixing tank by the screw feeder FD 84212 controlled by control loop WKIC 84212.

The mass flow rate set point (in kg/h) from the screw feeder is given by the following formula,

$$\frac{(Lime\ Dose\ Flow\ rate\ registered\ by\ FIT\ 85119\ in\ m^3/h) \times (Lime\ water\ concentration\ in\ mg/L)}{(Reactive\ lime\ in\ the\ hydrated\ lime\ in\ \%) \times (Clarifier\ operating\ efficiency\ in\ \%) \times 1000}$$

The lime water concentration, the reactive lime content of the hydrated lime and the clarifier operating efficiency are parameters that can be changed on the HMI screen by personnel with designated log-on privileges.

## 8.4.3 Vortex Mixer Inlet Water Flow Rate Control, FIC 84406

Control loop FIC 84406 is responsible for the controlled flow of lime water into the vortex mixer. The control loop operates at a set flow rate that is registered by flow transmitter FIT 84407 which provides the process value to the control loop. The control value from the controller determines that position of flow control valve VA 84406. The flow rate set point can be configured on the HMI display.

## 8.4.4 Mixing Tank Level Control, LIC 84412

Control loop LIC 84412 is responsible for the maintaining a preset operating water level in the mixing tank. The control loop operates at a set water level that is registered by level transmitter LIT 84412 which provides the process value to the control loop. The control value from the controller determines that position of flow control valve VA 84405.

Typical set point level is 75%. The set point can be configured on the HMI display.

## 8.5 Calculations

The following calculations are associated with the lime system.

### 8.5.1 Available Volume in Lime Silos

For a load-in operation, there must be available volume in the receiving silo to accept a full delivery load of hydrated lime. Depending on the silo capacity, the weight of each bulk delivery and the lime bulk density, the maximum volume and hence weight of the lime that can remain in the silo before re-filling can be calculated.

As an example, bulk deliveries of premium hydrated lime in tankers from Cockburn Cement are approximately 20 tonnes. A load-in operation will therefore add approximately 69 m<sup>3</sup> (20000 kg @ 290 kg/m<sup>3</sup> bulk density) into the silo. The silo will need to have sufficient room available to accommodate this full delivery of lime. Therefore, the remaining volume of lime in a 120 m<sup>3</sup> capacity silo with an operational volume of say 112 m<sup>3</sup> has to be less than 43 m<sup>3</sup> (112 - 69 m<sup>3</sup>) in order to accommodate a full delivery of premium lime.

The weight corresponding to the remaining volume of hydrated lime can be calculated from the following formula,

$$Weight\ (in\ tonnes) = \frac{remaining\ volume\ (m^3) \times bulk\ density\ of\ lime\ (in\ kg/m^3)}{1000}$$

The bulk density of the remaining lime is an Operator entered value on the HMI screen. This

value will depend on whether premium or industrial lime is used.

The value calculated from the above formula is the value applied to the re-order lime set point YSL 84102 and YSL 84202.

When the load cell on System 1 silo registers a value of less than YSL 84102, a message is displayed on the screen advising the Operator of the need to re-order lime and a light illuminates on the silo load-in panel to advise the delivery Operator that the silo can accept a full delivery (WAL 84102 triggered). Similarly with the silo for System 2 which responds to YSL 84202 (WAL 84202 triggered).

## 9 Pre-Requisites, Triggers and Interlock Conditions

### 9.1 Definitions

The following definitions have been applied,

Pre-requisite	Requirement for a sequence to commence
Interlock	Condition that will prevent an undesirable activation or outcome
Trigger	An event when the system is in an operational state that will initiate another sequence
Abort	A sequence resulting from an interlock that will return the system to the 'Stopped' state

### 9.2 Lime Water Dosing System

The following pre-requisites are required to transition the dosing system from a 'Stopped' state to the 'Ready' state.

Pre- requisites to Transition System to the 'Ready' State
Group Controller POT_LD_GC is selected to the AUTO position on the HMI display
<b>AND</b> Group Controller POT_LD_GC devices are 'Available' as defined in Section 1.6.
<b>AND</b> Level transmitter LALL 85110 'Not Active'
<b>AND</b> Level transmitter LALL 85103 'Not Active'

The following triggers will transition the dosing system from a 'Ready' state back to the 'Stopped' state.

Triggers that will Transition System to the 'Stopped' State
Group Controller POT_LD_GC devices are 'Not Available' as defined in Section 1.6.
<b>OR</b> Level transmitter LALL 85110 'Active'
<b>OR</b> Level transmitter LALL 85103 'Active'

The following trigger will initiate the sequence that will transition the dosing system from the 'Ready' state to the 'Dosing' state.

Trigger to Transition System to the 'Dosing' State
Flow transmitter FIT 85216 registers a recipient clear water flow > X m3/h for a period of 30 secs

The following pre-requisites are required to enable transition of the dosing system from the 'Ready' state to the 'Dosing' state.

Pre- requisites to Transition System to the 'Dosing' State
Group Controller POT_LC_GC is in the 'Ready' operational state
<b>AND</b> Group Controller POT_ML1_GC is in the 'Ready' operational state <b>OR</b> Group Controller POT_ML2_GC is in the 'Ready' operational state

The following interlocks will abort the 'Dosing' starting sequence and return the dosing system to the 'Stopped' state.

<b>Dosing Abort Interlocks</b>
Group Controller devices are 'Not Available' as defined in Section 1.6.
<b>OR</b> Level transmitter LALL 85110 'Active'
<b>OR</b> Level transmitter LALL 85103 'Active'

The following triggers will initiate the sequence that will transition the dosing system from the 'Dosing' state to the 'Ready' state.

<b>Triggers to Transition System to the 'Ready' State</b>
Flow transmitter FIT 85216 registers a recipient clear water flow <Xm3/h for a period of 30 secs.
<b>OR</b> Group Controller POT_LC_GC is in the 'Stopped' operational state
<b>OR</b> Group Controller POT_ML1_GC is in the 'Stopped' operational state for a period of 5 minutes <b>AND</b> Group Controller POT_ML2_GC is in the 'Stopped' operational state for a period of 5 minutes

The following trigger will initiate the sequence that will transition the dosing system from the 'Dosing' state to the 'Stopped' state.

<b>Dosing Abort Trigger</b>
Operator initiates 'Abort Dosing' command

## 9.3 Lime Clarification System

### 9.3.1 Lime Water Clarification Operation

The following pre-requisites are required to transition the clarification system from a 'Stopped' state to the 'Ready' state.

<b>Pre- requisites to Transition System to the 'Ready' State</b>
Group Controller POT_LC_GC is selected to the AUTO position on the HMI display
<b>AND</b> Group Controller POT_LC_GC devices are 'Available' as defined in Section 1.5.

The following triggers will transition the clarification system from a 'Ready' state back to the 'Stopped' state.

<b>Triggers that will Transition System to the 'Stopped' State</b>
Group Controller POT_LC_GC devices are 'Not Available' as defined in Section 1.5.

The following triggers will initiate the sequence that will transition the clarification system from the 'Ready' state to the 'Running' state.

<b>Triggers to Transition System to the 'Running' State</b>
Group Controller POT_LD_GC is selected to the AUTO position on the HMI display
<b>AND</b> Lime dosing pump PU 85111 'running' <b>OR</b> PU 85112 'running' <b>OR</b> PU 85113 'running'

The following pre-requisite is required to enable transition of the clarification system from the 'Ready' state to the 'Running' state.

<b>Pre- requisites to Transition System to the 'Running' State</b>
Group Controller POT_LC_GC devices are 'Available' as defined in Section 1.5.



The following interlocks will abort the 'Running' starting sequence and return the clarification system to the 'Stopped' state.

<b>'Running' Abort Interlocks</b>
Group Controller POT_LC_GC devices are 'Not Available' as defined in Section 1.5.

The following trigger will initiate the sequence that will transition the clarification system from the 'Running' state to the 'Ready' state.

<b>Trigger to Transition System to the 'Ready' State</b>
Lime dosing pump PU 85111 'not running' AND PU 85112 'not running' AND PU 85113 'not running'

The following triggers will initiate the sequence that will transition the clarification system from the 'Running' state to the 'Stopped' state.

<b>'Running' Abort Triggers</b>
Operator initiates 'Abort Running' command
<b>OR</b> Group Controller POT_LC_GC devices are 'Not Available' as defined in Section 1.5.
<b>OR</b> AAHH 84721 'Active' for 10 minutes

### 9.3.2 Underflow Pumping

Underflow pumping is not an operational state but a sequence that can only run when the clarification process is in a 'Running' or 'Ready' operational state.

There are triggers that initiate an underflow pumping sequence, pre-requisites for it to execute and interlocks that will terminate the sequence. The lime clarification system will continue to operate in the 'Running' operational state irrespective of the status of the underflow pumping system.

The following triggers will initiate an underflow pumping sequence.

<b>Triggers that will initiate an Underflow Pumping Sequence</b>
Interval timer between underflow pump operations on cyclic timer has timed out
<b>OR</b> Operator manually initiates start up of sequence from HMI screen

The following pre-requisites are required to execute an underflow pumping sequence.

<b>Pre- requisites to execute an Underflow Pumping Sequence</b>
Pump PU 84805 'Available' <b>OR</b> Pump PU 84815 'Available'
<b>AND</b> Valve VA 84712 'Available'
<b>AND</b> Valve VA 84706 'Available'

The following trigger will terminate an underflow pumping sequence.

<b>Triggers to terminate an Underflow Pumping Sequence</b>
Interval timer for underflow pump operation has timed out
<b>OR</b> Operator manually terminates operation from HMI screen

## 9.4 Milk of Lime Preparation System 1

### 9.4.1 Milk of Lime Mixing

The following pre-requisites are required to transition the milk of lime preparation system from a 'Stopped' state to the 'Ready' state.

<b>Pre- requisites to Transition System to the 'Ready' State</b>
Group Controller POT_ML1_GC is selected to the AUTO position on the HMI display
<b>AND</b> Group Controller POT_ML1_GC devices are 'Available' as defined in Section 1.4.
<b>AND</b> LAL 84313 'Not Active'
<b>AND</b> LALL 84312 'Not Active'
<b>AND</b> Level in tank TA 84310 greater than YSH 84312
<b>AND</b> WALL 84102 'Not Active'

The following triggers will transition the milk of lime preparation system from a 'Ready' state back to the 'Stopped' state.

<b>Triggers that will Transition System to the 'Stopped' State</b>
Group Controller POT_ML1_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR</b> LAL 84313 'Active'
<b>OR</b> LALL 84312 'Active'
<b>OR</b> WALL 84102 'Active'

The following triggers will initiate the sequence that will transition the milk of lime preparation system from the 'Ready' state to the 'Running' state.

<b>Triggers to Transition System to the 'Running' State</b>
Group Controller POT_LD_GC is selected to the AUTO position on the HMI display
<b>AND</b> Lime dosing pump PU 85111 'running' <b>OR</b> PU 85112 'running' <b>OR</b> PU 85113 'running'
<b>AND</b> Milk of lime preparation System 1 selected as Duty system <b>OR</b> Milk of lime preparation System 2 in 'Stopped' state

The following pre-requisite is required to enable transition of the milk of lime system from the 'Ready' state to the 'Running' state.

<b>Pre- requisites to Transition System to the 'Running' State</b>
Group Controller POT_ML1_GC devices are 'Available' as defined in Section 1.4.

The following interlocks will abort the 'Running' starting sequence and return the milk of lime system to the 'Stopped' state.

<b>'Running' Abort Interlocks</b>
Group Controller POT_ML1_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR</b> LAH 84313 'Active'
<b>OR</b> LAL 84313 'Active'
<b>OR</b> LAH 84309 'Active'
<b>OR</b> LAHH 84312 'Active'
<b>OR</b> LALL 84312 'Active'

<b>OR WALL 84102 'Active'</b>
-------------------------------

The following trigger will initiate the sequence that will transition the milk of lime system from the 'Running' state to the 'Ready' state.

<b>Trigger to Transition System to the 'Ready' State</b>
Lime dosing pump PU 85111 'not running' <b>AND</b> PU 85112 'not running' <b>AND</b> PU 85113 'not running'

The following triggers will initiate the sequence that will transition the milk of lime system from the 'Running' state to the 'Stopped' state.

<b>'Running' Abort Triggers</b>
Operator initiates 'Abort Running' command
Group Controller POT_ML1_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR LAH 84313 'Active'</b>
<b>OR LAL 84313 'Active'</b>
<b>OR LAH 84309 'Active'</b>
<b>OR LAHH 84312 'Active'</b>
<b>OR LALL 84312 'Active'</b>
<b>OR FAHH 84307 'Active'</b>
<b>OR FALL 84307 'Active' for 30 seconds</b>
<b>OR WALL 84102 'Active'</b>
<b>OR WALL 84112 'Active'</b>

## 9.4.2 Hydrated Lime Feeding

Feeding of hydrated lime into the weighing hopper of the loss-in-weight feeder is a sequence that can only run when the milk of lime preparation system is in a 'Running' or 'Ready' operational state.

There are triggers that initiate a feeding sequence, pre-requisites for it to execute and interlocks that will terminate the sequence. The drives associated with the feeding system are incorporated into the Group Controller for the milk of lime system and failure of a drive will abort operation of the milk of lime preparation system 1.

The following triggers will initiate a hydrated lime feeding sequence.

<b>Triggers that will initiate a Hydrated Lime Feeding Sequence</b>
A low weight in the weigh hopper registered by YSL 84112
<b>OR</b> Operator manually initiates start up of sequence from HMI screen

The following triggers will stop a hydrated lime feeding sequence.

<b>Triggers that will stop a Hydrated Lime Feeding Sequence</b>
A high weight in the weigh hopper registered by YSH 84112
<b>OR</b> Operator manually stops sequence from HMI screen

The pre-requisites and interlocks required to execute the sequence are also those associated with the aforementioned milk of lime mixing system.

## 9.5 Milk of Lime Preparation System 2

### 9.5.1 Milk of Lime Mixing

The following pre-requisites are required to transition the milk of lime preparation system from a 'Stopped' state to the 'Ready' state.

<b>Pre- requisites to Transition System to the 'Ready' State</b>
Group Controller POT_ML2_GC is selected to the AUTO position on the HMI display
<b>AND</b> Group Controller POT_ML2_GC devices are 'Available' as defined in Section 1.4.
<b>AND</b> LAL 84413 'Not Active'
<b>AND</b> LALL 84412 'Not Active'
<b>AND</b> Level in tank TA 84410 greater than YSH 84412
<b>AND</b> WALL 84202 'Not Active'

The following triggers will transition the milk of lime preparation system from a 'Ready' state back to the 'Stopped' state.

<b>Triggers that will Transition System to the 'Stopped' State</b>
Group Controller POT_ML2_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR</b> LAL 84413 'Active'
<b>OR</b> LALL 84412 'Active'
<b>OR</b> WALL 84202 'Active'

The following triggers will initiate the sequence that will transition the milk of lime preparation system from the 'Ready' state to the 'Running' state.

<b>Triggers to Transition System to the 'Running' State</b>
Group Controller POT_LD_GC is selected to the AUTO position on the HMI display
<b>AND</b> Lime dosing pump PU 85111 'running' <b>OR</b> PU 85112 'running' <b>OR</b> PU 85113 'running'
<b>AND</b> Milk of lime preparation System 2 selected as Duty system <b>OR</b> Milk of lime preparation System 1 in 'Stopped' state

The following pre-requisite is required to enable transition of the milk of lime system from the 'Ready' state to the 'Running' state.

<b>Pre- requisites to Transition System to the 'Running' State</b>
Group Controller POT_ML2_GC devices are 'Available' as defined in Section 1.4.

The following interlocks will abort the 'Running' starting sequence and return the milk of lime system to the 'Stopped' state.

<b>'Running' Abort Interlocks</b>
Group Controller POT_ML2_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR</b> LAH 84413 'Active'
<b>OR</b> LAL 84413 'Active'
<b>OR</b> LAH 84409 'Active'
<b>OR</b> LAHH 84412 'Active'
<b>OR</b> LALL 84412 'Active'

<b>OR WALL 84202 'Active'</b>
-------------------------------

The following trigger will initiate the sequence that will transition the milk of lime system from the 'Running' state to the 'Ready' state.

<b>Trigger to Transition System to the 'Ready' State</b>
Lime dosing pump PU 85111 'not running' AND PU 85112 'not running' AND PU 85113 'not running'

The following triggers will initiate the sequence that will transition the milk of lime system from the 'Running' state to the 'Stopped' state.

<b>'Running' Abort Triggers</b>
Operator initiates 'Abort Running' command
Group Controller POT_ML2_GC devices are 'Not Available' as defined in Section 1.4.
<b>OR LAH 84413 'Active'</b>
<b>OR LAL 84413 'Active'</b>
<b>OR LAH 84409 'Active'</b>
<b>OR LAHH 84412 'Active'</b>
<b>OR LALL 84412 'Active'</b>
<b>OR FAHH 84407 'Active'</b>
<b>OR FALL 84407 'Active' for 30 seconds</b>
<b>OR WALL 84202 'Active'</b>
<b>OR WALL 84212 'Active'</b>

## 9.5.2 Hydrated Lime Feeding

Feeding of hydrated lime into the weighing hopper of the loss-in-weight feeder is a sequence that can only run when the milk of lime system is in a 'Running' or 'Ready' operational state.

There are triggers that initiate a feeding sequence, pre-requisites for it to execute and interlocks that will terminate the sequence. The drives associated with the feeding system are incorporated into the Group Controller for the milk of lime system and failure of a drive will abort operation of the milk of lime preparation system 2.

The following triggers will initiate a hydrated lime feeding sequence.

<b>Triggers that will initiate a Hydrated Lime Feeding Sequence</b>
A low weight in the weigh hopper registered by YSL 84212
<b>OR</b> Operator manually initiates start up of sequence from HMI screen

The following triggers will stop a hydrated lime feeding sequence.

<b>Triggers that will stop a Hydrated Lime Feeding Sequence</b>
A high weight in the weigh hopper registered by YSH 84212
<b>OR</b> Operator manually stops sequence from HMI screen

The pre-requisites and interlocks required to execute the sequence are also those associated with the aforementioned milk of lime mixing system.

## 9.6 Associated Systems

### 9.6.1 Lime Silo TA 84110 Filling Operation

The lime silo for Milk of Lime Preparation System 1 will be available to load if the following pre-requisites are satisfied,

<b>Pre- requisites for Loading Lime into Silo TA 84110</b>
Level in silo below YSL 84102 (WAL84102 active)
<b>AND</b> Fan FN 84106 is 'Available'
<b>AND</b> YS84105 is 'Not Active' (Access Hatch is closed)

The following interlocks will abort the silo filling operation and close valve VA 84101

<b>Interlocks that will abort Loading Lime into Silo TA 84110</b>
Silo extraction fan FN 84106 'Not Available'
<b>OR</b> LAH 84103 'Active'
<b>OR</b> PAH 84104 'Active'
<b>OR</b> WAHH 84102 'Active'
<b>OR</b> Load-in valve VA 84101 Fault
<b>OR</b> YS 84105 'Active' (Access Hatch open)

### 9.6.2 Lime Silo TA 84210 Filling Operation

The lime silo for Milk of Lime Preparation System 2 will be available to load if the following pre-requisites are satisfied,

<b>Pre- requisites for Loading Lime into Silo TA 84210</b>
Level in silo below YSL 84202 (WAL84202 active)
<b>AND</b> Fan FN 84206 is 'Available'
<b>AND</b> YS84205 is 'Not Active' (Access Hatch is closed)

The following interlocks will abort the silo filling operation and close valve VA 84201

<b>Interlocks that will abort Loading Lime into Silo TA 84210</b>
Silo extraction fan FN 84206 'Not Available'
<b>OR</b> LAH 84203 'Active'
<b>OR</b> PAH 84204 'Active'
<b>OR</b> WAHH 84202 'Active'
<b>OR</b> Load-in valve VA 84201 Fault
<b>OR</b> YS 84205 'Active' (Access Hatch open)

## 10 Alarms

Alarming is divided into three priority categories:

- A ‘Critical’ level alarm is an alarm which will require immediate site operator actions. A ‘Critical’ level alarm will be transferred to telemetry provided RTU COMMS ENABLE is “on”.
- An ‘Urgent’ level alarm will require the operator to address the issue within a limited time period (less than an hour). An urgent level alarm may also be transferred to telemetry in some cases.
- A ‘Warning’ level alarm is an event logged in the alarm history for review at some appropriate time.

The following alarms are associated with the lime system. Critical, Urgent and Warning alarms are indicated on the HMI display in flashing red. Once these alarms have been accepted the alarm will stop flashing. If an alarm is no longer in an alarmed state, but has not been acknowledged then it will flash green.

Critical alarms indicate the potential to damage equipment, inability to achieve drinking water quality or personnel hazards.

### 10.1 Milk of Lime Preparation System 1 Alarms

The alarms from this part of the facility are shown in the table below.

Instrument Tag Number	Message	Control System Action	Alarm Status
ZA 84101	Load-in valve fault	None	Urgent
WIT 84102	WAHH 84102 Lime Silo TA 84110 overfull	Close valve 84101	Warning
	WAH 84102 Lime Silo TA 84110 full, stop load-in	Activates indicator light and siren on Load-in Panel	Warning
	WALL 84102 Lime Silo TA 84110 empty	Interlock to terminate operation of lime preparation system	Urgent
YSL 84102	WAL 84102 Lime Silo TA 84110 re-order level, ok to fill	Activates indicator light	Warning
LSH 84103	LAH 84103 Lime Silo TA 84110 level high	Close valve 84101	Warning
PSH 84104	PAH 84104 Lime Silo TA 84110 pressure high	Close valve 84101	Warning
YS 84105	YA 84105 Silo access hatch open	Interlock to prevent Valve 84101 from opening and Milk of Lime Preparation System 1 from operating	Urgent
YA 84108	Bin Activator BA 84108 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
YA 84106	Extraction fan FN 84106 fault	Close valve 84101	Urgent
YA 84111	Rotary valve RV 84111 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent

Instrument Tag Number	Message	Control System Action	Alarm Status
YA 84112	Weigh feeder FD 84112 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
YA 84311	Mixer MX 84311 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Critical
YA 84505	Milk of Lime Dosing Pump PU 84505 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
WIT 84112	WAHH 84112 weigh feeder overfull	None	Warning
	WKAH 84112 feed rate has exceeded the set point by more than 50%	None	Warning
	WKAL 84112 feed rate lower than the set point by more than 50%	None	Warning
	WALL 84112 weigh feeder failed to refill	Interlock to terminate operation of Lime Preparation System	Urgent
ZA 84305	Mixing water (tank) valve VA 84305 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
ZA 84306	Vortex mixer water valve VA 84306 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
ZA 84501	Milk of lime dosing valve VA 84501 fault	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
ZA 84502	Milk of lime flushing Valve VA 84502 fault	None	Urgent
LSH 84313	LAH 84313 mixing tank TA 84310 tank water level high	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
LSL 84313	LAL 84313 mixing tank TA 84310 tank water level low	Interlock to terminate operation of lime preparation System 1	Urgent
LSH 84309	LAH 84309 vortex mixer water level high	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
LIT 84312	LAHH 84312 mixing tank TA 84310 tank water level high high	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
	LAH 84312 mixing tank TA 84640 tank water level high	None	Warning
	LAL 84312 mixing tank TA 84640 tank water level low	None	Warning
	LALL 84312 mixing tank TA 84640 tank water level low low	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
FIT 84307	FAHH 84307 vortex mixer inlet water flow rate high high	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent
	FAH 84307 vortex mixer inlet water flow rate high	None	Warning
	FAL 84307 vortex mixer inlet water flow rate low	None	Warning
	FALL 84307 vortex mixer inlet water flow rate low low	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent



Instrument Tag Number	Message	Control System Action	Alarm Status
FIT 84509	FAHH 84509 milk of lime flow rate high high	None	Urgent
	FAH 84509 milk of lime flow rate high	None	Warning
	FAL 84509 milk of lime flow rate low	None	Warning
	FALL 84509 milk of lime flow rate low	Interlock to abort Milk of Lime Preparation System 1 operation	Urgent

## 10.2 Milk of Lime Preparation System 2 Alarms

The alarms from this part of the facility are shown in the table below.

Instrument Tag Number	Message	Control System Action	Alarm Status
ZA 84201	Load-in valve fault	None	Urgent
WIT 84202	WAHH 84202 Lime Silo TA 84210 overfull	Close valve 84201	Warning
	WAH 84202 Lime Silo TA 84210 full, stop load-in	Activates indicator light and siren on Load-in Panel	Warning
	WALL 84202 Lime Silo TA 84210 empty	Interlock to terminate operation of lime preparation system	Urgent
YSL 84202	WAL 84202 Lime Silo TA 84210 re-order level, ok to fill	Activates indicator light	Warning
LSH 84203	LAH 84203 Lime Silo TA 84210 level high	Close valve 84201	Warning
PSH 84204	PAH 84204 Lime Silo TA 84210 pressure high	Close valve 84201	Warning
YS 84205	YA 84205 Silo access hatch open	Interlock to prevent Valve 84201 from opening and Milk of Lime Preparation System 2 from operating	Urgent
YA 84208	Bin Activator BA 84208 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
YA 84206	Extraction fan FN 84206 fault	Close valve 84201	Urgent
YA 84211	Rotary valve RV 84211 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
YA 84212	Weigh feeder FN 84212 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
YA 84411	Mixer MX 84411 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Critical
YA 84605	Milk of Lime Dosing Pump PU 84605 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
WIT 84212	WAHH 84212 weigh feeder overfull	None	Warning

Instrument Tag Number	Message	Control System Action	Alarm Status
	WKAH 84212 feed rate has exceeded the set point by more than 50%	None	Warning
	WKAL 84212 feed rate lower than the set point by more than 50%	None	Warning
	WALL 84212 weigh feeder failed to refill	Interlock to terminate operation of Lime Preparation system	Urgent
ZA 84405	Mixing water (tank) valve VA 84405 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
ZA 84406	Vortex mixer water valve VA 84406 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
ZA 84601	Milk of lime dosing valve VA 84601 fault	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
ZA 84602	Milk of lime flushing Valve VA 84602 fault	None	Urgent
LSH 84413	LAH 84413 mixing tank TA 84410 tank water level high	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
LSL 84413	LAL 84413 mixing tank TA 84410 tank water level low	Interlock to terminate operation of Lime Preparation System 2	Urgent
LSH 84409	LAH 84409 vortex mixer water level high	Interlock to terminate operation of lime preparation system	Urgent
LIT 84412	LAHH 84412 mixing tank TA 84410 tank water level high high	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
	LAH 84412 mixing tank TA 84410 tank water level high	None	Warning
	LAL 84412 mixing tank TA 84410 tank water level low	None	Warning
	LALL 84412 mixing tank TA 84410 tank water level low low	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
FIT 84407	FAHH 84407 vortex mixer inlet water flow rate high high	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
	FAH 84407 vortex mixer inlet water flow rate high	None	Warning
	FAL 84407 vortex mixer inlet water flow rate low	None	Warning
	FALL 84407 vortex mixer inlet water flow rate low low	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent
FIT 84609	FAHH 84609 milk of lime flow rate high high	None	Urgent
	FAH 84609 milk of lime flow rate high	None	Warning
	FAL 84609 milk of lime flow rate low	None	Warning
	FALL 84609 milk of lime flow rate low	Interlock to abort Milk of Lime Preparation System 2 operation	Urgent

## 10.3 Lime Clarification Alarms

The following alarms are from instruments and drives that are part of the lime clarification system.

Instrument Tag Number	Message	Control System Action	Alarm Status
YA 84901	Pump PU 84901 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84902	Pump PU 84902 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84903	Pump PU 84903 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84805	Pump PU 84805 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84815	Pump PU 84815 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84723	Clarifier Draft Tube Impeller motor fault	None	Urgent
YA 84724A	Clarifier Rake motor fault	Interlock to terminate operation of lime clarification system	Critical
YA 84724B	Clarifier Rake motor gear box oil level low	None	Urgent
YA 84725	Clarifier Rake Lift motor fault	None	Urgent
WAH 84724	Clarifier Rake torque high	Interlock to lift rack after 30 seconds	Urgent
WAHH 84724	Clarifier Rake torque high high	Interlock to terminate operation of lime clarification system after 30 seconds	Critical
ZA 84712	Lime water clarifier underflow discharge valve, VA 84712 fault	None	Critical
ZA 84706	Lime Clarifier Underflow Flushing Valve, VA 84706 fault	None	Urgent
ZA 84917	Clarifier dilution water control valve VA 84917 fault	None	Urgent
FIT 84703	FAHH 84703 dilution water flow rate high high	None	Urgent
	FAH 84703 dilution water flow rate high	None	Warning
	FAL 84703 dilution water flow rate low	None	Warning
	FALL 84703 dilution water flow rate low low	None	Urgent
LIT 84719	LAHH 84719 sludge blanket level high high	None	Urgent

Instrument Tag Number	Message	Control System Action	Alarm Status
	LAH 84719 sludge blanket level high	None	Warning
	LAL 84719 sludge blanket level low	None	Warning
	LALL 84719 sludge blanket level low low”	None	Urgent
LIT 84718	LAHH 84718 bed sludge level high high	None	Urgent
	LAH 84718 bed sludge level high	None	Warning
	LAL 84718 bed sludge level low	None	Warning
	LALL 84718 bed sludge level low low”	None	Urgent
AIT 84721	AAHH 84721 lime water turbidity high high	Interlock to terminate operation of lime clarification system after 10 minutes. Clarifier rake to be kept in operation.	Critical
	AAH 84721 lime water turbidity high	None	Urgent
AIT 84722	AAHH 84722 lime water concentration high high	None	Warning
	AAH 84722 lime water concentration high	None	Warning
	AAL 84722 lime water concentration low	None	Warning
	AALL 84722 lime water concentration low low	None	Urgent
PIT 84809	PAH 84809 underflow line pressure high	None	Warning
	PAL 84809 underflow line pressure low”	None	Warning
FIT 84811	FAHH 84811 underflow line flow rate high high	None	Warning
	FAH 84811 underflow line flow rate high	None	Warning
	FAL 84811 underflow line flow rate low	None	Warning
	FALL 84811 underflow line flow rate low low	Interlock to terminate operation of PU 84805 & PU 84815.	Critical
PSH 84807	PAH 84807 pump PU 84805 discharge pressure high	None	Warning
PSH 84817	PAH 84817 pump PU 84815 discharge pressure high	None	Warning

## 10.4 Lime Dosing System

Instrument Tag Number	Message	Control System Action	Alarm Status
YA 85111	Pump PU 85111 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 85112	Pump PU 85112 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 85113	Pump PU 85113 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 85114	Pump PU 85114 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 85115	Pump PU 85115 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
ZA 85121	Dosing Pumps common delivery valve VA 85121 fault	Interlock to abort Lime Dosing System operation	Critical
LIT 85110	LAHH 85110 lime water tank level high high	Interlock to terminate operation of lime clarification system. Clarifier rake to be kept in operation.	Critical
	LAH 85110 lime water tank level high	None	Warning
	LAL 85110 lime water tank level lo	None	Warning
	LALL 85110 lime water tank level low low	Interlock to terminate operation of lime dosing system	Critical
LIT 85103	LAHH 85103 lime water tank level high high	Interlock to terminate operation of lime clarification system. Clarifier rake to be kept in operation.	Critical
	LAH 85103 lime water tank level high	None	Warning
	LAL 85103 lime water tank level low	None	Warning
	LALL 85103 lime water tank level low low	Interlock to terminate operation of lime dosing system	Critical
FIT 85119	FAHH 85119 lime water dosing flow rate high high	None	Critical
	FAH 85119 lime water dosing flow rate high	None	Warning
	FAL 85119 lime water dosing flow rate low	None	Warning
	FALL 85119 lime water dosing flow rate low low	Interlock to terminate operation of lime dosing system.	Critical

Instrument Tag Number	Message	Control System Action	Alarm Status
FSL 85132	FAL 85132 lime water make up flow rate low	Terminate operation of PU 85114 and initiate operate of standby pump PU 85115	Urgent
FSL 85133	FAL 85133 lime water make up flow rate low	Terminate operation of PU 85115 and initiate operate of standby pump PU 85114	Urgent

## 10.5 Sumps

Instrument Tag Number	Message	Control System Action	Alarm Status
YA 84610	Pump PU 84610 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
YA 84611	Pump PU 84611 motor fault	Interlock to terminate operation of pump and initiate operation of standby pump	Urgent
LSL 84617	None	Trigger to terminate operation of duty and standby sump pump	None
LSH 84617	None	Trigger to initiate operation of duty sump pump	None
LSHH 84617	LAHH 84617 lime building sump level high high	Trigger to initiate operation of standby sump pump (duty pump continues to run)	Warning
LSHHH 84617	LAHHH 84617 lime building sump level high high high	None	Urgent
YA 84820	Pump PU 84820 motor fault	None	Urgent
LSL 84825	None	Trigger to terminate operation of sump pump	None
LSH 84825	None	Trigger to initiate operation of sump pump	None
LSHH 84825	LAHH 84825 lime clarifier bund sump level high high	None	Urgent

# 11 Trends

The following trends will be recorded on the HMI system

Instrument Tag Number	Information	Typical Range	Data sampling interval
WIT 84102	Hydrated lime System 1 silo	0 – 30,000 kg	1 minute
WI 84112	Hydrated lime feed rate for System 1	0 – 300 kg/h	1 minute
LIT 84312	Mixing tank water level in tank TA 84310	0 – 3 metres	1 minute
FIT 84307	Vortex mixer inlet water flow rate for tank TA 84310	0 – 10 m <sup>3</sup> /h	1 minute
FIT 84509	Milk of lime flow rate for System 1	0 – 30 m <sup>3</sup> /h	1 minute
WIT 84202	Hydrated lime in System 2 silo	0 – 30,000 kg	1 minute
WI 84212	Hydrated lime feed rate for System 1	0 – 300 kg/h	1 minute
LIT 84412	Mixing tank water level in tank TA 84410	0 – 3 metres	1 minute
FIT 84407	Vortex mixer inlet water flow rate for tank TA 84410	0 – 10 m <sup>3</sup> /h	1 minute
FIT 84609	Milk of lime flow rate for System 2	0 – 30 m <sup>3</sup> /h	1 minute
FIT 84703	Dilution (Process) water flow rate to clarifier	0 – 400 m <sup>3</sup> /h	1 minute
LIT 84719	Sludge blanket level	0 – 5 metres	1 minute
LIT 84718	Sludge blanket level	0 – 5 metres	1 minute
AIT 84721	Lime water turbidity	0 – 300 NTU	1 minute
AIT 84722	Lime water conductivity	0 – 1000 mS/m	1 minute
PIT 84809	Underflow line pressure	0 – 1000 kPa	1 minute
FIT 84811	Underflow line flow rate	0 – 20 m <sup>3</sup> /h	1 minute
LIT 85110	Lime water tank level	0 – 10 metres	1 minute
LIT 85103	Lime water tank level	0 – 10 metres	1 minute
FIT 85119	Lime water dosing flow rate	0 – 400 m <sup>3</sup> /h	1 minute

## 12 Reports

The following reports will be created on a daily basis.

The reporting period will be from 0.00 hours to 0.00 hrs, namely from midnight to midnight.

<b>Instrument Tag Number</b>	<b>Information</b>	<b>Units</b>
WQI 84112	Daily totalised lime feed for preparation system 1	kg
WQI 84212	Daily totalised lime feed for preparation system 2	kg
FQI 84509	Daily totalised milk of lime flow through system 1	m <sup>3</sup>
FQI 84609	Daily totalised milk of lime flow through system 2	m <sup>3</sup>
FQI 84703	Daily totalised dilution (process) water flow	m <sup>3</sup>
FQI 84811A	Daily totalised lime clarifier underflow	m <sup>3</sup>
FQI 84811B	Daily totalised lime clarifier flushing water	m <sup>3</sup>
FQI 85119	Daily totalised lime water dosing flow	m <sup>3</sup>

Alarms will be captured on an alarm and event log.



## **13 Appendix A: Functional Description Overview**

The controls and interlocks of the Lime Storage, Mixing and Dosing System are summarised in the Functional Description Overview provided in this Appendix.

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