1. SYSTEM DESCRIPTION

1.1 TECHNICAL DATA

1.1.1 Equipment

Type:	Regenerative Oxidiser
Number of Canisters:	Two

1.1.2 Design Data

Flow Rate (Max):	104,000 Nm^3/hr
VOC Load :	2.87 g/Nm^3 (average), 6 g/Nm^3 (maximum).
Air Temperature at Inlet:	49 ^oC.
Primary Thermal Effectiveness:	95%
Heat Exchanger Media:	Lantec MLM 180
Canister Size:	3.66m x 5.49m
Media Depth - Initial Fill:	1.83m
Canister Changeover Time:	160 seconds (adjustable 60 and 200 seconds).

1.1.3 Dampers

Inlet Dampers - FV1A, FV2A

Travel Time:	4 seconds
Actuator:	Pneumatic
Control:	Double Acting

Outlet Dampers - FV1B, FV2B

Travel Time:	4 seconds
Actuator:	Pneumatic
Control:	Double Acting

High Solvent By-pass - TV11

Travel Time:	Modulating
Actuator:	Pneumatic
Control:	4-20 mA with positioner

Process Isolation - FV10

Travel Time:	10 seconds
Actuator:	Pneumatic
Control:	Double Acting

Fresh Air - FV9

Travel Time:	Modulating
Actuator:	Pneumatic
Control:	4-20 mA with positioner

1.1.4 Compressed Air

Receiver Capacity:	1000 Litres
Supply Pressure:	9 bar max
Minimum Pressure:	7 bar min

1.1.5 Burners

Quantity:	One
Burner Capacity:	1800 kW
Gas Train Inlet Pressure:	128 mbar

1.1.6 Combustion Air Fan

Flow Rate:	2000 Nm³/hr
Temperature:	Ambient
Pressure:	95 mbar
Motor Size:	11 kW
Motor Speed:	2900 rpm
Fan Speed:	2900 rpm
Type of Drive:	Direct Drive

1.1.7 Main Process Fan

Flow Rate:	123,300 Am³/hr (104,000 Nm³/hr at 49 °C)
Temperature:	100 °C Max at reduced flow
Pressure:	5.8 kPa
Motor Size:	280 kW
Fan/Motor Speed:	Variable 150 to 1500 rpm
Type of Drive:	Direct
Speed Control:	4-20 mA signal from PLC

MACHINE NUMBER	VOLUME (Nm³/hr)
No. 1	11,168
No. 3	16,404
No. 4	7,267
No. 7	23,262
No. 8	27,374
Extra Capacity	18,525
TOTAL	**104,000 Nm³/hr**

1.2 PRINCIPLE OF THERMAL OXIDATION

The principle of operation is that of thermal oxidation. Thermal oxidation relies on heating an air stream to a high temperature and holding it at that temperature (retention time). This allows for the conversion of hydrocarbons (VOC's) to carbon dioxide (CO_2) and water vapour (H_2O)

The heating of the process air is brought about by a combination of pre-heating the air, through a heat exchanger, the heat released from the VOC and a gas fired burner system. The higher the VOC concentration the lower the heat provided by the burner.

1.2.1 Principle of Regenerative Thermal Oxidiser (R.T.O)

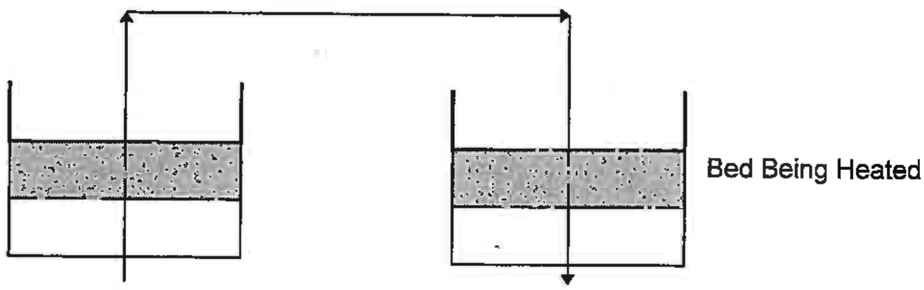
With Regenerative Thermal Oxidation the pre-heating is achieved using ceramic media which is used as a heat exchanger and is installed in the base of each of the canisters.

The canisters perform different functions on a cyclical basis with the air movement being controlled by actuated dampers.

In one cycle the air enters through one canister, where it takes heat from the ceramic media, and passes through the retention chamber, where it is heated above the required oxidation temperature for the desired retention time, before exiting through another canister, where the air is cooled (heat is given up and transferred to the ceramic media) before leaving the oxidiser (Fig 1).

Fig 1 - Cycle 1

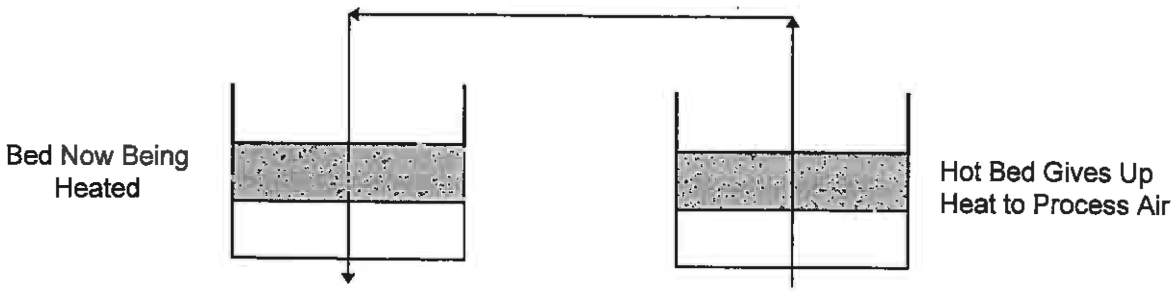
Heating



On the next cycle the canister that was the outlet, which has now been heated, now becomes the inlet. This heated media gives up its heat to the incoming air heating it requiring less additional energy to heat it to the required oxidation temperature (Fig 2).

Fig 2 - Cycle 2

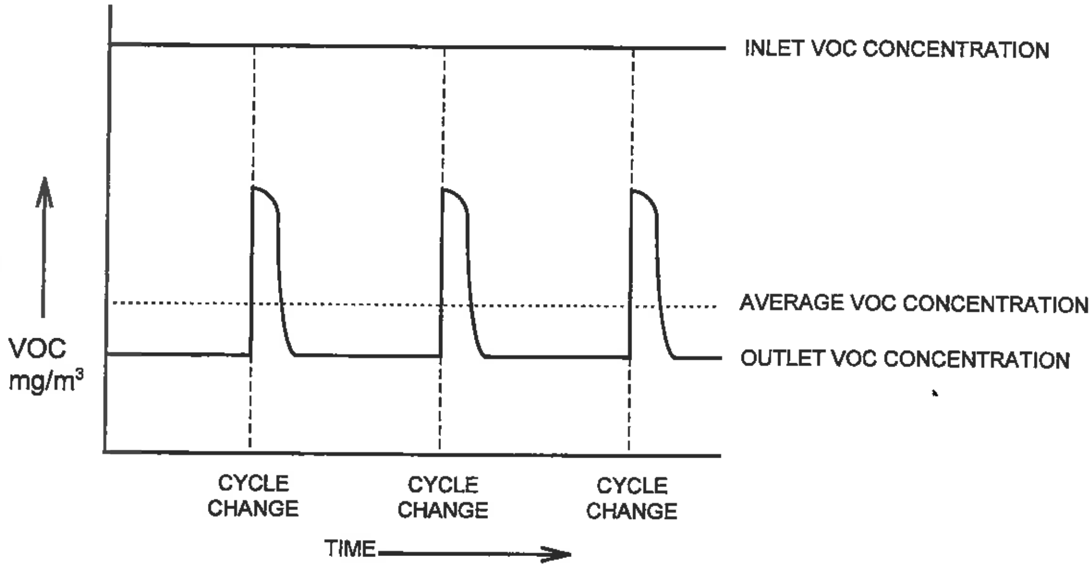
Heating



The cycles would continue to change so that the outlet always becomes the inlet during the next cycle.

Two canister RTO's release a small amount of VOC laden air during a cycle change. This happens when the inlet becomes the outlet and the air that hasn't reached the retention chamber for oxidation, is exhausted directly to atmosphere. This momentary peak of VOC at the outlet is accepted because UK emissions legislation relies on an average VOC concentration over an agreed period of time (Fig 3)

Fig 3



The performance of a two canister RTO is enhanced by lengthening the time between cycle changes (there is however a limit to extending the cycle before effecting the heat transfer), and minimising the volume of air passed on changeover by keeping plenum volumes small and allowing the dampers to open and close very quickly.

1.2.2 Regenerative Thermal Oxidiser Dampers

Because the RTO requires cycling between the heat exchanger canisters, a series of high efficiency dampers are installed in the inlet and outlet ducting of the system to handle the flow changes and sequential operation of the system.

The dampers are specially selected for very low leakage since any leakage would result in the contamination of the clean oxidiser gases being discharged from the heat exchanger vessel with VOC containing emissions from the process.

1.2.3 Process Air Flow Control

The process air for treatment is drawn from the sources of VOC via a centrifugal fan.

This fan is positioned upstream of the oxidiser which forces air through the oxidiser (known as a 'forced draft system').

Forced draft systems are used because they can offer savings on both capital and running costs because the air temperature is lower.

Regardless of the type of system adopted the principle of controlling the process air are the same by way of inlet pressure control. A pressure transmitter is positioned at the inlet to the oxidiser system which monitors the inlet pressure. This pressure transmitter provides a 4-20mA signal to the oxidiser control system (usually within the PLC). The actual pressure is compared to the set point (the value for the set point is entered on commissioning), the controller (PLC) then sends another 4-20mA signal to a variable frequency drive (VFD) which is connected to the main fan motor. This VFD controls the speed of the fan to maintain the desired inlet pressure.

1.2.5 Temperature Control

For a thermal oxidiser to perform correctly it is important that the temperature required to oxidation is controlled to maintain the destruction efficiency of the system.

The air is heated by a combination of preheating the air using a heat exchanger, by burning the VOC present in the process fume and by using natural gas support burners.

The oxidiser is started up off-line without process air. This allows the oxidiser to be brought to the correct operating (oxidation) temperature. This heating is provided by a natural gas support burner controlled by a modulating valve connected to a thermocouple via a PID Controller inside the PLC.

When the oxidiser heat up has been completed and it is 'Ready for Fume' air can be introduced to the oxidiser.

Any VOC present in the process air will be burned and the heat energy released into the oxidiser. The gas burner will modulate up and down to compensate for the change in VOC concentration. If the VOC concentration is high enough the burners will turn to their low fire position.

1.2.5.1 Auto Thermal Operation

Under certain conditions the burner can be switched off and the combustion temperature can be maintained on burning the VOC only. This is known as 'auto thermal operation'. When the VOC level drops the burners are reignited.

2.1 PRE START-UP CHECKS

Before starting up the oxidiser, it is recommended that the following inspections are carried out. It is important that operating personnel become familiar with the safety procedures, system components, theory of operation, operating and maintenance instructions contained in this manual.

Please refer to the Proprietary Component Information and Reference Drawings which we have provided in conjunction with the following text.

2.1.1 External Inspection

Before Switching on Power Supply

Check for correct physical location of all piping, valves and controls as specified on the drawings.

Check that all wiring is correct and also for the correct voltage supply to control panel and all field equipment.

2.1.2 Internal Inspection

Before entering the unit, check to ensure the oxidiser control panel is isolated and locked in the OFF position and that the natural gas supply and pneumatic supply isolating cocks are in the OFF position. Inspect the combustion chamber, the plenum chambers beneath each media bed and ductwork internally, with regard to the following:-

NOTE: Do not walk directly on ceramic media installed in the combustion chamber - use temporary floor boards, plywood or similar to distribute weight.

1. Check for any internal damage, especially to insulation.

2. Check the burner to ensure the main burner nozzle is clean and free of obstruction. Check the spark electrode & flame rod are clean and correctly positioned.

3. Check that all loose items such as welding rods, boards and any other debris have been removed.

4. Check thermocouples for the correct installation.

5. Check dampers, especially for damage to seals and tightness.

When internal inspection is complete, close all access doors making certain internal door insulation is not damaged and is correctly installed. If door assemblies do not fit tightly against the oxidiser installation, fill gaps with fibrefax blanket insulation, or equivalent.

2.1.3 Drying out New Insulation

A once off dry out is required for Insulation materials. This will be carried out during commissioning by supplier.

2.2 THEORY OF OPERATION

AIRFLOW TESTS 9 JANUARY 2001

NO 8 PRESS RE-MEASURED 25 JANUARY 2001

Machine	Temp °C	Volume Nm³/hr	M/C Speen m/min
No 1	53.3	11,168	250
No 3	40.8	16,404	200
No 4	36.3	7,267	220
No 7	44.2	23,262	160
No 8	35.8	27,374	245
	Total	**85,475**	

MAXIMUM OXIDISER FLOW RATE = 104,000 Nm³/hr.

2.2.1. RTO DAMPERS

2.2.1.1 Fail-safe Positions

1.1.1 Canister inlet dampers fail open.
1.1.2 Canister outlet dampers fail open.
1.1.3 Fresh air isolation damper fails open.
1.1.4 Process isolation damper fails closed.
1.1.5 Process exhaust dampers divert to atmosphere.
1.1.6 High solvent damper fails closed

2.2.1.2 Compressed Air Operated Damper Actuators

The system has an air receiver with sufficient capacity to put the oxidiser dampers into their fail-safe positions if the compressed air supply fails.

A pressure switch is fitted to prove incoming compressed air supply to the air receiver. Loss of compressed air pressure will alarm and put the oxidiser to a shut down condition.

Compressed air cooling at a minimum flow to the combustion chamber peep sight and burner components is maintained continuously for heat protection.

2.2.1.3 Damper timing programme (DTP)

Canister dampers are opened and closed by a damper timing programme in the PLC software which outputs to solenoid valves controlling the movement of the damper actuators.

The damper timing programme is detailed in appendix 1.

The design cycle time of 160 seconds can be adjusted between 60 and 200 seconds.

When starting the oxidiser following a shut down, the damper timing programme starts at the position where it was last stopped. It does not always start with the same canister as the inlet.

Canister 1 is designated as the canister closest to the inlet of the oxidiser.

2.2.1.4 Canister Inlet and Outlet dampers

Open and closed limit switches are mounted on each damper shaft.
If either the open or closed limit switch fails to confirm movement within an allowed operating time of 8 seconds an 'incomplete damper operation' alarm is given for the respective damper. This gives a recorded alarm and a continuous audible alarm at the Operator Interface but has no other action. Repeated alarms of the same limit switch are ignored until the Audible alarm is manually acknowledged at the Operator Interface.

If both limit switches on a damper fail to confirm that a damper has moved to the closed position, a 'Canister Damper Failed to Move' alarm is given and an 'RTO Immediate Shutdown' is activated.

If both limit switches on a damper fail to confirm that a damper has moved to the open position, a 'Canister Damper Failed to Move' alarm is given and an 'RTO Immediate Shutdown' is activated.

The damper opening and closing rate is governed mechanically by setting valves which adjust the flow rate to the damper actuators. The adjustment range is between 1 and 6 seconds.

2.2.1.5 Oxidiser inlet "Fire" alarm

In the event of the oxidiser detecting a second high inlet temperature (possible duct fire) or upon cancellation of the clients fire system not active interlock, the oxidiser will remove authorisation for the process machines to be diverted to the oxidiser, the process isolation damper shall close, the fresh air damper will open and the main fan will switch to idle speed setting.

The oxidiser will remain in this condition until the trigger has been cleared and the alarm message acknowledged and cleared at the operator interface.

Note: It is the clients responsibility to ensure that the process dampers immediately return to atmosphere upon the removal of authorisation to divert to the oxidiser.

2.2.1.6 Process isolation damper

This damper opens when the oxidiser is in a 'ready to accept fume' condition. When the 'ready to accept fume' condition is lost, the process isolation damper closes.

A 'Ready for fume' signal to the Clients process machines is given when the oxidiser has attained a 'ready for fume' condition and the process isolation damper has been confirmed open.

2.2.1.7 Fresh air isolation damper (Modulating)

The fresh air isolation damper only closes when the process isolation damper is open and the process is sending fume to the oxidiser. Opening of this damper is when the process is not sending fume.
As some of the process machines (when running less than all of the printing stations) may supply less process air than the maximum turn down of the oxidiser, it is necessary for the fresh air damper to part open in order to supply the additional air required. This is achieved by monitoring the main exhaust fan speed. Should the main fan running frequency fall to 7Hz setting then the fresh air damper modulates to try to maintain the static pressure in the process duct of -100Pa.

If the damper limit switches indicate that the fresh air inlet damper and the process isolation damper are simultaneously in the closed position a 'Fresh Air Damper Failed to Open' fault is given and an 'RTO immediate shutdown' is activated.

2.2.1.8 High solvent by-pass damper

The high solvent damper modulates to control the combustion chamber temperature when the VOC (Solvent) concentration in the process exhaust is greater than the concentration necessary to maintain combustion chamber temperature.

2.2.1.9 Process exhaust dampers

Each of the Clients process exhausts has an actuated damper arrangement, mechanically linked dampers (one actuator and two limit switches) which will divert process exhaust from atmospheric exhaust to oxidiser exhaust.

Limit switches on each damper signal 'open to atmosphere' and 'open to oxidiser'.

Process exhaust dampers are enabled to divert to oxidiser provided the oxidiser is in a 'Ready for Fume' condition and the Process is 'on-line'. (See section 2.2.9 Process Interlocks). If no processes are 'on-line' and the fresh air damper fails to prove open, an 'RTO immediate shutdown' is activated.

Note 1: If the oxidiser is not 'Ready for Fume', diversion of process exhaust to the oxidiser may cause hazards at the process and at the oxidiser. It is important that the operation of the process exhaust dampers is interlocked with both process and oxidiser operation.

Note 2: If the Clients process exhaust dampers are not 'fail safe' to an 'Open to Atmosphere' condition, they may fail in a mid or open to oxidiser position in the event of a control line rupture, or control system failure. Suitable precautions should be taken to protect the oxidiser in this eventuality.

2.2.2. GAS BURNER SYSTEM

The gas burner installation complies with BS EN746-2.

Components on the gas train and burner head comprise the following:-

2.1. Low gas pressure switch.
2.2. Modulating air/gas ratio controls.
2.3. Two main gas safety valves.
2.4. Main valves pressure proving unit.
2.5. High gas pressure switch.
2.6. Flame detector.
2.7. Spark electrode and HT transformer.
2.8. Honeywell 7800 Burner Controller (or equivalent)

When in an 'Oxidiser purged' condition (see section 3), a burner enable signal from the PLC will initiate burner ignition. Loss of the burner enable signal will switch off the burner.

2.2.3. AUTOMATIC START UP SEQUENCE

The Oxidiser may be started in an automatic start up sequence locally.

The start up sequence is as follows : [1]

2.2.3.1 The canister damper cycle starts.

Initially, there is a 'fast cycle' sequence to 'warm through' the dampers. The 'fast cycle' sequence continues until all cycling dampers have completed two successive cycles with no damper faults monitored. When two successive fault free cycles are completed, the damper timing program reverts to the 'normal' cycle time. Damper fault signalling is suppressed during 'fast cycle'. If the dampers have not successfully completed the fast cycle within a pre-set time the 'faulty' dampers are alarmed and displayed on the operator interface.

The 'fast cycle' program can be over ridden through the operator interface, to enable immediate re-start following a temporary shut-down.

2.2.3.2 The combustion air pressure switch is proved to be in the 'below minimum' position.

The combustion air fan starts and the combustion fan motor contactor is proved energised

The combustion air pressure switch confirms the pressure to be 'above minimum'.

2.2.3.3 The main fan motor starts and runs up to its pre-set purge speed (VFD fixed speed 1)

Main Fan Running Relay is energised and the Main Fan at Purge Speed Relay is energised.

2.2.3.4 For the oxidiser to be purged prior to lighting the burners the PLC must complete the above sequence and confirm the oxidiser to be in a ready to purge condition.

Additionally the following hardwired interlocks must be proved and must remain proved throughout operation in order to maintain an 'Oxidiser Purging' or 'Oxidiser Purged' signal :

2.2.3.4.1 Main Fan Running relay is energised

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[1] During an automatic start up, each step must be completed successfully before the next step is enabled.

2.2.3.4.2 Main Fan above minimum speed relay is energised
2.2.3.4.3 Oxidiser Minimum Air pressure relay is energised.
2.2.3.4.4 Combustion Air Fan Contactor is energised.
2.2.3.4.5 Combustion Minimum Air is proved.
The following hardwired interlocks are required for the duration of the oxidiser purge time :

3.4.1. Process Isolation Damper is fully closed.
3.4.2. Fresh Air Damper is fully open.
3.4.3. Main Fan is at Purge speed.

2.2.3.5 An electro-mechanical timer purges the system for four minutes. The main fan purge rate (VFD fixed speed 1) is set so that this gives a minimum of five complete air changes of all internal spaces from the fresh air damper to the exhaust stack. [2]

On completion of the purge time the 'Oxidiser Purged' relay is energised and conditions [3.4.7 & 3.4.8] above are latched until the 'Oxidiser Purged' signal is lost.

A purge timer is also run in the PLC, set 20 seconds less than the hardwired timer. If this timer exceeds the hardwired timer, an 'Insufficient Purge Time' alarm is given and a 'Normal Shutdown' fault is triggered. [3] [4]

During the purge period the burner modulating motor drives to high fire to prove the 'high fire' limit switch and then it closes to the 'low fire / burner ignition' position ready for burner ignition.

2.2.3.6 The main fan reduces to its 'idle' speed (VFD fixed speed 2) and the gas burner is enabled.

2.2.3.7 The burner controller goes through an automatic light up sequence to ignite the burner via the spark electrode and prove ignition through the flame detector.

During burner operation the flame is monitored by the flame detector and if any failure occurs the burner goes into lockout. If the burner goes into lockout then the cause requires investigating and the burner lockout needs

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[2] If a gas valve leak test is required, it is done at this stage. If the leak test fails, an alarm is given and the oxidiser goes to normal shut down. The alarm must be manually reset at the operator interface before initiating an oxidiser re-start.
[3] If the combustion air is held full open for the duration of the purge cycle, there is a possibility that the Oxidiser exhaust temperature will rise above its safe temperature limit during a 'hot' start.

[4] Installations having High Solvent By-pass Dampers or Oxidiser By-pass Dampers should be programmed to open the dampers at the start of the Purge period, for sufficient time to purge five volumes through the respective ductwork, and then to close the dampers for the remainder of the Purge period.

to be re-set before the burner controller will attempt another light up sequence.

2.2.3.8 When successfully lit and the flame is established, the burner goes to full fire and the combustion chamber temperature rises. [5]

As the combustion chamber temperature rises the speed of the main fan is increased to heat the oxidiser beds at best efficiency. This also ensures that the temperature rise in the beds is not too rapid.

When the oxidiser reaches its combustion chamber 'ready for fume' temperature and the oxidiser exhaust temperature increases to the 'exhaust ready for fume' temperature, or if it is already above this temperature, a time out period starts. This time period is adjustable between 0 and 15 minutes and on time out a 'ready for fume' condition is reached which gives a signal for the process isolation damper to open.

When the process isolation damper is proved open, the 'Oxidiser ready for fume' signal is given.

If the process isolation damper fails to prove open in a pre-set time, the 'Oxidiser ready for fume' signal is lost and a fault signalled at the operator interface.

2.2.3.9 If none of the process exhausts are sending a 'request' signal to the oxidiser control panel, the main fan switches back to its pre-set 'idle' speed (VFD fixed speed 2).

2.2.3.10 The 'Accept' signal enables the process exhausts to divert to the Oxidiser once they have 'requested' abatement. When this occurs, (i.e. 'request + 'Accept') the main fan switches to automatic speed control. When any processes which are 'Requesting' have diverted from atmosphere to oxidiser, the damper 'open to oxidiser' position switch will make and will give a 'confirmed sending fume' signal to the oxidiser. This signal enables the fresh air damper to close. Failure to receive a 'sending fume' signal will show a process damper fault and hold the fresh air damper open.

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[5] This may be done by a ramp programme in the PLC, by a stepped sequence in the PLC, or if the main fan is vortex damper controlled by progressively opening the vortex damper.

2.2.4. AUTOMATIC SHUTDOWN SEQUENCES

2.2.4.1 Operator initiated

Locally by pressing the 'Auto stop' push button.

When automatic shutdown is selected the 'ready for fume' signal is withdrawn and any process exhausts remaining on line automatically revert to atmospheric exhaust. Concurrently the following shut down sequence takes place.

2.2.4.1.1 The fresh air damper opens and gas burner shuts down.
The main fan goes to idle speed (VFD fixed speed 2)

2.2.4.1.2 After a pre-set time, to enable the fresh air damper to open and the main fan to start deceleration, the process isolation damper closes.

2.2.4.1.3 When the temperature in the combustion chamber falls to below 'auto shutdown temperature' the main fan stops.

2.2.4.1.4 At a pre-set time after the main fan has stopped, the combustion fan stops and the damper timing programme stops.

The canister dampers go to their fail-safe positions.

The compressed air cooling solenoid valve opens when the combustion air fan is stopped. This solenoid valve is a 'fail open' valve.

2.2.4.1.5 The compressed air solenoid valve closes when the combustion chamber drops below the 'oxidiser cool' temperature.

2.2.4.1.6 Re-start during a normal shut down

If the 'auto start' push button is pressed during the shut down sequence, the shutdown will be terminated and the oxidiser 'automatic start up' sequence will commence as close as possible to the condition at which the 'shut down' terminated.

2.2.4.2 Oxidiser fault triggering a Normal shut down

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[6] In contrast to the start up sequence, steps in the shutdown sequence are not proven in order to progress to the next step. If a fault condition occurs the alarm system will take the appropriate action.

[7] Unless otherwise agreed, it is the Clients responsibility to ensure that all process ductwork upstream of the oxidiser purge system is maintained in a safe condition at all times. Under normal operation the process exhausts should be post-purged for a timed period prior to shutting down the oxidiser to clear any residual VOC from the exhaust systems.

If at any time during operation an alarm is given which triggers a Normal shut down, the alarm message is displayed at the operator interface and the oxidiser automatically shuts down in accordance with 4.1 above.

2.2.4.3 Oxidiser fault triggering an Immediate shut down

An immediate shut-down is implemented for critical oxidiser safety protection features when it is essential that all equipment is brought to a standstill and fail safe positions in the quickest time. Overheating of some component parts may occur as result of an immediate shut-down and the cause should be identified and corrected as quickly as possible.

The Immediate shut down sequence is similar to the Normal shut down except that the main fan and damper timing programme stop immediately, instead of being combustion chamber temperature dependent.

The oxidiser may be re-started when the alarm condition is accepted and cleared at the operator interface, and the automatic start sequence is initiated.

2.2.4.4 Emergency Stop

Any emergency stop will immediately isolate all power supplies, including power to the PLC. A Pilz relay is used for this function.

2.2.5. TEMPERATURE CONTROL OF THE COMBUSTION CHAMBER

The temperature of the combustion chamber is detected by two type K thermocouples in the combustion chamber with analogue inputs to the PLC. The two inputs are continuously compared within the PLC and any deviation from set limits is alarmed as a 'thermocouple fault'.

The two thermocouple readings are averaged and used for all PLC control functions.

A PID temperature control loop in the PLC gives a 4 - 20 mA output to the gas burner modulating motor to maintain combustion chamber temperature control.

Auto-thermal operation

If the VOC heat content in the process exhaust is greater than the RTO heating load, the combustion chamber temperature will rise above set point and the burner will modulate to low fire. When the 'burner cut off' temperature is reached the burner will shut down. The combustion air fan will remain running at minimum volume flow, and to achieve this the burner control will drive to a 'burner off' position, lower than the 'low fire' setting.

The PLC will enable a burner re-ignition and re-establishment of automatic flame supervision when the combustion chamber temperature drops below the 'burner cut in' set point temperature, provided the combustion chamber temperature remains above 760 C during the re-ignition programme. To ensure reliable ignition under any combustion chamber back pressure (main fan speed) the burner control will drive to a 'burner ignition' position during the ignition period.

High Solvent By-pass

At high VOC loading, the combustion chamber temperature will continue to rise after the support burner has been switched off. A PID control loop within the PLC controls the combustion chamber temperature at the High Solvent by-pass set-point by modulating the High Solvent Damper from closed to open. Initially this is set as a 'proportional only' control, with the PLC giving a 4mA output to the HSB damper positioner 'Closed' at 840 deg C, increasing proportionally to 20 mA output 'Open' at 860 deg C. High solvent bypass damper control is not initiated until the combustion chamber has reached 860 deg C.

PLC Temperature Safety Limits

If the combustion chamber temperature rises above normal limits the PLC will give a high temperature warning.

If no remedial action is taken and the temperature continues to rise, a second alarm set point will shut down the oxidiser.

The combustion chamber temperature control has an alarm set point to inhibit the 'ready for fume' signal if the combustion chamber temperature falls below 'ready for fume' temperature limit.

If the combustion chamber temperature falls below the 'ready for fume' temperature when a 'burner lockout' alarm is active, the oxidiser will go to a 'normal shut down'.

Thermocouples are installed in the oxidiser exhaust duct, and in the plenum below each canister. Each of these has a two level alarm system, the first to give a high temperature alarm and warning, and the second to shut down the oxidiser.

A thermocouple is also installed in the oxidiser inlet duct. Upon detection of first high temperature the alarm is displayed at the operator interface and an audible alarm is generated. In the event of the oxidiser detecting a second high inlet temperature (possible duct fire), the oxidiser will remove authorisation for the process machines to be diverted to the oxidiser, the process isolation damper shall close, the fresh air damper will open and the main fan will switch to idle speed setting. The oxidiser will remain in this condition until the trigger has been cleared and the alarm message acknowledged and cleared at the operator interface.

Independent Temperature Safety Limits

A safety temperature alarm controller, independent of the PLC and fed from an independent combustion chamber thermocouple, is installed to give a Combustion chamber high temperature alarm and shutdown if the temperature rises above the 'high temperature' alarm set point. The same controller will give a low temperature alarm and loss of the 'ready for fume' signal if the temperature falls below the 'low temperature' alarm set point whilst in a 'ready for fume' condition.

A safety temperature alarm controller is installed to give independent protection for high Exhaust temperature.

A safety temperature alarm controller is installed to give independent protection for high inlet temperature.

Normally, independent high temperature alarms will be set slightly above the PLC alarm settings, and low temperature alarms will be set slightly below the PLC alarm settings.

2.2.6. CHART RECORDER

A graphic chart recorder provides continuous monitoring of the Combustion Chamber temperature, Inlet temperature, and Exhaust temperature from independent thermocouples.

2.2.7. PRESSURE CONTROL

When the Oxidiser is on-line to process exhaust, the volume flow through the oxidiser is controlled by varying the speed of the main fan through it's variable frequency drive.

A pressure sensor (PTI), located in the process exhaust duct, measures the static pressure and transmits it as a 4-20 mA signal to the PLC. (Standard range 4mA = +2000Pa and 20mA = -1000Pa).

A PID control loop in the PLC compares this input signal with the static pressure set point (Initially set at -250 Pa) and gives a 4-20 mA output signal to the main fan VFD which varies the main fan speed to maintain constant pressure at the sensing point (PT1).

As process exhaust is directed to the oxidiser the static pressure will rise and the fan speed will increase to compensate. Similarly, if the process exhaust reduces, the pressure will fall and the fan speed will reduce. During commissioning the flow from each machine on Oxidiser exhaust at the static pressure control set point should be balanced with its flow when under atmospheric exhaust.

The limits of fan speed under automatic control are 100% (50Hz) maximum, and 10% (5 Hz) minimum.

To minimise the effect of temporary pressure imbalance as diverter dampers change over and the main fan accelerates, diverter damper opening to Oxidiser and fresh air damper closing should be set to the longest practicable operating time (10 to 30s). Fresh air damper opening and diverter damper opening to atmosphere should be set to the shortest practicable operating time (2 to 10s)

If the Oxidiser is not on line to Process exhaust, the automatic speed control is over-ridden by the respective VFD fixed speed (VFD fixed speed 2 if in idle or shut down mode; VFD fixed speed 1 if purging or during heat up).

The oxidiser inlet ductwork has a vacuum break damper to protect against excessive negative duct pressure. This has a limit switch indicating the 'closed' position with input to the PLC for monitoring purposes only.

2.2.8. MAIN FAN SPEED DETECTOR

Main fan operation is proved using a shaft speed detector, typically of Hengstler manufacture supplied by RS components No200 - 1049, with an input from a NPN inductive proximity switch Telemecanique type XS4-P30NA370, RS type 249-2524 or equivalent. This fan speed detector has two relay outputs one is used to prove minimum speed and is interlocked into the main fan run circuit, the other output is used for above purge speed and is interlocked with the hardwired purge circuit in series with the VFD purge speed relay.

2.2.9. PROCESS INTERLOCKS

The Oxidiser control interfaces with the Clients process control through a series of interlocks designed to ensure the safe and stable operation of both systems in relation to each other.

Each of the Clients process exhausts will have mechanically linked dampers (one actuator and two limit switches) which will divert process exhaust from atmospheric exhaust to oxidiser exhaust.

Limit switches on each damper signal 'open to atmosphere' and 'open to oxidiser'.

The dampers are controlled by the respective machine control circuit to enable the machines to purge directly to atmosphere and not through the oxidiser.

When the oxidiser is ready to accept fume, a volt free signal is given indicating that it is OK to divert fume to the oxidiser ('ready for fume' signal). When a machine starts producing fume the clients control is to issue a 'Request' abatement signal to the oxidiser control system. Upon receipt of the request signal and provided that the oxidiser is still in a ready for fume condition, then the oxidiser will acknowledge the machine request signal with an 'Accept' signal. Upon receipt of the 'Accept' signal the process machine will initiate changeover of it's process damper from atmospheric exhaust to abatement exhaust. Once the damper has been 'confirmed' open to oxidiser, via a damper mounted limit switch, the oxidiser fresh air damper shall be enabled to close and the oxidiser will control automatically on process fume. Upon issuing the first 'Accept' signal the PLC will change the VFD from fixed speed to automatic speed control.
The 'Accept' signal has the facility to be a staggered allowing only one process to be diverted to the oxidiser at any one time. A programmable time period is incorporated for this function to allow this control to be optimised thus keeping machine waiting times to a minimum.

If the PLC does not receive a 'confirmed' signal within a set time (twice the damper operating time) of the 'Accept' signal, the fresh air damper will not close (assuming first machine to be diverted), and a diverter damper fault alarm will be given.

If the PLC receives a 'confirmed' signal whilst the Oxidiser is not in a 'ready for fume' condition, the fresh air damper will not close and a diverter damper fault alarm will be given. [This alarm will display at the RTO operator interface only, and does not initiate any corrective action at the process. See Note 1 below]
If the 'Ready for fume' signal is lost for any reason the Process isolation damper will close. The Client's process control must ensure that all machines on line to the Oxidiser immediately divert to atmosphere in order to avoid process fuming and possible VOC build up.

If there is only one machine on line to the Oxidiser and this machine is subsequently switched off line, then the fresh air damper will open and the main fan will go to 'idle' speed (VFD fixed speed 2)

Note 1: It is the Client's responsibility to give a valid 'confirmed' signal and failure to do this could put the oxidiser and process exhaust into a potentially hazardous situation.

2.2.10. EMERGENCY STOP CIRCUIT

All oxidiser control circuits include an emergency stop relay to conform to CEI IEC204-1. Typical relays would be Pilz PNOZ or Telemecanique Preventa with 3 N/O separate circuits for interrupting the oxidiser and main fan AC inverter (VFD) hardwired control circuits, PLC outputs circuits. Action of any emergency stop push-button would cause all motors to stop, the burners to extinguish and all dampers move to their fail-safe positions. An emergency stop reset push-button/indicator lamp is fitted and should be operated after correcting the problem and releasing the emergency stop push-button lock out.

2.2.11. BAKE OUT

Condensed or solidified VOC products can accumulate in the lower parts of the oxidiser canisters and plenums which can lead to a restricted flow through the oxidiser and a possible fire risk. The oxidiser PLC program has provision for supervised automatic bake out and if there is evidence of such accumulations a bake out procedure is recommended.

This would normally be carried out during an RTO service in the following sequence:

1. The 'Bake Out' is initiated by protected keypad instruction at the Operator Interface. Initiation is only accepted when the oxidiser is 'ready for fume' and off line in an 'idle' operating condition (i.e. No processes are requesting the RTO). The 'ready for fume' signal to process exhausts is suppressed whilst the RTO is in the bake out cycle. [8]

2. The PLC programme checks that all process to atmosphere dampers are not confirmed open to oxidiser, the fresh air damper is open, the process isolation damper is closed, the high solvent by pass damper is closed, and the main is running at 'bake out' speed (this would normally be the 'idle' speed).

3. The normal damper cycle is over ridden for the duration of the 'bake out'.

The current position of the inlet and outlet dampers is maintained continuously until the temperature in the plenum of the outlet canister reaches the bake out control temperature.

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[8] If a tempering air damper is installed this will be open during bake out

4. When the bake out temperature is reached, the inlet and outlet dampers move to their next cycle position and this sequence continues cycle by cycle until all canisters have been 'baked out'

5. When the 'bake out' sequence is complete, a 'bake out cooling' timer is started and the inlet and outlet dampers are allowed to resume the normal cycle sequence (All the other dampers remain in position). When the 'bake out cooling' timer has timed out the control system returns the Oxidiser to normal operation

6. The most recent initiation of bake out, and times taken for each canister to reach the bake out temperature are logged to the Operator Interface display

2.2.12 PLC CONTROL

PLC control sequences includes the following :-

Oxidiser pre-start status control.
Canister damper timing programme.
Automatic start up programme including motor control enables
Oxidiser operating status programme.
Automatic shutdown programme.
Combustion chamber temperature control.
Oxidiser static pressure control.
Damper fault monitoring
Control fault monitoring (fan speed verification, burner status etc.)
Temperature fault monitoring (high/low temperature limits etc.)
Fire condition programme.
Bake out programme.

For the PLC to control the above, analogue and digital inputs and outputs will consist of approximately 64 digital , 6 thermocouples and 1 x 4-20mA. (Pressure transmitter) inputs as follows:-

Damper open and closed limit switches.
Modulating motor high and lowfire positions on burners
Motors running and overload signals.
Oxidiser temperature alarms.
Pressure controller low/high static pressure (analogue)
Emergency stop operated.
Inverter healthy, running and at speed.
Compressed air supply pressure switch.
Burners selected, gas supply pressure switch, burners lit, burner lockout, combustion air pressure switch and high gas pressure switch for the burner.

Oxidiser purging, purged and ready for fume.
Auto start and shutdown.
Bake out requested.
'Process going on line' and 'Fume confirmed to oxidiser' signals.
Vacuum breaker actuated.

Approximately 32 digital and 3 x 4-20mA analogue outputs as follows:

Oxidiser damper solenoids.
Motor enable signals.
Main fan fixed speed signals.
Burner enable signal.
Burner modulating motor override to high and lowfire positions.
Oxidiser 'ready for fume' to process machines, and timed delays to enable post-purging.
Combustion chamber temperature control by burners and high solvent by-pass (analogue)
Oxidiser pressure control. (analogue)
Oxidiser alarm to signal audible and visual and signal to client.
Communications link with the Operator Interface (Panelview 600).

In addition to the PLC inputs and outputs the oxidiser control circuit uses approximately 30 control relays in hardwiring circuits and signals common to hardwiring and PLC inputs.

PLC programming loading and programme editing will be through a PC interface. The connection of the PC interface will enable on-line changes to be made to the programme.

On line changes to PLC program variables such as timers and control settings will also be possible through the Operator Interface key pad.

The PLC will have capability to download any software program changes whilst the PLC is in the 'run' mode.

The Main Control Panel design is to provide for a power socket, access, and all necessary connections for the functioning and operation of the PC interface.

2.2.13 PANEL VIEW 600 - OPERATOR INTERFACE MODULE

The PLC interfaces with a Panelview 600 operator terminal and displays typically purge/start up conditions, canister damper sequence, oxidiser status, current alarms and alarm history (time and date), temperature and inlet pressure indication accessed via function keys on the terminal.

The display pages for the operator interface include :-

- **Title page** with Oxidiser name plate data and index via function keys to the following other screens:- F2 Process Overview, F3 Oxidiser Overview, F5 Manual Control, F7 alarm Page, F8 Engineers Menu, F9 Adjust Setpoints, F10 Info Screen.
- **Main Menu** list of available pages with associated function keys for selection.
- **Process Overview** displaying process on / off line status, inlet duct static pressure, Process isolation, fresh air, and vacuum break damper status, main fan running speed (Hz) and inlet temperature. Also displayed on this page are status lamps indicating - Purging, Purged, Ready For Fume and Alarm. Indexing to other pages is also possible by operation of the following function keys:- F1 Main Menu, F7 Alarm page, F3 Oxidiser Overview, F10 Alarm reset.
- **Oxidiser Overview** displaying representation of the oxidiser, indicating status of canister dampers, main fan speed (Hz), inlet pressure and temperature, canister temperatures, combustion chamber temperature, exhaust temperature, burner on / off status, % output to burner modulating motor, and combustion air fan status. Also displayed on this page are status lamps indicating - Purging, Purged, Ready For Fume and Alarm. Indexing to other pages is also possible by operation of the following function keys:- F1 Main Menu, F7 Alarm page, F2 Process Overview, F10 Alarm reset.
- **Process Setpoint Adjustment**, this page is accessed via function key selection in the main menu and is password protected. Adjustment of burner control setpoint and static pressure control setpoint is possible through this page. Indexing to other pages is also possible by operation of the following function keys:- F1 Main Menu and F7 Alarm Page.
- **Engineering Menu,** this page is accessed via function key selection from other pages and is password protected with a separate password to the Process Setpoint Adjustment password. Adjustment of all timers, PID terms, main fan fixed speed settings, pressure / temperature setpoints and manual control of motors is possible through designated function key operation within this page.
- **Alarm Page,** this page is accessed via function key selection from other pages and contains a list of current alarms complete with time and date stamps. **Alarms can be acknowledge via operation of the F4 function key and reset, when alarm has condition has cleared, via operation of the F10 function key.** From this page access to the alarm history is also possible through operation of the designated function key.
- **Alarm History,** This page contains the history of the last 500 logged alarms complete with time and date stamps. Access to active alarms can be gained through operation of the F7 function key and the alarm history can be cleared by operation of the F3 function key. The main menu can once again be accessed by operation of the F1 function key.
- **Information Screen,** this screen contains contact information details of Haden Environmental.

2.2.14 OXIDISER PROCESS AND INSTRUMENTATION DIAGRAMS

Equipment identification references and labelling on the Contract P & ID drawings are to be used on all electrical schematics, wiring diagrams and PLC ladder diagrams and the Panelview 600 operator interface module.

<u>APPENDIX 1</u>

Damper timing programme

<u>APPENDIX 2</u>

Control settings

<u>APPENDIX 3</u>

Alarm listing

Appendix 1

Damper Timing Programme

1. Two Canister RTO Damper Timing Programme

Based on a 4 second damper operating time and a 160 second cycle time

Tag	Damper	Operation	Cycle Step	Step Time (Seconds)	Full Cycle Time (Seconds)
FV1A	Canister 1 Inlet	Closes	1	0	0
FV2B	Canister 2 Outlet	Closes	1	0	0
FV1B	Canister 1 Outlet	Opens	1	0.5	0.5
FV2A	Canister 2 Inlet	Opens	1	0.5	0.5
	End of Step		Next Step		160
FV1B	Canister 1 Outlet	Closes	2	0	160
FV2A	Canister 2 Inlet	Closes	2	0	160
FV1A	Canister 1 Inlet	Opens	2	0.5	160.5
FV2B	Canister 2 Outlet	Opens	2	0.5	160.5
	End of Cycle		Return to 1		320

APPENDIX 2
Oxidiser control settings

1 Combustion Chamber Temperature Control Settings at the PLC

The combustion chamber temperature analogue inputs to the PLC provides the following PLC output control signals :-

		Initial set point (deg C)
1.1	Oxidiser cool (Compressed Air cooling not required, Solenoid SV4 powered to close)	on>200, off<150
1.2	Oxidiser below shut down temperature	on<500, off>500
1.3	Oxidiser below 'ready for fume' temperature	on>750, off<740
1.4	Oxidiser heat-up ramp (VFD speed increase from 10Hz to 30Hz)	on >790 off <550
1.5	Combustion chamber burner control setpoint	800
1.6	Oxidiser above auto-thermal/fuel injection active set point	on>830, off<790
1.7	High solvent by-pass control (Proportional control - closed to open)	840 to 860
1.8	Oxidiser 1st high temperature warning	on>890, off<880
1.9	Oxidiser 2nd high temperature shut down	on>910, off<885

2. Combustion Chamber Safety Controller Settings

Independent alarm controller

		Initial set point (deg C)
2.1	Oxidiser high temperature safety shut down	on>940, off<910
2.2	Oxidiser minimum temperature (When 'ready for fume')	on>750, off<740

3 Canister Temperature Control Settings at the PLC

Thermocouples below each canister give analogue inputs to the PLC and provide the following PLC output control signals :-

		Initial set point (deg C)
3.1	1st high temperature alarm below canister 1	on>250, off<200
3.2	1st high temperature alarm below canister 2	on>250, off<200
3.3	2nd high temperature alarm below canister 1	on>300, off <260
3.4	2nd high temperature alarm below canister 2	on>300, off <260

3.5	Burn through temperature control canister 1	on>440, off <200
3.6	Burn through temperature control canister 2	on>440, off <200

4 Exhaust Temperature Control Settings at the PLC

A thermocouple in the oxidiser exhaust gives an analogue input to the PLC and provides the following PLC output control signals :-

		Initial set point (deg C)
4.1	Exhaust above oxidiser heat up temperature	on > 45, off < 25
4.2	1st high exhaust temperature alarm	on>270, off<200
4.3	2nd high exhaust temperature alarm	on>320, off<250

5. Exhaust Temperature Safety Controller Settings

		Initial set point (deg C)
5.1	High exhaust temperature shut down alarm	on>340, off<300

6 Inlet Temperature Control Settings at the PLC

A thermocouple in the oxidiser inlet gives an analogue input to the PLC and provides the following PLC output control signals :-

		Initial set point (deg C)
6.1	1st high inlet temperature alarm	on>200, off<180
6.2	2nd high inlet temperature alarm	on>250, off<220

7. Inlet Temperature Safety Controller Settings - (Customer option)

		Initial set point (deg C)
7.1	High inlet temperature alarm	on>260, off<220

8 Static Pressure Control Settings at the PLC

A pressure transmitter at the oxidiser inlet, upstream of the process isolation damper, gives an analogue input to the PLC and provides the following PLC output control signals :-

Initial set point (Pa)

8.1	Main induced draft fan speed control set point	- 250
8.2	High inlet static pressure alarm	on>750 off<500
8.3	Low inlet static pressure alarm	on<-1750 off>-1500

9 <u>Combustion air pressure switch</u>

Air pressure switch downstream of the combustion air fan suitable for a pressure range 3000 to 15000 Pa (0.5 to 30 mb) . Maximum pressure 10 kPa

		Initial set point (Pa)
9.1	Combustion air supply satisfactory	+ 4500
9.2	Combustion air supply not satisfactory	+ 3000

10 <u>Oxidiser differential pressure switch</u>

A differential pressure switch across the oxidiser between inlet and outlet ducts suitable for a pressure range 30 to 3000 Pa (0.3 to 30 mb).
Maximum pressure 8 kPa. Minimum pressure -1 kPa.

		Initial set point (Pa)
10.1	Oxidiser pressure differential satisfactory	+ 130
10.2	Oxidiser pressure differential low	+100

11 <u>Compressed air pressure switch</u>

A pressure switch in the compressed air supply to confirm the availability of cooling air to the burners, suitable for a pressure range 2 to 8 Bar.
Maximum pressure 10 bar.

		Initial set point (Bar)
11.1	Compressed air pressure satisfactory	5

12 <u>Main induced draft fan variable speed drive (Assumed full fan speed = 50 Hz)</u>

Variable frequency drive fixed speed settings to confirm oxidiser flow rates for pre-start purging, and oxidiser 'idle' operating conditions.

		Initial set point (Hz
12.1	1st Fixed Speed - Oxidiser in 'pre-start purge' condition	20
12.2	2nd Fixed Speed - Oxidiser in 'idle' operating condition	10
12.3	Minimum speed - Main fan in auto speed control	7

13 <u>Gas burner control settings</u>

Positions for the combustion air modulating control damper

Initial set point (%)

13.1	'Auto-thermal' or 'Fuel injection' position [Burners off]	0%
13.2	Low fire setting	10%
13.3	High fire setting	100%
13.4	Ignition setting	20%

4. ELECTRICAL CONTROL SYSTEM

4.1 PANEL DESCRIPTION

The oxidiser electrical controls are housed in a multi compartment control panel inside the GRP enclosure adjacent to the oxidiser.

4.1.1 Variable Frequency Drive Unit

The first sections (LHS from the front) contain the variable frequency drive for the oxidiser main exhaust fan.

Mounted on the door of this compartment are the following:-
HMI Keypad
Drive on/off/reset selector switch
Supply on indicator
Emergency stop pushbutton

Immediately to the left of the inverter drive bay is a narrow section containing the main incoming MCCB
Inlet RFI filter
Distribution busbars
63 Amp MCCB for oxidiser controls supply

Mounted on the door of this compartment is the main isolator operating handle.

The next bay is a 'wardrobe' style section containing the following equipment:-

2 KVA Control transformer
Star / Delta contactor set for the combustion air fan
Control MCB's
Control section isolator
Burner controller
Over/under temperature alarm units
PLC
24v Power supply
Control relays
Control terminals
Main fan shaft tachometer, control relays and control terminals.

The doors of this section contains the emergency stop, auto start, auto stop, E.stop reset , burner lockout rest pushbuttons and Panel View 600 operator interface.

5.1 INTRODUCTION

WARNING

Before the oxidiser is opened for any reason, or persons allowed to enter the interior, the temperature of the interior must be ambient and purged of fumes. Adequate ventilation must be provided i.e. doors removed, and the regulations for entry into confined spaces must be followed.

When carrying out any maintenance or adjustments (other than actual running adjustments), the mains isolator on the main electrical control panel must be switched to the OFF position and padlocked. The key must be retained by the person carrying the work on, or in, the oxidiser. A similar foolproof method must be applied to the gas manual isolating valve. Where maintenance is to be carried out on the fuel equipment, observe general pre-fuel equipment maintenance instructions.

Details of specific maintenance procedures follow the maintenance schedules.

The following maintenance schedules detail the minimum attentions considered necessary to ensure safety, reliability and trouble-free operation of the unit. The information is presented in chart form, summarising the maintenance required to be carried out, the schedules are laid out in a check list form. It is suggested that they are photocopied and used as a basis for planned maintenance records. An effective maintenance system is devised over a long period of time and by use of a check list the system can be modified according to experience. Any remarks can be entered on the back of the check list.

During checks, it is advisable to replace any components that show signs of wear rather than delaying until component failure results in loss of production.

Indicate on the check list as follows, according to findings:-

Carried out or checked and required no action	✓
Carried out or checked and rectified	0
Carried out or checked and requires attention	✗
Checked, awaiting spares	S

5.2 EXTERNAL INSPECTION

Before Switching on Power Supply:

Check for correct physical location of all piping, valves and controls as specified on the drawings.

Check that all wiring is correct and also for the correct voltage supply to control panel and all field equipment.

5.3 INTERNAL INSPECTION

Before entering the unit, check to ensure the oxidiser control panel is isolated and locked in the OFF position and that the gas supply isolating cock is in the OFF position. It is preferable for the atmosphere in the unit to be checked prior to entry using proprietary monitoring equipment. All normal "confined space" entry procedures should be applied. Inspect the combustion chamber, the plenum chambers beneath each media bed and ductwork internally, with regard to the following:-

NOTE: Do not walk directly on ceramic fibre insulation installed in the combustion chamber - use temporary floor boards, plywood or similar to distribute weight:

1. Check for any internal damage, especially to insulation.
2. Check the burners to ensure the ultra violet (UV) scanner orifice, pilot nozzle and main burner nozzles are clean and free of obstruction. Check the spark electrodes are correctly positioned.
3. Check that all loose items such as welding rods, boards and any other debris have been removed.
4. Check thermocouples for correct installation.
5. Check dampers, especially for damage to seals and tightness.

When internal inspection is complete, close all access doors making certain internal door insulation is not damaged and is correctly installed. If door assemblies do not fit tightly against the oxidiser installation, fill gaps with fibrefax blanket insulation, or equivalent.

5.4 DRYING OUT NEW INSULATION

Minimal dry out is required for ceramic Pyrobloc materials. However, because there are mortars and rigidiser coatings used in this type of construction, the unit should be kept at 120°C for 3 hours to prevent blowholes from forming and to dry out the burner quarls.

The unit may then be brought up to final operating temperatures in 100°C steps at 1 hour intervals.

5.5 FUEL EQUIPMENT MAINTENANCE INSTRUCTIONS

It should be clearly understood that the information supplied is not intended to revoke or override instructions issued by any other competent or authorised body, and reference should be made to all relevant codes of practice i.e. DIN standards.

Before any maintenance is attempted, the appropriate "De-commissioning Procedure" must be observed, and any standing instructions on "Venting Down Procedures" and/or Health & Safety at Work Act, must be observed.

If it is necessary to clear the system of gas then with the burner ignited, shut off gas at main isolating valve. Allow the gas within the pipework to burn off. Isolate the gas supply and secure in the OFF position.

Note A complete gas test procedure must be carried out on completion of gas maintenance.

5.6 GENERAL

Reference should be made to the detailed manuals relating to each piece of equipment and which are given elsewhere in these manuals.

5.7 CHECKING FANS FOR VIBRATION

Check by feel that vibration is not excessive or increasing each time it is checked. If it is, investigate urgently.

Possible causes to look for are:-

i) Build up of deposits on fan blades, or, if build up is uneven, one section of deposits may have fallen off.

ii) Damaged or broken blades.

iii) Faulty bearings.

5.8 CARE OF THERMOCOUPLES

Thermocouples are fitted to the Oxidiser.

When maintenance or cleaning is carried out in areas containing thermocouples, care must be taken as the tip of the exposed type used protrudes approximately 2 inches into the oxidiser interior.

5.9 LUBRICATION GRADES

Grade "F":	Grease - Medium soft
Type:	Lithium based grease of NLGI No 2 consistency. It is a medium-soft grease with good anti corrosion, anti oxidant and water-repellent properties and can be used over a wide temperature range.
Suitability:	This is a multi-purpose grease suitable for all points fed by grease nipples, e.g., ball and roller bearings, plain bearings, slides etc. It is suitable for ball and roller bearings which are "packed for life" and for light gearboxes which are designed for packing with grease and for light duty open gears.
Drop Point:	180^{o}C.

5.10 BUILD UP IN DUCTWORK

It is vitally important that condensate is not allowed to build up into excessive amounts within the oxidiser inlet ductwork. This condensate must be mechanically/chemically removed on a regular basis.

If excess condensate is allowed to build up this increases the risk of fire and in the event of serious fire can release dangerous quantities of combustible material into the air stream.

5.11 WEEKLY MAINTENANCE SCHEDULE

MECHANICAL MAINTENANCE CHECK LIST

DATE

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	COMMENTS
Gas burners & valves	Check for gas leakage or damage around burners and valve trains. Flame failure safety check.		
Exhaust, purge and combustion fans	Check bearing temperatures and for vibration.		
Expansion joints.	Inspect for wear, leakage or damage		
Greasing/lubrication	Refer to individual manuals		

MECHANICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
General Interior	1. Inspect ducting for deterioration and any build up of deposits on inside. 2. Inspect burners for deterioration. 3. Inspect refractory lining for deterioration. 4. Inspect retention chamber shell for loose fastenings.		
Gas Train Filter	Check and clean filter.	See proprietary component literature.	
All fans	Check carefully	See proprietary component literature.	
Dampers	Inspect bearings and seals.	See proprietary component literature.	

MECHANICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
All motors	Dismantle, clean out bearings and re-pack with grease. If required	Specification and equivalents of greases are found in section 5.9	
Gas Supply	General Servicing of gas train and pilot. Refer to proprietary component literature in section 8.	Observe general equipment maintenance instructions. A complete gas test procedure must be carried out by engineers on completion of gas train maintenance.	

MECHANICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
All Fans	Carry out vibration footprint check. Examine, re-lubricate and replace bearings as necessary. Replace Automatic lubricator units (if fitted). Visually examine fan casing and all static parts for wear/paint deterioration and repair.	Observe fan supplier maintenance procedure. Proprietary component literature.	

ELECTRICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
Control Sequence	Correct light up and shutdown.		
All push buttons/indicator lamps.	Correct operation. Check for physical damage.		
All cables and conduits.	Check for physical damage.		

ELECTRICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
Electrical control panel	Visually examine for physical damage or deterioration to control equipment.		
AC Variable speed drive	Carry out recommendations made by manufacturers.	See proprietary component literature	
Limit Switches Dampers open/closed limit switches.	Visually examine for physical damage or deterioration to limit switches or cables.		
Pressure Switches 1. Combustion fan air flow 2. Compressed air 3. Oxidiser minimum air flow	Visually examine for physical damage or deterioration. Manually trip to ensure correct operation.		
Rotation Detector Main oxidiser fan rotation	Visually examine for physical damage or deterioration		

ELECTRICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
Modulating Motor Gas/Air Valve	Visually examine for physical damage or deterioration of motor.		
Flame Detectors & Cables Main Gas Burners	Visually examine for physical damage or deterioration, including cleaning.		
Thermocouples	Visually examine for physical damage or deterioration.	See care of thermocouples paragraph 5 in this section	

ELECTRICAL MAINTENANCE CHECK LIST

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	DATE COMMENTS
Fuel Electrical shutoff valves Burner pilot supply	Visually examine for any signs of deterioration or physical damage.		
Pneumatic Solenoid Valves	Visually examine for any signs of deterioration or physical damage.		
Pressure transmitter PT1.	Visually examine for any signs of deterioration or physical damage. See proprietary literature.		

ELECTRICAL MAINTENANCE CHECK LIST

DATE

EQUIPMENT/ITEM DESCRIPTION	MAINTENANCE REQUIRED	REMARKS	COMMENTS
Motor Contactors	Examine for: 1. Wear in moving parts. 2. Oxidation & excessive pitting of contacts. 3. Loose connections.		
Power Relays	Examine for: 1. Wear in moving parts. 2. Oxidation & excessive pitting of contacts. 3. Loose connections.		
Main inverter drive	See proprietary literature.		