Labcat Operation Manual

Description

This document details the operation procedures for the Catagen Labcat System (20kW)

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Details

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1 Preamble

This document outlines the basic operating procedures of the Labcat system

The Catagen Team is committed to providing leading edge, world-class products and services to our customers. If at anytime the customer organization requires information and or assistance, please do not hesitate to contact a member of the team. Catagen make all efforts to meet customer needs and requirements.

The Management Team

Catagen Ltd

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4 Labcat Basic Description

The Labcat system is a machine primarily used for the testing of single catalytic Converter samples, (catalysts). The typical catalyst testing volume is in the range of 0.2 Liters to 1.2 Liters and the flow rates from 6g/second to 20g/second at a range of temperatures between 300°C and 1000°C. Testing of catalysts under various conditions allow the customer to both age and characterize the catalyst with a number of performance tests (including light-off testing, sweep testing, OSC [oxygen storage] testing). This will allow the customer to carryout research and development of catalyst formulations/engine conditions and will aid in meeting emissions legislation.

The Labcat uses sophisticated computer control and feedback to recreate and circulate an exhaust gas composition similar to that emitted by internal combustion engines. This exhaust gas is passed through the catalyst sample for long periods of time to simulate accelerated driving conditions. A typical aging test will last around 100 hours but some aging tests have been known to run for 2000 hours. The Labcat system is designed and built to run unattended and has automated fail-safes should the system deviate from testing parameters. The major advantage of the system is to reduce testing costs for the automotive industry as this testing technique is much more economical than traditional engine based testing methods.

Figure 4:1 The Catagen 20Kw Labcat

5 Labcat System Layout

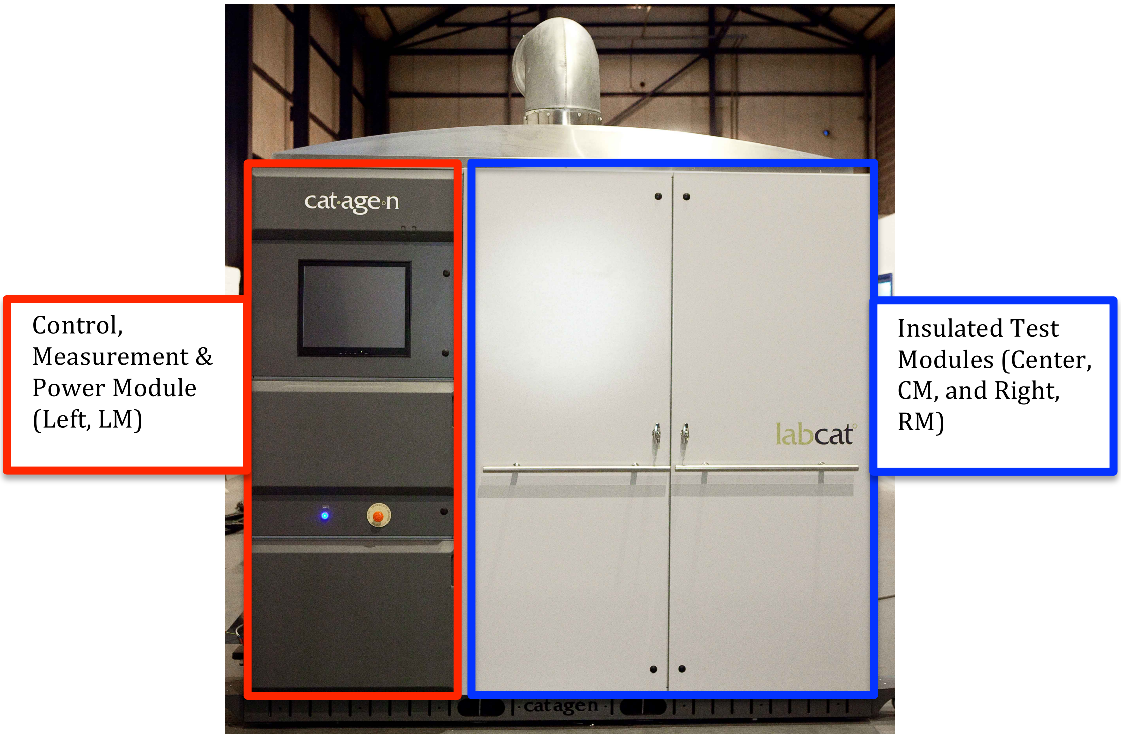


Figure 5:1 Labcat Main System Components

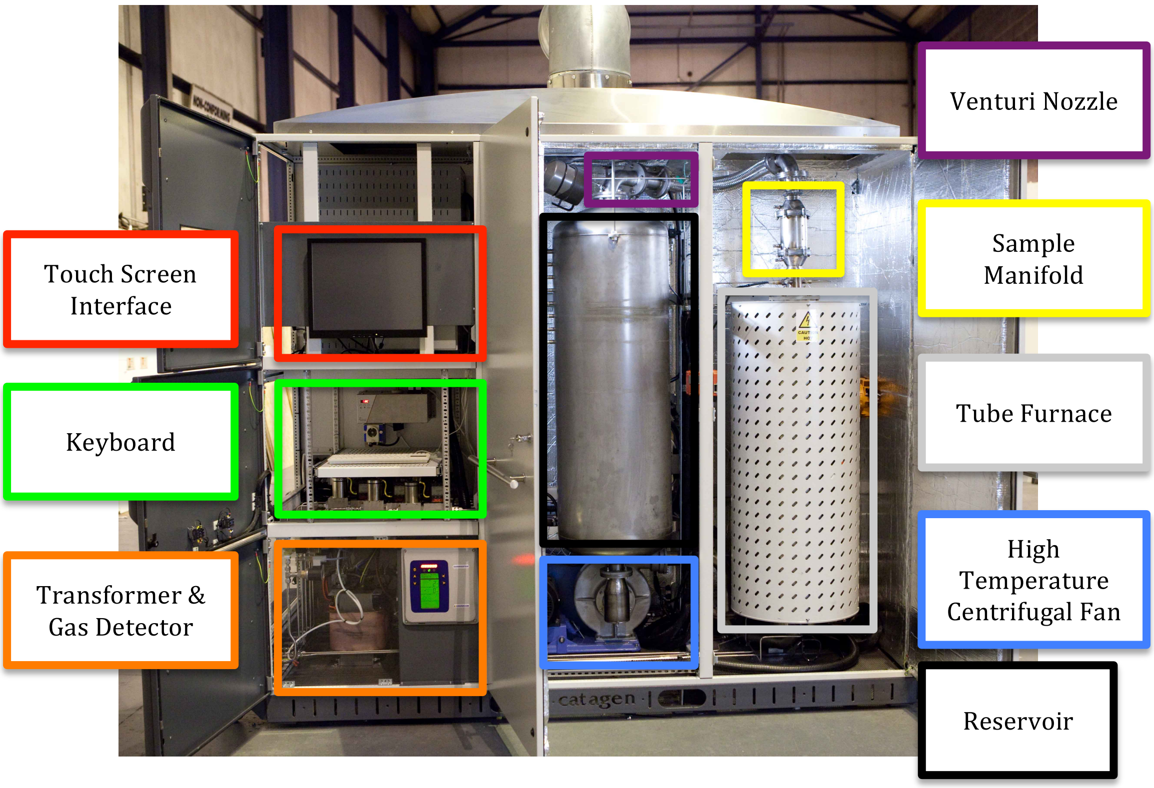


Figure 5:2 Main System Components

6 Schematics

6.1 Facilities USA Specifications

Facilities required for correct operation of this Labcat tool are as follows:

Gas Lines:	100% HC Delivered at 6 bar Pressure Terminated in ¼” Tubing
	100% CO_2 Delivered at 6 bar Pressure Terminated in ¼” Tubing
	100% N_2 Delivered at 6 bar Pressure Terminated in ¼” Tubing
	100% CO Delivered at 6 bar Pressure Terminated in ¼” Tubing
	100% Air Delivered at 8 bar Pressure Terminated in ½” Tubing
Water Drain:	1 X ¼” tubing to remove de-ionized water from the system
Exhaust Duct:	315mm Exhaust Duct
Power Supply:	208VAC
(USA config.)	60Hz
	Three Phase & N/E [5 Wire]
Peak Current:	95 Amp
LAN Connections:	Internet Connection RJ45
	Multigas 2030 Connection RJ45

6.2 Electrical Schematics

The Labcat electrical drawings are as follows and can be viewed in Appendix 2:

1. DWG NO: LC_20kW_POWER_DIST_1
2. DWG NO: LC_20kW_POWER_DIST_2
3. DWG NO: LC_20kW_POWER_DIST_3
4. DWG NO: LC_20kW_PILZ_SAFETY

6.3 Fluid Flow Schematics

The Labcat gas line schematics for the system are as follows and can be viewed in Appendix 2:

1. DWG NO: LC_20kW_GAS_DIST_1

7 Safety

7.1 Hazard Alert/Safety Labels

The following section defines the Hazard Alert / Safety Labels that are located on the equipment and the hazards associated with them.

These labels are displayed to help prevent injury to personnel or damage to equipment. Potential Hazards are identified so that they can be prevented; observe all warning labels on the system and in this manual. The labels and their locations are identified below. Operation and maintenance personnel should be aware of potential hazards associated with this system so they can take proper precautions to avoid injury to personnel and damage to equipment.

This section identifies the relevant hazards associated with this system. Personnel using this system should familiarize themselves with the content of this section. Photographs of the relevant safety features on this system are included in this manual, along with electrical drawings in the Appendix section.

These illustrate the location of hazards, safety interlocks, EMO buttons etc., along with basic system features and their operation. Study this manual carefully to educate yourself regarding the safety hazards and features of the system.

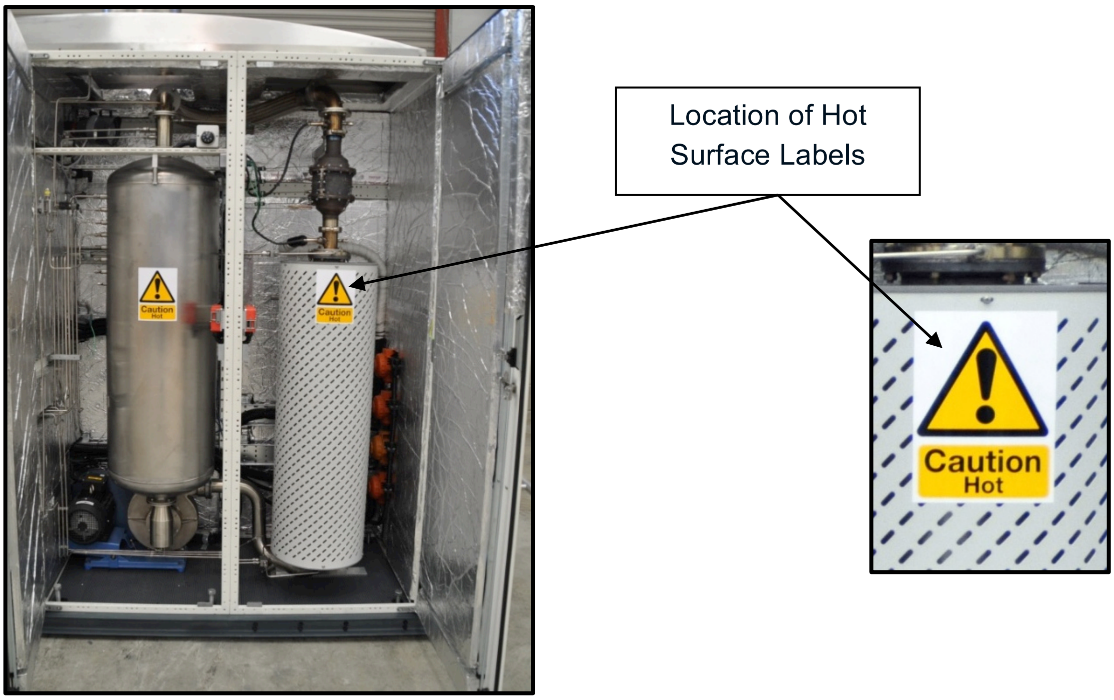


Figure 7:1 Caution Hot Surfaces

This label as shown in Fig 7.1 is located on each of the modules at the locations shown. Only trained personnel wearing the appropriate PPE as defined in this manual should handle the samples and components within this system to avoid injury.

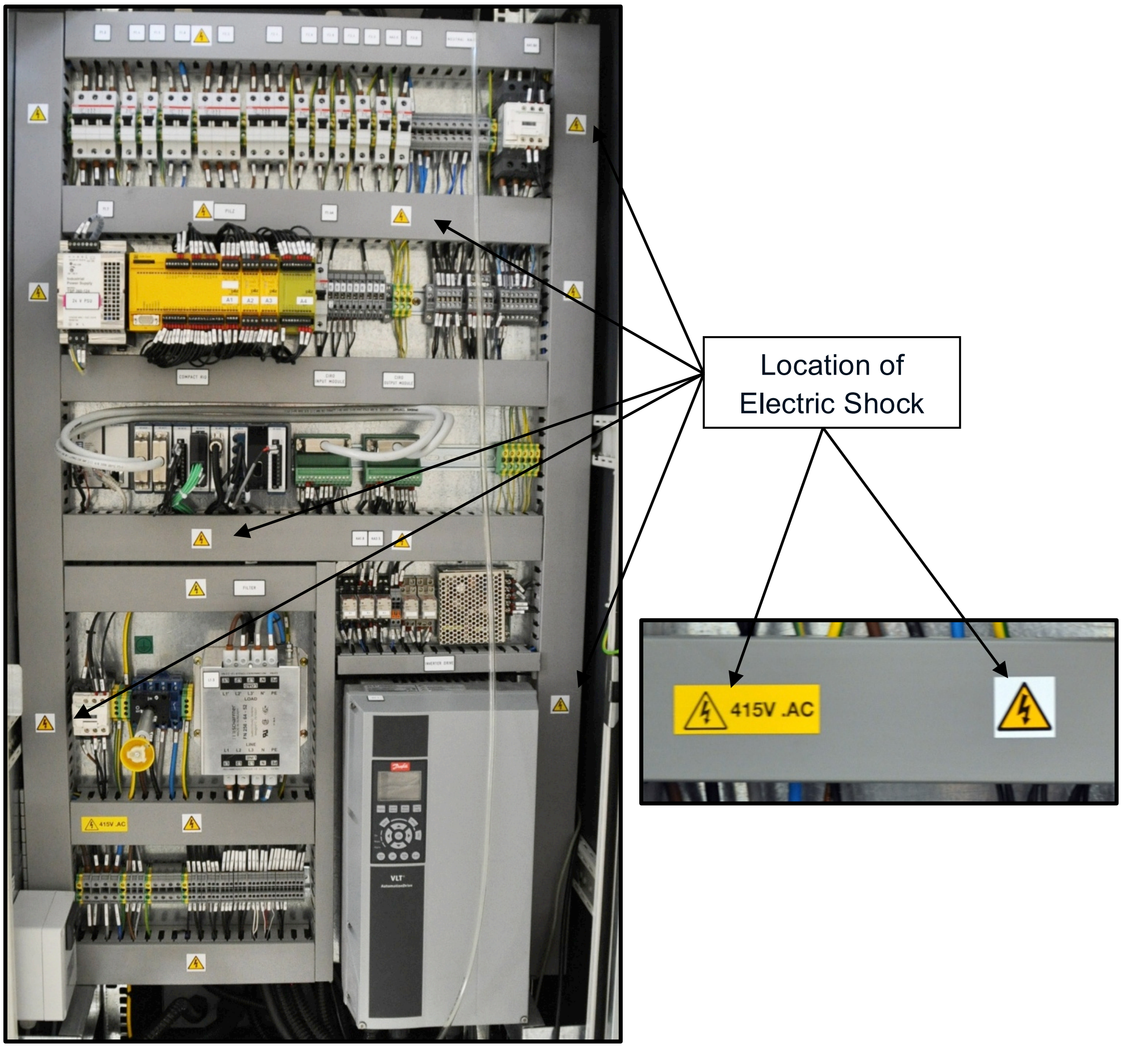


Figure 7:2 Caution Electric Shock

The Catagen USA Labcat requires 208VAC to operate and therefore contains hazardous, dangerous electrical energy; the maximum voltage inside the system is stepped up to 415V. Only skilled, trained personnel should connect power to the Labcat. Only Catagen staff should perform maintenance on the electrical circuits. The labels as shown in Figure 7.2 are located in the electrical panel.

7.2 Catalytic Converter Sample Change out Safety Procedures

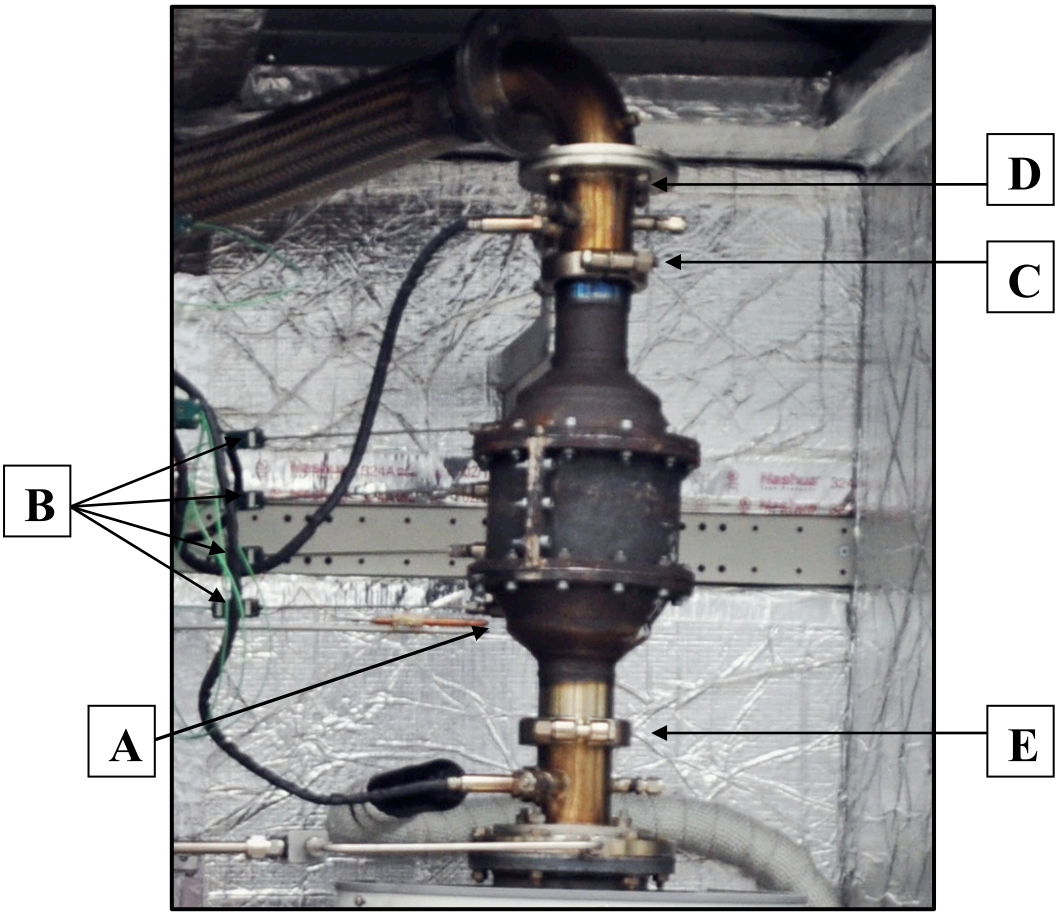


Figure 7:3 Catalytic Converter Sample change out

When changing the sample please follow the procedure below to ensure safe operation **[this task should only be carried out by trained personnel]**:

1. Ensure the correct PPE is being worn
2. Ensure the Labcat is in standby condition with the doors open, Eyecat Software.
3. On opening the door, check to makes sure the thermostat bulb is in close proximity to the catalyst sample surface (within 30mm). A
4. Remove thermocouple plugs from the thermocouple socket probes entering the sample. B
5. Using appropriate tools, remove the clamp holding the top of the sample to the flexible pipework. C Take care doing this operation, as the flexible pipe will need to be supported to stop it springing backwards. D
6. Once the clamp has been removed, place the flexible hose on the support hook provided. D
7. Carefully remove the gasket material from the top sample coupling.
8. Remove the second quick release coupling using appropriate tools. E
9. Lift the sample off and remove gasket material.

To mount a sample, please follow the above procedure in the reverse order beginning by placing the sample on the receiving collar A and putting a fresh gasket in place. **Catagen recommend that new gaskets be used when a sample is replaced.**

7.3 Lock out Tag out [LOTO]

This procedure establishes the minimum requirements for the lockout or tag out of energy isolating devices. The procedure is utilized to ensure that the equipment is isolated from all potentially hazardous energy, and locked out or tagged out before maintenance personnel perform any servicing or maintenance activities where the unexpected energizing, start-up or release of stored energy could cause injury. All maintenance personnel should be instructed in the safety significance of the lockout (or tag out) procedure.

7.3.1 Lockout Tag-Out Procedure

1. Notify all affected employees that a lockout or tag out system is going to be utilized and the reason for doing so. Maintenance personnel shall know the type and magnitude of energy that the machine or equipment utilizes and shall understand the hazards thereof.
2. If the machine or equipment is operating, shut it down by activating stop on the Eyecat software.
3. Wait until the cool down procedure has been executed by the system and the system returns to standby and the doors open
4. Press the close button on the Eyecat software
5. Shut down the on board computer by opening windows and selecting shutdown
6. Wait for the windows system to power down and turn off the on board computer
7. Activate the main isolator switch as shown in Figure 7.4.
8. Operate the facilities electrical isolation switch on the wall near the machine.
9. Operate all of the gas line isolation switches on the wall near the machine and depressurize lines at valves.
10. After ensuring that no personnel are exposed, and as a check on having disconnected the energy sources, operate the push button or other normal operating controls to make certain the equipment will not operate.
11. Lockout and tag out the energy isolating devices with assigned individual lock(s) and tag(s).
12. The equipment is now locked out or tagged out.

In the preceding steps, if more than one individual is required to lockout or tag out equipment, each person shall place his/her own personal lockout device or tag out device on the energy isolating device(s). When an energy-isolating device cannot accept multiple locks or tags, a multiple lockout or tag out device (hasp) may be used.

7.3.2 Basic rules for using Lock-Out Tag-Out System

All equipment shall be locked out to protect against accidental or inadvertent operation when such operation could cause injury to personnel. Do not attempt to operate any switch, valve, or other energy-isolating device that is locked out.

Figure 7:4 Mains Isolator Switch

7.4 Gas Connections

There are five gas lines in total entering the Labcat system. These gas lines must all be isolated and regulated to a maximum of 10 Bar pressure by certified regulators which are in turn connected to internal supplies or gas bottles.

The incoming gas lines are as follows:

1. 100% Industrial HC Line (C3H8 or other) – Propane– Supplied at 6 Bar
2. 100% CO_2 Line – Carbon Dioxide –Supplied at 6 Bar
3. 100% N_2 Line - Nitrogen (Oxygen Free Nitrogen) - Supplied at 8 Bar
4. 100% CO Line – Carbon Monoxide – Supplied at 6 Bar
5. Compressed Air (with standard line oil filters) – Supplied at 8 Bar

All bulkhead fittings on the Labcat system for connection to incoming gas lines are suited to tubing outer diameter of 6mm (metric). The only exception is the Air gas line, which has a 10mm (metric) bulkhead fitting.

Connection of the external incoming gas lines will be carried out by a customer certified engineer or technician and will be supervised by Catagen personnel. That representative must ensure that all tubing has been cut squarely and filed to remove any debris or burrs.

Figure 7:5 Incoming Gas Lines

Key to Note: The customer must take precautions that the incoming gas lines are suitably protected from damage by foot traffic or any other potential piercing dangers. This again may involve the installation of suitable cable tray(s) and barrier at floor level. Catagen recommend that any fuel lines be either solid stainless steel or have appropriate armor/braid protection.

The Customer personnel must be independently trained in the changing of gas bottles at the regulator and have necessary certifications in place. Catagen cannot accept any responsibility for connections of the gases to the system.

7.5 Location of EMO button

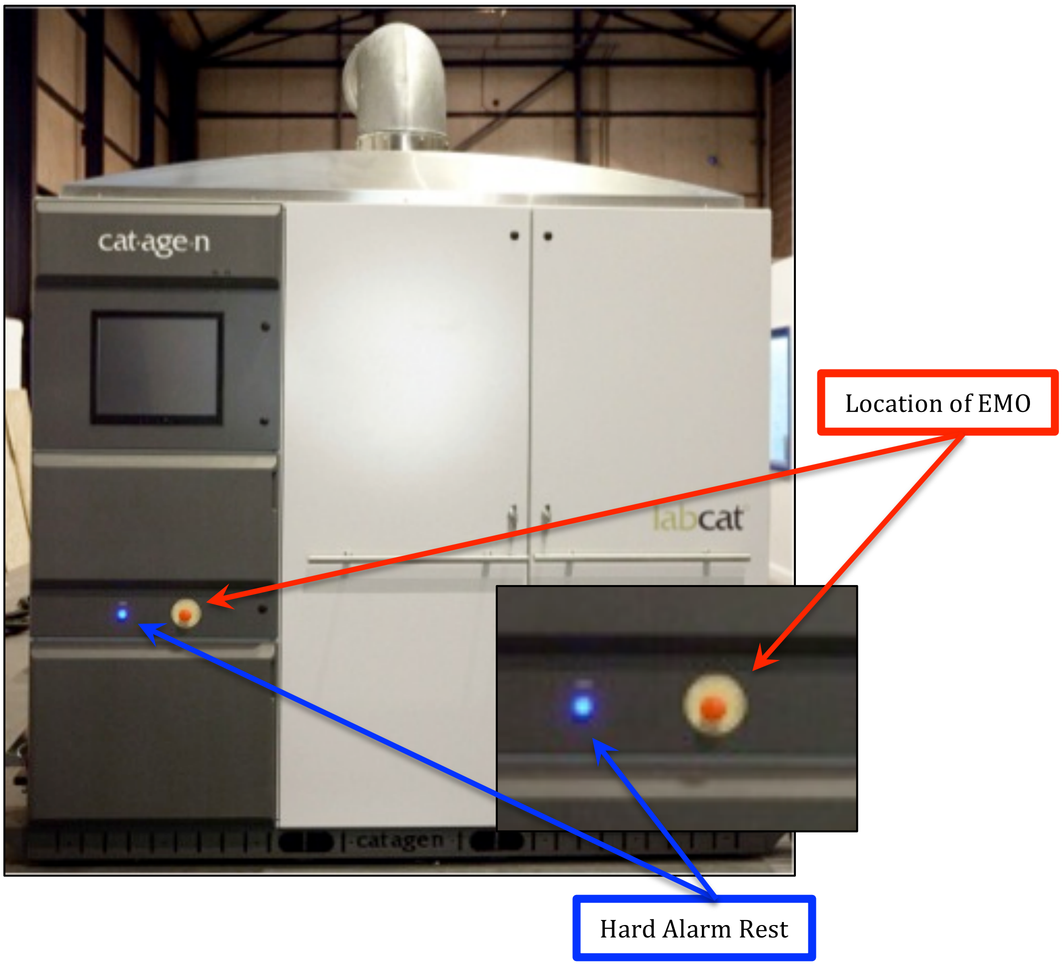


Figure 7:6 Location of EMO button on front of Labcat

The EMO, (emergency machine off0 button is located on the front face of the system and is to be activated by the user in an emergency condition. In order to reactivate the system after a manual or automatic EMO, one must activate the hard alarm reset button.

****NB After the system is turned on with the mains isolator (figure 7.4) the alarm-reset button must be pressed to activate all components.**

7.6 Hard Alarms

The following is a description of the hard alarms within the system under normal operation:

The PILZ safety circuit controls the ultimate safety of the system and is located in the electrical panel. Figure 7.7 shows the PILZ safety circuit. Under no circumstances must any unauthorized person interfere with the normal operation of the circuit and or programming.

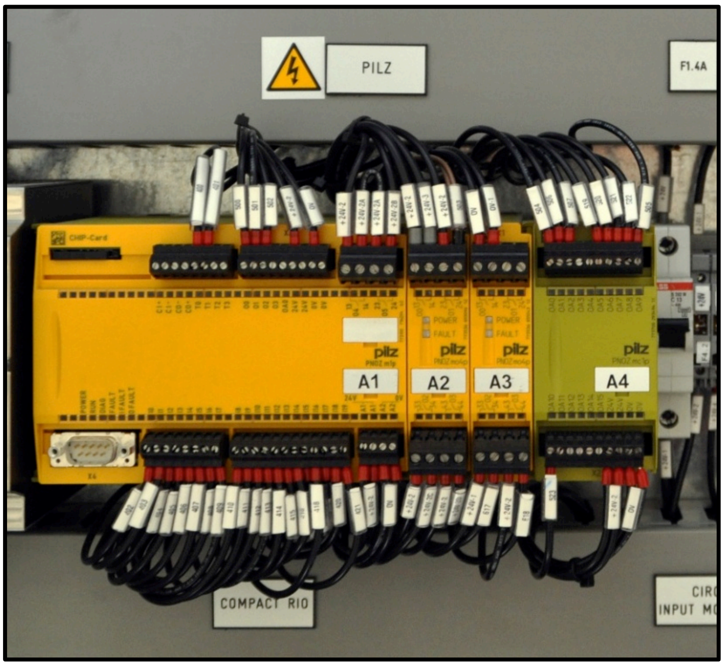


Figure 7:7 PILZ Safety Circuit

The circuit will isolate the gas line coming into the unit and the electrical components within the system under the following conditions:

A. Manual Emergency Stop Activated
B. Fan Inverter Alarm
C. CO Detected in System
D. HC Detected in system

Please note: Under normal hard alarm operation, the fan extractor will continue to removing both heat and the possibility of leaking gases from the pipework. Leaking gases will be detected using the Crowcon gas detection system as shown in Figure 7.8.

Figure 7:8 Gas detection sensors within Labcat

When there is a hard alarm the system automatically carries out the following:

- PILZ Circuit receives alarm Information
- PILZ Circuit isolates all gases entering the system excluding Nitrogen
- PILZ Circuit isolates all safety critical electrical components
- PILZ Circuit ensures extractor fan is ON
- PILZ Circuit communicates to Eyecat the alarm type
- PILZ Circuit turns on the alarm reset button to flashing (ready for activation)
- Eyecat opens the alarm page and the hard alarm indicator is illuminated
- Eyecat logs the alarm type, description, time and date into the log file
- Eyecat indicates the alarm type, i.e. Hard Alarm
- System awaits interaction from user

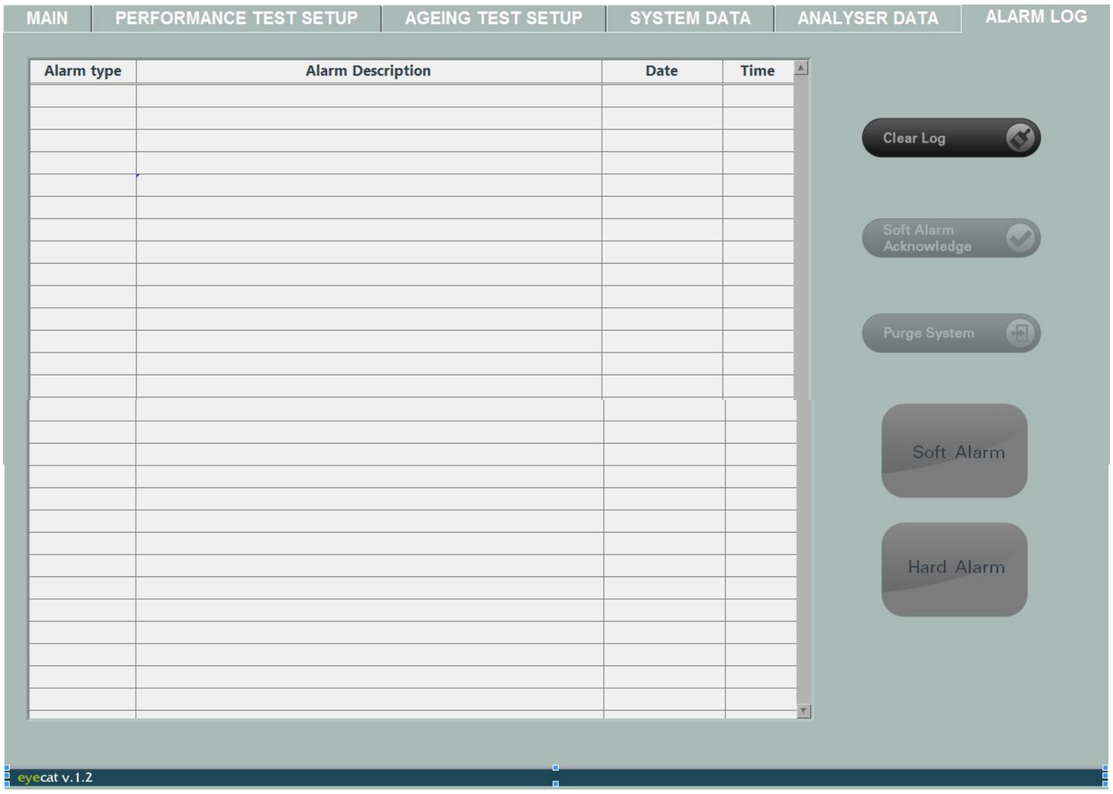


Figure 7:9 Eyecat Alarm Screen

****Please note:** Under a hard alarm condition even though the system is isolated, the user can choose to purge the system with nitrogen as an extra safety precaution. The purge system button will become active in an alarm condition. When activated, the nitrogen will flow into the system for a length of time set by the user in the advanced settings page on Eyecat [see section 8.4]. This will assist in removing any potentially dangerous gases from the system. Under a hard alarm condition the normally open solenoid valve releases any pressure and / or gases to the fan extractor.

7.6.1 Resetting Hard Alarm Condition

To reset the hard alarm please execute the following procedure:

Manual EMO Hard Alarm

A. Inspect the system for any problems and make sure it is safe to reset
B. Twist and pull the EMO button to reset
C. Activate the blue flashing reset button (Figure 7.6)

Gas Detection Hard Alarm

A. Inspect the system for any problems and make sure it is safe to reset
B. Inspect the Crowcon panel gas concentration reading and see if there are gases still in the system (figure 7.10). Only proceed to next step when there are no gases detected – Otherwise wait.
C. Presses the 'alarm bell silence' button on the Crowcon panel
D. Activate the blue flashing reset button (Figure 7.10)

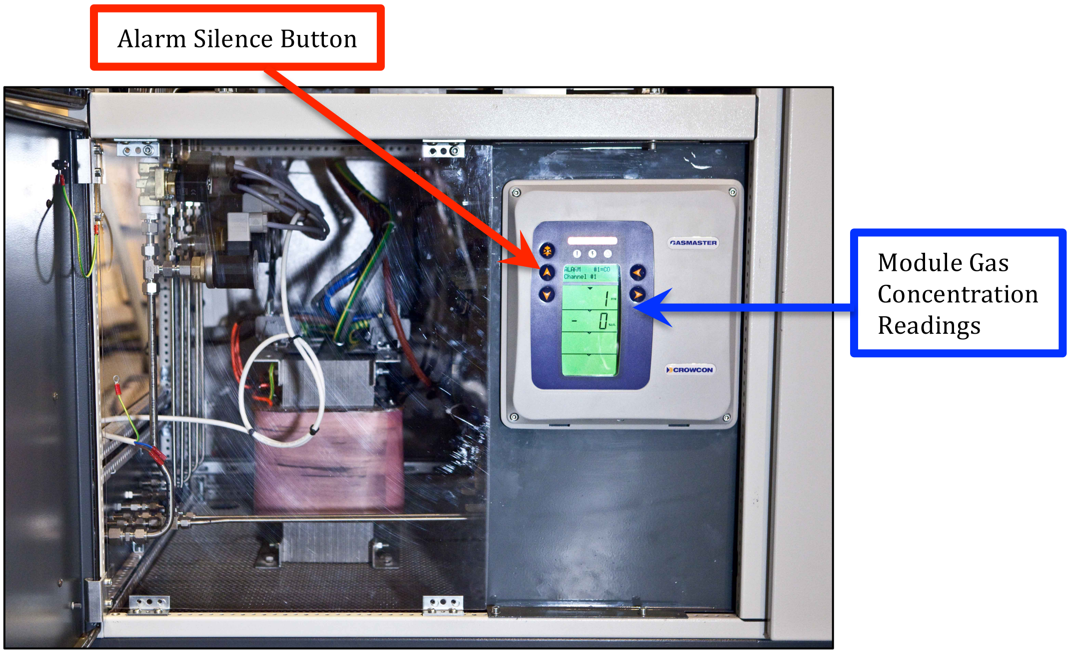


Figure 7:10 Crowcon Panel

If a leak is detected in the system please carry out leak inspection as described in Section 8.3.

NB If any other hard alarms activate please contact Catagen**

7.7 Soft Alarms

The Eyecat software and the cRIO control the soft alarm conditions. They are to ensure that the testing happens within the correct testing conditions. Figure 7.11 shows the cRIO unit mounted in the electrical panel.

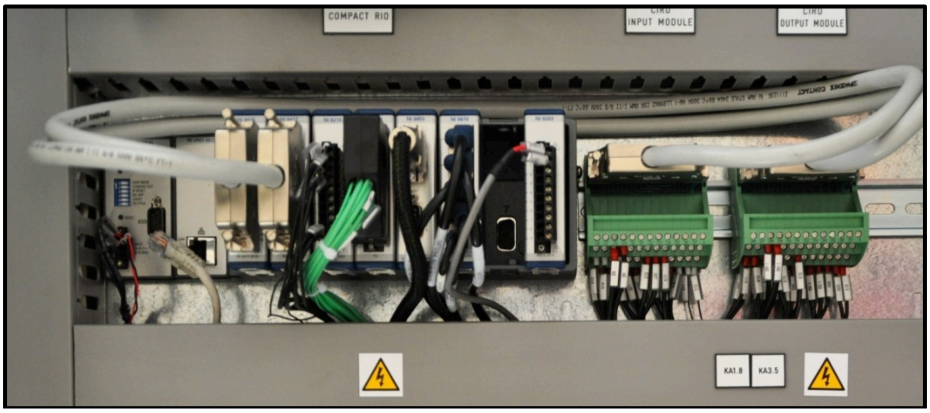


Figure 7:11 cRIO Mounted in the Electrical panel

The system undergoes a soft alarm for the following conditions:

1. Low Pressure in Air Line
2. Low Pressure in HC line
3. Low Pressure in CO line
4. Low Pressure in N_2 line
5. Low Pressure in CO_2 line
6. Fan Bearing Temperature Exceeded Limits
7. System Process Control Thermocouple Error
8. Sample Bed Temperature Exceeded Specified Limits

For each of these alarms Eyecat activates the following process:

1. Eyecat senses alarm condition
2. Eyecat forces system into cool down followed by standby condition
3. Eyecat opens the alarm page and the soft alarm indicator is illuminated
4. Eyecat logs the alarm type, description, time and date into the log file
5. System awaits interaction from user

In order for the user to reset a soft alarm he/she must follow the following instructions (the soft alarm is acknowledged on the alarm page on Eyecat see Figure 7.9):

	Soft Alarm Condition	1st Action	2nd Action
1	Low Pressure in Air Line	Check > 4 Bar Air is supplied to System	Acknowledge Soft Alarm on Eyecat
2	Low Pressure in HC Line	Check > 4 Bar HC is supplied to System	Acknowledge Soft Alarm on Eyecat
3	Low Pressure in CO Line	Check > 4 Bar CO is supplied to System	Acknowledge Soft Alarm on Eyecat
4	Low Pressure in N_2 Line	Check > 4 Bar N_2 is supplied to System	Acknowledge Soft Alarm on Eyecat
5	Low Pressure in CO_2 Line	Check > 4 Bar CO_2 is supplied to System	Acknowledge Soft Alarm on Eyecat
6	Fan Bearing Temperature Exceeded Limits	Contact Catagen	**Do not run system**
7	System Process Control Thermocouple Error	Check TC1 and TC2 are connected	Acknowledge Soft Alarm on Eyecat
8	Sample Bed Temperature Exceeded Specified Limits	Problem with Test Specification - Check	Acknowledge Soft Alarm on Eyecat

Figure 7:12 Soft Alarms and Actions

Please note: Under soft alarm condition 9, process control thermocouple error, the operator must check to see if thermocouples 1 and 2 are connected properly. Failure to connect these thermocouples to the catalyst inlet and bed will result in the system not being able to execute a test.

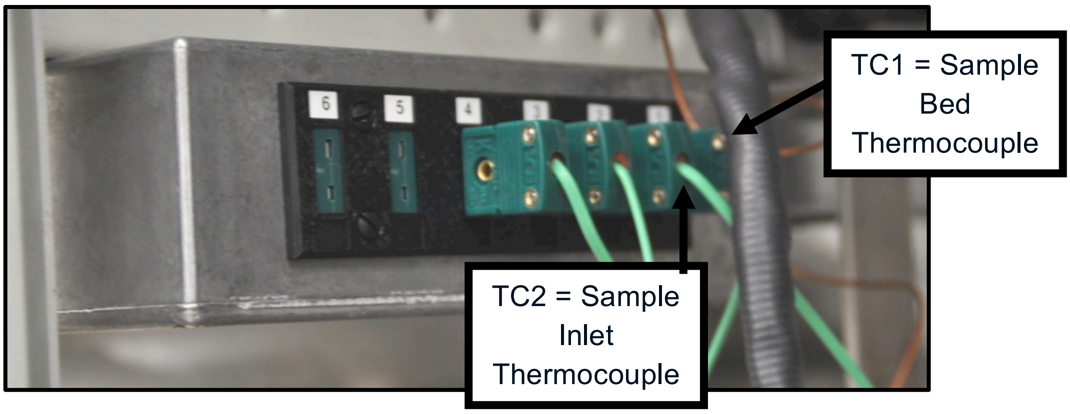


Figure 7:13 Thermocouple Sockets

7.8 Door Interlock Position and Operation

Door Interlocks are located on the Doors of each of the test modules. The primary purpose of the interlock control is safety to ensure that operators are kept away from hot surfaces and potentially dangerous gases and that the doors remain closed during testing to allow normal operation of the system.

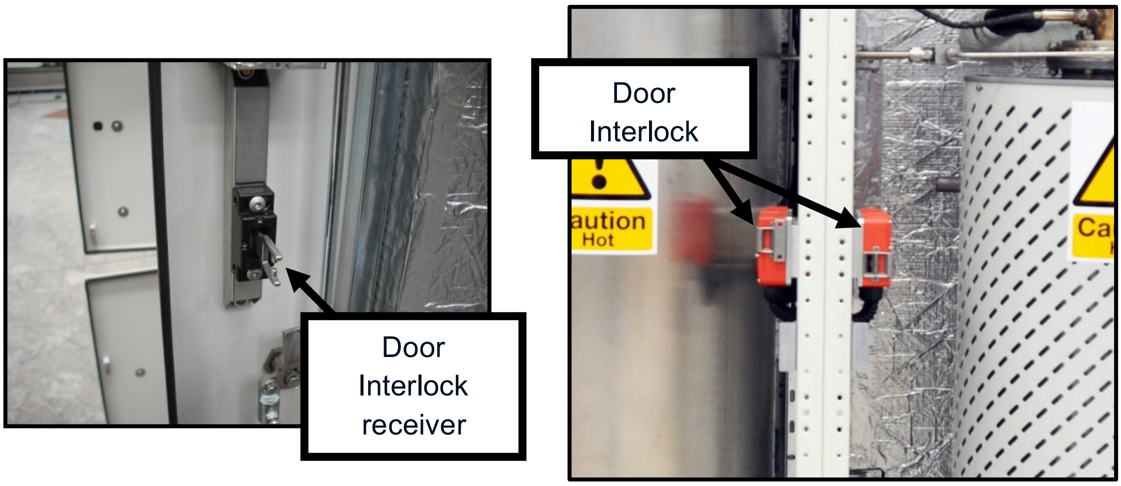


Figure 7:14 Door Interlock arrangement

The doors are interlocked under the two following conditions:

- Temperature at the sample is greater than the thermostat set point. Catagen have set the thermostat to 40ºC and recommend that it must remain at this temperature set point for safe operation.
- Gas detected in system – the door will remain locked

Figure 7:15 Thermostat Control - NOT to be adjusted

When the interlock is deactivated after cool down, indicators on the main page of the Eyecat software will indicate that the doors are safe to open. When the door is opened, all electrical components within the test modules are isolated meaning that the operator is under no danger of electric shock. In order for the system to run a test the doors must be closed and locked using the key provided. Only then will a test begin and the interlocks engage.

7.9 Personal Protective Equipment (PPE)

It is a requirement that the following personal protective equipment (PPE) be worn when changing a sample or servicing this system.

- Safety Glasses
- Heat Resistant Gloves
- Safety Boots/Shoes

It is the customer's responsibility to ensure that any person using this tool is suitably qualified to do so. It is also the customer's responsibility to ensure that the above-specified PPE items are available along with first aid facilities.

7.10 Sound Attenuation

The Labcat system is enclosed in a sound attenuated cabinet system and the decibel level under normal operation does not exceed 75db at 1 meter.

8 System Operation

8.1 Controls

Please refer to figure 8.1, system controls, when reviewing the following:

1. Touchscreen – This is the main user interface with this system.
2. Keyboard & mouse pad – Secondary user interface with this system
3. EMO – Emergency stop affected by the operator
4. Reset Button – (Described in section 7.5)
5. Mains Isolator – (Described in section 7.3)

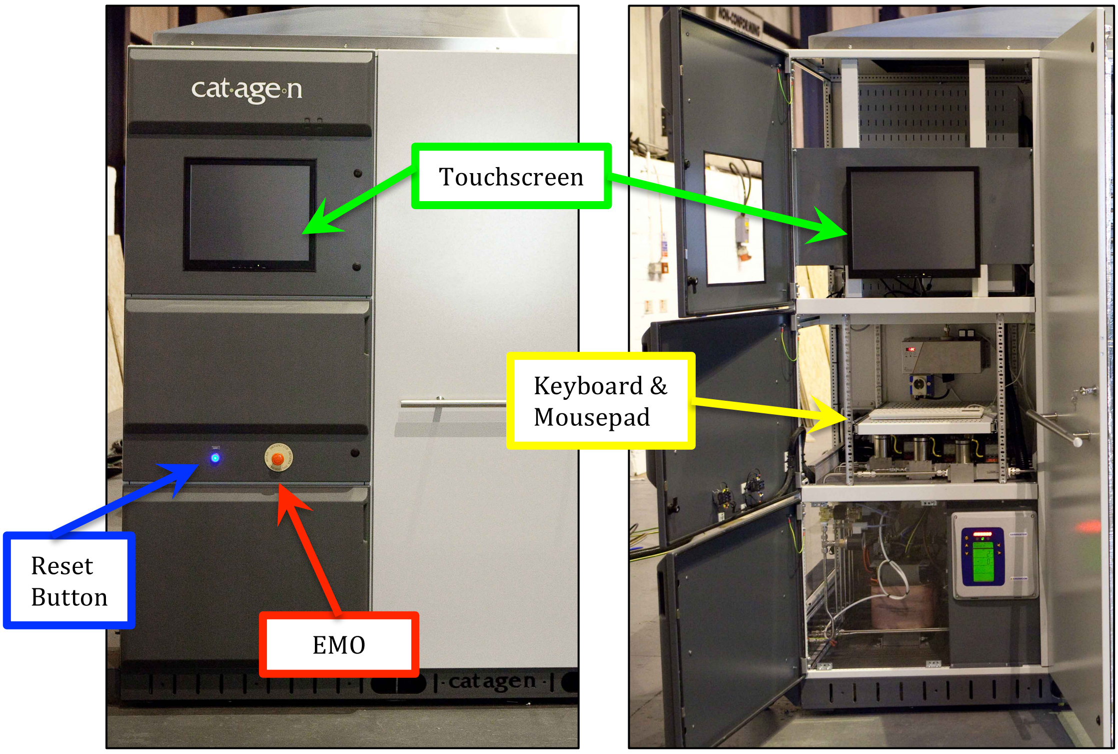


Figure 8:1 System Controls

8.2 Powering the System Up

1. Ensure all facilities are hooked up and to the standards defined in Section 10 of this document
2. If connecting to Multigas 2030, ensure the Multigas is powered on, Ethernet and gas sample line is connected properly, and MKS Toolkit software activated in the Labcat PC.
3. Turn on the facilities N_2 Supply to specified pressure
4. Turn on the facilities Air Supply to specified pressure
5. Turn on the facilities CO_2 Supply to specified pressure
6. Turn on the facilities CO Supply to specified pressure
7. Turn on the facilities HC Supply to specified pressure
8. Turn on the facilities 208V mains Supply
9. Ensure system doors are closed and secured with key provided
10. Turn on the system Mains Isolator (Figure 7.4)
11. Activate the 'hard alarm reset button' the take the system out of safe mode
12. When prompted on the touch screen interface, enter the system login password, [default password Labcat]
13. Windows 7 will automatically launch
14. If connecting to Multigas 2030, launch the 'Multigas Toolweb' software and ensure communications are established with the external analyzer
15. Launch by Eyecat V1.2 software, icon on desktop and in programs folder
16. Alternatively, one can launch Eyecat from the desktop icon, or by selecting, start, all programs, Catagen, Eyecat

Before beginning testing the operator should check the following:

1. The Multigas 2030 is working within correct parameters
2. The sample is correctly mounted and has all necessary thermocouples and Lambda sensors connected

8.3 Main Screen Page

After the procedure in section 8.2 has been executed, the operator will be presented with the following screen. This is the main page for the Eyecat software.

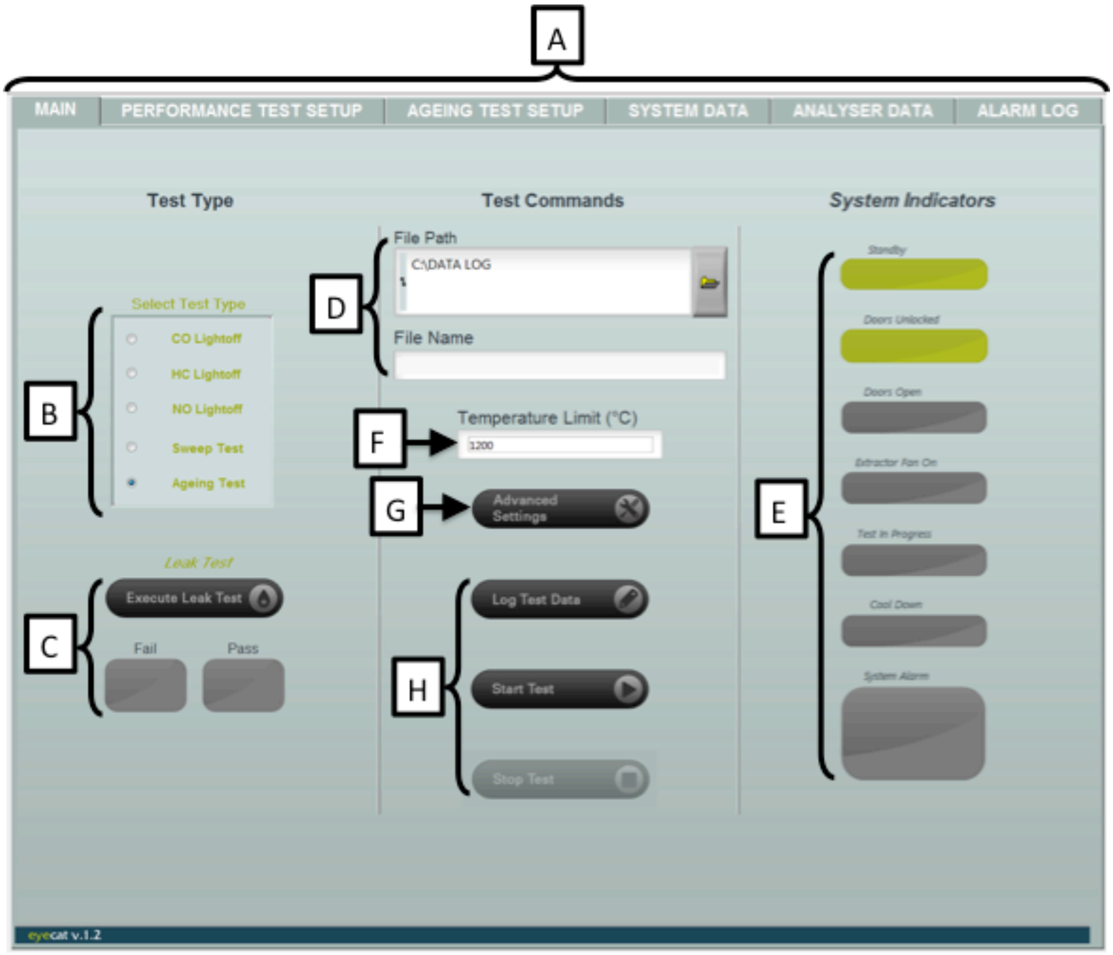
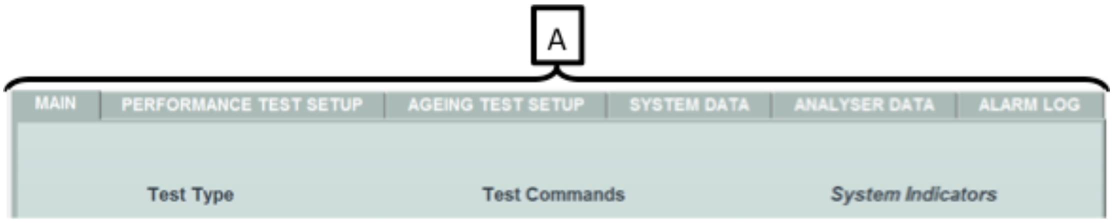
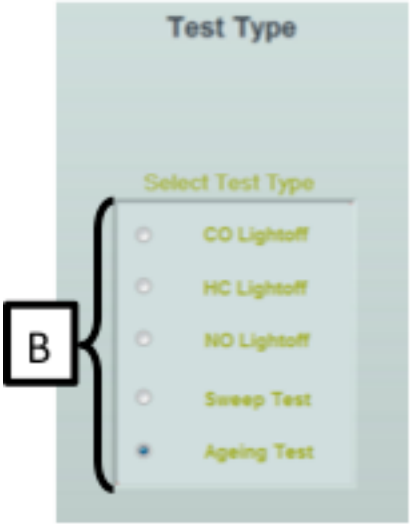


Figure 8:2 Eyecat Main Screen

1. The operator can toggle between the tabs shown on the top of the screen as shown in figure 7.2 either by use of the touchscreen or mouse pad.

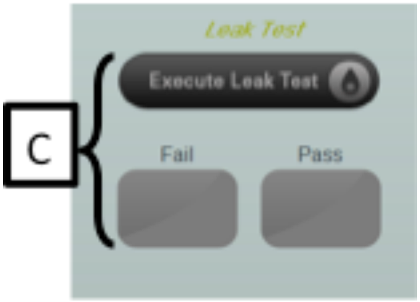


2. The operator selects the test type here after the test has been specified

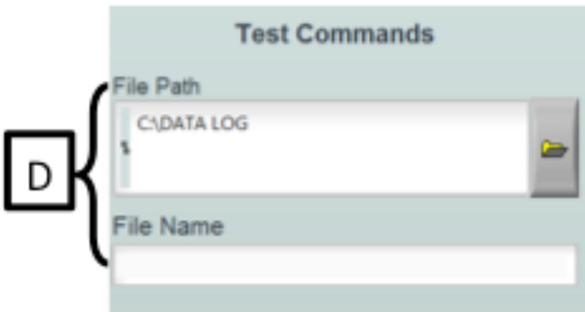


3. When the system is in standby condition, the operator can carry out a leak test on the system by pumping N_2 into the system. This test automatically executes and produces a pass or fail indicator. The doors can be open for this operation. It is for indication purposes of a major leak.

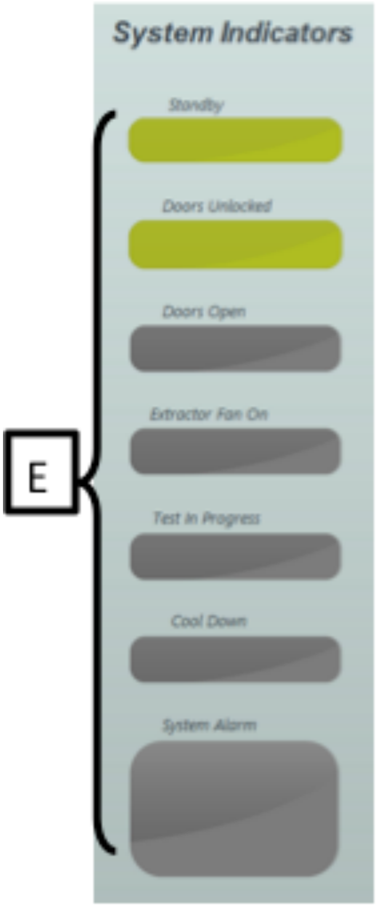
   The system naturally has gas seepage through the gasket material and is not always strictly airtight.



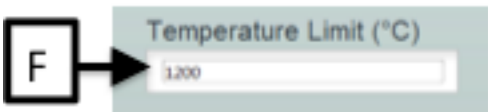
4. The operator selects the root for the destination data file and creates the file name here. ****Please note: if the operator leaves the file name blank, Eyecat creates the data file with the date and time substituted into the name as the test begins.**



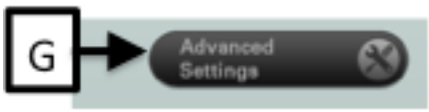
5. System indicators – instantly tells the operator the status of the system and what condition the machine is undergoing.



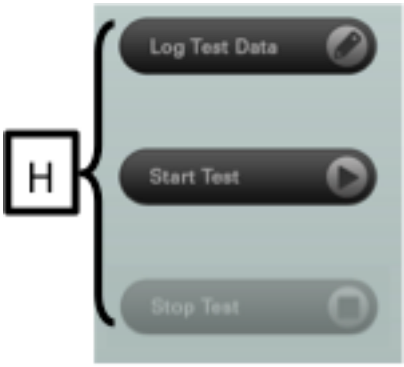
6. Temperature limit. This setting limits the temperature of the catalyst bed during a test i.e. if the temperature experienced by thermocouple 1 (TC1) exceeds the value input here, the system will initiate soft alarm and shutdown the test. (The default value is set at 800°C).



7. Advanced settings (discussed in the following paragraph)



8.
   a. Log Test Data – Must be pressed if the operator wished to record data produced in a test by the Eyecat software.
   b. Start Test – Begins the test as specified by the user
   c. Stop Test – can be executed anytime during a test and will initiate a controlled shutdown of the test



8.4 Advanced Settings Tab

8.4.1 System Advanced Settings

2. SO_2 Concentration (ppm) – Operator sets the gas bottle concentration of the SO_2 attached into the system
3. NO Setting (ppm) – Operator sets the gas bottle concentration of the NO entering the system
4. CO Concentration (%) – Operator sets the gas bottle concentration of the CO entering the system
5. HC Concentration (%) – Operator sets the gas bottle concentration of the HC entering the system
6. Bleed Ratio N_2 – Operator sets the $N_2/CO_2/H_2O$ bleed ratio with use of this input (% input)
7. Bleed Ratio CO2 – Operator sets the $N_2/CO_2/H_2O$ bleed ratio with use of this input (% input)
8. Bleed Ratio H_2O – Operator sets the $N_2/CO_2/H_2O$ bleed ration with use of this input (% input)
9. Purge Duration (seconds) – This is input determines the length of time the 'cool down' and 'purge system' cycle lasts, i.e. injection of N_2 into the system.

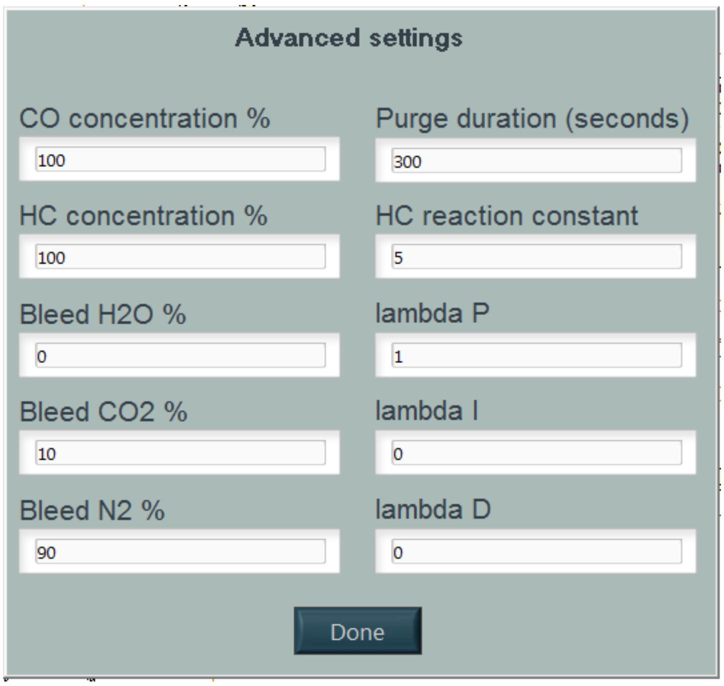


Figure 8:3 Advanced settings page

8.5 Performance Test Setup Interface

The following description and screen shot describes how to setup a performance test for the following:

1. CO Light-off Test
2. HC Light-off Test
3. AFR Sweep Test

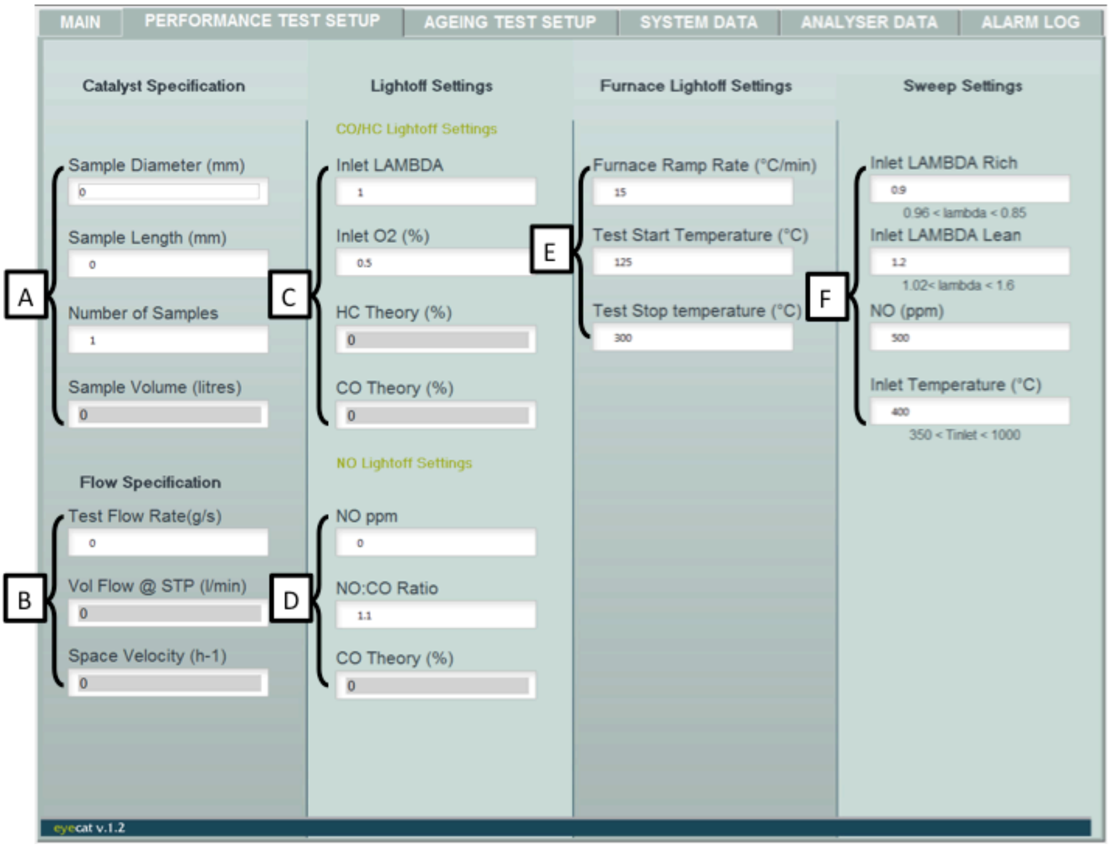
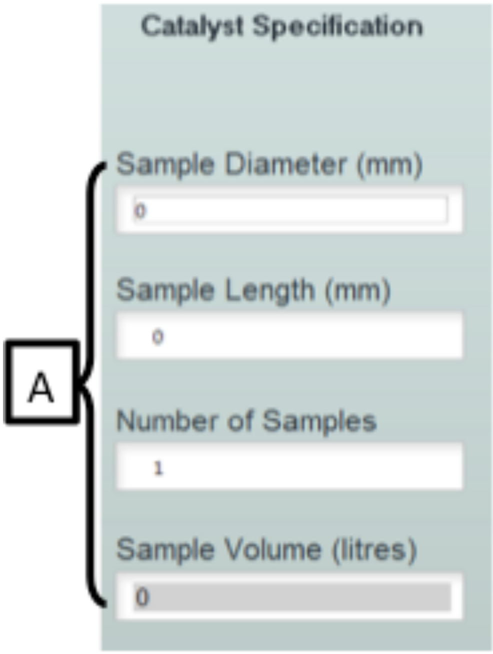


Figure 8:4 Performance Test Setup Page

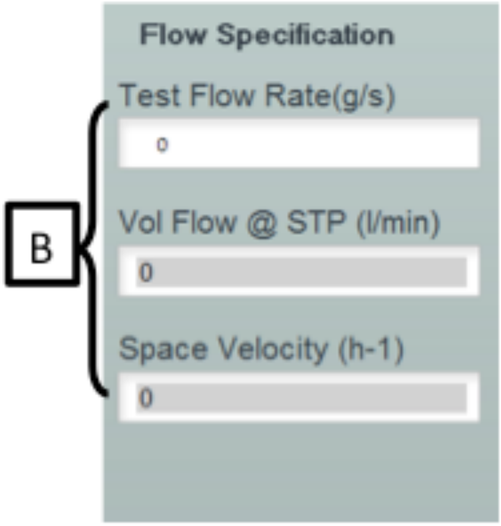
A. Defines the catalyst sample specification

   a. Sample Diameter – input the sample monolith diameter in mm
   b. Sample length – Input the sample monolith length in mm
   c. Number of samples – please input if single sample or multiple cores **Please note – performance testing is not possible of multiple samples at once (aging is permitted).
   d. Sample Volume – the Eyecat software calculates the sample volume from values entered.



B. Defines the Flow Specification for Performance Tests

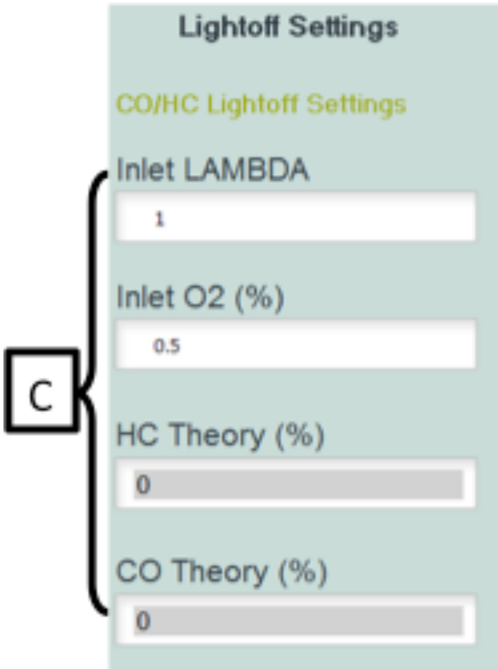
   a. Test Flow Rate (g/s) – Operator to input the flow rate requirement for the performance test
   b. Vol Flow @ STP (l/min) – This field outputs the calculated volume flow rate at standard temperature and pressure (1 atmosphere at 25°C). This value is calculated from sample flow rate and volume.
   c. Space Velocity (h-1) – This field outputs the space velocity that is calculated from sample flow rate and volume.



C. CO/HC Light-off Settings

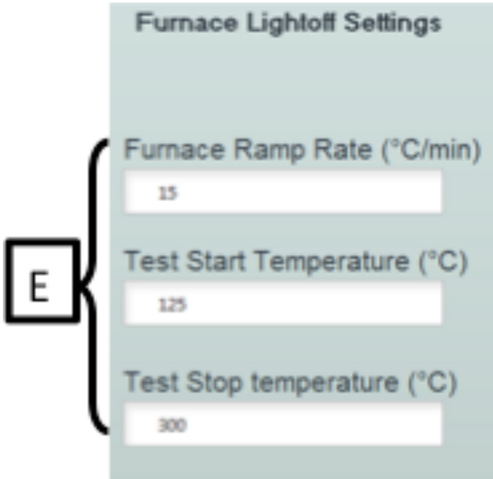
a. Inlet Lambda – Operator to input the catalyst inlet lambda set point requirement for the CO/HC Light-off test here
b. Inlet O2% – Operator to input the inlet O_2% set point requirement for the CO/HC Light-off test here
c. HC Theory (ppm) – This field outputs the theoretical HC concentration that is calculated from lambda and O_2% set-points
d. CO Theory (%) – This field outputs the theoretical CO concentration that is calculated from lambda and O_2% set-points

After completion, the operator then selects which performance test to carry out on the main page before beginning the test.



D. Furnace Light-off Settings

a. Furnace Ramp Rate – this value is a universal value for all tests including the aging test, i.e. this dictates the ramp rate of the furnace in ^{o}C /minute. ****Please note: It is recommended that this value be kept at a maximum of 15^{o}C/minute but typically between 5 – 7 ^{o}C.**
b. Test Start Temperature (^{o}C) – This value applies to the Light-off tests only. It dictates at what value the test will start at and the furnace will begin to ramp upwards at the specified ramp rate. This value is measured at the catalyst inlet (TC2). This is to stabilize the pre light-off conditions.



**** Please note: There are two conditions to be satisfied before a Light-off test will begin:**

i. The measured inlet temperature (TC2) must be with 3oC of the start temperature set-point
ii. The O_2% within the system must be less than 0.1%

c. Test Stop Temperature (^{o}C) – This value applies to the Light-off tests only. It dictates at what value the test will stop and the system will enter a cool down period. This value is measured at the catalyst inlet (TC2).

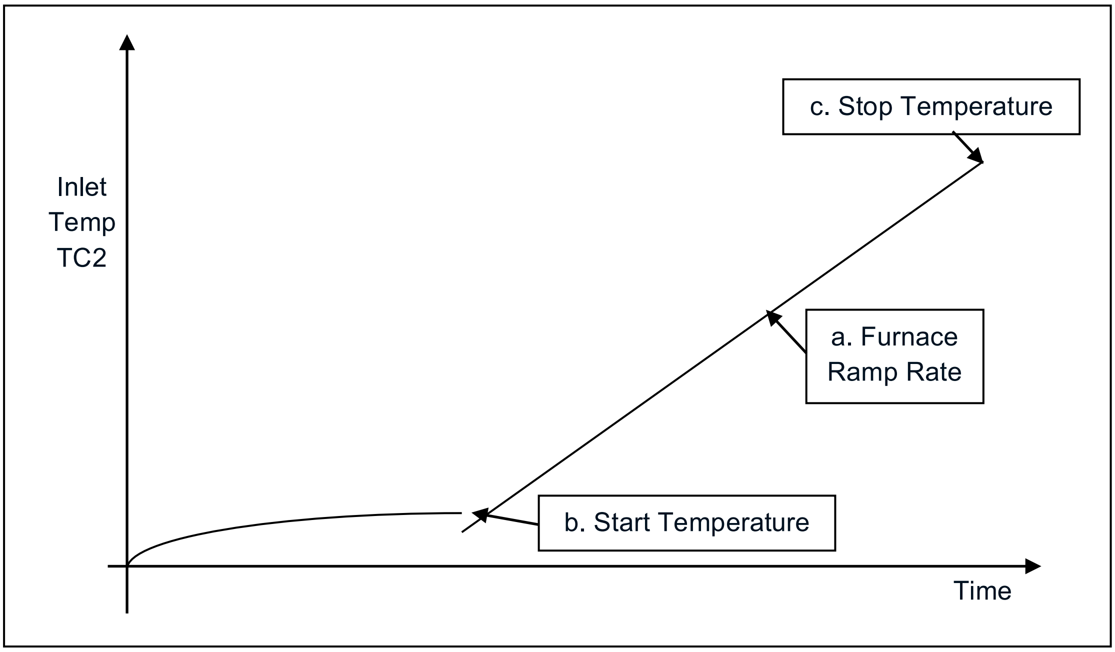
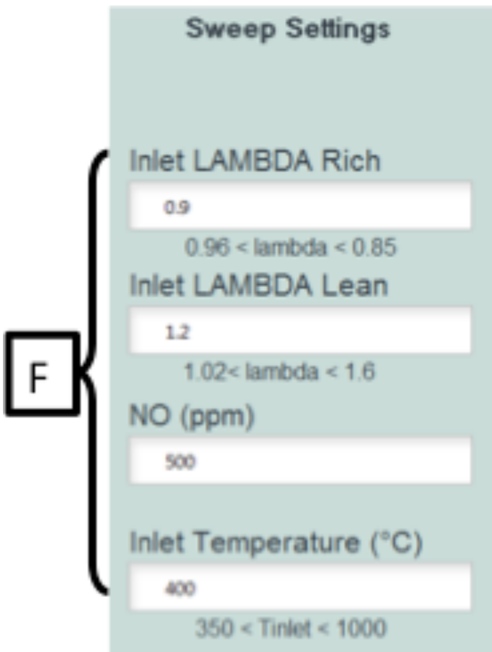


Figure 8:5 Light-off Furnace Control Theory

F – Sweep Settings

The sweep test is setup and behaves as follows:

1. Inlet Lambda Rich – Operator to input rich set-point limit of the sweep test here.
2. Inlet Lambda Lean – Operator to input lean set-point limit of the sweep test here.
3. Inlet Temperature (°C) - Inlet temperature of the sweep test dictated by the furnace



**** Please note: There are two conditions to be satisfied before a sweep test will begin:**

1. **The measured inlet temperature (TC2) must be with 3°C of the Inlet temperature set point (d)**
2. **The O_2% within the system must be less than 0.1%**

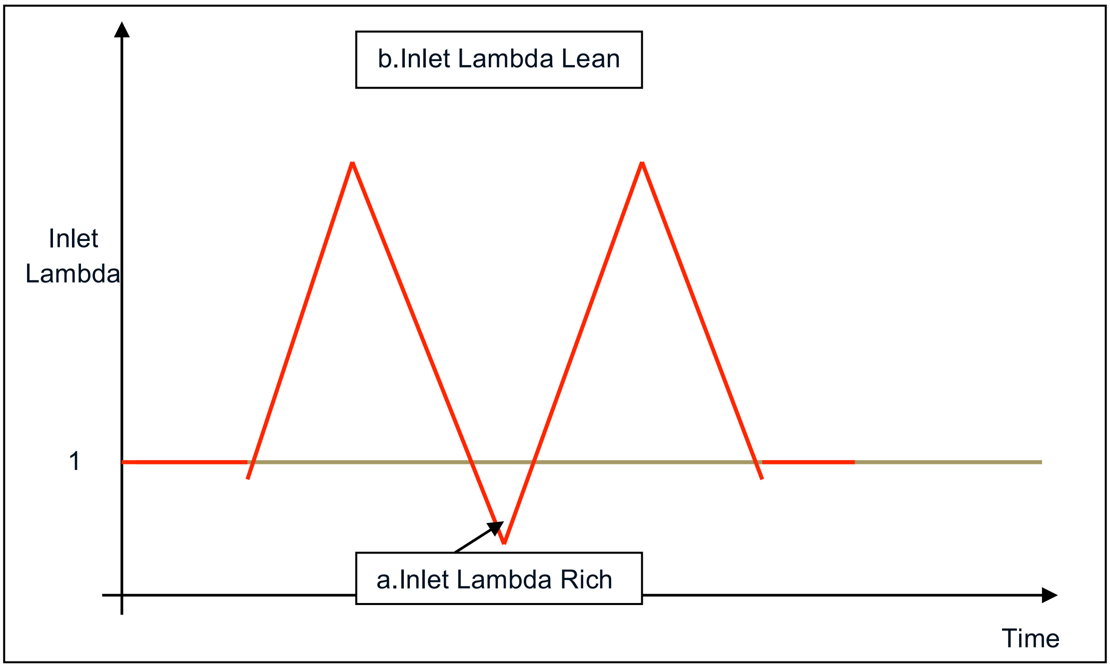


Figure 8:6 Sweep Lambda Control Theory

The system will automatically execute the sweep test depending on the settings laid out by the operator.

8.6 Ageing Test Setup Interface

This section details how a cycle is designed and compiled for testing.

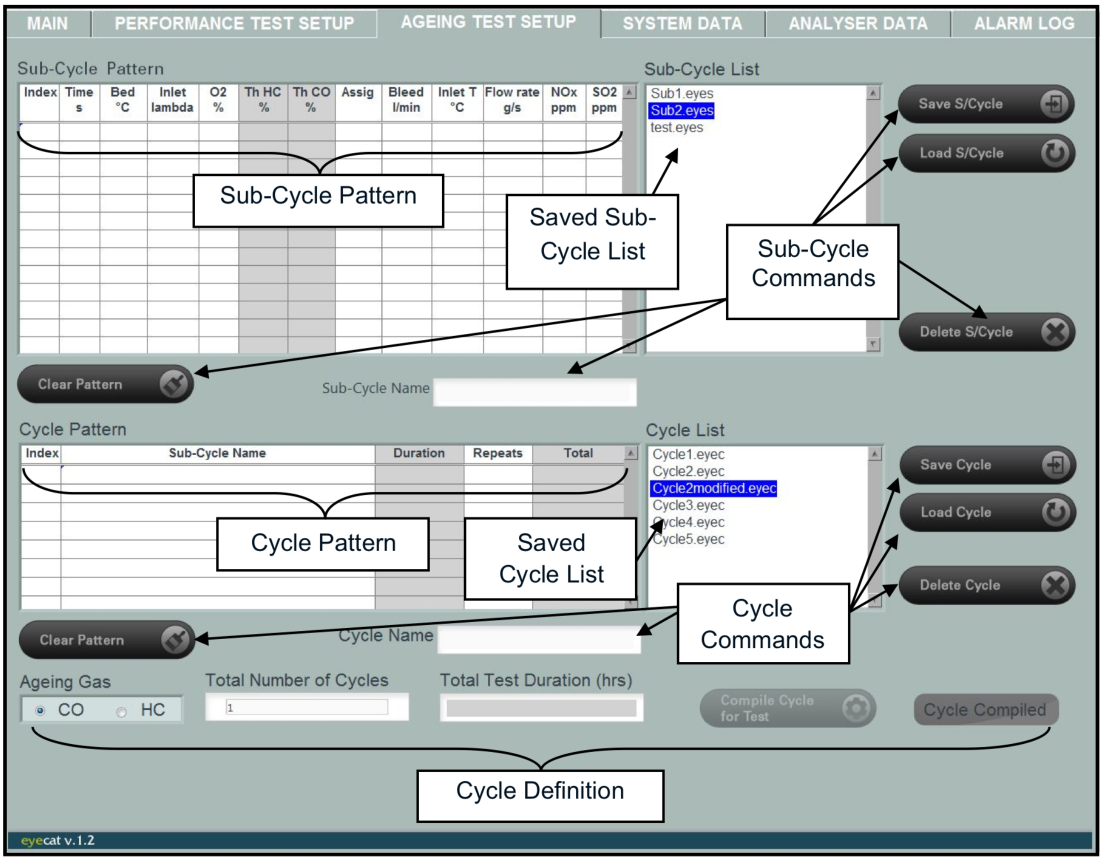


Figure 8:7 Aging Test Setup

8.6.1 Creating a Sub Cycle

1. Clear the fields in the sub-cycle by pressing ‘Clear Pattern’ button
2. In order to create a sub-cycle, one must fill out the fields shown for the cycle.
   a. Index increases incrementally from 1,2….and so on
   b. Time s, tells the program how long to use the settings in this row in seconds. The time step ends when the next row begins.
   c. Bed °C, Target bed temperature (not used in control, indication only)
   d. Inlet Lambda, used in baseline, ‘B’ control, PID control of air addition
   e. O_2%, Used in baseline control, inlet O_2% set-point
   f. Th HC% - Theoretical hydrocarbon concentration calculated from lambda and O_2% - Value injected in ‘O’ open loop operation
   g. Th CO% - Theoretical CO concentration calculated from Lambda and O_2% - Value injected in ‘O’ open loop operation

h. Assignment – Operator tells program if 'Baseline' feedback lambda control by assigning 'B' here or open-loop control by assigning 'O' here
i. Bleed – Operator can choose to inject N_2/CO_2 (ratio defined in advanced settings) here into the tank to blow off unwanted gases if needed.
j. Inlet T ^oC - Bed temperature PID controlled by furnace and inlet TC2. Inlet temp not to change between Sub-cycles.
k. Flow Rate (g/s) – Set point for flow rate for aging test. Flow rate set point not to change between Sub-cycles. 2013
l. NO (ppm) – Inlet NO ppm closed loop control with NOx CAN sensor
m. SO_2 (ppm) – Inlet SO_2 (ppm) closed loop control from Multigas 2030.

3. Enter an appropriate name for the sub-cycle in the sub-cycle name field.
4. Press 'Save Sub-Cycle' button and sub-cycle will appear in the sub-cycle list ready to be selected in the create cycle steps.
5. Load Sub-Cycle and Delete Sub-Cycle are commands to edit or delete existing Sub-Cycles

8.6.2 Creating a Cycle for Testing

1. Clear the fields in the Cycle pattern by pressing 'Clear Pattern' button
2. In the Cycle pattern field execute the following:
   a. Input the index number
   b. Select the sub cycle name from the pull down menu
   c. Duration of sub-cycle will automatically populate
   d. Enter the number of times you wish for the sub cycle to repeat in 'repeats column'
   e. Duration of sub-cycle will automatically populate
   f. Move to next row to create the next sub-cycle
3. Once cycle pattern is complete of either one or more sub-cycles, enter an appropriate name for the cycle in the cycle name field
4. Press 'Save Cycle' button and cycle will appear in the cycle list ready to be used in testing.
5. Load Cycle and Delete Cycle are commands to edit or delete existing Sub-Cycles
6. Select the Aging Gas for the Test – HC or CO (For Customer Aging Testing CO must be selected)
7. Input the total number of cycles required for testing that are comprised of the sub-cycle list
8. Total test duration will be calculated and indicated
9. Select 'Compile Cycle' to create the cycle pattern for testing – the cycle compiled indicator will illuminate, (this indicator must be lit before testing). Select aging test on the main page and begin test.

8.7 System & Sample Data Interface

The system data tab shows time traces of the following:

1. Sample temperatures, TC1, TC2, TC3 and TC4, typically located in the catalyst inlet bed and outlet positions
2. System temperatures give time traces of the temperatures of key components around the system such as the tank, bearings and Venturi temperatures.
3. Flow rate is the calculated flow rate in g/s using the Venturi nozzle and once settled should oscillate around the point set in the Performance Test Set-up Page

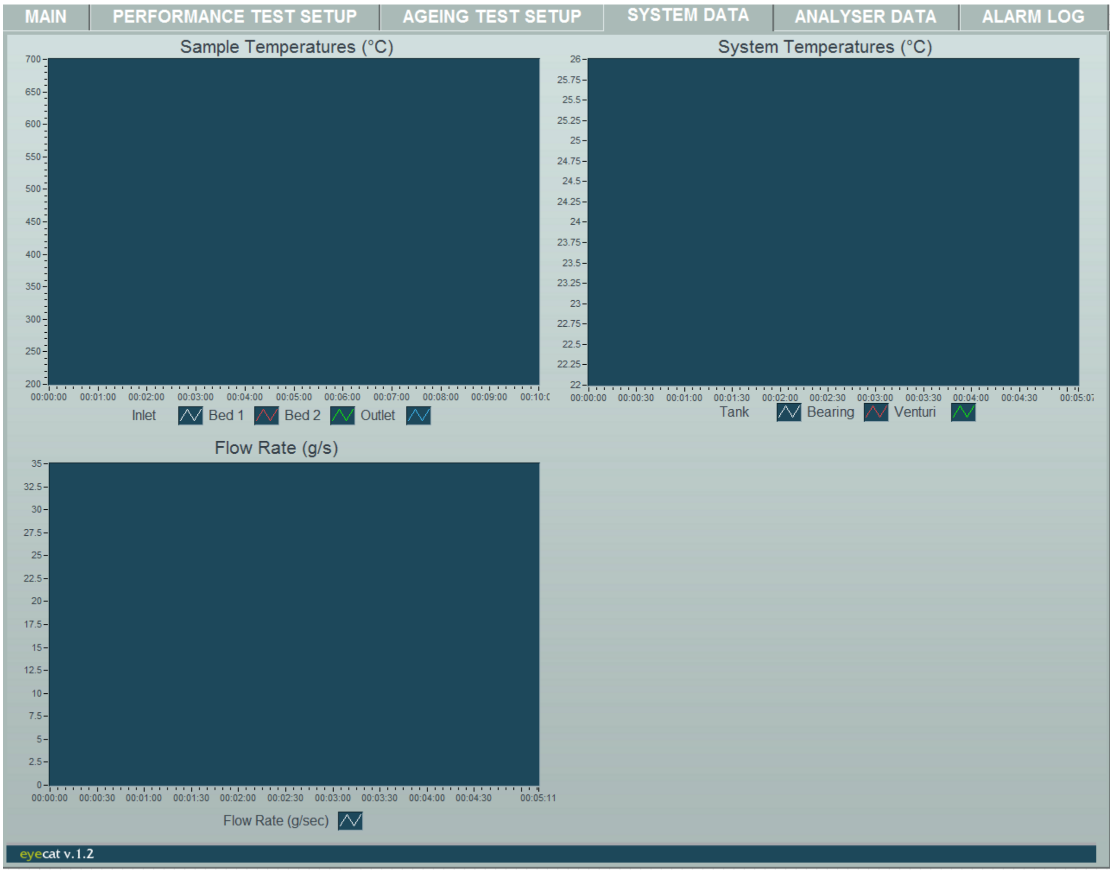


Figure 8:8 System Data Traces

The analyzer data tab shows time traces of the following:

1. Inlet and Outlet measurements of the following gas concentrations in %
   1. CO_2
   2. CO
   3. O_2
2. Upstream and Downstream HC concentrations in ppm
3. Upstream and Downstream Lambda Measurements

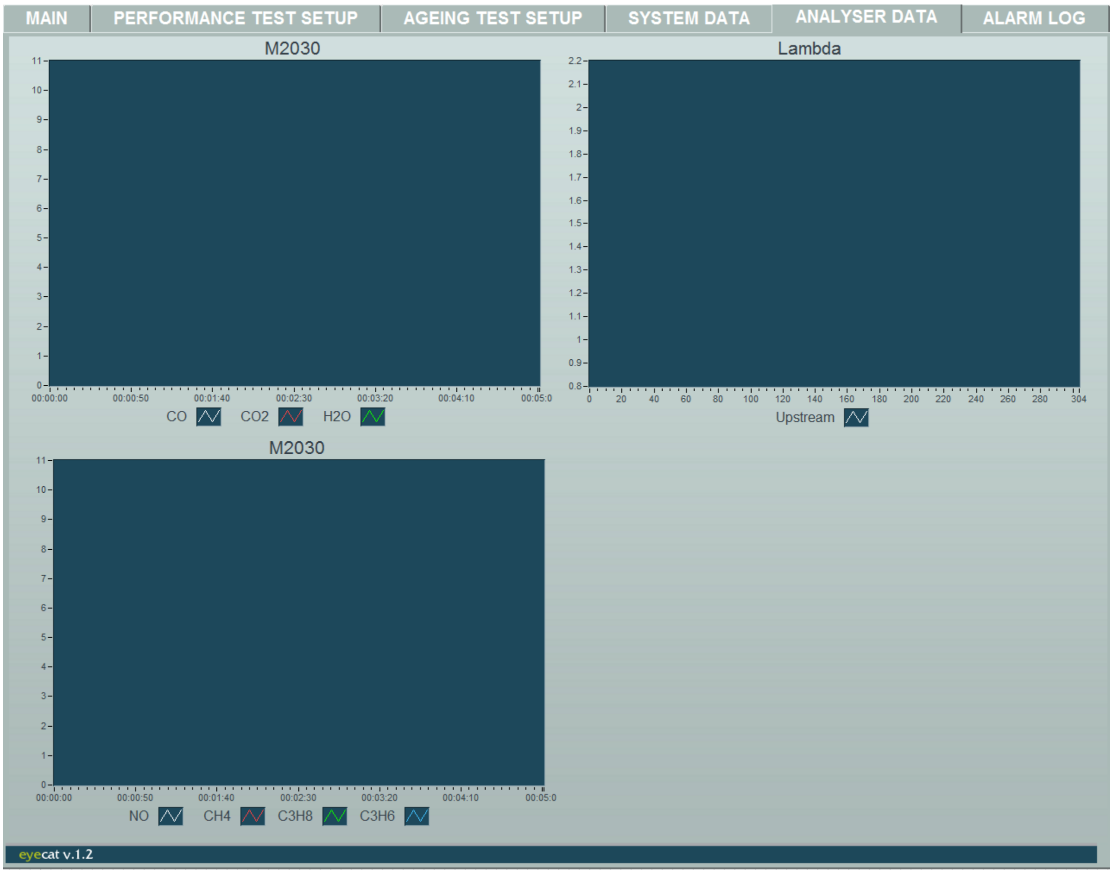


Figure 8:9 Analyzer Data Traces

9 Maintenance

Speak to a Catagen representative about the maintenance programs on offer to their customers.

OEM data sheets for components included can be provided on request.

10 Labcat Installation

10.1 Footprint and Space Requirements

The floor area that the system is to be sited on must be clear of debris, protrusions and relatively level in all directions.

The Labcat system must be sensibly sited to allow normal working practices and regular maintenance program to ensure a high availability of the system. An ideal 1-meter clearance is required around the Labcat system to facilitate these needs. Please see Figure 10.2 of a typical maintenance operation.

The system is wheeled into position with castors that are provided and then feet are manually extended and adjusted until the system is perfectly level and square with the walls. The castors are then removed for a more permanent installation and can be reattached to facilitate mobilization.

The Labcat footprint dimensions are:

Length - 2.4m
Depth - 0.8m

The System can be sited at General Motors R&D as per the layout, shown in Figures 10.1 or a mutually agreed alternative.

Key to Note: The left hand side of the front of the machine must be close to the incoming services, i.e. electrical cabling, water drain and gas line(s). Please note the incoming services are mounted on a suitably sized floor level cable tray.

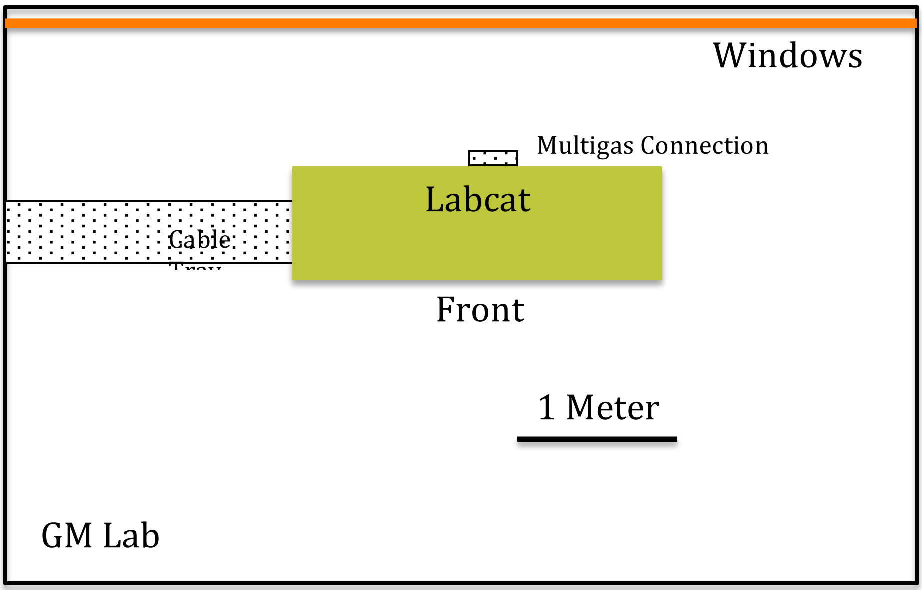


Figure 10:1 Approximate Scaled Plan Drawing of Labcat Position

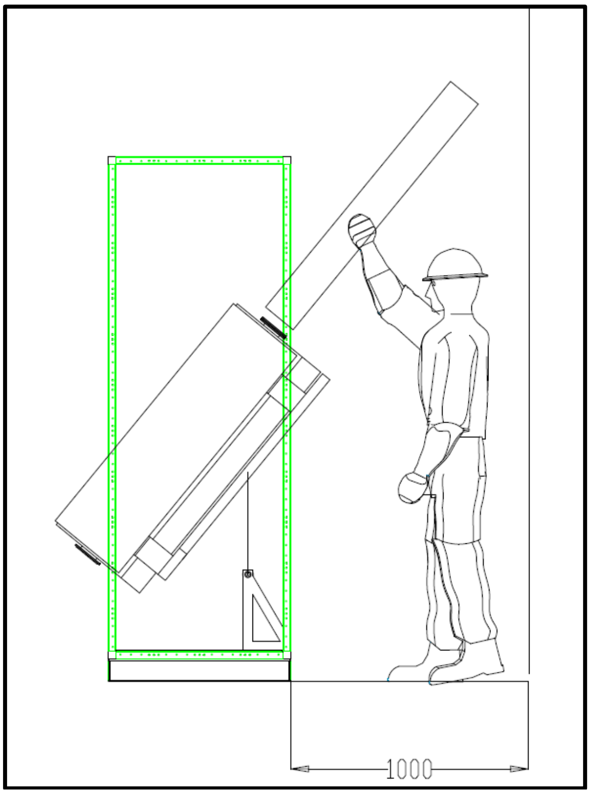


Figure 10:2 Maintenance Operation - Removal of Furnace Worktube

10.2 Height Requirements

It is preferable to site the Labcat is in a position that allows adequate space between the unit canopy assembly and the ceiling.

The total height of the Labcat Unit is 2.65m, which includes stainless steel extractor canopy and adaptor, (See Figure 10.5).

Key to Note: An inline duct extractor fan needs to be mounted on the outgoing canopy assembly. The configuration of this extractor fan to and how to connect to it is detailed in Section 10.8.

10.3 Electrical Connection

Key to Note: The customer must provide three phase supply isolated at 160 Amps per phase at 208V, 60Hz, (US 3 Phase Voltage), and connect this supply to the Labcat system.

The customer must supply cabling that will meet necessary standards and is specified to carry the current and voltage requirements of the GM Labcat system. The cabling supplied must have suitable insulation and protection to ensure the safety of laboratory personnel. Connection of external electrical supply will be carried out by a GM certified electrical engineer or technician and will be supervised by Catagen personnel.

It is recommended that any external cabling to the Labcat system be placed and secured on suitable floor level cable tray(s) within the laboratory. The path of the cable tray must be away from doorways and areas of heavy foot traffic from personnel.

The recommended cable path tray orientation is shown in Figure's 10.1.

10.4 Gas Connections

There are five gas lines in total entering the GM Labcat system. These gas lines must all be isolated and regulated to a maximum of 10-bar pressure by certified regulators that are in turn connected to internal supplies or gas bottles.

The incoming gas lines are as follows:

1. 100% N2 Line - Nitrogen (Oxygen Free Nitrogen) - Supplied at 8-Bar
2. 100% CO2 Line – Carbon Dioxide –Supplied at 6-Bar
3. Compressed Air (with standard line oil filters) – Supplied at 8-Bar
4. 100% CO Line – Carbon Monoxide – Supplied at 6-Bar
5. 100% Industrial HC Line (C3H8 or C3H6) – Either Propane or Propene can be supplied – Final decision from GM R&D – Supplied at 6-Bar

All bulkhead fittings on the Labcat system for connection to incoming gas lines are suited to tubing outer diameter of ¼ inch. The only exception is the Air gas line, which has a bulkhead fitting to accommodate ½ inch tubing. The system stainless steel bulkhead fitting will come with olives and ferrules to ensure a sealed connection.

Connection of the external incoming gas lines will be carried out by a GM certified electrical engineer or technician and will be supervised by Catagen personnel. That representative must ensure that all tubing has been cut squarely and filed to remove any debris or burrs.

Key to Note: GM R&D must take precautions that the incoming gas lines are suitably protected from damage by foot traffic or any other potential piercing dangers. This again may involve the installation of suitable cable tray(s) at floor level. Catagen recommend that any fuel lines be either solid stainless steel or have appropriate armor/braid protection.

Please note figure 10.3 where the typical bulkhead connections are shown. Incoming gas lines and out going water drains lines.

Figure 10:3 Typical Labcat Bulkhead connections

Figure 10.4 shows a LAN/Ethernet connection, (2 in total, 1 X connection to Multigas 2030 and 1 X connection to GM network if Required)

Figure 10:4 Typical LAN Connection

10.5 Water Drain Connection

Alongside the incoming gas lines to the Labcat system is the need for a water drain line. This is to remove water from the gas concentration sample lines that has been created as part of the chemical reaction occurring in the catalyst. A small peristaltic pump drives the small amounts of water out of the Labcat system. The water drain line has a bulkhead fitting that is suited again to ¼" tubing. The customer must either direct the tubing into a collection point or drain.

Key to Note: Customer must take precautions that the water drain line is protected from damage by foot traffic or any other potential piercing dangers. This again may involve the installation of suitable cable tray(s) at floor level.

10.6 Multigas 2030 Ethernet Connection

When requested as part of a customer Labcat Specification the following communication line is required:

1. External Ethernet connection to the Multigas System to facilitate feedback into Eyecat software

The Ethernet connection will be a standard LAN cable supplied by the customer to run from the Multigas 2030 system to the Labcat system. The Eyecat software will send a signal to the Multigas 2030 to request measurement data from the analyzer to be streamed into the Labcat.

The Labcat will parse this data and the SO_2 measured value used in the PID control of the SO_2 levels at the catalyst inlet. All of the measured data from the Multigas 2030 will be stored in the Eyecat main data storage file alongside the Labcat system data.

Key to Note: GM must take precautions that the Ethernet line is protected from damage by foot traffic or any other potential hazards. This again may involve the installation of suitable cable tray(s) at floor level.

10.7 Multigas 2030 Gas Line Connection

When requested as part of a customer Labcat Specification the following gas sample line is required.

1. Connection of gas sample line to the catalyst sample inlet of the Labcat system to the external Multigas 2030 Analyzer.

The customer must supply and connect the Multigas 2030 to the Labcat system. The Labcat has a terminated fitting at the bulkhead to allow connection of 6mm (metric) tubing. Internally the Labcat system is equipped with 2 x heated lines that will not permit any condensation of water vapor.

The heated lines come directly from the sample inlet and is terminated internally at the bulkhead at which point there is a solenoid valve installed. Again, this connection must be carried out by a GM certified engineer or technician and will be supervised by Catagen personnel.

Key to Note: GM must take precautions that the heated line is protected from damage by foot traffic or any other potential piercing dangers. This again may involve the installation of suitable cable tray(s) at floor level.

The gas line connection is at the rear of the Labcat system, in the middle at low level.

10.8 Connection of Extraction Ducting

The Labcat system requires a constant flow of air through the unit to cool the internal ambient temperature. It also serves to remove gases blown off from the system during testing. These gases will typically be N2, CO2 and Water Vapor. In the unlikely event of a leak in the system during testing, the extractor duct will remove any potential gases and the system will stop testing and go into alarm condition.

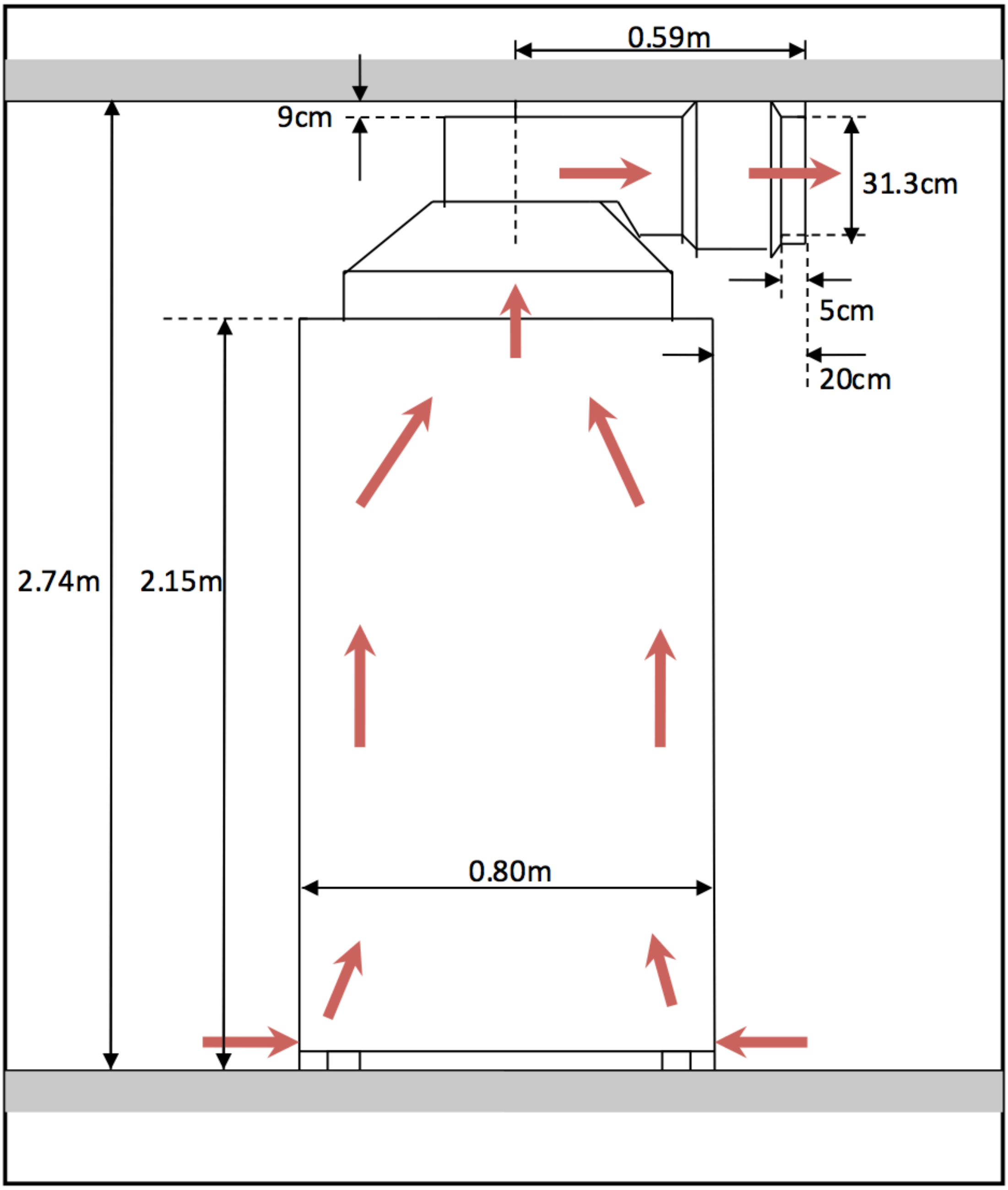


Figure 10:5 Catagen Labcat End View – GM Ducting Configuration

The airflow is provided by a 315mm diameter in line 'Vent Axia' extractor fan. The extractor fan is mounted horizontally and extends from the rear of the Labcat system at high level. The duct extends from the center of the Labcat unit to the rear. The overall height of the unit (excluding canopy assembly) is 2.15m from the floor to the top panel of the Labcat. The canopy including hood adaptor extends another 0.50m leaving a total system height of 2.650m to the horizontal edge of the ducting adapter on the ceiling of the Labcat system.

Please note: GM R&D must supply necessary ducting piping to facilitate extraction into their building extraction system. Connection of external ducting will be carried out by a GM certified engineer or technician and will be supervised by Catagen personnel. The ducting service work going to the Labcat System must be adequately supported.

10.9 Packaging

The Labcat system will come pre-packed in a wooden case. The wooden case will be lined with materials to discourage friction and mechanical shock to the Labcat system. GM staff are permitted to unpack the Labcat, attach the castor wheels provided and wheel it into position should they wish to. Catagen will take no responsibility for any damage caused to the Labcat system due to movement once it has arrived on the GM site. Alternatively, GM can carryout this operation under supervision of Catagen personnel.

Action Required: GM must provide a forklift truck to lift the packaged Labcat system from the truck to loading bay on the day of delivery to GM R&D. The system will be mounted at a suitable height on feet to allow forks to lift the system from below. The weight of the system is approximately 1 metric ton.

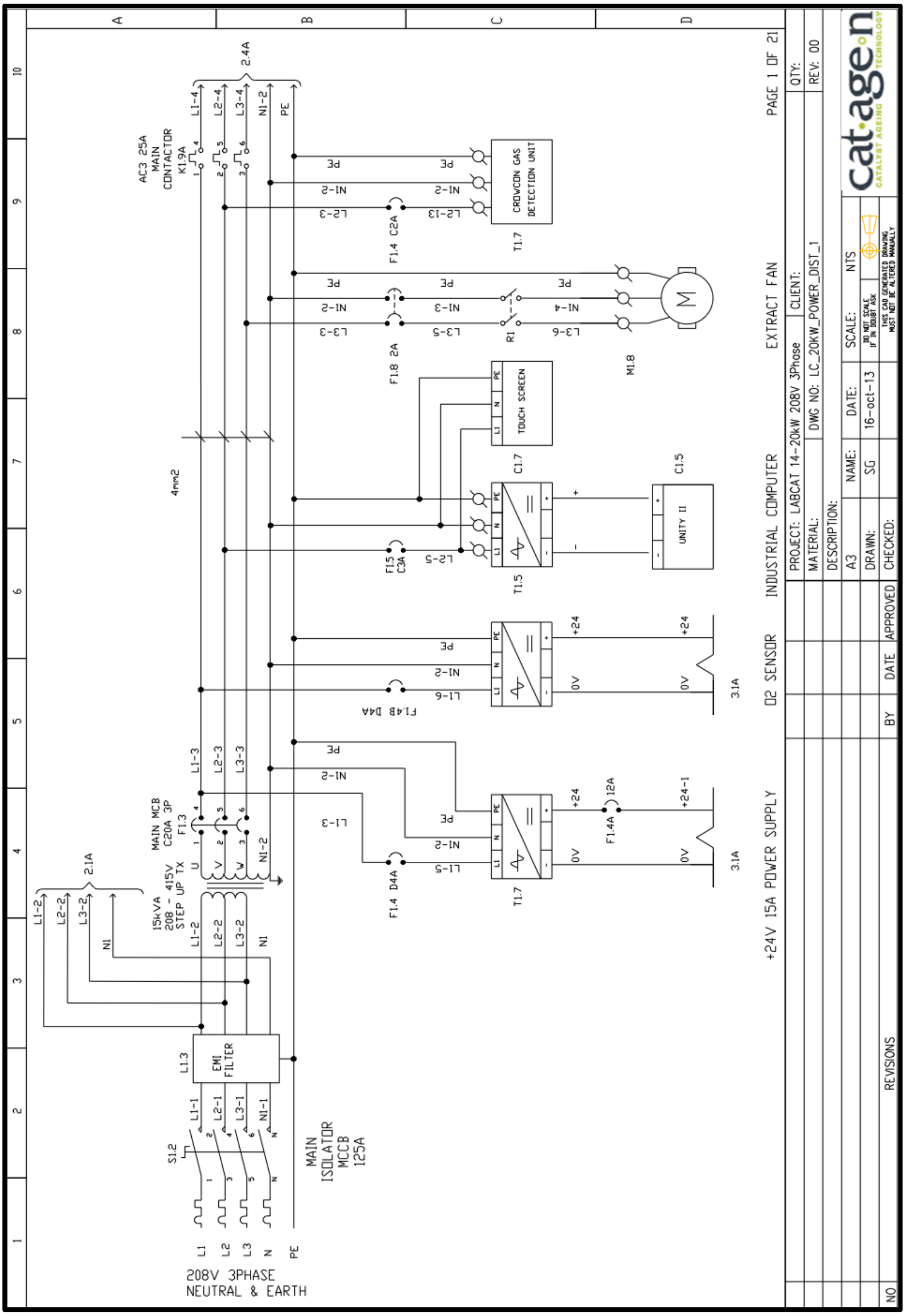
10.10 Summary

It is hoped that this document will provide clarity to the GM staff about the nature of services required to the Labcat system. This information outlined within should provide adequate instruction to enable ease of installation of the Labcat system. Should GM R&D have any queries, please do not hesitate to respond to a Catagen representative.

11 Appendices

11.1 Appendix 1 Electrical Schematics

Page	Description	Drawing No.
1	POWER DISITRIBUTION 1	LC_20KW_POWER_DIST_1
2	POWER DISTRIBUTION 2	LC_20KW_POWER_DIST_2
3	POWER DISTRIBUTION 3	LC_20KW_POWER_DIST_3
4	PILZ SAFETY	LC_20KW_PILZ_SAFETY


208V 3PHASE
NEUTRAL & EARTH
MAIN ISOLATOR MCCB 125A
EMI FILTER
15kVA 208 - 415V STEP UP TX
MAIN MCB C20A 3P
AC3 25A MAIN CONTACTOR
+24V 15A POWER SUPPLY
O2 SENSOR
INDUSTRIAL COMPUTER
EXTRACT FAN
CROWCON GAS DETECTION UNIT
TOUCH SCREEN
UNITY II
PAGE 1 OF 21
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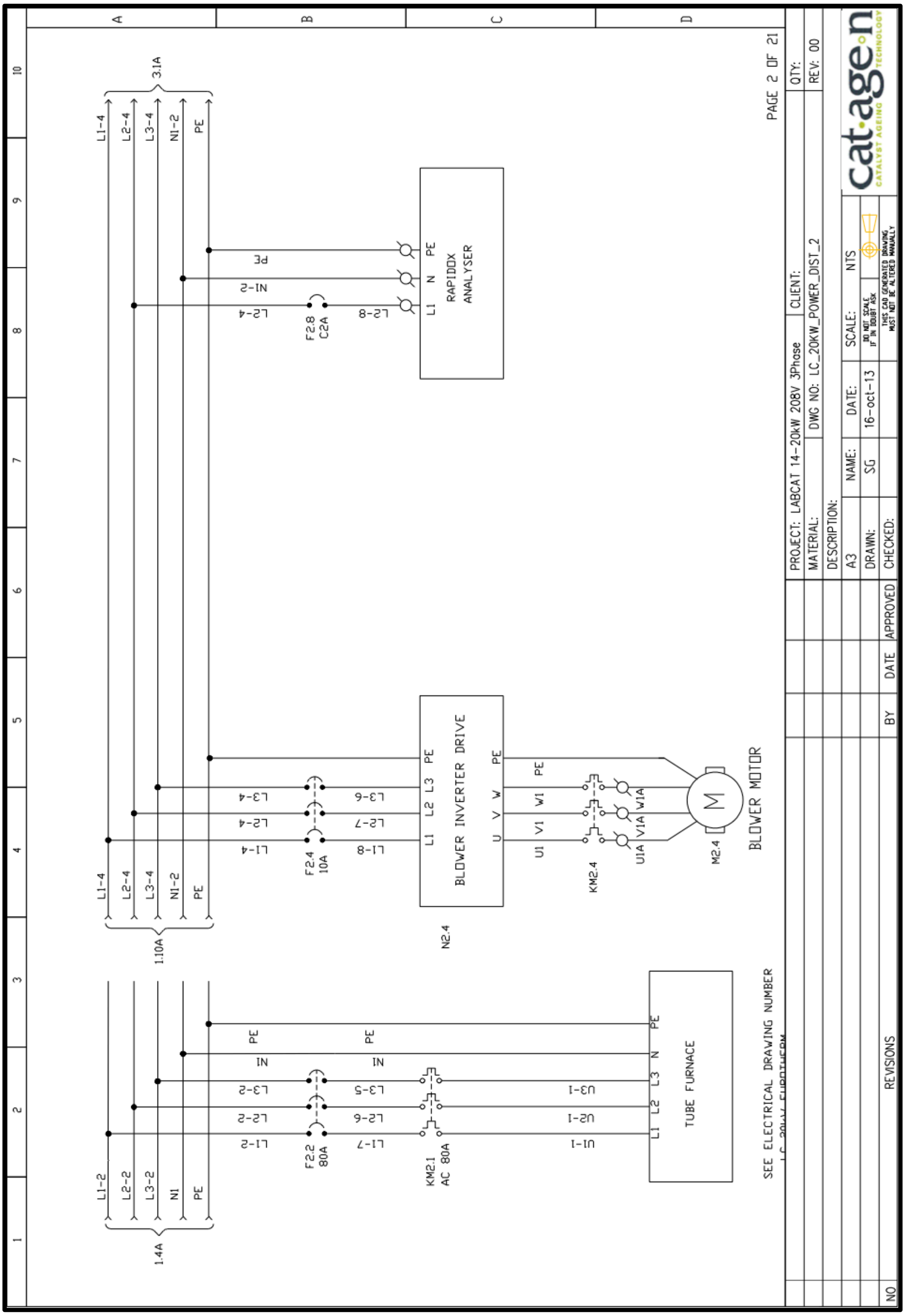
SCALE: NTS
REV: 00
REVISIONS



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PAGE 2 OF 21
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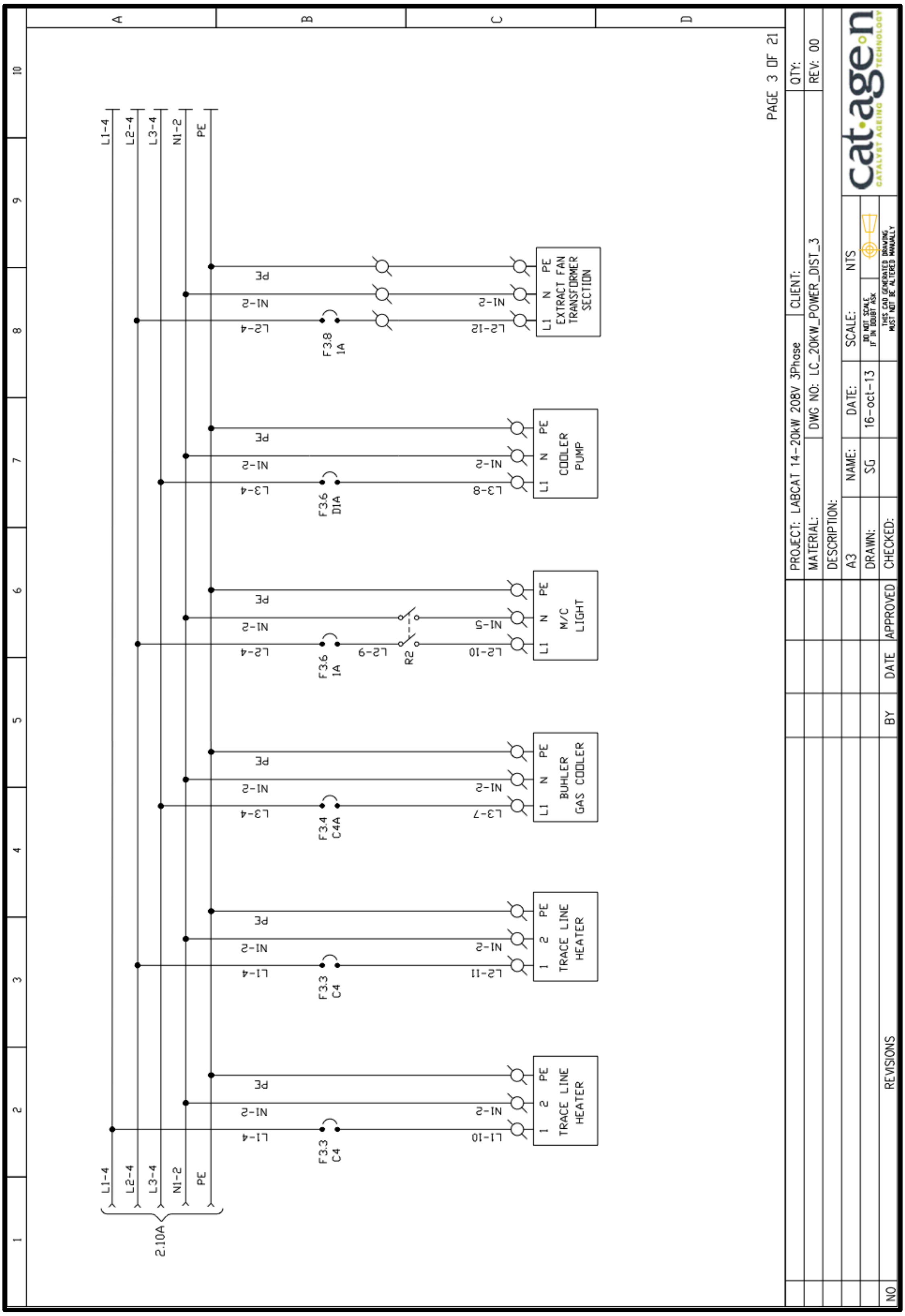
BLOWER INVERTER DRIVE
BLOWER MOTOR
TUBE FURNACE
SEE ELECTRICAL DRAWING NUMBER
REVISIONS


PAGE 3 OF 21
L1-4
L2-4
L3-4
N1-2
PE
2.10A
F3.3
C4
L1-10
TRACE LINE HEATER
L2-11
F3.4
C4A
L3-7
BUHLER GAS COOLER
F3.6
1A
L2-9
R2
N1-5
L2-10
M/C LIGHT
D1A
L3-8
COOLER PUMP
F3.8
L2-12
EXTRACT FAN TRANSFORMER SECTION
PROJECT: LABCAT 14-20kW 208V 3Phase
CLIENT:
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DWG NO: LC_20KW_POWER_DIST_3
DESCRIPTION:
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REV: 00
A3
NAME:
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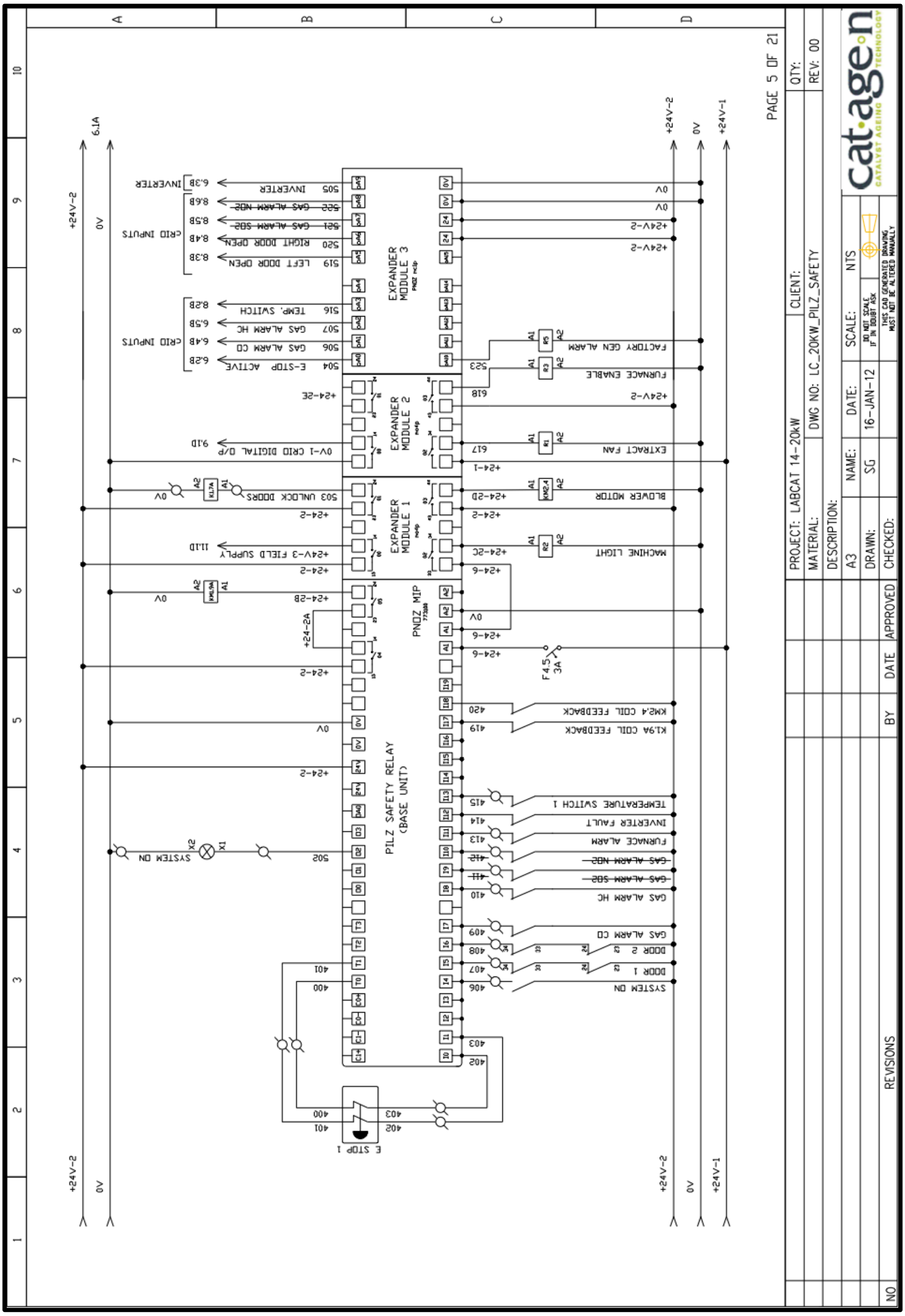
SCALE:
NTS
DRAWN:
SG
16-oct-13
CHECKED:
NO
REVISIONS
BY
DATE
APPROVED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DRAWN:
CHECKED:
APPROVED
DATE
BY
REVISIONS
NO
PILZ SAFETY RELAY (BASE UNIT)
EXPANDER MODULE 1
EXPANDER MODULE 2
EXPANDER MODULE 3
PNOZ MIP
E STOP 1
SYSTEM ON

11.2 Appendix 2 Fluid Flow Schematics