

Control Scheme--RC2000 Engine Drive, Reciprocating Unit

The RC2000 Control system is used to monitor, control and protect the engine and compressor package. All shutdowns, alarms, start-up and shutdown sequences, as well as speed, bypass, and suction control are performed by the control system. This includes the automatic depressurization on shutdown, prelube sequence, auto crank sequence, engine warm-up, loading, and auto cooldown. Password protected adjustable timers and analog settings are accessible from the **Settings** button. This allows easy access to the various timers and settings for parameters such as minimum prelube time, prelube permissive pressures, minimum load RPM, maximum load RPM, crank time, crank cut out, etc.

Start-up and Shutdown Sequence

When the unit is first powered up, the RC2000 Controller records the power loss, initializes all the I/O boards, and proceeds to the ‘Shutdown State’—State 1. Any time the unit is shutdown (either due to a shutdown or by pushing the Stop or Auto Cooldown button) the system goes to State 1.

State 1 - Shutdown State

In **State 1**, all the discrete outputs are turned off immediately except the ignition. The ignition is turned off after the **Ignition Off Timer** has elapsed. The analog (variable) outputs are forced to a value of zero. This effectively closes the suction valve, opens the bypass valve, and forces the governor to minimum speed (providing the governor is set up properly). All the PID control loops are turned off except the Louver controls.

Any time there are active shutdowns, the name of the shutdown will appear on the 2nd line of the LCD screen. The **Reset** button must be pushed to clear any shutdowns. Of course the shutdowns will only clear if they have gone from a Fault to Healthy state. Once **ALL** the shutdowns have been cleared and the Reset button is, the message “OK to Start Compressor” will appear—**State 2**.

State 2 - OK to Start Compressor

To start the unit, the operator must push the Start button. A choice of **[1] Auto Crank, [2] Manual Crank, or [Enter] Exit (Cancel Start)** will appear when the Start button is pushed. Typically the Auto Crank is selected; however, if Manual Crank is selected, the operator will have to push the **Start** button once the unit is ready to crank (explained in more detail later). As soon as option [1] or [2] is selected the controller advances to the next state.

State 3 - Setting Startup Pressures

This state is broken up into two parts: the **Auto Pressurize**, and the **Auto Depressurize**. These are activated from the *Settings* button, by selecting [9] *Start Pressures* menu and then selecting either [3] Auto Pressurize or [4] Auto Depressurize or both (explained below).

To activate the Auto Pressurize sequence, option [3] **Auto Pressurize** must be in the **ON** position and either an auto Suction Control Valve or an auto Purge valve is required. Typically this is done with the auto Suction Control Valve. If this is activated, the controller will insure the suction pressure is above the minimum start pressure. This value is entered from the *Start Pressures* menu by selecting [1] **Minimum Pressure** and entering a value, then press enter again. A password is required to change any of these values.

To activate the Auto Depressurize sequence, option [4] **Auto Depressurize** must be in the **ON** position and an auto Blowdown Valve is required. If this is activated, the controller will insure the suction pressure is below the maximum start pressure. This value is entered from the *Start Pressures* menu by selecting [2] **Maximum Pressure** and entering a value, then press enter again.

Once the suction pressure is above the **Minimum Start Pressure** and below the **Maximum Start Pressure** the controller will advance to the **Prelube State**.

State 4 - Prelube State

The **Prelube State** turns on the engine and compressor prelube pumps. Both the Engine and Compressor prelube pumps run a minimum of **Min Prelube Time** (typically 10 seconds). Wait for the engine oil pressure to be greater than **Engine Oil Perm** and the compressor oil pressure to be greater than **Compressor Oil Perm**—advance to the **OK To Crank** sequence. If this is not achieved within the **Prelube Failure Time**—GO BACK TO STATE 1.

State 5 - OK to Crank & State 6 - Engine Cranking

When option [1] **Auto Crank** is chosen above, the **Auto Crank Sequence** is initiated. This will initiate the crank solenoid, wait for 20 RPM, turn on the ignition, followed by the fuel gas solenoid (after the **Fuel On Delay Timer** has expired—typically 3 seconds). The **Auto Crank Sequence** now cranks for the **Crank on Time** (typically 25 seconds), if the engine does not start; it will turn off the crank solenoid for the **Crank OFF Time** (typically 8 seconds). The unit will continue this cycle (Crank On/Crank Off) until the **Maximum Crank Time** has expired (typically 120 seconds) or until the unit starts. The fuel gas solenoid gets turned off whenever the crank button is turned off AND the RPM is less than 200 RPM. The crank solenoid will continue to be turned on until the RPM exceeds the **RPM Crank Cut Out** (typically 250 RPM). All of these timers are adjustable in the **Crank Settings** and **Fuel/Ign Delays** menu under the *Settings* button. Once the engine RPM exceeds 600 RPM the unit advances to the **Unit Warm Up Cycle**.

If **[2] Manual Crank** is chosen, the controller waits for the **Start** button to be pressed, waits for 20 RPM, turns on the ignition, followed by the Fuel Gas solenoid (after the **Start Purge Timer** has expired). In this case, the **Start** button is a momentary switch so as soon as it is released the Crank solenoid will be turned off. The operator has the ability to manually determine the crank on time and time between cranks. The Fuel Gas solenoid gets turned off when the Crank is released **AND** the RPM is below 200 RPM. Once the engine RPM exceeds the **Underspeed** setpoint (typically 600 RPM) the unit advances to the **Engine Warm Up Cycle**.

State 7 - Unit Warm-up Cycle

Once in the **Unit Warm up Cycle** a Suction Start-up PID (low setpoint) is turned on to insure minimal suction pressure is maintained and the RPM PID is turned on and set to **Idle RPM** (typically 800 RPM). At the same time, the controller starts the **Maximum Warm-up Timer** (typically 600 seconds), waits for the **Minimum Warm Up Timer** (typically 30 seconds) to expire and then waits for the **Jacket Water Permissive** (typically 60 °C) and **Compressor Oil Temperature Permissive** (typically 20 °C) to be satisfied. Once both the minimum time and permissive temperatures have been achieved, the controller advances to the next state and starts to load up the unit. The above **timers and temperature setpoints** can be adjusted from the **Warm Up** menu under the **Settings** button. If the temperature permissives have not been achieved within the period of the **Maximum Warm-up Timer**, the start sequence will abort and go back to State 1, the Shutdown state. During this state, if at any time the Suction Controller is put in manual, this will shut off the Suction Start-up PID (this is so it is not fighting the manual operation of the Suction Controller).

State 8 - Compressor Running

Assuming all the PID controllers are in **Auto Mode**, the unit will start to load. In the **Load Sequence** the controller first ramps up the engine speed to **Minimum Load RPM** (typically 1050 RPM on a 1200 RPM engine). This is done by putting in a speed setpoint 50 RPM above the **Minimum Load RPM**. Once the **Minimum Load RPM** is achieved, the setpoint is set to **Minimum Load RPM**. At this time, both the Suction Control PID and the Master PID are turned on and the Suction Start-up PID is turned off. The Master PID is set up so that as long as the suction pressure is above the **Suction Pressure Override** and the final discharge pressure is below the **Discharge Pressure Override** the unit controller will gradually close the Bypass Valve, and ramp the speed up to full RPM. **Note:** Once the Bypass Valve is 100% closed the Master controller adds an offset value to the **Discharge Pressure Override** and subtracts an offset value from the **Suction Pressure Override** only on the Bypass PID. This is to prevent the Speed PID and the Bypass PID from fighting each other. Both the **Suction Pressure Override** and the **Discharge Pressure Override** are adjustable from the Master Load Control button. This is explained in detail in the Operators Manual.

SHUTDOWN SEQUENCES

The RC2000 Controller has the conventional Class A, B, and C shutdowns as well as a Class D, and Class E (explained below). Class A shutdowns are always active, Class B shutdowns get activated after the unit is up and running and the Class B timer has expired (typically 120 seconds). Class C shutdowns are only active once the initial setpoint has cleared (i.e. Low Suction Pressure—the shutdown becomes active once the suction pressure climbs above the setpoint). In the RC2000 controller, Class C shutdowns can also have an overriding timer such that if the value does not exceed the shutdown setpoint within a certain time it will activate the alarm or shutdown. Class D shutdowns must be healthy to start, and then bypassed after start and during normal running (i.e. temperature permissive). Class E shutdowns must be satisfied to start, but are bypassed for a timed period after start (used for oil level shutdowns).

Three types of shutdowns are built into the control logic as standard: Auto Cool Down Stop; Sudden Stop; and ESD. They are all described below.

Sudden Stop

A **Sudden Stop** shutdown at any time will force the unit back to the **State 1 - Shutdown State**. At this time all the discrete outputs are turned off immediately except the ignition. The ignition is turned off after the **Ign Off Delay Timer** has elapsed. The analog (variable) outputs are forced to a value of zero. This effectively closes the suction valve, opens the bypass valve, and forces the governor to minimum speed (providing the governor is set up properly). All the PID control loops are turned off except the Louver controls. A postlube sequence is initiated if the unit was in the Warm-up or run state. This sequence turns on the lube pumps until the **Post Lube Timer** has expired (typically 120 seconds). The **Post Lube Timer** is adjusted from the **Post Lube** menu and the **Ign Off Delay Timer** is adjusted from the **Fuel/Ign Delays** menu, all under the **Settings** button.

Auto Cool Down Stop

The Auto Slowdown sequence is used to gradually unload the compressor package and let it run unloaded for several minutes prior to shutting down the package. The Auto Slowdown sequence is initiated by pushing the **Stop** button and answering [1] **Auto Cool Down Stop** when the controller asks if you want to perform the action. Most of the shutdowns in the RC2000 are set to **Auto Cool Down**. Each of the Auto Cool Down shutdowns also have an offset number that works as follows: if the process value continues to exceed the shutdown setpoint by this offset value, this will cause a **Sudden Stop** shutdown (ie. A Jacket Water shutdown is set @ 96 °C with a 2°C offset—in this case if the temperature climbs to 98 °C it will terminate the Auto Cool Down sequence and stop immediately). The offset is an added safety feature built into the Auto Cool Down.

The following events happen when the Auto Slowdown is initiated: 1) The Master PID control is turned off; 2) the RPM is ramped down to **Minimum Load RPM**; 3) the Bypass Valve is gradually opened, and; 4) the Suction Valve is gradually closed. Once the Bypass Valve is fully open and the

Suction Valve is fully closed, the engine will be slowed down to idle speed. Wait for approximately 3 minutes and then shut down the unit as per above. (refer to above shutdown sequence).

ESD Shutdown

An ESD shutdown acts identical to a sudden stop with the addition on a block and blowdown sequence. This effectively stops the machine, close the Suction and Discharge ESD valves (also Utility ESDs if applicable), and opens the Blowdown valve. It also turns off the ESD status. The postlube sequence will still carry on in an ESD shutdown.

SUBROUTINES

Manifold Pressure Override

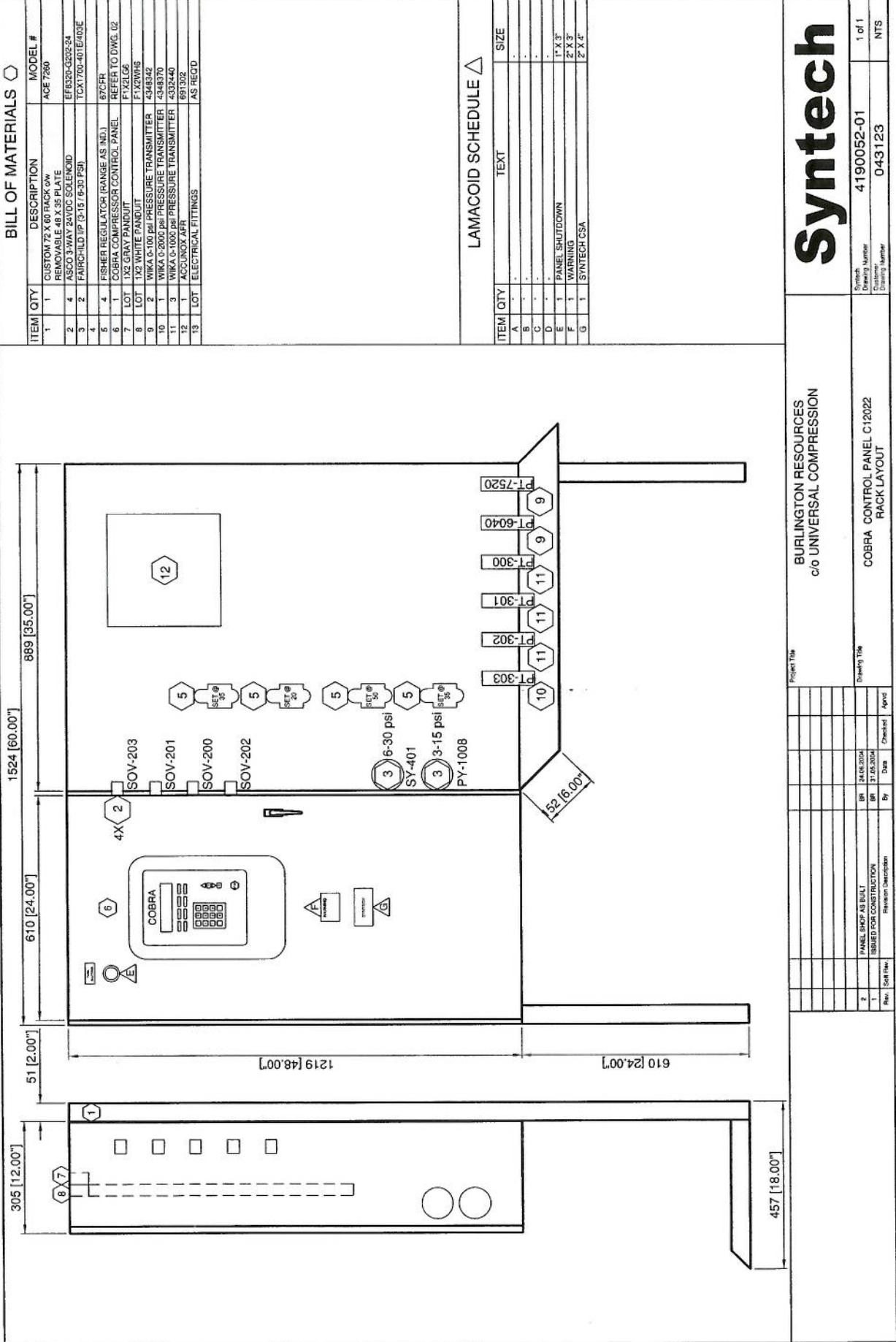
The Manifold Pressure Override sequence uses the Suction Control Valve to control manifold pressure. On a V-type engine, there is a Left Manifold Pressure Override PID and a Right Manifold Pressure Override PID. Four setpoints are used: *Left Manifold Override On; Left Manifold Override Off; Right Manifold Override On, and; Left Manifold Override Off*. These are all adjusted from the *Manifold Override* menu under the *Settings* button. Whenever the left or right manifold pressure exceeds the *Override On* setpoint, the main Suction PID is turned off and either the Right or Left Manifold Pressure Override PID is turned on depending which of the manifold pressures exceeded the *Override On* setpoint. A message will appear on the display stating either “Left Manifold Override” or “Right Manifold Override” depending which override is active. The control setpoint for these Override PID’s are usually set very close or equal to the *Override On* setpoints. This prevents cycling back and forth between suction pressure control and manifold pressure control. The Override PID (right or left) will be turned off and the Suction Control PID turned on when the manifold pressure drops below the *Override Off* setpoint for the corresponding Override PID.

1) Remote Idle or Unload (optional)

The Remote Idle sequence is used to gradually unload the compressor package and let in run unloaded (on full bypass) until the Remote Idle is turned off. The unit will gradually load up and go back to normal operating condition when the Remote Idle is turned off. The Remote Idle sequence is initiated remotely via the RS 485 using the Modbus RTU protocol or can be set up to be activated from a hard wired discrete input. The following events happen when the Remote Idle is initiated: 1) The Master PID control is turned off; 2) the RPM is ramped down to *Minimum Load RPM*; 3) the Bypass Valve is gradually opened, and; 4) the Suction Valve is gradually closed. Once the Bypass Valve is fully open and the Suction Valve is fully closed, the engine will be slowed down to idle speed. Wait until the Remote Idle is turned off and then essentially reverse the auto slowdown process to load the engine up again. This involves



ramping the speed up to the ***Minimum Load RPM***, turning on the Master Control PID (closes the Bypass and ramps the engine speed to full RPM unless a suction or discharge override exists), and turns on the Suction Control PID.



BILL OF MATERIALS ◇			LAMACOID SCHEDULE △		
ITEM	QTY	DESCRIPTION	ITEM	QTY	TEXT
1	1	EUROBOX NEMA 4 ENCLOSURE	A	1	INCENDIVE I/O
2	2	INPUT MODULE	B	1	24VDC DISTRIBUTION
3	1	OUTPUT MODULE	C	1	IGNITION DISTRIBUTION
4	2	WIELAND 40 PIN TERMINATION BLOCK	D	-	-
5	4	WIELAND 26 PIN TERMINATION BLOCK	E	1	PANEL SHUTDOWN
6	2	WDX 2.5 STACKED FEED THROUGH TERMINAL	F	1	WARNING
7	24	WDX 1.0 FEED THROUGH TERMINAL	G	1	SYNTECH CSA LAMACOID
8	2	WELD. WPE 4 GROUND TERMINAL	H	1	POWER RESET
9	1	TELE. RED PUSH BUTTON	I	-	-
10	2	NIC CONTACT BLOCK	J	-	-
11	3	WEID. SAMS 1A FUSED TERMINAL	K	-	-
12	2	WEID. SAMS 1A FUSED TERMINAL	L	-	-
13	2	WEID. WU 2.5 FEED THROUGH TERMINAL	M	-	-
14	6	WEID. WU 1.0 FEED THROUGH TERMINAL			
15	1	COBRA CPU MODULE			
16	LOT	1X2 GRAY PANJOINT			
17	LOT	1X2 WHITE PANJOINT			
18	LOT	1X3 WHITE PANJOINT			
19	LOT	2X3 WHITE PANJOINT			
20	LOT	GROUND BAR			
21	1	COBRA CPU MODULE			
22	1	WEID. SPARE FUSE HOLDER			
23	1	ILSCO ISOLATED GROUND LUG			
24	1	ILSCO PANEL GROUND LUG			

Project No. : Drawing No. : 1 of 1

BURLINGTON RESOURCES
c/o UNIVERSAL COMPRESSION

COBRA CONTROL PANEL C12022
PANEL LAYOUT

SYntech

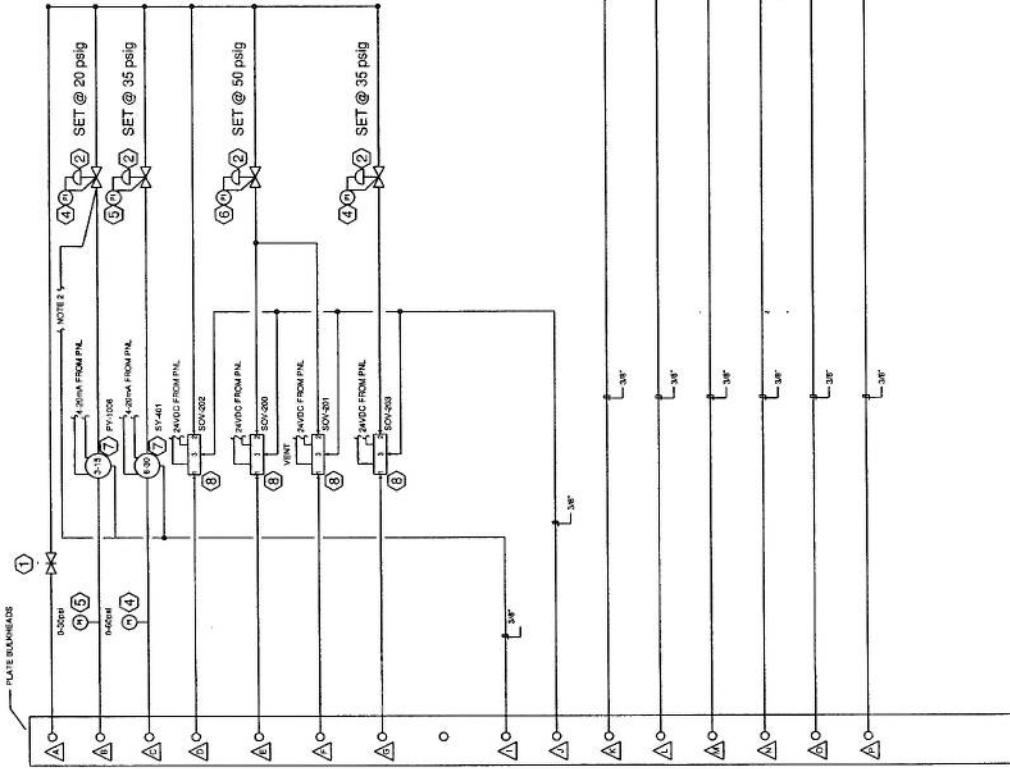
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BILL OF MATERIALS ◇

ITEM #	DESCRIPTION	MODEL #
1	SWAGELOCK NEEDLE VALVE (3/8")	SS-1-VSB
2	FISHER REG. (125psi SET AS INDICATED)	67-CFR
3	-	-
4	3 WINKA 0-10psi GAUGE 2 1/2" SS	9205439
5	2 WINKA 0-30psi GAUGE 2 1/2" SS	9205464
6	1 WINKA C-100psi GAUGE 2 1/2" SS	9205455
7	2 FAIRCHILD DP 0-1616-30PSI	TOXT03-401EUS
8	4 ASCO 3 WAY SOLENOID	EF8320-G302-24
9	1 WINKA 0-2000 psi TRANSMITTER	438870
10	3 WINKA 0-1000 psi TRANSMITTER	4382440
11	-	-
12	2 WINKA 0-100psi TRANSMITTER	438342

LAMACOID SCHEDULE △

ITEM #	QTY	SIZE	TEXT
A	1	MAIN SUPPLY	-
B	1	PPV100B	-
C	1	SV-401	-
D	1	SOV-200	-
E	1	SOV-200	-
F	1	SOV-200	-
G	1	SOV-203	-
H	1	UP VENT	-
J	1	UP VENT	-
K	1	PT-300	-
L	1	PT-301	-
M	1	PT-302	-
N	1	PT-6040	-
P	1	PT-7520	-



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Syntech

SYNTECH
Drawing Number: 4190052-04
Drawing Date: 04/31/2013
1 of 1
NTS

Project Name	COBRA CONTROL PANEL C12022		
Drawing Name	BULKHEAD CONNECTIONS		
Sheet Number	4190052-04		
Revision Number	043123		

NOTES:
1. ALL TUBING TO BE 1/4" UNLESS OTHERWISE SPECIFIED.
2. IPS AND REGULATOR VENTS SET TOGETHER.

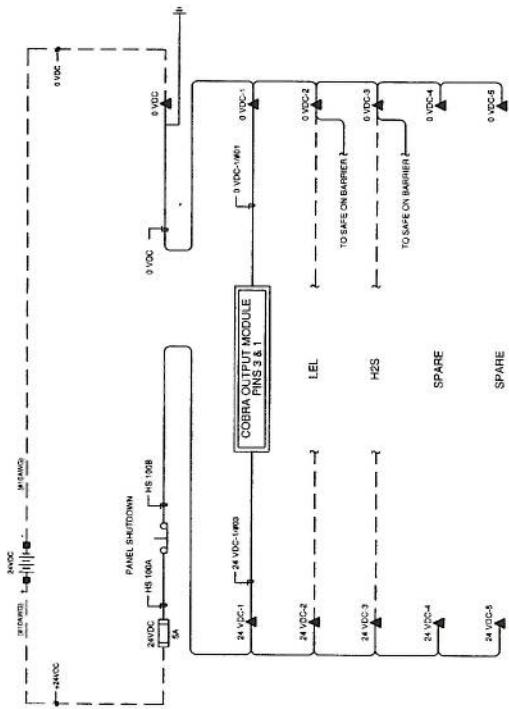
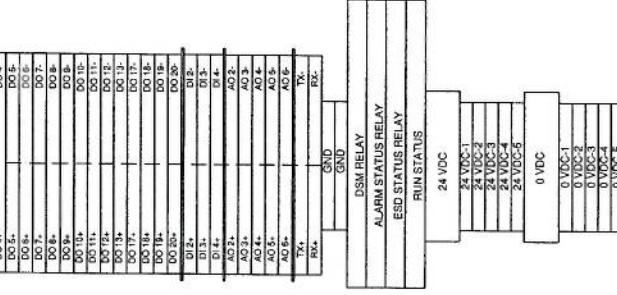
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24VDC POWER DISTRIBUTION

24VDC TERMINAL LAYOUT

TOP LEVEL

BOTTOM LEVEL



NOTES:
1. ALL FUSES ARE GDA TYPE.

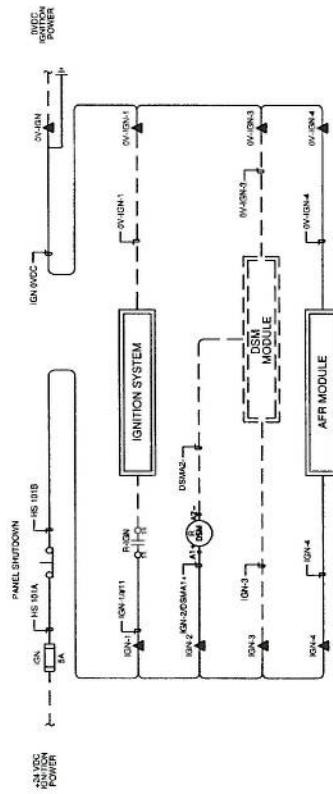
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Rev.	Sheet No.	Revised On	By	Drawn	Checked	Approved
1	4190052-05	24-06-2004	BB	24-06-2004	BB	24-06-2004
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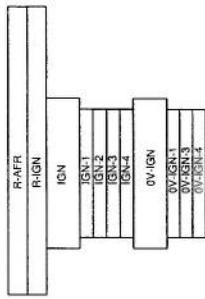
Syntech

Branch Drawing Number
Customer Drawing Number
NTS

IGNITION DISTRIBUTION

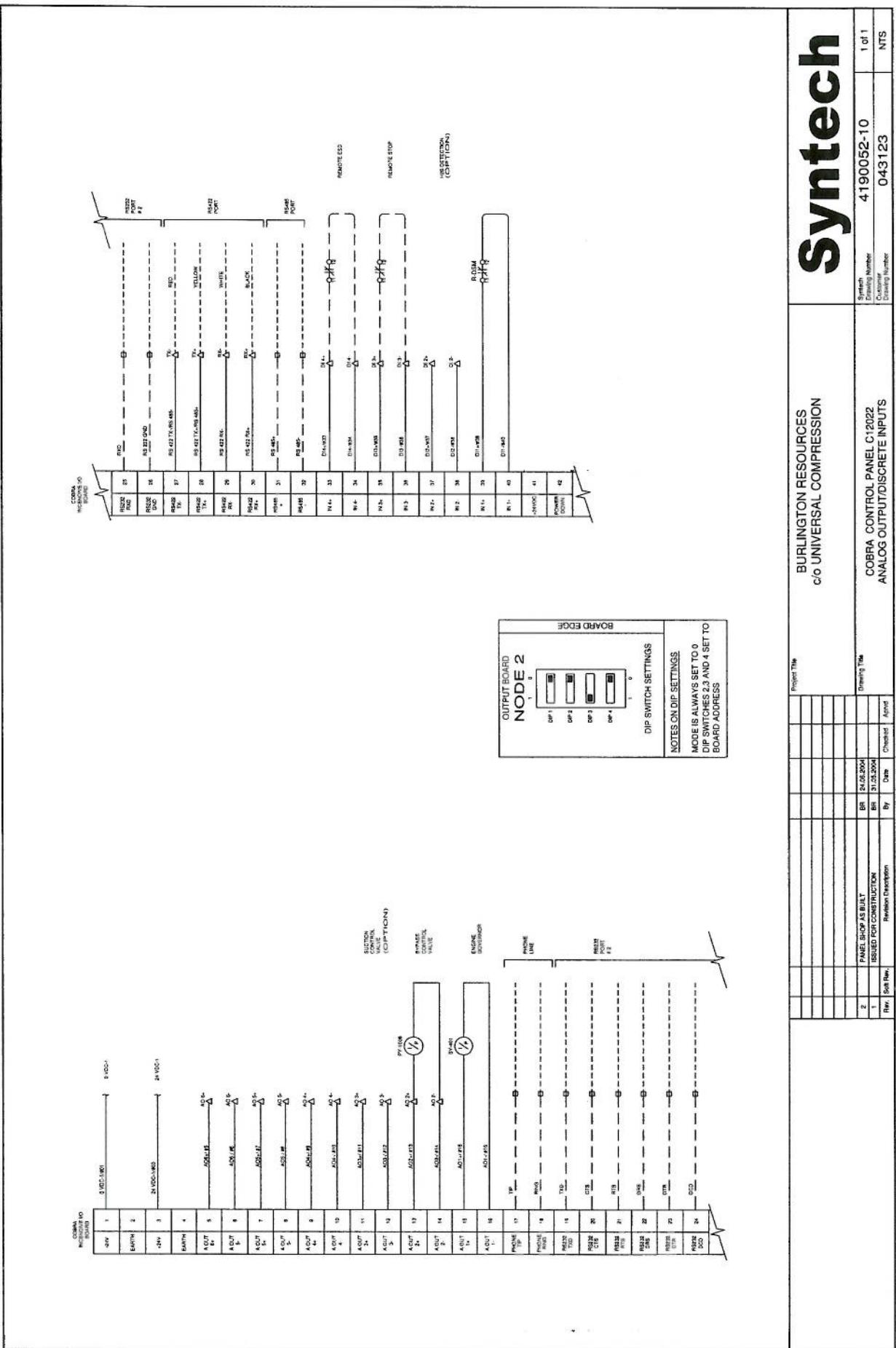


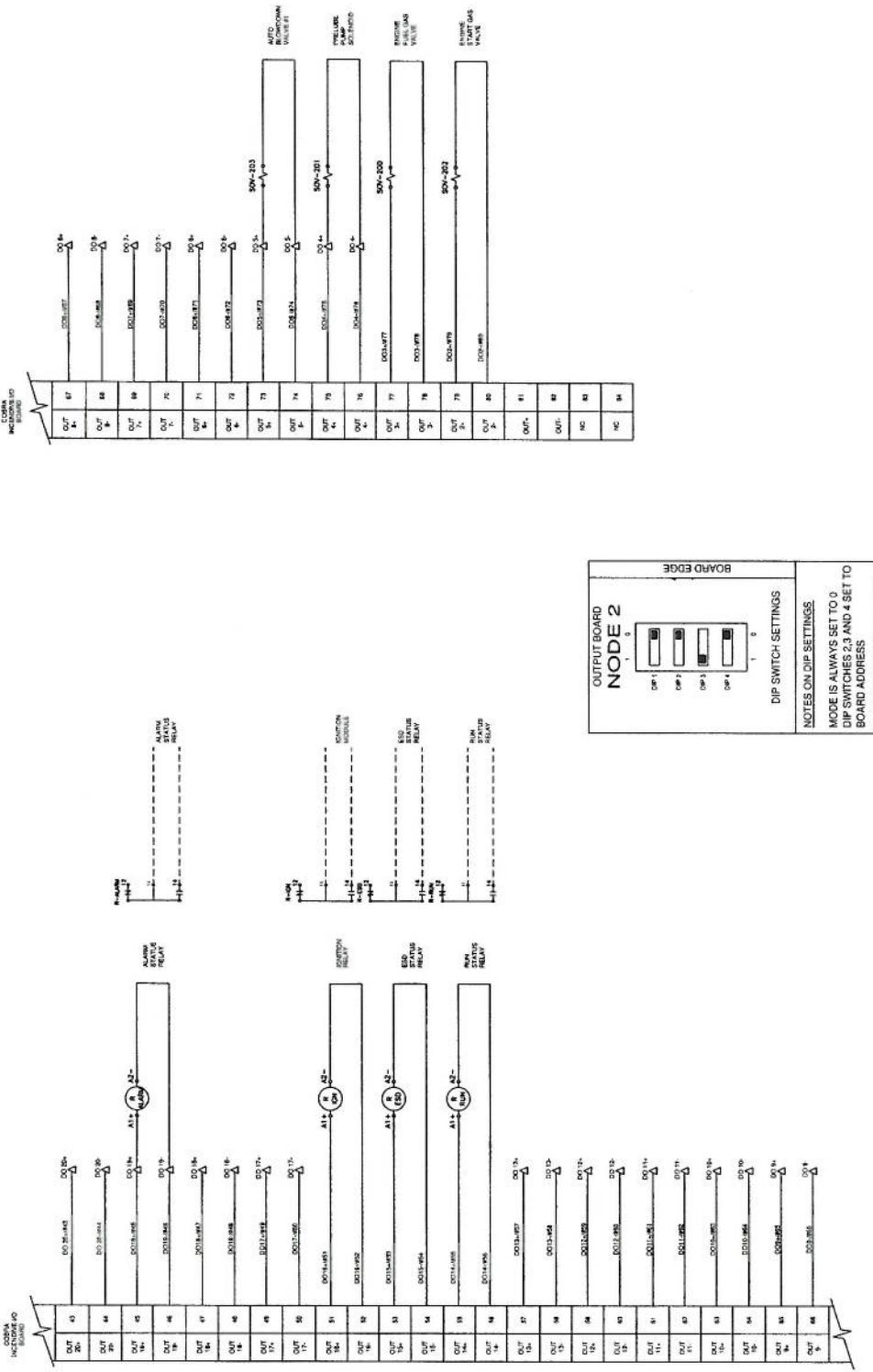
IGNITION TERMINAL LAYOUT

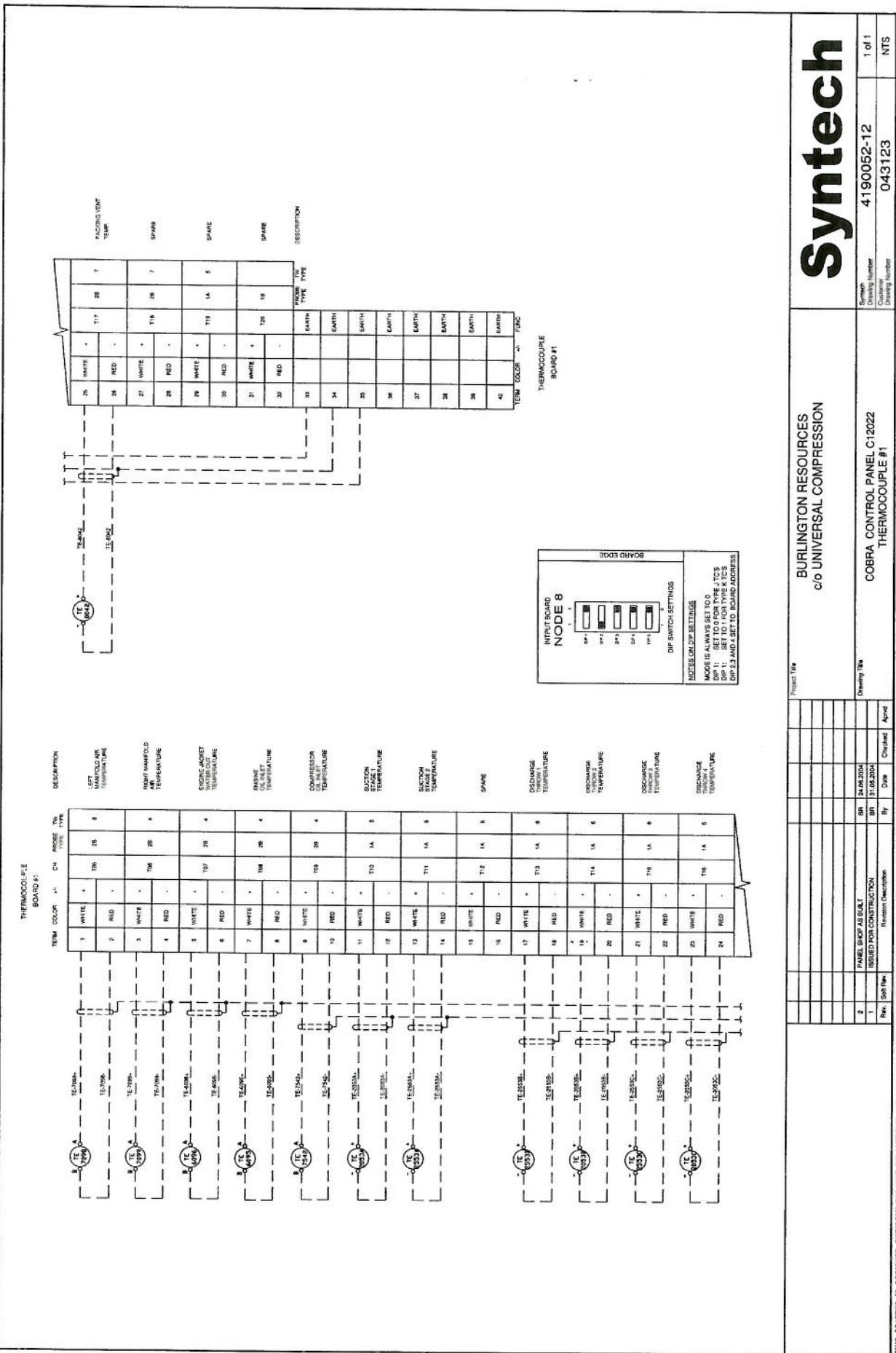


Project Title		BURLINGTON RESOURCES c/o UNIVERSAL COMPRESSION		Syntech	
Drawing Title		COBRA CONTROL PANEL C12022		Sheet	4190052-06
Rev.	Soft Fw.	Date	Checklist	Customer Drawing Number	1 of 1 043123
1	TESTED FOR CONSTRUCTION	BR 24.06.2024	Approved	NTS	
2	PANEL SHOP AS BUILT	BR 31.06.2024			

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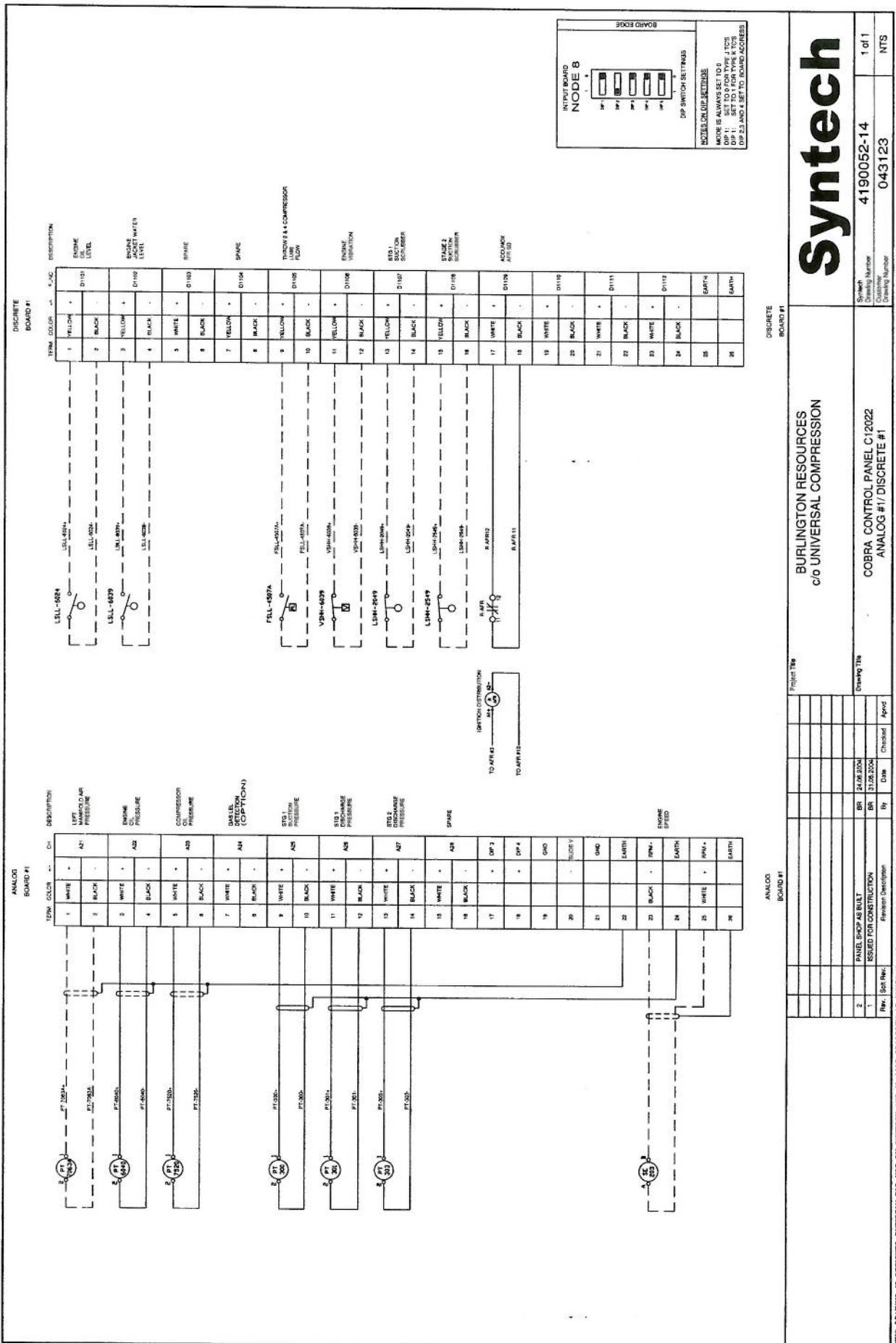


BURLINGTON RESOURCES
c/o UNIVERSAL COMPRESSION

COBRA CONTROL PANEL C12022
THERMOCOUPLE #1

Project Name: Syntech
Drawing No.: 4190052-12
Rev. / S/N: 043123
Customer Name: NTS
Driving Date: 04/05/2024
Completed: Yes
Customer Drawing Number:

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