Background

MicroCODE Control is part of a new Windows 10 Industrial Internet of Things (IIOT) application suite to support custom machine control and remote monitoring:

- **Control** – Local control of machines and/or processes
- **Cloud** – Cloud based data collection
- **Remote** – Internet access to Machine data and status

This new system is made possible through several advances in manufacturing:

1 – Industrial Internet of Things (IIOT)
2 – Cloud based commuting
3 – Ubiquitous Smart Phones

The MicroCODE Control application can support all these processes using existing Industrial Personal Computers (IPCs) with the addition of small Programmable Logic Controllers (PLCs) and state-of-the-art IO-Link hardware.

Hardware Requirements

The **Control** App requires the following hardware for proper execution:

- Windows 10 IoT Device – Advantech **UNO-2372G**
- Advantech Touch Screen – 1280 x 1024
- Optional: USB Keyboard and Mouse
- Optional: USB Hand Scanner
- Optional: Ethernet I/O (for Machine Sensors)

Software Requirements

The **Control** App requires the following software for proper execution:

- **Windows 10 IoT LTSB** – preinstalled on the Advantech UNO-2372G device
- **Microsoft .NET 4.0** – preinstalled on the Advantech UNO-2372G device
- MicroCODE **Control** Windows 10 .NET Application
- MicroCODE Application Extension PLC (**AXP**)

The Control App does ***not*** require any software licenses:

- No Software License (MicroCODE owned application)
- No Rockwell Automation RSLinx required
- No 3rd Party OPC Server
- No 3rd Party Communication Software

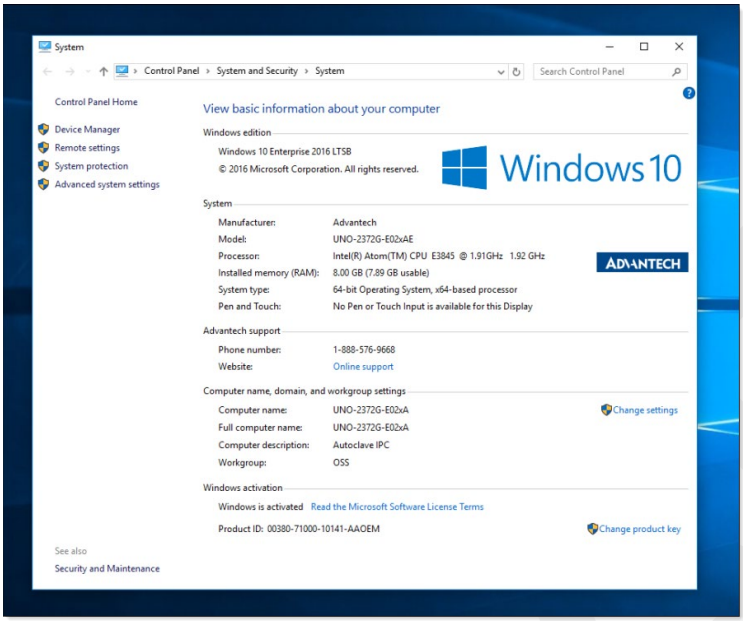
Windows 10 IoT

4.0
Microsoft®
.NET

Software Build

The Advantech UNO-2372G ships with:

- **Windows 10 Enterprise 2016 LTSB*** – preinstalled
- **Microsoft .NET 4.0** – preinstalled on the Advantech UNO-2372G device



- **Advantech Support Suite*** – preinstalled

Advantech DiagAnywhere Server	Advantech	222 KB 9/30/2017
Advantech EC Lmsensor Driver	Advantech	10.2 MB 2/23/2019
Advantech SNMP Subagent	Advantech Co., Ltd.	14.2 MB 2/23/2019
Advantech Watchdog Driver	Advantech	11.6 MB 2/23/2019
Advantech Windows PTP	Advantech Co., Ltd.	4.01 MB 2/23/2019

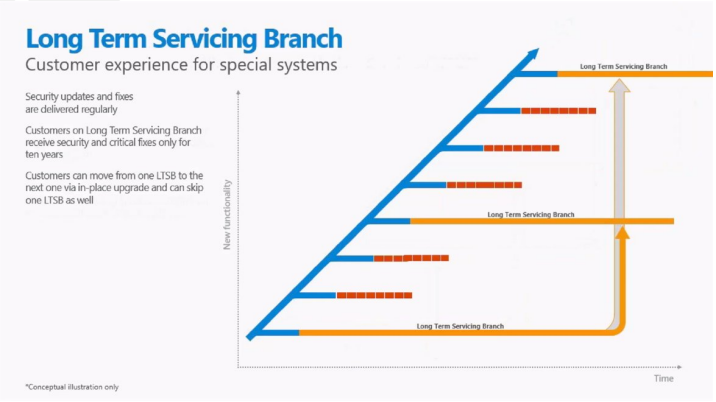
* **DiagAnywhere Server** allows for remote control of the IPC from any PC in the Shop

- **Microsoft Office 2017 Viewers** – preinstalled

Microsoft Office Excel Viewer	Microsoft Corporation	163 MB 10/17/2016
Microsoft Office Word Viewer 2003	Microsoft Corporation	53.1 MB 10/17/2016
Microsoft PowerPoint Viewer	Microsoft Corporation	306 MB 10/17/2016

Compatibility Pack for the 2007 Office system	Microsoft Corporation	86.0 MB 10/17/2016

- **Long Term Servicing Branch (LTSB)** – 10+ year Operating System Support Model from Microsoft



The Control App Hardware

The MicroCODE Control App uses a **Windows 10** Industrial Internet of Things (**IIoT**) Industrial Personal Computer (**IPC**) from Advantech, an Allen-Bradly **CompactLogix** Programmable Logic Controller (**PLC**) and Balluff IO-Link intelligent I/O Blocks together to control the Autoclave using modern, flexible, upgradable hardware.

Advantech Windows 10 IPC

The **IPC** computer is an industrial PC with no moving parts; no fan, no hard disk, just flash memory. It supports local Ethernet I/O, Plant Ethernet connections, and local USB devices.

LAN A – **Plant** Network - PLCs

LAN B – **Private** Ethernet I/O

Advantech 17" Touch Screen

The user interface is handled by an Advantech 17" Touch Screen, capable of being mounted in a plant environment, right is a control panel door.

Allen-Bradly CompactLogix PLC

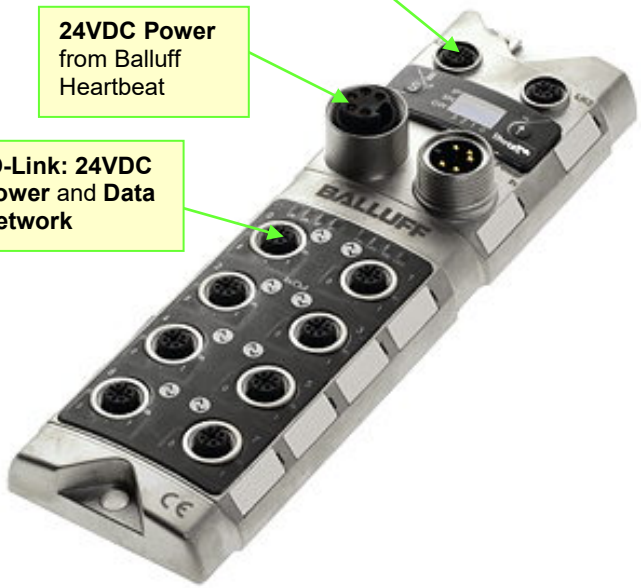
The **PLC** is an industrial standard controller from Allen-Bradley, programmed with Rockwell Software **Studio 5000**.

Balluff IO-Link Master Block (BNI004A or BNI006A)
This device provides an intelligence bridge from Ethernet to all the required Digital and Analog I/O devices in the control system.

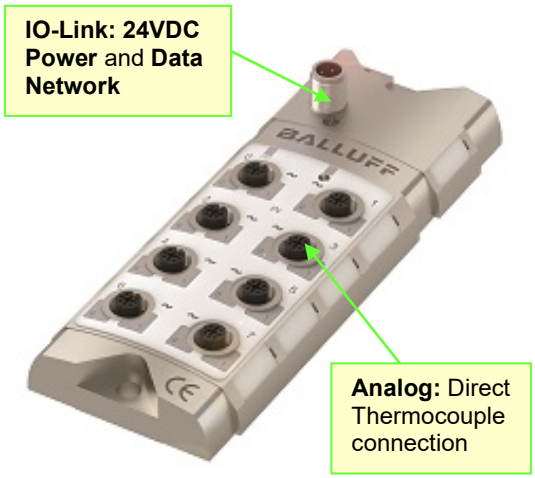
Ethernet connection to IPC and PLC

24VDC Power from Balluff Heartbeat

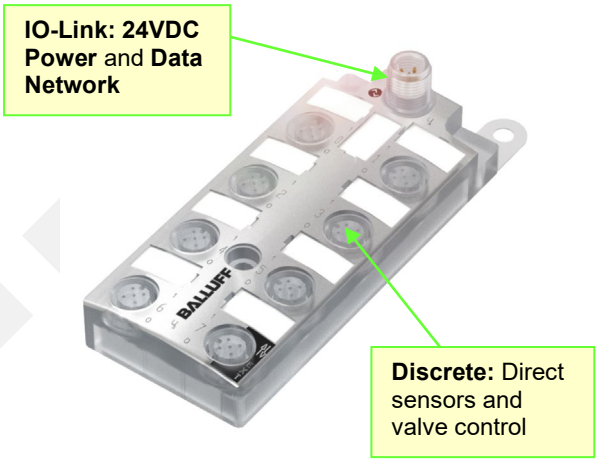
IO-Link: 24VDC Power and **Data Network**



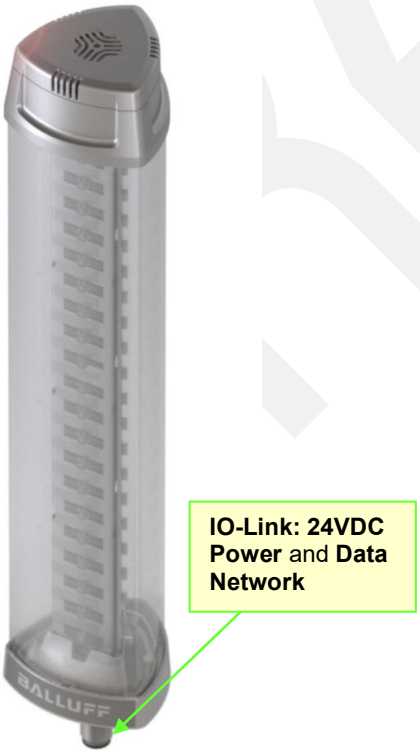
Balluff IO-Link Analog-to-Digital I/O (BNI00AJ)
These devices provide a direction connection from the control system to the Autoclave Thermocouples



Balluff Discrete I/O Block (BNI007Z)
This device provides an interface to discrete sensors and actuators over ab IO-Link connection.



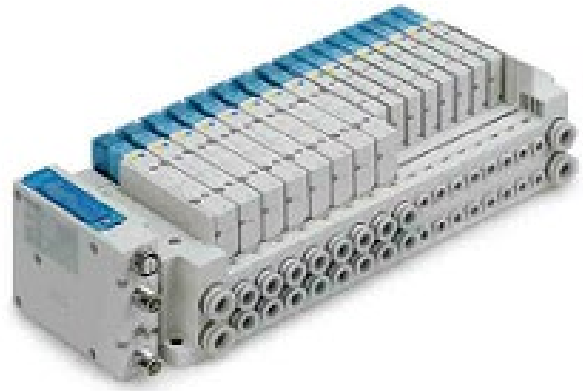
Balluff Smart Stacklight (BNI0085)
This device provides an 'at-a-glance' status of the Autoclave process that can be seen from across the shop floor. It provides colored set of LED lights and a horn for getting the Operator's attention.



Balluff 24VDC Power Supply (BAE00ET)
This device provides an isolated power source for all the IO-Link equipment.

Balluff IO-Link
Pressure Sensors (BSP0098 and BSP008M)
These devices provide direct pressure sensing—for valve control—over an IO-Link connection to the PLC.

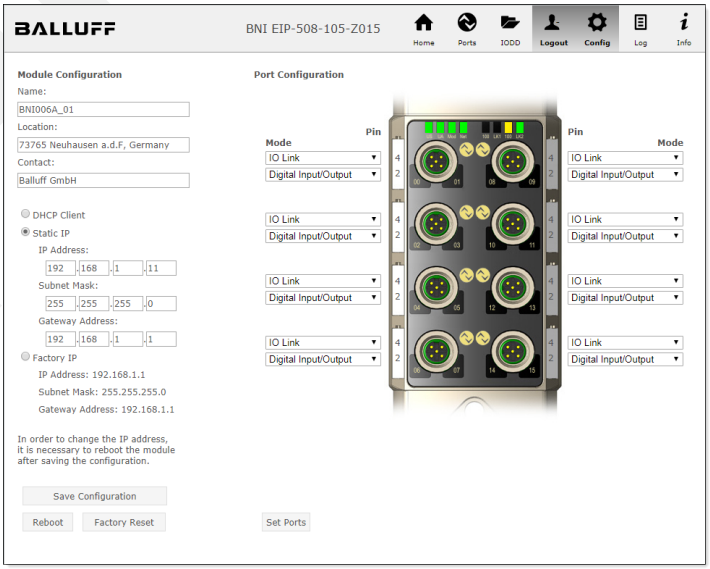
SMC Multi-Valve Control Manifold (SMC EX250-X210)
This manifold provides direct valve control—for vacuum lines and autoclave fill pressure—over an IO-Link connection to the PLC.



Balluff Web Server
Each Balluff IO-Link Master Block (**IMB**) has a Web Server buiult in for monitoring and configuration of the blocks…

Out-of-the-box the IMB are set to **192.168.1.1**

Default password: "BNIEIP"



Control App Software

Application Framework

The underlying the Control App application framework supports the following requirements:

- **HMI Style Application** – graphical for ease of configuration and operation.
- **Multi-Threaded, Event Based Code** – this construct supports fast, very efficient code, allows a simple, inexpensive processor to handle control and interface tasks.
- **Extensive Logging** – supporting six (6) different logs the Control App can produce reports and data for all Production and Application support needs:

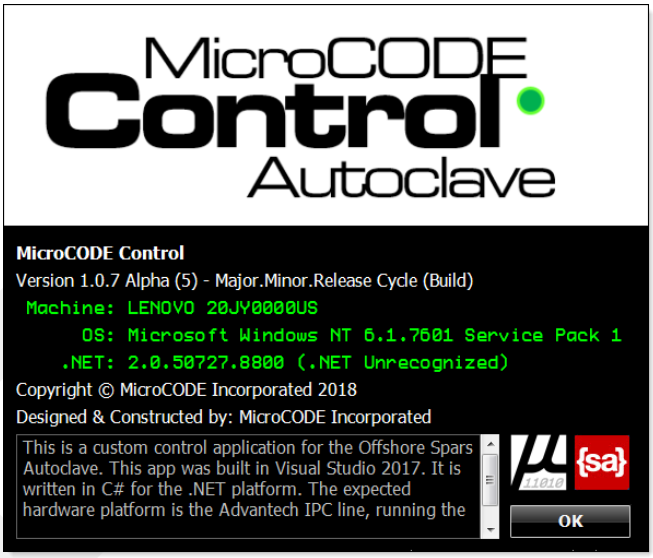
  1) ***Application Event Log*** – internal application events of interest to Support Staff and Developers and operator related events of interest to Production Staff.

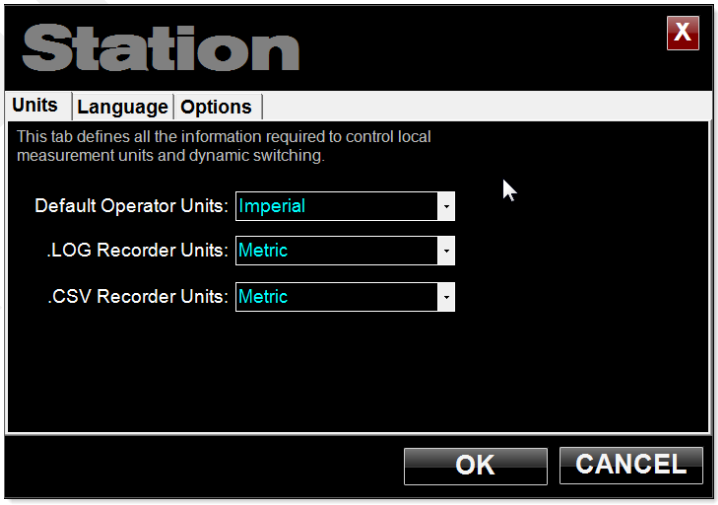
  2) ***Product History Log*** – record of every product that has passed through the Control App Station's span of control.

  3) ***Operator Event Log*** – record of every major action that the Operator initiated

  4) ***Product Data Log*** – system collected data during product production, based on a Part Profile which includes data collection interval.

- **HMI Integration** – built-in visualization for Operator control and monitoring.
- **Programmable Logic Controller (PLC) Communication** – for the Control App can be directly extended by industry standard PLCs for larger systems.
- **Integrated Help and Tools** – all information required to configure the Control App devices is included in application screens where the actual work is performed.
- **Support Mode** – built into the Production application to allow for extensive data collection to help remotely trouble shoot problem.



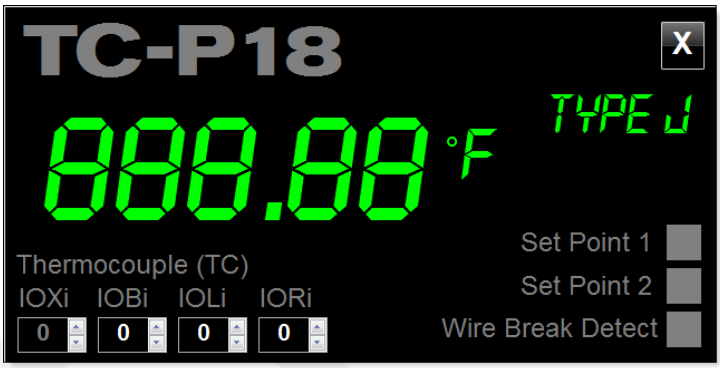


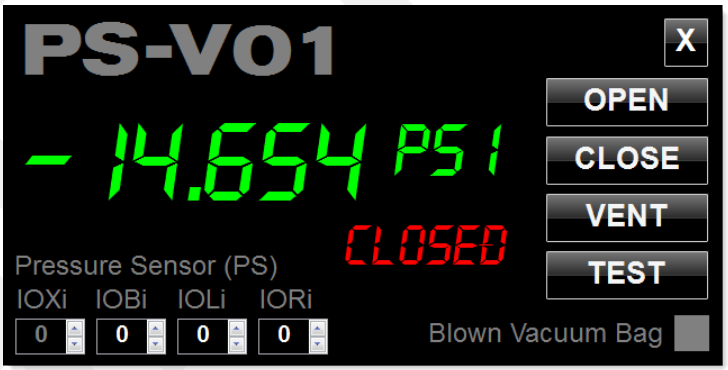
Control App Software

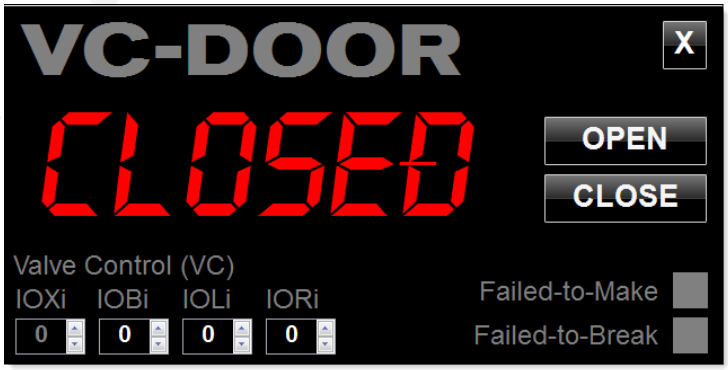
App Features

The MicroCODE Control App provides the following Autoclave control features:

- **TC Monitoring and Recording** – always visible of the main display and recorded at configurable intervals in both a SQL Database and Text Log file.
- **Pressure Monitoring and Recording** – always visible of the main display and recorded at configurable intervals in both a SQL Database and Text Log file.
- **Automatic and Manual Valve Control** – all configured Valves—Air, Vacuum, and Hydraulics—are controlled by the Part Cure Profile (PCP) during execution with manual override available. (Safety protocols will prevent certain operations based on Autoclave conditions).
- **Automatic Pressure and Vacuum Control –** all pressures and vacuums are controlled by the Part Cure Profile (PCP)
- **Automatic Oven Heat Control –** Oven Heat output is controlled by the Part Cure Profile (PCP) – based on Ramp to target temperature and Soak at temperature
- **Process Status Light & Alarms** – any deviation from the configured PCP is immediately display on: PLC Status Light, and IPC Panel Display; and will be records in the App Event Log.

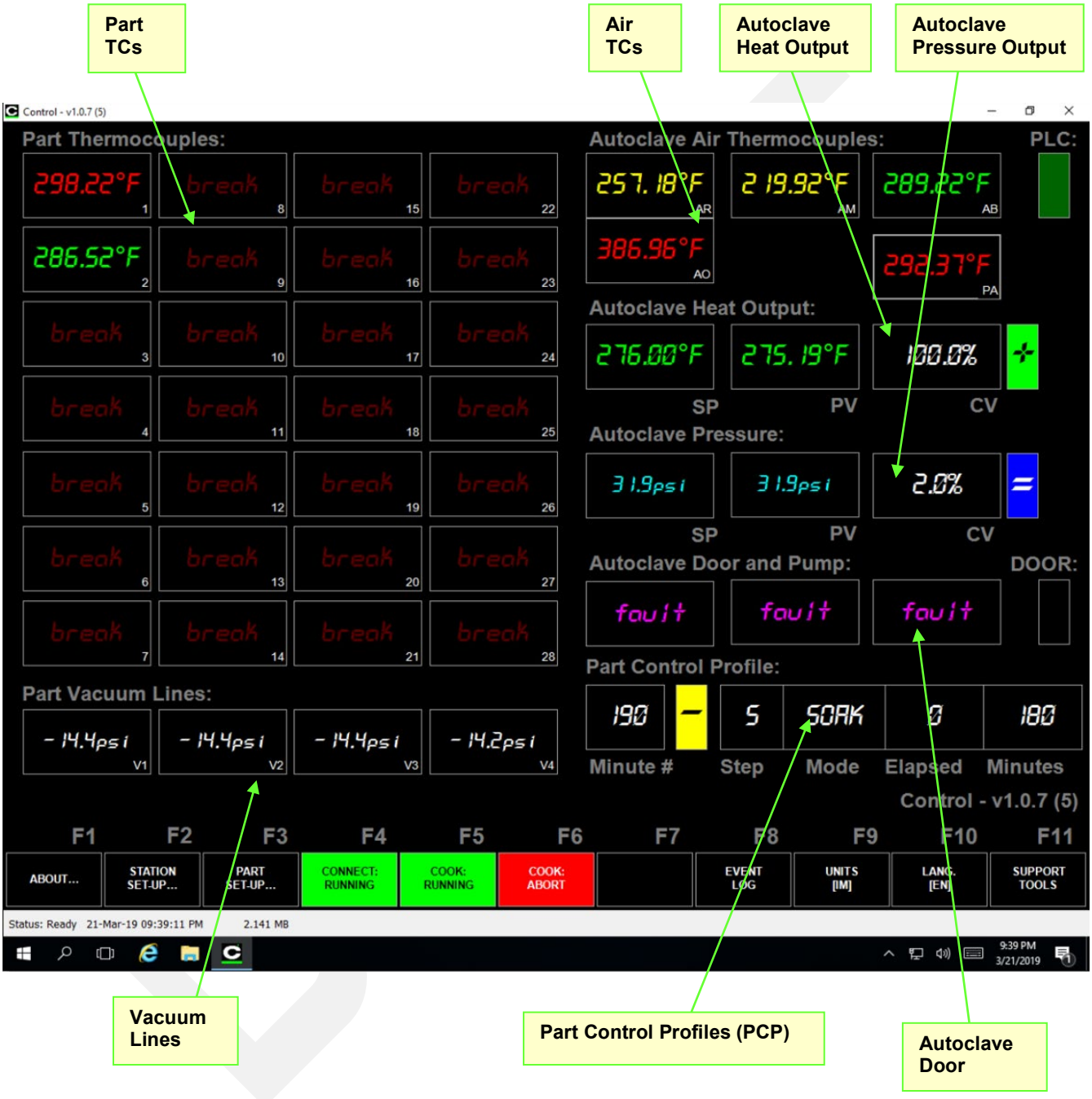






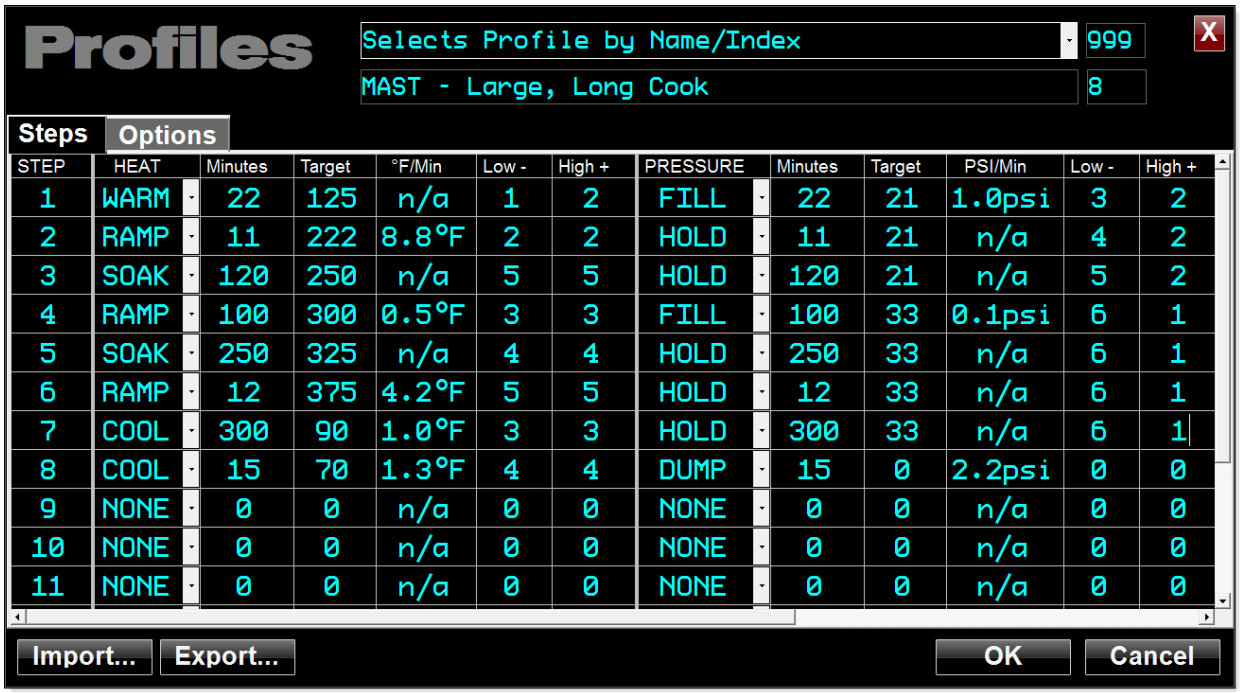
App Layout

The main App Screen is used to both configure and monitor all Autoclave functions.

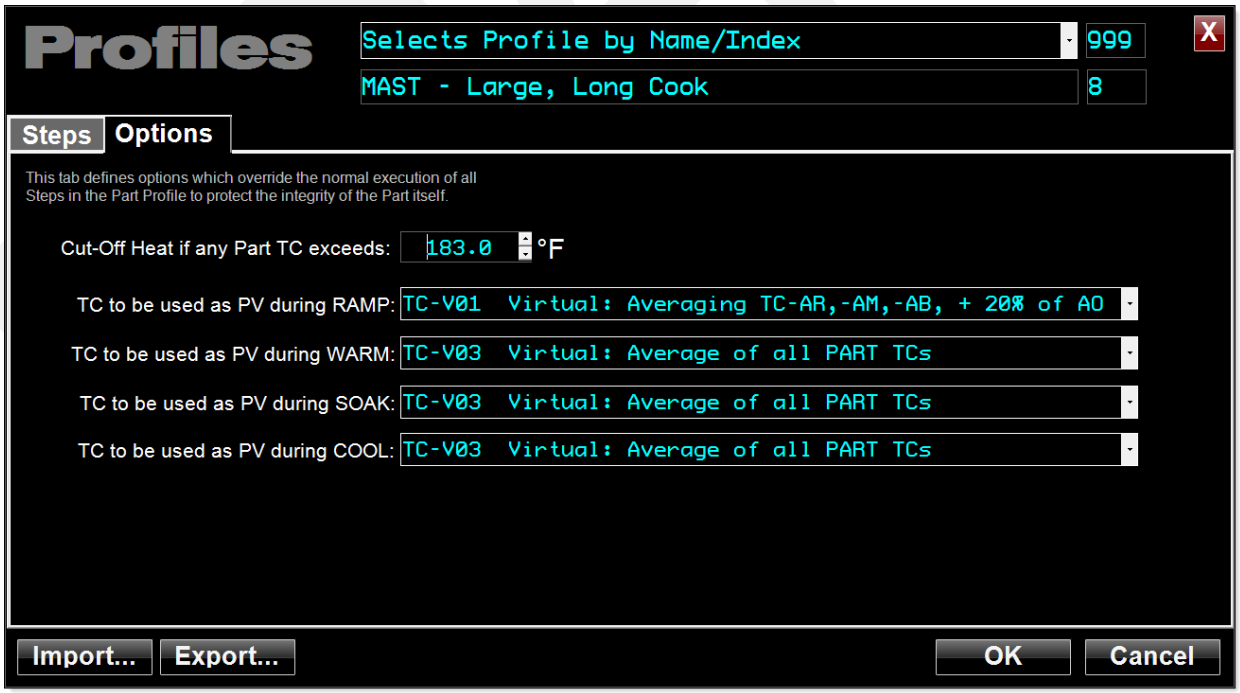


Part Cure Control

The App gives complete control over Heat, Pressure, Vacuum, and data sources.

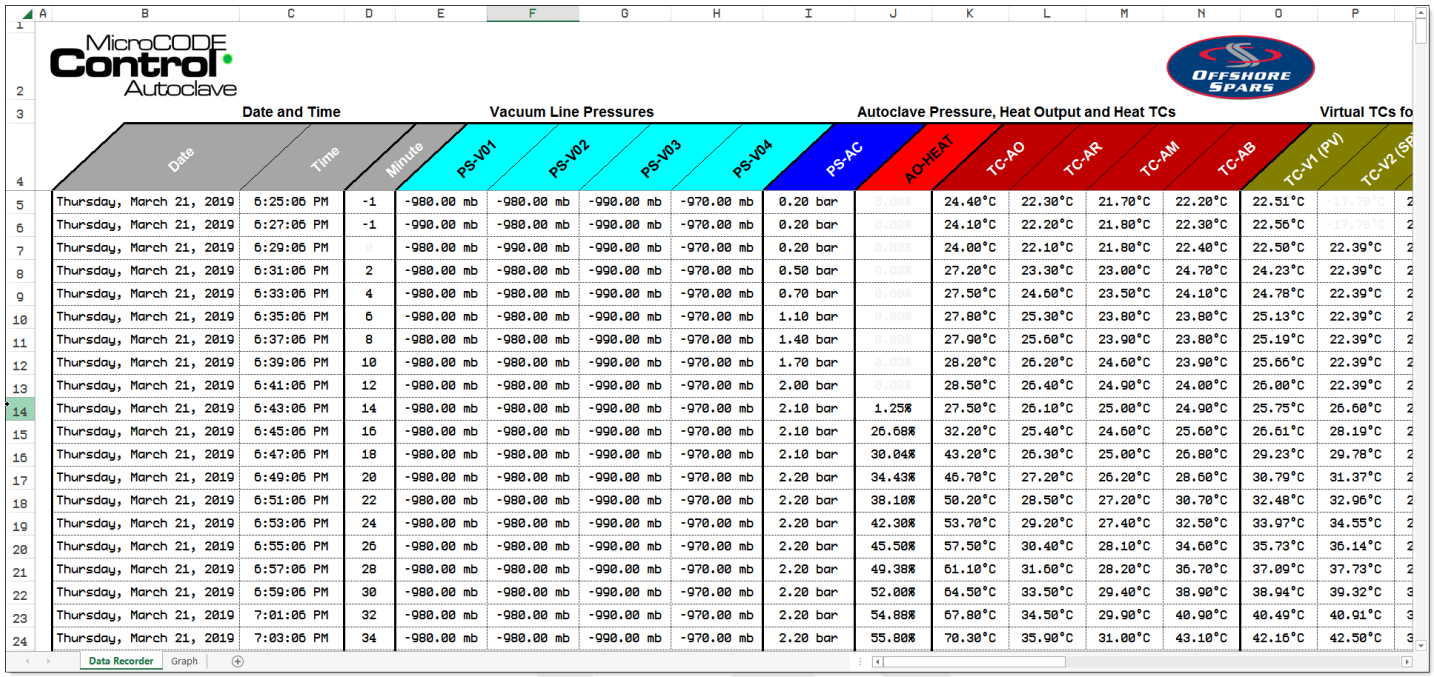


STEP	HEAT	Minutes	Target	°F/Min	Low -	High +	PRESSURE	Minutes	Target	PSI/Min	Low -	High +
1	WARM	22	125	n/a	1	2	FILL	22	21	1.0psi	3	2
2	RAMP	11	222	8.8°F	2	2	HOLD	11	21	n/a	4	2
3	SOAK	120	250	n/a	5	5	HOLD	120	21	n/a	5	2
4	RAMP	100	300	0.5°F	3	3	FILL	100	33	0.1psi	6	1
5	SOAK	250	325	n/a	4	4	HOLD	250	33	n/a	6	1
6	RAMP	12	375	4.2°F	5	5	HOLD	12	33	n/a	6	1
7	COOL	300	90	1.0°F	3	3	HOLD	300	33	n/a	6	1
8	COOL	15	70	1.3°F	4	4	DUMP	15	0	2.2psi	0	0
9	NONE	0	0	n/a	0	0	NONE	0	0	n/a	0	0
10	NONE	0	0	n/a	0	0	NONE	0	0	n/a	0	0
11	NONE	0	0	n/a	0	0	NONE	0	0	n/a	0	0

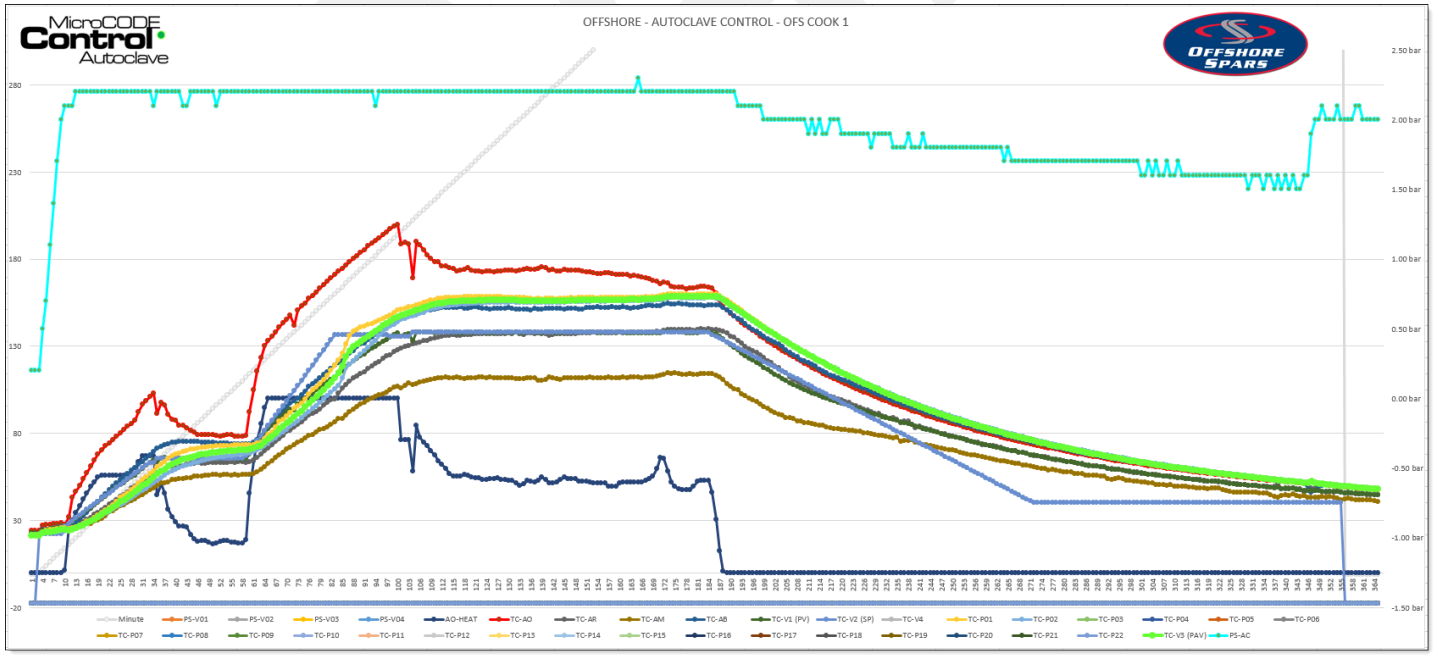


Data Recorder

All input and output control data are recorded by a user selectable frequency and is available as a standard CSV file for use in other applications like Excel for analysis.

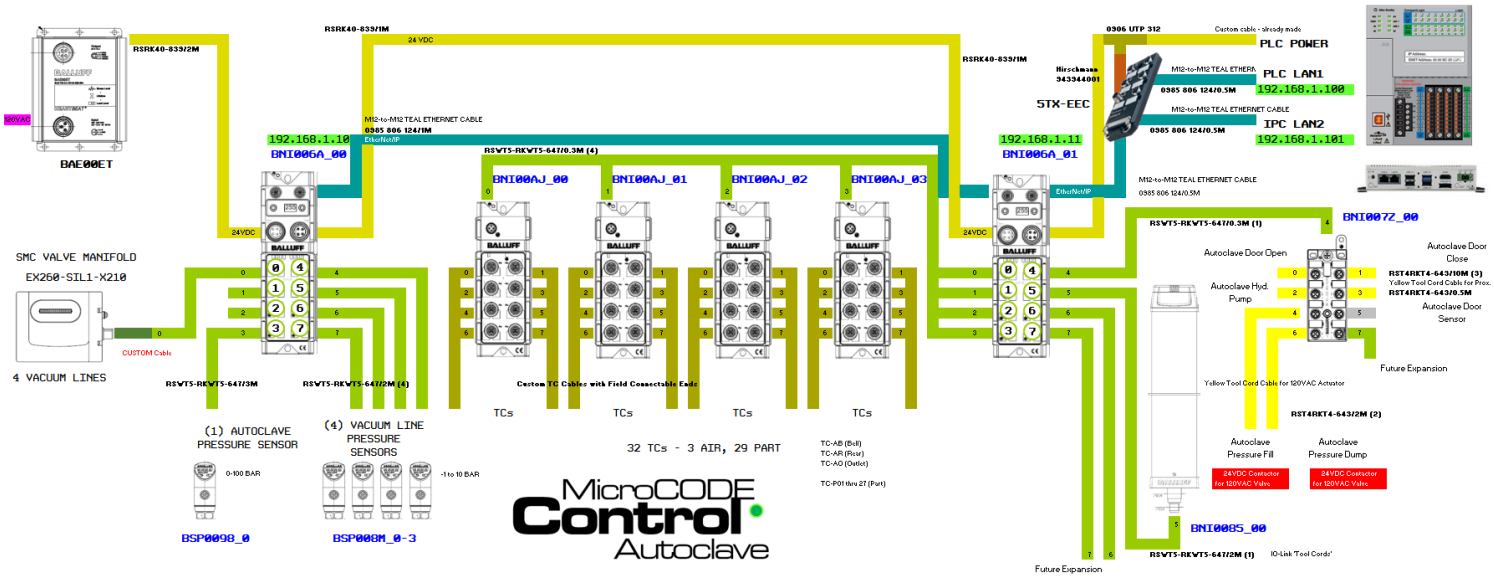


Date	Time	Minute	PS-V01	PS-V02	PS-V03	PS-V04	PS-AC	AO-HEAT	TC-AO	TC-AR	TC-AM	TC-AB	TC-V1 (PV)	TC-V2 (SP
			Date and Time			Vacuum Line Pressures			Autoclave Pressure, Heat Output and Heat TCs					Virtual TCs fo
Thursday, March 21, 2019	6:25:06 PM	-1	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	0.20 bar		24.40°C	22.30°C	21.70°C	22.20°C	22.51°C	
Thursday, March 21, 2019	6:27:06 PM	-1	-990.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	0.20 bar		24.10°C	22.20°C	21.80°C	22.30°C	22.56°C	
Thursday, March 21, 2019	6:29:06 PM		-980.00 mb	-990.00 mb	-990.00 mb	-970.00 mb	0.20 bar		24.00°C	22.10°C	21.80°C	22.40°C	22.50°C	22.39°C
Thursday, March 21, 2019	6:31:06 PM	2	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	0.50 bar		27.20°C	23.30°C	23.00°C	24.70°C	24.23°C	22.39°C
Thursday, March 21, 2019	6:33:06 PM	4	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	0.70 bar		27.50°C	24.50°C	23.50°C	24.10°C	24.78°C	22.39°C
Thursday, March 21, 2019	6:35:06 PM	6	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	1.10 bar		27.80°C	25.30°C	23.80°C	23.80°C	25.13°C	22.39°C
Thursday, March 21, 2019	6:37:06 PM	8	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	1.40 bar		27.90°C	25.60°C	23.90°C	23.80°C	25.19°C	22.39°C
Thursday, March 21, 2019	6:39:06 PM	10	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	1.70 bar		28.20°C	26.20°C	24.60°C	23.90°C	25.66°C	22.39°C
Thursday, March 21, 2019	6:41:06 PM	12	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.00 bar		28.50°C	26.40°C	24.90°C	24.00°C	26.00°C	22.39°C
Thursday, March 21, 2019	6:43:06 PM	14	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.10 bar	1.25%	27.50°C	26.10°C	25.00°C	24.90°C	25.75°C	26.60°C
Thursday, March 21, 2019	6:45:06 PM	16	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.10 bar	26.68%	32.20°C	25.40°C	24.60°C	25.60°C	26.61°C	28.19°C
Thursday, March 21, 2019	6:47:06 PM	18	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.10 bar	30.04%	43.20°C	26.30°C	25.00°C	26.80°C	29.23°C	29.78°C
Thursday, March 21, 2019	6:49:06 PM	20	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	34.43%	45.70°C	27.20°C	26.20°C	28.60°C	30.79°C	31.37°C
Thursday, March 21, 2019	6:51:06 PM	22	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	38.10%	50.20°C	28.50°C	27.20°C	30.70°C	32.48°C	32.96°C
Thursday, March 21, 2019	6:53:06 PM	24	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	42.30%	53.70°C	29.20°C	27.40°C	32.50°C	33.97°C	34.55°C
Thursday, March 21, 2019	6:55:06 PM	26	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	45.50%	57.50°C	30.40°C	28.10°C	34.60°C	35.73°C	36.14°C
Thursday, March 21, 2019	6:57:06 PM	28	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	49.38%	61.10°C	31.60°C	28.20°C	36.70°C	37.09°C	37.73°C
Thursday, March 21, 2019	6:59:06 PM	30	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	52.00%	64.50°C	33.50°C	29.40°C	38.90°C	38.94°C	39.32°C
Thursday, March 21, 2019	7:01:06 PM	32	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	54.88%	67.80°C	34.50°C	29.90°C	40.90°C	40.49°C	40.91°C
Thursday, March 21, 2019	7:03:06 PM	34	-980.00 mb	-980.00 mb	-990.00 mb	-970.00 mb	2.20 bar	55.80%	70.30°C	35.90°C	31.00°C	43.10°C	42.15°C	42.50°C



Hardware Layout

Overview of the hardware used by MicroCODE Control
for an Autoclave utilizing up to (28) Part Thermocouples.

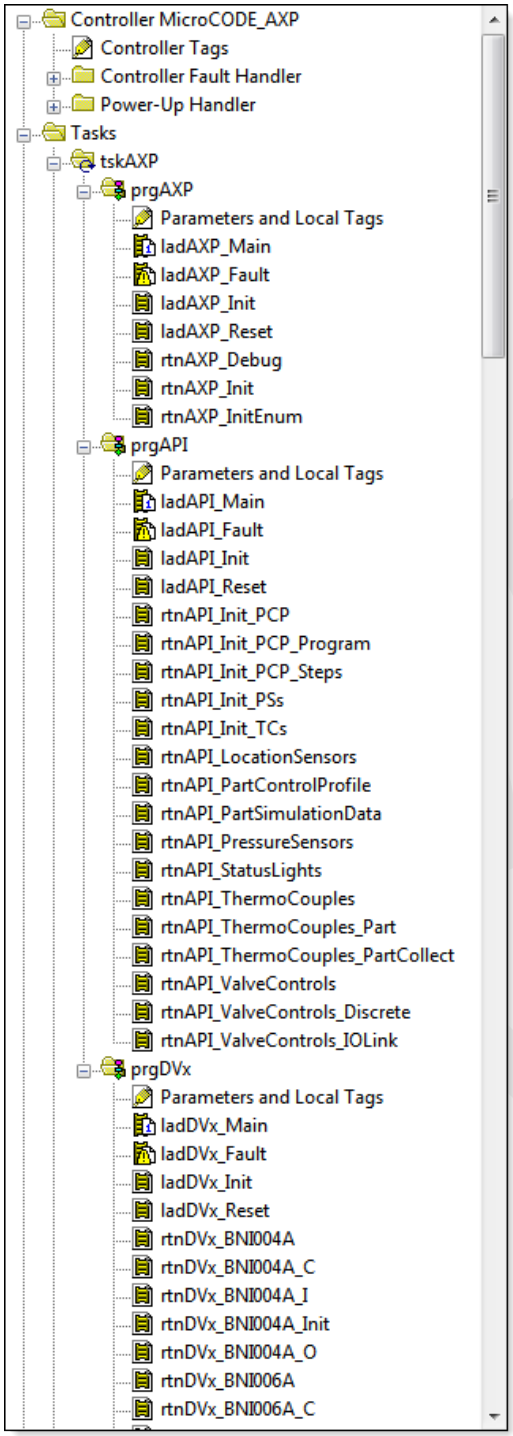


Features:

- **Supports up to (28) Thermocouples**
- **Hydraulic Door Controls**
- **Support up to (4) Vacuum Lines w/monitoring**
- **Support Autoclave Pressure Fill / Dump Valves**
- **Endless Data Recorder with CSV export**
- **Shop Annunciation of abnormal conditions**

ControlLogix IO-Link Support

The MicroCODE Application Program Interface (API) with the CompactLogix provide an industrial strength connection from the IPC C# App to the IO-Link hardware on the shop floor:



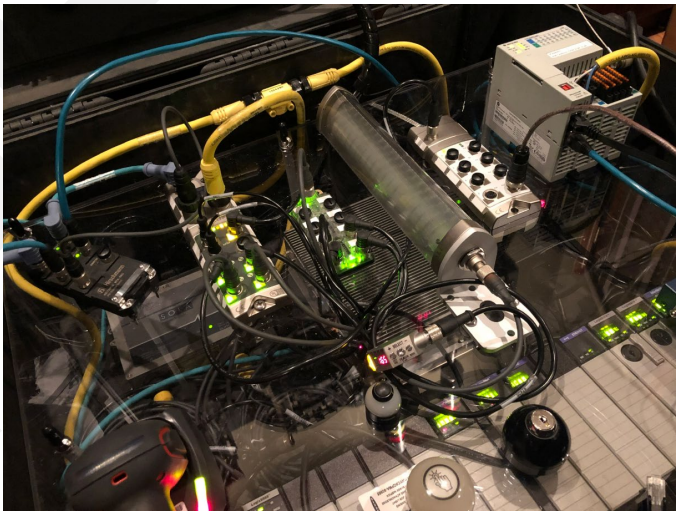
Control App Software Distribution Web Site

The MicroCODE Control App system is designed to be self-deployed by Plant personnel from a MicroCODE web site:

- Application **software** releases
- Application **documentation**
- **Video Training** for all aspects of the MicroCODE Control App Hardware and Software
- Application Support Notes
- Application Hot Fixes

MicroCODE Support Lab

The MicroCODE Control App is supported by a fully equipment—and portable—IO-Link Lab:



Control System Acronyms

All the software and documentation for this MicroCODE Control System utilize a small set of acronyms:

Control Application Level…

AC = **A**uto**c**lave

TC = **T**hermo**c**ouple

VC = **V**alve **C**ontrol

PS = **P**ressure **S**ensor

LS = **L**ocation **S**ensor

AO = **A**nalog **O**utput

SL = **S**tack/Status/Smart **L**ight

Hardware Level…

PLC = **P**rogrammable **L**ogic **C**ontroller

IPC = **I**ndustrial **P**ersonal **C**omputer

Industry Software Level…

IoT = **I**nternet **o**f **T**hings

IIoT = **I**ndustrial **I**nternet **o**f **T**hings

LTSB = **L**ong-**T**erm **S**ervicing **B**ranch

MicroCODE Control Software Level…

AXP = **A**pplication E**x**tension **P**LC

API = **A**pplication **P**rogram **I**nterface

DVx = **D**e**v**ice E**x**tensions

IMB = **I**O-Link **M**aster **B**lock
IOL = **I**/**O**-**L**ink
IOR = **I**/**O** **R**eceptacle

CFG = **C**on**fig**uration Data

CTL = **C**on**t**ro**l** Data

PCP = Part Control Profile – Ramp/Soak Profile

App Device Enumerations…

TC-AB = **T**hermo**c**ouple Autoclave **A**ir @**B**ell
TC-AM = **T**hermo**c**ouple Autoclave **A**ir @**M**iddle
TC-AR = **T**hermo**c**ouple Autoclave **A**ir @**R**ear
TC-AO = **T**hermo**c**ouple Autoclave **A**ir @Heat **O**utlet

TC-V1 = **T**hermo**c**ouple **V**irtual Temperature Blend #1
…
TC-Vn = **T**hermo**c**ouple **V**irtual Temperature Blend #nn

TC-P01 = **T**hermo**c**ouple **P**art Temperature #1
…
TC-Pnn = **T**hermo**c**ouple **P**art Temperature #nn

VC-V01 = **V**alve **C**ontrol for **V**acuum Line #1
…
VC-Vnn = **V**alve **C**ontrol for **V**acuum Line #nn

PS-V01 = **P**ressure **S**ensor for **V**acuum Line #1
…
PS-Vnn = **P**ressure **S**ensor for **V**acuum Line #nn

VC-A01 = **V**alve **C**ontrol for **A**C Pressure – Fill
VC-A02 = **V**alve **C**ontrol for **A**C Pressure – Dump

PS-A01 = **P**ressure **S**ensor for **A**C Pressure

VC-D01 = **V**alve **C**ontrol for AC Door – Power
VC-D02 = **V**alve **C**ontrol for AC Door – Open
VC-D03 = **V**alve **C**ontrol for AC Door – Close

LS-D01 = **L**ocation **S**ensor AC Door – Closed

AC-H01 = **A**nalog **C**ontrol for Autoclave **H**eat Control

Autoclave Control Objects…

AC-PART = Collection of Part Cure Profile (PCP) and all associated Thermocouples (TC-PXX)

AC-DOOR = Autoclave Door Control and Power Unit (VC-D01/D02/D03, PX-D01)

AC-VAC1 = Autoclave Vacuum #1 (VC-V01, PS-V01)
AC-VAC2 = Autoclave Vacuum #2 (VC-V02, PS-V02)
AC-VAC3 = Autoclave Vacuum #3 (VC-V03, PS-V03)
AC-VAC4 = Autoclave Vacuum #4 (VC-V04, PS-V04)

AC-PRES = Autoclave Pressure (VC-A01/A02, PS-A01)

AC-HEAT = Autoclave Heat Control (AC-H01: Heat Control, and TC-AO, TC-AR, TC-AB)

SL-A01 = **S**tack **L**ight for Autoclave #1

ALPHA 2 - 4

Corrected in Version v1.0.11 a (2)

The following defects were fixed in **MicroCODE Control (SEP)** in this Release:

1) Corrected Installation

Issue: The App install was not delivering the updated documentation correctly.

Correction: Now delivers files with the exact same version numbering as the App they accompany to remove cross referencing by the user.

New in Version v1.0.11 a (2)

The following features were added to **MicroCODE Control (SEP)** in this Release:

1) Standard Windows App Installation

Issue: The App need to be installed manually in prior Builds.

Correction: The App is now installed with a standard 'Microsoft Installer' package (.**msi**) file.

See the User Guide for complete information.

ALPHA 5

Corrected in Version v1.0.11 a (5)

The following defects were fixed in **MicroCODE Control (SEP)** in this Release:

1) Some PROFILE data is not described

Issue: The number of PROFILES and number of STEPS within a PROFILE were not obvious to users.

Correction: Tool Tips now describe each item.

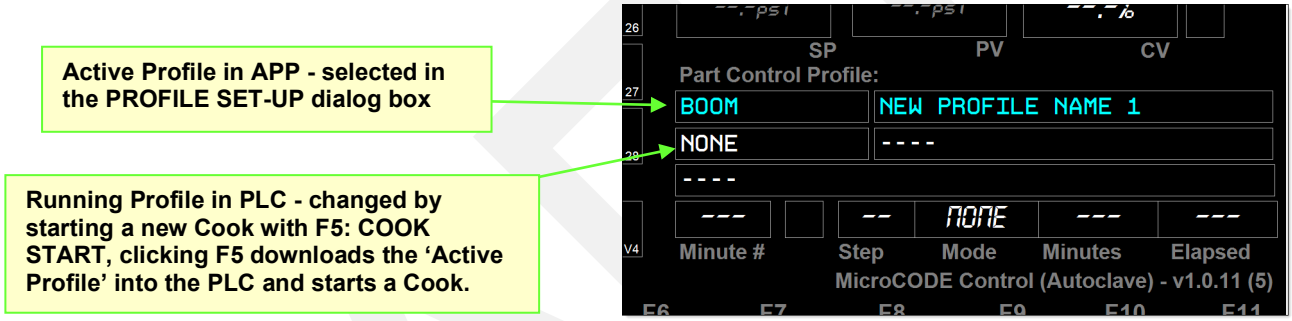
New in Version v1.0.11 a (5)

The following features were added to **MicroCODE Control (SEP)** in this Release:

1) The Active Profile in the App is now visible at all times

In prior versions only the PLC Profile was visible in the main application screen…

NEW DISPLAY:



Control App Software Version Numbers

The SEP/GEP CE application software version numbers follow this convention…

vM.m.R *c* (B)

M = Major software version; represents application architecture, underlying technology, etc. Incrementing this number is associated with a '**Major Release**'.

m = Minor software version; represents new components within the application. Incrementing this number is associated with a '**Component Support Release**'.

R = Incremental Release Number; represents collections of new features within the application. Incrementing this number is associated with a '**New Feature Release**'.

c = Development Cycle as in ALPHA/DEMO, BETA/PILOT, or PRODUCTION. In the case of PRODUCTION, the Cycle label is removed. Changing this label is associated with a '**Code Cycle Promotion**', i.e.: Internal Build Promotion. This is a rebuild/relabeling only no code is changed. e.g.: v2.0.0 Beta (017), vs. v2.0.0 (001).

B = Build Number. This is the internal build number of the application from within the development group; any time code is changed and released into the Support Staff this number must be incremented, no matter how small the change. Incrementing this number is associated with a '**Defect Correction Release**'.

Current MicroCODE Control App Version

This is the highest currently released version of the MicroCODE Control application:

V1.0.11 a (5)
Alpha

For More Information

See the Control App System documentation on the software distribution **MicroCODE** Site:

Version Compatibility Matrix

This table explains which PLC Code releases are compatible with specific releases of the MicroCODE Control App CE Actions application.

Version	MicroCODE Control CE App – Build Matrix			
System	Win 10 OS	.NET	C# App	PLC + FW
v1.0.11	2016 LTSB	2.0 to 4.0	v1.0.0	v1.0.0 v24.11

This **application** was designed and developed by:

MICROCODE INC