Instruction Manual
Model 1602
Rolling Ball Viscometer

Revision K – February 2014
Part Number 1602-1D01

S/N _____

CHANDLER ENGINEERING®

AMETEK®

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General Information

Warning: Pressurized vessels and associated equipment are potentially dangerous. The apparatus described in this manual should be operated only by personnel trained in procedures that will assure safety to themselves, to innocent spectators, and to the equipment.

Use this instrument only in a well-ventilated room. Improper use with hydrogen sulfide or other hazardous fluids may result in personal injury or death from breaks, leaks or explosions. Keep oxygen close by and take all the safety precautions as described in this operating manual.

Introduction

Chandler Engineering's high pressure viscometer is a manual, time-measuring, instrument that operates on the principle of the measurement of time required for a rolling ball, affected by shear and pressure of the fluid, to travel a pre-determined distance at controlled conditions. It employs a rolling nickel ball for determining the dynamic viscosity of liquid-phase samples at constant temperatures and pressures. The ball is positioned inside the measuring barrel with the test fluid sample so that it is limited to only rolling type motion. An electronic timer records the time required for the ball to roll through the barrel.

The Chandler Engineering high pressure Rolling Ball Viscometer is a precision instrument used to determine the viscosity of bottom-hole and surface samples of reservoir oils at elevated temperatures and pressures to 10,000 psi at 300°F. Accurate and reproducible engineering data is obtainable, whether the specific application is to determine the viscosity of petroleum fluids at simulated reservoir conditions, or liquid phase viscosities at other predetermined pressures and temperatures. The samples measured must be electrically non-conductive.

The viscometer operates on a rolling-ball principle where the roll-time of a ¼-inch-diameter ball is used to obtain viscosity data. Viscosity values are then obtained by correlation of the measured data with curves of fluids with known viscosities and densities.

Description

The viscometer consists of the mechanical test assembly (Drawing #1602-717) and control unit with clock (Drawing #1609-0017).

The Viscometer Cell Assembly (Drawing #1602-1) consists of a measuring barrel (Item #13) inside a heavy wall stainless steel pressure housing (Item #1). This barrel has a finely honed and lapped cylindrical bore in which a ¼-inch nickel ball rolls. A plug, containing the solenoid (Item #12), closes the housing on its upper end. A plug containing the bottom contact (Item #10) closes the lower end. The housing is equipped with electric heating elements (Item #2) clamped onto the pressure vessel (Item #1). Two high pressure valves (Item #16) protrude from the housing through the jacket to connect the equipment. The inlet and outlet openings in the housing are at the extreme top and bottom of the cavity when it is in the operating position.

The test assembly (Drawing #1602-717) consists of the instrument base (Item #1) with two "A" frames supporting the Viscometer Cell Assembly (Drawing #1602-1) so that it can be tilted in different positions. The base is equipped with leveling screws and a reference level vial.

The control unit with instrument panel (Drawing #1602-0017), contains all the necessary electrical equipment for operation. A lead from the unit connects to the appropriate power source for the supply of current. The test assembly and control unit are interconnected with multi-conductor cables having polarized plug-in connectors and receptacles. Two signal lights (Item #6); **Top** (lit when the ball makes contact at the top of the barrel) and **Bottom** (lit when the ball makes contact at the bottom of the barrel) indicate the different phases of the operating cycle. The **Power** switch (Item #7) controls the line current; the **Alarm** switch (Item #11) enables the audible alarm (Item #5); the **Timer Enable** switch (Item #36) enables the **Timer** and Position Sensing Circuit (Top / Bottom lights and Drop switch); and the **Drop** switch (Item #12) operates the solenoid.

Features and Benefits

The measuring system consists of two main units: (1) the mechanical test assembly and (2) the auxiliary control unit with solid-state electronic circuitry. The following standard features are characteristic of the viscometer system:

- Digital time clock for measurements of falling (rolling) time of ball.
- Electric heating jacket control system for making measurements at accurately controlled temperatures. This eliminates the need for circulating hot water through coils or submerging the test assembly in a tank of hot oil or water. Operation of the instrument is therefore more efficient and safe.
- Leveling screws and vial are mounted on the base of the instrument for leveling the test assembly.

- A novel design is the utilization of a solenoid to hold the nickel ball at the top of the test assembly measuring barrel. The ball will not fall or roll through the fluid sample until the solenoid current is activated. Therefore, the human element in timing the ball roll-time is eliminated. The breaking of the electrical contact made when the ball is at the start of its travel starts the Timer and the contact made when the ball reaches the end of its travel stops the Timer.

In general, the instrument is most suitable for laboratory study of single-phase reservoir fluids (and of the liquid phase of a two-phase fluid) where high levels of repeatability are required. The samples measured must be electrically non-conductive.

Storage

The viscometer and test assembly should be stored, when not in service, at room temperature. It is not an instrument for field service and should never be exposed over any extended periods of time to outdoor environments other than that required for transporting the instrument. Areas designated for storing the instrument should be kept dry, particularly where the control box and electrical components are maintained.

Specifications

Maximum Working Pressure:	10,000 PSI
Proof Pressure:	15,000 PSI
Maximum Working Temperature:	300°F (150°C)
Power Requirement:	115V/2 amps, 230V/1 amp, single-phase, 50/60 Hz.
Warm-Up Time:	1 to 2 hours after operating, temperature has been set.
Fluid Capacity:	a) test chamber: 20cc b) gas chamber: 50cc
Roll Angles:	23°, 45° & 70°

Safety Requirements

- Operator SHOULD avoid contact with the bare surface of the test assembly jacket when in operation.
- The instrument control box SHOULD NOT at any time be opened during operation. An unskilled person SHOULD NOT troubleshoot potentially dangerous equipment.
- Safety SHOULD NOT be assumed. The operator must keep in mind, even the most sophisticated instrument cannot think; (a) insulators do not always insulate, (b) conductors do not always conduct properly, (c) resistors do not always dissipate the required heat. For these reasons, the operator should carefully follow the outlined instructions of this manual and consult the manufacturer when specific questions arise.

CAUTION: Exposure to H_2S is potentially fatal. Use adequate safety procedures when handling H_2S samples. Consult your safety department for proper procedures for handling H_2S.

Laboratory monitoring units are available from a number of suppliers. A few are listed below:

General Monitors
Costa Mesa, CA 92626
(714) 540-4895

Delphian Corporation
Northvale, NJ 07647-1977
(201) 767-7300

National Draeger Inc.
P.O. Box 120-T
Pittsburgh, PA 15230
(412) 787-8383

Gemini Detectors, Inc.
Houston, TX 77058
(713) 488-1541

Section 1 - Installation

Unpacking the Instrument

Note: Verify all parts listed on the packing slip have been shipped with the instrument. If parts are missing, contact Chandler Engineering.

The viscometer base plate and A-frame should first be removed from the shipping crate, and assembled. A check to make sure the leveling vial is in working condition is advisable at this time. It is suggested the box and packing material be retained for future use.

Section 2 - Operation

Basic Principle

In the rolling-ball viscometer, the time it takes a metal ball to roll from one end of a fluid-filled tube to the other is an indication of the viscosity for the fluid. Mathematically this is expressed as:

$$\mu = \frac{(\rho_B - \rho_F) g R^2 \sin\theta}{v_\infty}$$

Where,

μ	=	Dynamic Viscosity
ρ_B	=	Density of the ball
ρ_F	=	Density of the fluid
g	=	Acceleration due to gravity
R	=	Diameter of the ball
θ	=	Angle of the measuring barrel
v_∞	=	Velocity normal to the Earth in the down direction Defined as distance over time (d / t)

For a given set of tests, the distance variable of the velocity term, along with g, R and θ, remain constant. Therefore, the above equation can be conveniently expressed as follows:

$$\mu = K\, t\ \ (\rho_B - \rho_F)$$

Where K is a constant unique to the set of tests.

From the above equation it can be seen that for a constant ball and fluid density ($\rho_B - \rho_F$), the viscosity (μ) is directly proportional to the ball roll-time (t). Effectively, the ball is forced down the tube due to gravitational effects at a rate dependent upon the fluid viscosity and the difference between the density of the ball and that of the fluid. Any increase in fluid density reduces the effect of gravity acting on the ball. The ball will correspondingly fall more slowly (an increase of the t term), and indicates a higher viscosity value. Conversely, as the density term diminishes to zero, the viscosity value also approaches zero.

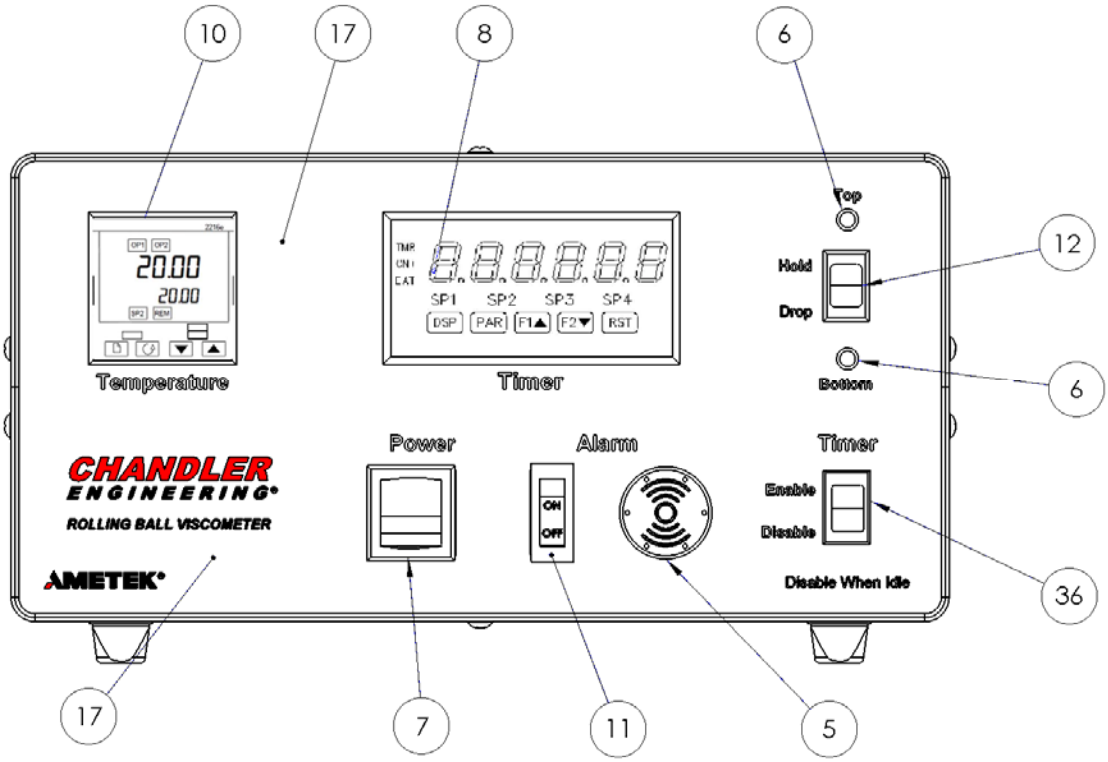


Figure 1 - FRONT PANEL

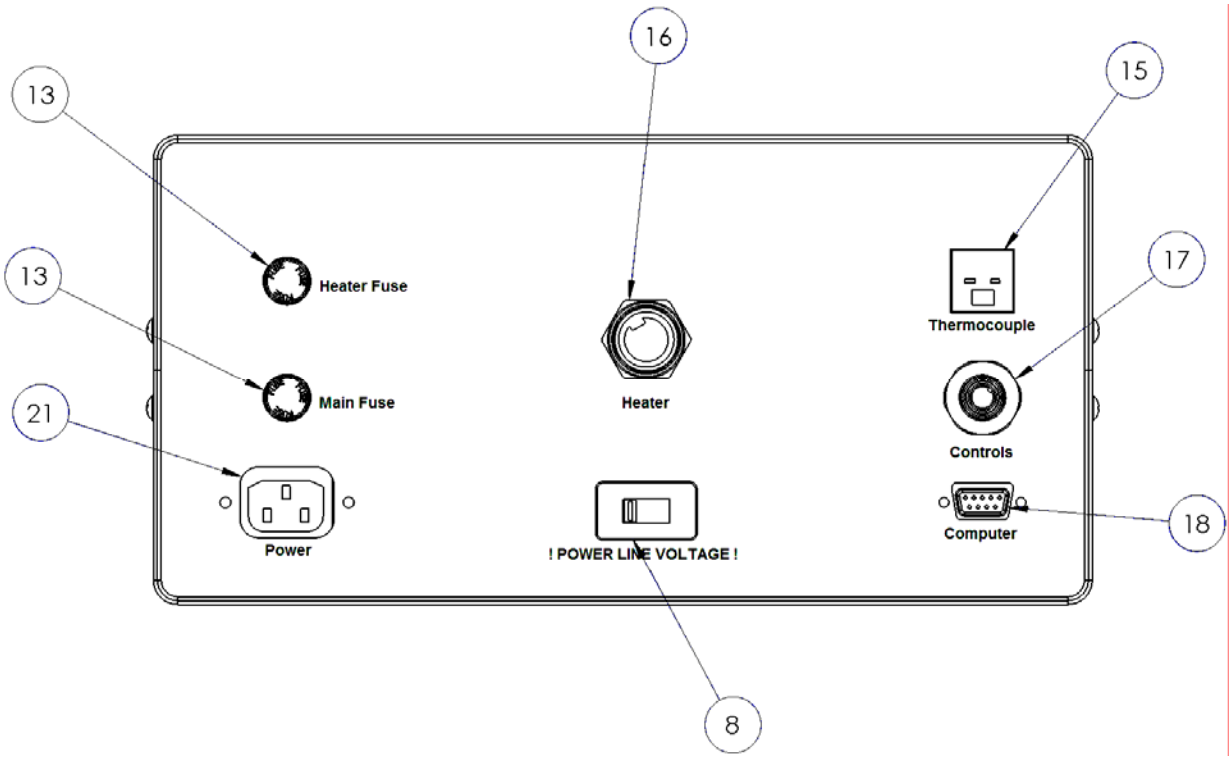


Figure 2 - REAR PANEL

Component Function & Location

Front Panel (See Figure 1)

Item	Description	Function
10	Temperature	PID Temperature Controller. Used to control the temperature of the test assembly. Also displays the current temperature of the test assembly.
8	Timer	Elapsed Timer. Numerically displays roll-time in seconds.
6	Top (indicator)	Illuminates when the ball makes contact at the top of the measuring barrel.
6	Bottom (indicator)	Illuminates when the ball makes contact at the end of the measuring barrel. This signal will stop the Timer.
12	Drop (rocker switch)	Used to apply power to the coil.
36	Timer Enable (rocker switch)	Enables the Timer and Position Sensing Circuit.
11	Alarm (rocker switch)	Alarm Switch is used to enable / disable item #5.
5	Alarm	Provides the operator with an audible alarm when the ball has ended its roll through the barrel.
7	Power (rocker switch)	Main power switch; used to energize the system and test assembly.

Rear Panel (See Figure 2)

Item	Description	Function
13	Heater Fuse (Fuse Holder)	Contains the in-line fuse protecting the Heaters.
13	Main Fuse (Fuse Holder)	Contains the in-line fuse protecting the internal electronics.
16	Heater (4-pin Female Connector)	Junction for the connection of the heaters.
15	Thermocouple	Connector to the thermocouple used as a temperature sensor for the system.
17	Controls (5-pin Female Connector)	Junction for the system main control cable.
18	Computer (9-pin Male Connector)	Junction for configuration of Temperature Controller.
8	Power Line Voltage	Voltage selector switch; reconfigures the heaters to be in series (for 230V operation) or parallel (for 115V operation).
21	Power	Power inlet connector; also suppresses power line noise.

Test Assembly (See Drawing #1602-1)

Item	Description	Function
16	Valve	High pressure needle valve used to for Test Fluid Inlet / Outlet and to pressurize and evacuate the pressure housing.
12	Coil / Sensor Assy.	Portion on the solenoid and barrel valve that contains the coil windings. Provides the magnetic field required to hold and release the ball.
10	Lower Contact Assy.	Used as an automatic switching device for stopping the clock, illuminating the Bottom light and sounding the alarm when the ball has ended its roll through the measuring barrel.
13	Measuring Barrel	Used to contain the sample fluid and the measuring ball during operation.
2	Cylinder Heaters	Provides overall heat input for system.

Operation

1. Choose the correct ball size. This can be done by examining the sample fluid. If the fluid viscosity is estimated to be below 25 centipoise (above 25° API), a .252-inch or .248-inch diameter ball should be used. Above 25 centipoise (below 25° API), the .234-inch diameter ball will be appropriate. The balls are not interchangeable and must be kept separate.
2. Clean the test assembly. Since the barrel, ball and inner chamber must be completely free of dirt and lint, care should be taken to ensure a clean test assembly before undertaking any measurements. A light oil and thin paper should be used to clean the ball and chamber.
3. Place the ball into the empty measuring barrel while in a horizontal position. Slowly raise the barrel from horizontal and allow the ball to gently roll to the bottom. Do NOT allow the ball to free-fall through an empty measuring barrel as damage to the bottom contact point may occur.
4. Evacuate the test assembly. This is done by opening the vacuum pump valve at the upper end of the unit and closing the charging valve.
5. Charge the test sample fluid to the viscometer. The vacuum valve should be closed while the high pressure charging valve should now be opened.
6. Rock the test assembly to obtain a single-phase sample. A mixing device called the "Slip Ring Mixer" is installed to facilitate the effort. Effectively, the task is completed when pressure fluctuations of the sample have ended and consistent Roll Times are obtained. Particularly in the case of heavy fluids, a bubble trapped under the ball will sometimes hinder it from free-fall. The surface tension of the oil prevents the bubble from passing between the confines of the barrel and ball; the bubble thus reduces the weight of the ball and lengthens its roll-time or might prevent electrical contact entirely.
7. The **Power Line Voltage** switch must be set BEFORE turning on the main **Power** switch. Set the desired temperature on the temperature controller (this is done by pressing the Up and Down arrows). The **OP 1** light will flash to indicate the proper temperature cycling. During heating, it is very important that the **Timer Enable** switch be in the **Diable** position. It is also very important that the chamber be open to a pressure control system. Allow one hour after the temperature set point has been reached for the test unit and sample to reach thermal equilibrium. Once the desired temperature and pressure has stabilized, rock the test assembly several times to homogenize the sample and then close the charging valve.
8. Enable the Timer, Hold / Drop switch and Position Sensing Circuit with the **Timer Enable** toggle switch in the **Enable** position. Bring the ball into the **TOP** position at the upper end of the measuring barrel by rotating the receptacle arm handle (See Drawing #1602-717: Item #3). The handle should be rotated towards the upper end of the test unit until the 180° stop assembly engages with the stop lug mounted on the test unit. The **Top** indicator will illuminate when the ball has travelled through the length of the barrel and made contact with the Coil / Sensor Assembly. At this time, the appropriate resolution of

the timer may be determined. The Timer has a 6-digit display with a default resolution of 0.001 seconds; this setting yields a maximum test time of approximately 16 minutes and 40 seconds. If the ball takes longer than this to fall from the bottom to the top, adjust the resolution of the Timer (refer to manufacturers' manual for instructions).

9. The test unit is then returned to the operating position.
10. Zero the clock by pushing the **RST** button on the **Timer** (the clock will also automatically re-zero when the **Hold / Drop** switch is switched to the **Drop** position).
11. Release the ball by toggling the **Drop** switch to the **Drop** position. The **Timer** will start and the **Top** light will turn off. When the ball makes contact at the end of the roll, the **Timer** stops, the **Alarm** sounds and the **Bottom** light illuminates. Return the **Hold / Drop** switch to the **Hold** position.

Operating Tips

- The Rolling Ball Viscometer detects the position of the ball because the ball completes the circuit between each Contact Point and the Measuring Barrel. If the Sample Fluid is mildly conductive (for example, if water is present) a small amount of current can flow from the Contact Point through the Sample Fluid to the Measuring Barrel. This current can cause corrosion to occur on the Contact Point. The **Timer Enable** switch removes this electrical potential from the Test Assembly. The **Timer Enable** switch should be in the **Disable** position while the unit is heating or is otherwise idle (for example, when the unit is left on overnight).

- When the **Timer Enable** switch is in the **Disable** position, the ball will still fall if the **Hold / Drop** switch is moved to the **Drop** position; however, the **Timer** will not start. Likewise, the **Top** and **Bottom** indicators will not change when the ball arrives at each end of the Test Assembly. If an indicator is on when the **Timer** is disabled, the indicator will stay on.

- The ball is held at the Top by a permanent magnet in the Coil Assembly. When the **Hold / Drop** switch is in the **Drop** position, the solenoid in the Coil Assembly is activated. This pulls the permanent magnet away from the ball and the ball falls. The permanent magnet must be held away from the ball for a sufficient amount of time such that the falling ball is not hindered by the magnet returning to the Hold position. Chandler Engineering recommends that the **Hold / Drop** switch be in the **Drop** position for the entire Fall time. However, the Coil Assembly does produce heat when active and this can affect the viscosity of the sample (especially at lower temperatures).

Calibration

As stated previously, operation of the Chandler Engineering Rolling Ball Viscometer is based on the following equation:

$$\mu = K\, t\ (\rho_B - \rho_F)$$

Where,

μ	=	Dynamic Viscosity
K	=	Calibration Constant
t	=	Roll Time
ρ_B	=	Density of the Ball
ρ_F	=	Density of the Fluid

The Calibration Constant (K) is dependent upon the size of the ball, the angle of the measuring barrel and the vertical distance travelled. Therefore, everything else being equal, the value of K varies with each ball and roll angle. A calibration should be conducted for each individual ball used at each measuring angle.

Chandler Engineering recommends an annual "spot check" of the Calibration Constant for each ball used, at each angle and at least three (3) temperatures. A simple "spot check" procedure would be to measure the viscosity of a Viscosity Standard. A full calibration should also be performed if any critical component (the ball, Measuring Barrel, Coil Assembly, Lower Contact Assembly, control cable or Control Box) is replaced.

Calibration Procedure

One or more Viscosity Standards (fluids of known density and viscosity at test temperatures) should be used. A roll-time mean is taken from at least five consecutive and consistent readings at each desired Roll Angle. All calibrating tests are done at atmospheric pressure unless a different pressure is indicated with the data sheet from the Viscosity Standard.

1. Choose the correct ball size. If the viscosity of the Viscosity Standard is below 25 centipoise (above 25° API), a .252- or .248-inch diameter ball should be used. Above 25 centipoise (below 25° API), the .234-inch diameter ball will be appropriate. The balls are not interchangeable and must be kept separate.
2. Check and record the diameter and density of the selected ball.
3. Select a Test Temperature. For best results, a temperature listed on the Calibration Report provided with the Viscosity Standard should be used.
4. Clean the test assembly. Since the barrel, ball and inner chamber must be completely free of dirt and lint, care should be taken to ensure a clean test assembly before undertaking any measurements. A light oil and thin paper should be used to clean the ball and chamber.
5. Place the ball into the empty measuring barrel while in a horizontal position. Slowly raise the barrel from horizontal and allow the ball to gently roll to the bottom. Do NOT allow

the ball to free-fall through an empty measuring barrel as damage to the bottom contact point may occur.

6. Fill the viscometer with the Viscosity Standard. Rock the test assembly to obtain a single-phase sample.
7. Set the temperature controller to the desired test temperature. Allow one hour after the set point has been reached to allow the temperature to balance throughout the unit.
8. Run several roll tests until at least five (5) consecutive and consistent roll times are obtained at each measuring angle: 70°, 45°, and 23°.
9. Repeat steps 7 and 8 above for each desired test temperature.
10. Select as many different Viscosity Standards as required and repeat the above procedure.
11. Compute the mean roll time for each set of roll times (i.e. for each combination of ball, measuring angle, Viscosity Standard and temperature).
12. Divide the known viscosity of the Viscosity Standard by the product of the mean roll time and the difference in density of the selected ball and that of the Viscosity Standard; this is the Calibration Constant. Tables similar to the one below may facilitate this process.

Test Temperature	**°F**
Roll Angle (circle one)	**23° 45° 70°**
Density of Ball (ρ_B)	**g/cc**
Density of Fluid (ρ_F)	**g/cc**
$\Delta\rho$ ($\rho_B - \rho_F$)	**g/cc**
Viscosity of Standard at Temperature (μ)	**cP**
Mean Roll Time (t)	**s**
Calibration Constant K = μ / ($t \times \Delta\rho$)	

Section 3 - Maintenance

Protection of the Contact Point

Based on experimental observations, a sharp point on the contact assembly provides a better circuit continuity than any other form. Therefore, every effort should be made to protect the point from possible damages by the ball after normal duty cycles of the system. The ball should not be allowed to fall freely against the point in the absence of fluid in the test assembly. Although the contact point contains a hardened insert, repeated pounding by a freely falling ball will eventually peen the point flat.

A periodic examination, compatible with the user operating schedule, of the contact point under a suitable lens should be conducted. Similarly, the nickel ball should also be periodically checked for apparent damages.

Cleaning Test Assembly

The test assembly should be kept clean at all times. It should be cleaned before and after operation. Thin oil with a thin paper may be used for this purpose. The measuring barrel and body inner chamber must be thoroughly stroked with the cleaning agent, making sure that any sample fluid films are not left on the walls. Use of an in-line filter is also recommended to facilitate the overall effort.

Care of the Thermocouple

The expected accuracy in measuring the temperature of any object or space primarily depends upon how closely the measuring junction of the thermocouple can be brought to the temperature of the object or space. The greater the difference in temperature at steady conditions, the less accurate the temperature measurement will be. The viscometer thermocouple has been installed with adequate clamping devices such that faulty junction connections should not occur under normal use and handling of the assembly. However, submission of the thermocouple wires to tension beyond that required at the time of installation should be avoided, as this may cause a faulty connection between the junction and the body.

Thermocouple wires should always be electrically insulated along its length and maintained as dry as much as possible. Before attempting to change a thermocouple, it is suggested the user refer to the manufacturers instructions of this manual or consult with the supplier for specific details.

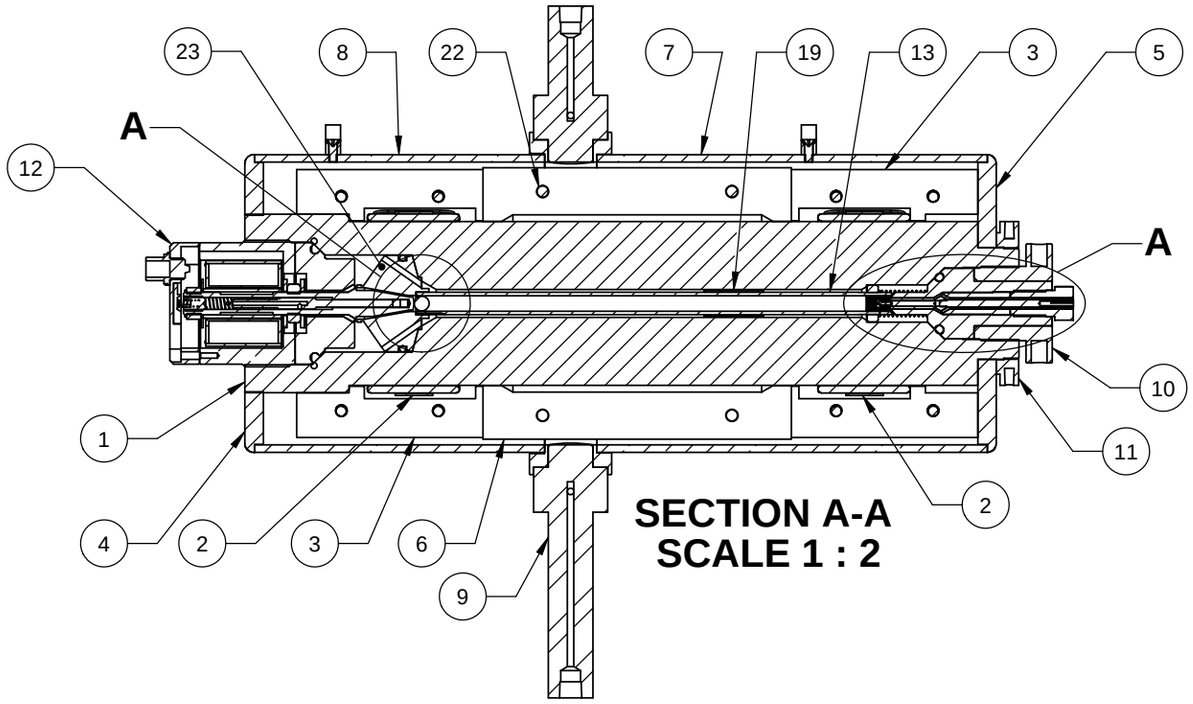
Section 4 – Replacement Parts

Part Number	Description
1600-1-25	Insulation, Upper Contact
1600-1-26	Insulation, Middle Contact
1600-1-33	Ring, Jacket Lock
1600-1-42	Spring Stop
1600-1-47	Spring, 180°F
1600-16-10	Spring, Barrel
1600-16-28	Nut, Contact Packing
1600-16-69	Mixer, Slip Ring
1600-18	Plunger Assembly
1600-21	Barrel Assembly
1600-22	Contact Point Holder
1600-79	Solenoid Assembly
1602-1-3	Cap
1602-1-4	Cover
1602-1-9	Heat Dissipater
2000-4	Angle Needle Valve Assembly
32-120	Heater, 300W, 120 VAC
32-121	Heater, 300W, 240 VAC
54-905-210	O-ring, Buna, 90D
54-905-223	O-ring, National, 90D

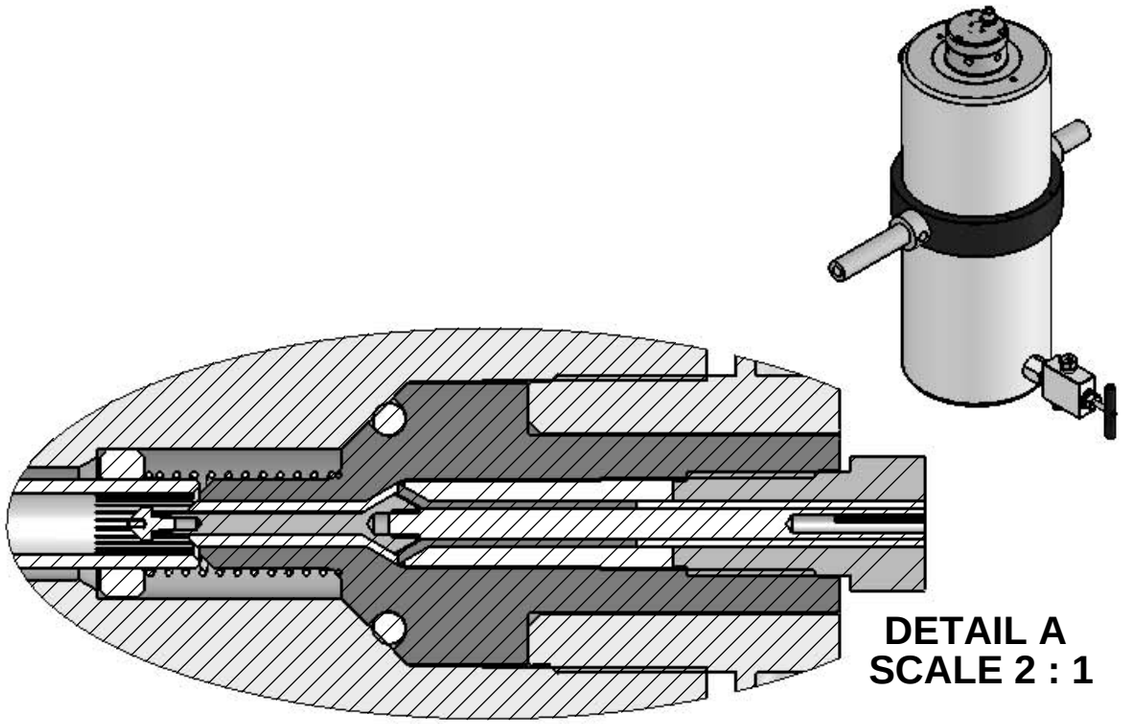
Section 5 - Drawings and Schematics

Drawing Number	Title
1602-1	Viscometer Cell Assembly
1602-0003P	Procedure, RBV- Eurotherm Controller Setup
1602-0004P	Procedure, Control Box Setup and Test
1602-0017	Control Box Assembly
1602-0020	Control Box Schematic
1602-0039	Coil/Sensor Assembly
1602-717	Mechanical Test Assembly
1602-830	Viscometer Test Assembly

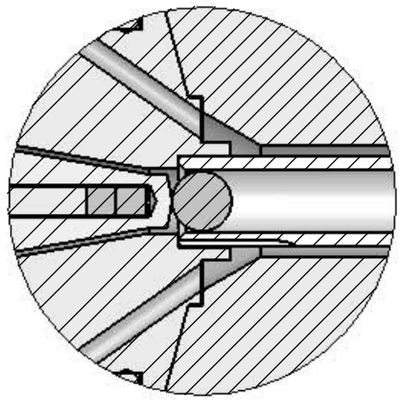
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	M	ECN T3276: IMPROVED DESIGN OF 1602-0050, REVERSED PORT LOCATIONS ON 1600-0020	9/2/2010	JJM
	N	ECN T4020: ITEM 15 WAS QTY. 2, ITEM 16 WAS QTY. 2, AND ADDED ITEM 26	7/28/11	DAH



SECTION A-A
SCALE 1 : 2



DETAIL A
SCALE 2 : 1



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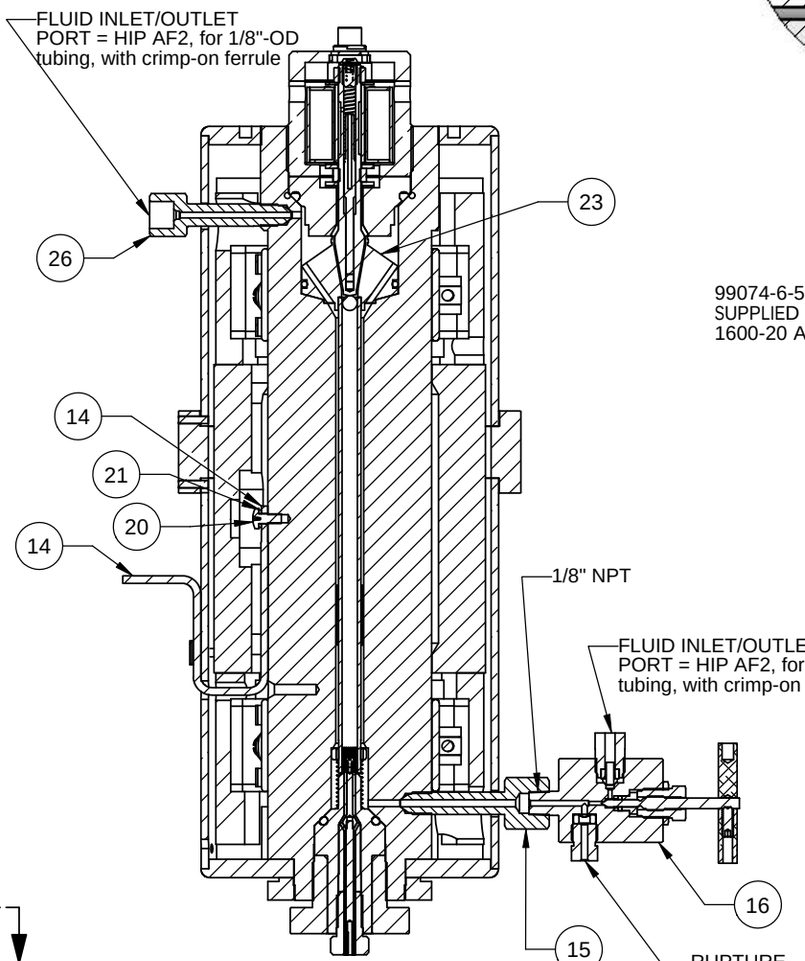

SECTION B-B
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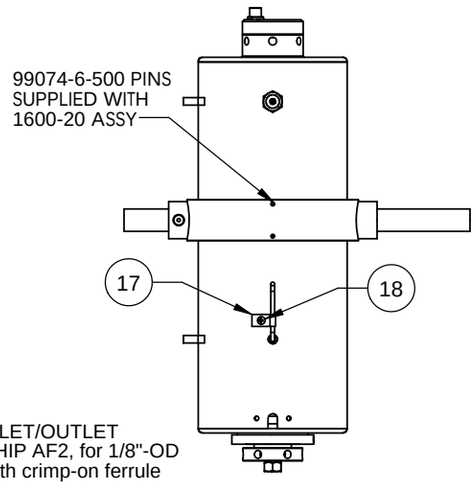
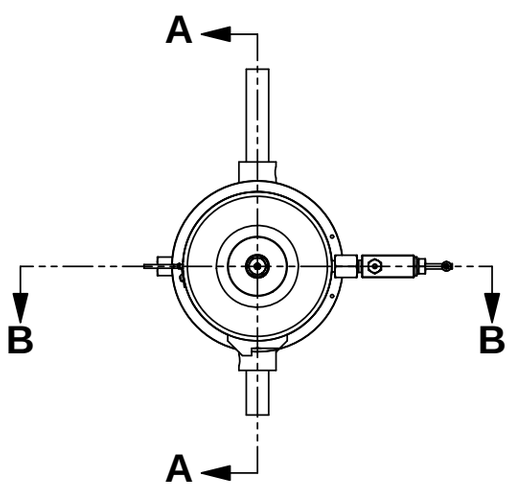




ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1602-16-1	BODY,CELL-HPV	1
2	32-120	HEATER,WATLOW 300W	2
3	1602-0034	INSULATING JACKET ASSEMBLY	2
4	1602-1-3	CAP - VISCOMETER	1
5	1602-1-4	COVER,BOT-VISCOSIMETER	1
6	1602-1-9	HEAT DISSIPATOR	1
7	1602-2	SOLDER ASSY, LONG	1
8	1602-4	HEATR,JKT,SLDR ASY,LG-HIPRVISC	1
9	1600-20	TRUNNION ASSY	1
10	1602-0032	LOWER CONTACT ASSY	1
11	1600-1-33	RING,JACKETLOCK - HI PRS VISC	1
12	1602-0039	COIL/SENSOR ASSEMBLY	1
13	1600-15	ASSY, BARREL	1
14	C12237	THERMOCOUPLE,K,BLT WSHR STYLE	1
15	1602-0023	COUPLING, HIGH PRESSURE	1
16	C13236	VALVE,ANGLE,RUP DISK,10KSI,SS	1
17	13-582	CLAMP,HALF,STL,1/8"DIA	1
18	70-128-501	RHMS 6-32 X 1/4 SS	1
19	1600-16-69	SLIP RING MIXER	1
20	H-8011	SCREW,BHMS,SS,8-32X0.375	1
21	H-8001	WASHER,LOCK,SS,#8	1
22	C10442	SCREW,SHCS,SS,10-24X1.500,AL	4
23	1602-0050	RETAINER, TUBE	1
25	C11258	.ORING,VITON,2-127-V75	1
26	1602-1203	ADAPTER,LONG,1/8AF2-3/16FLR,SS	1

-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			
.				.			
.				.			
1602-717				.			
NEXT ASSY				USED ON			
APPLICATION							
BREAK SHARP EDGES, DEBURR							

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH

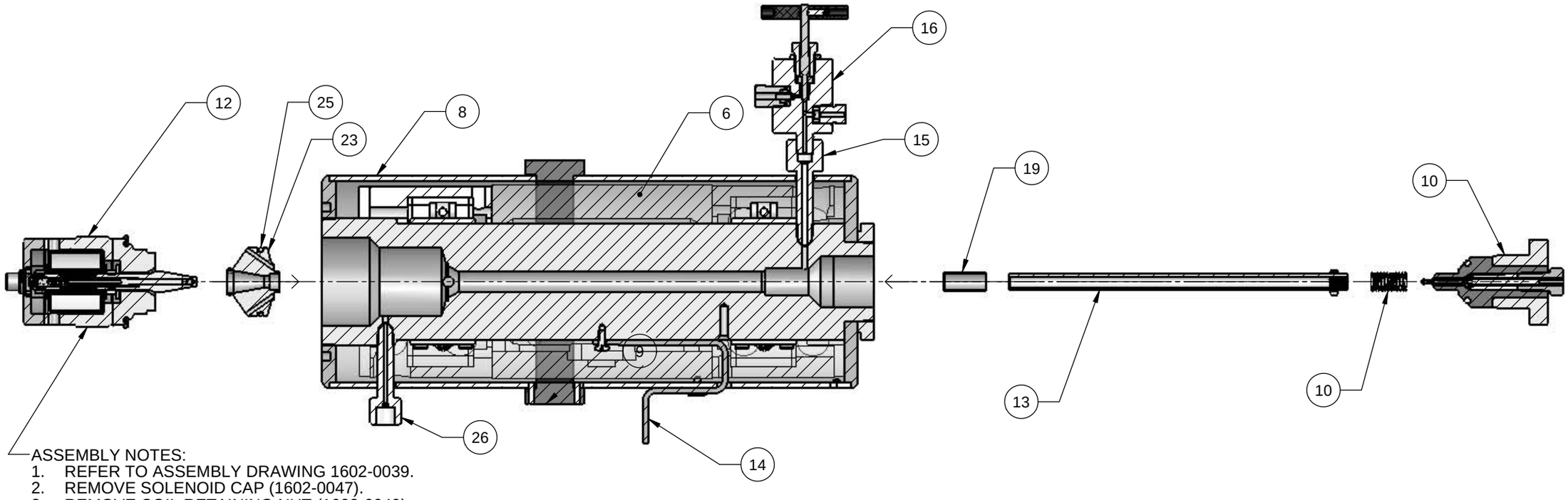
CHANDLER ENGINEERING

TITLE
CELL ASSEMBLY,RBV

APPROVALS		DATE
DRAWN:	TDM	8/1/08
CHECKED:	JJM	05/17/09
ENGR.:	JJM	05/17/09

SIZE	DWG NO.	REV.
C	1602-1	N

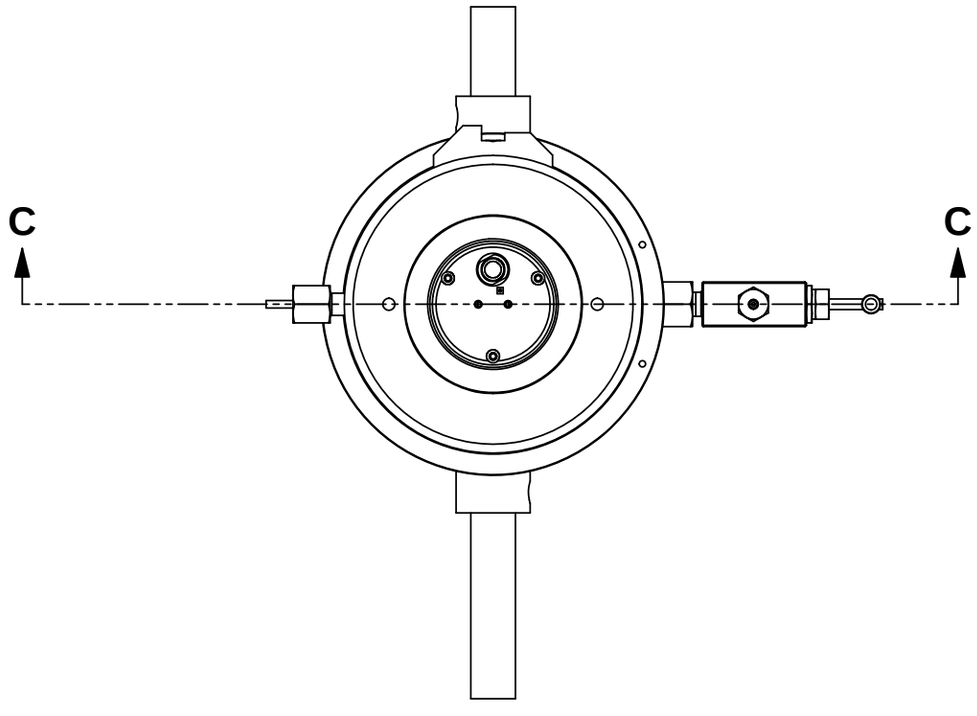
SCALE: 1:4 | TITLE BLOCK REV: 2.0 | SHEET: 1 of 2



ASSEMBLY NOTES:

1. REFER TO ASSEMBLY DRAWING 1602-0039.
2. REMOVE SOLENOID CAP (1602-0047).
3. REMOVE COIL RETAINING NUT (1602-0049), GROUND WIRE, WASHERS.
4. SLIDE SOLENOID COIL (C12910) OUT OF HOUSING.
5. REMOVE RETAINING NUT (1602-0042).
6. REMOVE UPPER PLUG (1602-0040).
7. TO REASSEMBLE, REVERSE THESE STEPS.

SECTION C-C
SCALE 1 : 2



							1
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			
.				.	UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES		
.				.	TOLERANCES:		
1602-717				.	1 PLACE ±0.030 2 PLACE ±0.010 3 PLACE ±0.005 ANGLES ±1/2° SURF. FINISH √		
NEXT ASSY				USED ON			
APPLICATION							
BREAK SHARP EDGES, DEBURR					APPROVALS	DATE	
					DRAWN: TDM	8/1/08	
					CHECKED: JJM	5/17/09	
					ENGR.: JJM	5/17/09	

CHANDLER ENGINEERING

TITLE

CELL ASSEMBLY,RBV

SIZE	DWG NO.	REV.
C	**1602-1**	**N**

SCALE: 1:4 | TITLE BLOCK REV: 2.0 | SHEET: 2 of 2

TITLE: Procedure, 1602 RBV Eurotherm Setup

Revision	Date	Revised By	Description	Checked By
F	5/10/10	BW	ECN T2959	AMH
G	6/1/2010	BW	ECN T3014	TC

PURPOSE: This document lists all of the parameters that are changed from the factory default on the Eurotherm Temperature controller used on the Model 1602 Rolling Ball Viscometer. This document also includes select pages from the Eurotherm Installation and Operation Handbook. These parameters can be loaded using the Eurotherm iTools program; Use the 1602-DegF_RevA file in the S:\DCI Test Lab\Controller Config Files folder.

The following parameters are set in the "Operation" Lists. See the attached Navigation Diagram and Parameter Tables or Chapter 1 "Operation" (pages 1-14 through 1-21) of the Eurotherm Installation and Operation Handbook.

HOME LIST: No Changes

ALARM LIST: No Changes

AUTOTUNE LIST: No Changes

PID LIST:

Display	Description	Units	Value
Pb	Proportional Band	as display	20 (°F) OR 11 (°C)
ti	Integral Time	seconds	840
td	Derivative Time	seconds	202

SETPOINT LIST:

Display	Description	Units	Value
SP1.L	Setpoint 1 low limit	As display range	32 (°F) OR 0 (°C)
SP1.H	Setpoint 1 high limit	As display range	300 (°F) OR 150 (°C)

INPUT LIST: No Changes

OUTPUT LIST:

Display	Description	Units	Value
OP.Hi	High (power) output limit	%	40

Communication List: No Changes

Access List: No Changes – used to enter different Access Levels (see below).

The following parameters are set in the "Configuration" Lists. See the attached Navigation Diagram and Parameter Tables or Chapter 5 "Configuration" (pages 5-4 through 5-13) of the Eurotherm Installation and Operation Handbook. For instructions on how to access these parameters, see attached (Selecting Configuration Level) or pages 5-2 and 5-3 of the Eurotherm Installation and Operation Handbook.

Instrument Configuration List:

Display	Description	Value
Unit	Instrument Units	°F or °C as desired

Input Configuration List:

Display	Description	Value
InPt	Input Type	k.tc
rnG.L	Input Range Low	32 (°F) OR 0 (°C)
rnG.H	Input Range High	350 (°F) OR 175 (°C)

TITLE: Procedure, 1602 RBV Eurotherm Setup

Revision	Date	Revised By	Description	Checked By
F	5/10/10	BW	ECN T2959	AMH
G	6/1/2010	BW	ECN T3014	TC

User Calibration Configuration List: No Changes

Alarms Configuration List: No Changes

Communications Configuration List:

Display	Description	Value
bAud	Baud Rate	19.2

Output 1 Configuration List:

Display	Description	Value
id	Identity of module installed	LoG
Func	Function	HEAt

Output 2 Configuration List: No Changes

Output 3 Configuration List: No Changes

Password Configuration List: No Changes

5.1 SELECTING CONFIGURATION LEVEL

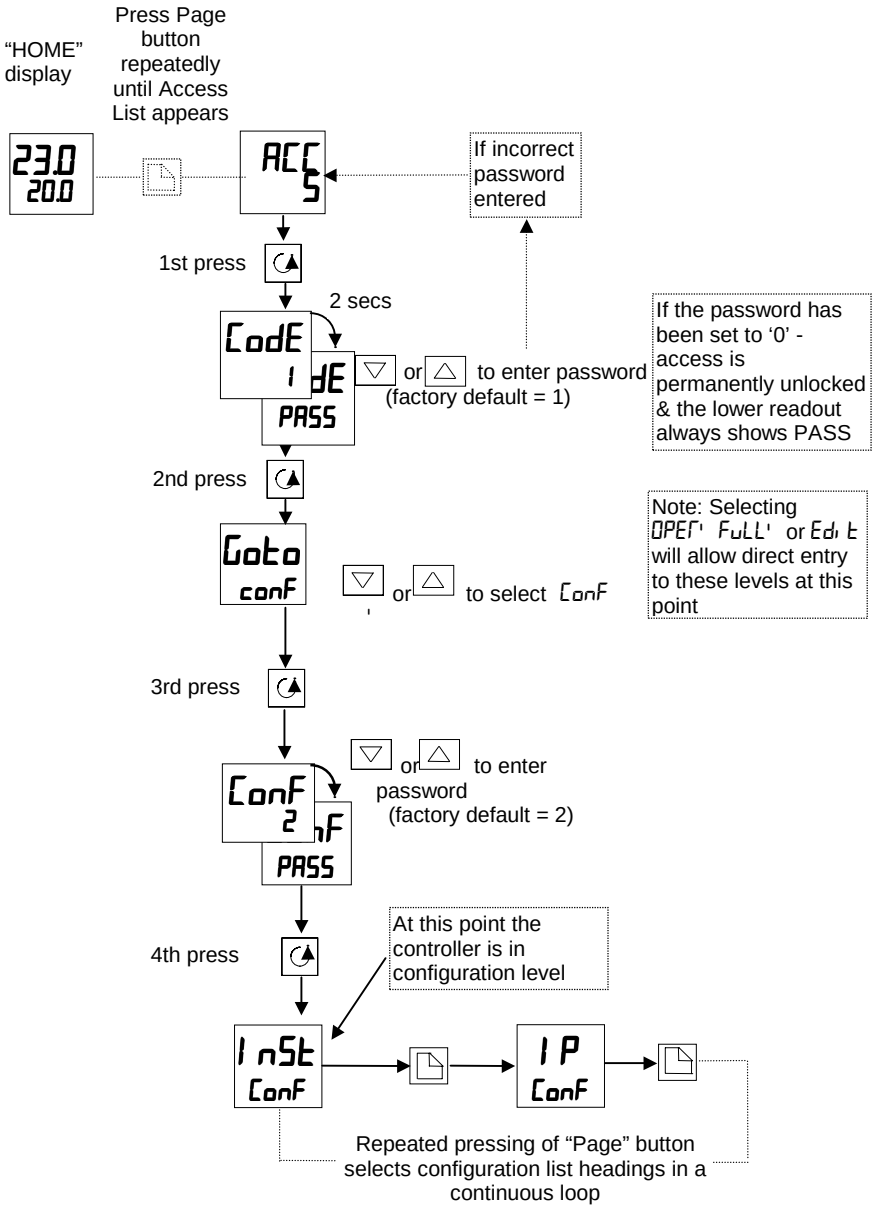


Figure 5.1

5.2 SELECTING A CONFIGURATION PARAMETER

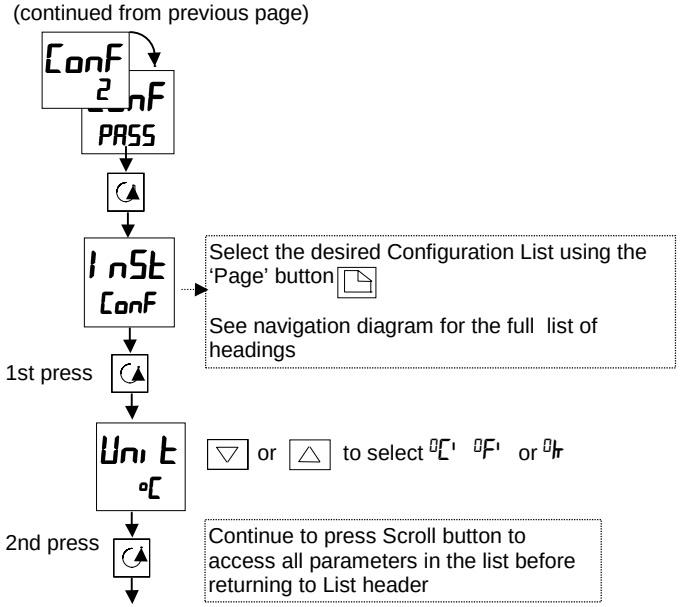


Figure 5.2

5.3 LEAVING CONFIGURATION LEVEL

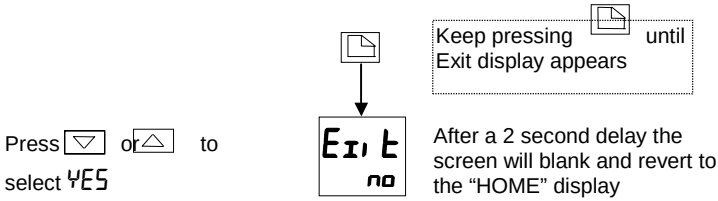
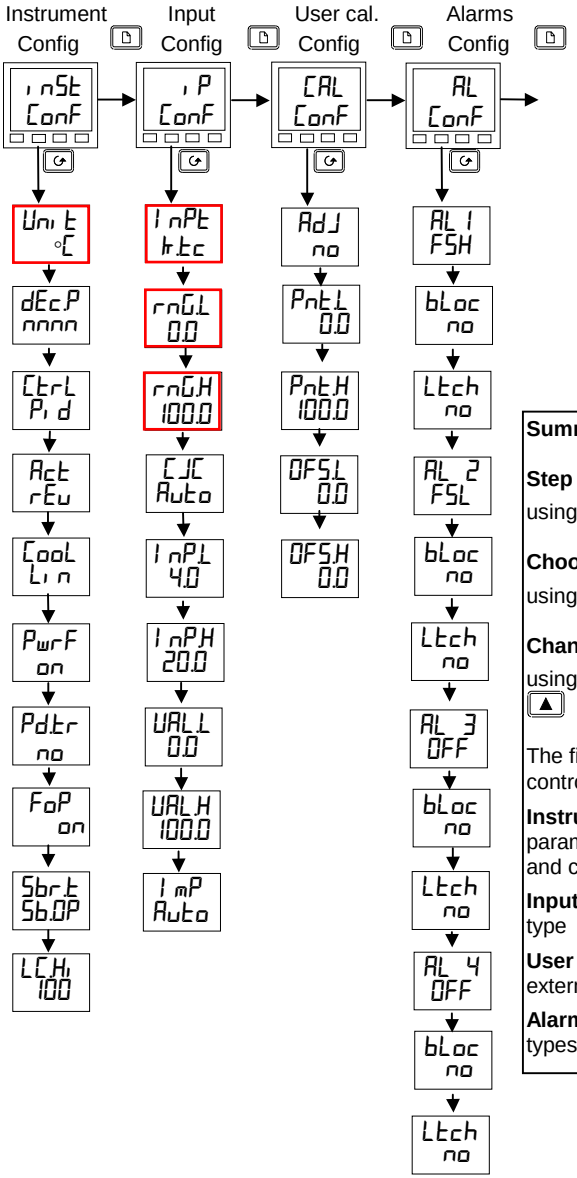


Figure 5.3

5.4 STEPS INVOLVED IN CONFIGURING A CONTROLLER

The navigation diagram which follows shows the general location of parameters which define the way in which the controller works. They are grouped under headings.
The actual parameters shown in your controller may differ slightly since some appear only as a result of selecting others. A full list of possibilities is included in the PARAMETER TABLES which follow the navigation diagram.

5.5 NAVIGATION DIAGRAM *(PART A)*



Summary

Step through List Headers
using the 'Page' button

Choose a parameter from a list
using the 'Scroll' button

Change value
using the 'Raise/Lower' buttons or

The first four headings set up the controller functions, as follows**:**

Instrument Config. - Groups those parameters associated with the display and control action.

Input Config. - selects the input sensor type

User cal. Config. - to calibrate to external reference sources

Alarms Config. - sets up the alarm types

Fig 5.4a Navigation Diagram (Part A)

5.6 NAVIGATION DIAGRAM *(PART B)*

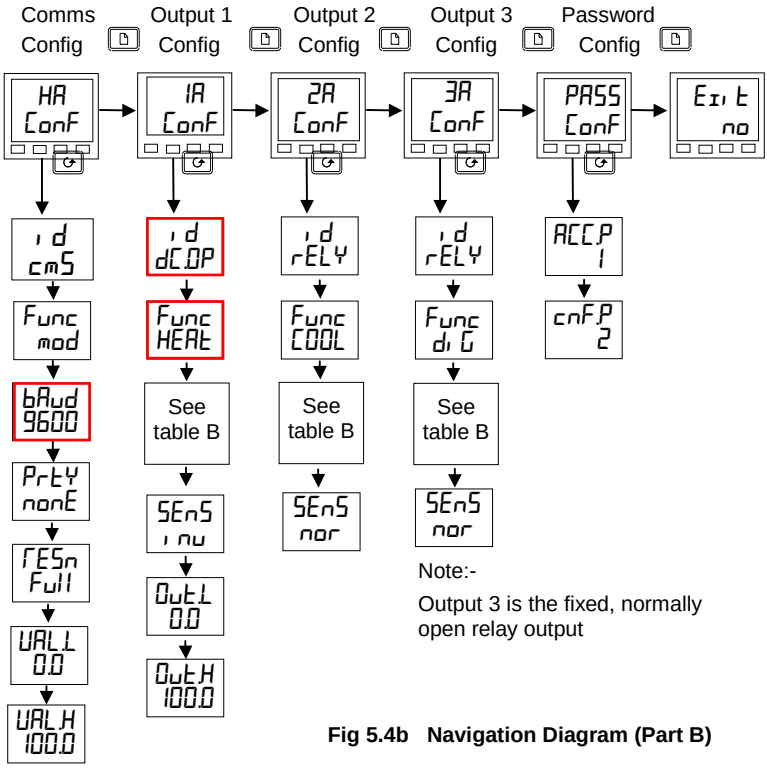


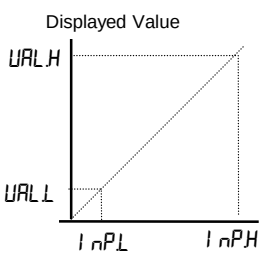
Fig 5.4b Navigation Diagram (Part B)

Heading	Input/Output Functions	Wiring Terminals
The first four headings set up the controller functions as follows:		
inSt conF	Sets up display and control parameters	Not applicable
iP conF	Selects the input sensor type	Not applicable
CAL conF	To calibrate to external reference sources	Not applicable
AL conF	Sets up the alarm types	Not applicable
The remaining headings configure the controller input/output functions. The upper readout corresponds to rear terminal numbers associated with a particular i/o		
HA conF	Sets up digital comms. type	HA to HF
1A conF	Sets up the output 1 module	1A & 1B
2A conF	Sets up the output 2 module	2A & 2B
3A conF	Sets up the action of the relay on output 4	3A to 3C
PASS conF	To choose new passwords	
Ei t conF	To leave configuration level and return to operator level	

5.7 CONFIGURATION PARAMETER TABLES

Name	Parameter description	Values	Meaning
inSt	**Instrument configuration**		
unit	Instrument units	°C	Centigrade (default UK)
		°F	Fahrenheit (default USA)
		°K	Kelvin
		nonE	Display units will be blanked
dECP	Decimal places in the displayed value	nnnn	None
		nnn.n	One
		nn.nn	Two
CtrL	Control type	On.OF	On/off control
		Pid	PID control
		UP	Valve position control unbounded
Act	Control action	rEu	Reverse acting (required for temperature control) - output decreases on approach to setpoint.
		dir	Direct acting
cooL	Type of cooling	Lin	Linear
		oil	Oil (50mS min on time)
		H2O	Water(non-linear)
		FAn	Fan (0.5S min on time)
PwrF	Power feedback	on	Power feedback is on (compensates for changes in supply voltage)
		OFF	Power feedback is off
Pdtr	Bumpless Manual/Auto transfer when using PD control	no	Non-bumpless transfer
		YES	Bumpless transfer (auto to manual and manual to auto)
FoP	Forced manual output	no	Non-bumpless transfer
		YES	Bumpless transfer (auto to manual and manual to auto)
Sbrt	Sensor break output	Sb.OP	Go to pre-set value (maintains output at a known, safe level)
		HoLd	Freeze output (maintains output at value immediately before break)
LCHi	Load current scaling factor	100	See Chapter 9

Factory default parameter values and states are included where applicable and are indicated by the shaded areas in the following tables.

Name	Parameter description	Value	Meaning
IP	**Input configuration**		
InPt	Input type	JtC	J thermocouple (default USA)
		ktC	K thermocouple (default UK)
		LtC	L thermocouple
		rtC	R thermocouple (Pt/Pt13%Rh)
		btC	B thermocouple (Pt30%Rh/Pt6%Rh)
		ntC	N thermocouple
		ttC	T thermocouple
		StC	S thermocouple (Pt/Pt10%Rh)
		PL2	PL 2 thermocouple
	NOTE:	rtd	100Ω platinum resistance thermometer.
	After selecting an input type, do not forget to adjust the setpoint limits in Full Access level	CtC	Custom downloaded input type. The default is C thermocouple, or the name of the downloaded custom input will be displayed.
		mV	Linear millivolt (Also mA input via an external 2.49Ω current sense resistor)
		uoLt	Linear voltage
rnGL	Input range low		Display low range for input
rnGH	Input range high		Display high range for input
CJC	CJC ref. temperature	Auto	Automatic cold junction compensation
	(CJC does not appear for linear inputs)	0°C	0°C external reference
		45°C	45°C external reference
		50°C	50°C external reference
Linear Input Scaling - *The next 4 parameters only appear if a linear input is chosen*			
InPL			Input value low
InPH			Input value high
VALL			Displayed reading low
VALH			Displayed reading high
Imp	Sensor break input impedance trip level	OFF	Sensor break detection is disabled *Appears for mV or V inputs only*
		Auto	Trip level set by the sensor input table
		Hi	Trip level set at 7.5KΩ
		Hi Hi	Trip level set at 15KΩ (must be selected when uoLt input is enabled)

Name	Parameter description	Value	Meaning
CAL	**User calbration config.**		**See Chapter 6 - User calibration**
AdJ	User cal enable	no	User calibration is disabled
		YES	User calibration is enabled
PntL	User calibration point low	0	This is the value (in display units) at which a User last performed a low point calibration
PntH	User calibration point high	100	This is the value (in display units) at which a User last performed a high point calibration
OFSL	Low point calibration offset	0	Offset, in display units, at the user low calibration point 'Pnt.L'. This value is automatically calculated when performing low point calibration.
OFSH	High point calibration offset	0	Offset, in display units, at the user high calibration point 'Pnt.H'. This value is automatically calculated when performing a high point calibration.

*If User calibration is enabled, then the User calibration parameters will appear in the Input list of Operator Full access level. See Chapter 6, *User calibration.*

Name	Parameter description	Values

AL	Alarm configuration	Values	Defaults if not specified
AL 1	Alarm 1 Type	As table A	OFF
bLoc	Alarm 1 Blocking(1)	no' YES	no
Ltch	Alarm 1 Latching	no/Auto/mAn/ Eut	no
AL2	Alarm 2 Type	As table A	OFF
bLoc	Alarm 2 Blocking(1)	no' YES	no
Ltch	Alarm 2 Latching	no/Auto/mAn/ Eut	no
AL3	Alarm 3 Type	As table A	OFF
bLoc	Alarm 3 Blocking(1)	no' YES	no
Ltch	Alarm 3 Latching	no/Auto/mAn/ Eut	no
AL4	Alarm 4 Type	As table A	OFF
bLoc	Alarm 4 Blocking(1)	no' YES	no
Ltch	Alarm 4 Latching	no/Auto/mAn/ Eut	no
Table A: Alarm types			
OFF	No alarm		
FSL	Full scale low		
FSH	Full scale high		
dEu	Deviation band		
dHi	Deviation high		
dLo	Deviation low		
Lcr	Low current		
Hcr	High current		

(1) Blocking allows the alarm to become active only after it has first entered a safe state.

These are 'soft' alarms ie. Indication only. They would normally be attached to an output. See Chapter 7 for a step by step guide.

HA	Comms module config	Functions	Meaning
id	Identity of the option installed	PdSi cmS	PDS setpoint input 2- or 4-wire EIA-485 (422) or EIA-232 comms module
Func	Function		
Some of the following parameters may appear if one of the comms options is installed			
		cmS nonE	DIGITAL Communication protocol ordered (ModBus, EIBisynch or DeviceNet) None
The following parameters will appear if the PDSIO setpoint input option is installed.			
		nonE SPiP	No PDS function PDS setpoint input
UALL	PDS low input value	Range = -999 to 9999	
UALH	PDS high input value	Range = -999 to 9999	
The following parameters will appear if id = cmS			
bAud	Baud Rate - ModBus	1200 (1), 2400, 4800, 9600, 19.20, 1920 (19200)	
bAud	Baud Rate - DeviceNet	125(K), 250(K), 500(K)	
PrtY (2)	Comms Parity	nonE EuEn Odd	No parity Even parity Odd parity
rESn (2)	Comms Resolution	FuLL Int	Full resolution Integer resolution

Note 1: 1200 baud rate not supported by EIBisynch
Note 2: Not used with some communication protocols. Please consult factory.

Name	Parameter description	Function	Meaning

1A	Output 1 configuration	Function	Meaning
io1d	Identity of module installed	none	No module fitted
		rELY	Relay output
		dC.OP	DC output (isolated)
		LoG	Logic or PDS output
		SSr	Triac output
Func	Function	none	
		di G	Function set by di GF
		HEAt	Heating output
		COOL	Cooling output
	Only appear for io1d = dC.OP	OP	Retransmission of output demand
	Only appear for io1d = dC.OP	PU	Retransmission of process value
	Only appear for io1d = dC.OP	Err	Retransmission of error
	Only appear for io1d = dC.OP	wSP	Retransmission of setpoint
	Only appear for io1d = LoG	SSr.1	PDS mode 1 heating
	Only appear for io1d = LoG	SSr.2	PDS mode 2 heating
For Function = di G go to table B on page 5-12			
SEnS	Sense of output	nor	Normal *(e.g. heating and cooling)*
		inu	Inverted *(alarms - de-energise in alarm)*
DC output scaling For io1d = dC.OP the following parameters appear			
OutL	DC output minimum		0mA to 'OutH'
OutH	DC output maximum		'OutL' to 20mA

Table B The following parameters appear if 'dI G' is chosen as the function.			
dI GF	Digital output functions Any number of the functions listed can be combined on to the output. Use the ▲ and ▼ buttons to select a desired digital function. After two seconds the display will blink and return to the 'noCH' display. Use the arrows again to scroll through the function list. The previously selected function display will show two decimal points indicating that it has been added to the output.	noCH CLr 1 - - - 2 - - - 3 - - - 4 - - - mAn Sbr Lbr HtrF LdF End SPAn SSrF nwAL rmtF	No change Clear all existing functions Alarm 1* Alarm 2* Alarm 3* Alarm 4* Manual/Auto Sensor break Loop break PDS Heater fail PDS Load failure End of program PV out of range PDS Solid state relay failure New alarm Remote setpoint failure

*In place of the dashes, the last three characters indicate the alarm type as per table A in the AL list: eg IFSL = Full Scale Low
If an alarm is not configured the displayed name will differ: e.g. 'AL 1' will be shown, for the first alarm

Name	Parameter description	Function	Meaning
2A	**Output 2 configuration**	**Function**	**Meaning**
id	Identity of module installed	none rELY LoG SSr	No module fitted Relay output Logic output Triac output
Func	Function	none	none
	Outputs	diG HEAt COOL	Function set by diGF Heating output Cooling output
	Logic inputs	man rmt SP2 tiH AcAL Loc.b rSEt StbY	Manual mode select Remote setpoint select Setpoint 2 select Integral hold Acknowledge alarms Lock buttons (keypad) Ramp/dwell reset Standby - ALL outputs = OFF
For Func = diG go to table B on previous page			
SEnS	Sense of output	nor inu	Normal *(heat and cool outputs*) Inverted *(alarms - de-energise in alarm)*

3A	Output 3 configuration	As per output 2A configuration

PASS	**Password list**
ACCP	FuLL or Edit level password (default = 1)
cnFP	Configuration level Password (default = 2)

Note:- When passwords are changed please make a note of the new numbers

Exit	**Exit Configuration**	no YES

1.10 PARAMETER TABLES

The tables which follow list all parameters that are available in Full operator level.

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				

Display mnemonic

Brief description of parameter or function

Factory configured value

1.10.1 HOME Display

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
	Home List						
Home	Measured Value and Setpoint(SP)	SP=25° C	SP=75° F			as display	
uPoS	Valve positioner output power			0.0	100.0	%of mtr	
OP	% Output Level			-100.0	100.0	%	
wSP	Working setpoint					as display	
SP	Setpoint			-999	9999	as display	
AmPS	Heater current (PDS modes 2 and 5)			0	100	AmPS	
m-A	Auto/manual select	Auto	Auto				
di SP	Configure lower readout of home display	Std	Std				nonE Std' AmPS' OP' StAt' uPoS
Cid	Customer ID	0	0	0	9999		
Additional parameters may appear in the Home display if the 'promote' feature has been used (see *Edit Level*, Chapter 3).							

1.10.2 Alarm List

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
AL	**Alarm List**						
1---	Alarm 1 set point value	0	0			as display	
2---	Alarm 2 set point value	0	0			as display	
3---	Alarm 3 set point value	0	0			as display	
4---	Alarm 4 set point value	0	0			as display	
In place of dashes, the last three characters indicate the alarm type, as follows:							
-FSH	Full Scale High alarm			-999	9999	as display	
-FSL	Full Scale Low alarm			-999	9999	as display	
-dEu	Deviation band alarm			0	9999	as display	
-dHi	Deviation High alarm			0	9999	as display	
-dLo	Deviation Low alarm			0	9999	as display	
-Lcr	Low current alarm			0	100	Amps	
-Hcr	High current alarm			0	100	Amps	
HY	Hysteresis			0	9999	as display	
HY.EU	Hysteresis for event alarms. See Note 1			0	9999	as display	
LbE	Loop break time	OFF	OFF	0	9999	secs	

1.10.3 Autotune List

AtUn	**Autotune List**						
tunE	Self tune enable	OFF	OFF	OFF	On		
Adc	Automatic droop compensation (Manual Reset) enable (only present if ti set to OFF)	mAn	mAn	mAn	CALC		

1.10.4 PID List

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
PId	**PID List**						
Pb	Proportional band	20.0	30	1	9999	as display	
ti	Integral time	360	360	OFF	9999	seconds	
td	Derivative time	60	60	OFF	9999	seconds	
rES	Manual reset (appears when ti set to OFF)	0.0	0.0	0.00	100.0	%	
Lcb	Cutback low	Auto	Auto	0	9999	as display	
Hcb	Cutback high	Auto	Auto	0	9999	as display	
rELC	Relative cool gain (set 1)	1.00	1.00	0.01	9.99		

1.10.5 Setpoint List

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
SP	Set Point List						
SSEL	Select SP1 or SP2	SP 1	SP 1	SP 1	SP2		
L-r	Local or remote setpoint select	Loc	Loc	Loc	rmt		
SP 1	Setpoint 1 value	25	70	As display range			
SP2	Setpoint 2 value	25	70	As display range			
rm.SP	Remote setpoint	0	0	As display range			
Loct	Local trim	0	0	As display range			
SP 1L	Setpoint 1 low limit	0	32	As display range			
SP 1H	Setpoint 1 high limit	1000	2 100	As display range			
SP2L	Setpoint 2 low limit	0	32	As display range			
SP2H	Setpoint 2 high limit	1000	2 100	As display range			
LocL	Local setpoint trim low limit	-2 10	-346	As display range			
LocH	Local setpoint trim high limit	1200	2 192	As display range			
SPrr	Setpoint rate limit	OFF	OFF	Units per minute			
dwEll	Dwell time	OFF	OFF	0.1 to 999.9 minutes			
Endt	End type	rES	rSEt	rSEt hoLd StbY dwEll			
ProG	Program control	rSEt	rSEt	run' rSEt			
StAt	Status of program		OFF	rmP dwEll End OFF			

1.10.6 Input List

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
InP	**Input list**						
*FiLt	Input filter time constant	1.6	1.6	0.0 oFF	999.9	secs	
OFSt	PV Offset			-999	9999	as display	
The next 5 parameters will appear if User calibration has been enabled in configuration level. To perform a user calibration refer to Ch 6.							
CAL	FACt will re-instate factory settings and disable User Calibration. Default setting FACt USEr will re-instate any previously set User Calibration offsets and make available User Calibration parameters as follows:						
CAL.S	User calibration select	nonE	nonE				Hi' Lo' nonE
AdJ~	Adjust calibrated reference source						
The following two parameters are always present in Full Access level but not in Operator level							
CJC°	Cold Junction compensation temperature						
mV	Millivolt input						

* A minimum filter time constant of one second is recommended to provide sufficient noise immunity.

~ Do not make adjustments to the AdJ parameter unless you wish to offset the controller calibration.

1.10.7 On/Off List

OnOF	**On/off list**						
This set of parameters only appear if On/Off control has been configured							
HYS.H	Heat hysteresis	0	0	0	9999	as display	
HYS.C	Cool hysteresis	0	0	0	9999	as display	
HC.db	Heat/Cool dead band	1	1	0	9999	as display	

1.10.8 Output List

Name	Parameter Description	Default Value		Min Value	Max Value	Units	Customer Setting
		UK	USA				
oP	**Output list** Note; If On/Off control is configured only Sb.OP, ontH and ontC will appear in the following list						
OPLo	Low (power) output limit	0.0 or -100.0 (cool)		-100.0	100.0	%	
OPHi	High (power) output limit	100.0	100.0	-100.0	100.0	%	
Sb.OP	Output setting when in sensor break	0.0		-100.0	100.0	%	
[1]CYCH	Heat cycle time	1.0 (logic) 20 (relay)		0.2	999.9	secs	
ontH	Heat output min. on time	0.1	0.1	Auto (50mS)	999.9		
[1]CYCC	Cool cycle time	1.0 (logic) 20 (relay)		0.2	999.9	secs	
[1]ontC	Cool output min. on time	0.1	0.1	Auto (50mS)	999.9	secs	
mtr	VP motor travel time			0.0	999.9	secs	

[1] Are not used for Valve Position Control.

1.10.9 Communications List

cmS	**Comms list**						
Addr	Communications address	1	1	1	254		

1.10.10 Access List

ACCS	**Access list**						
codE	Full and Edit level password	1	1	0	9999		
Goto	Goto level' OPEr' FuLL Edit' or conF	OPEr	OPEr	OPEr	conF		
ConF	Configuration level password	2	2	0	9999		

TITLE: Procedure, Control Box Setup and Test
REF. NEXT ASSY: Model 1602 Viscometer

Revision	Date	Revised By	Description	Checked By
E	6/1/2010	BW	ECN T3011	TC
F	3/30/2011	BW	ECN T3746	TC

NOTE: This test should be done prior to the Pressure Test (1602-0001P)

1. Set the **POWER LINE VOLTAGE** switch for the appropriate test voltage and turn on the unit.

2. Toggle the **Hold / Drop** switch and verify that the coil is energized when appropriate; use one of the following methods:
   - **Hold / Drop a ball:** When in the **Hold** position, a ball (C12555, C12556 or C12557) should be held at the point of the Coil Assembly (1602-0039). The ball should fall when switched to the **Drop** position. The ball can be held to the side of the point of the Coil Assembly regardless of the position of the Hold / Drop switch; conduct this test with the ball at the point of the Coil Assembly.
   - **Measure DC Voltage:** Verify that 24VDC (polarity does not matter) is across pins 3 and 4 of **Controls** cable when in the **Drop** position; 0VDC when in the **Hold** position.

3. The polarity of the magnets (C12861) in the Coil Assembly is important at high temperatures. For this step, the Solenoid Coil (C12910) is removed from the assembly but still wired to the Solenoid Cap (1602-0047) and the magnets are attached to the Steel Core (1602-0048).
   a. Attach the **Controls** cable to the connector on the Solenoid Cap and to the Control Box.
   b. Set the Hold / Drop switch to the **Drop** position to energize the Solenoid Coil.
   c. Insert the magnet end of the Steel Core into the **bottom** side of the Solenoid Coil. Flip the magnets on the Steel Core and insert into the Solenoid Coil again.
   d. The magnets in one polarity will be repelled by the magnetic field of the Solenoid Coil. In the other polarity, the magnets will be attracted to it. Arrange the magnets such that they are **repelled** by the Coil.
   e. Re-assemble the Coil Assembly; the set screw (H-25-008) MUST be backed off 2 full turns from flush with the Magnet Tube (1602-0043).

4. Verify **Timer** operation and that the **Top** and **Bottom** lights illuminate at the appropriate time.
   a. See attached PARAMETER VALUE CHART and PROGRAMMING QUICK OVERVIEW to set appropriate RedLion Timer parameters.
   b. Connect the Controls cable (C12314) to the Control Box:
      i. **Top** should light when the Coil Assembly is touched to the body of the vessel or when pins 1 and 5 on the **Controls** cable are shorted (**Bottom** light should go out if on).
      ii. **Timer** should start when the **Drop** switch is activated (**Top** light should remain on).
      iii. **Bottom** should light, **Top** should go out, **Timer** should stop and **Alarm** should sound (if the **Alarm** switch is in the ON position) when the End-of-Roll Contact Cable (1602-9) is touched to the body of the vessel or when pins 2 and 5 of the Controls cable are shorted.

TITLE: Procedure, Control Box Setup and Test
REF. NEXT ASSY: Model 1602 Viscometer

Revision	Date	Revised By	Description	Checked By
E	6/1/2010	BW	ECN T3011	TC
F	3/30/2011	BW	ECN T3746	TC

5. With the unit OFF and heaters connected, verify **POWER LINE VOLTAGE** switch wiring. Measure resistance across switch at pins 1B and 2 (or pin 2 of Heater Relay to White terminal blocks):
    a. ≤ 24Ω at with switch set to 115V
    b. ≤ 96Ω at with switch set to 230V

6. Verify **Temperature Controller** operation:
    a. Load the 1602 Eurotherm iTools Clone file to the controller; the file is located in the S:\DCI Test Lab\Controller Config Files folder.
    b. Connect a K-type Thermocouple.
    c. Set the temperature controller to 100°F. The light on the Heater Relay in the Control Box should match the OP1 light on the Temperature Controller.
    d. Disconnect the Thermocouple. The temperature controller should display the "Sensor Break" error (S.br flashes on the upper readout). The light on the Heater Relay should remain off and the ALM light on the Over Temperature module should flash.

7. Verify **Over Temperature** module operation:
    a. Connect a Thermocouple Calibrator to the thermocouple input on the Control Box.
    b. Set the Thermocouple Calibrator to K-Type.
    c. Set the Thermocouple Calibrator output to 350°F; the ALM light on the Over Temperature module should flash.
    d. Set the Thermocouple Calibrator output to 300°F; the ALM light on the Over Temperature module should stop flashing and remain off.

PARAMETER VALUE CHART
PAXCK Clock Timer

Programmer _____ Date _____

Meter# _____ Security Code _____

1- INP Timer Input Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
rANGE	TIMER RANGE	555555	555.555
INP OP	TIMER INPUT OPERATION	LEVEL	Edge-2
FILtEr	TIMER INPUT FILTERING	00	OFF
t dir	TIMING DIRECTION	UP	
t Strt	TIMER START VALUE (A)	000000	
	TIMER START VALUE (B)*	000000	
t StOP	TIMER STOP (A & B*)	no	
VALUE	TIMER STOP VALUE (A)	000000	
	TIMER STOP VALUE (B)*	000000	
FLASH	FLASH TIMER ANNUNCIATOR	no	
InP-UP	TIMER INPUT STATE AT POWER-UP	StOP	
t P-UP	TIMER RESET AT POWER-UP	no	yES

2-FnC User Input and Function Key Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
USEr-1	USER INPUT 1	no	OSEt-L
USEr-2	USER INPUT 2	no	OSEt-L
USEr-3	USER INPUT 3	no	OrSt-L
F1	FUNCTION KEY 1	no	
F2	FUNCTION KEY 2	no	
rSt	RESET KEY	drSt-E	
SEC-F1	SECONDARY FUNCTION KEY F1	no	
SEC-F2	SECONDARY FUNCTION KEY F2	no	

USEr-1 OSEt-L
SP-1 yES
SP-2 NO

USER-2 OSEt-L
SP-1 NO
SP-2 yES

USEr-3 OrSt-L
SP-1 NO
SP-2 yES

3-LOC Display and Program Lock-out Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
t-dSP	TIMER DISPLAY LOCK-OUT	rEd	
C-dSP	CYCLE COUNT DISPLAY LOCK-OUT	LOC	
rtC-d	RTC DATE DISPLAY LOCK-OUT	LOC	
rtC-t	RTC TIME DISPLAY LOCK-OUT	LOC	
SP-1	SP1 ON VALUE ACCESS	LOC	
SPOF-1	SP1 OFF VALUE ACCESS	LOC	
tOUt-1	SP1 TIME-OUT VALUE ACCESS	LOC	
SP-2	SP2 ON VALUE ACCESS	LOC	
SPOF-2	SP2 OFF VALUE ACCESS	LOC	
tOUt-2	SP2 TIME-OUT VALUE ACCESS	LOC	
SP-3	SP3 ON VALUE ACCESS	LOC	
SPOF-3	SP3 OFF VALUE ACCESS	LOC	
tOUt-3	SP3 TIME-OUT VALUE ACCESS	LOC	
SP-4	SP4 ON VALUE ACCESS	LOC	
SPOF-4	SP4 OFF VALUE ACCESS	LOC	
tOUt-4	SP4 TIME-OUT VALUE ACCESS	LOC	
t Strt	TIMER START VALUE ACCESS	LOC	
t StOP	TIMER STOP ACCESS	LOC	
C Strt	COUNTER START VALUE ACCESS	LOC	
C StOP	COUNTER STOP VALUE ACCESS	LOC	
SEt-t	RTC TIME SETTING ACCESS	LOC	
CodE	SECURITY CODE	000	

4-Cnt Cycle Counter Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
C Src	CYCLE COUNTER COUNT SOURCE	nonE	
C dir	CYC. CNTR. COUNTING DIRECTION	UP	
C Strt	CYCLE COUNTER START VALUE (A)	000000	
	CYCLE COUNTER START VALUE (B)*	000000	
C StOP	CYCLE COUNTER STOP (A & B*)	no	
VALUE	CYCLE COUNTER STOP VALUE (A)	000000	
	CYCLE COUNTER STOP VALUE (B)*	000000	
C P-UP	CYC. CNTR. RESET AT POWER-UP	no	

5-OPEr Timer Operating Modes

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
t OPEr	PREDEFINED TIMER OPER. MODE	no	
SP-1	SETPOINT 1 ON VALUE	000000	
SPOF-1	SETPOINT 1 OFF VALUE	000.100	
tOUt-1	SETPOINT 1 TIME-OUT VALUE	000.100	

** See Module 2, Exchanging Parameter Lists, for details on programming this value.*

Shaded areas are model dependent.

6-SPt Setpoint (Alarm) Parameters

DISPLAY	PARAMETER	SP-1 FACTORY SETTING	SP-1 USER SETTING	SP-2 FACTORY SETTING	SP-2 USER SETTING	SP-3 FACTORY SETTING	SP-3 USER SETTING	SP-4 FACTORY SETTING	SP-4 USER SETTING
ASn-n	SETPOINT ASSIGNMENT	nonE		nonE		nonE		nonE	
ACt-n	SETPOINT ACTION	LAtCH	ON-OFF	LAtCH	ON-OFF	LAtCH		LAtCH	
Out-n	OUTPUT LOGIC	nor		nor		nor		nor	
On-n	SETPOINT ON (A)	VALUE	01-ON	VALUE	02-ON	VALUE		VALUE	
	SETPOINT ON (B)*	VALUE		VALUE		VALUE		VALUE	
SP-n	SETPOINT ON VALUE (A)	000000		000000		000000		000000	
	SETPOINT ON VALUE (B)*	000000		000000		000000		000000	
OFF-n	SETPOINT OFF (A)	VALUE	t-StOP	VALUE	02-OFF	VALUE		VALUE	
	SETPOINT OFF (B)*	VALUE		VALUE		VALUE		VALUE	
SPOF-n	SETPOINT OFF VALUE (A)	000 100		000 100		000 100		000 100	
	SETPOINT OFF VALUE (B)*	000 100		000 100		000 100		000 100	
tOUt-n	TIME-OUT VALUE (A)	00.0 t00		00.0 t00		00.0 t00		00.0 t00	
	TIME-OUT VALUE (B)*	00.0 t00		00.0 t00		00.0 t00		00.0 t00	
d On-n	DAILY ON OCCURRENCE (A)	Mon-Fri		Mon-Fri		Mon-Fri		Mon-Fri	
	DAILY ON OCCURRENCE (B)*	Mon-Fri		Mon-Fri		Mon-Fri		Mon-Fri	
dOFF-n	DAILY OFF OCCURRENCE (A)	Mon-Fri		Mon-Fri		Mon-Fri		Mon-Fri	
	DAILY OFF OCCURRENCE (B)*	Mon-Fri		Mon-Fri		Mon-Fri		Mon-Fri	
tStP-n	TIMER STOP	no		no		no		no	
AUtO-n	TIMER/COUNTER AUTO RESET	no		no		no		no	
OrSd-n	OUTPUT RESET W/DISPLAY RESET	no		no		no		no	
L it-n	SETPOINT ANNUNCIATOR	nor	OFF	nor	OFF	nor		nor	
P-UP-n	POWER-UP STATE	OFF		OFF		OFF		OFF	

7-SrL Serial Communication Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
bAUd	BAUD RATE	9600	
dAtA	DATA BITS	7	
PAr	PARITY BIT	Odd	
Addr	METER UNIT ADDRESS	00	
Abbr	ABBREVIATED PRINTING	no	
rtC Ft	REAL-TIME CLOCK PRINT FORMAT	YES	
OPt	PRINT OPTIONS		
t-dSP	TIMER DISPLAY	YES	
C-dSP	CYCLE COUNTER DISPLAY	no	
rtC-d	RTC DATE DISPLAY	no	
rtC-t	RTC TIME DISPLAY	no	
SPnt	SETPOINT VALUES	no	
SPntOF	SETPOINT OFF/ TIME-OUT VALUES	no	

8-rtC Real-Time Clock Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
dSP-t	TIME DISPLAY FORMAT	12-59P	
dSP-d	DATE DISPLAY FORMAT	12-31	
Ch-dSt	AUTO TIME CHANGE FOR D.S.T.	no	
SYnC	SYNCHRONIZATION UNIT TYPE	SLAVE	
CAL	CALIBRATE REAL-TIME CLOCK		
OFFSEt	RTC CALIBRATION OFFSET VALUE	00	

9-FCS Factory Service Parameters

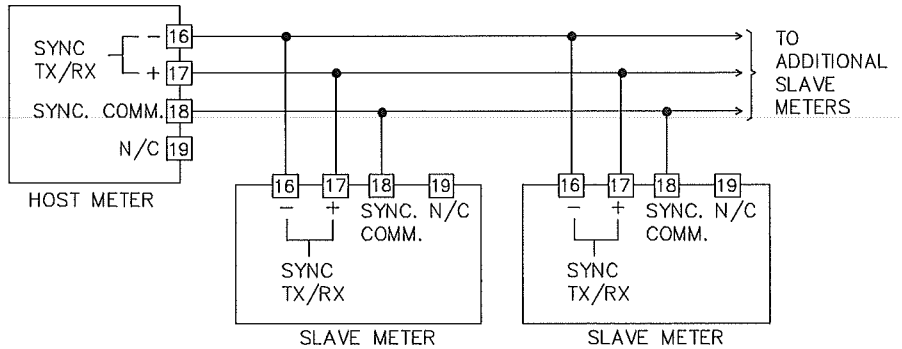
DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
d-LEV	DISPLAY INTENSITY LEVEL	3	

** See Module 2, Exchanging Parameter Lists, for details on programming this value.*

Shaded areas are model dependent.

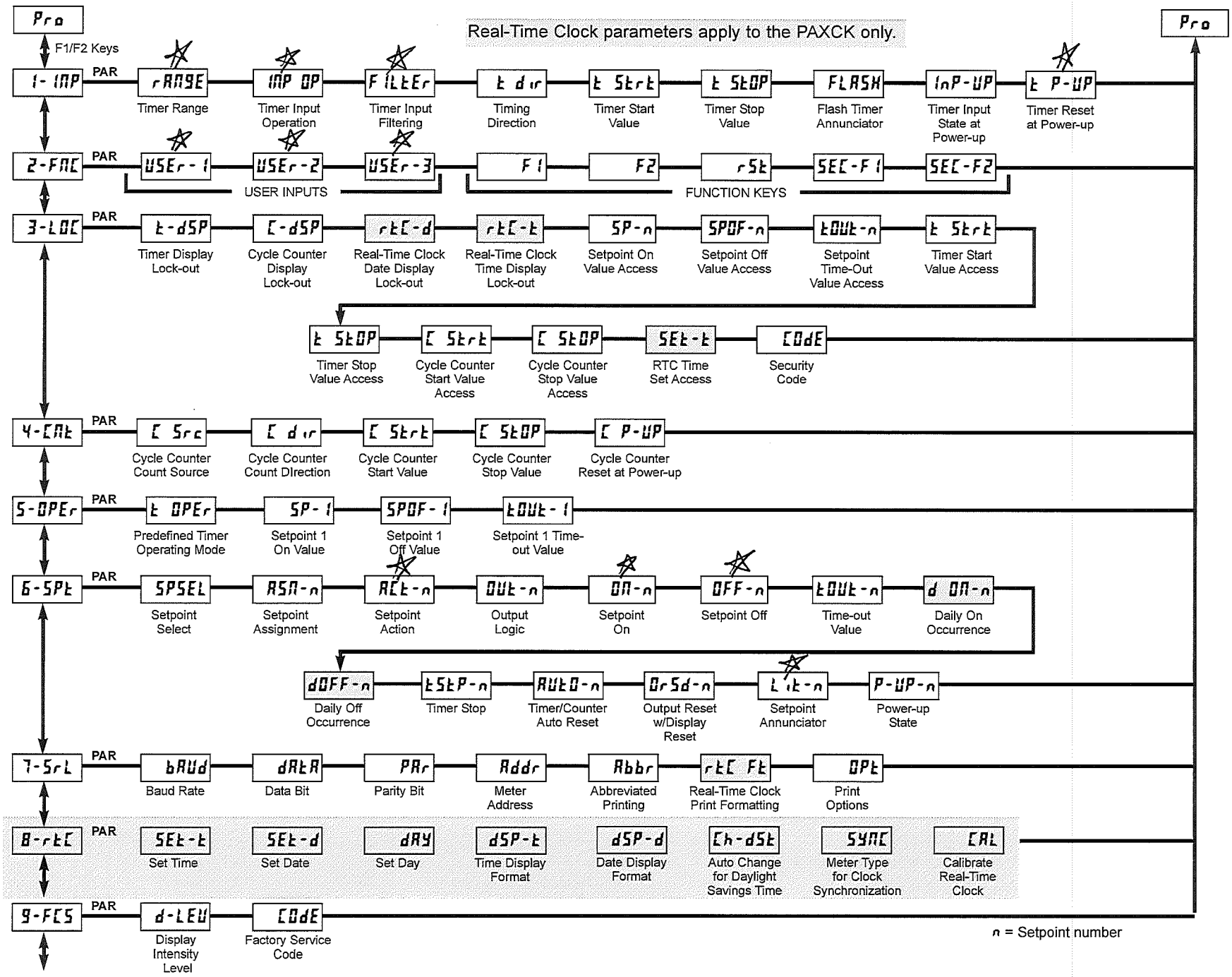
PAXCK Application

A big application request has always been for Real-Time Clocks to display time throughout the plant. The challenge has been to keep all the various clock locations synchronized with the right time. With the new PAXCK Timer/Real-Time Clock this problem is history. The clocks can be provided in three different sizes, the PAXCK (0.56 inch LEDs), the LPAXCK (1.5 inch LEDs), or the EPAX (4 inch LEDs). You can mix and match any number of the two versions, up to a maximum of 32 units. Simply select one of the units in the system as the host and the balance are programmed as slaves. The host will send out a synchronization pulse every hour to correct the time on any clock unit wired in the system.

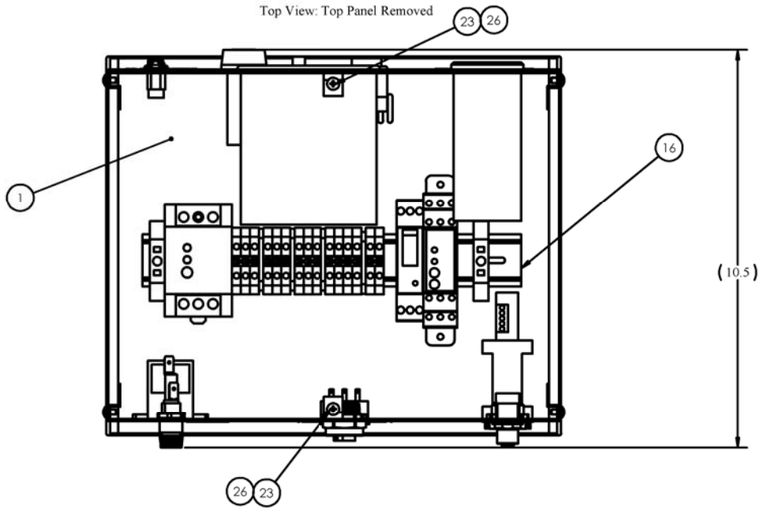


Real-Time Clock Synchronization Network

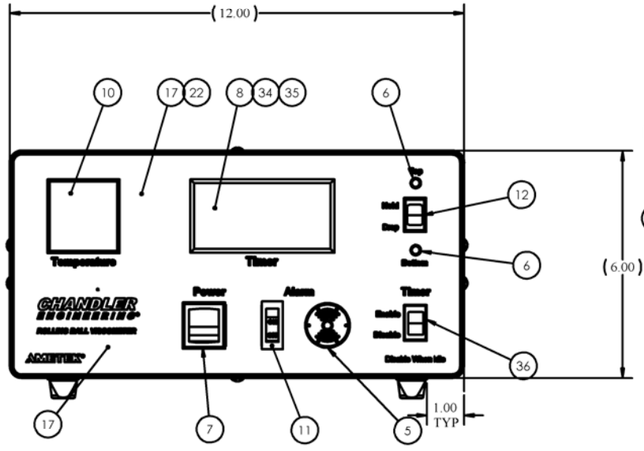
PAXTM/PAXCK PROGRAMMING QUICK OVERVIEW

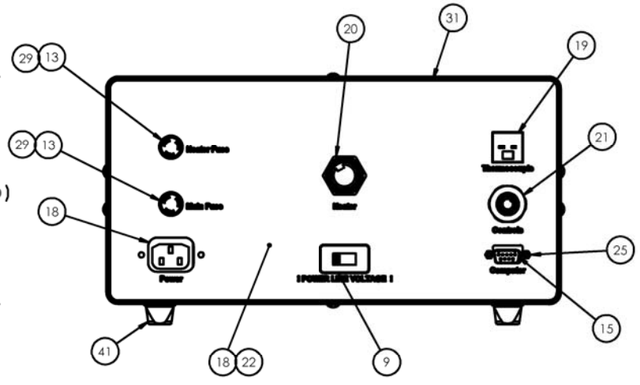


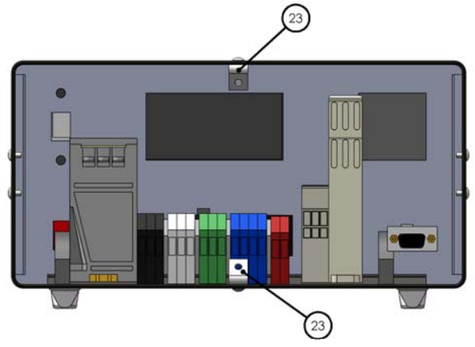
REV.	DESCRIPTION	DATE	APPROVED
L	ECN T3276: UPDATED THE FRONT OVERLAY ART	9/2/2010	JJM



NOTE:
1. SETUP AND TEST PER 1602-0004P







Rear View: Rear Panel Removed

ITEM NO.	PART NUMBER	DESCRIPTION	Defa Unit Qty
1	-1602-0020	WIRING DIAGRAM, CONTROL BOX	REF
5	C12318	BUZZER, 24VDC 25MA, PNL MNT	1
6	C11161	LED, GREEN, 5VDC/12VDC, PANEL	2
7	80-893	SWITCH ROCKER 15A-250 VAC DPDT	1
8	C11733	TIMER, 6-DIGIT, 85-250VAC, 1/8 DIN	1
9	C12311	SWITCH, DPDT, PWR, PNL MNT	1
10	C09772	CONTROLLER, MODEL 2404	1
11	C08106	SWITCH,SPDT,ROCKER,OFF/NONE/ON	1
12	C10966	SWITCH,DPDT,ON/ON,SOLDER	1
13	26-195	FUSE HOLDER	2
14	24-623	CONN,AC RCPT LINE FILTER 3 CK	1
15	C10792	CONVERTER, RS232/RS485	1
16	1602-0018	ASSY, ELECTRICAL RAIL	1
17	1602-0015	FRONT OVERLAY	1
18	1602-0016	REAR OVERLAY	1
19	C09577	CONN,TC,TYPE K MINI,PANEL SIDE	1
20	C11551	CONN, MINIFAST, RECEPT, 4-PIN FEM	1
21	C12315	RCPT, TURCK, FK4.5-05/14.5	1
22	1602-0019	ENCLOSURE, MODIFIED	1
23	71015-23	MTG BRKT, LWR CNTRL PANEL	4
24	C10967	NUT,CONDUIT,1/2"	2
25	C09285	STDF,HEX,ZN,0.18X0.31,4-40,M/F	2
26	H-6017	SCREW,TRH,6-32PHLPS,SST	4
NOT SHOWN	27 C12312	CABLE,TURCK,RSM RKM 40-2M	1
NOT SHOWN	28 C12314	CABLE,TURCK,RK4.5T-2-RS4.5T	1
NOT SHOWN	29 26-228	FUSE,5.000A,250V,3AB,TIMEDELAY	2
NOT SHOWN	30 1602-0038	THERMOCOUPLE CABLE	1
	31 C12097	ENCLOSURE, BUD, 10X12X6	1
NOT SHOWN	32 C07859	RES,619 OHM,1/4W,1%,MF	2
	33		
NOT SHOWN	34 C11734	MODBUS FOR C11733	1
NOT SHOWN	35 C11735	RELAY OUTPUT FOR C11733	1
	36 C13151	SWITCH,ROCKER,ON/OFF,SPST	1
NOT SHOWN	37 C09878	WIRE,20 AWG, K TYPE TC	2.5'
NOT SHOWN	38 C09583	MODBUS CARD, RS485, 2 WIRE, EUROT	1
NOT SHOWN	39 70617-89	CORD, POWER, 3 COND, 14AWG, STRD	1
NOT SHOWN	40 84-0067	CABLE ASSY, 200-240VAC	1
	41 C08795	BUMBER,STICK-ON,GRAY	4

NEXT ASSY	USED ON
APPLICATION	
BREAK SHARP EDGES, DEBURR	

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH 32

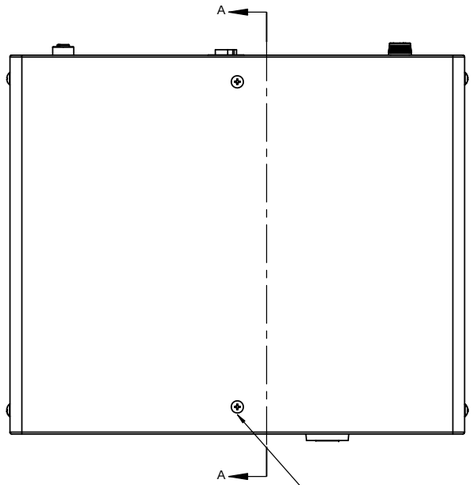
APPROVALS	DATE
DRAWN: TDM	3/12/08
CHECKED: TC	3/12/08
ENGR.: TDM	3/12/08

CHANDLER ENGINEERING

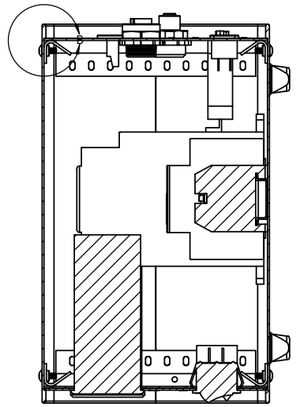
TITLE: ASSY, CONT BOX - BALL VISC 110/230

SIZE	S.O. NO.	DWG NO.	REV.
D		1602-0017	L

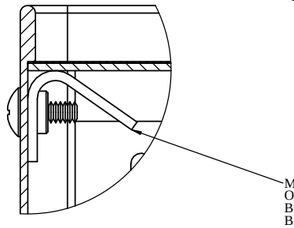
SCALE: 1:2 | TITLE BLOCK REV. 1.0 | SHEET: 1 of 2



DRILL TOP AND BOTTOM
OF CONTROL BOX AT ASSEMBLY
FOR 6-32 SCREW.

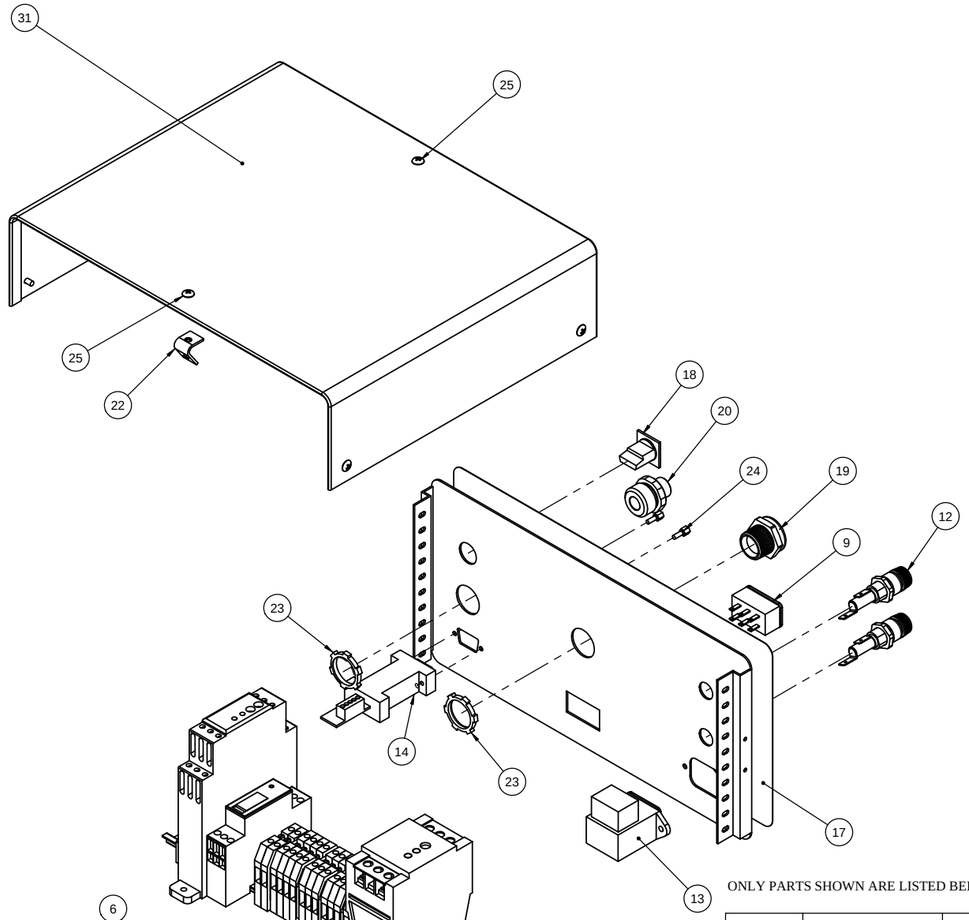


SECTION A-A



MOUNTING BRACKET IS TO BE LOCATED
ON CENTERLINE OF CONTROL BOX, TOP AND
BOTTOM. BRACKET IS TO KEEP FRONT AND
BACK PANEL FROM FLEXING.

DETAIL B
SCALE 2 : 1



ONLY PARTS SHOWN ARE LISTED BELOW. SEE SHEET 1 FOR COMPLETE BOM.

ITEM NO.	PART NUMBER	DESCRIPTION	Exploded view/QTY.
1	-1602-0020	WIRING DIAGRAM, CONTROL BOX	REF
5	C12318	BUZZER, 24VDC 25MA, PNL MNT	1
6	C11161	LED, GREEN, 5VDC/12VDC, PANEL	2
7	80-893	SWITCH ROCKER 15A-250 VAC DPDT	1
8	C11733	TIMER, 6-DIGIT, 85-250VAC, 1/8 DIN	1
9	C12311	SWITCH, DPDT, PWR, PNL MNT	1
10	C09772	CONTROLLER, MODEL 2404	1
11	C10966	SWITCH,DPDT,ON/ON,SOLDER	1
12	26-195	FUSE HOLDER	2
13	24-623	CONN,AC RCPT LINE FILTER 3 CK	1
14	C10792	CONVERTER, RS232/RS485	1
15	1602-0018	ASSY, ELECTRICAL RAIL	1
16	1602-0015	FRONT OVERLAY	1
17	1602-0016	REAR OVERLAY	1
18	C09577	CONN,TC,TYPE K MINI,PANEL SIDE	1
19	C11551	CONN, MINIFAST, RECEPT, 4-PIN FEM	1
20	C12315	RCPT, TURCK, FK4.5-05/14.5	1
21	1602-0019	ENCLOSURE, MODIFIED	1
22	71015-23	MTG BRKT, LWR CNTRL PANEL	4
23	C10967	NUT,CONDUIT,1/2"	2
24	C09285	STDF,HEX,ZN,0.18X0.31,4-40,M/F	2
25	H-6017	SCREW,TRH,6-32PHLPS,SST	4
30	C12097	ENCLOSURE	1
35	C13151	SWITCH,ROCKER,ON/OFF,SPST	1
40	C08795	BUMBER,STICK-ON,GRAY	1
41	C08106	SWITCH,SPDT,ROCKER,OFF/NONE/ON	1

NOTES:
1. USE 1 (SET OF 4) C08795 (BUMPER, STICK-ON, GRAY) TO REPLACE THE FEET SUPPLIED WITH THE ENCLOSURE.

		UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
		TOLERANCES:
		1 PLACE ±0.030
		2 PLACE ±0.010
.	.	3 PLACE ±0.005
NEXT ASSY	USED ON	ANGLES ±1/2°
APPLICATION		SURF. FINISH 32
BREAK SHARP EDGES, DEBURR		APPROVALS / DATE

DRAWN: TDM	3/12/08	
CHECKED: TC	3/12/08	
ENGR.: TDM	3/12/08	

CHANDLER ENGINEERING

TITLE: ASSY, CONTROL BOX
ROLLING BALL VISC 110/230

SIZE	DWG NO.	REV.
D	1602-0017	L

SCALE: 1:2 | TITLE BLOCK REV: 2.0 | SHEET: 2 of 2

REVISIONS				
ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS
E4	G	ECN T3709, UPDATE JUMPER BAR	3/22-11	SS TC
	H	ECN T5766; ADDED C07993	2/14/14	TC TC

1602-0038

C09577

RED
YEL

RED
YEL

C09878
K-TYPE T/C
24 AWG

C10792
C09285 (x2)

GND BLK
TD(A) WHT
TD(B) RED

C07646

C09878 K T/C 24 AWG

22 YLW

RED

YEL

(HD) BLK
(HE) WHT
(HF) RED

C07646
(14) BLK
(13) WHT
(12) RED

CAUTION:
SEE MANUFACTURES MANUAL
FOR INSTALLATION OF
C11734 AND C11735

C11733
C11734
C11735
"TIMER"

1600-1-71

C08226 STOP,END (x2)
C09740 T BLOCK, BLK (x3)
C10435 T BLOCK, WHITE (x3)
C09742 T BLOCK, YEL/GRN (x3)
C09738 T BLOCK, BLUE (x4)
C09739 T BLOCK, RED (x2)
C07990 JUMPER BAR (x2)
C07991 SECT ,END,GRAY (x4)
C07994 DIN RAIL,IDEC BAM-1000

C11068
"SSR"

22 RED

22 RED

1A 1B
2A 2B
3A 3B

HA HB HC HD HE HF
L N E VI V+ V-

C09772
C09583
"TEMPERATURE"

C12317 "ALARM LATCH"
NOTE: SET DIALS TO 350F
SET SW2 & SW4 TO ON
(DIP SWITCHES ON SIDE)

GENERAL PURPOSE FILTER FOR CONTROL OF
LINE-TO-GROUND NOISE. 50/60 HZ. 115/230VAC
24-623

POWER
HI
LO
C_{F_1}
L_{F_1}
C_{F_2}
C_{F_3}
L_{F_2}
24-623

F_1 5A 26-228
MAIN FUSE

F_2 5A 26-228
HEATER FUSE

S_1 80-893
"POWER"

1 2
4 5

-V +V
L N E
C10179

C12237

T.C.

16 GRN

18 BLK
18 BLK
18 BLK
AC HI
AC HI
AC HI
18 BLK
18 BLK
C11733 PIN 1

18 WHT
18 WHT
C11551 PIN 4
AC LO
AC LO
AC LO
18 WHT
C11733 PIN 2
18 WHT

18 GRN/YEL
C12315 PIN 5
EARTH
EARTH
EARTH
18 GRN/YEL
C11733 PIN 4
18 GRN/YEL

22 BLU
C12315 PIN 4
OVDC
OVDC
OVDC
22 BLU
22 BLU
22 BLU

22 RED
+24VDC
+24VDC
22 RED
22 RED

C07993

S_5 C08106
"ALARM"

X1
X2

C12318

22 GRN/YEL C11733 PIN 5
22 BRN C11733 PIN 7
22 WHT C11733 PIN 6

C11161 "BOTTOM"
WHT RED
R_3 / R_4 619 OHM
C07859 (x2)
WHT RED
C11161 "TOP"

1602-0031
C12313
C12312

32-120 (x2)

HEAT 1
HEAT 1
HEAT 2
HEAT 2

C11551 "HEATER"
1 18 BRN
2 18 WHT
3 18 BLU
4 18 BLK

1A 1 1B
2A 2 2B

S_2 C09210 "POWER LINE VOLTAGE"

C07993

S_3 C09210
"DROP"
WIRE TOP 4 PINS

S_4 C13151 "TIMER ENABLE"

(1600-0039)

BLU
BLK
BRN
GRY
WHT

COIL
COIL
START OF ROLL
GND
END OF ROLL

3 22 BLU
4 22 BLK
1 22 BRN C13152 PIN 5
5 22 GRY
2 22 WHT C13152 PIN 4

C12572

C12316

C12314

C12315 "CONTROLS"

1600-15-0
VISCOMETER TEST ASSY. 1602

1602-9

HEATER VOLTAGE SELECTION DETAIL (C09210)

1B
1
1A
2B
2
2A
H1
H2

IN PARALLEL (115 VAC)
R MAX≤ 24 OHMS

IN SERIES (230 VAC)
R MAX≤ 96 OHMS

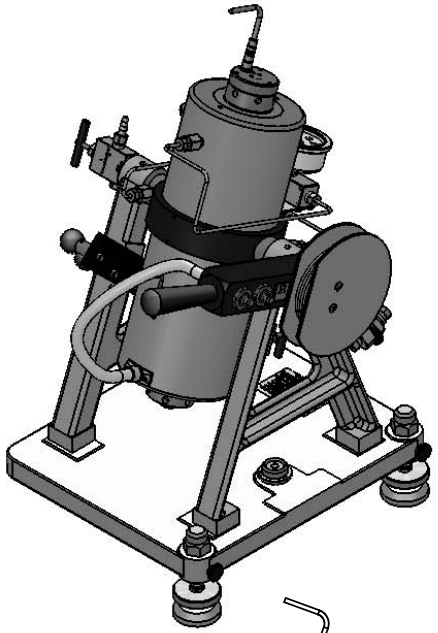
		UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm]		
	1609-723	TOLERANCES:		
	1609-722	1 PLACE ±		
	1609-721	2 PLACE ±		
NEXT ASSY	USED ON	3 PLACE ±		
APPLICATION		ANGLES ±		
		SURF. FINISH ✓	APPROVALS	DATE
			DRAWN: BJW	2/28/08
			CHECKED: TC	2/28/08
			ENGR.: BJW	2/28/08

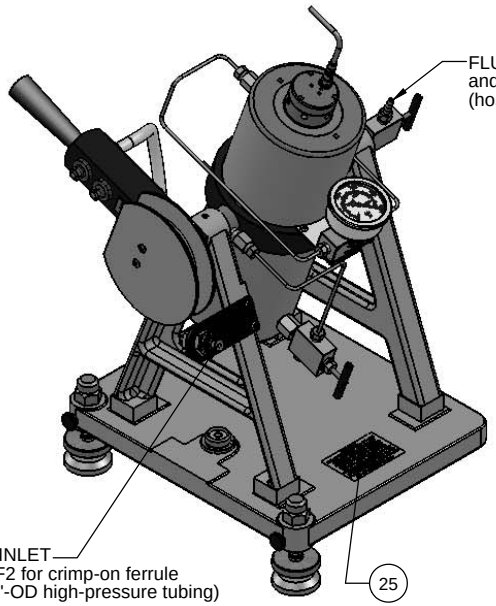
CHANDLER ENGINEERING

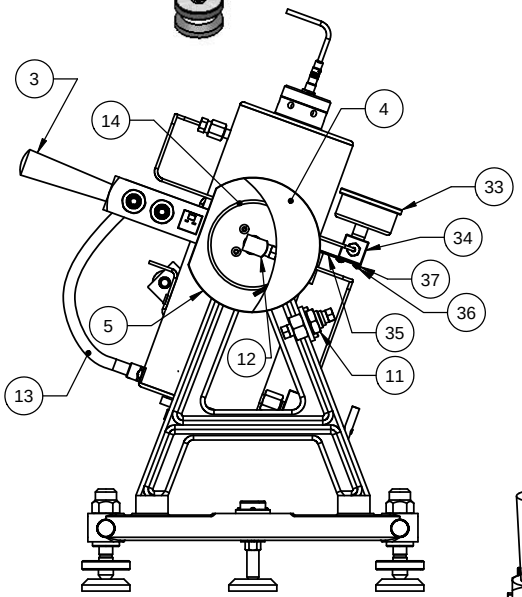
TITLE
CONTROL BOX ASSEMBLY
VISCOMETER

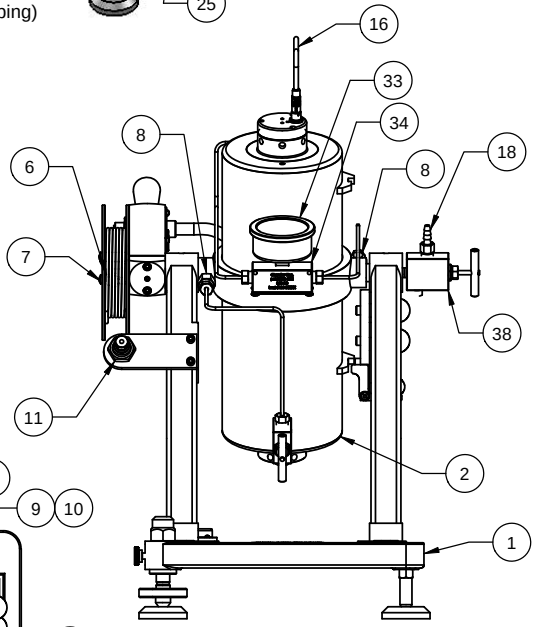
SIZE	S.O. NO.	DWG NO.	REV.
A2		1602-0020	H
SCALE: 1 = 1	DO NOT SCALE DRAWING	SHEET: 1 of 1	

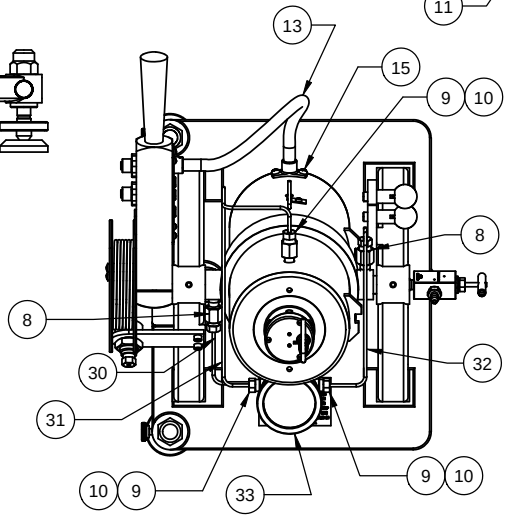
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	G	ECN T3276: REVERSE TUBE CONNECTIONS ON TRUNNION. CREATE TUBE 1 AND TUBE 2 DETAILS	9/2/2010	JJM
	H	ECN T4020: Item 18 was #1602-0036. Item 31 was #1602-717-TUBE2. Add Items 32 - 38.	7/28/11	DAH











ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1602-0028	STAND ASSY, HI PRS VISC	1
2	1602-1	CELL ASSEMBLY,RBV	1
3	1602-0026	ASSY, ARM CONNECTIONS	1
4	1600-1-65	PLATE 2,SPIRAL DVR -HIPRSVISC	1
5	1600-1-64	SPIRAL COVER PLATE	1
6	75-236	SPACER .375DX .88LX .140ID	2
7	71-137-1101	OHMS 10-32 X 1/2SS	2
8	C10819	ADAPTER,SS,1/8FHPX1/8MP,HIP	2
9	C10314	GLAND, HIP,1/8	6
10	C10681	SLEEVE, 1/8 HIP AF2, 316SS	6
11	C10796	CPLG,BULKHEAD,HIP 1/8 AF2,SS	1
12	1602-0027	FTG,ANG,1/8NPTMXAF2	1
13	1602-0031	HEATER CABLE JACKET ASSY	1
14	1600-16-67	COIL,HELIX	1
15	71-114-501	SCREW,RHMS,SS,10-24X0.250,SLOT	2
16	1602-0035	ASSY, SOLENOID CABLE	1
17	1602-9	CABLE,BOTTOM CONTACT - RBV	1
18	1602-1204	ADAPTER,1/8AM2-1/4HOSE BARB,SS	1
19	C10487	WRENCH,SPANNER,0.187, PIN	1
20	C10488	WRENCH,SPANNER,0.250, PIN	1
21	C12555	BALL,NICKEL 200,.248"DIA	2
22	C12556	BALL,NICKEL 200,.252"DIA	2
23	C12557	BALL,NICKEL 200,.234"DIA	2
24	86-871	SS,TBG,0.125x0.035W,316,ANNLD	20'
25	99236-260	WARNING LABEL	1
26	-1602-0001P	PROC, PRESSURE TEST	REF
27	-1602-0002P	PROC, CALIBRATION	REF
28	-1602-0003P	PROC, PRESS CONTROLLER CAL	REF
29	-1602-0020	WIRING DIAGRAM	REF
30	1602-717-TUBE1	TUBE,RBV,SHAFT-TO-BOTTOM,SS	1
31	1602-717-TUBE3	TUBE,RBV,TOP-TO-TEE,SS	1
32	1602-717-TUBE4	TUBE,RBV,TEE-TO-SHAFT,SS	1
33	C10334	GAUGE,10000PSI,2.5",1/4NPT,SS	1
34	1602-1201	TEE,1/8AF2-1/4NPT-1/8AF2,SS	1
35	1602-1202	BRACKET,GAUGE TEE,SS	1
36	H-6015	SCREW,THMS,SS,6-32X0.375,PHIL	6
37	H-6001	WSHR,LOCK,SS,#6	6
38	C13236	VALVE,ANGLE,RUP DISK,10KSI,SS	1

.	.	
.	.	
.	.	
NEXT ASSY	USED ON	
APPLICATION		
BREAK SHARP EDGES, DEBURR		

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH 32

APPROVALS		DATE
DRAWN:	TDM	6/12/08
CHECKED:	BW	6/12/08
ENGR.:	TDM	6/12/08

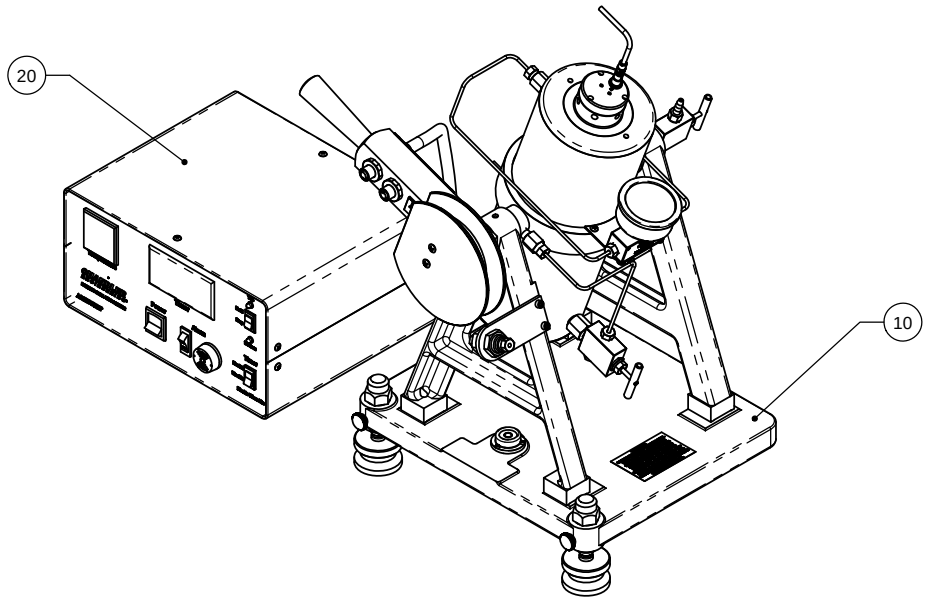
CHANDLER ENGINEERING

TITLE
VISC W/O CONT 240V H2S SRVC

SIZE	DWG NO.	REV.
C	1602-717	H

SCALE: 1:4 | TITLE BLOCK REV: 2.0 | SHEET: 1 of 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	G	ECN T3276; UPDATED ARTWORK AND TUBING LOCATIONS	9/2/2010	JJM
	H	ECN T4020; UPDATED BOM	7/28/11	TC



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	1602-717	VISC W/O CONT 240V H2S SRVC	1
20	1602-0017	ASSY, CONTROL BOX	1
30	1602-ACCESS	ACCESSORIES, MODEL 1602	1
0	-1602-0002P	PROC,CALIBRATION	REF
0	-1602-0003P	PROC,TEMP CONTROLLER SETUP	REF
0	-1602-0004P	PROC,CONTROL BOX SETUP/TEST	REF

			.	.	.	.	1
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			
.				.			
.				.			
.				.			
NEXT ASSY				USED ON			
APPLICATION							
BREAK SHARP EDGES, DEBURR							

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH √

APPROVALS		DATE
DRAWN:	JJM	09/02/10
CHECKED:	TC	9/2/10
ENGR.:	JJM	09/02/10

CHANDLER ENGINEERING

TITLE
VISCOSIMETER,220VAC,H2S

SIZE	DWG NO.	REV.
C	1602-830	H

SCALE: 1:8 | TITLE BLOCK REV: 2.0 | SHEET: 1 of 1

APPENDIX I

EXAMPLE CALIBRATION AND MEASUREMENT

The following is an example test using the Chandler Rolling Ball Viscometer.

CALIBRATION

This example calibration was performed using the Cannon S6 Viscosity Standard with a 0.249 Ball (density ρ_B = 8.8469 g/cc), a Test Temperature of 77°F and at atmospheric pressure. A REPORT OF CALIBRATION was included with the Viscosity Standard. That report listed the Viscosity (μ_C) and Density (ρ_F) at various temperatures. Several roll tests were conducted at each Roll Angle until consistent results were obtained.

Calibration Fluid			
Test Temperature	77 **°F**		
Fluid Density (ρ_F)	0.8723 **g/mL**		
$\Delta\rho$ ($\rho_B - \rho_F$)	7.9746 **g/mL**		
Known Viscosity (μ_C)	103.9 **cP**		
Roll Angle	**70°**	**45°**	**23°**
Mean Roll Time (t)	159.4418 **s**	199.325 **s**	321.2714 **s**
Calibration Constant (K) $K = \mu_C / (t\,\Delta\rho)$	0.081715	0.065365	0.040554

VISCOSITY MEASURMENT

This example viscosity measurement was then performed using the test fluid at the same test conditions of the calibration (0.249 ball, 77°F Test Temperature, atmospheric pressure). The density of the test fluid at test temperatures was measured or obtained prior to the test. Again, several roll tests were conducted at each Roll Angle until consistent results were obtained.

Test Fluid			
Test Temperature	77 **°F**		
Fluid Density (ρ_F)	0.8731 **g/mL**		
$\Delta\rho$ ($\rho_B - \rho_F$)	7.9738 **g/mL**		
Mean Roll Time (t)	12.5996 **s**	15.3884 **s**	25.072 **s**
Measured Viscosity (μ_M) $\mu_M = K\,t\,\Delta\rho$	8.2097 **cP**	8.0205 **cP**	8.1075 **cP**

APPENDIX II

VISCOSITY UNIT CONVERSION FACTORS

1 cP =	Customary Unit	= cP
1.450 377 378 E - 7	**(lbf-s)/in²**	6.894 757 290 E + 6
2.088 543 423 E - 5	**(lbf-s)/ft²**	4.788 025 900 E + 4
1.019 716 213 E - 4	**(kgf-s)/m²**	9.806 650 E + 3
6.719 689 948 E - 4	**lbm/(ft-s)**	1.488 163 900 E + 3
0.01	**(dyne-s)/cm²**	100
0.001	**Pa·s**	1000
2.419 088 329	**lbm/(ft·hr)**	0.413 378 870

APPENDIX III

VISCOSITY STANDARDS

Cannon S6

(example; see Calibration sheet)

Temperature (°F)	Viscosity (Centipoise)	Density (gm/cc)
77	7.86	0.873
122	3.77	0.854
212	1.45	0.822

Cannon S60

(example; see Calibration sheet)

Temperature (°F)	Viscosity (Centipoise)	Density (gm/cc)
77	104.1	0.873
122	29.77	0.858
212	6.23	0.826

DOW CORNING 200-5 FLUID

Temperature (°F)	Viscosity (Centipoise)	Density (gm/cc)
77	4.60	0.920
100	3.60	0.908
150	2.32	0.883
250	1.31	0.836

NORMAL HEXANE

Temperature (°F)	Viscosity (Centipoise)	Density (gm/cc)
77	0.311	0.655
100	0.277	0.644
110	0.263	0.639

PROPANE

Pressure (PSIA)	Temperature (°F)	Viscosity (cP)	Density (g/cc)
600	100	0.0905	0.485
800	100	0.0932	0.489
1000	100	0.0956	0.492
1500	100	0.1017	0.501

APPENDIX IV

VISCOSITY AND DENSITY CALCULATIONS

A. To convert centistokes to centipoise

Centipoise (cP) = Centistokes (cSt) x calculated density at temperature of test. That is:

Stokes = cm^2 / s	Poise = $g / cm\text{-}s$	$\Rightarrow$	$cSt = cP / (g / cm^3) \Leftrightarrow cP = cSt \cdot (g / cm^3)$
square centimeters per second	grams per centimeter-seconds		

B. To compute density at different temperatures

From D-C Silicone notes #200-5; fluid has density (specific gravity) of 0.920 at 77°F.

Coefficient of cubic expansion per $^{o}C = 10.5 \ x \ 10^{-4}$; per $^{o}F = 5.8 \ x \ 10^{-4}$

$$\rho = \frac{\rho \ (t = 77^\circ)}{1 + c \ \Delta \ t}$$

EXAMPLE:

$$(t = 100^\circ F) \Rightarrow \frac{0.920}{1 + \left[(5.8 \times 10^{-4})(+23)\right]} \Rightarrow \frac{0.920}{1.0133} \Rightarrow 0.908 \ \ g / cc$$

$$(t = 150 \ ^\circ F) \Rightarrow \ 0.883$$

$$(t = 250 \ ^\circ F) \Rightarrow \ 0.836$$

GLOSSARY OF TERMS

1. ADJUSTMENT, ANGLE - Process of changing the slope of an imaginary line along the length of the measuring barrel.
2. ASSEMBLY, TEST - That portion of an instrument which is used primarily in the final analysis of experimental events or activities.
3. BLEED - To let a fluid, liquid, or gas, escape under controlled conditions from a pipe, or container through a valve or outlet.
4. BOILING POINT, FLUID - The temperature at which the vapor pressure of the fluid equals the environmental pressure surrounding the fluid.
5. CALIBRATE - To determine by measurement or comparison with a standard, the correct value of each scale reading on a device or setting on a control knob so that a system will operate within a certain limit.
6. CELL, BATH - A process tank in which fluid samples are usually prepared for testing.
7. CENTIPOISE - A unit of absolute viscosity equal to 0.01 poise. A poise is a unit of dynamic viscosity equal to the dynamic viscosity of a fluid in which there is a tangential force, 1 dyne per square centimeter, resisting the flow of two parallel fluid layers past each other when their differential velocity is 1 centimeter per second per centimeter of separation.
8. CHANGE - To introduce or load a fluid material into a pressure chamber.
9. CONTINUITY, CIRCUIT - Continuous effective contact of components of an electric circuit to give a high conductance path by providing low resistance along the current flow path.
10. CORRECTION FACTOR, TEMPERATURE - A quantity added or subtracted to a calculated or observed temperature value to obtain the true value.
11. CURVE, CALIBRATION - A plot of calibration data giving the correct value for each indicated reading of a meter or control dial.
12. DATA, REPRODUCIBLE - Information that is duplicated with the same type measuring device.
13. DENSITY, FLUID-BALL - The mass of a given substance per unit volume.
14. EVACUATE - To remove a fluid or gas from an enclosure.
15. FLUID SINGLE-PHASE - The state of a substance, as a gas or liquid, but not in combination of the two.
16. FREQUENCY, BASE - The fundamental frequency from which all other required frequencies are derived.
17. GAS CHAMBER - The volume above the upper barrel support.
18. MEASURING JUNCTION - Usually as in thermocouples, the measuring junction is one of two points between which a thermo-electric voltage is developed and observed.

19. PVT SYSTEM - Set of precision instruments used for observing pressure, volume and temperature of a test sample.

20. REPEATABILITY, MEASUREMENT - The level of accuracy with which a system permits the operator to duplicate a measured value.

21. TEST CHAMBER - The volume inside and outside the test barrel filled from lower plug to the top of the upper barrel support.

22. VISCOSITY, RELATIVE - As distinguished from absolute, an index used to determine the actual viscosity value.

23. VISCOSITY STANDARD – A reference fluid used for calibration and verification of kinematic and dynamic viscosity test equipment.

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Please Send Us Your Comments on This Manual

Model Number _____ **Serial Number** _____

Printing Date of this manual (from the Title Page) _____

Please circle a response for each of the following statements. Use:

(1)= Strongly agree (2) =Agree (3) =Neutral, no opinion (4) =Disagree (5) =Strongly disagree

a) The manual is well organized. 1 2 3 4 5

b) I can find the information I want. 1 2 3 4 5

c) The information in the manual is accurate. 1 2 3 4 5

d) I can easily understand the instructions. 1 2 3 4 5

e) The manual contains enough examples. 1 2 3 4 5

f) The examples are appropriate and helpful. 1 2 3 4 5

g) The manual layout is attractive and useful. 1 2 3 4 5

h) The figures are clear and helpful. 1 2 3 4 5

i) The sections I refer to most often are _____

_____

Other comments _____

_____

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