INSTALLATION AND INSTRUCTION MANUAL

PHASE DYNAMICS, INC.

Water in Hydrocarbon Analyzer

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Document Number 0040-00000-000
Revision I

IMPORTANT NOTE

Your Phase Dynamics analyzer is a MATCHED SET of a measurement section and a computer. For proper operation, the following ID numbers of measurement section and computer **MUST BE** used together. The serial number is typically located on the end of the measurement section opposite the explosion-proof housing. The computer ID is located on the processor board of the computer chassis.

The MATCHED SET of your analyzer is:

Measurement Section S/N: _____

EPROM ID: _____

WARRANTY

This Phase Dynamics product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Phase Dynamics will, at it's option, either repair or replace products which are defective.

For warranty service or repair, this product must be returned to Phase Dynamics. Buyer shall prepay shipping charges to Phase Dynamics and Phase Dynamics shall pay shipping charges to return the product to the Buyer. However, Buyer shall pay ALL shipping charges, duties, and taxes for products returned to (or from) Phase Dynamics from (or to) a country other than the United States of America.

Phase Dynamics warrants that its software and firmware designated by Phase Dynamics for use with an instrument will execute its programming instructions when properly installed on that instrument. Phase Dynamics does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

EXCLUSIVE REMEDIES

The remedies provided herein are Buyer's sole and exclusive remedies. Phase Dynamics shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

This document is Revision I per Phase Dynamics Engineering Change Order Number 163.

PREFACE

SAFETY INFORMATION

THIS PRODUCT AND RELATED DOCUMENTATION MUST BE REVIEWED FOR FAMILIARIZATION WITH SAFETY MARKINGS AND INSTRUCTIONS BEFORE OPERATION.

SAFETY LABELS

WARNING
Denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION
Denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

This product is provided with a protective earth terminal, located on the power input board which is located under the front panel on the left side of the chassis.

BEFORE APPLYING POWER

Verify that the line voltage is appropriate for the analyzer and the correct fuse is installed. Refer to Installation section.

ELECTROSTATIC DISCHARGE

All of the printed circuit board assemblies of this system are susceptible to damage or failure from electrostatic discharge (ESD).

CAUTION
Protect circuit boards from ESD at all times.

SAFETY EARTH GROUND

WARNING
An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals. Using Neutral as Earth Ground may cause a potential shock hazard that could result in personal injury.

Any interruption of the protective grounding conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction), make sure the common terminal is connected to the earth pole terminal (neutral) of the power source.

Instructions for adjustments while covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform such adjustments or servicing unless qualified to do so.

For continued protection against fire, replace the line fuse only with a fuse of the same current rating and type (for example, normal blow or time delay). Do not use repaired fuses or short-circuited fuse holder.

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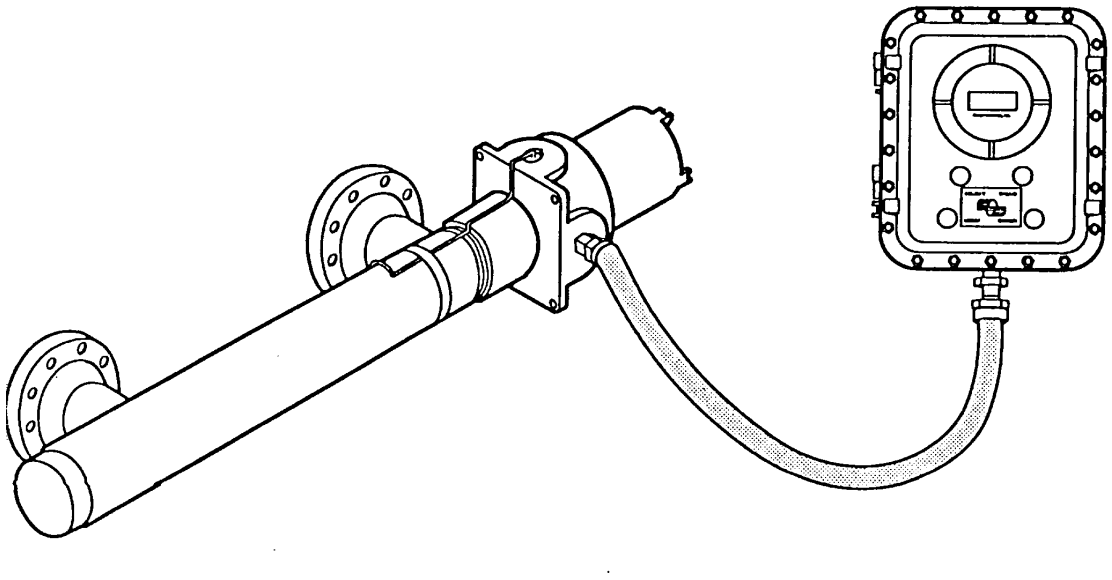
INSTALLATION AND INSTRUCTION MANUAL

PHASE DYNAMICS, INC.

Water in Hydrocarbon Analyzer



1. SPECIFICATIONS

SYSTEM

Power Requirements	120 VAC +15 / -25%, 60 Hertz or 230VAC +15 / -25%, 50 Hertz or 24 VDC +15 / -25%; typical 25 watts, 60 watts maximum at turn-on.
Range of Measurement	0 to 4%, 0-10%, or 0-20% water content with out-of-range error message
Alarm Contact Set-Point	Water content field-selectable with delay (zero to 300 seconds selectable)
Minimum detectability	400 ppm water in crude oil
Accuracy	+ / - 1% of scale
Repeatability	+ / - .05% of scale
Flowing Fluid Temperature	40° to 160°F; optional 220°F - high temperature unit.

ELECTRONICS UNIT

Ambient Operating Temperature	32° to 130°F
Storage Temperature	-50° to 160°F
Installation weight and size	See installation drawings in Appendix E
Shipping weight	Installation weight plus 10 pounds

MEASUREMENT SECTION

Ambient Operating Temperature	-10° to 130°F
Pressure rating	Up to 1,500 psig, depending on process connection
Storage Temperature	-50° to 160°F
Installation weight	See installation drawings in Appendix E
Shipping weight	Installation weight plus 15 pounds

FEATURES

- Wetted metal 316L stainless steel
- No moving parts for low maintenance
- Real-time measurement of water content
- Temperature compensated measurement for high accuracy
- Lightning protection at line voltage input
- Built-in self-diagnostic tests warn of any errors
- Two relay outputs; one for system errors, one for alarm contact set point
- Analog output (0-20 or 4-20 mA field selectable); 12-bit accuracy (4092 steps)
- RS-422 communication channel provided
- Net oil computer; accepts outputs of flowmeter (pulse or current, field-selectable) to give net oil, net water, and / or total fluid values.

OPTIONS

- Materials of construction (Duplex 2205, Carpenter 20, etc.)
- Process connections include: Threaded; ANSI 150, 300, or 600 flanges; others upon request
- Computer electronics enclosure: Cast aluminum (NEMA 4, 7 and 9); fiberglass (NEMA 4X); panel/rack mount.
- Extended ranges (i.e. 0 to 10% or 0 to 20% available)
- Power input voltage (230 VAC, 24 VDC, etc.)
- Heater circuit for electronics unit for cold weather operation
- Ceramic seal plugs for higher temperatures

2. SYSTEM OVERVIEW

2.1 Description

This Phase Dynamics analyzer measures the percentage of water in a flowing hydrocarbon liquid stream. The measurement technique is based on a principle known as oscillator load pull. The system is designed with no moving parts and is calibrated for the highest accuracy over a broad range of pressure, flow rate and temperature.

The system consists of three components as shown in Figure 2.1(a);

1) a measurement section,
2) an electronics unit, and
3) a system cable connecting the two.

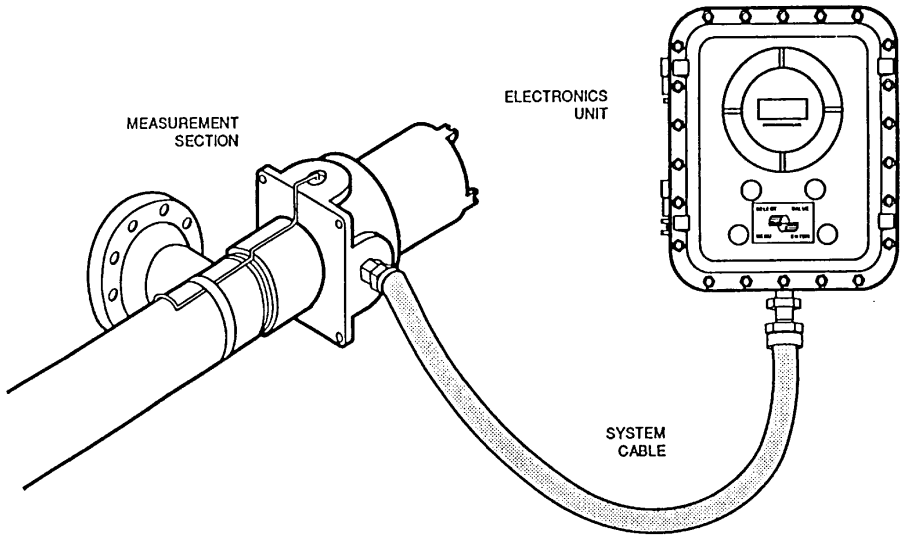


Figure 2.1(a) Phase Dynamics Load-Pull System for Measuring Water in Hydrocarbons

The measurement section, shown in Figure 2.1(b), is an assembly of;

1) a pipe section,
2) a temperature sensor, and
3) a microwave oscillator module mounted in a protective enclosure.

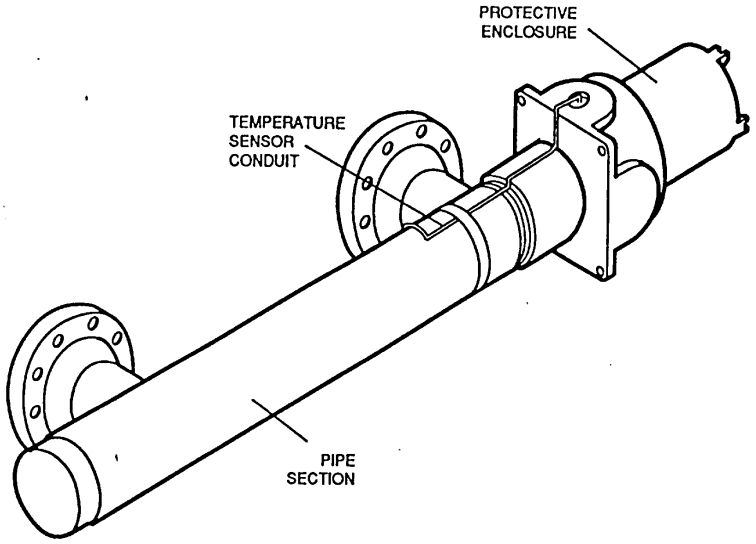


Figure 2.1(b) Measurement Section

The electronics unit is an application-specific computer which provides a variety of functions;

1) liquid crystal display,
2) four switches for operator interface,
3) input voltage regulation,
4) DC voltage for oscillator module, and
5) all input/output functions necessary for proper operation.

The system cable provides the "link" over which the electronics unit provides the necessary voltages to the oscillator module. The oscillator also sends the appropriate signals of frequency, temperature, and reflected power to the computer for calculation of water content.

2.2 Typical operation

Under normal conditions, the analyzer's operating sequence may be described by the following chain of events.

The input voltage is converted to the necessary DC voltages. At turn-on, the electronics unit performs a set of self-diagnostic tests to assure functionality. The power supply provides 15 and 30 VDC to the oscillator module: 15 V to the oscillator and 30 V to a heater which maintains the oscillator at 160° F. This eliminates any frequency drift due to circuit temperature changes which could result in errors in water content. A 5 V supply operates the electronics unit's digital circuitry.

The fluids flowing through the pipe section act on the un-buffered microwave oscillator to force a change in its natural frequency of oscillation.

The temperature sensor is inserted directly into the liquid stream through the pipe wall of the saddle nearer the microwave oscillator. The sensor's wires, enclosed in stainless steel tubing, transmit this signal to the oscillator module and then on to the electronics unit.

The oscillator's reflected power signal is measured. This information is used to determine an out-of-range condition. Inside the oscillator module, frequency counting and division circuits lower the microwave signal to a frequency which can be transmitted over the system cable's shielded twisted pair.

The frequency, temperature, and reflected power signals are transmitted via the system cable from the oscillator module to the electronics unit. These signals are routed to the microprocessor where a temperature-compensated water content is calculated from the factory-derived coefficients.

Simultaneously, a signal proportional to water content appears at the analog loop transmitter and the LCD provides an instantaneous readout of the calculated water content and measured temperature.

The frequency measurement cycle is repeated approximately once per second to provide an instantaneous, continuous, and real-time measurement of water content.

While the continuous measurement of water content is going on, the electronics unit periodically executes self-diagnostic checks to determine if any functional aspect of the system is in error. Occasionally, the LCD will show the various tests being checked and passed (Checking EPROM, Checking SRAM, Checking INTRAM, etc.)., These self-diagnostics tests are completed "in the background" and in no way affect the fundamental measurement or calculation of water content.

If at any time any system error is detected, two things happen:

1) the LCD exhibits the specific ERROR message, and
2) the ERROR relay contact closes.

The four switches labeled "MENU", "SELECT", "VALUE", and "ENTER" allow the operator to access a variety of parameters and coefficients. The value for these parameters may be changed and entered into the operating memory of the system to provide proper outputs and accurate water content measurements.

2.3 Principle of operation (oscillator load pull)

Phase Dynamics' analyzers achieve superior performance by utilizing microwave oscillator load pull. Load pull is the term given to describe the frequency change of an un-buffered oscillator as its output load varies. Circuit components and the external load impedance determine an un-buffered oscillator's frequency. The permitivity of the materials in the measurement section, through which the microwaves propagate, determine the output load. For low-loss materials such as low water content crude oil, the dielectric constant approximates the permitivity of the emulsions.

The measurement section is a small solid rod mounted inside a larger diameter pipe, as shown in Figure 2.3(a). One end of the rod is connected to an un-buffered oscillator and the other end connects to the center of a welded "shorting" plug. Electrically this pipe and rod combination is a coaxial transmission line, terminating into a short circuit. The fluids flow through the measurement section via the connections that mount perpendicular to the run section, one at each end. The microwave signal travels the length of the pipe twice; down the pipe from the oscillator, then totally reflects at the shorting plug and traverses back to the oscillator module.

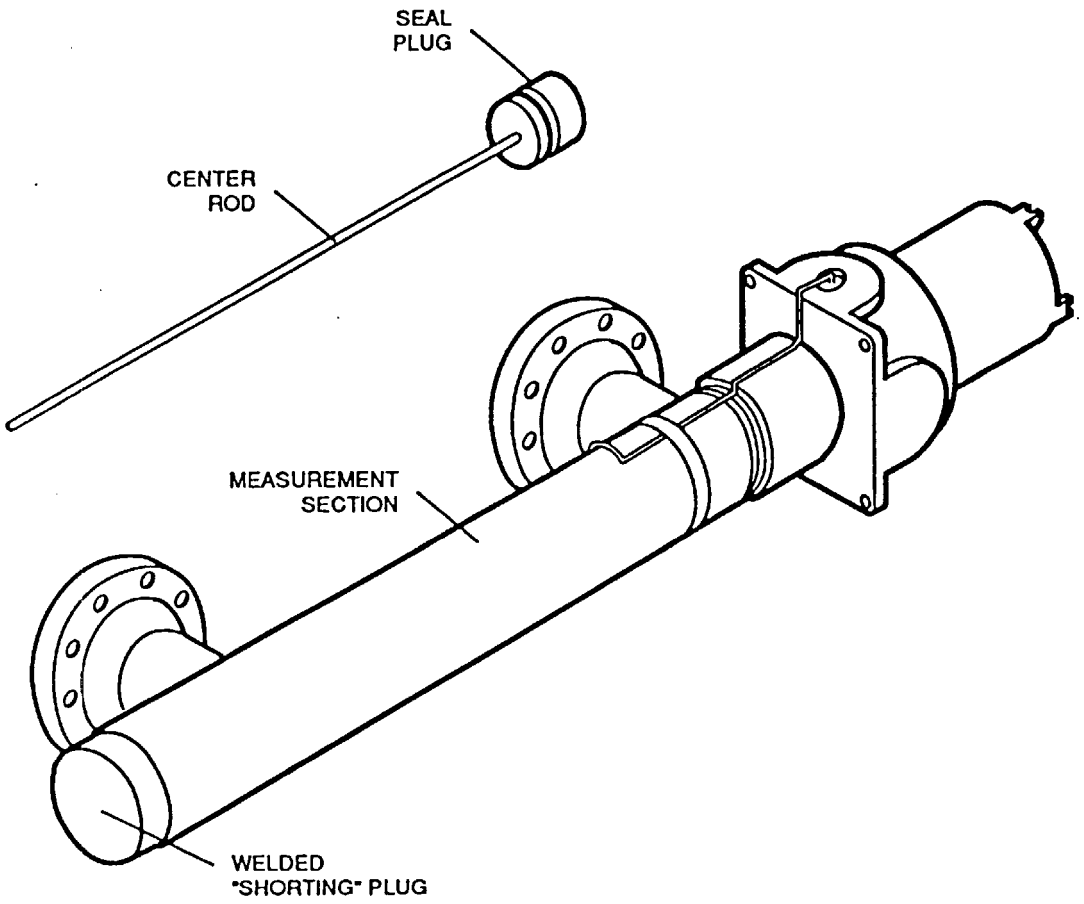


Figure 2.3(a) Measurement Section and Center Rod

Primarily the dielectric constant of the emulsion in the pipe section determines the un-buffered oscillator's frequency. There is a large difference in the relative dielectric constant of oil (2.2) and water (68). This large dielectric difference results in the design of an instrument of manageable size and a reasonable oscillator frequency. The dielectric constant of the fluid is proportional to the water-to-oil ratio in the measurement section. As the complex load impedance changes, due to a change in the percentage of water in the oil, the frequency of the oscillator changes. The frequency and the fluid temperature are continuously measured. These values are used to calculate the water content.

In summary, the permitivity of the oil-water emulsion in the pipe section provides a complex impedance, or load. The load acts directly upon the un-buffered oscillator to force a predictable, repeatable, and precise change in frequency. This frequency is proportional to the water content of the emulsion. The microprocessor uses the measured frequency to calculate and update the water content each second.

3. INSTALLATION

3.1 Pre-installation notes

The materials of construction for Phase Dynamics' analyzer are capable of withstanding a wide variety of harsh environments. The pipe section itself is made of standard pipe and flanges used on a routine basis for the industry serviced. The microwave oscillator is assembled in a protective housing which is then completely enclosed in an explosion-proof junction box, provided with a screw-on cap for access. The individual printed wiring boards of the electronics unit are mounted on a protective aluminum chassis. This chassis is then mounted and protected in either a cast-aluminum explosion-proof enclosure (rated NEMA 4,7, and 9) or a fiberglass enclosure (rated NEMA 4X) which is rain-tight, dust-proof, and corrosion resistant. A rack mount version is available as an option.

The ambient operating temperature of the electronics unit is specified as 32° to 130°F. For proper operation, the electronics should not be cooled below 32°F. The electronics enclosure should be mounted to avoid exposure to prevailing winds in freezing climates. An optional heater circuit is available for continuous cold weather operation. Conversely, the enclosure should be mounted in a shaded area to avoid direct sunlight for geographic regions where ambient temperatures are above 100°F. Both the explosion-proof and fiberglass enclosures are rated as watertight.

The measurement section is rated for AMBIENT temperatures from -10° to 130°F (maximum FLUID temperature 160°F). The oscillator module contains a miniature heater circuit to maintain the critical circuit at 160°F. The junction box protecting the oscillator module is provided with an O-ring for the screw-on cap and forms a watertight seal.

3.2 Mounting considerations

3.2.1 Measurement section

The preferred orientation of the measurement section is horizontal with the fluid connections in a plane parallel to the ground. Fluid flow comes into the connection closest to the oscillator and exits the other port. For best results, liquid flow in the measurement section should be turbulent to keep the oil/water mixed and to "flush" any gas or water accumulation in the pipe section. (A static mixer may be necessary for very low flow rates; it is not necessary for high flow rates.)

If free gas is present in the liquid stream, the output should be mounted higher than the input to allow the gas to escape the pipe section. Gas tends to decrease the calculated water content.

For slip-stream applications, verify that the fluids flowing through the measurement section precisely represent the fluids of the main stream. For best results in slip-stream plumbing, the input line-pipe should be the same diameter, or smaller, as that of the measurement section.

While the above guidelines are the preferred orientation, field experience has verified the accurate measurement of water content for a variety of mounting schemes, including vertical, either end up, horizontal, flanges up or down, and the measurement section "on its side". The most important points to keep in mind are:

4) well-mixed water and oil in the measurement section,
5) turbulent flow,
6) zero gas content (or, at least, long term constant gas content), and
7) representative emulsions in slip-streams.

3.2.2 Electronics unit

CAUTION
The electronics unit is mounted relatively close to the measurement pipe section. A system cable of 20 feet is supplied to connect the two. Longer system cables (up to 100 feet) are available from Phase Dynamics, if required. Phase Dynamics recommends the use of one single cable; DO NOT splice cables together!

The viewing angle of the LCD, located on the front control panel, is adjustable from perpendicular to 30 degrees above perpendicular. As such, the enclosure should be mounted about five feet above the ground. Ease of viewing, convenience of wiring, and simplicity of operation are the only restrictions in orientation of the electronics enclosure.

3.3 Installation drawings

Detailed installation drawings are included with each system to assist in preparation of mounting and installation. Refer to the appropriate drawings for installation of your particular system.

3.4 Basic electrical hook-up

Mount the electronics unit and the measurement pipe section according to the appropriate installation drawing.

WARNING
The Phase Dynamics system does not include an internal on/off switch for the input power. During the routine installation and field calibration it may be convenient to turn off power to the unit occasionally. It is recommended that a user-supplied on/off switch be installed prior to entry into the electronics enclosure.

Wire the main power to the connector on the Power input board on the left side of the chassis under the front control panel, as shown in Figure 3.4(a). The wire size may be from 18 GA to 14 GA. For 120 VAC systems, typical power consumption is 25 watts (fused at 3/4 Ampere); maximum 60 watts at turn-on.

WARNING
An uninterruptible safety earth ground MUST BE provided from the main power source to the Power input board terminal marked EARTH GROUND.

Failure to provide EARTH GROUND may cause a shock hazard that could result in personal injury. Also, the instrument may be damaged and will not operate properly - the warranty is voided.

Connecting NEUTRAL to EARTH GROUND is NOT sufficient for safety earth ground.

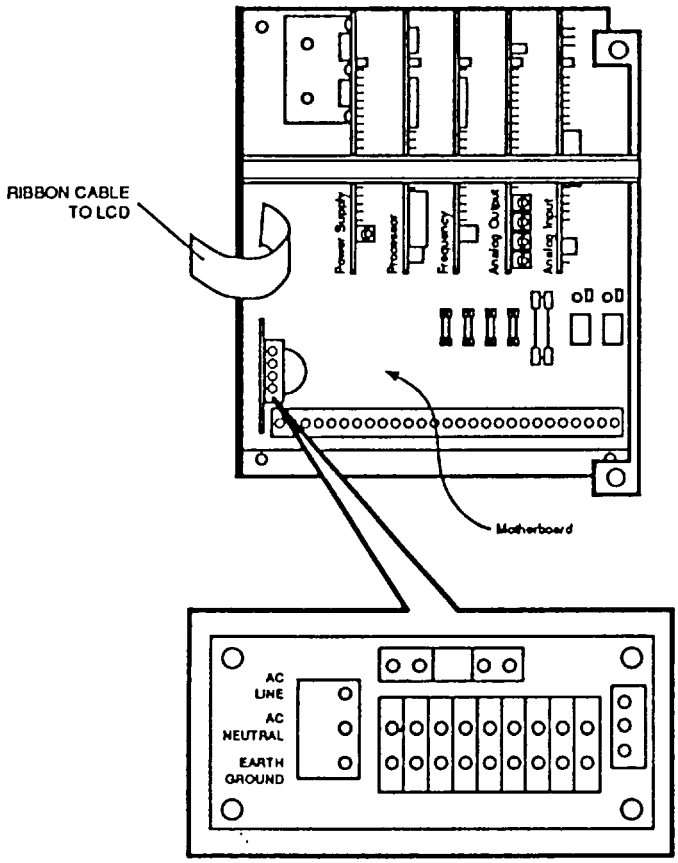


Figure 3.4(a) Power Input Board for AC Voltages

Connect the electronics unit to the oscillator module with the system cable, as shown in Figure 3.4(b). A factory-installed circular connector is soldered to one end of the cable while the other end requires stripping the individual wires. This circular connector fits through the threaded hole of the enclosure protecting the oscillator module and then is connected to the mating circular connector at the rear of the oscillator module.

Each Phase Dynamics analyzer is equipped to measure the process stream temperature with a four-wire RTD. Verify that the wires of the temperature probe are connected properly to the terminal strip on the end of the oscillator module.

Connect the four-wire RTD as follows:

Wire Color	Terminal ID	Wire Function
Red	P+	RTD drive high
Red	P1	RTD sense high
Black	P2	RTD sense low
Black	P3	RTD drive low

Table 3.4(1). RTD Temperature Sensor Connections

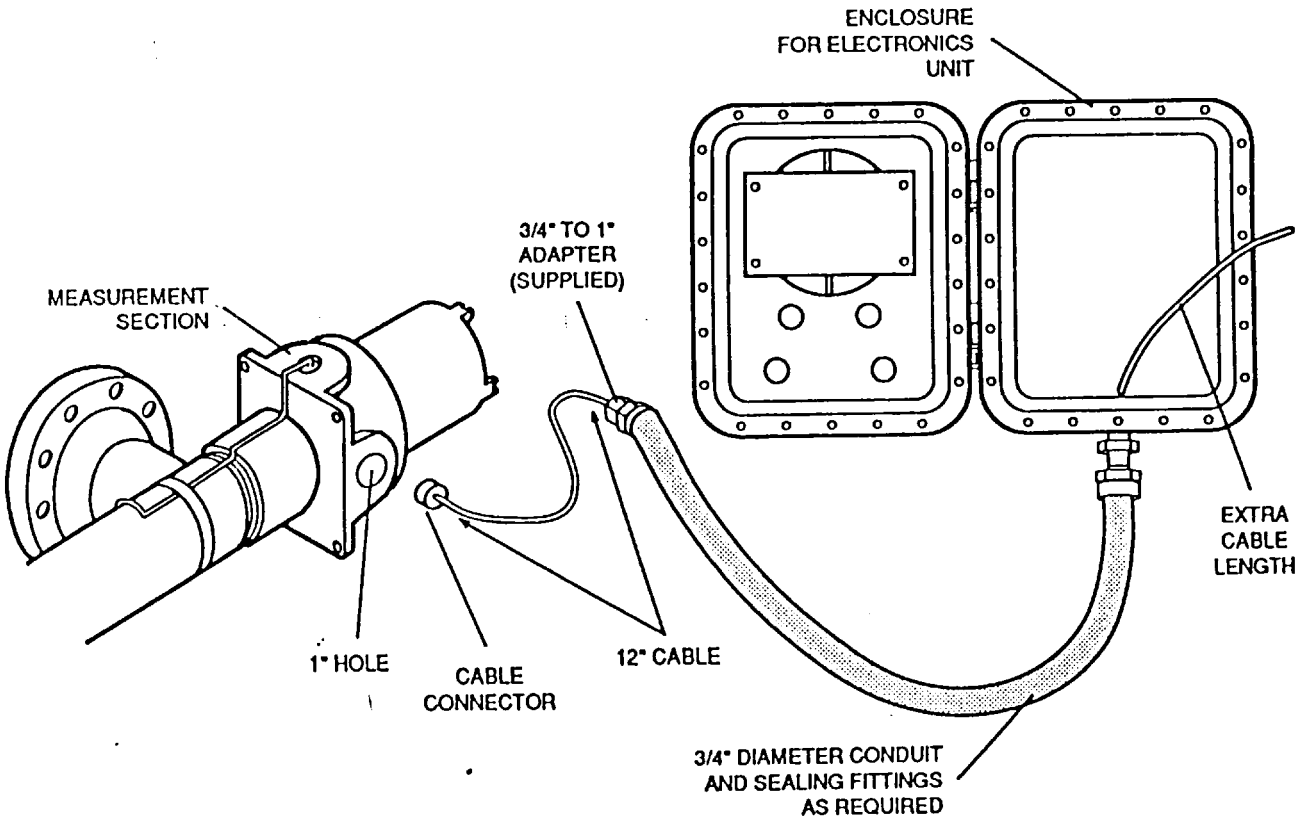


Figure 3.4(b) System Cable Installation

Install conduit between the measurement section and the electronics unit. The use of a conduit union near the measurement section is recommended to allow future measurement section removal without cutting the system cable. Pull the system cable through the conduit from the measurement section end to the electronics unit end. Cut the excess cable length and strip the individual wires. Connect the wires to the terminal block of the electronics unit according to Table 3.4(2). The terminal block is located under the front panel at the lower edge of the motherboard, as shown in Figure 3.4(c).

Once connected, the Phase Dynamics system is ready for operation.

Terminal Number	Wire Color	Terminal Description	Wire Function
15	White/Yellow	EXTUNE	Used in troubleshooting
16	White/Green	VTUNE	Used in troubleshooting
17	Yellow	OSCSEL	Oscillator select
18	Drain from White/Red & White/Orange twisted pair	GND	Ground
19	White/Red	FREQ+	Oscillator frequency +
20	White/Orange	FREQ-	Oscillator frequency -
21	White/Brown	P+	Temp. probe drive high
22	White	P1	RTD sense high or signal
23	Grey	P2	RTD sense low
24	Violet	P3	RTD drive low
25	Blue	VREF	Reflected power
26	Green	VINC	Incident power
27	Brown	GNDSEN	Ground Sense
28	Orange	HTR	Heater voltage, 24-36 VDC
29	White/Black	HTR RTN	Ground
30	Red	+15V	+15 VDC supply
31	Black and Drain from Brown & White/Green twisted pair	GND	Ground

Table 3.4(2) Wiring Table

Wires not used (cut short):

White/Blue
White/Violet
White/Grey
Drain from White/Violet & White/Grey twisted pair

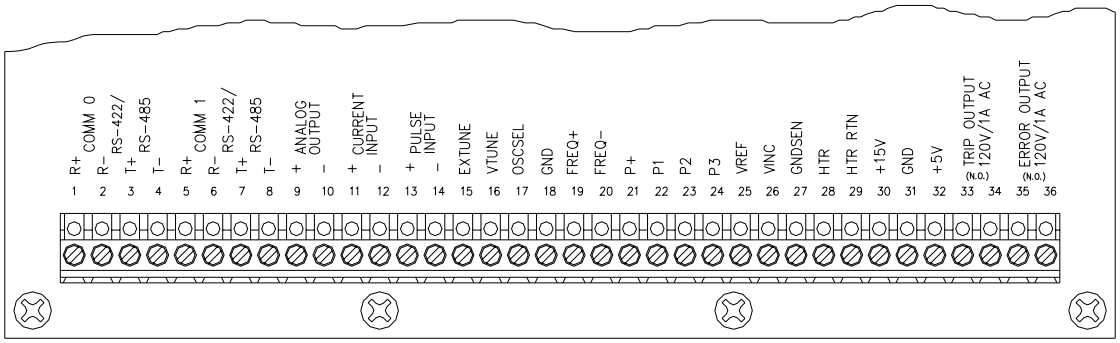


Figure 3.4(c) Terminal Block for Wire Connections

3.5 Connection of features and options

Each system includes these standard features:

1) Isolated analog output for water content,
2) Relay output for alarm contact set point,
3) Relay output for any system error,
4) RS-422 interface, and
5) Net oil computer, requiring a user-supplied flowmeter input. The input is NON-ISOLATED, so the system and flowmeter should be powered from the same input voltage to keep ground common.

The wiring connections for feature and options are summarized in Table 3.5(1).

Feature	Terminal Numbers	Terminal Description
Analog output	9, 10	Analog output, + and -
Alarm relay	33, 34	Trip output, 120V/1A AC
Error relay	35, 36	Error output, 120V/1A AC
RS-422	1, 2, 3, 4, 5, 6, 7, 8	Comm 0(1) RS-422/RS-485
Current input	11, 12	Current input, + and -
Pulse input	13, 14	Pulse input, + and -

Table 3.5(1) Connecting Feature and Options

3.5.1 Analog output (4-20 mA or 0-20 mA)

The analog output is a current proportional to water content. The output is **SELF-POWERED** and **ISOLATED** from any system ground. The current range and the end-point water content values are user-definable.

The terminal connections are located on the motherboard and are marked ANALOG OUTPUT, + and -.

Connect the remote loop receiver's (supplied by user) positive terminal to the transmitter's positive and negative to negative. When using a shielded cable, connect the shield to the negative terminal at the transmitter end and leave it open at the receiver end.

The maximum allowable loop resistance for the current loop output, 4-20 or 0-20 mA, is 600 Ohms.

3.5.2 Alarm relay output

This relay provides contact closure (rated 1 Ampere, 120 VAC) when the system's water content exceeds a user-defined limit for a user-defined period of time (Time Delay).

The terminal connections are located on the motherboard and are marked TRIP OUTPUT, 120V/1A AC.

3.5.3 Error relay output

This relay provides contact closure (rated 1 Ampere, 120 VAC) when any system error is detected by the electronics unit. An audio or visual alarm may be connected to this relay to warn the user of a system error. The specific ERROR message will be displayed on the LCD of the front control panel. Specific errors detected include Error Messages 3, 4, 7, 8, 9, 10, 14, 15, 16, and 17, as defined by the Comprehensive List of Error Messages.

The terminal connections are located on the motherboard and are marked ERROR OUTPUT, 120V/1A AC.

3.5.4 RS-422 interface

The Phase Dynamics analyzer system is provided with an RS-422 communication channel with a 4000 foot range.

For details concerning the RS-422 channel, please refer to Appendix A.

The terminal connections are located on the motherboard and are marked Comm 1 RS-422/RS-485.

3.5.5 Current input

The current input may be used as a flowmeter input to provide a current proportional to the flow rate. The input is **NOT SELF-POWERED** and it is **NOT ISOLATED** from system ground.

When used as a flowmeter input, the net oil feature combines the measured water content and the output of a user-supplied flowmeter to provide total fluid, net oil, or produced water values. The input is a current proportional to rate with field-selectable ranges of 0-20 or 4-20 mA and field-selectable maximum flow rate values. Zero or 4 mA always represents zero flow rate.

The terminal connections for current input are located on the motherboard and are marked CURRENT INPUT, + and -.

3.5.6 Pulse input

The pulse input is used as a flowmeter input to provide a pulse per unit of volume fluid. The net oil feature combines the measured water content and the output of a user-supplied flowmeter to provide total fluid, net oil, or produced water values. The input is a frequency proportional to rate with field-selectable values.

The terminal connections for pulse input are located on the motherboard and are marked PULSE INPUT, + and -.

4. GENERAL OPERATION AND INITIAL START-UP

Four modes of operation are available with this Phase Dynamics analyzer; Normal, Supervisor, Technician, and User-defined Mode. Each mode provides certain features and parameters to the user for change or modification. The two position DIP switch located at the edge of the microprocessor board determines the particular mode in which the system is currently operating. The location of the DIP switch is as shown in Figure 4(a). The two white switches are clearly marked on the body of the switch, "1" and "2".

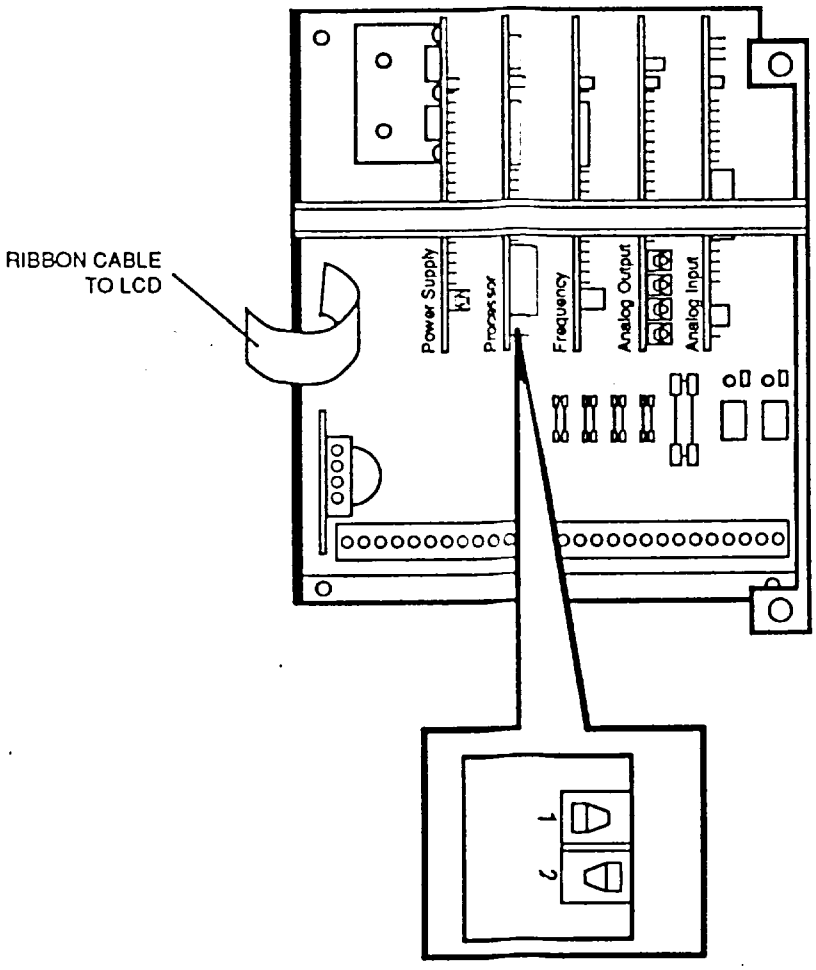


Figure 4(a) Location of Two-Position DIP Switch

Table 4(1) below defines the position of the two switches for the four available modes of operation:

Mode of Operation	Switch 1 Location	Switch 2 Location
Normal	right	right
Supervisor	right	left
User-defined	left	right
Technician	left	left

Table 4(1) Accessing the Four Modes of Operation

The Phase Dynamics load-pull system may be operated safely and properly for any length of time in any of the four modes. The particular mode of operation is chosen by the user and is typically determined by the specific conditions for a given installation.

4.1 User interface switches and functions

The four user interface switches are labeled "MENU", "SELECT", "VALUE", and "ENTER". These control keys allow the user to interact with the electronics unit to complete a variety of tasks including scaling of outputs, adjusting calibration factors, and modifying factory coefficients.

The MENU key scrolls through the list of MENU items. Each time MENU is pressed a new item is displayed until all items have been shown and the normal display returns. To return to the top of the MENU list, simply press and hold MENU for approximately two seconds.

The SELECT and VALUE keys change the value of the selected menu item. Pressing SELECT moves a blinking cursor to the digit of the parameter to be changed. The VALUE key increments the digit's value by one each time VALUE is pushed. Once the digit's value is nine, the next time VALUE is pushed, the digit's value becomes zero and increments to nine again.

The ENTER key stores a changed value for the selected menu item. Once ENTER has been pushed, the new value is stored and THE OLD VALUE IS LOST.

NOTE: The ENTER button must be pushed to store a new parameter's value, otherwise the desired new value is ignored and the last valid value is retained.

Each time the ENTER button is pushed, the new value is stored and the next menu item is displayed.

Pressing two or more of the switches simultaneously or pressing any key out of sequence, will result in a "Switch Error" message on the LCD. All switches must be released to allow the system to recover to normal operation; no changes were entered.

4.2 Initial start-up

After installation, verify that switch 1 and 2 are to the right to access the Normal Mode. Apply power and observe the LCD. The following series of tests is executed at power on and any errors will be reported;

1) POWER,
2) EPROM,
3) EEPROM,
4) INTRAM,
5) SRAM, and
6) Analog Input Calibration.

Note any ERROR message and refer to the comprehensive list of ERROR messages found in Section 7.

Once the self tests are completed, the display will show the calculated water content and measured temperature, as shown in Figure 4.2(a). Throughout the Normal Mode of operation, the self-diagnostic testing will continue and messages sent to the LCD. This testing is completed "in the background" and in no way interferes with or interrupts the basic measurement of water content. If a system error is detected the appropriate ERROR message will be displayed; hardware related system errors cause the error relay's contacts to close.

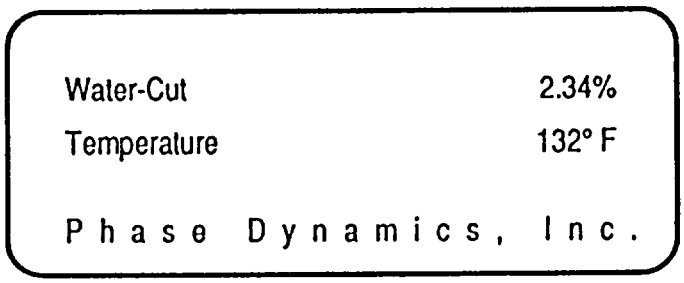


Figure 4.2(a) Normal Mode Display, Flow Input Disabled

Figure 4.2(a) shows the Normal Mode display for the as-delivered factory default condition with Flow Input Disabled (no fluid volumes shown). The Normal Mode display for Flow Input Enabled will look slightly different, as shown in Figure 4.2(b).

For this condition, the selected fluid totals are displayed, in addition to the water content and measured temperature.

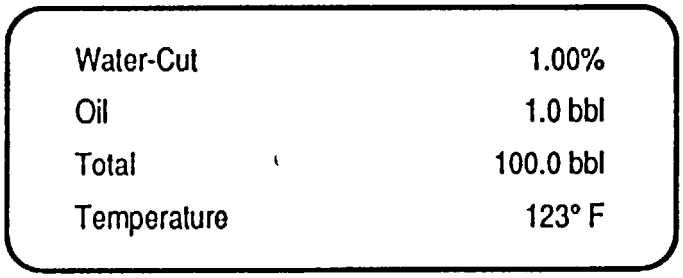


Figure 4.2(b) Normal Mode Display, Flow Input Enabled

4.3 LCD adjustments

Both the background lighting and viewing angle of the LCD are adjustable. Two potentiometers, located on the back of the LCD circuit board [see Figure 4.3(a)] are used for adjustment.

R1 adjusts for background lighting. It should be set as low as possible while allowing easy reading in reduced light.

R3 adjusts the viewing angle from zero to 30 degrees above perpendicular.

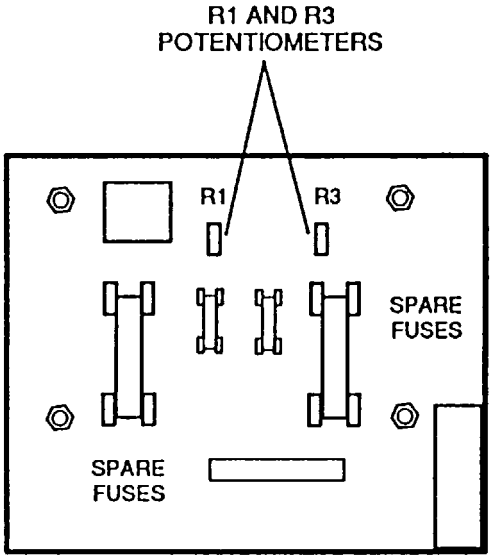


Figure 4.3(a) Display Board Showing R1 and R3 Potentiometers

5. MODES OF OPERATION

The four modes of operation include Normal, Supervisor, Technician, and User-defined Modes. Each of these modes provides a different set of parameters and features which may be helpful to the user.

The Normal Mode contains a list of the most common and useful MENU items for proper operation of the system. This is the mode the instrument is in when delivered from the factory.

The Supervisor Mode provides one function; the MENU items to appear in the User-defined Mode are selected by the user.

The User-defined Mode is a mode containing a subset of Normal Mode MENU items which have been identified by the system supervisor. This may be helpful if the user would like the ability to change or modify a specific set of coefficients or values without having to step through the entire list of MENU items of the Normal Mode. For example, the User-defined Mode may contain only the Cal Factor value and the Alarm Contact Set Point. The user-defined MENU items for this mode are defined while in the Supervisor Mode.

The Technician Mode is a universal mode; the values of all parameters and coefficients may be displayed, one item at a time. The values for all field-selectable parameters may be changed while in the Technician Mode. The Technician Mode also includes the capability to reset all coefficients to their factory default values.

5.1 Normal Mode

5.1.1 Accessing the Normal Mode

The Normal Mode is accessed when both switches 1 and 2 of the dual DIP switch, located at the edge of the microprocessor board, are moved to the right.

CAUTION
Steps should be taken to eliminate any static charges on your hands or tools so as not to damage any surrounding electrical components when changing the switch positions. Also, since both switches are fairly close to each other, care should be taken to open or close only the necessary switch.

5.1.2 MENU items for the Normal Mode

For each MENU item that is field selectable, the LCD will display the UPPER and LOWER limits which are allowed for that item. If a user-selected value which is out of range is "ENTER"-ed, the display will prompt "Value Out of Range" and will return the item's value to the last valid value.

To advance to the next MENU item without changing its value simply press MENU.

To return to the Normal Mode Display (and the top of the list of MENU items), simply press and hold MENU for approximately two seconds.

Following are the MENU items in the order which they are accessed in the Normal Mode. Included is a brief description of the item and the factory-supplied default value (shown in [ ]).

Cal Factor [0.00%]; Calibration Factor; A calibration factor (+ or -) may be added to the calculated water content to compensate for the difference between field and factory conditions,

Displayed water content =
Calculated water content + Cal Factor.

SELECT and VALUE change the value. ENTER stores the desired value.

The analog loop output current also includes the Cal Factor value, as does the RS-422 value for process value.

Alarm Point [4.00%];	Alarm set point; Water content values greater than (or less than) this value cause the alarm relay contacts to close. However, the water content value must have been greater than (or less than) the set point for a period of time determined by Time Delay. Once the Set Point has been entered, the system will ask "Greater than" or "Less than" the Set Point value. SELECT toggles between the two conditions, ENTER stores the chosen direction. Thus, the alarm condition will occur for a measured water content value above or below a given value, as determined by the user.
Time Delay [0 sec];	The amount of time that the water content value must be above (or below) the Alarm Set Point before closing (or opening) the alarm relay contacts (sometimes referred to as "dead band"). SELECT and VALUE change the value. ENTER stores the desired value.
Zero Counters;	Requires flowmeter input. Press ENTER to reset all fluid volumes to zero. If Flow Input is Disabled, this MENU item will not be displayed.
Alternate Display [Normal Mode Display];	Press SELECT to toggle between Normal Mode display, Figure(s) 4.2(a) or 4.2(b), and the Alternate Display, which is similar to the Technician Mode display, Figure 5.4.2(a). ENTER selects the desired display. Use of the Alternate Display is helpful when recording the measured values of oscillator frequency, reflected power, and temperature during instrument setup or troubleshooting. After five minutes, the system will automatically return to the Normal Mode display.
Flow Input [Disabled];	Flowmeter input option. The SELECT switch toggles between Flow Input Disabled, Pulse Flow Input, 0-20 mA Flow Input, and 4-20 mA Flow Input. Press ENTER to execute the desired Flow Input. If any of the three flow inputs are ENTER-ed, the user will be asked to define four items; units of volume, minimum flow rate, maximum flow rate, and displayed volumes.

To choose the UNIT of volume, press SELECT to scroll through the choices of barrels, gallons, or liters. Press ENTER to execute the desired UNIT.

For Pulse Flow Input selected, the default value is 15,000 pulses; this represents one UNIT of total fluid [15,000 pulses/UNIT]. Zero pulses represents zero flow rate. For 0-20 mA or 4-20 mA Flow Input selected, the default flow rate for minimum current input, 0 or 4 mA, is zero [0 UNITs/day]. The default flow rate for maximum current input, 20 mA, is 5,000 UNITs/day [5,000 UNITs/day].

The SELECT and VALUE buttons change the default values for minimum and maximum flow rates. ENTER stores the desired values.

Next, the user may choose the desired fluid volumes to be displayed on the LCD. All volumes are displayed are in the user-selectable UNIT of volume.

Press SELECT to scroll through the choices of OIL and WATER, OIL and TOTAL, or WATER and TOTAL. Press ENTER to display the desired combination of totalized fluids.

Temp Adjust [0.0°F]; Temperature Adjust; A calibration factor (+ or -) may be added to the measured temperature for improved accuracy, i.e.,

Adjusted Temp = Meas. temp + Temp Adj.

The Adjusted Temp value is always displayed and used in all temperature compensation calculations.

SELECT and VALUE change the value. ENTER stores the desired value.

Analog Output [4-20 mA]; SELECT toggles the analog output loop between the ranges of 4-20 mA or 0-20 mA. ENTER stores the desired range.

4 mA (or 0 mA) [0.00%]; The minimum analog loop current represents zero water content.

SELECT and VALUE change the value. ENTER stores the desired value.

20 mA [1.00%];	The factory default value for maximum analog loop current represents 1.00% water content. SELECT and VALUE change the value. ENTER stores the desired value.

5.2 Supervisor Mode

5.2.1 Accessing the Supervisor Mode

The Supervisor Mode is accessed when switch 1 of the dual DIP switch, located at the edge of the microprocessor board, is moved to the right and switch 2 is moved to the left.

CAUTION
Steps should be taken to eliminate any static charges on your hands or tools so as not to damage any surrounding electrical components when changing the switch positions. Also, since both switches are fairly close to each other, care should be taken to open or close only the necessary switch.

5.2.2 Supervisor Mode display

The initial display for the Supervisor Mode is the same as that of the Normal Mode. Two displays are available, one for Flow Input Disabled and one for Flow Input Enabled. To proceed from the initial display to the definition of MENU items for the User-defined Mode, press MENU.

5.2.3 Defining the MENU items for the User-defined Mode

The Supervisor Mode is used to define the MENU items which are available in the User-defined Mode. The display includes four lines of text;

Line 1 - will show "Defining User Mode",
Line 2 - will show "Present status of",
Line 3 - will show the current MENU item under consideration, and
Line 4 - will show "is: ENABLED" or "is: DISABLED".

Defining the MENU items for the User-defined Mode is straightforward. The display will show each MENU item of the Normal Mode, one at a time. For each item, the system will ask the user which items are to be included in the User-defined Mode. Once "ENABLED", only those chosen MENU items are available for access and change when in the User-defined Mode.

The User-defined Mode may be redefined at any convenient time by accessing the Supervisor Mode and selecting from the complete list of MENU items. At all times the Supervisor Mode shows the current status of each MENU item of the User-defined Mode.

For each MENU item, the display will prompt;

1) Present status is ENABLED, or
2) Present status is DISABLED.

SELECT toggles between the choice of ENABLED or DISABLED for the specific item being displayed; ENTER will direct the system to execute the desired choice and move to the next MENU item.

If the current status shown is acceptable, press MENU to move to the next MENU item. The total list of MENU items from which to choose include the items of the Normal Mode. The complete list is repeated here;

1) Cal Factor,
2) Alarm Point,
3) Time Delay,
4) Zero Counters,
5) Flow Input,
6) Temp Adjust,
7) Analog Output,
8) 4 mA (or 0 mA) Value, and
9) 20 mA Value.

Note: The MENU item, Alternate Display, does not appear in the above list; it is the only permanent MENU item of the User-defined Mode and may not be removed.

5.3 User-defined Mode

5.3.1 Accessing the User-defined Mode

The User-defined Mode is accessed when switch 1 of the dual DIP switch, located at the edge of the microprocessor board, is moved to the left and switch 2 is moved to the right.

CAUTION
Steps should be taken to eliminate any static charges on your hands or tools so as not to damage any surrounding electrical components when changing the switch positions. Also, since both switches are fairly close to each other, care should be taken to open or close only the necessary switch.

While in User-defined Mode the display will be the same as Normal Mode. The MENU will contain only those items that are enabled through the Supervisor Mode.

5.4 Technician Mode

5.4.1 Accessing the Technician Mode

CAUTION
Steps should be taken to eliminate any static charges on your hands or tools so as not to damage any surrounding electrical components when changing the switch positions. Also, since both switches are fairly close to each other, care should be taken to open or close only the necessary switch.

The Technician Mode is accessed when both switches 1 and 2 of the dual DIP switch, located at the edge of the microprocessor board, are moved to the left.

5.4.2 Technician Mode display

While in the Technician Mode, the LCD will display different parameters than those shown during normal operation. The Technician Mode display is as shown in Figure 5.4.2(a).

The parameters displayed are defined as follows:

Water	Displayed water content value, including Cal Factor and Index (%).
Freq	Frequency, oscillator frequency, as measured by frequency board (MHz, or Mega Hertz).
Ref Pwr	Reflected Power, voltage indicative of signal level reflected from the measurement section (Volts).
Temperature	Fluid temperature, including Temp Adjust (°F).

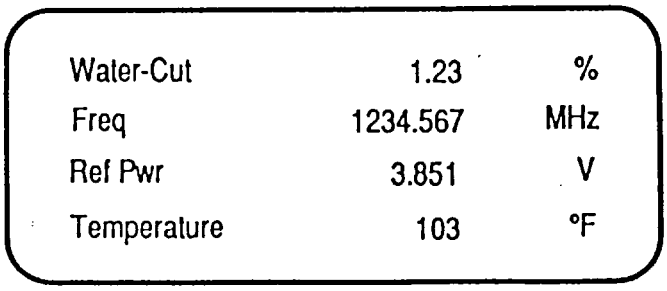


Figure 5.4.2(a) Technician Mode Display

5.4.3 MENU items for the Technician Mode

The Technician Mode MENU includes the capability to view ALL of the coefficients and parameters which are necessary for proper operation of the system. In this universal mode, the user can view the current values for all coefficients and parameters and can change them.

The list of MENU items is given below in the order in which they appear along with a brief description of each. Some items are also found in the Normal Mode, some are found in the Technician Mode only. The order in which the items appear in this mode are not necessarily the same as that of the Normal Mode. Normal Mode MENU items are not described again.

The MENU items of the Technician Mode and factory default values (shown in [ ]) are;

Cal Factor [0.00%]; See Normal Mode.

Alarm Point [4.00%]; See Normal Mode.

Reference Current [4mA]; The user may select a current value between 0 and 20 mA, or 4 and 20 mA, in order to establish the zero and span of output devices such as chart recorders. See Reference current section.

Modify K-constants; Allows the user to change the values of the K-constants relating measured oscillator frequency to process value.

Press ENTER to change K-constants. Press MENU to proceed to next menu item.

For each factory calibration temperature, there is a set of K-constants.

To change the value of a K-constant, the user must first choose a calibration temperature. SELECT scrolls through the available temperatures. ENTER chooses the desired temperature.

Next, MENU scrolls through the K-constants which correspond to the ENTER-ed temperature, one at a time. SELECT and VALUE change the value. ENTER stores the new value.

After each set of K's, the system returns to the calibration temperatures. Press SELECT, as before, to choose

	another temperature. Press MENU to proceed to the next menu item.
P1, P0;	The slope and intercept values relating frequency to the reflected power threshold used to determine an overrange condition. SELECT and VALUE change the value. ENTER stores the desired value.
Index [0.000 MHz];	A frequency index used for adjustments during field calibration. See Theory of Operation. SELECT and VALUE change the value. ENTER stores the desired value.
Reset factory values;	This downloads the factory default values for all coefficients. See Resetting factory coefficients section.
Zero Counters;	See Normal Mode.
Time Delay [0 sec];	See Normal Mode.
Alternate Display;	See Normal Mode.
Flow Input [Disabled];	See Normal Mode.
Temp Adjust;	See Normal Mode.
Analog Output [4-20 mA];	See Normal Mode.
4 mA (or 0 mA) [0.00%];	See Normal Mode.
20 mA [1.00%];	See Normal Mode.
Comm 0 [Disabled];	Communication Channel 0 option. The SELECT switch toggles between Comm 0 Disabled and Comm 0 Enabled. Press ENTER to execute the desired Comm 0 status. Reserved for future use.
Comm 1 [Disabled];	Communication Channel 1 option. The SELECT switch toggles between Comm 1 Disabled and Comm 1 Enabled. Press ENTER to execute the desired Comm 1 status. See Appendix A. ASCII Terminal Communication Protocol for further explanation.

	If Comm 1 is Enabled, the user will be asked to defined two additional items: Echo and Termination.
Echo [Disabled];	Echo character option. The SELECT switch toggles between Echo Disabled and Echo Enabled. Press ENTER to execute the desired Echo status.
Termination [CR];	Termination option. The SELECT switch toggles between Termination CR and Termination CR/LF. Press ENTER to execute the desired Termination.

5.4.4 Reference current

The reference current feature allows user-selectable values of current to be generated for the calibration and setup of output devices connected to the analog output. This may be helpful in establishing the zero and span of output devices such as chart recorders.

For the 0 to 20 mA range for the analog output, 0 to 20 mA reference current levels may be generated. For the 4 to 20 mA range for the analog output, 4 to 20 mA reference current levels may be generated.

Press ENTER to select this feature. Current values from 0 to 20 mA (or 4 to 20 mA) in 1 mA increments are selected by pressing the SELECT switch. Press ENTER to generate the current at the analog output loop terminals marked "ANALOG OUTPUT" on the motherboard of the electronics unit.

To exit the reference current feature and proceed to the next MENU item, press MENU.

To exit the reference current feature and return to the Technician Mode display press MENU and hold for approximately two seconds.

5.4.5 Resetting factory coefficients

This MENU item allows the user to download the factory-default values for the various coefficients. The coefficients to be reset and their factory default values are;

1) Cal Factor [0.00%],
2) Alarm Point [4.00%],
3) Time Delay [0 sec],
4) Zero Counters [0 totals],
5) Alternate Display [Normal Mode Display],
6) Flow Input [Disabled],
7) Temp Adjust [Factory Value],
8) Index [0.000 MHz],
9) Analog Output [4-20 mA],
10) 4 mA value [0.00%],
11) 20 mA value [1.00%],
12) Reference Current [4 mA],
13) Modify K-constants [No],
14) P1 [System Specific], and
15) P0 [System Specific].

The factory default values are reset as follows;

1) Access Technician Mode (switch 1 closed, switch 2 closed),
2) View LCD,
3) Display prompts "Press ENTER to reset to factory defaults",
4) Press ENTER to reset (press MENU to move to next MENU item),
5) Display prompts "Press SELECT if you are sure",
6) Press SELECT to confirm (press MENU to move to next MENU item),
7) Display confirms "Factory Defaults Restored" for approximately three seconds and then returns to the Technician Mode display.

6. CALIBRATION PROCEDURE

6.1 Factory calibration

Each Phase Dynamics analyzer is carefully calibrated at the factory prior to delivery. A precisely controlled flow loop is used to determine the unit's frequency response as a function of water content. This response determines the coefficients used to compute water content from the measured frequency. Also, the calibration flow loop is used to measure the effects of temperature on the system so that temperature compensation of the measured water content is included. An appendix includes a comparison of various laboratory methods for the determination of water in crude oil.

6.2 Field calibration

Field conditions may differ from those simulated in the factory. The analyzer may require field adjustment to compensate for these differences. A worksheet [Table 6.2(1)] is included to assist in field calibration of the analyzer. The recommended procedure for field calibration of the analyzer is as follows:

1) Collect an appropriate sample of crude oil and water for analysis. The sample must represent the crude oil and water flowing through the measurement section. While collecting the sample, note and record the analyzer's displayed value. Record the fluid temperature displayed by the analyzer. Also record the Cal Factor and Index values.

2) Measure the water content of the sample via some laboratory method (distillation or titration recommended).

3) Compare this result to the analyzer's displayed value.

4) Repeat the above steps of collection and analysis for a few samples and a range of water contents.

5) Calculate the difference for each pair of displayed and measured water contents. Typically, the difference will be constant for all the samples.

6) Enter the Cal Factor value needed so that the displayed water content is equal to the laboratory-measured water content via the user-interface switches.

If the difference between the displayed and laboratory-measured values vary appreciably for several samples, collect and analyze enough samples to be confident

that the difference is not constant. Call Phase Dynamics, Inc. for support and assistance if necessary.

Date:_____ Location:_____

Serial Number of Unit: _____

Method of Calibration: _____

Sample ID	Time	Displayed Temp	Displayed Content	Measured Content	Cal Factor	Index

Table 6.2(1) Calibration Worksheet

7. COMPREHENSIVE LIST OF ERROR MESSAGES

Table 7(1), below, is a complete list of all error messages which may be encountered including a brief explanation and the initial action needed to solve the error.

Error	Cause	Action Needed
Frequency Error #1	Frequency is out of range.	Record frequency and consult factory.
Frequency Error #2	Frequency is out of range.	Record frequency and consult factory.
Frequency Error #3	Oscillator frequency is not being received by electronics unit; or oscillator has lost power.	Check for loose or fault system cable.
Temp Comp Error #4	Temperature is out of range for the given compensation values.	Check for defective temperature probe. Check Temp Offset value in MENU.
Scaling Error #5	Unable to scale water content value for current output loop.	Check end-point values for current loop in MENU.
Cal Factor Error #6	Addition of the Cal Factor has caused an overrange condition.	Check Cal Factor value in MENU.
EPROM Error #7	Incorrect EPROM checksum was calculated during built-in tests.	EPROM chip failure. Replace processor board.
EPROM Error #8	Incorrect EEPROM checksum was calculated during built-in tests.	Use Technician Mode to return to factory defaults and try again. Replace processor board.
INTRAM Error #9	Internal RAM failure.	Replace processor board.
SRAM Error #10	Static RAM failure.	Replace processor board.

Table 7(1) Comprehensive List of ERROR Messages

Error	Cause	Action Needed
Cal Factor Error #11	Cal Factor value is not positive enough to compensate for a negative calculated water content.	Increase Cal Factor in MENU.
Cal Factor Error #12	Calculated water content and Cal Factor are both negative.	Changed Cal Factor to a positive value.
Cal Factor Error #13	Negative Cal Factor has caused the calculated water content to become negative.	Change Cal Factor to a less negative value.
Power Error #14	15 volt supply has failed.	Check wiring for short to 15 volt supply. Replace power supply board.
Output Loop Error #15	Actual output loop current does not correspond with calculated value.	Check output loop using Reference Current in MENU.
EEPROM Error #16	EEPROM failure while trying to restore factory defaults.	Replace processor board.
Divide Error #17	Attempted divide by zero.	Power OFF, then ON. Reset factory coefficients. Replace processor board.
No Flow #18	Zero flow rate. Indicates input at flowmeter terminals is zero. During flow, this message disappears.	Check flow input wiring and selection of pulse or current input in MENU.
Overrange Error #19	Calculated water content is greater than 4.00%.	Check Cal Factor. Verify water content by other means.
Overrange Error #20	Reflected power measurements have determined that the water content is greater than 4.00%.	Verify water content by other means.

Table 7(1) Comprehensive List of ERROR Messages (cont.)

If Error Messages 8 or 16 are displayed at anytime, press MENU to proceed directly to "Reset factory values", regardless of the current mode of operation. Reset factory values as directed. If Error Messages 8 or 16 are still detected, replace processor board.

8. THEORY OF OPERATION

The following sections describe, in detail, the specific operation of the Phase Dynamics load-pull system and how it is used to measure water content. The sections are separated into two main parts - one describing the fundamental behavior of the instrument to changing water content and one describing temperature effects.

8.1 Detailed description of frequency response

The load-pull system relates a measured oscillator frequency to water content. During factory calibration, coefficients are derived to relate the measured frequency to water content for a given temperature. The water content is calculated as follows;

$$\begin{aligned} \text{Water content} &= K3 * (\text{Freq} + \text{Index})^3 \\ &+ K2 * (\text{Freq} + \text{Index})^2 \\ &+ K1 * (\text{Freq} + \text{Index}) \\ &+ K0 \\ &+ \text{Cal Factor} \end{aligned}$$

where Freq is the measured oscillator frequency,
K3, K2, K1 and K0 are the K-constants,
Index is a frequency index value, and
Cal Factor is a linear offset value.

The factory default values for Index and Cal Factor are zero (0). In this case the above equation simplifies to;

$$\text{Water content} = K3 * \text{Freq}^3 + K2 * \text{Freq}^2 + K1 * \text{Freq} + K0.$$

The Figure 8.1(a) shows a typical factory calibration curve for constant temperature.

To compensate for differences between the factory calibration and actual process conditions, a linear offset factor, Cal Factor, may be added to or subtracted from the computed water content. The effect of Cal Factor is as shown in Figure 8.1(b).

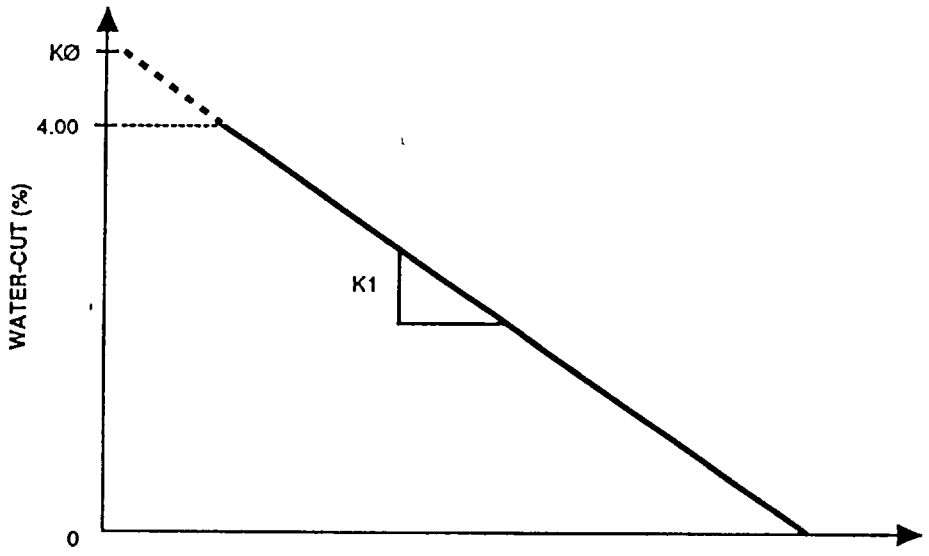


Figure 8.1(a) Factory Calibration, Frequency Versus Water Content

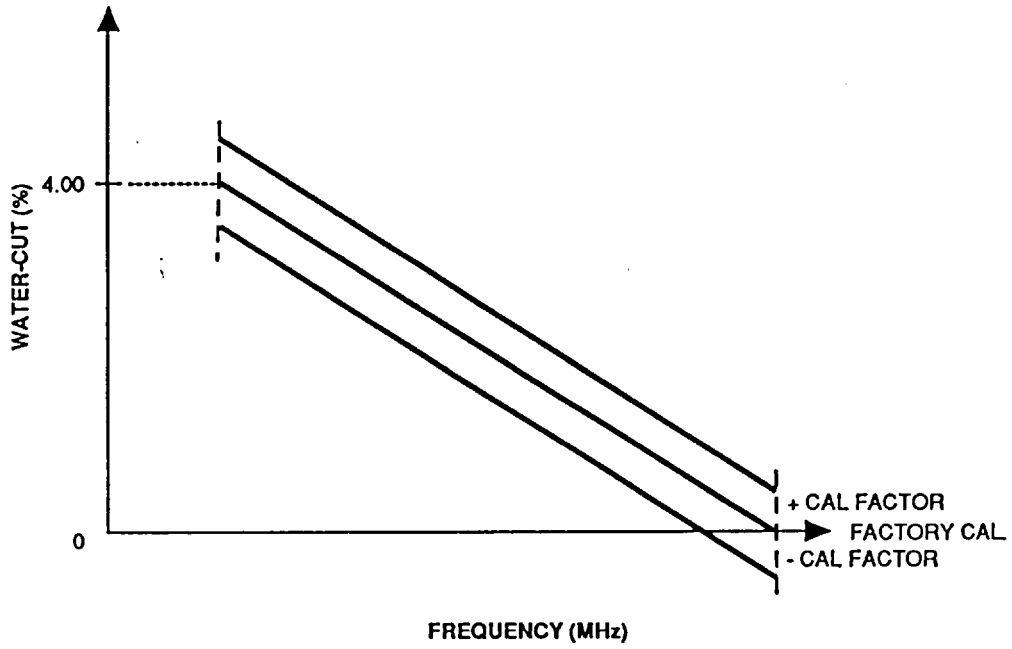


Figure 8.1(b) Effect of Changing Cal. Factor

On rare occasions, it may be necessary to include a frequency index, Index, for improved accuracy. The effect of Index is as shown in Figure 8.1(c). Note: The preferred method for field calibration includes the use of Cal Factor, as opposed to Index. However, Index is included to provide greater flexibility to the user, if needed.

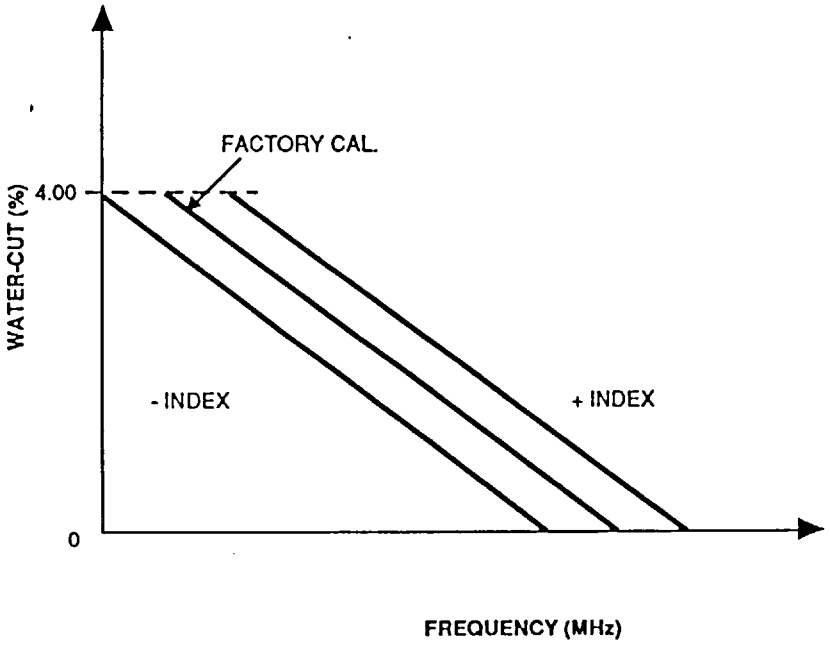


Figure 8.1(c) Effect of Changing Index

The Phase Dynamics Water in Hydrocarbon Analyzer includes an operational feature which allows the instrument to determine an overrange condition for the measured water content. The reflected power (Ref Pwr) signal from the oscillator module is measured and compared to a threshold value; it is a DC voltage indicative of the signal level reflected from the measurement section. Typically, the measured level will be above the threshold value when the measured water content is in range. For the overrange condition, the reflected power level will be below the threshold value.

The reflected power threshold level (RP Threshold) may be frequency dependent and is given by;

RP Threshold = P1 * (Freq + Index) + P0

where Index is the frequency index,
P1 is the slope of the threshold curve, and
P0 is the intercept of the threshold curve.

Figure 8.1(d) shows a typical reflected power threshold curve for the Phase Dynamics Analyzer.

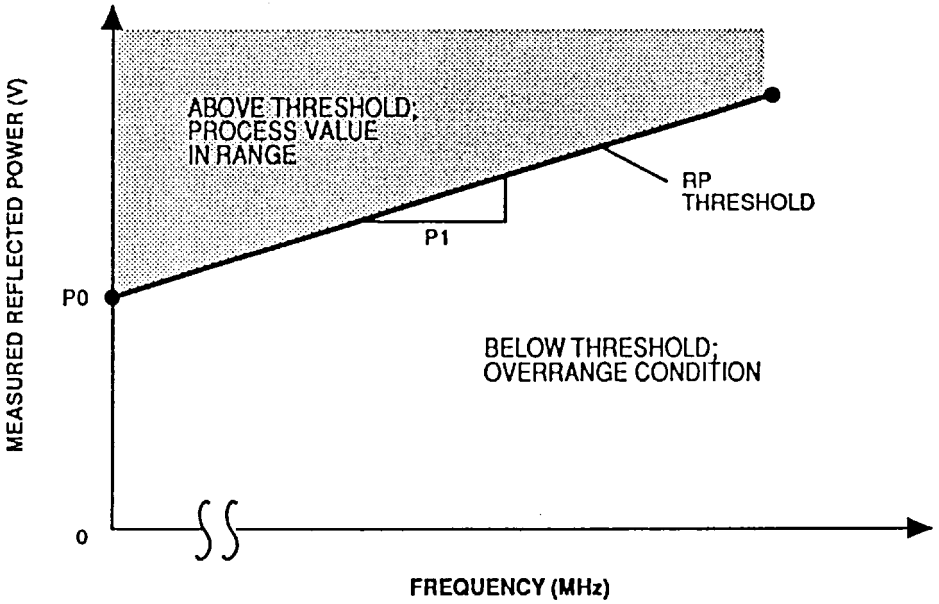


Figure 8.1(d) Reflected Power Threshold Curve

8.2 Temperature compensation

Compensation for temperature effects must be included for best performance of the analyzer. Temperature changes the permittivity of most materials; this change in permittivity presents a changing load to the oscillator which would change its frequency. Thus, without temperature compensation, a changing process temperature would cause changes in frequency which would lead to errors in the calculated water content.

Temperature is measured by a probe inserted into one of the pipe saddles and directly into the process stream. This temperature signal is carried through stainless tubing back to the oscillator module. The system cable then delivers this signal to the electronics unit where the temperature compensation is calculated.

Figure 8.2(a) shows the effect of temperature for a typical application. Temperature compensation is included by factory calibrating the analyzer over a range of temperatures. Coefficients relating frequency to water content are derived for each calibration temperature. For example, a unit calibrated at 60, 100, and 140 degrees Fahrenheit will have three sets of K-constants, one set at each temperature.

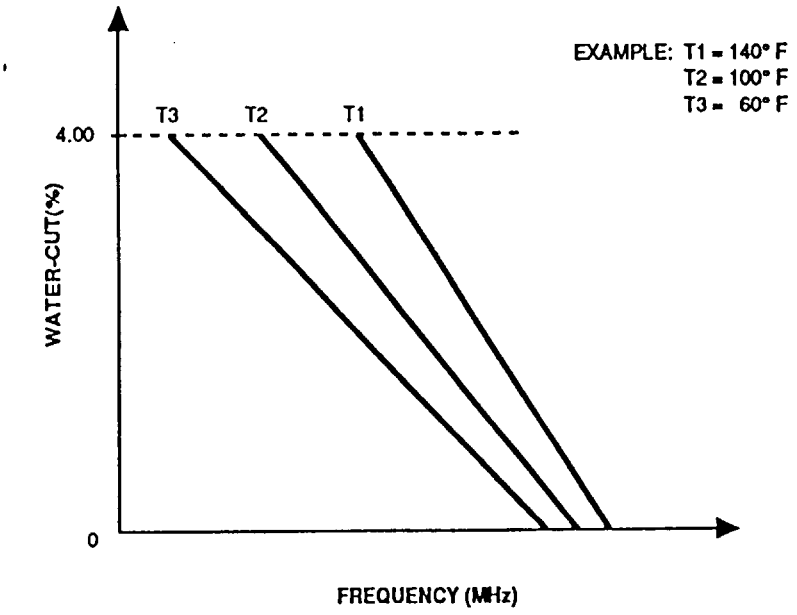


Figure 8.2(a) Effect of Temperature on Frequency

The displayed water content (and the RS-422 value of water content) includes compensation for fluid temperature; no manual compensation by the user is necessary. The measured process temperature is also displayed on the LCD. The Temp Adjust feature is used to adjust the temperature probe's measured value to match the actual liquid temperature, if necessary.

For measured temperatures which are between factory calibration temperatures, a linear interpolation is used to compensate for temperature effects.

9. DETAILED FUNCTIONAL DESCRIPTIONS

Following is a description of various operating routines for the Phase Dynamics analyzer and functional descriptions of each printed circuit board.

9.1 Automatic systems test

Upon powering up, the system executes a series of self tests. The EPROM and EEPROM checksums are verified for device integrity. The SRAM is tested for bit failure. The time base interval is checked for accuracy. The oscillator frequency is checked to be in range. The D/A and A/D are compared for accuracy. The fluid temperature is measured and checked to be in range. If any failures are detected, the appropriate error message will be displayed on the LCD and the error relay will close.

After passing self test the microprocessor initializes the data and peripherals. The software is interrupt driven and the main loop updates the LCD with the latest values and checks for any switches which have been pressed.

9.2 Power-up self test

With application of AC power to the system, a series of self tests are performed that take approximately five seconds to complete. The front panel display shows which test is executing and reports any error messages.

The major functional areas checked by the self tests are:

power supply,
program memory integrity (EPROM),
constant memory integrity (EEPROM),
internal microprocessor memory (INTRAM),
data memory (SRAM),
time base generator,
oscillator frequency,
temperature sensor,
current loop input/output.

9.3 Built-in test

About once every 15 minutes, the system performs a series of tests that take about five seconds to execute. These tests execute in the background and do not interrupt normal operation of the instrument. The liquid crystal display shows the test that is executing and reports any error messages.

The major functional areas checked by the built-in tests are:

power supply,
program memory integrity (EPROM),
constant memory integrity (EEPROM),
internal microprocessor memory (INTRAM),
data memory (SRAM),
time base generator,
oscillator frequency,
temperature sensor,
current loop input/output.

9.4 Normal operation

The main interrupt event is the end of the one second time interval that measures the microwave oscillator frequency. At this time the microprocessor reads the counters and computes a raw frequency. The fluid temperature is measured. The temperature-compensated water content value is then calculated using the coefficients which were determined during calibration and stored in EEPROM. The Cal Factor may be adjusted from the user menu. If the water content remains above (or below) the alarm set point for the delay time then the trip relay activates until the water content remains below (or above) the alarm set point for the same amount of time. The water content value is continuously available at the current loop output.

For the net oil feature, a dedicated counter within the electronics unit measures the pulse output of the flowmeter. As the total fluid value accumulates, the measured water content value is used to compute and update the net oil value. All values are updated and displayed on the front panel LCD approximately once per second.

9.5 AC input board

Power is applied to the AC board. Nine MOVs on this board suppress transients (voltage spikes) to protect the system. Three are paralleled across the AC common and power, three across power and safety ground, and three across common and safety ground. These MOVs are included to help prevent system damage due to lightning. In the event of a failure of any other circuit board in the system due to lightning, it is strongly recommended that the AC input board be replaced at the same time. A 3/4 Ampere, 250 Volt fuse is used in the AC power line before the MOV shunts. The output of this board connects to the power transformer that has a secondary winding for the +5 and a secondary for the +15 and +30 Volt supplies.

9.6 DC input board

Power is applied to the DC board. Six MOVs on this board suppress transients (voltage spikes) to protect the system. Three are paralleled across the DC power and safety ground and three across DC return and safety ground. These MOVs are included to help prevent system damage due to lightning. In the event of a failure of any other circuit board in the system due to lightning, it is strongly recommended that the DC input board be replaced at the same time. A 3 Ampere, 250 Volt fuse is used in the DC power line before the MOV shunts. The input voltage is then filtered and an MOV is used to prevent overvoltage. The output of this board connects to the motherboard.

9.7 Motherboard

The motherboard contains:

connectors for the daughter boards,
terminal connectors for external signals,
diode bridges and filter capacitors for the power supply,
LEDs to indicate the presence of +5 and +15 Volts,
a fuse for the microwave oscillator heater,
four fuses and two MOVs (for the I/O current loop),
trip point and system error relays with drive circuitry.

9.8 AC power supply board

The AC power supply board contains the regulators for the +5 and +15 Volts. Both supplies contain circuitry (crowbars) to help protect the system from overvoltage. It provides a "Power Good" signal to allow the microprocessor to begin to function and a "Power Down" signal to inform the microprocessor that it is about to lose power and should do any necessary "housekeeping" functions.

9.9 DC power supply board

The DC power supply board contains the DC to DC convertors to provide +5 and +15 Volts. Additionally, this board provides -5 and isolated +15 Volts which are available from separate transformer windings in AC powered systems. The +5 and +15 Volt supplies contain circuitry (crowbars) to help protect the system from overvoltage. It provides a "Power Good" signal to allow the microprocessor to begin to function and a "Power Down" signal to inform the microprocessor that it is about to lose power and should do any necessary "housekeeping" functions.

9.10 Microprocessor board

The heart of the microprocessor board is the NEC V25. The V25 is a powerful 16-bit, single-chip CMOS microprocessor with the following built-in features:

software compatible with the 8086/88,
24 parallel I/O lines and two serial interfaces,
programmable interrupt controller,
clock generator,
two timers,
time base counter,
programmable wait state generator.

The board contains 64K EPROM for program storage and 32K SRAM for data storage. There is 2K EEPROM for calibration, configuration, and permanent data storage.

9.11 Frequency board

The frequency board contains a total of six 16-bit programmable counter/timers. A stable crystal oscillator is divided down and counted to provide a one second time interval. This time interval gates a series of counters to measure the microwave oscillator frequency. When using the net oil feature, another counter counts the pulse output of a flowmeter to keep track of total volumes. A magnetic pulse amplifier/conditioner is included for flowmeters providing pulse outputs.

The system has two serial RS-422 communication channels. The first channel is for a built-in software monitor that allows trained technicians to test and debug the system. The second channel communicates with a variety of personal computers. These RS-422 communication drivers and receivers along with switch selectable line termination resistors are also on the frequency board.

9.12 Analog input board

The analog input board has a 16-bit A/D, 4-channel 8-bit A/D, LT1019-2.5 precision voltage reference, -5 volt supply, and the current loop receiver. The 16-bit A/D is used to measure the fluid temperature that is provided by an RTD (thermocouple). The 4-channel 8-bit A/D measures the oscillator incident and reflected power levels along with the output from the current loop receiver. An LED indicates a valid output for the -5 volt supply.

The current loop input signal feeds a 250 Ohm resistor. An 8-bit (256 step) A/D reads the voltage across the resistor. The input is **NOT SELF-POWERED** and it is **NOT ISOLATED** from system ground. The input device should be powered from the same AC circuit to keep ground common. The receiver's negative terminal connects to

system ground through a 1 Ampere fuse and system ground connects to the measurement section, which is normally in contact with earth or AC ground. The fuse on the negative terminal will open should the ground loop current exceed 1 Ampere. The positive terminal is over-voltage and reverse-protected to be undamaged by application of 120 Volts AC. It is also fused at 1 Ampere and uses a MOV shunt to open that fuse if higher voltages are applied.

9.13 Analog output board

The analog output board has a 12-bit D/A, 4-channel 8-bit D/A, LT1019-5 precision voltage reference, isolated +12 and +24 volt supplies, and the current loop transmitter. The 4-channel 8-bit D/A is used to control the microwave oscillator. An LED indicates a valid output for the +12 volt supply.

The current loop transmitter (driver) will output 4-20 or 0-20 mA. A 12-bit (4096 step) D/A drives the transmitter. The output is **SELF-POWERED** and **ISOLATED** from any system ground, thus an external supply is not required. The maximum output is 20 volts so the total loop resistance must be 600 Ohms or less. The transmitter's positive and negative terminals are fused at one Ampere. An MOV shunt is used to protect against over-voltage.

9.14 Display board

The Liquid Crystal Display (LCD) module includes a standard 8-bit parallel interface. A small printed circuit board is piggy-backed to the LCD module. This board contains the contrast control circuitry to adjust the viewing angle of the LCD, the control to adjust the back lighting, and the connectors for the control keys and ribbon cable. Also, several spare fuses are attached to this display board, two rated 1.0A/250V, one rated 2.0A/250V, and one rated 0.75A/250V.

9.15 Microwave oscillator module

The measurement section, microwave oscillator module, and microprocessor board are a MATCHED SET. Information derived about the measurement section and oscillator during calibration is stored in an EPROM on the microprocessor board.

THE OSCILLATOR MODULE SHOULD NEVER BE REMOVED FROM THE MEASUREMENT SECTION!

The microwave oscillator is heated to maintain an internal temperature of approximately 160°F for proper operation. It has no output buffer amplifier or isolation circuit which are typically used in oscillator applications.

10. INSTRUMENT REPAIR AND SERVICE

10.1 Assistance and factory address

Product maintenance agreements and other customer assistance agreements are available for this Phase Dynamics analyzer.

Phase Dynamics, Inc.
1251 Columbia Drive
Richardson, TX 75081

972-680-1550 Fax 972-680-3262

10.2 Electrostatic discharge (ESD)

All of the printed wiring board assemblies contain electronic components which are sensitive to electrostatic discharge. Components damaged by ESD greatly increase the likelihood of a system error or failure.

CAUTION
Protect circuit boards from ESD at all times.

The circuit boards are more susceptible to damage from electrostatic discharge when they are not plugged into the motherboard. At all times care should be taken to prevent damage from electrostatic discharge when working with the system. The person should be wearing a ground strap. Boards removed from the system should be kept in anti-static metalized shielding bags.

10.3 Power supply checks

Both the 5 and 15 volt supply have an LED (on the motherboard) that lights when voltage is present.

10.4 Fuses and protection circuits

The power input board has a 3/4 Ampere, 250 Volt fuse before the metal oxide varistor (MOV) shunts. The motherboard has five fuses: one is a 2 Ampere fuse for the measurement section oscillator heater power and the other four are 1 Ampere fuses (and two MOVs) to protect the input and output current loops.

10.5 Measurement section and oscillator module

No field repair of the measurement section, oscillator module, or temperature probe should be necessary. If repair of these parts is needed, please consult factory.

10.6 Returning items to the factory

Please telephone Phase Dynamics prior to returning any equipment for service or repair. A return authorization number may be required prior to shipment. Please include the following information with returned items:

Company Name and Address
Key Contact Name and Address
Serial number of item being returned
Brief description of problem
Return authorization number (if required)

10.7 Returning measurement section

Please drain and clean the measurement section of any and all dangerous or hazardous materials before returning to the factory.

Repack the measurement section in the original shipping carton. If the original carton is missing contact Phase Dynamics.

Place a packing slip on the outside of the carton containing both the return authorization and the serial number.

10.8 Returning electronics unit

Repack the electronics unit in the original shipping carton. If the original carton is missing contact Phase Dynamics, Inc.

Place a packing slip on the outside of the carton containing both the return authorization and the serial number.

APPENDIX A. ASCII TERMINAL COMMUNICATION PROTOCOL

The Phase Dynamics analyzer has the capability to transmit and receive ASCII command strings from a "host" computer. These command strings allow the "host" to perform certain system functions. This appendix describes the protocol that is used for communication.

The Phase Dynamics analyzer has a full-duplex RS-422 serial interface. The interface parameters are as follows :

1)	Speed	9600 baud
2)	Character length	8 bit
3)	Parity	None
4)	Stop bits	1

The RS-422 interface uses two twisted pairs of wire to communicate. The wire may be up to 4000 feet in length. The motherboard connectors are labeled "COMM 1 RS-422/RS-485" and individually :

1)	R+	Receive +
2)	R-	Receive -
3)	T+	Transmit +
4)	T-	Transmit -

Please note that the Receive and Transmit markings are with respect to the analyzer's serial interface. A 100 ohm termination resistor is supplied across each pair of wires (Receive and Transmit).

The protocol is very simple. It has little error checking and no error messages or retries. It is up to the "host" computer to provide checks and retries. There are only two types of commands and one response.

The serial interface is enabled on the analyzer by accessing the Technician Mode. After enabling COMM 1, you can set whether the analyzer "echoes" the command string. This is helpful when using an ASCII terminal or emulator. You can also set the Command Termination to either a Carriage Return or a Carriage Return and Line Feed. See the Technician Mode section.

Read Parameter

R		X	CT

R

Read command

Space (blank)

X

Parameter number

CT

Command termination (carriage return or carriage return/line feed)

This command string will read an analyzer parameter. The parameter number is defined in a later section. The analyzer will respond with a string similar to the following.

-	Y	Y	.	Z	Z	CT

-

Negative sign (if value is negative)

Y

Integer portion of parameter

.

Decimal point

Z

Fraction portion of parameter

CT

Command termination (carriage return or carriage return/line feed)

The number of ASCII digits returned depends on the parameter.

Note: Leading zeros or blanks are **NOT** sent by the analyzer to the "host" computer.

Write Parameter

W		X		-	Y	.	Z	Z	CT

W	Write command
	Space (blank)
X	Parameter number
	Space (blank)
-	Negative sign (if value is negative)
Y	Integer portion of parameter
.	Decimal point
Z	Fraction portion of parameter
CT	Command termination (carriage return or carriage return/line feed)

This command string will write an analyzer parameter. The parameter number and the number of ASCII digits sent is defined in a later section. The analyzer will not return anything. The "host" computer should read the parameter and compare the reading to what it sent.

Note: Leading and trailing zeros or blanks **MAY** be sent by the "host" computer. This should help with any ASCII conversions that may be required.

Parameter List

Not all parameters are used for every application. Use only those that apply to your specific application. Consult the Installation and Instruction Manual for further descriptions and information.

Number	Description	Format	Read	Write
1	Content - Percentage of the process variable being measured	YYY.ZZ	X	
2	Temperature - Measured in degrees C or F depending upon application	YYY.Z	X	
3	Phase (Full Range Analyzer only) - 0 = Water continuous 1 = Oil continuous	Y	X	O
4	Salinity (Full Range Analyzer only) - Measured in percent	YY.ZZ	X	X
5	Stream (Full Range Analyzer only) - Current active stream	YY	X	X
6	Water Adj. (Full Range Analyzer only) - Water continuous calibration factor	YYY.ZZ	X	X
7	Oil Adj. (Full Range Analyzer only) - Oil continuous calibration factor	YYY.ZZ	X	X
8	Cal Factor (All except Full Range Analyzer) - Calibration factor	YYY.ZZ	X	X
9	Total Oil (Water/Oil Analyzers only)	YYYYYY.Z	X	R
10	Total Water (Water/Oil Analyzers only)	YYYYYY.Z	X	R
11	Frequency	YYYY.ZZZ	X	
12	Incident Power	Y.ZZZ	X	
13	Reflected Power	Y.ZZZ	X	
14	Phase Control (Full Range Analyzer only) 0 = Internal logic phase ermination 1 = External phase control	Y	X	X
15	Wat Idx (Full Range Analyzer only)	YYY.ZZZ	X	X

R = Reset O = When Phase Control External

APPENDIX B. INSTRUCTIONS FOR ELECTRONICS UNIT ENCLOSURE HEATER

B.1 120 VAC Enclosure Heater

Phase Dynamics Part 2050-00016-000

Description

This optional heater assembly is used in cold environments to maintain a minimum temperature of 32°F inside the Phase Dynamics electronics enclosure. The heater features an on-off automatic thermostat, and draws 100 Watts from the AC line when operating.

Wiring Instructions

Attach AC line and neutral wires size 18 AWG or larger to the heater assembly terminal block as shown in the drawing below.

Fuse

The heater assembly is internally fused at 2 amperes. Other values should not be substituted.

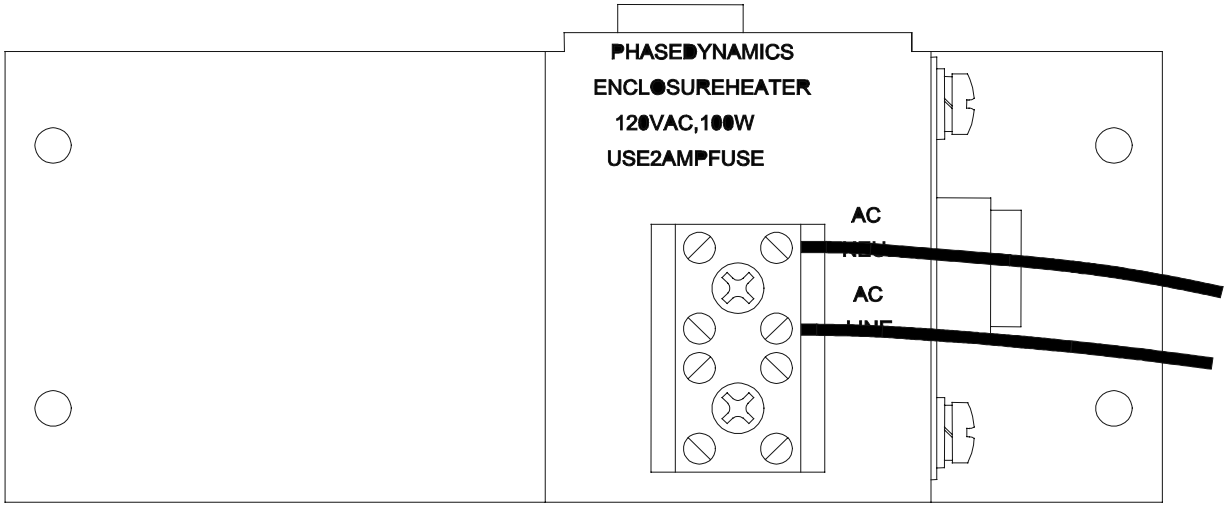


Figure B.1(a) 120 VAC Heater Assembly Terminal Blaock Showing User Supplied Wiring

B.2 240 VAC Enclosure Heater

Phase Dynamics Part 2050-00019-000

Description

This optional heater assembly is used in cold environments to maintain a minimum temperature of 32°F inside the Phase Dynamics electronics enclosure. The heater features an on-off automatic thermostat, and draws 100 Watts from the AC line when operating.

Wiring Instructions

Attach AC line and neutral wires size 18 AWG or larger to the heater assembly terminal block as shown in the drawing below.

Fuse

The heater assembly is internally fused at 1 amperes. Other values should not be substituted.

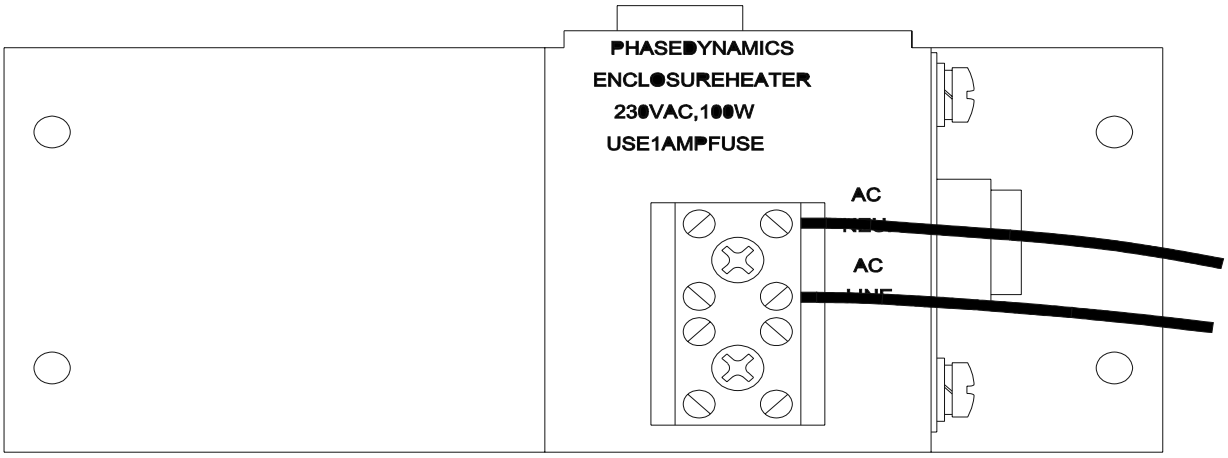


Figure B.2(a) 240 VAC Heater Assembly Terminal Block Showing User Supplied Wiring

APPENDIX C. INSTRUCTIONS FOR GROUND WIRE KIT

Phase Dynamics Part 2050-00018-XXX

Description

This kit contains a 16 AWG ground wire which is to be installed between the electronics enclosure and measurement section enclosure of the Phase Dynamics analyzer system. The wire provides a secondary ground connection between the two enclosures, and must be installed as described below in order to meet CSA requirements for operation in hazardous locations.

Parts Contained

- 16 AWG green ground wire, with lug for #10 screw installed on one end
- #10-24 screw
- #10 lock washer
- crimp lug for ¼" screw
- ¼" lock washer

Installation Instructions

1. Attach the ground wire to the collar inside the measurement section enclosure, as shown in the drawing below, using the #10-24 screw and lock washer.
2. Pull the other end of the ground wire through the (user supplied) conduit connecting the two enclosures. It may be most convenient to perform this operation when the main system cable is installed, pulling the ground wire and system cable through the conduit at the same time.
3. Cut the ground wire to length, and strip the insulation from the end.
4. Crimp the lug for ¼" screw onto the ground wire and install this lug under the ¼" ground screw which is located inside the electronics enclosure, using the ¼" lock washer.

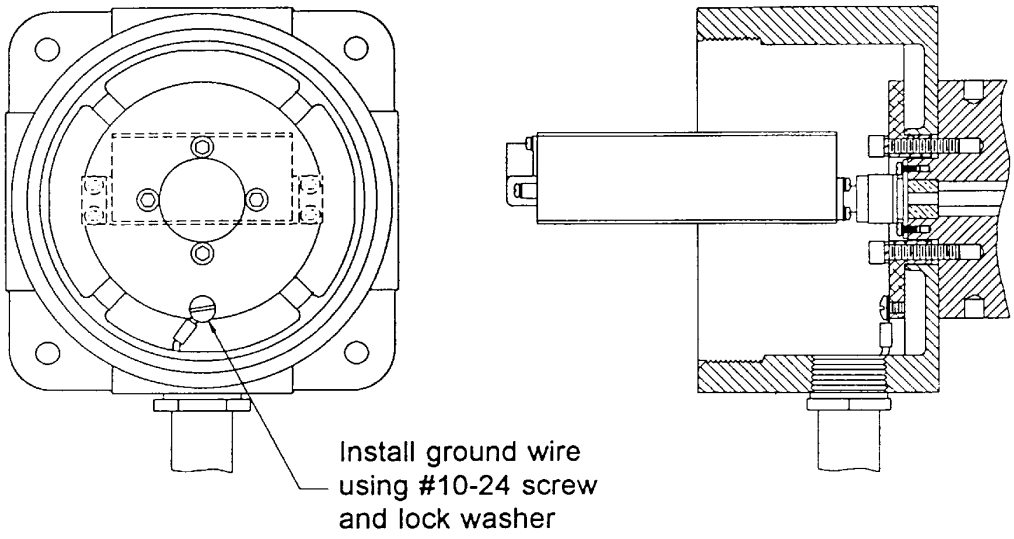


Figure C(a) Measurement Section Enclosure with Cover Removed

APPENDIX D. COMPARISON OF METHODS FOR THE DETERMINATION OF WATER IN CRUDE OIL

Three methods for determination of water content are distillation, titration and centrifugal separation (shake-out). The ASTM designations for these are D4006, D4377, and D4007, respectively.

Table D(1) summarizes the comparison between these methods.

Method	ASTM	Sample Size	Reproducibility	Repeatability
Distillation	D4006	200 ml. min	0.08%	0.11%
Titration	D4377	2-5 grams	0.04%	0.15%
Centrifuge	D4007	100 ml.	0.12%	0.28%

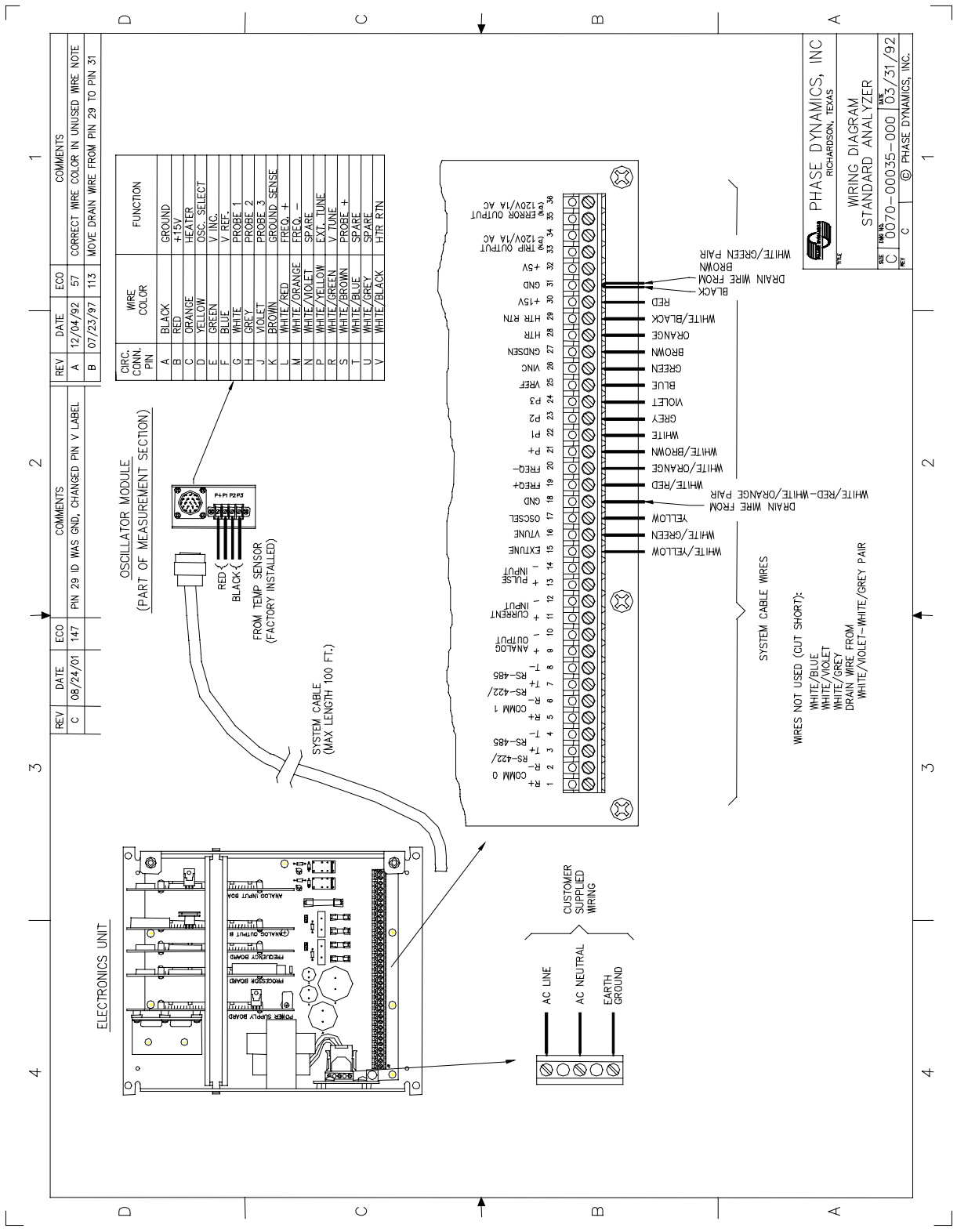
4

Table D(1) Comparison of Water in Crude Methods of Water Contents Less than 1%

Repeatability is the difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material. Reproducibility is the difference between the two single and independent test results obtained by different operators working in different laboratories on identical test material. Both distillation and titration are excellent tests to verify the water content of an oil/water emulsion. Centrifuge is not recommended for precise water contents less than 1.0%.

APPENDIX E. INSTALLATION DRAWINGS

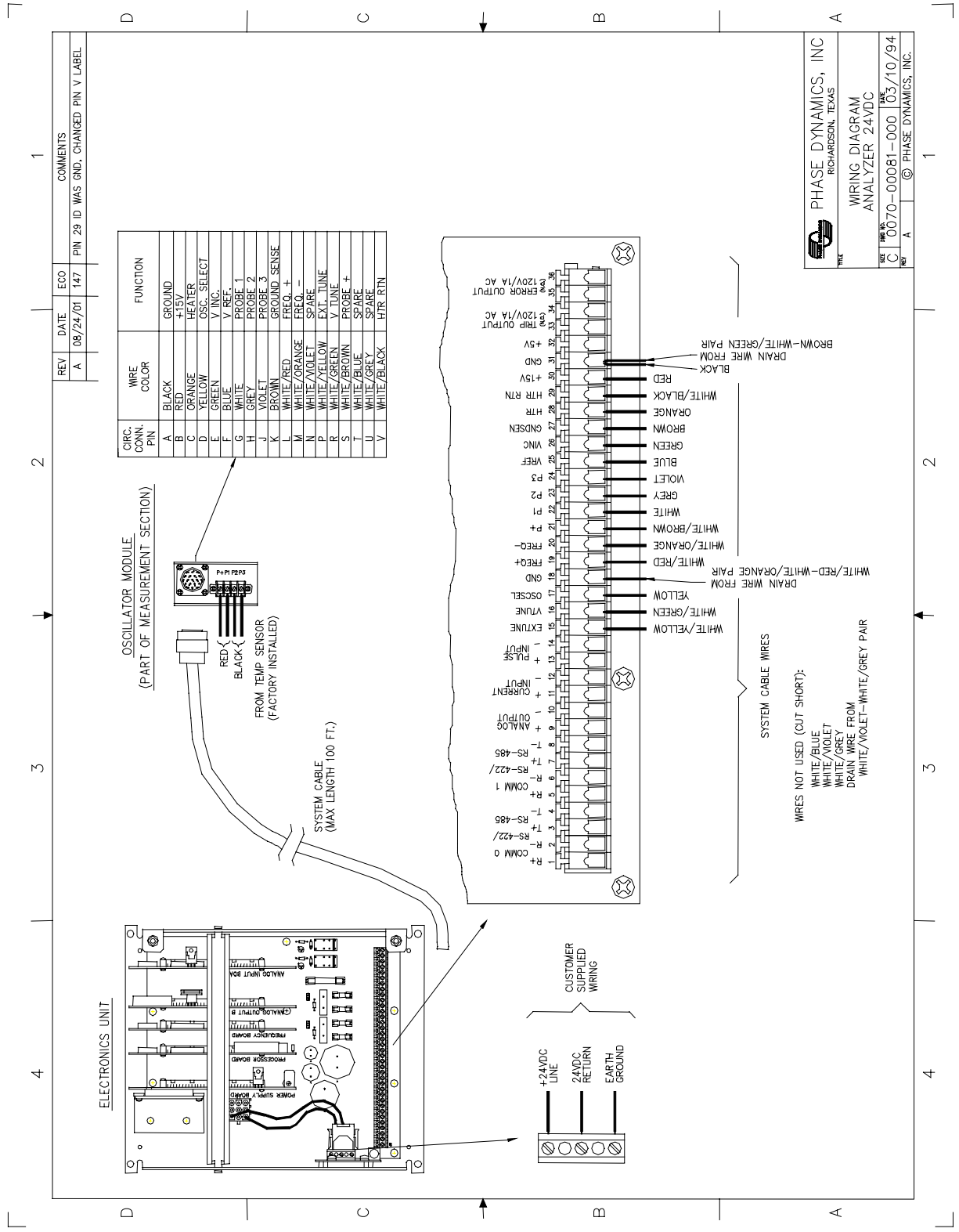
Attached are various installation drawings needed for proper mounting and installation of the Phase Dynamics Water in Hydrocarbon Analyzer. Please consult the factory for other drawings not included.

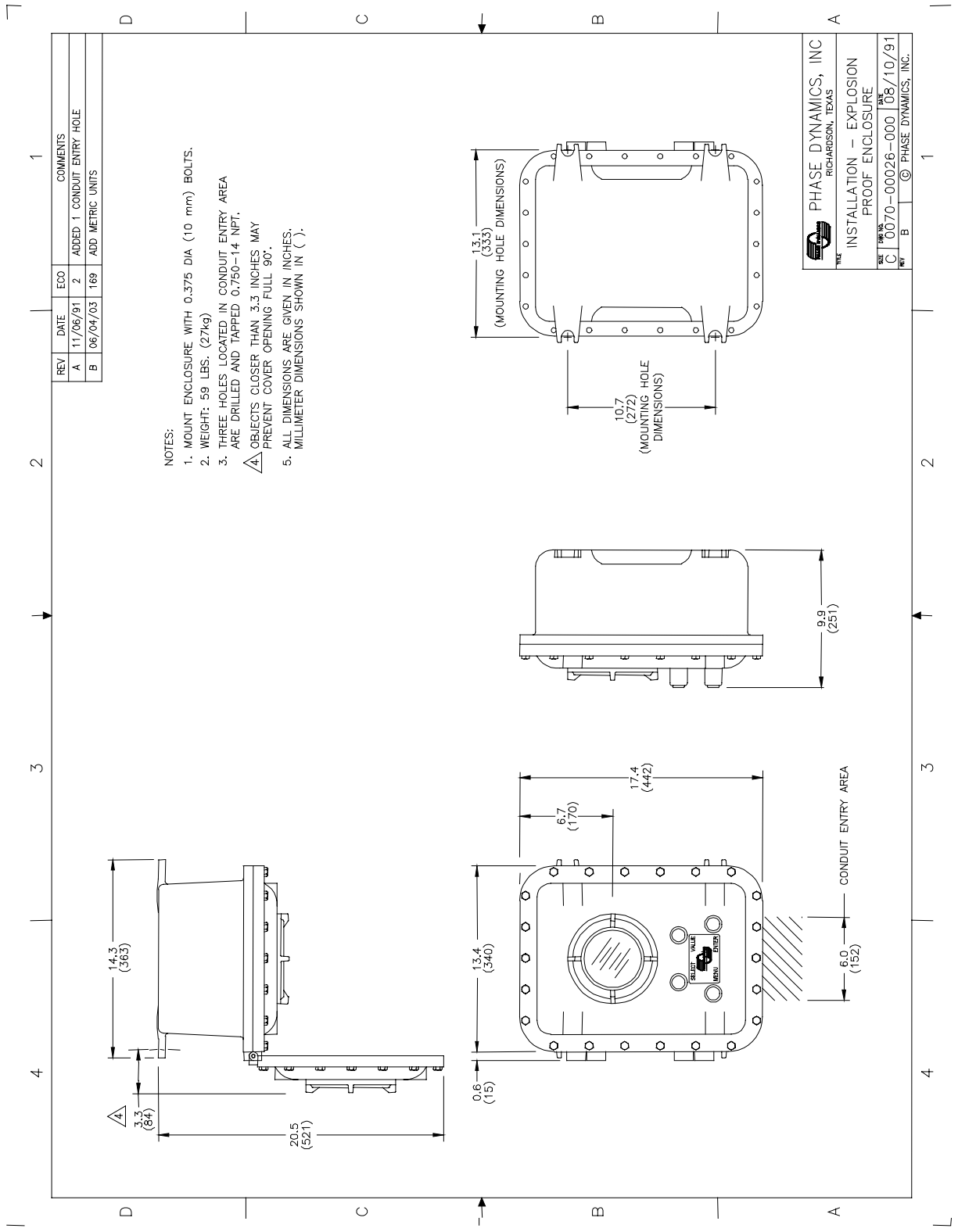


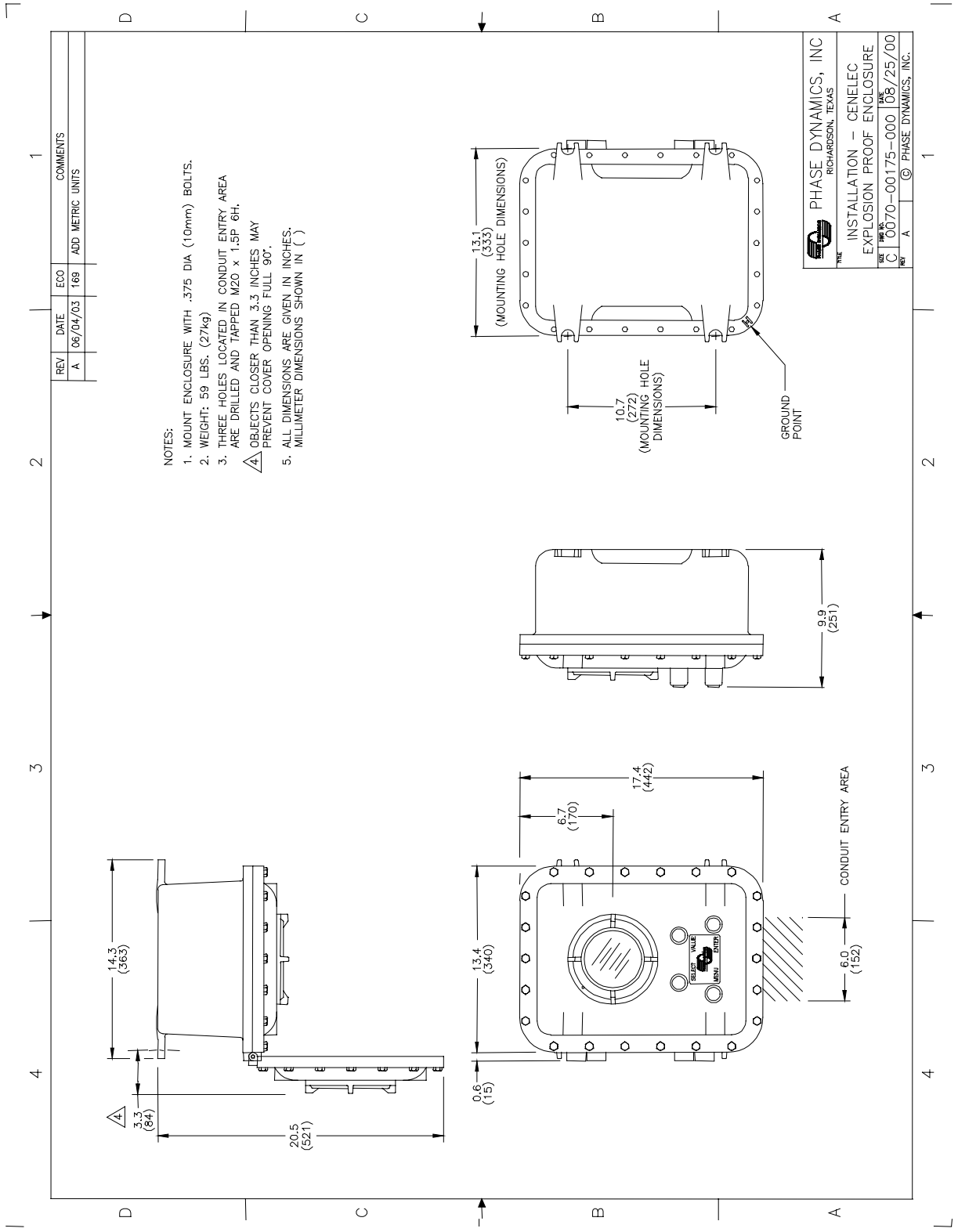
CIRC. CONN. PIN	WIRE COLOR	FUNCTION
A	BLACK	GROUND
B	RED	+15V
C	ORANGE	HEATER
D	YELLOW	OSC. SELECT
E	GREEN	V ING.
F	BLUE	V REF.
G	WHITE	PROBE 1
H	GREY	PROBE 2
J	VIOLET	PROBE 3
K	BROWN	GROUND SENSE
L	WHITE/RED	FREQ. +
M	WHITE/ORANGE	FREQ. –
N	WHITE/VIOLET	SPARE
P	WHITE/YELLOW	EXT. TUNE
R	WHITE/GREEN	V TUNE
S	WHITE/BROWN	PROBE +
T	WHITE/GREY	SPARE
U	WHITE/BLACK	SPARE
V		HTR RTN

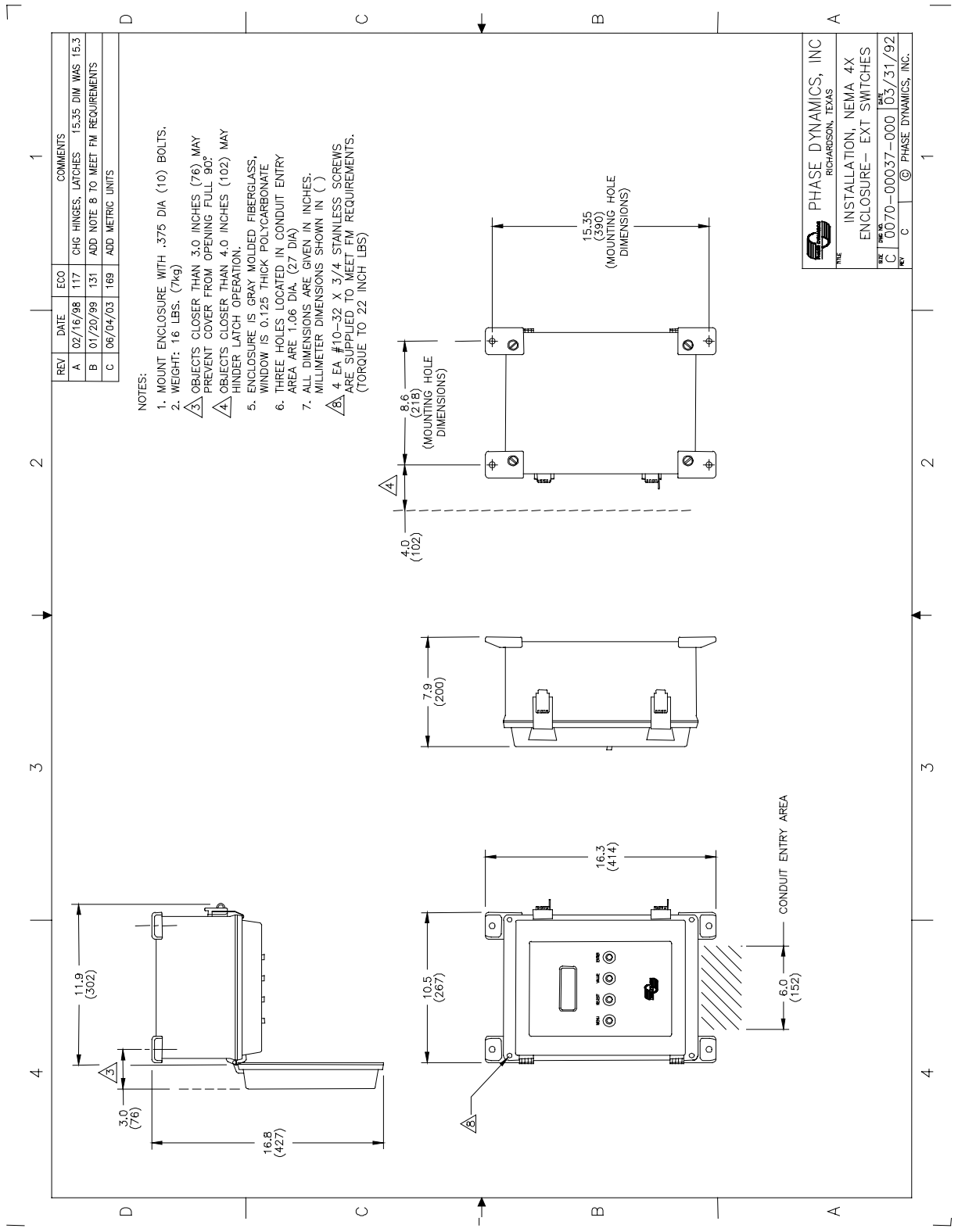
REV	DATE	ECO	COMMENTS
A	12/04/92	57	CORRECT WIRE COLOR IN UNUSED WIRE NOTE
B	07/23/97	113	MOVE DRAIN WIRE FROM PIN 29 TO PIN 31

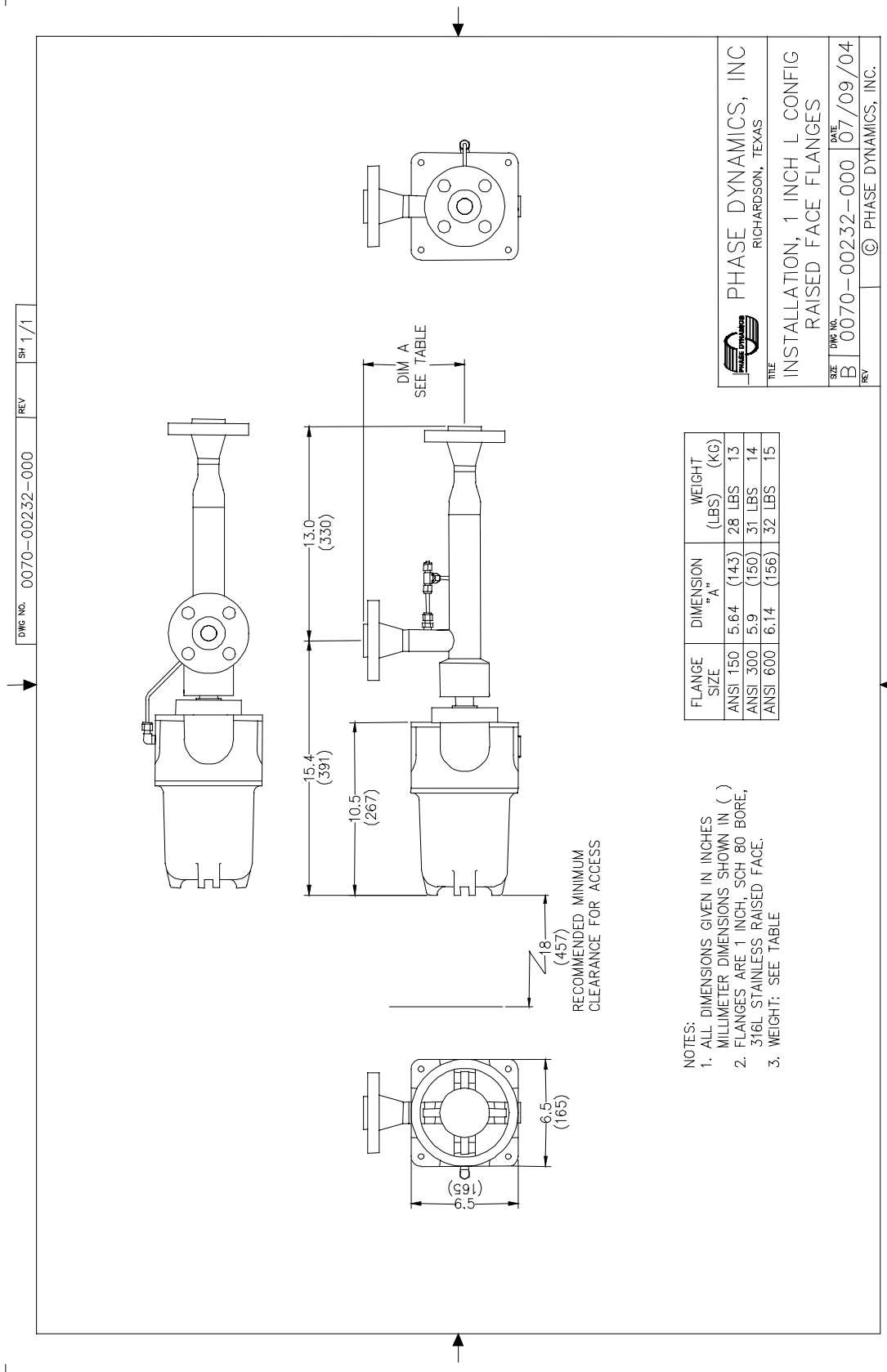
REV	DATE	ECO	COMMENTS
C	08/24/01	147	PIN 29 ID WAS GND, CHANGED PIN V LABEL


PHASE DYNAMICS, INC
RICHARDSON, TEXAS
WIRING DIAGRAM
ANALYZER 24VDC
0070-00081-000
03/10/94
© PHASE DYNAMICS, INC.
REV DATE ECO COMMENTS
A 08/24/01 147 PIN 29 ID WAS GND, CHANGED PIN V LABEL
CIRC. CONN. PIN
WIRE COLOR
FUNCTION
A BLACK GROUND
B RED +15V
C ORANGE HEATER
D YELLOW OSC. SELECT
E GREEN V INC.
F BLUE V REF.
G WHITE PROBE 1
H GREY PROBE 2
J VIOLET PROBE 3
K BROWN GROUND SENSE
L WHITE/RED FREQ. +
M WHITE/ORANGE FREQ. -
N WHITE/VIOLET SPARE
P WHITE/YELLOW EXT. TUNE
R WHITE/GREEN V TUNE
S WHITE/BROWN PROBE +
T WHITE/BLUE SPARE
U WHITE/GREY SPARE
V WHITE/BLACK HTR RTN
OSCILLATOR MODULE
(PART OF MEASUREMENT SECTION)
P+ P1 P2 P3
RED
BLACK
FROM TEMP SENSOR
(FACTORY INSTALLED)
SYSTEM CABLE
(MAX LENGTH 100 FT.)
ELECTRONICS UNIT
ANALOG INPUT BOA
ANALOG OUTPUT B
FREQUENCY BOARD
PROCESSOR BOARD
POWER SUPPLY BOARD
CUSTOMER SUPPLIED WIRING
+24VDC LINE
24VDC RETURN
EARTH GROUND
TRIP OUTPUT 120V/1A AC (NO)
ERROR OUTPUT 120V/1A AC (NC)
BLACK
DRAIN WIRE FROM BROWN-WHITE/GREEN PAIR
GND
+5V
RED
+15V
WHITE/BLACK
HTR RTN
ORANGE
HTR
BROWN
GNDSEN
GREEN
VINC
BLUE
VREF
VIOLET
P3
GREY
P2
WHITE
P1
WHITE/BROWN
P+
WHITE/ORANGE
FREQ-
WHITE/RED
FREQ+
DRAIN WIRE FROM WHITE/RED-WHITE/ORANGE PAIR
GND
YELLOW
OSCSEL
WHITE/GREEN
VTUNE
WHITE/YELLOW
EXTUNE
PULSE INPUT
CURRENT INPUT
ANALOG OUTPUT
RS-485 T- T+ R-
RS-422/ R+
COMM 1
RS-485 T- T+ R-
RS-422/ R+
COMM 0
SYSTEM CABLE WIRES
WIRES NOT USED (CUT SHORT):
WHITE/BLUE
WHITE/VIOLET
WHITE/GREY
DRAIN WIRE FROM WHITE/VIOLET-WHITE/GREY PAIR

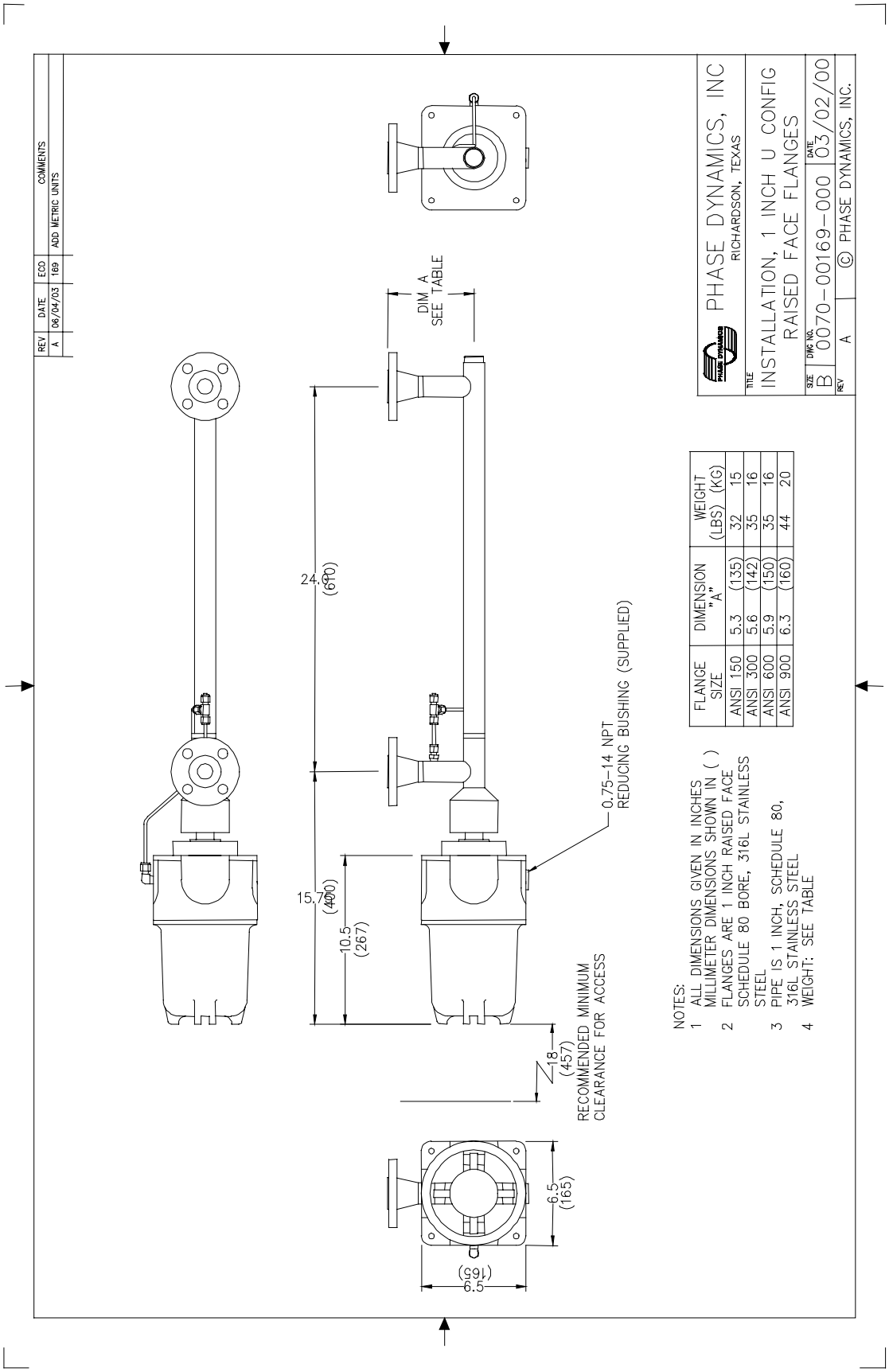

REV | DATE | ECO | COMMENTS
A | 11/06/91 | 2 | ADDED 1 CONDUIT ENTRY HOLE
B | 06/04/03 | 169 | ADD METRIC UNITS
NOTES:
1. MOUNT ENCLOSURE WITH 0.375 DIA (10 mm) BOLTS.
2. WEIGHT: 59 LBS. (27kg)
3. THREE HOLES LOCATED IN CONDUIT ENTRY AREA ARE DRILLED AND TAPPED 0.750-14 NPT.
4. OBJECTS CLOSER THAN 3.3 INCHES MAY PREVENT COVER OPENING FULL 90°.
5. ALL DIMENSIONS ARE GIVEN IN INCHES. MILLIMETER DIMENSIONS SHOWN IN ( ).
13.1 (333) (MOUNTING HOLE DIMENSIONS)
10.7 (272) (MOUNTING HOLE DIMENSIONS)
9.9 (251)
14.3 (363)
3.3 (84)
20.5 (521)
17.4 (442)
6.7 (170)
13.4 (340)
0.6 (15)
6.0 (152)
CONDUIT ENTRY AREA
SELECT
VALUE
MENU
ENTER
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION - EXPLOSION PROOF ENCLOSURE
SIZE C | DWG NO 0070-00026-000 | DATE 08/10/91
REV B | © PHASE DYNAMICS, INC.


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
NOTES:
1. MOUNT ENCLOSURE WITH .375 DIA (10mm) BOLTS.
2. WEIGHT: 59 LBS. (27kg)
3. THREE HOLES LOCATED IN CONDUIT ENTRY AREA ARE DRILLED AND TAPPED M20 x 1.5P 6H.
4 OBJECTS CLOSER THAN 3.3 INCHES MAY PREVENT COVER OPENING FULL 90°.
5. ALL DIMENSIONS ARE GIVEN IN INCHES. MILLIMETER DIMENSIONS SHOWN IN ( )
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION – CENELEC
EXPLOSION PROOF ENCLOSURE
SIZE C | DWG NO. 0070-00175-000 | REV A | DATE 08/25/00
© PHASE DYNAMICS, INC.
13.1 (333) (MOUNTING HOLE DIMENSIONS)
10.7 (272) (MOUNTING HOLE DIMENSIONS)
GROUND POINT
9.9 (251)
14.3 (363)
3.3 (84)
20.5 (521)
17.4 (442)
6.7 (170)
13.4 (340)
0.6 (15)
CONDUIT ENTRY AREA
6.0 (152)
SEND
VALVE
DRIVE
VENT

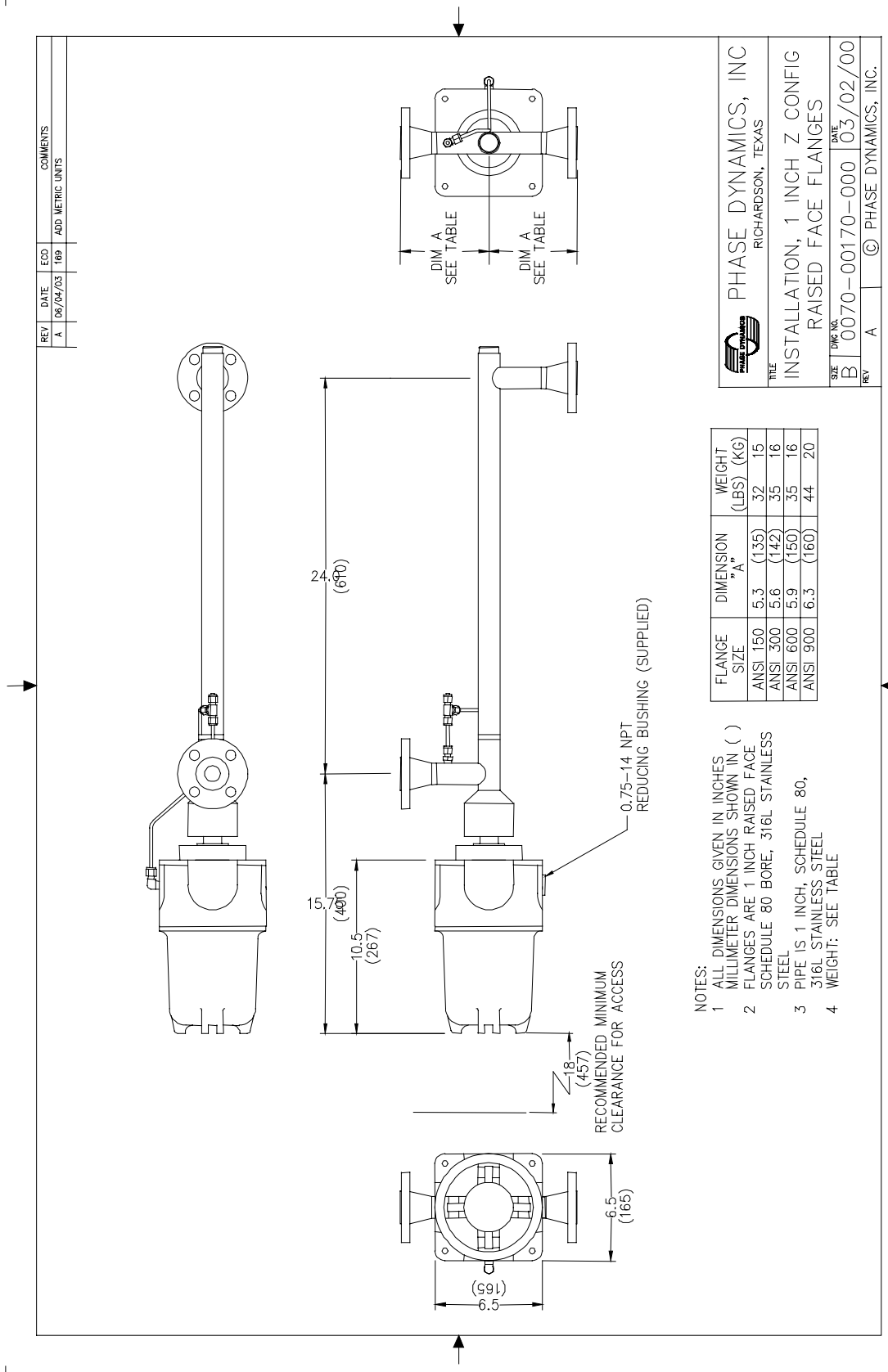

REV | DATE | ECO | COMMENTS
A | 02/16/98 | 117 | CHG HINGES, LATCHES 15.35 DIM WAS 15.3
B | 01/20/99 | 131 | ADD NOTE 8 TO MEET FM REQUIREMENTS
C | 06/04/03 | 169 | ADD METRIC UNITS
NOTES:
1. MOUNT ENCLOSURE WITH .375 DIA (10) BOLTS.
2. WEIGHT: 16 LBS. (7kg)
3. OBJECTS CLOSER THAN 3.0 INCHES (76) MAY PREVENT COVER FROM OPENING FULL 90°
4. OBJECTS CLOSER THAN 4.0 INCHES (102) MAY HINDER LATCH OPERATION.
5. ENCLOSURE IS GRAY MOLDED FIBERGLASS, WINDOW IS 0.125 THICK POLYCARBONATE
6. THREE HOLES LOCATED IN CONDUIT ENTRY AREA ARE 1.06 DIA. (27 DIA)
7. ALL DIMENSIONS ARE GIVEN IN INCHES. MILLIMETER DIMENSIONS SHOWN IN ( )
8. 4 EA #10-32 X 3/4 STAINLESS SCREWS ARE SUPPLIED TO MEET FM REQUIREMENTS. (TORQUE TO 22 INCH LBS)
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION, NEMA 4X
ENCLOSURE- EXT SWITCHES
SIZE C | DWG NO 0070-00037-000 | DATE 03/31/92
REV C | © PHASE DYNAMICS, INC.
15.35 (390) (MOUNTING HOLE DIMENSIONS)
8.6 (218) (MOUNTING HOLE DIMENSIONS)
4.0 (102)
7.9 (200)
16.3 (414)
10.5 (267)
6.0 (152)
CONDUIT ENTRY AREA
11.9 (302)
3.0 (76)
16.8 (427)



FLANGE SIZE	DIMENSION "A"		WEIGHT (LBS)	(KG)
ANSI 150	5.64	(143)	28 LBS	13
ANSI 300	5.9	(150)	31 LBS	14
ANSI 600	6.14	(156)	32 LBS	15

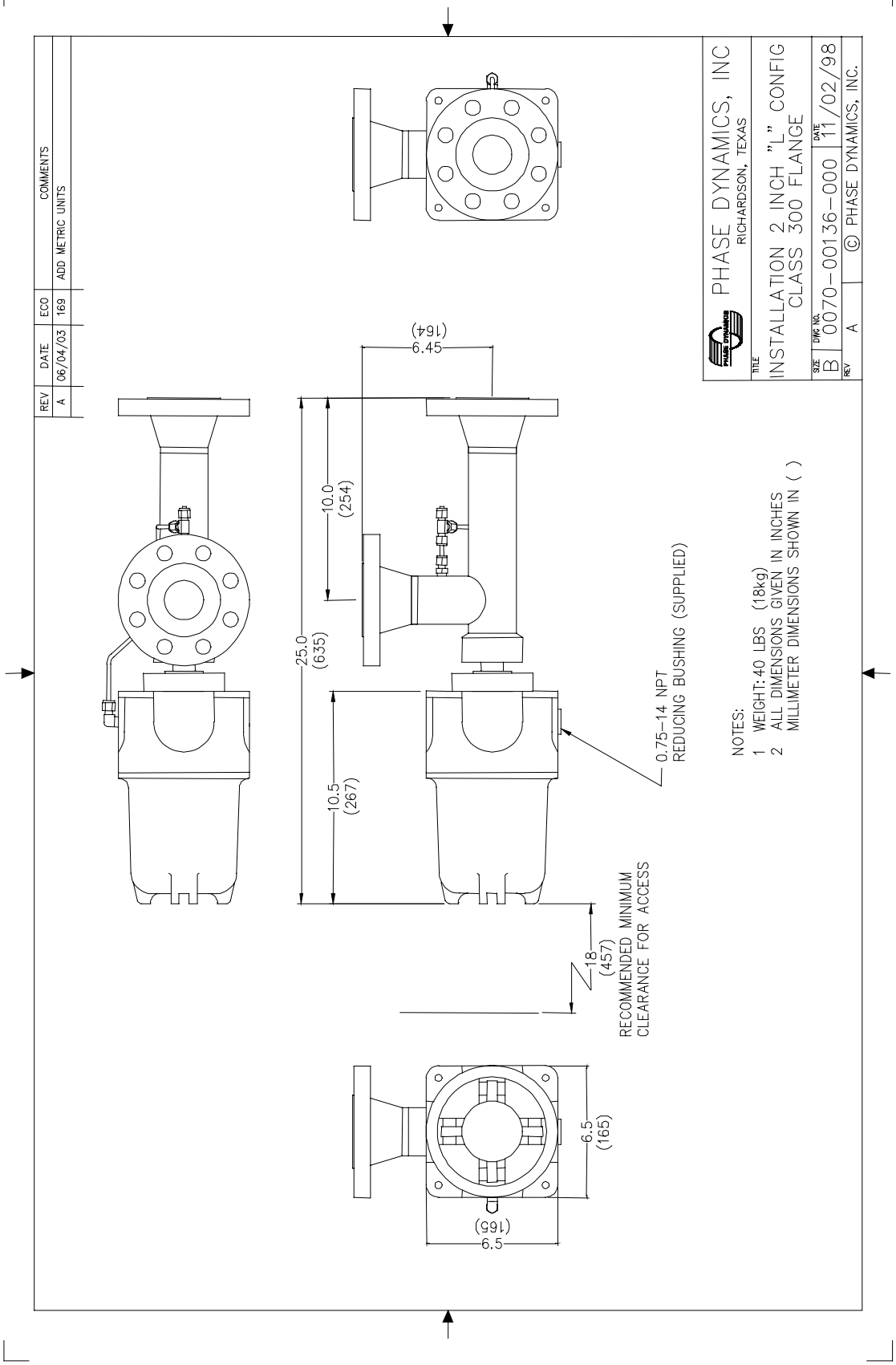


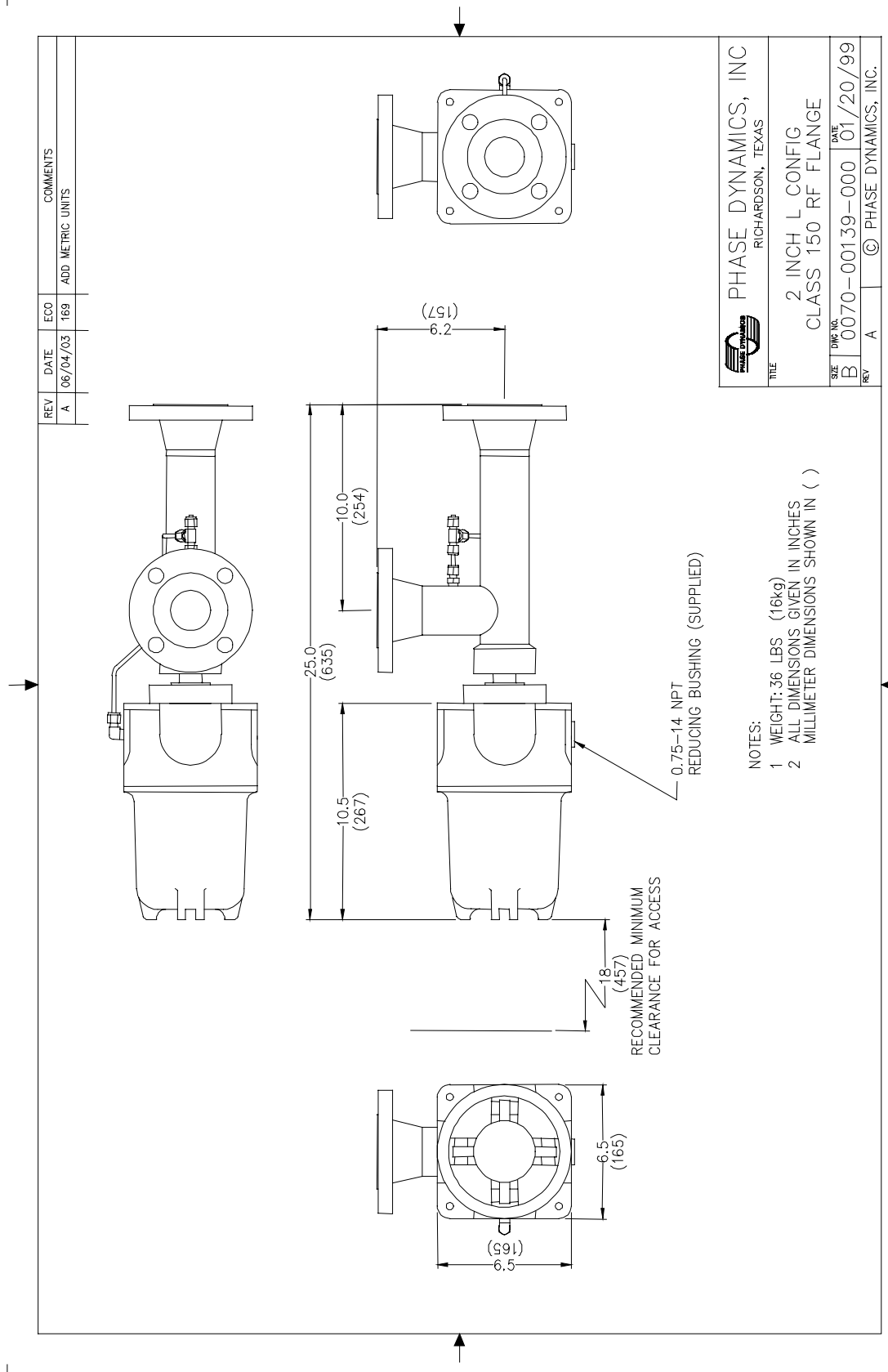
FLANGE SIZE	DIMENSION "A"		WEIGHT (LBS)	(KG)
ANSI 150	5.3	(135)	32	15
ANSI 300	5.6	(142)	35	16
ANSI 600	5.9	(150)	35	16
ANSI 900	6.3	(160)	44	20

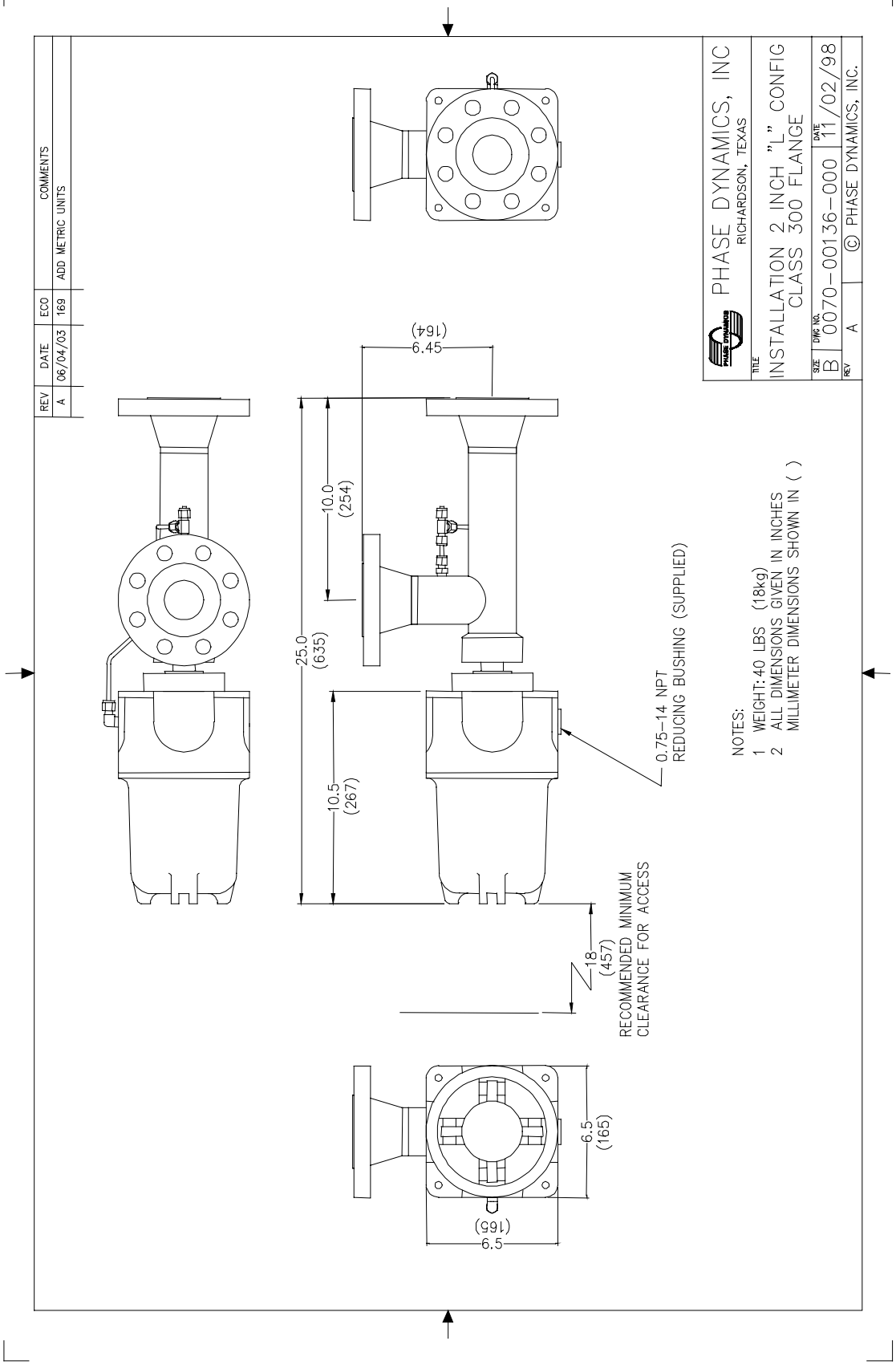


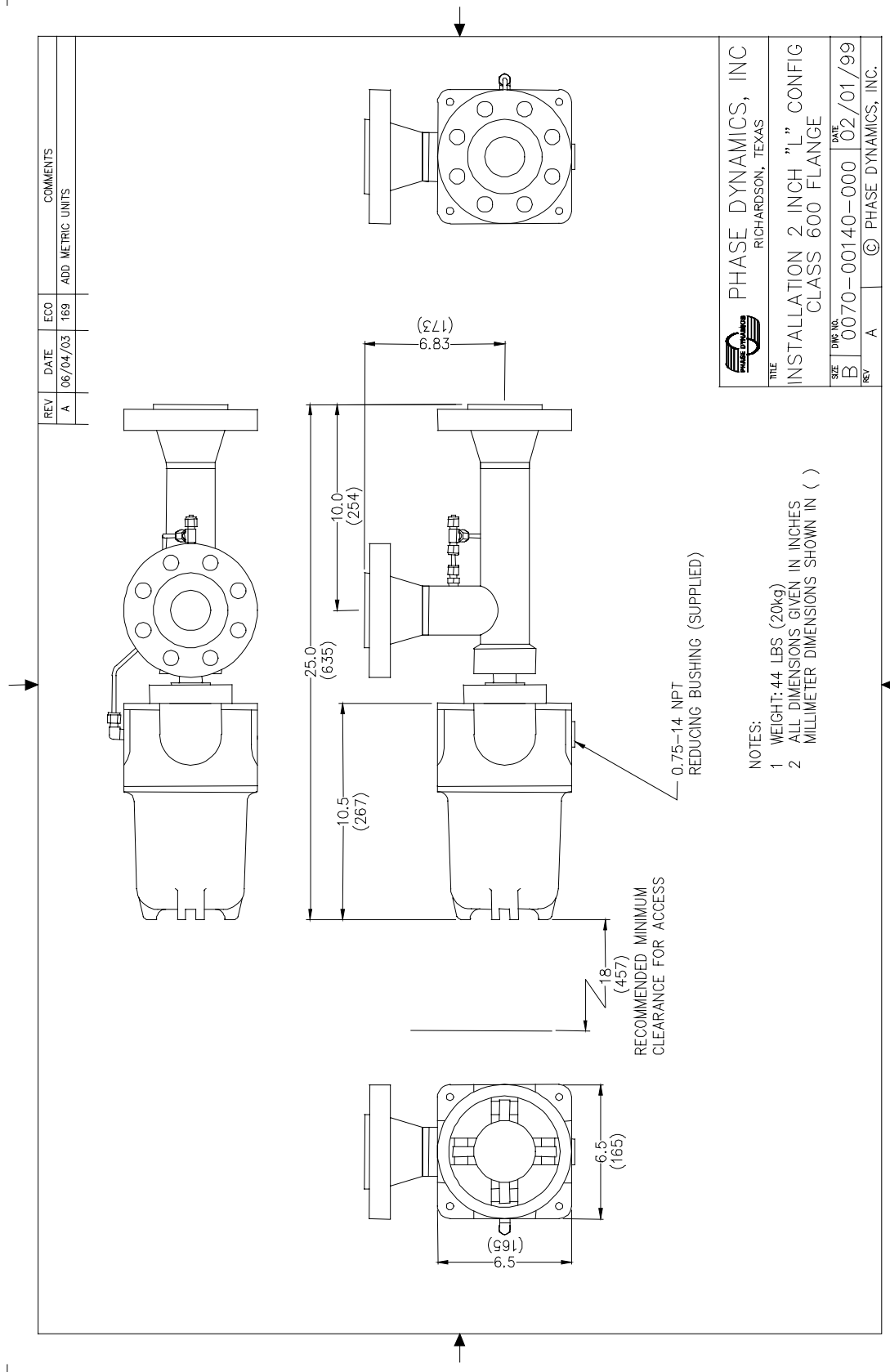
FLANGE SIZE	DIMENSION "A"		WEIGHT (LBS)	(KG)
ANSI 150	5.3	(135)	32	15
ANSI 300	5.6	(142)	35	16
ANSI 600	5.9	(150)	35	16
ANSI 900	6.3	(160)	44	20

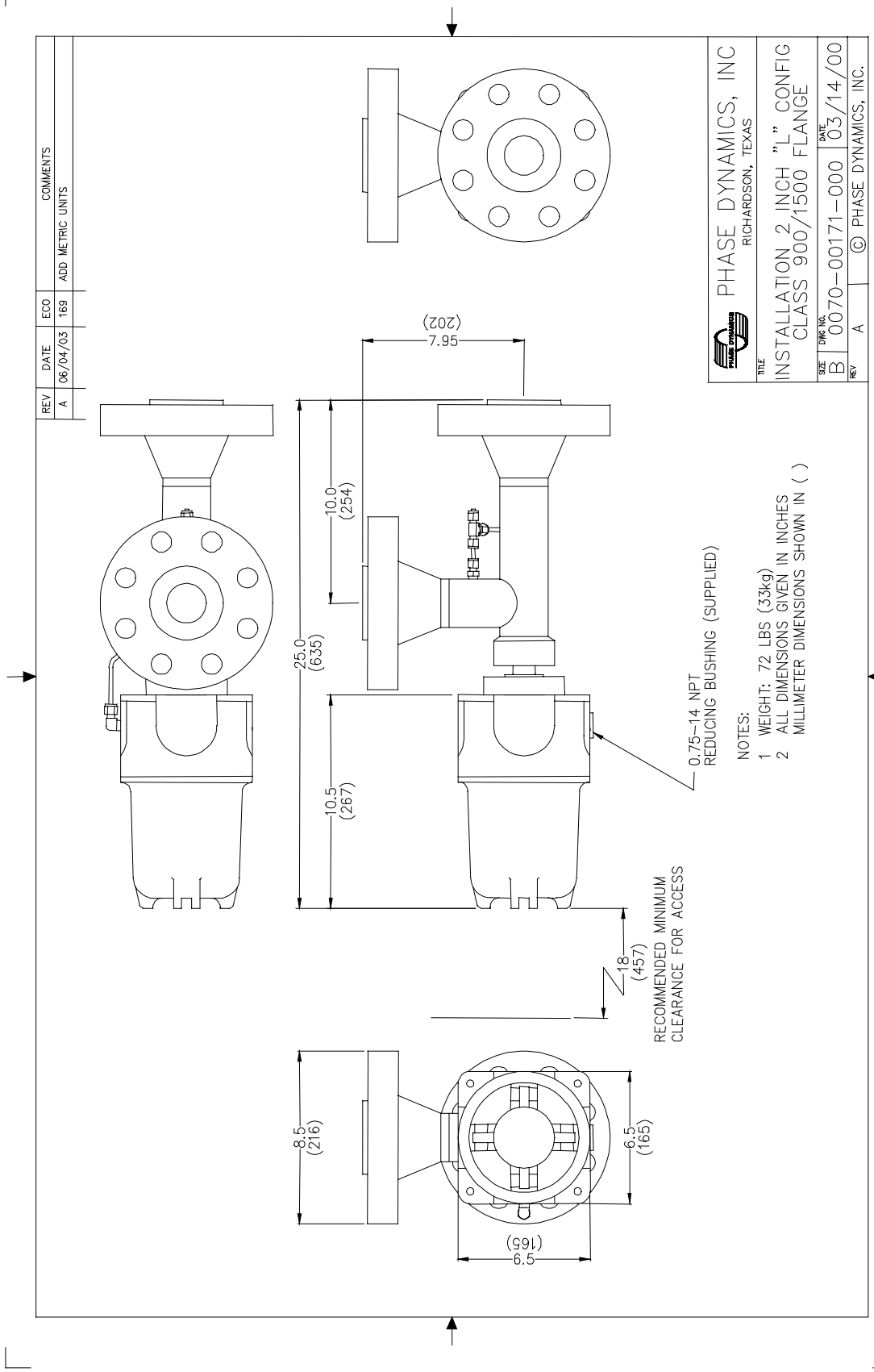
NOTES:
1 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
2 FLANGES ARE 1 INCH RAISED FACE SCHEDULE 80 BORE, 316L STAINLESS STEEL
3 PIPE IS 1 INCH, SCHEDULE 80, 316L STAINLESS STEEL
4 WEIGHT: SEE TABLE

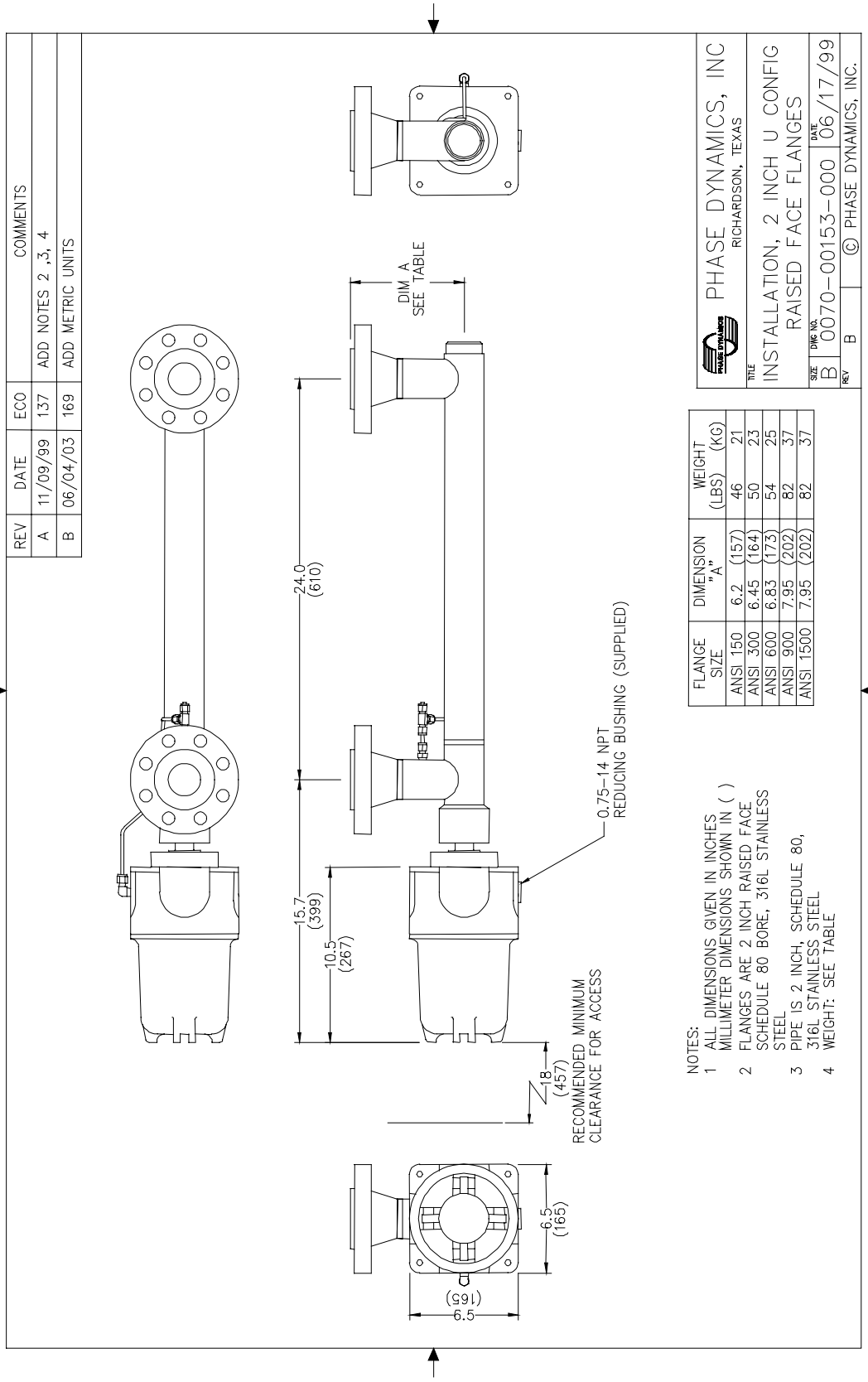

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 2 INCH "L" CONFIG
CLASS 300 FLANGE
SIZE B | DWG NO. 0070-00136-000 | DATE 11/02/98
REV A
© PHASE DYNAMICS, INC.
(164)
6.45
10.0
(254)
25.0
(635)
10.5
(267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18
(457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5
(165)
(165)
6.5
NOTES:
1 WEIGHT: 40 LBS (18kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
2 INCH L CONFIG
CLASS 150 RF FLANGE
SIZE B | DWG NO. 0070-00139-000 | DATE 01/20/99
REV A | © PHASE DYNAMICS, INC.
(157)
6.2
10.0
(254)
25.0
(635)
10.5
(267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
NOTES:
1 WEIGHT: 36 LBS (16kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
18
(457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5
(165)
(165)
6.5


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 2 INCH "L" CONFIG
CLASS 300 FLANGE
SIZE B | DWG NO. 0070-00136-000 | DATE 11/02/98
REV A
© PHASE DYNAMICS, INC.
6.45 (164)
10.0 (254)
25.0 (635)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 40 LBS (18kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 2 INCH "L" CONFIG
CLASS 600 FLANGE
SIZE B | DWG NO. 0070-00140-000 | DATE 02/01/99
REV A | © PHASE DYNAMICS, INC.
6.83 (173)
10.0 (254)
25.0 (635)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 44 LBS (20kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 2 INCH "L" CONFIG
CLASS 900/1500 FLANGE
SIZE B | DWG NO. 0070-00171-000 | DATE 03/14/00
REV A | © PHASE DYNAMICS, INC.
7.95 (202)
10.0 (254)
25.0 (635)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
NOTES:
1 WEIGHT: 72 LBS (33kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
8.5 (216)
6.5 (165)
6.5 (165)



REV	DATE	ECO	COMMENTS
A	11/09/99	137	ADD NOTES 2 ,3, 4
B	06/04/03	169	ADD METRIC UNITS

FLANGE SIZE	DIMENSION "A"		WEIGHT (LBS)	(KG)
ANSI 150	6.2	(157)	46	21
ANSI 300	6.45	(164)	50	23
ANSI 600	6.83	(173)	54	25
ANSI 900	7.95	(202)	82	37
ANSI 1500	7.95	(202)	82	37

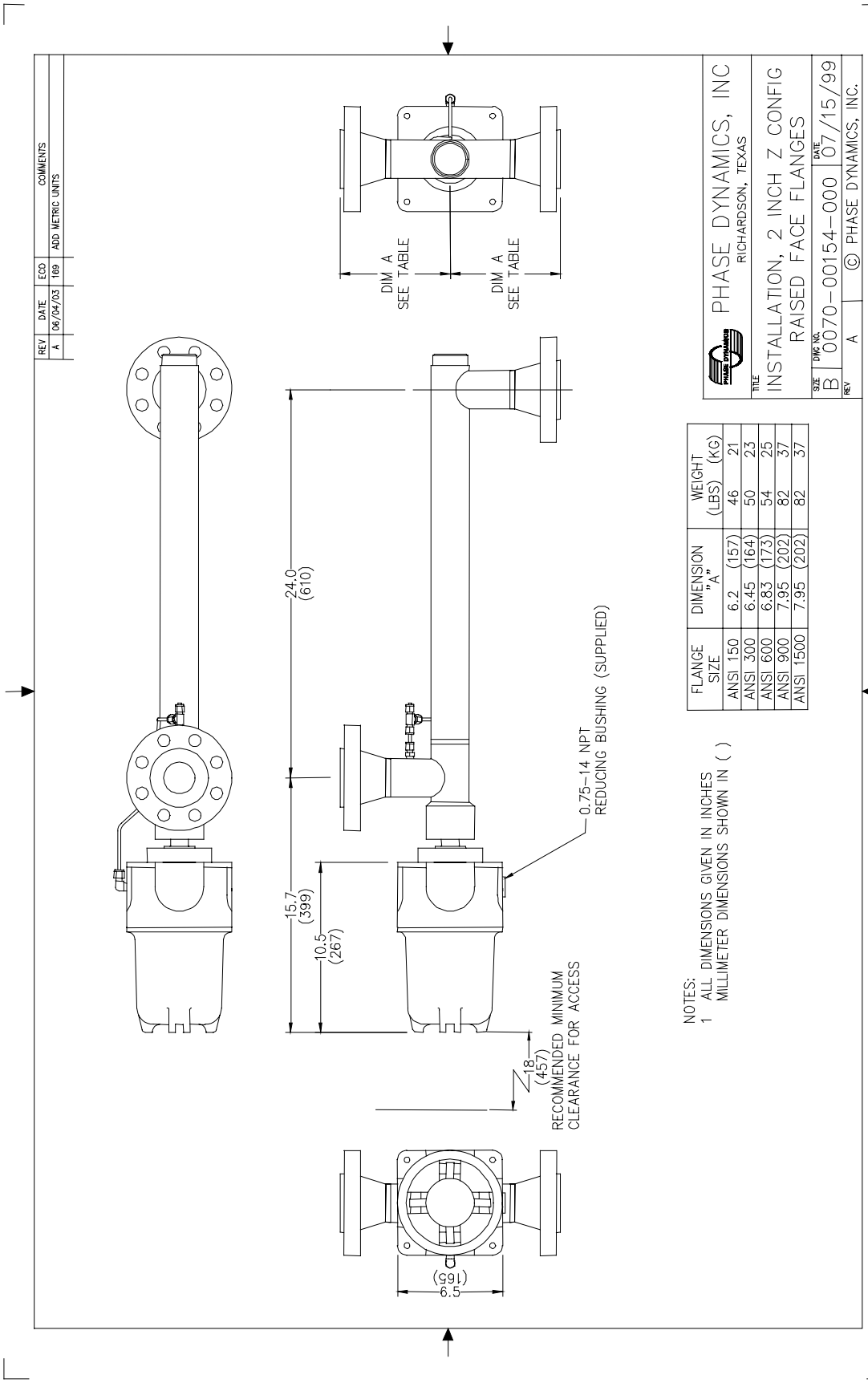
NOTES:
1 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
2 FLANGES ARE 2 INCH RAISED FACE SCHEDULE 80 BORE, 316L STAINLESS STEEL
3 PIPE IS 2 INCH, SCHEDULE 80, 316L STAINLESS STEEL
4 WEIGHT: SEE TABLE

PHASE DYNAMICS, INC
RICHARDSON, TEXAS

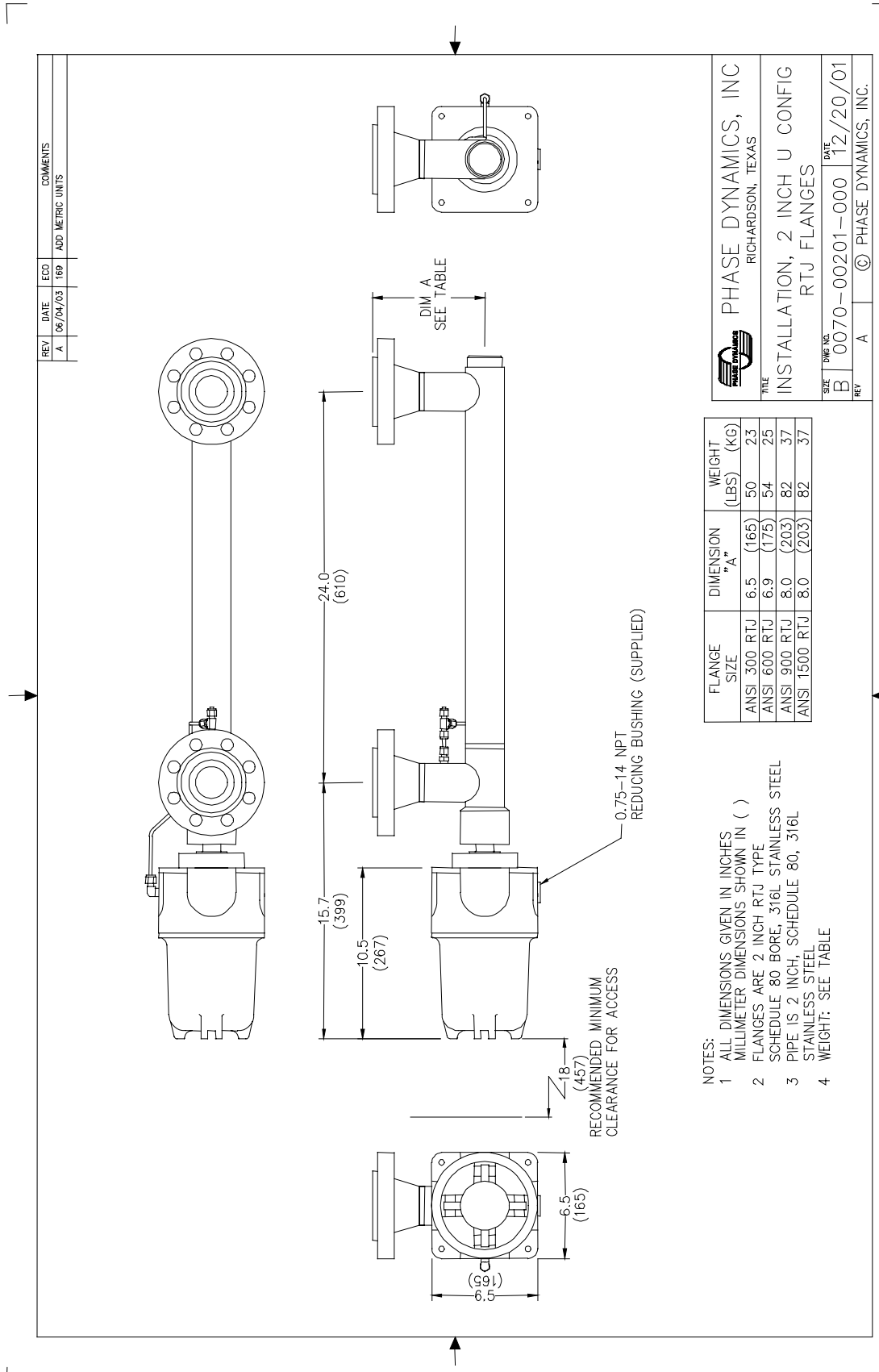
TITLE
INSTALLATION, 2 INCH U CONFIG
RAISED FACE FLANGES

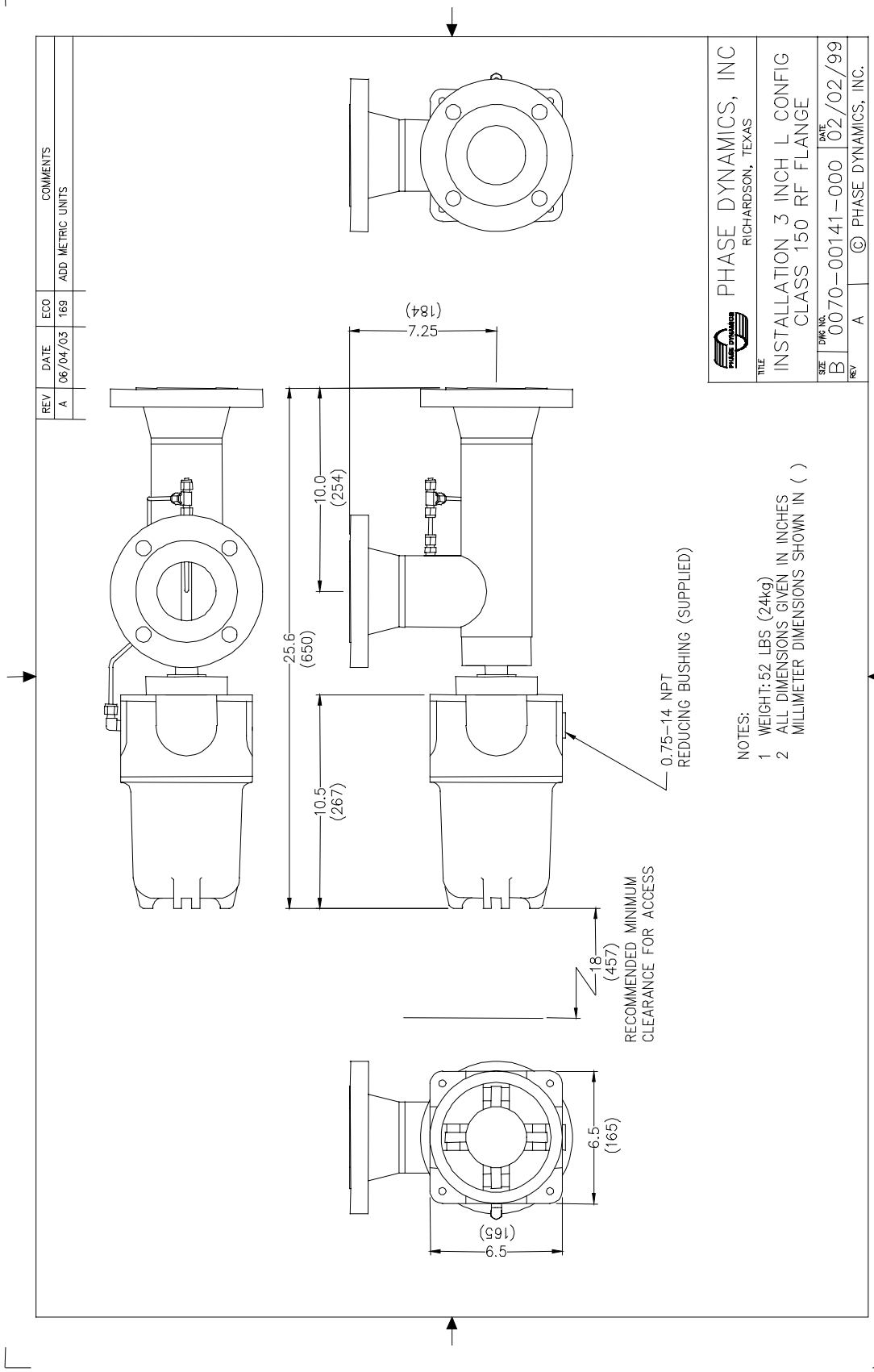
SIZE	DWG NO.	DATE
B	0070-00153-000	06/17/99

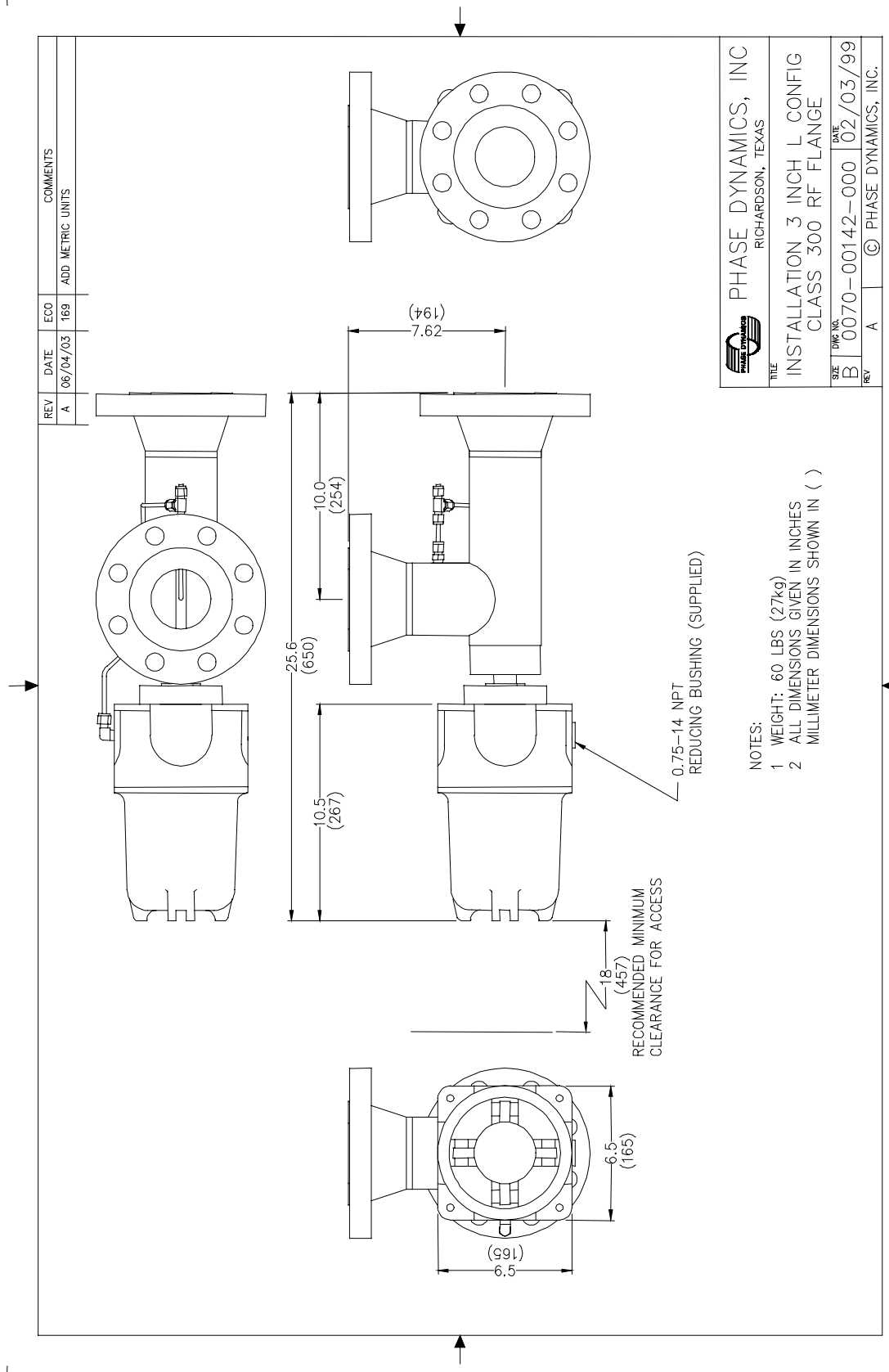
REV		
B	© PHASE DYNAMICS, INC.	

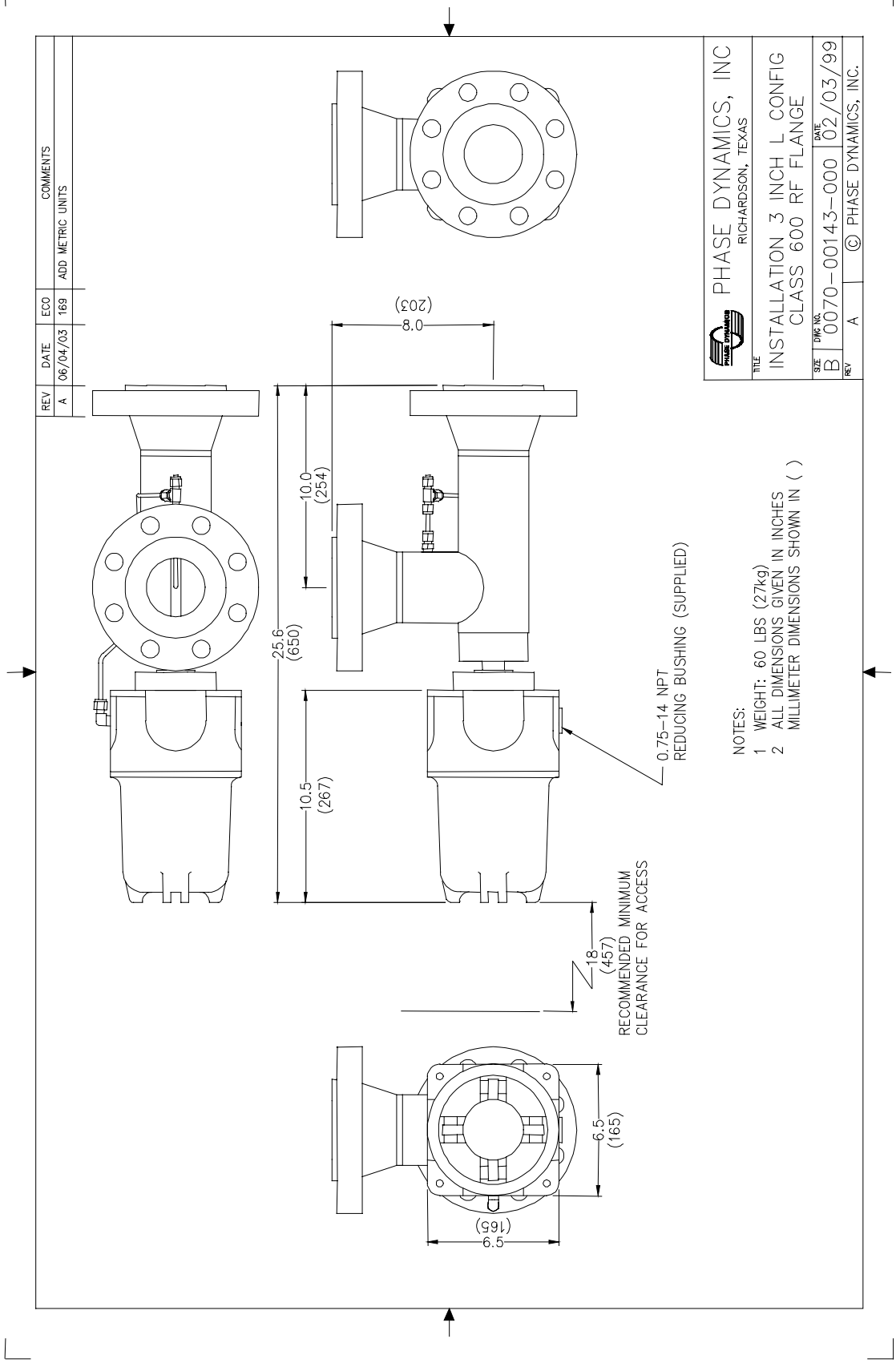


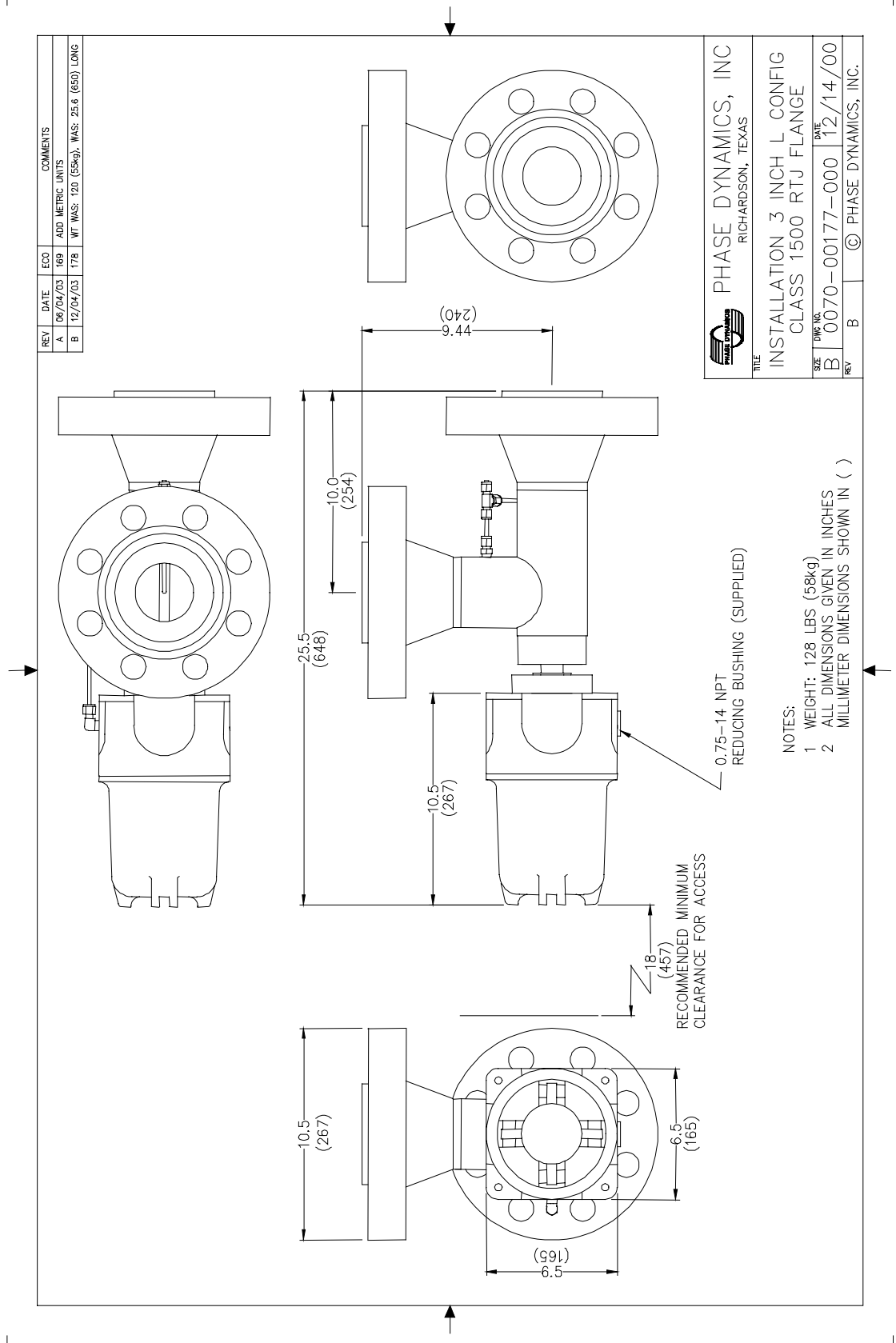
FLANGE SIZE	DIMENSION "A"	WEIGHT (LBS)	(KG)
ANSI 150	6.2 (157)	46	21
ANSI 300	6.45 (164)	50	23
ANSI 600	6.83 (173)	54	25
ANSI 900	7.95 (202)	82	37
ANSI 1500	7.95 (202)	82	37

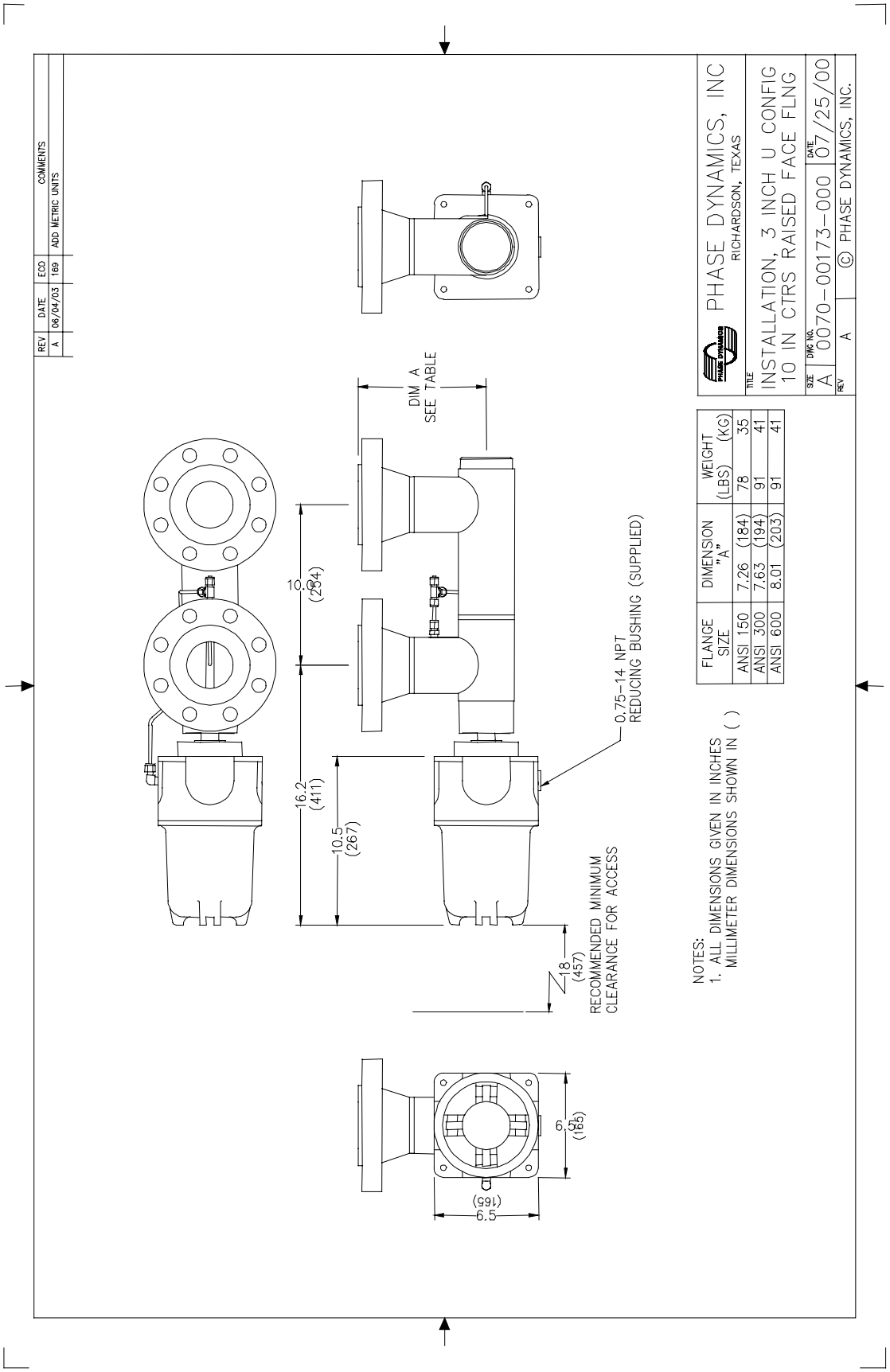

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
DIM A SEE TABLE
24.0 (610)
15.7 (399)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
2 FLANGES ARE 2 INCH RTJ TYPE SCHEDULE 80 BORE, 316L STAINLESS STEEL
3 PIPE IS 2 INCH, SCHEDULE 80, 316L STAINLESS STEEL
4 WEIGHT: SEE TABLE
FLANGE SIZE | DIMENSION "A" | WEIGHT (LBS) (KG)
ANSI 300 RTJ | 6.5 (165) | 50 23
ANSI 600 RTJ | 6.9 (175) | 54 25
ANSI 900 RTJ | 8.0 (203) | 82 37
ANSI 1500 RTJ | 8.0 (203) | 82 37
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 2 INCH U CONFIG RTJ FLANGES
SIZE B
DWG NO. 0070-00201-000
DATE 12/20/01
REV A
© PHASE DYNAMICS, INC.

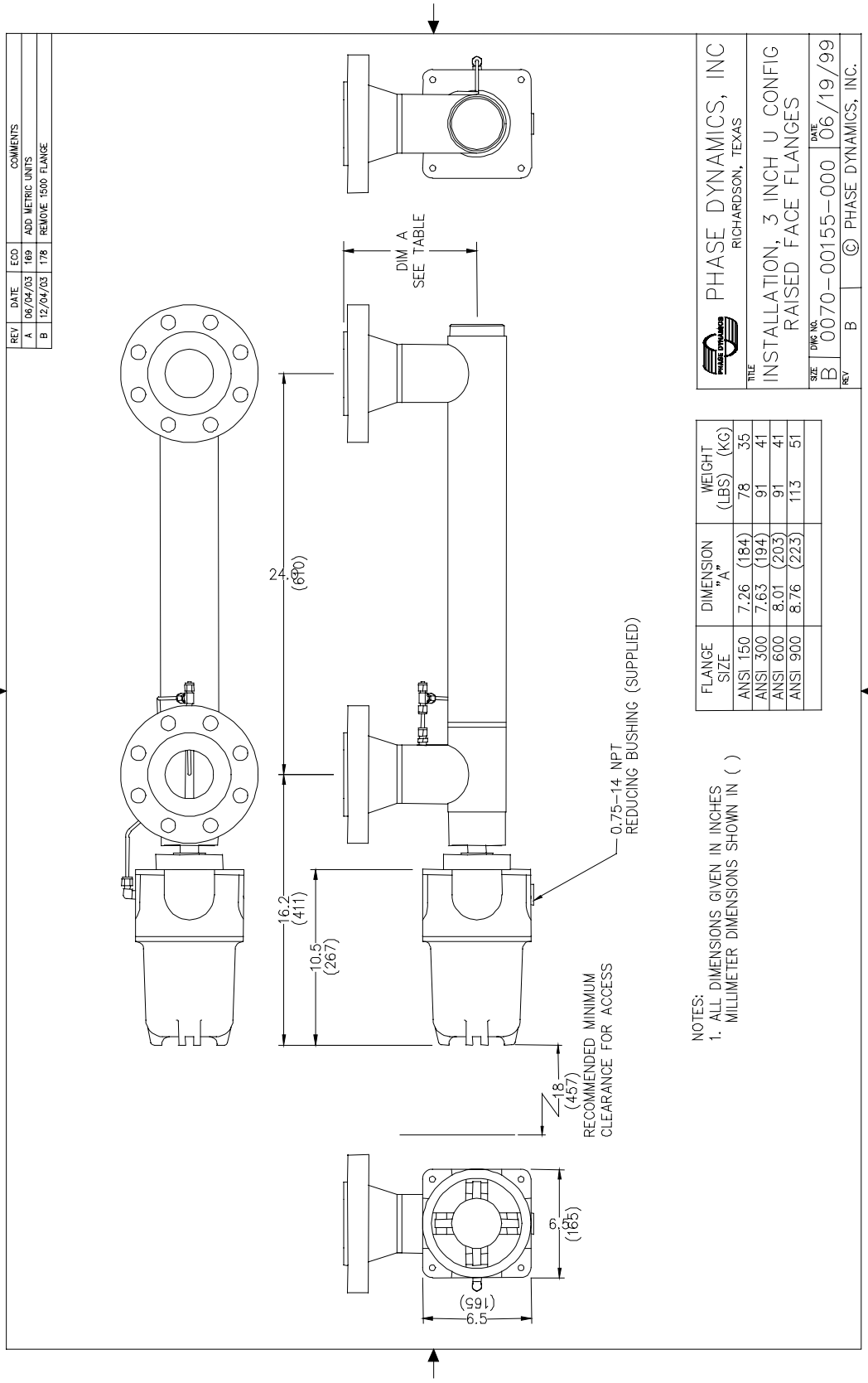

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 3 INCH L CONFIG
CLASS 150 RF FLANGE
SIZE B
DWG NO. 0070-00141-000
DATE 02/02/99
REV A
© PHASE DYNAMICS, INC.
7.25 (184)
10.0 (254)
25.6 (650)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
NOTES:
1 WEIGHT: 52 LBS (24kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

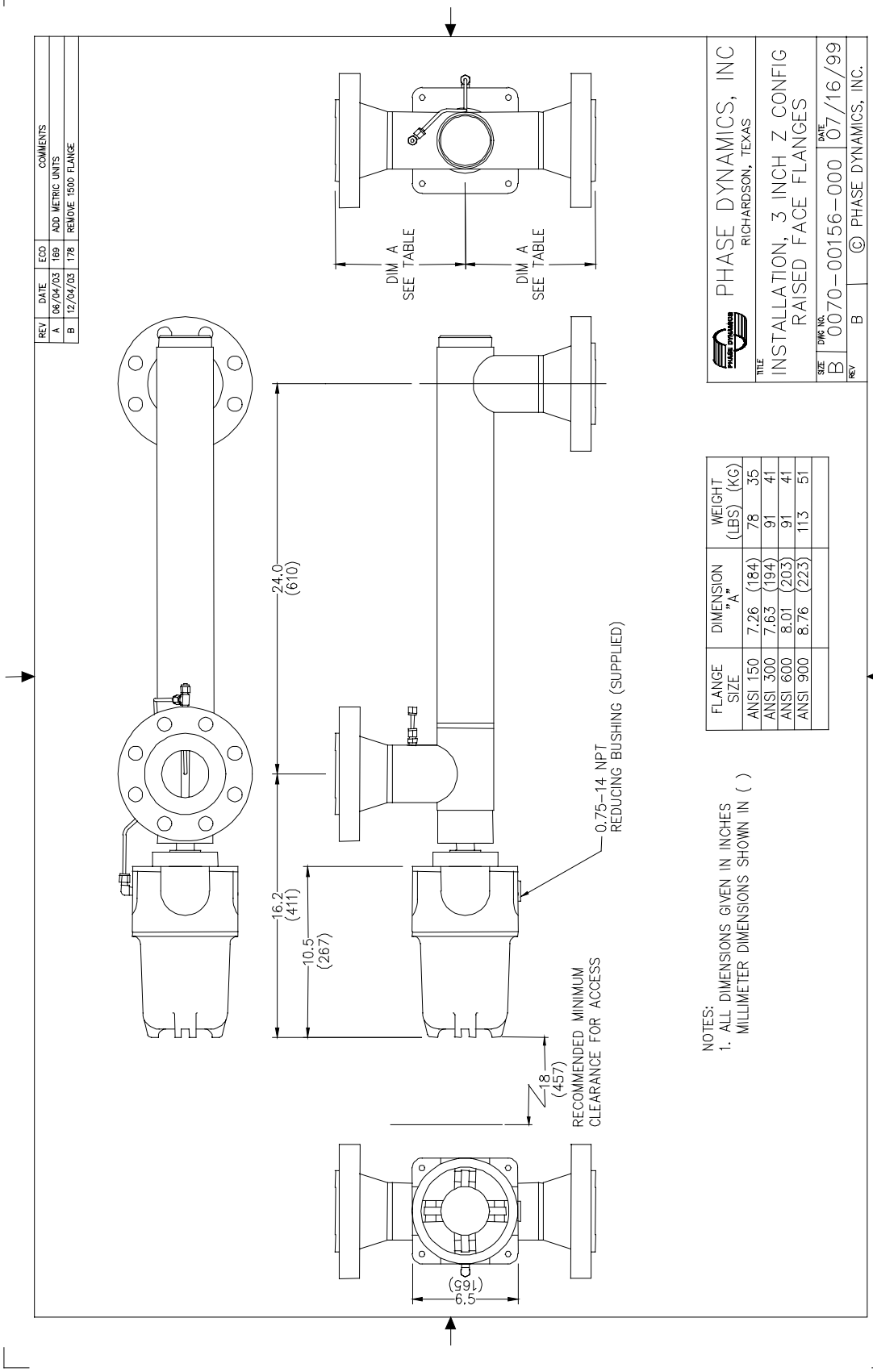

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 3 INCH L CONFIG
CLASS 300 RF FLANGE
SIZE B | DWG NO. 0070-00142-000 | DATE 02/03/99
REV A | © PHASE DYNAMICS, INC.
7.62 (194)
10.0 (254)
25.6 (650)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 60 LBS (27kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

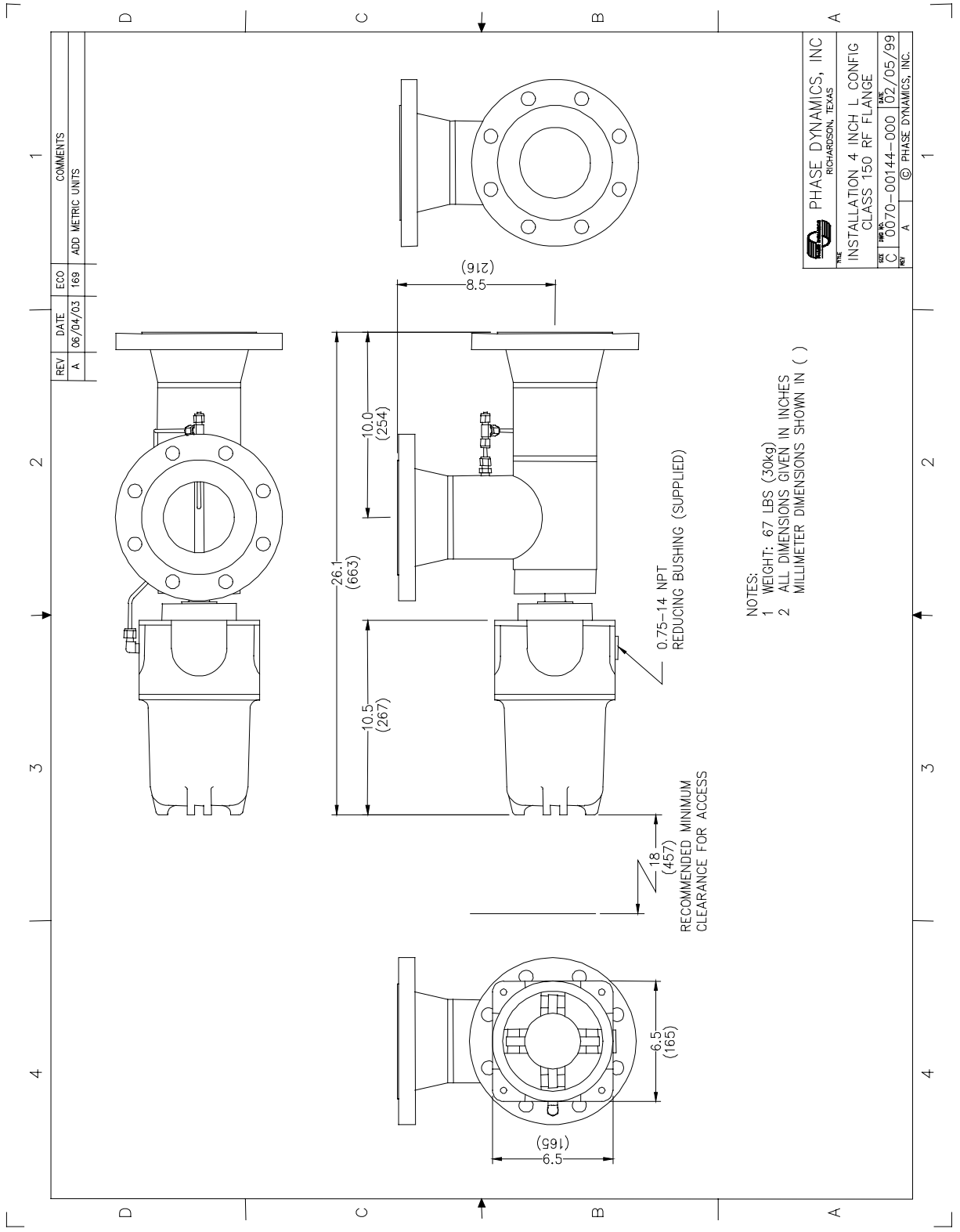

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 3 INCH L CONFIG
CLASS 600 RF FLANGE
SIZE B | DWG NO. 0070-00143-000 | DATE 02/03/99
REV A | © PHASE DYNAMICS, INC.
8.0 (203)
10.0 (254)
25.6 (650)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
NOTES:
1 WEIGHT: 60 LBS (27kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)

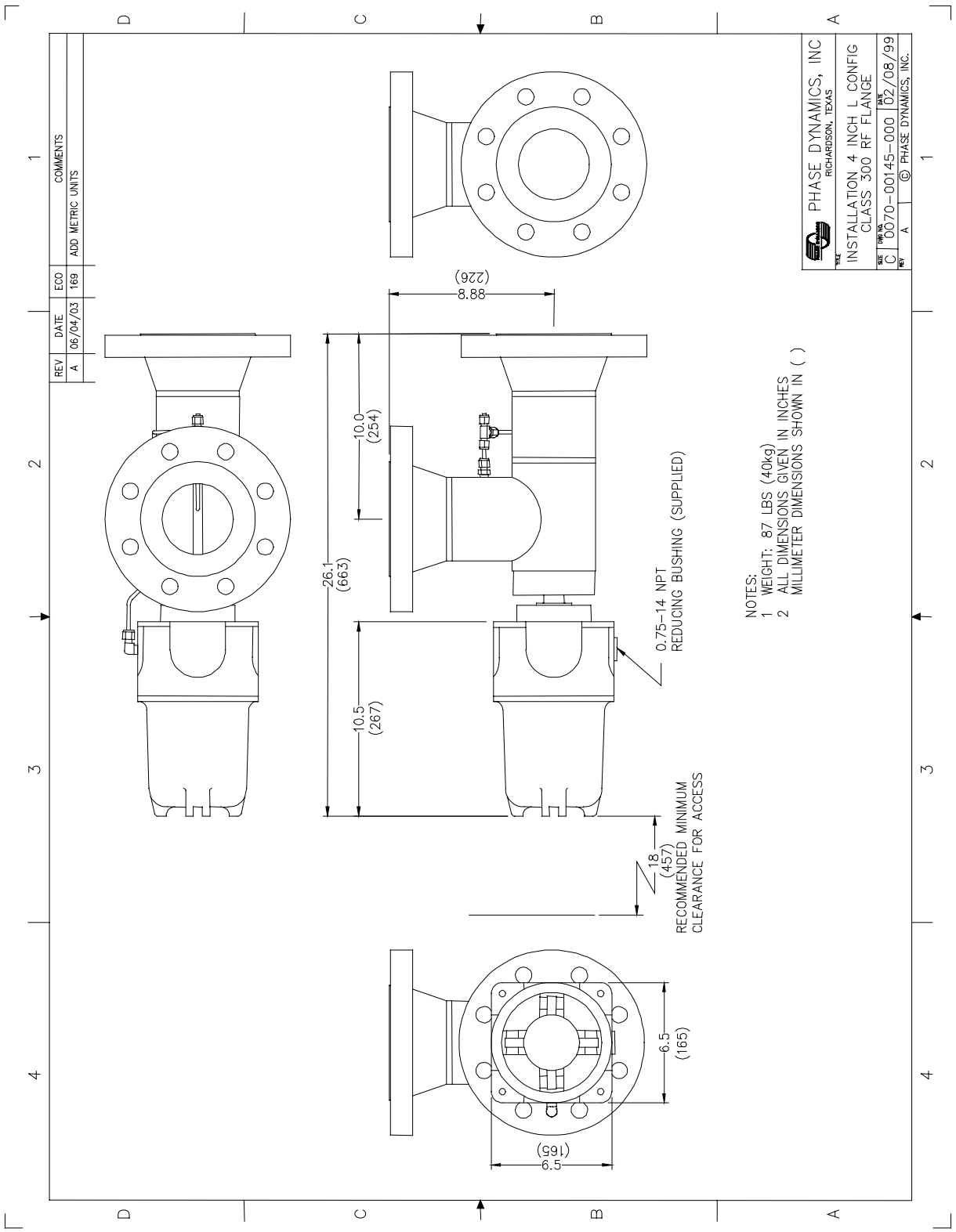

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
B | 12/04/03 | 178 | WT WAS: 120 (55kg), WAS: 25.6 (650) LONG
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION 3 INCH L CONFIG
CLASS 1500 RTJ FLANGE
SIZE B
DWG NO. 0070-00177-000
DATE 12/14/00
REV B
© PHASE DYNAMICS, INC.
9.44 (240)
10.0 (254)
25.5 (648)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
10.5 (267)
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 128 LBS (58kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

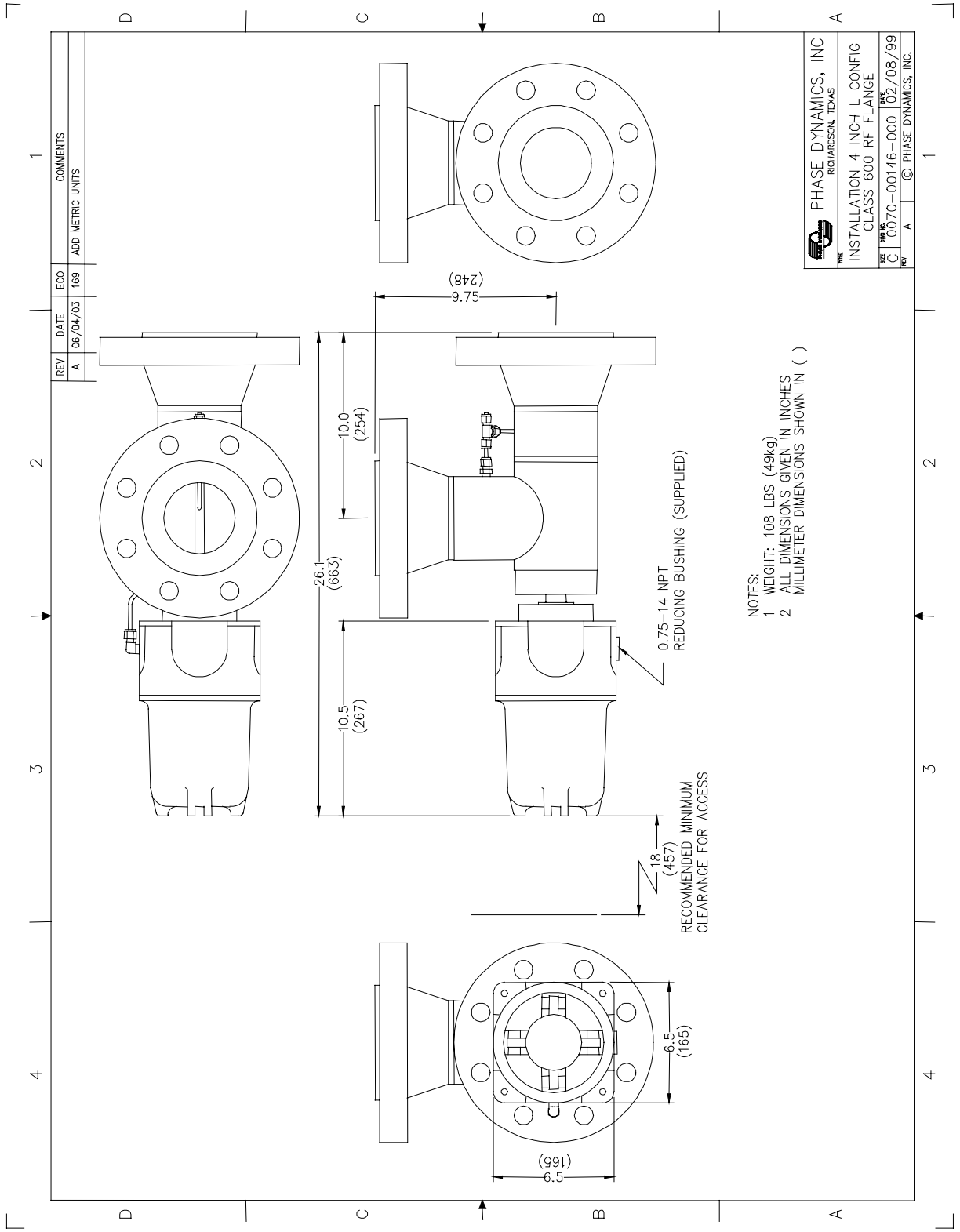

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 3 INCH U CONFIG
10 IN CTRS RAISED FACE FLNG
SIZE A
DWG NO. 0070-00173-000
REV A
DATE 07/25/00
© PHASE DYNAMICS, INC.
DIM A
SEE TABLE
10.0 (254)
16.2 (411)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1. ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
FLANGE SIZE | DIMENSION "A" | WEIGHT (LBS) (KG)
ANSI 150 | 7.26 (184) | 78 35
ANSI 300 | 7.63 (194) | 91 41
ANSI 600 | 8.01 (203) | 91 41

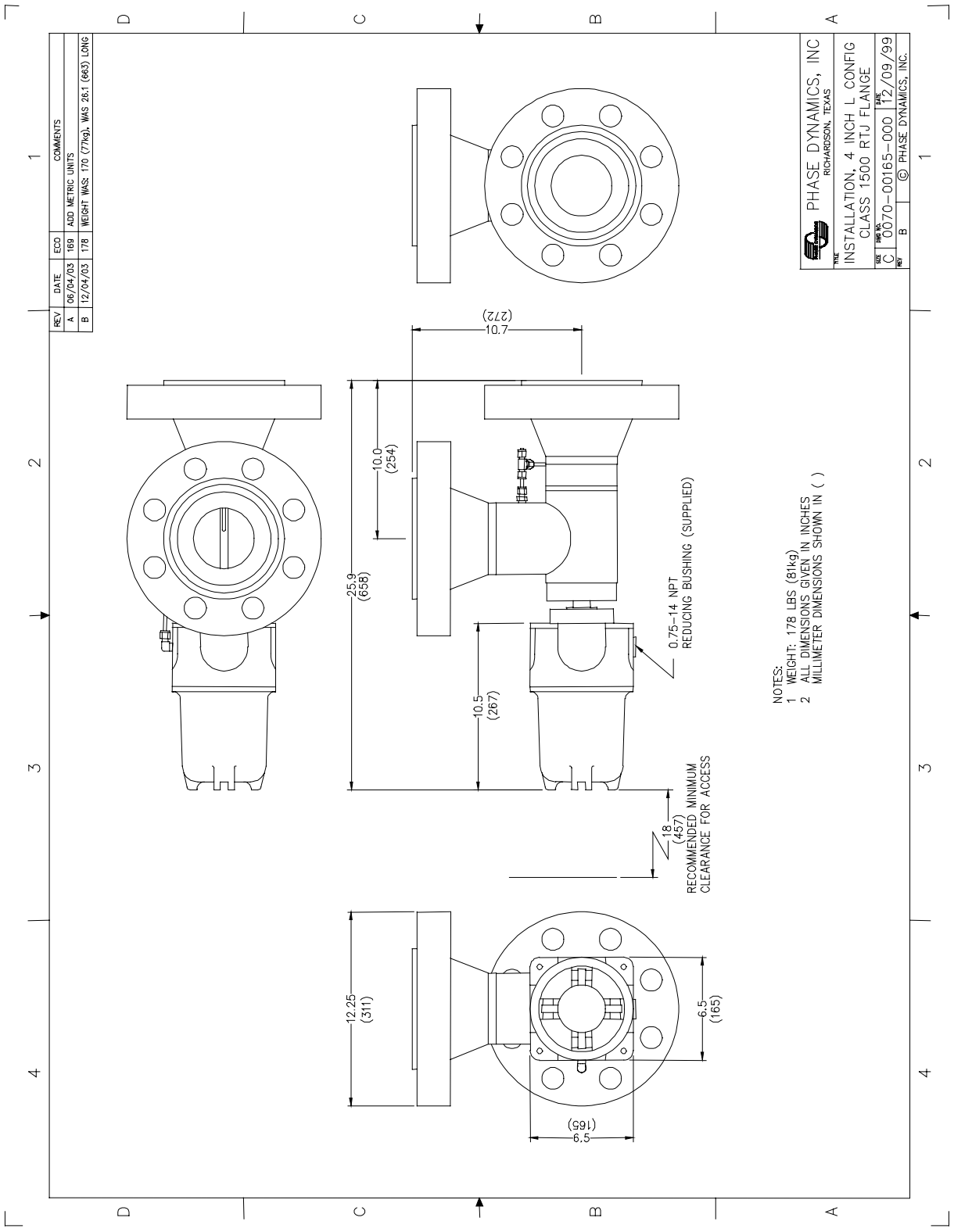

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
B | 12/04/03 | 178 | REMOVE 1500 FLANGE
DIM A SEE TABLE
24.0 (610)
16.2 (411)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1. ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
FLANGE SIZE | DIMENSION "A" | WEIGHT (LBS) (KG)
ANSI 150 | 7.26 (184) | 78 35
ANSI 300 | 7.63 (194) | 91 41
ANSI 600 | 8.01 (203) | 91 41
ANSI 900 | 8.76 (223) | 113 51
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 3 INCH U CONFIG RAISED FACE FLANGES
SIZE B
DWG NO. 0070-00155-000
DATE 06/19/99
REV B
© PHASE DYNAMICS, INC.

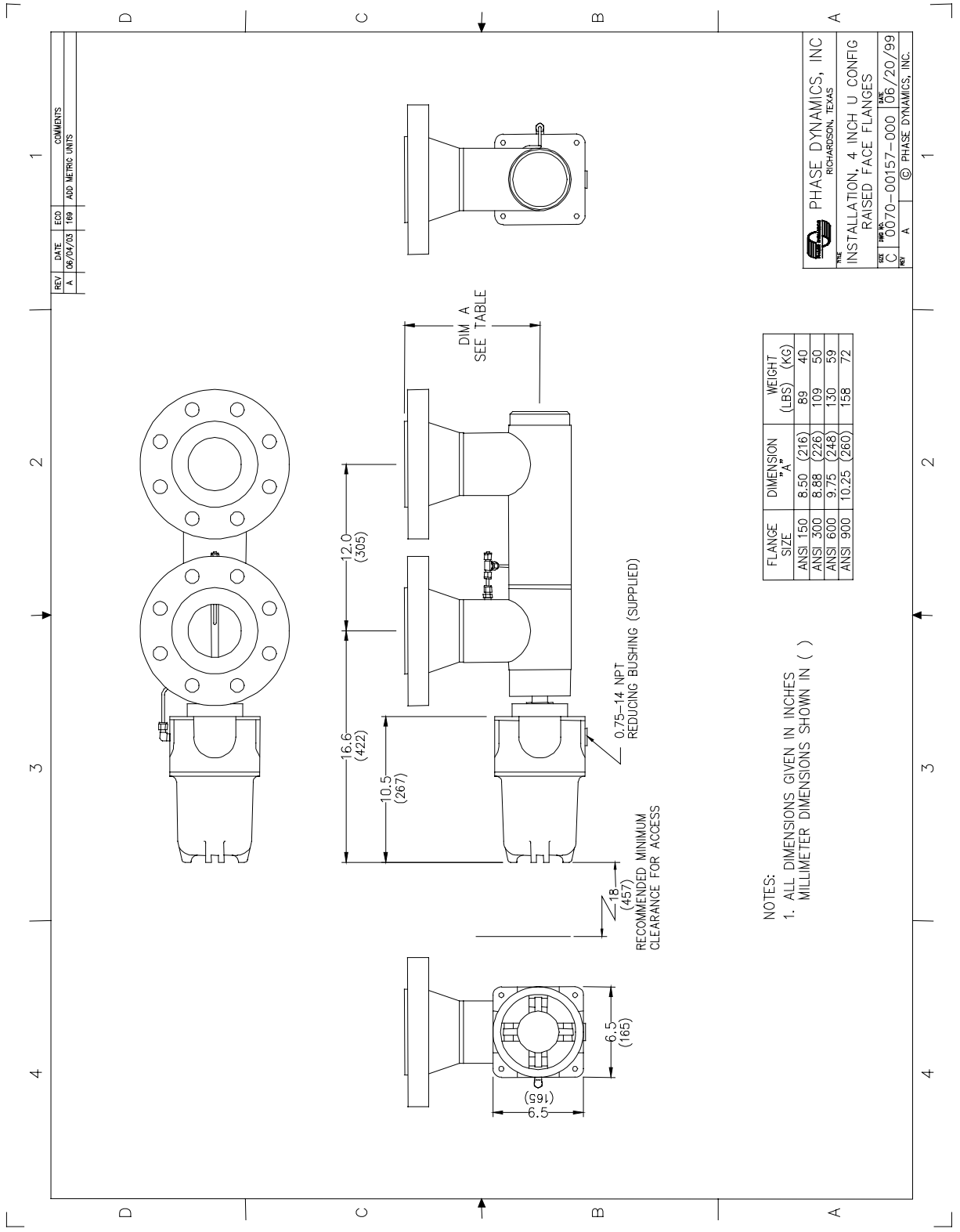

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
B | 12/04/03 | 178 | REMOVE 1500 FLANGE
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 3 INCH Z CONFIG
RAISED FACE FLANGES
SIZE B
DWG NO. 0070-00156-000
REV B
DATE 07/16/99
© PHASE DYNAMICS, INC.
DIM A SEE TABLE
DIM A SEE TABLE
24.0 (610)
16.2 (411)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
FLANGE SIZE | DIMENSION "A" | WEIGHT (LBS) (KG)
ANSI 150 | 7.26 (184) | 78 35
ANSI 300 | 7.63 (194) | 91 41
ANSI 600 | 8.01 (203) | 91 41
ANSI 900 | 8.76 (223) | 113 51
NOTES:
1. ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )


REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION 4 INCH L CONFIG
CLASS 150 RF FLANGE
SIZE C | DWG NO 0070-00144-000 | REV A | DATE 02/05/99
© PHASE DYNAMICS, INC.
8.5 (216)
10.0 (254)
26.1 (663)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 67 LBS (30kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

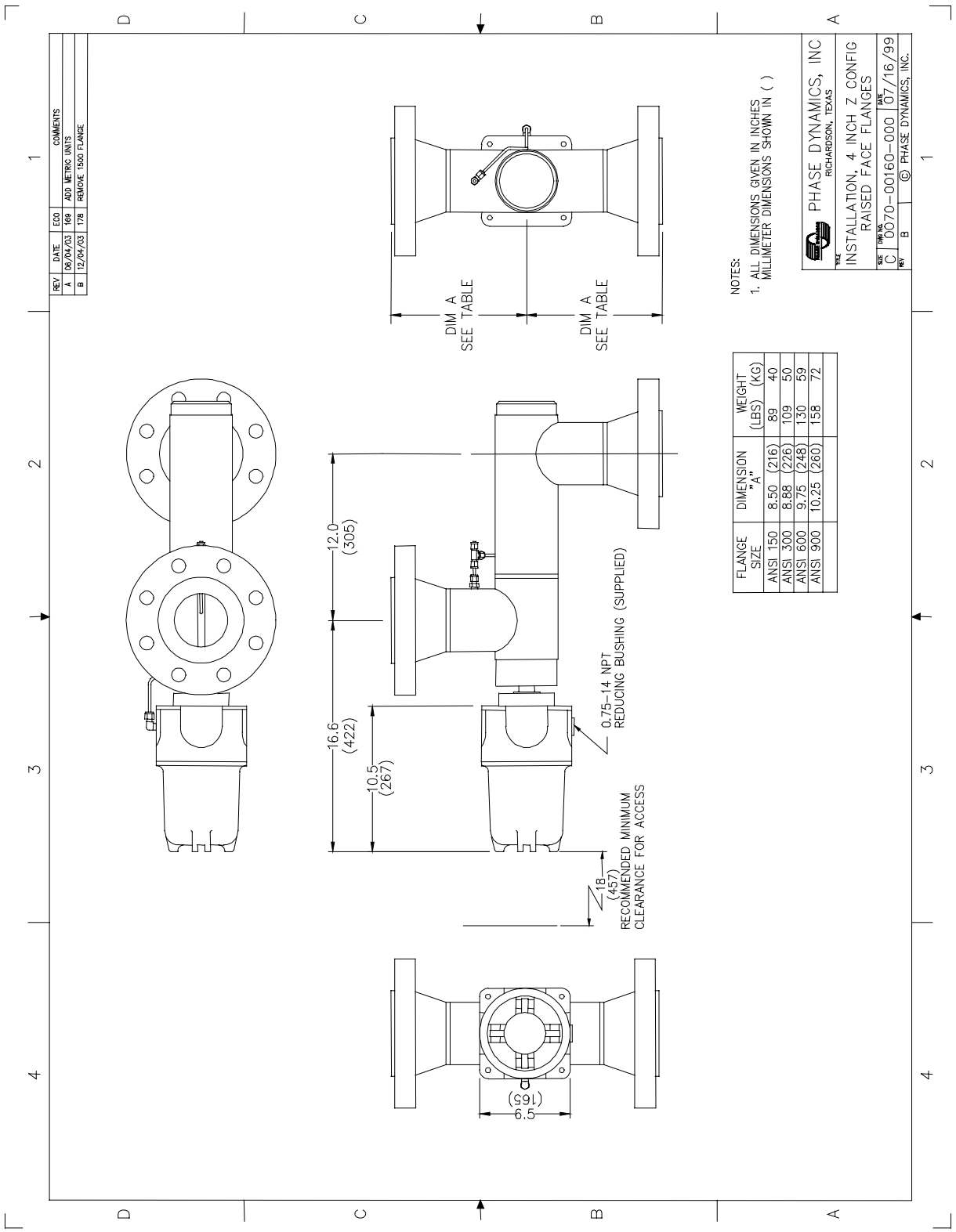

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION 4 INCH L CONFIG
CLASS 300 RF FLANGE
SIZE C | DWG NO 0070-00145-000 | REV A | SHEET 1 | 02/08/99
© PHASE DYNAMICS, INC.
8.88 (226)
10.0 (254)
26.1 (663)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 87 LBS (40kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

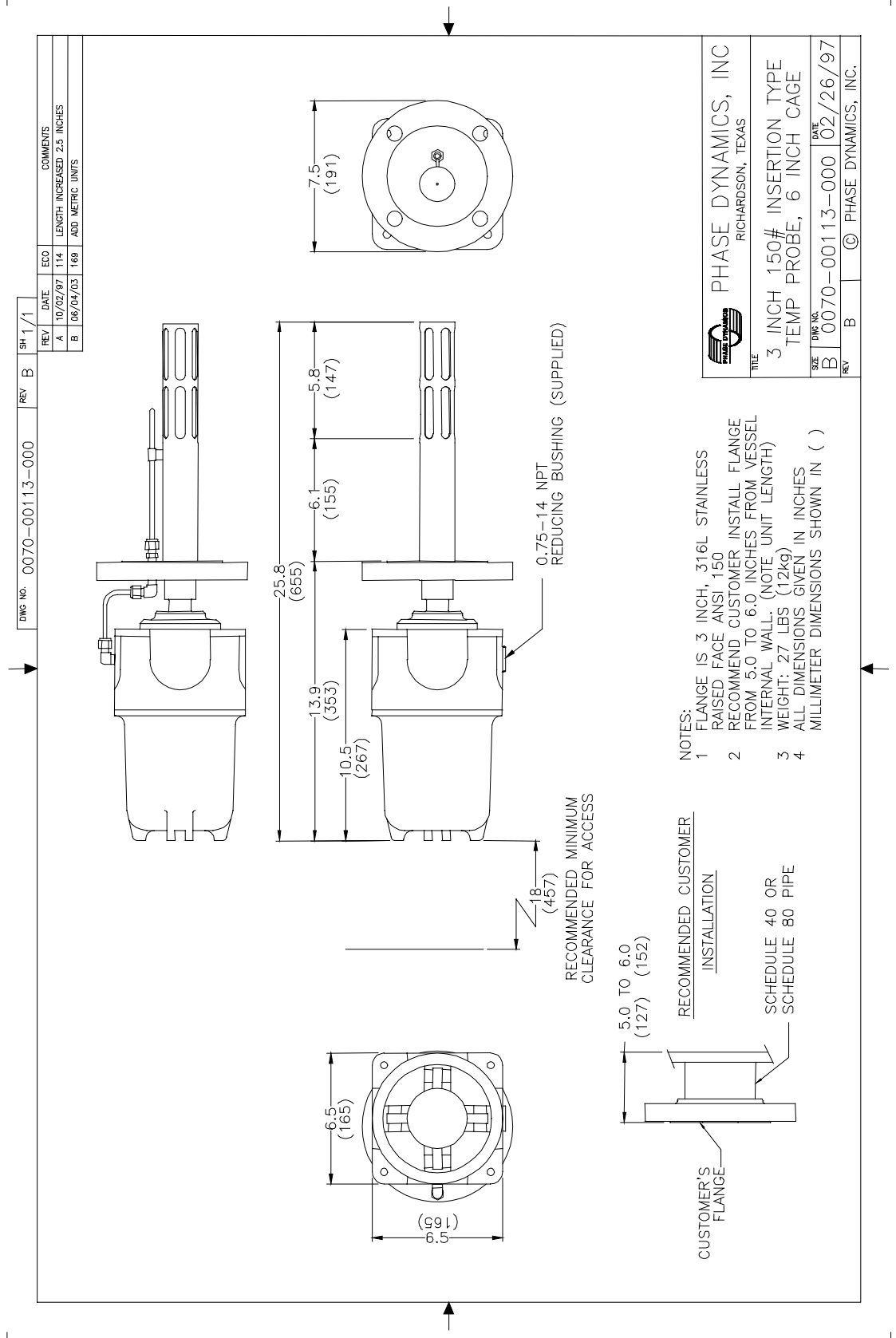

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION 4 INCH L CONFIG
CLASS 600 RF FLANGE
SIZE C | DWG NO. 0070-00146-000 | REV A | DATE 02/08/99
© PHASE DYNAMICS, INC.
9.75 (248)
10.0 (254)
26.1 (663)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 WEIGHT: 108 LBS (49kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

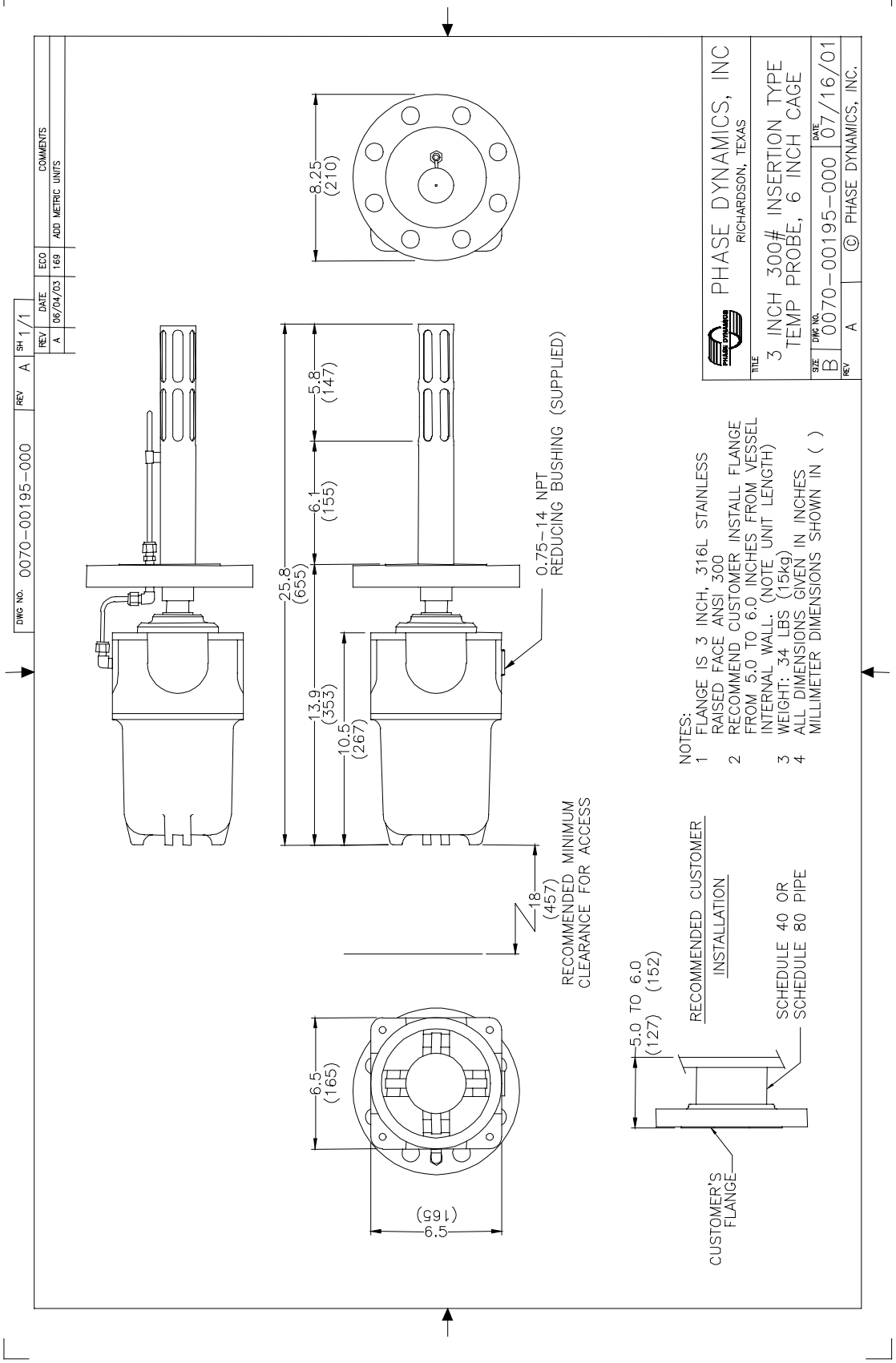

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
B | 12/04/03 | 178 | WEIGHT WAS: 170 (77kg), WAS 26.1 (663) LONG
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION, 4 INCH L CONFIG
CLASS 1500 RTJ FLANGE
SIZE C | DWG NO 0070-00165-000 | REV B | DATE 12/09/99
© PHASE DYNAMICS, INC.
(272) 10.7
10.0 (254)
25.9 (658)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
12.25 (311)
6.5 (165)
(165) 6.5
NOTES:
1 WEIGHT: 178 LBS (81kg)
2 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )

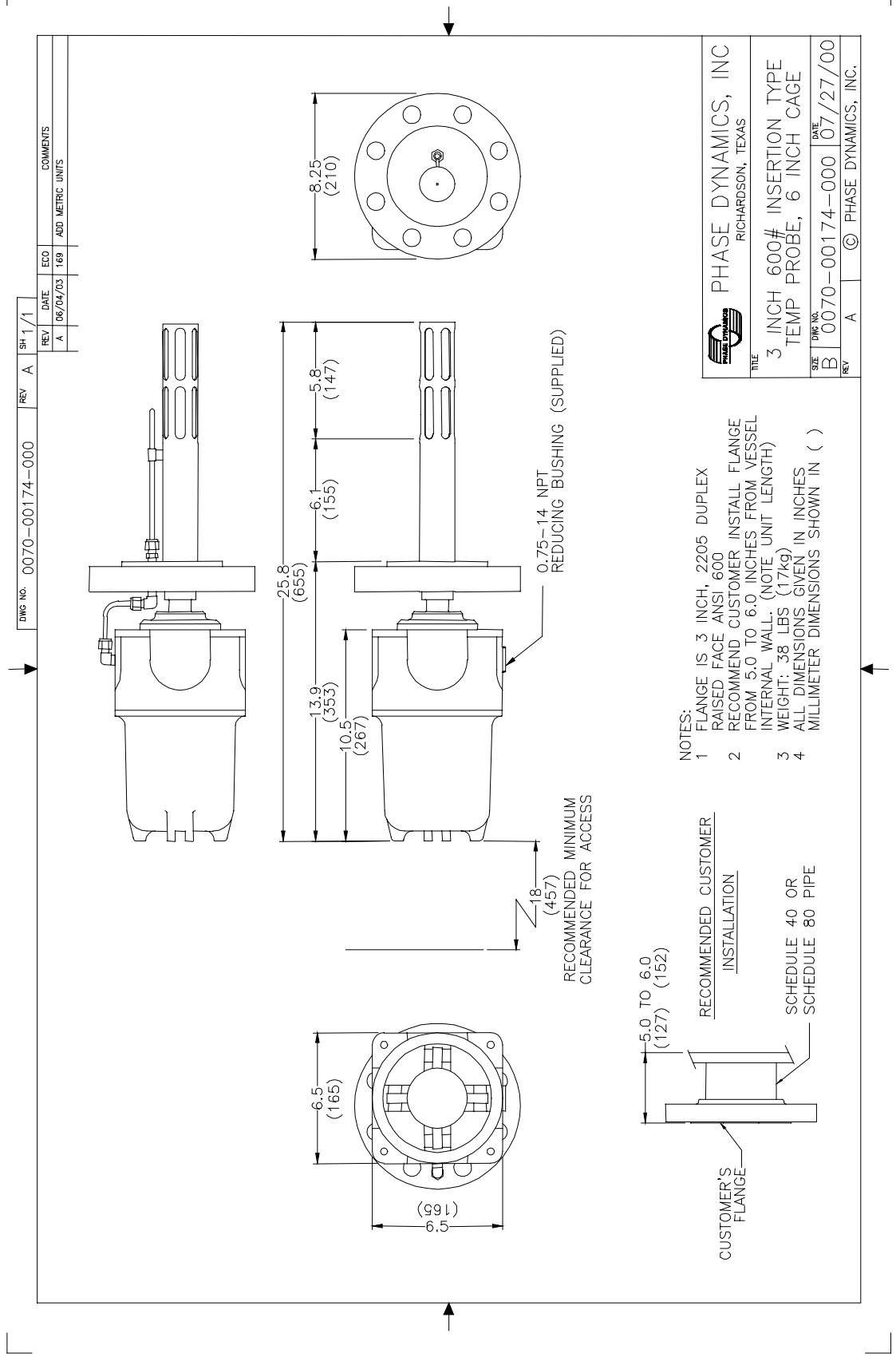


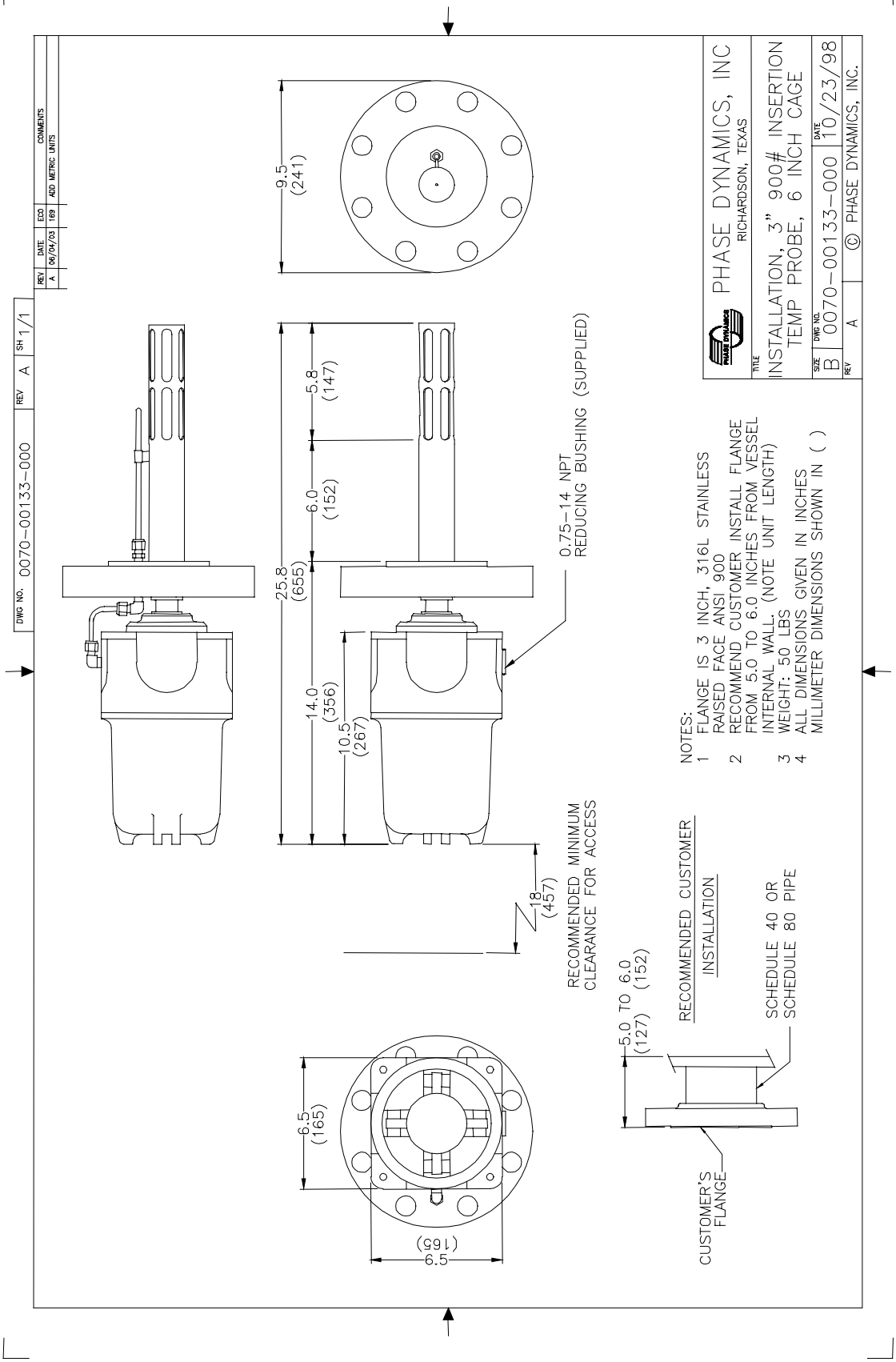
FLANGE SIZE	DIMENSION "A"	WEIGHT (LBS) (KG)
ANSI 150	8.50 (216)	89 40
ANSI 300	8.88 (226)	109 50
ANSI 600	9.75 (248)	130 59
ANSI 900	10.25 (260)	158 72

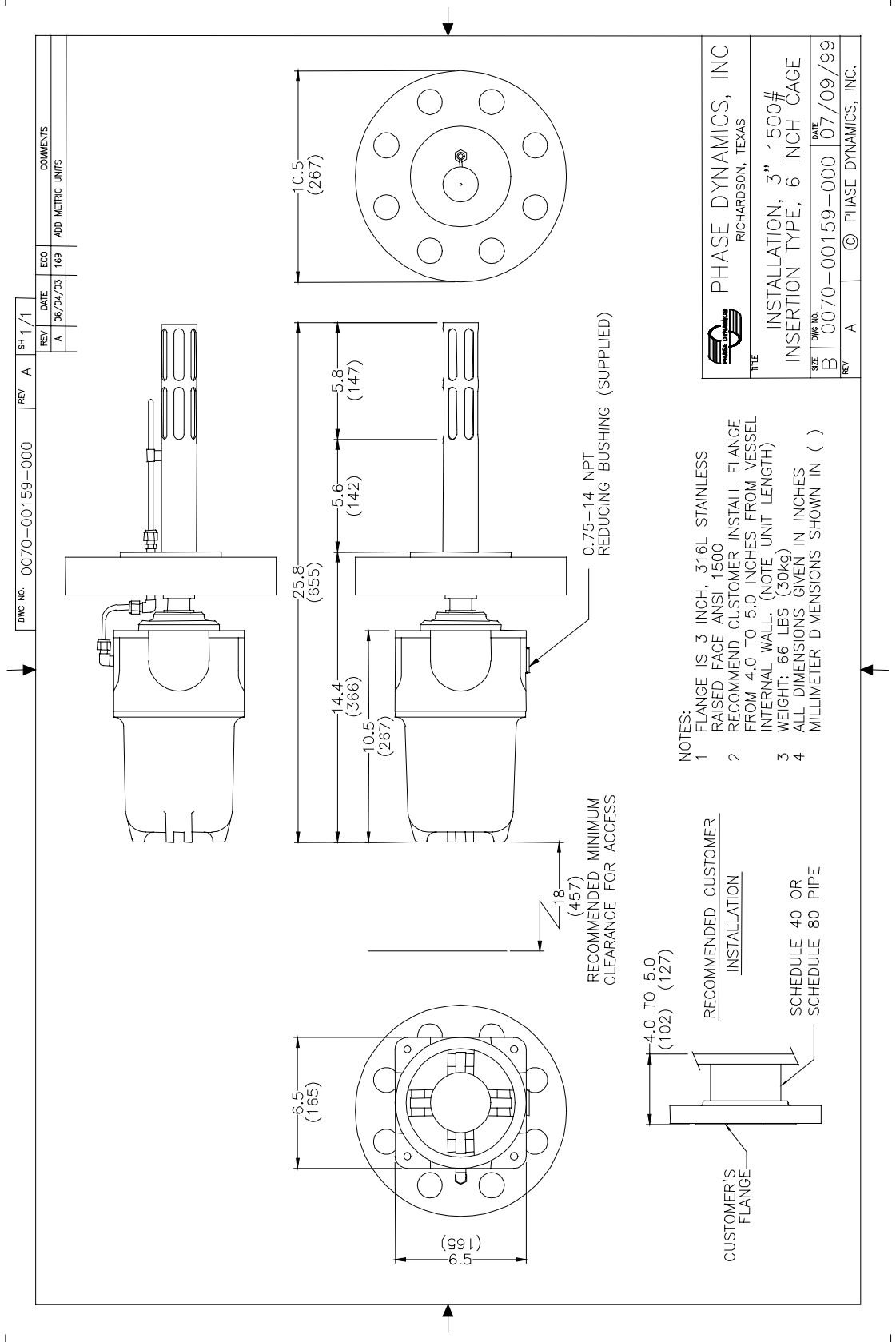

REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
B | 12/04/03 | 178 | REMOVE 1500 FLANGE
NOTES:
1. ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
INSTALLATION, 4 INCH Z CONFIG
RAISED FACE FLANGES
SIZE C | DWG NO 0070-00160-000 | REV B | DATE 07/16/99
© PHASE DYNAMICS, INC.
FLANGE SIZE | DIMENSION "A" | WEIGHT (LBS) (KG)
ANSI 150 | 8.50 (216) | 89 40
ANSI 300 | 8.88 (226) | 109 50
ANSI 600 | 9.75 (248) | 130 59
ANSI 900 | 10.25 (260) | 158 72
DIM A SEE TABLE
DIM A SEE TABLE
12.0 (305)
16.6 (422)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)

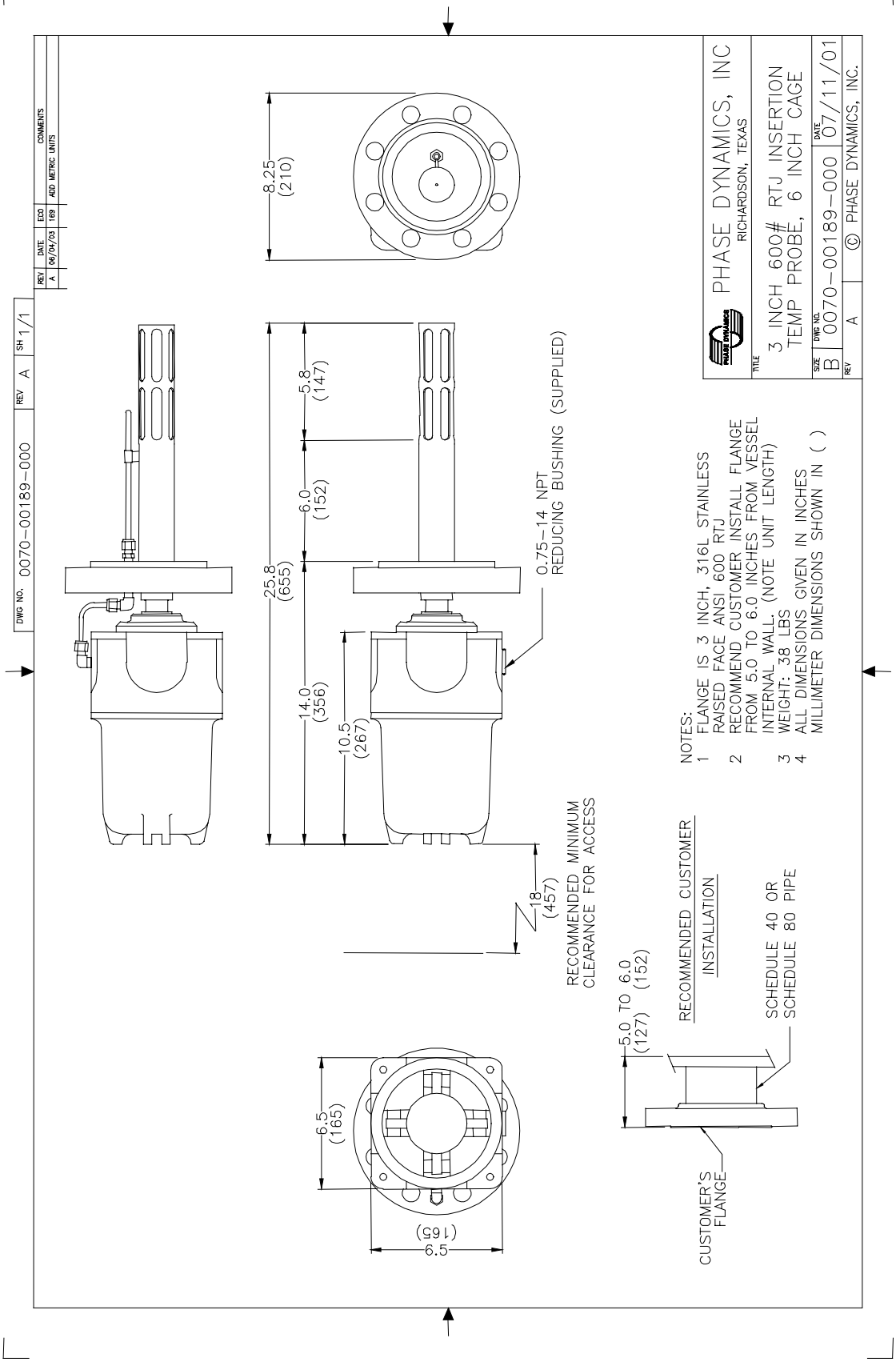

DWG NO. 0070-00113-000
REV B
SH 1/1
REV DATE ECO COMMENTS
A 10/02/97 114 LENGTH INCREASED 2.5 INCHES
B 06/04/03 169 ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
3 INCH 150# INSERTION TYPE
TEMP PROBE, 6 INCH CAGE
SIZE B
DWG NO. 0070-00113-000
DATE 02/26/97
REV B
© PHASE DYNAMICS, INC.
7.5 (191)
5.8 (147)
6.1 (155)
25.8 (655)
13.9 (353)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS
RAISED FACE ANSI 150
2 RECOMMEND CUSTOMER INSTALL FLANGE
FROM 5.0 TO 6.0 INCHES FROM VESSEL
INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 27 LBS (12kg)
4 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER
INSTALLATION
5.0 TO 6.0
(127) (152)
SCHEDULE 40 OR
SCHEDULE 80 PIPE
CUSTOMER'S
FLANGE
6.5 (165)
6.5 (165)

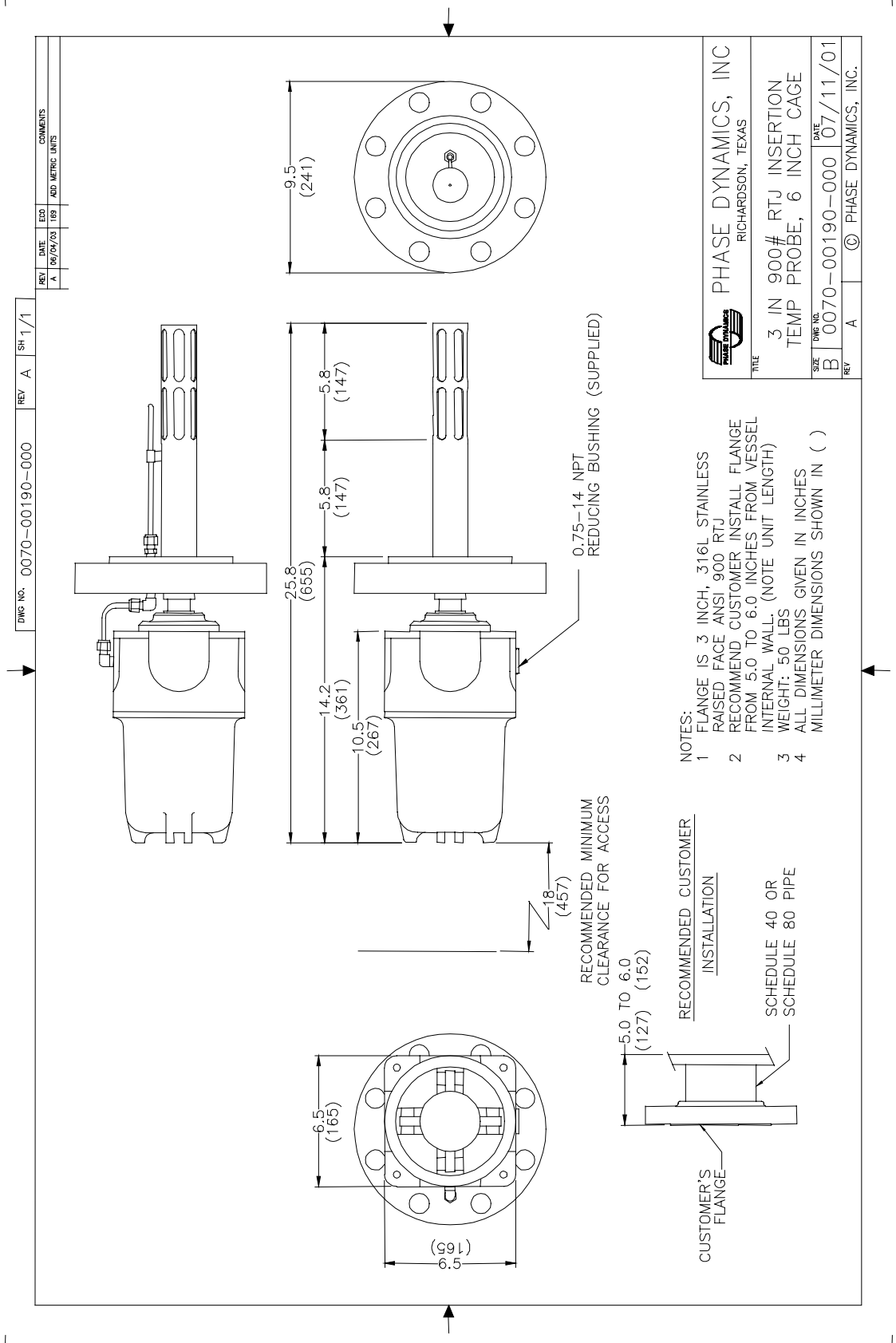

DWG NO. 0070-00195-000
REV A
SH 1/1
REV DATE ECO COMMENTS
A 06/04/03 169 ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
3 INCH 300# INSERTION TYPE
TEMP PROBE, 6 INCH CAGE
SIZE B DWG NO. 0070-00195-000 DATE 07/16/01
REV A © PHASE DYNAMICS, INC.
8.25 (210)
5.8 (147)
6.1 (155)
25.8 (655)
13.9 (353)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS RAISED FACE ANSI 300
2 RECOMMEND CUSTOMER INSTALL FLANGE FROM 5.0 TO 6.0 INCHES FROM VESSEL INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 34 LBS (15kg)
4 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER INSTALLATION
5.0 TO 6.0 (127) (152)
SCHEDULE 40 OR SCHEDULE 80 PIPE
CUSTOMER'S FLANGE


DWG NO. 0070-00174-000
REV A
SH 1/1
REV DATE ECO COMMENTS
A 06/04/03 169 ADD METRIC UNITS
8.25 (210)
5.8 (147)
6.1 (155)
25.8 (655)
13.9 (353)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 FLANGE IS 3 INCH, 2205 DUPLEX RAISED FACE ANSI 600
2 RECOMMEND CUSTOMER INSTALL FLANGE FROM 5.0 TO 6.0 INCHES FROM VESSEL INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 38 LBS (17kg)
4 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER INSTALLATION
5.0 TO 6.0 (127) (152)
SCHEDULE 40 OR SCHEDULE 80 PIPE
CUSTOMER'S FLANGE
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
3 INCH 600# INSERTION TYPE TEMP PROBE, 6 INCH CAGE
SIZE B
DWG NO. 0070-00174-000
DATE 07/27/00
REV A
© PHASE DYNAMICS, INC.


DWG NO. 0070-00133-000
REV A
SH 1/1
REV DATE ECO COMMENTS
A 06/04/03 169 ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 3" 900# INSERTION TEMP PROBE, 6 INCH CAGE
SIZE B
DWG NO. 0070-00133-000
DATE 10/23/98
REV A
© PHASE DYNAMICS, INC.
9.5 (241)
5.8 (147)
6.0 (152)
25.8 (655)
14.0 (356)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS RAISED FACE ANSI 900
2 RECOMMEND CUSTOMER INSTALL FLANGE FROM 5.0 TO 6.0 INCHES FROM VESSEL INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 50 LBS
4 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER INSTALLATION
5.0 TO 6.0 (127) (152)
SCHEDULE 40 OR SCHEDULE 80 PIPE
CUSTOMER'S FLANGE


DWG NO. 0070-00159-000
REV A
SH 1/1
REV DATE ECO COMMENTS
A 06/04/03 169 ADD METRIC UNITS
10.5 (267)
25.8 (655)
5.8 (147)
5.6 (142)
14.4 (366)
10.5 (267)
0.75-14 NPT REDUCING BUSHING (SUPPLIED)
18 (457) RECOMMENDED MINIMUM CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS RAISED FACE ANSI 1500
2 RECOMMEND CUSTOMER INSTALL FLANGE FROM 4.0 TO 5.0 INCHES FROM VESSEL INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 66 LBS (30kg)
4 ALL DIMENSIONS GIVEN IN INCHES MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER INSTALLATION
4.0 TO 5.0 (102) (127)
SCHEDULE 40 OR SCHEDULE 80 PIPE
CUSTOMER'S FLANGE
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
INSTALLATION, 3" 1500# INSERTION TYPE, 6 INCH CAGE
SIZE B DWG NO. 0070-00159-000 DATE 07/09/99
REV A
© PHASE DYNAMICS, INC.


DWG NO. 0070-00189-000
REV A
SH 1/1
REV DATE ECO COMMENTS
A 06/04/03 169 ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
3 INCH 600# RTJ INSERTION
TEMP PROBE, 6 INCH CAGE
SIZE B
DWG NO. 0070-00189-000
DATE 07/11/01
REV A
© PHASE DYNAMICS, INC.
8.25 (210)
5.8 (147)
6.0 (152)
25.8 (655)
14.0 (356)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
6.5 (165)
6.5 (165)
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS
RAISED FACE ANSI 600 RTJ
2 RECOMMEND CUSTOMER INSTALL FLANGE
FROM 5.0 TO 6.0 INCHES FROM VESSEL
INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 38 LBS
4 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER
INSTALLATION
5.0 TO 6.0
(127) (152)
SCHEDULE 40 OR
SCHEDULE 80 PIPE
CUSTOMER'S
FLANGE


DWG NO. 0070-00190-000
REV A
SH 1/1
REV | DATE | ECO | COMMENTS
A | 06/04/03 | 169 | ADD METRIC UNITS
PHASE DYNAMICS, INC
RICHARDSON, TEXAS
TITLE
3 IN 900# RTJ INSERTION
TEMP PROBE, 6 INCH CAGE
SIZE B
DWG NO. 0070-00190-000
DATE 07/11/01
REV A
© PHASE DYNAMICS, INC.
9.5 (241)
5.8 (147)
5.8 (147)
25.8 (655)
14.2 (361)
10.5 (267)
0.75-14 NPT
REDUCING BUSHING (SUPPLIED)
18 (457)
RECOMMENDED MINIMUM
CLEARANCE FOR ACCESS
NOTES:
1 FLANGE IS 3 INCH, 316L STAINLESS
RAISED FACE ANSI 900 RTJ
2 RECOMMEND CUSTOMER INSTALL FLANGE
FROM 5.0 TO 6.0 INCHES FROM VESSEL
INTERNAL WALL. (NOTE UNIT LENGTH)
3 WEIGHT: 50 LBS
4 ALL DIMENSIONS GIVEN IN INCHES
MILLIMETER DIMENSIONS SHOWN IN ( )
RECOMMENDED CUSTOMER
INSTALLATION
5.0 TO 6.0
(127) (152)
SCHEDULE 40 OR
SCHEDULE 80 PIPE
CUSTOMER'S
FLANGE
6.5 (165)
6.5 (165)