

***LightHawk*[®] 560ES/560DI** **Compliance Opacity Monitor** **Operations Manual**



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SERIAL NUMBER: _____

DOCUMENT NO.: 1860-3410-01 REV B

July 2015

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APPENDIX E ENHANCED SERIAL PORT COMMUNICATION PROTOCOL

1.0 SYSTEM OVERVIEW

This manual describes the installation, operation, calibration and routine maintenance of the Teledyne Monitor Labs *LightHawk*[®] Model 560ES Opacity/Dust Monitor.

This instrument is based on the principle of transmissometry. A light beam with specific spectral characteristics is projected through the effluent stream of a stack or duct exhausting combustion or process gases. The amount of light reflected back to the instrument from a reflector, after passage through the stream, is compared with the maximum possible return when no effluent is present. The return signal is an indication of the transmittance of the effluent. Particulate matter in the effluent stream attenuates the projected light beam. The opacity of the gas stream is determined by measuring the attenuated signal from the instrument. The opacity is usually expressed as a percentage.

The *LightHawk*[®] 560ES is designed to exceed all requirements of the ASTM D6216 "Standard Practice for Continuous Opacity Monitor Manufacturers to Certify Design Conformance and Monitor Calibration". The *LightHawk*[®] 560ES can be used in US compliance opacity applications regulated by Performance Specification D6216-12 & Appendix A1, 10% or below Opacity.

The *LightHawk*[®] 560ES system consists of the following standard equipment:

- Optical Head Assembly
- Retroreflector Assembly
- Protective Purge Air System (Single)
- Enhanced Remote Panel (Not supplied with 560DI)
- Ethernet Module
- Calibration Kit Assembly
- Attenuators
- Hardware Kit

As shown on the *LightHawk*[®] 560ES Installation Drawing, the first 3 are located on the stack. The Enhanced Remote Panel Assembly is located in the Control Room. A Calibration Kit and Attenuators are supplied in a protective case. A hardware kit is also provided.

Optional items include:

- Protective Purge Air System (Dual)
- Weather Cover Retro
- Purge Shutter Assemblies (Optical Head and Retroreflector)
- Instrument Air Purge System
- High Efficiency Purge Air Filtration System
- Hinged Fiberglass Weather Covers
- Purge Air Heater
- Optical Head Dust Cover
- High Temperature Options (500° F to 1500° F)
- Optical Head Transport Cover
- Alignment Scope Mounting Flange
- Adapter Plates
- 6PT I/O Option (560DI)

A description of each optional item can be found in Section 2.0. To verify what options this monitor is equipped with see the Site Specification Data Sheets in the back of this manual.

1.1 SYSTEM DESCRIPTION, STANDARD EQUIPMENT

1.1.1 Optical Head Assembly

The Optical Head Assembly contains all the active electronics necessary to project a light beam across the sample medium to the Retroreflector Assembly. The Retroreflector Assembly reflects the light back to the Optical Head where a determination of the light attenuation is made. This optical configuration is called a *double pass* system because the

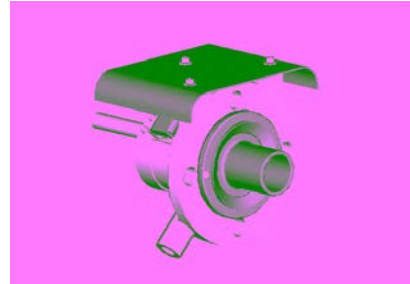


beam travels through the medium twice before it is measured by the Optical Head circuitry.

A numeric display and keypad are available for operator interface. Data transfer with the Enhanced Remote Panel, or other optional components, is via a commercial network communication protocol. Automated simulated zero and upscale calibration devices are incorporated into the Optical Head Assembly.

1.1.2 Retroreflector Assembly

The Retroreflector Assembly is mounted on the opposite side of the stack from the Optical Head Assembly and contains a precision reflector to direct the light beam back to the Optical Head Assembly. It is mounted in a cast aluminum housing which is “O” ring sealed and connected to the Protective Purge Air System to prevent contamination of the optical surface.



1.1.3 Protective Purge Air System (Single)

The Purge Air System provides filtered air to the Optical Head and Retroreflector Assemblies. The Purge Air System consists of the blower motor, hose, air filter, blower mounting plate, and protective cover. The Purge System provides filtered air in a manner that keeps the effluent from contaminating the instrument optical surfaces.

There is a Purge Status Assembly on both the Optical Head and Retroreflector Assemblies. They are pressure switches to determine if the Purge Air System is delivering sufficient airflow to protect the instrument.

1.1.4 Enhanced Remote Panel with Multi I/O Board

The Enhanced Remote Panel is built with a modular design. It is rack mountable. The software is menu driven and uses a commercial network communications platform. It uses a membrane switch keypad, a 4 ½” LCD display with graphics capability, and a key lockout for critical functions. The Multi I/O Board has eight relay outputs, eight digital inputs, and four individually isolated analog outputs.



1.1.4.1 Ethernet Module

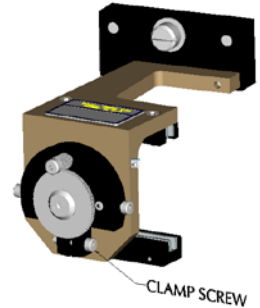
The Ethernet Module is a single printed circuit board located inside of the ERP chassis. External connection to the Ethernet Module is made via a standard RJ45 connector socket in the rear panel of the ERP. The module will provide web browser-based remote access, configuration and control of the *LightHawk*[®]

560ES. At the same time the Ethernet Module can provide HTML web pages for user interface and fast Modbus TCP access to instrument data and parameters.

The details of this powerful ERP feature are described in its own instruction manual which is provided with the instrument. The customer supplied network cable may be installed into the socket marked “Ethernet” at the right hand side of the ERP rear panel.

1.1.5 Calibration Kit

The Calibration Kit is a fixture designed to mount in front of the exit window of the Optical Head when performing maintenance or audits. It is adjusted to simulate a Clear Path Zero Condition. It also holds certified attenuators used to check upscale system response. Each Calibration Kit is unique to the monitor for which it was adjusted. It is labeled with a serial number that matches the monitor for which it was adjusted.



1.1.6 Attenuators

Three certified attenuators and an opaque blocking plate are provided to insert into the Calibration Kit. Each attenuator gives a different upscale response. The opaque disk is used to simulate a 100% opacity reading. The opacity values of the three certified attenuators are marked on their edge. The attenuators are certified according to the procedures specified in 40CFR60, Appendix B, PS-1. The attenuators are stored in a protective container.



1.1.7 Hardware Kit

A hardware Kit is provided that includes hardware, seals and accessories for mounting the instrument to 2” ports. Also included are wiring connections and a ribbon cable so you can operate the instrument with the cover off for testing purposes.

1.2 SPECIFICATIONS (STANDARD SYSTEM)

PHYSICAL DIMENSIONS

Optical Head (w/o Purge Shutter)	17" (423mm)(L) X 9-1/4" (235mm)(W) X 15" (381mm)(H)
Optical Head (with Purge Shutter)	22" (559mm)(L) X 9-1/4" (235mm)(W) X 15" (381mm)(H)
Retro Assembly (w/o Purge Shutter)	10" (254mm)(L) X 7" (178mm)(Diameter)
Retro Assembly (with Purge Shutter)	15" (381mm)(L) X 7" (178mm)(Diameter)
Single Purge Blower Assembly	22-1/4" (565mm)(L) X 20" (508mm)(W) X 33" (838mm)(H)
Dual Purge Blower Assembly	2 assemblies with Single Purge Blower dimensions
Enhanced Remote Panel	3U 19" (483mm) Rack Mount 5-1/4" (133mm)(H) X 9" (229mm)Depth

PHYSICAL WEIGHTS

Optical Head (w/o Purge Shutter)	27 lbs. (12.3 kg)
Optical Head (with Purge Shutter)	31.25 lbs. (14.2 kg)
Retro Assembly (w/o Purge Shutter)	6 lbs. (2.7 kg)
Retro Assembly (with Purge Shutter)	10.25 lbs. (4.7 kg)
Single Purge Blower Assembly	65 lbs. (29.5 kg)
Dual Purge Blower Assembly	2 assemblies with Single Purge Blower weights
Enhanced Remote Panel	10 lbs. (4.5 kg)

OPTICAL CHARACTERISTICS

Optical Measurement Technique	Double Pass Extinction
Angle of View	Less than 4 degrees
Angle of Projection	Less than 4 degrees
Spectral Response	Peak: 500 to 600 nm Mean: 500 to 600 nm 94% of Energy: 500 to 600 nm

SYSTEM MEASUREMENT CHARACTERISTICS **

Response Time (To 95% of change)	Less than 10 seconds
Calibration Zero Operation	On command
Upscale Calibration Operation	On command
Calibration Error (Mean Error + Confidence Coefficient)	1.0% Opacity Maximum
Long Term (60 Day) Drift	Zero: 0.5% Opacity Maximum Span: 0.5% Opacity Maximum
Stability Over Operating Temperature Range	±.3% Opacity Maximum per 40°F (22.2°C) change in temperature (as per ASTM D6216-12) Appendix A1
External Zero device operating temperature range	±.4% Opacity from 32°F(0°C) to +105°F(41°C)
Stability Over Operating Mains Voltage Range	±.2% Opacity Maximum (as per ASTM D6216-12)
Off Axis performance	±.5% opacity, 1/4° off axis (as per ASTM D 6216-12, Appendix A1)
Flange-to-Flange Range	2 ft. (0.61 M) to 60 ft. (18.3 M)

POWER REQUIREMENTS

Optical Head	85-245 VAC, 47-63Hz, Single Phase, 30 VA Maximum <u>Fuses</u> Power Supply Board: 1.25 Amp Time Delay, 250V, TR5 Power Input Module: 5 Amp Fast Acting, 250V, 5x20mm
Single Purge Blower System***	115VAC/230VAC, 60/50 Hz, Single Phase, 414 VA Maximum
Dual Purge Blower System***	Two circuits, each with same requirements as Single Purge Blower
Enhanced Remote Panel	85-245 VAC, 47-63Hz, Single Phase, 30 VA Maximum <u>Fuses</u> 2 Amp Time Delay, 250V, 5x20mm

LIGHTHAWK® 560ES OPACITY/DUST MONITOR

AMBIENT OPERATING CONDITIONS

Optical Head	Temperature Range:-4 to +140°F (-20 to +60°C)(startup) -25 to +140°F (-32 to +60°C)(operating) Relative Humidity Range: 0 to 100% condensing
Enhanced Remote Panel	Temperature Range: +32 to +104°F(0 to +40°C) Relative Humidity Range: 0-95% noncondensing

MEASUREMENT MEDIUM CONDITIONS

Static Pressure Range***	Single Purge Blower:-15.0 to +5.0 inches H2O (-3736 to +1246 Pa) Gauge Dual Purge Blowers:-15.0 to +15.0 inches H2O (-3736 to +3736 Pa) Gauge >+15 inches H2O consult factory.
Gas Composition	not critical
Humidity	must be noncondensing for valid measurement
Maximum Temperature***	+500°F (260°C) (without High Temperature Option) +1500°F (816°C) (with High Temperature Option) Consult factory for higher temperature operation

OPTICAL HEAD HUMAN/MACHINE INTERFACE (HMI) CHARACTERISTICS

Display Type	Six 7 Segment LED's
Indicating LED's	Fault, Set, In Cal, Power
User Input Controls	10-key keypad

WIRING REQUIREMENTS, OPTICAL HEAD TO ENHANCED REMOTE PANEL

Network Transceiver Type	Free Topology Transceiver (FTT10A)
Cable Type	2 conductor shielded twisted pair, 16 AWG (Alpha 5610B1601 or equivalent)
Termination Style	Jumper Selectable Double Termination (Internal)
Maximum Distance Between Optical Head & Enhanced Remote Panel	3281 feet (1000 meters) [must be Double Terminated]
Maximum Total Network Length	3281 feet (1000 meters) [must be Double Terminated]

ENHANCED REMOTE PANEL HUMAN/MACHINE INTERFACE (HMI) CHARACTERISTICS

Display Type	Graphics mode liquid crystal with LED backlight
Display Resolution	240 X 128
Indicating LED's	Fault, Alarm, Power
User Input Controls	20-key keypad, security keyswitch

WIRING REQUIREMENTS, Ethernet Module

Ethernet	Double Shielded (braid and foil shields) Category 5 or 5e (suitable for 10/100 BASE T)
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ENHANCED REMOTE PANEL SERIAL PORT CHARACTERISTICS

Number	2 (one RS232C, one RS422 or RS485 [jumper selectable])
RS232C Port Configuration	
BAUD Rate	9600
Data Bits	8
Stop Bits	2
Parity Type	No Parity
Connector Designation & Type	J16, DB9
RS422/RS485 Port Configuration	
BAUD Rate	9600
Data Bits	8
Stop Bits	2
Parity Type	No Parity
Connector Designation & Type	J17, DB15

MULTI I/O BOARD ANALOG OUTPUTS

Number	4
Isolation Type	<i>Optical & capacitive barriers; channel to channel, channel to circuit common & earth</i>
Minimum Isolation Voltage	<i>500Vpeak*, 500VDC*</i>
Output Type	<i>4-20mA with live 4mA zero</i>
Maximum Load Resistance	<i>900 ohms</i>
Maximum Offset	<i>±0.05% of full scale</i>
Total Output Error	<i>±0.30% of full scale</i>

MULTI I/O BOARD DIGITAL INPUTS

Number	8
Modes	<i>Isolated and Non-isolated</i>
Isolated Mode Minimum Isolation Voltage	<i>500Vrms*</i>
Isolated Mode Minimum Actuation Voltage	<i>5VDC (user supplied)</i>
Isolated Mode Maximum Actuation Voltage	<i>24VDC (user supplied)</i>
Isolated Mode Maximum Input Current	<i>50mA @ 24VDC</i>
Non-Isolated Mode Actuation Condition	<i>Dry contact closure</i>
Non-Isolated Mode Internal Operating Voltage	<i>5VDC</i>

MULTI I/O BOARD RELAY OUTPUTS

Number	<i>8 SPST, N.O. (Single Pole Single Throw, Normally Open)</i>
Minimum Isolation	<i>500Vrms*</i>
Maximum Contact Voltage	<i>250VAC</i>
Maximum Contact Current	<i>3Amps AC, 3Amps DC</i>

* I/O wires with respect to earth (common mode).

** Measurement based on single pass response with a PLCF of 1.00.

*** Does not apply to Instrument Air Purge version. Consult factory.

1.3 MEASUREMENT UNITS

The amount of light received after passage through the gas stream is compared with the light returned when no effluent is present. This is an indication of the transmittance of the effluent. The amount of attenuation is defined as opacity and is usually expressed as a percentage. Opacity and transmittance account for 100% of the light. The percentage opacity is equal to 100% minus the percentage transmittance. No instrument outputs are displayed in terms of transmittance; however, other measurement units are often expressed in terms of their relationship to transmittance.

The relationship between transmittance and opacity is as follows:

$$\text{OPACITY} = 1 - \text{TRANSMITTANCE}$$

Where opacity and transmittance are expressed as a decimal

For a *CLEAR PATH* condition:

$$\text{TRANSMITTANCE} = 100\% \quad \text{OPACITY} = 0\%$$

For a *BLOCKED STACK* condition:

$$\text{TRANSMITTANCE} = 0\% \quad \text{OPACITY} = 100\%$$

Outputs in terms of Optical Density are also available from the Enhanced Remote Panel. The mathematical relationship between opacity, transmittance, and optical density is:

$$\text{O.D.} = \log \frac{1}{\text{transmittance}} \quad \text{O.D.} = \log \frac{1}{1 - \text{opacity}}$$

Where: O.D. = Optical Density

transmittance and opacity are expressed as a decimal

Display outputs from the Optical Head or Enhanced Remote Panel Assemblies may also be configured to correlate particulate mass. These outputs can be configured only after comprehensive source testing is performed at the user's site. Simultaneous collection of the *LightHawk*® 560ES attenuation data and gravimetric analysis of the particulate mass of the stack effluent must be performed over a wide range of particulate mass conditions in order to generate a correlation curve. The measurement unit available is milligrams per cubic meter (mg/m^3).

1.3.1 Correction for Exit Path Length

In many applications the path length where the effluent exits to the atmosphere is different from the path length at the monitor location. Most opacity emission regulations are specified to be in terms of the opacity at the stack exit. In order to make this correction properly, the distance the light is traveling through the medium (inside dimension of the stack or duct) at the measurement path must be known (*monitoring pathlength*). The inside dimension at the stack exit (*emission outlet pathlength*) must also be known. This relationship is called the Path Length Correction Factor (PLCF).

$$\text{PLCF} = \text{Path Length Correction Factor} = \frac{\text{emission outlet pathlength}}{\text{monitoring pathlength}}$$

The correct Path Length Correction Factor (PLCF) must be entered at either the Optical Head Assembly keypad or at the Enhanced Remote Panel keypad.

1.4 SAFETY

This equipment is intended only for the purposes specified in this manual. Safety protections inherent in this equipment may be impaired if the LightHawk[®] 560ES is used in a manner different than specified herein.

The following are internationally recognized symbols used on the LightHawk[®] 560ES along with specific cautions applicable to the equipment.



Label Standard Number:

ISO 3864 B.3.1

Generic meaning:

CAUTION: RISK OF DANGER. CONSULT MANUFACTURER'S DOCUMENTATION.

Cautions Invoked By This Label for the LightHawk[®] 560ES:

1. Optical Head and Junction Box Cover Screws must be tightened beyond finger-tight.
2. Optical Head and Junction Box Covers are to be removed only by trained service personnel.
3. This equipment must be installed by a qualified electrician.



Label Standard Number:

ISO 3864 B.3.6

Meaning:

CAUTION: RISK OF ELECTRIC SHOCK.

Hazardous AC supply inside. Remove power before servicing.

2.0 OPTIONAL EQUIPMENT

The components listed below are optional on the *LightHawk*® 560ES Opacity/Dust system. They are not included on a standard system. Please consult the Site Specification Data Sheets in the back of this manual for the details of your particular system.

2.1 PROTECTIVE PURGE AIR SYSTEM (DUAL)

The Dual Protective Purge Air System consists of a separate blower and weather cover for the Optical Head and the Retroreflector. This option can be added to any *LightHawk*® 560ES but is mandatory in cases of high positive stack pressures. Required for pressures >5" H₂O.

2.2 WEATHER COVER, RETRO

Provides the Retro Assembly with an additional level of protection from ambient weather conditions.

2.3 PURGE SHUTTER ASSEMBLIES

The Purge Shutter option uses a pair of air valves, one for the Optical Head and one for the Retroreflector. They mount in place of the standard purge nozzles and are designed to close on loss of purge air. This prevents stack gas from reaching the optical surfaces during a *temporary* loss of purge air. Extended purge failures may still cause damage to the instrument.

2.4 INSTRUMENT AIR PURGE

When this option is chosen, the customer must supply and install ½ inch pipe to carry the plant supplied Instrument Air. The air must be delivered at a dynamic pressure of 30 PSIG (7473 PaG) minimum at the regulator, at a flow rate of 25 CFM (707 LPM) minimum. Connection to the Retroreflector and Optical Head Assemblies is 3/8 inch tube. This option can be used with Purge Shutter Assemblies.

2.5 HIGH EFFICIENCY PURGE AIR FILTRATION SYSTEM

Our optional High Efficiency Filtration System may be employed where users have very dusty ambient conditions at the Optical Head or Retroreflector locations. This system uses three successive levels of particulate filtering to remove both coarse and fine dust before the purge air enters the blower. By removing the majority of coarse particles in the first stage, it prevents the subsequent filters from being overwhelmed and extends the periods between required maintenance.

2.6 HINGED FIBERGLASS WEATHER COVERS

The optional fiberglass weather cover(s) (1860-3113-01) are sealed and constructed of corrosion-resistant materials for very challenging outdoor applications. They provide additional protection to the purge air system from wind-blown rain, dust, snow and corrosive atmospheres; yet their top-hinged design still allows easy access to the instrument during maintenance and audit activities. Also available in a side hinge design. Consult Teledyne Monitor Labs for additional pricing, clearance and application information.

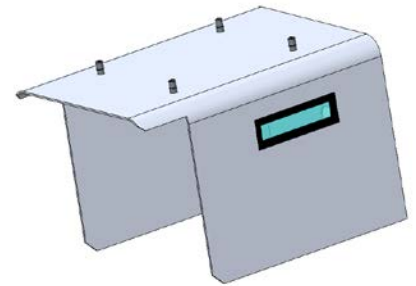
2.7 PURGE AIR HEATER (DUAL BLOWERS REQUIRED)

The *LightHawk*® 560ES Purge Air Heater option is offered only to those customers whose measured gas stream contains high moisture content with a dew point below the typical purge air temperature. In some rare cases, the inclusion of the relatively cool purge air may cause the stack water vapor to condense at the interface between the purge air and the stack effluent. Under these conditions the indicated opacity or particulate readings would be biased high because of the attenuation created by the condensed moisture.

The Purge Air Heater employs a 650 watt, 115VAC heater with over-temperature protection housed in a stainless steel pipe. Teledyne Monitor Labs Technical Support should be consulted prior to the decision to install this option, since there are additional site specific issues that must be considered in order to insure that the option is safe and effective.

2.8 OPTICAL HEAD DUST COVER

Provided in lieu of the Optical Head Weather Cover. This is only recommended for installations where the Optical Head is not subjected to outdoor weather conditions, for instance when the instrument is mounted indoors or in an annular space between the liner and exterior shell of a smokestack.



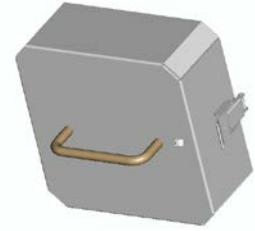
2.9 HIGH TEMPERATURE OPTIONS

2.5.1 High Temperature option 1 includes fiberglass seals, Stainless Steel Nozzles and Hi-Temp purge hose. These ***MUST*** be purchased for applications where the stack gas temperature exceeds 260° C (500° F).

2.5.2 High temperature option 2 is a Heat Shield where radiant heat is a problem. This is typically necessary for stack temperatures of 538° C (1000° F) or more but in some instances may not be required when the stack is very well insulated. (Consult factory.)

2.10 OPTICAL HEAD TRANSPORT COVER

The Rear Optical Section Transport Cover is a very useful optional device. It may be used whenever the Rear Optical Section of the transceiver is removed from the stack for maintenance, calibration or repair. The cast aluminum Transport Cover will protect the exposed Cal Mechanism and optical surfaces while providing a convenient and secure carrying handle to facilitate safe handling.



2.11 ALIGNMENT SCOPE, MOUNTING FLANGE

An aid in determining the optical center line between the two ports during installation. See section on Installation in this manual.

2.12 ADAPTER PLATES FOR FLANGE S OTHER THEN 2”

If ports exist from other equipment, adapter plates can be supplied so the 560ES can be mounted to them. Consult the factory for available sizes and price.

2.13 6PT I/O PC BOARD OPTION

The Six Point I/O Board option is used as a Direct Interface feature in the LightHawk® 560ES where analog output and control signals are required from the Optical Head Assembly. The 6Pt I/O is packaged under the Optical Head rear cover and is mounted vertically on the left side. External connections are in the Integral Junction Box. Two analog outputs, two digital inputs & two Relay outputs are provided with this option. (See 5.0 for specific details)

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3.0 OPTICAL HEAD ASSEMBLY

3.1 OVERVIEW

Section 3.0 describes the Optical Head mechanical, optical, electrical and user interface configurations. It also defines the Optical Head status and mode codes and status LEDs. A numeric display and keypad are mounted directly on the *LightHawk*[®] 560ES Optical Head.

3.2 MECHANICAL DESCRIPTION

The Optical Head Assembly is constructed primarily of cast aluminum. It is comprised of a Rear Optical Section, an Integral Junction Box, and the automated Calibration Mechanism. The Rear Optical Section houses the electronic circuit boards and the primary projection and receive optics. The Integral Junction Box acts as a weather tight junction box to permit user power and signal wiring to connect with the instrument. The Calibration Mechanism acts as an automated simulated zero/upscale device. It receives its drive and control from a motor inside the Rear Optical Section. The optical portion of the Calibration Mechanism is housed in a plenum area that is protected by the Purge Air System. This mechanism is located outside of the Rear Optical Section and may be manually or automatically commanded to rotate two separate reflective devices into the optical field of view.

Access to the Calibration Mechanism and Exit Window may be gained by releasing the catches on both sides of the Optical Head Assembly. The Rear Optical Section may be swung to the right to fully access this area.

3.3 OPTICAL DESCRIPTION

The *LightHawk*[®] 560ES uses a solid state light source (LED). The projected light intensity is monitored by a reference detector and maintained constant by control circuitry. A series of lenses and beamsplitters are used to collimate the light, project it to the Retroreflector and then focus the return energy onto a signal detector. An eyepiece is provided to allow the user to visually observe the alignment of the Optical Head. The eyepiece and instrument alignment may be viewed through a window in the Rear Optical Section cover.

The optical configuration is called double pass because the projected light travels through the medium once, on the way to the Reflector and a second time on the way back to the Optical Head. Figure 3-1 is a schematic diagram of the *LightHawk*[®] 560ES Optical System.

The Calibration Mechanism intercepts the projected light from the LED when the mechanism is activated. Two separate optical references simulate both zero and upscale signals returned to the detection system. The effluent reading from the Retroreflector is interrupted while the device is activated.

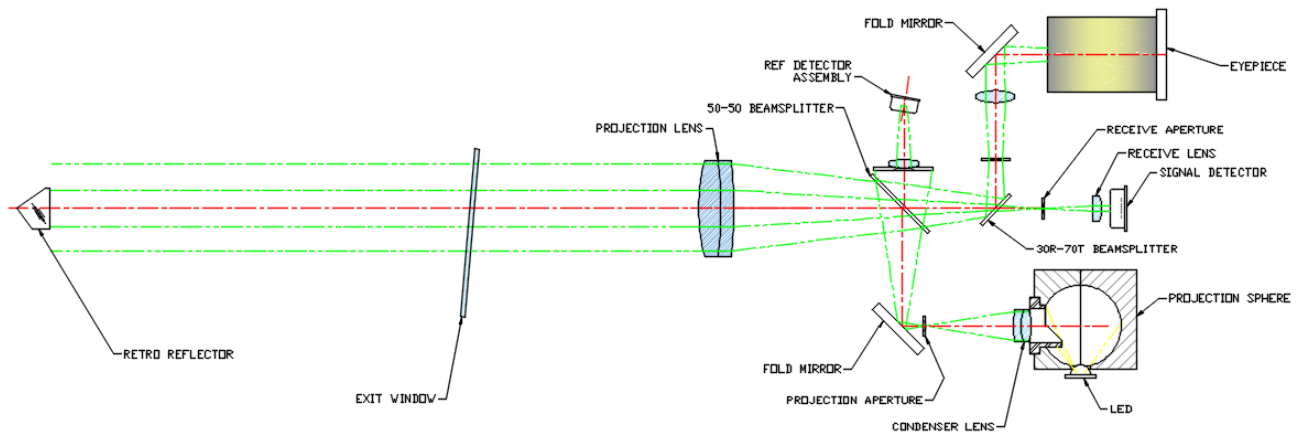


Figure 3-1

3.4 ELECTRICAL DESCRIPTION

The electrical configuration of the Optical Head includes connections for AC power wiring from user supplied circuits, internal signal processing electronics and Calibration Mechanism drive and position decode circuitry.

3.4.1 AC Power Connections

The Optical Head has been designed to operate over a wide range of international power supply ranges and frequencies without the need for modifications or adjustments. (See Section 1.0 of this manual for input power specifications.) All AC power connections from user supplied circuits are made to the Integral Junction Box located on the bottom of the Optical Head Assembly. Terminals for the network communication wiring between the Optical Head Assembly and peripheral devices are also located in this Integral Junction Box.

3.4.2 Signal Processing Electronics

A family of small electronic circuit boards is located inside the Rear Optical Section. These boards are responsible for the LED drive/modulation, signal detection, computer processing, display driver, keypad control and supporting power supply functions. These circuit boards are nested around the optical components and connected to the keypad on the electronics cover by a ribbon cable. (See the block diagram of the Optical Head Circuitry, Figure 3-2.)

3.4.3 Simulated Zero/Upscale Device Drive Components

A DC motor and associated position encoder are also located inside the Rear Optical Section cover. They drive and control the simulated zero/upscale device position. The position signals are transmitted through the Optical Amplifier Board and allow the signal processing electronics to determine whether the detector signals are being generated from the cross stack Retroreflector or the zero/upscale device.

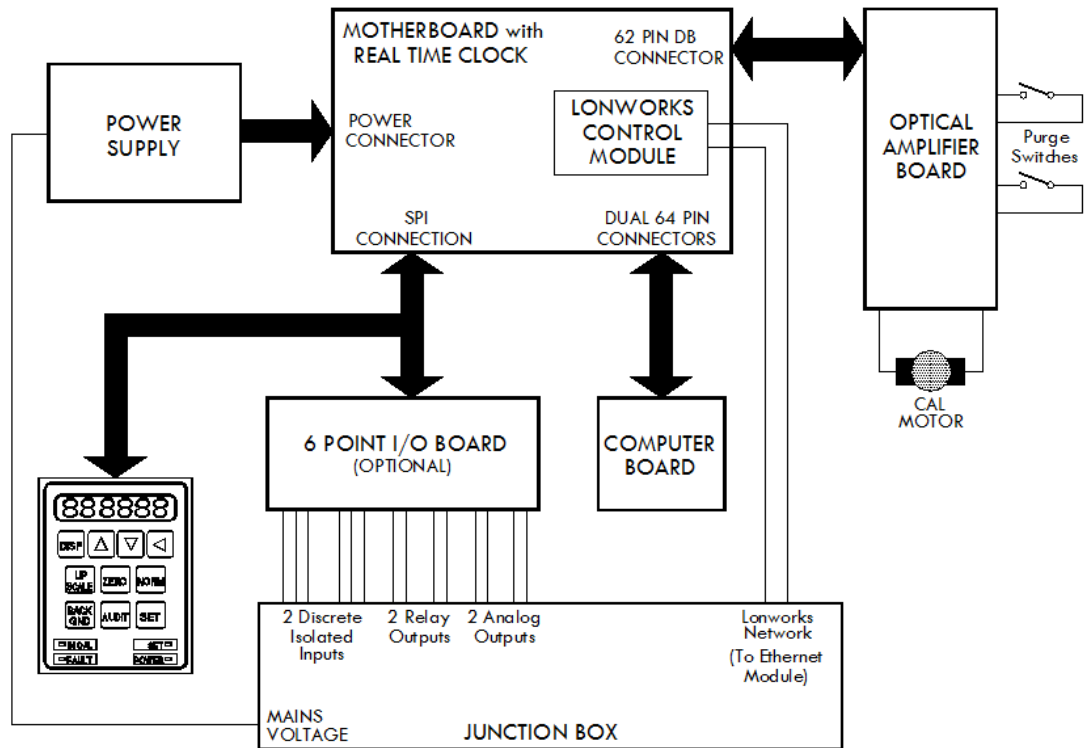


Figure 3-2

3.5 USER INTERFACE DESCRIPTION

The Optical Head Assembly user interface consists of a six character LED display and a keypad for data entry and display control.

3.5.1 Six Character LED Display

The Optical Head Assembly contains a 6 character, 7 segment display and a keypad. The two leftmost characters are GREEN while the 4 remaining characters to the right are RED. The display is organized so that the 2 GREEN characters describe the memory location of data, operational variables, markers or configuration modifiers. The 4 RED characters to the right hold the value of the data, status or marker in that memory location.

The locations are organized into different categories or BANKs of data and parameters. The leftmost GREEN letter character describes the BANK or category of display information, while the second GREEN numeric character identifies the individual memory location within the BANK.

The data BANKs are organized:

"U" - User data

"S" - Service data

"F" - Fundamental parameters

"C" - Calibration parameters

"A" - Auxiliary parameters

3.5.2 Key Pad

The Optical Head keypad contains 10 individual function keys that act both independently and in conjunction with one another to initiate actions, configure operations and control the six character display. The keypad also contains 4 LED status lights that provide operational information to the user.

3.5.2.1 Individual Keys

"SET": Used by itself to enter the value currently displayed into a parameter location. When pressed by itself while a data field is currently displayed, there is no effect. When pressed and held simultaneously with "CAL", "NORMAL", "ZERO" or "BACKGND" keys, a "SET" function is initiated for each respective mode key.

- "DISP": Increments the variable number and bank displayed, when used in conjunction with the ↑ ↓ or ← keys.
- ▲ "↑": Increases the value of the parameter displayed. For example if the value of location F3 is 1.32, pressing "↑" increases the F3 value to 1.33. Repeat functions are supported for this key. No effect if data is displayed.
- ▼ "↓": Decreases the value of the parameter displayed. For example if F3 is 1.32, pressing "↓" decreases the F3 value to 1.31. Repeat functions are supported for this key. No effect if data is displayed.
- ◀ "←": Used by itself only to select the character column for data input. Shifts the display to the next bank when pressed in conjunction with the "DISP" key.
- "UPSCALE": Initiates an UPSCALE calibration.
- "ZERO": Initiates a calibration ZERO.
- "NORM": Places instrument in NORMAL mode.
- "BACKGND": Has no function when used alone. Used in conjunction with the "SET" key to perform a BACKGROUND SET function during maintenance or calibration.
- "AUDIT": Used in conjunction with the Audit Marker parameter (F4) and the "ZERO", "UPSCALE", "NORM" and "BACKGND" keys to mark the current selectable average Opacity, Optical Density and Particulate Mass data as audit data. See "Combination of Keys" section for more details. When actuated alone, the "AUDIT" button will toggle the LED display between U2 (Selectable Average) and F4 (Audit Marker).

3.5.2.2 Combinations of Keys

- SET*ZERO: Initiates a ZERO SET function.
- SET*BACKGND: Initiates a BACKGROUND SET function.
- SET*NORMAL: Initiates a Clear Stack SET.
- UPSCALE*ZERO: Initiates a complete Calibration Cycle.

- DISPLAY*LEFT: Toggles the display from User data (U) to Service data (S) and parameter (F, C, A) banks when pressed and held for about a second. After 10 minutes with no keypad activity, the display defaults back to the User data bank (U).
- DISPLAY*INC: Increments the variable number displayed, i.e., U0 becomes U1, F0 becomes F1, etc.
- DISPLAY*DEC: Decrements the variable number displayed, i.e., U5 becomes U4, F5 becomes F4, etc.
- AUDIT*ZERO: Used in conjunction with the Audit Marker parameter (F4). Marks the current selectable average values for Opacity, Optical Density and Particulate Mass as either Initial Zero (F4=10XX) or Final Zero (F4=50XX). The user must press “SET” after this key combination to propagate the data value over the network.
- AUDIT*NORM: Used in conjunction with the Audit Marker parameter (F4). Marks the current selectable average values for Opacity, Optical Density and Particulate Mass as the Low Filter. The Run Number is defined by the value in the F4 at the time of button actuation. If F4=11XX, it is Filter Run #1 Low Filter; if F4=21XX, it is Filter Run #2 Low Filter; and so on. The user must press “SET” after this key combination to propagate the data value over the network.
- AUDIT*UPSCALE: Used in conjunction with the Audit Marker parameter (F4). Marks the current selectable average values for Opacity, Optical Density and Particulate Mass as the Mid Filter. The Run Number is defined by the value in the F4 at the time of button actuation. If F4=12XX, it is Filter Run #1 Mid Filter; if F4=22XX, it is Filter Run #2 Mid Filter; and so on. The user must press “SET” after this key combination to propagate the data value over the network.
- AUDIT*BACKGND: Used in conjunction with the Audit Marker parameter (F4). Marks the current selectable average values for Opacity, Optical Density and Particulate Mass as the High Filter. The Run Number is defined by the value in the F4 at the time of button actuation. If F4=13XX, it is Filter Run #1 High Filter; if F4=23XX, it is Filter Run #2 High Filter; and so on. The user must press “SET” after

this key combination to propagate the data value over the network.

3.5.3 Status LEDs

The status LEDs in the Optical Head overlay are defined as follows:

IN CAL: Lights when the calibration mechanism is in UPSCALE or ZERO position. Blinks when the calibration mechanism is in NORMAL position but the analog outputs contain DUST COMP or PLCF information.

FAULT: Lights when an instrument malfunction occurs.

SET: Lights when ZERO, NORMAL, or BACKGROUND sets are in progress or when parameter changes have been accepted. Blinks when ZERO, NORMAL or BACKGROUND sets are about to begin.

POWER: Lights when power is being delivered to the Optical Head.

3.5.4 Data Banks and Parameter Location Definitions

The memory locations are organized into different categories or BANKs of data and parameters. The leftmost GREEN letter character describes the BANK or category of display information, while the second GREEN numeric character identifies the individual memory location within the BANK.

The "DISP" and "←" keys on the keypad are used to cycle the display through the different BANKs. Once inside the desired BANK, the "DISP" and "↑" and "↓" keys are used to cycle through the individual locations.

Example:

*To display the data in location **U2***

Press and hold the display ("DISP") key

Then press the "←" key until the left letter character displays the letter "U"

Press and hold the display ("DISP") key

Then press the "↑" key until the second character increments to the number "2"

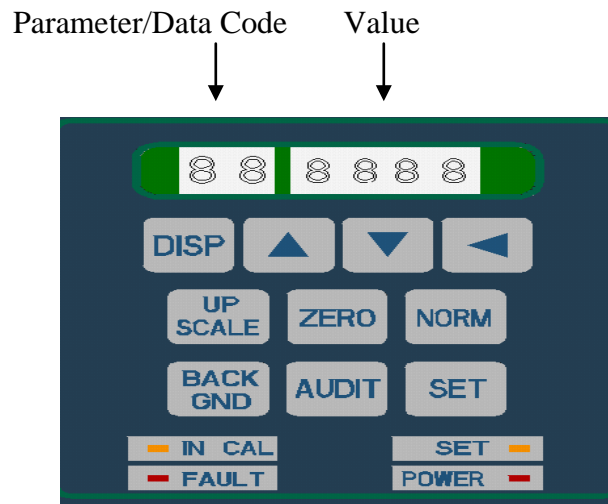
The value of the data in location U2 will be displayed on the RED 4 digit display to the right of the location identifier.

A laminated card describing the memory location definitions and display information is secured at the Optical Head for quick reference.

3.5.4.1 Data Codes

Data are not user configurable. They are primarily measurements that the instrument produces. There are two data banks:

1. User Data Bank
2. Service Data Bank



3.5.4.1.1 U Bank (User Data Bank)

The U Bank variables are outputs that users need to see regularly. The U Bank is referred to as the User Data Bank.

The following are the definitions of the data contained in the U BANK locations:

- U0: Instantaneous Opacity {Optical Density}[Particulate Mass]
- U1: 1 Minute Average Opacity {Optical Density}[Particulate Mass]
- U2: Selectable Average Opacity {Optical Density}[Particulate Mass]

U3: Primary Status Code

Primary Status Code Definition

The following is the definition of the 4 digit Status Code displayed at location U3.

4 X X X = CLEAR STACK SET voltage out of range

2 X X X = BACKGROUND SET in progress

1 X X X = ZERO SET in progress

X 4 X X = CLEAR STACK SET in progress

X 2 X X = UPSCALE position not achieved

X 1 X X = ZERO position not achieved

X X 4 X = NORMAL position not achieved

X X 2 X = Reference Fault

X X 1 X = ADC Fault

X X X 4 = Out of Service

X X X 2 = Purge Failure Retro Side

X X X 1 = Purge Failure Analyzer Side

U4: Extended Status Code

Extended Status Code Definition

The following is the definition of the 4 digit Status Code displayed at location U4.

X X 1 X = Excessive DUST Compensation

X X X 4 = UPSCALE Calibration bad

X X X 2 = ZERO Calibration bad

X X X 1 = ZERO SET voltage out of range

U5: Mode Code

Mode Code Definition

The following is the definition of the 4 digit Mode Code displayed at location U5.

Calibration Mechanism Condition

XXX0 = Unknown Mode

XXX1 = NORMAL (Stack) Mode

XXX2 = ZERO Calibration Mode

XXX3 = UPSCALE Calibration Mode

Audit Mode Filter Value

X0XX = ZERO VALUE or Not in Audit Mode

X1XX = LOW FILTER

X2XX = MID FILTER

X3XX = HIGH FILTER

Audit Mode Condition

0XXX = Not in Audit Mode

1XXX = Run #1 and Initial Zero

2XXX = Run #2

3XXX = Run #3

4XXX = Run #4

5XXX = Run #5 and Final Zero

U6: Last ZERO Calibration {ZERO Optical Density}[ZERO Particulate Mass]

- U7: Last UPSCALE Calibration {UPSCALE Optical Density}[UPSCALE Particulate Mass]
- U8: Dust Compensation {Dust Comp. Optical Density}[Dust Comp. Particulate Mass]
- U9: ML Correction Factor {Particulate Mass Load Correction Factor} [multiplicative correction of Particulate Mass data to standard temperature and pressure conditions]
- UA: 332 Version. Software version of 68332 microprocessor code.
- UB: Neuron Version. Software version of Neuron microprocessor code.

3.5.4.1.2 S Bank (Service Data Bank)

The S Bank data locations contain maintenance-oriented data from the analyzer. The S Bank is referred to as the Service Data Bank.

- S0: Signal Voltage
- S1: Reference Voltage
- S2: LED Current
- S3: Clear Stack SET Voltage
- S4: Calibration ZERO SET Voltage
- S5: BACKGROUND SET Voltage
- S6: Optical Head Temperature, °C
- S7: Calibration Mechanism Position
- S8: +15V Power Supply Voltage (+/-5%)
- S9: -15V Power Supply Voltage (+/-5%)
- SA: +5VA (analog) Power Supply Voltage (+/-5%)
- SB: -5VA (analog) Power Supply Voltage (+/-5%)
- SC: +5VD (digital) Power Supply Voltage (+/-5%)

SD: Stack Temperature, °C

SE: Stack Pressure, kPa

3.5.4.2 Parameter Codes

Parameters are configuration-oriented variables. All are user configurable only after password entry, except F7 (PLCF), which must be factory configured. They are divided into F, C and A Banks, where F represents Fundamental, C represents Calibration and A signifies Auxiliary.

3.5.4.2.1 F Bank (Fundamental Parameter Bank)

F0: Measurement Unit (Opacity = 1, Optical Density = 2, Particulate Mass = 3)

F1: Time of Day, Hours Minutes

F2: Date, Month Day

F3: Year, YYYY

F4: Audit Marker

Audit Mode Condition

(This column may be edited by user to change audit run number.)

0XXX = Not in Audit Mode

1XXX = Run #1 and Initial Zero

2XXX = Run #2

3XXX = Run #3

4XXX = Run #4

5XXX = Run #5 and Final Zero

Audit Mode Filter Value

(This column modified by AUDIT * NORM, AUDIT * UPSCALE, etc., key combinations.)

X0XX = ZERO VALUE or Not in Audit Mode

X1XX = LOW FILTER

X2XX = MID FILTER

X3XX = HIGH FILTER

F5: Six Point I/O Control (Normal 6PIO AO data = 0, 6PIO AO's to TEST ZERO SCALE = 1, 6PIO AO's to TEST MID SCALE = 2 , 6PIO AO's to TEST FULL SCALE = 3)

F6: Service Marker (Normal Data = 0, Out of Service = 1)

F7: *PLCF (Factory setting, not user adjustable)*

- F8: Signal Gain
- F9: Reference Gain
- FA: Common Gain
- FB: Averaging Interval, minutes
- FC: Reference Temperature, °C
- FD: Reference Pressure, kPa
- FE: Six Point I/O Full Scale (may be % opacity, optical density, or mg/³ depending on Measurement Unit [F0])
- FF: Six Point I/O Zero/Dust Comp Scaling Flag (0 = NORMAL mode scaling; 1= EXPANDED scaling)

3.5.4.2.2 C Bank (Calibration Parameter Bank)

- C0: Calibration ZERO Set Point, % Opacity
- C1: Calibration UPSCALE Set Point, % Opacity
- C2: Dust Compensation Tolerance, % Opacity
- C3: Calibration Tolerance (Delta), % Opacity
- C4: Hour of Calibration
- C5: Minute of Calibration
- C6: Interval Between Calibration, Hours
- C7: Seconds of ZERO (In Calibration Automatic Daily Cycle)
- C8: Seconds of UPSCALE (In Calibration Automatic Daily Cycle)
- C9: Seconds of PLCF (In Calibration Automatic Daily Cycle)
- CA: Seconds of DUST COMP (In Calibration Automatic Daily Cycle)
- CB: Six Pt. I/O Analog Output Cal Flag (0=none, 1=DAC1, 2= DAC2, 3=DAC1 & DAC2)

3.5.4.2.3 A Bank (Auxiliary Parameter Bank)

A0: Instantaneous Alarm 1 Level

A1: Selectable Average Alarm 1 Level

A2: Password: (Password = 9860, expires after 2 hour boundaries are crossed, cleared at RESET)

A3 through A8 contain the three point Optical Density to Particulate Mass correlation curve

A3: X1, Input Point #1, Optical Density

A4: Y1, Output Point #1, Particulate Mass, mg/m³

A5: X2, Input Point #2, Optical Density

A6: Y2, Output Point #2, Particulate Mass, mg/m³

A7: X3, Input Point #3, Optical Density

A8: Y3, Output Point #3, Particulate Mass, mg/m³

4.0 ENHANCED REMOTE PANEL WITH MULTI I/O MODULE

4.1 OVERVIEW

The Enhanced Remote Panel is menu driven. It features a touch sensitive keypad, a 4 ½" (11.4 cm) LCD display, key lockout, RS-232 and RS-422/485 serial communication capability, and a commercial network communication node. The Multi I/O Board has eight relay outputs, eight digital inputs, and four individually isolated analog outputs.

4.2 MECHANICAL DESCRIPTION

The Enhanced Remote Panel uses a modular design. The components of the display are mounted in a 19" rack mountable enclosure. The enclosure is 5-1/4" (13.3 cm) high, x 8-3/8" (21 cm) deep, x 16 ½" (42 cm) wide.

All external connections are made from the back panel with pluggable connectors. Access to the inside of the unit is through the top panel. The top panel and is removed by taking out four screws. Once this is done, lift out the top panel for access.

Inside the enclosure there are eight circuit boards, a power entry module, several interconnect cables, and the LCD display. The LCD Driver Board is integral to the display and the keypad is built into the front panel. The Terminal Block PC Board mounts to the back panel. The Ethernet module board mounts vertically along the left side of the chassis. Five boards mount off of the bottom panel in a stacked arrangement. The Mother Board, I/O Board, and Power Supply Board mount on standoffs and are connected by ribbon cables. The SBC332 Processor Board and the LonWorks® Board mount directly into sockets on the Mother Board.

Modules of the Enhanced Remote Panel

- Mother Board
- SBC332 Processor Board
- LonWorks® LTM-10 Board
- Terminal Block PC Board
- Power Supply Board
- Multi I/O Board
- LCD w / Driver Board

- ❑ Power Entry Module
- ❑ Keypad / Front Panel Assembly
- ❑ Ethernet Module Board

4.3 ELECTRICAL DESCRIPTION

4.3.1 Input Power Requirement

The Enhanced Remote Panel has been designed to operate over a wide range of international power supply ranges and frequencies without the need for modifications or adjustments. (*See Section 1.0 of this manual for input power specifications.*) The internal DC supply is auto-ranging and automatically adjusts for the power mains voltage.

4.3.2 Circuit Description (Overview)

The Enhanced Remote Panel with Multi I/O Board is two separate networked devices mounted in a single package: the Enhanced Remote Panel Mother Board node (hereafter referred to as the Enhanced Remote Display) and Multi I/O Board node (hereafter referred to as the Multi I/O Board). Each has independent software and a unique network address. They share a common power supply and chassis. The Enhanced Remote Display acts as the operator interface. The Multi I/O Board is the peripheral hardware interface.

4.3.2.1 Liquid Crystal Display

The display is a graphics capable, 240x128 pixel, backlit LCD. The Display Driver Board is integral with the LCD and communicates to the Mother Board via ribbon cable. The contrast and backlight brightness are adjustable from the keypad.

4.3.2.2 Keypad

The Keypad is a light touch, membrane switch array. It is built into the front panel assembly and connects directly to the Mother Board via a ribbon cable.

4.3.2.3 Front Panel LEDs

The Power, Fault, and Alarm LEDs are also integral to the front panel assembly. They are connected to and driven by the Mother Board via a six pin ribbon cable (J3).

4.3.2.4 Security Key Switch

The Security Key Switch is functionally in parallel with the administrator password. Protected variables can be unlocked with the administrator password or Key Switch.

4.3.2.5 Power Supply Board

The Power Supply Board produces the +5 VDC logic power for the Enhanced Remote. It has two connectors -- one for input and one for output. The input wires come from the input power module that contains the line cord connector power switch, and initial filtering. Surge protection and fusing are located on the board.

4.3.2.6 Terminal Block PC Board

The Terminal Block PC Board mounts to the rear panel and handles all I/O connections. It has ten connector plugs mounted on the outside that extend through the metal panel. Incoming wires terminate in the female half of the connector with the push of a screwdriver. This type of connector allows the wires to be removed one wire at a time or by connector group.

4.3.2.7 Enhanced Remote Panel Mother Board

The Enhanced Remote Panel Mother Board has two microprocessors, a 68332, and an LTM-10. Each is laid out on a separate Daughter Board that plugs horizontally into the Mother Board. The Mother Board has circuits to perform the following:

- Interface the two processors
- Buffer the data buss
- Adjust contrast and brightness outputs to the display
- Drive and Buffer the keypad
- Drive the FTT10 A network communication port
- ESD protection for all I/Os
- Drive the front panel LEDs for Fault and Alarm
- Communicate with the display
- Provide -20 VDC and -24 VDC for the LCD

NOTE: *See jumper and test point tables along with schematic drawing for complete detail.*

4.3.2.8 RS-232 and RS-422/485

A simple serial communication interface for monitoring of network variables is provided. The user can use a standard terminal emulator program on a PC to communicate with the panel. Communication is provided on both the RS-232 and

RS-422 ports. The RS-422 port can be converted to a RS-485 port with an internal jumper located on the Mother Board.

The protocol is strictly a polled mode. The user sends a command in ASCII characters in the format 'nnn?<CR>', where nnn is a number from 1 to 255 from a list of available network variables provided to the user, and <CR> is the carriage return character. All other characters are ignored. A time delay of more than 10 seconds between characters will cause the previously sent characters to be discarded. The panel responds to the request with the following output: text identifying the variable and the current value of the variable, terminated with <CR>, or '**UNRECOGNIZED COMMAND**' for input not in the above format, OR '**INVALID VARIABLE NUMBER**' for an input number that is not on the list of available variables, terminated with <CR>. The output appears on the port where the command is received. An example command and subsequent transmission is shown below.

User sends: 1?<CR>

Enhanced Remote Display responds with: 1 Head Status : 0<CR>

Transmission of the characters '255?<CR>' will cause all available variables to be sent sequentially, i.e., starting with variable 1, followed by 2, etc., until the last variable is reached.

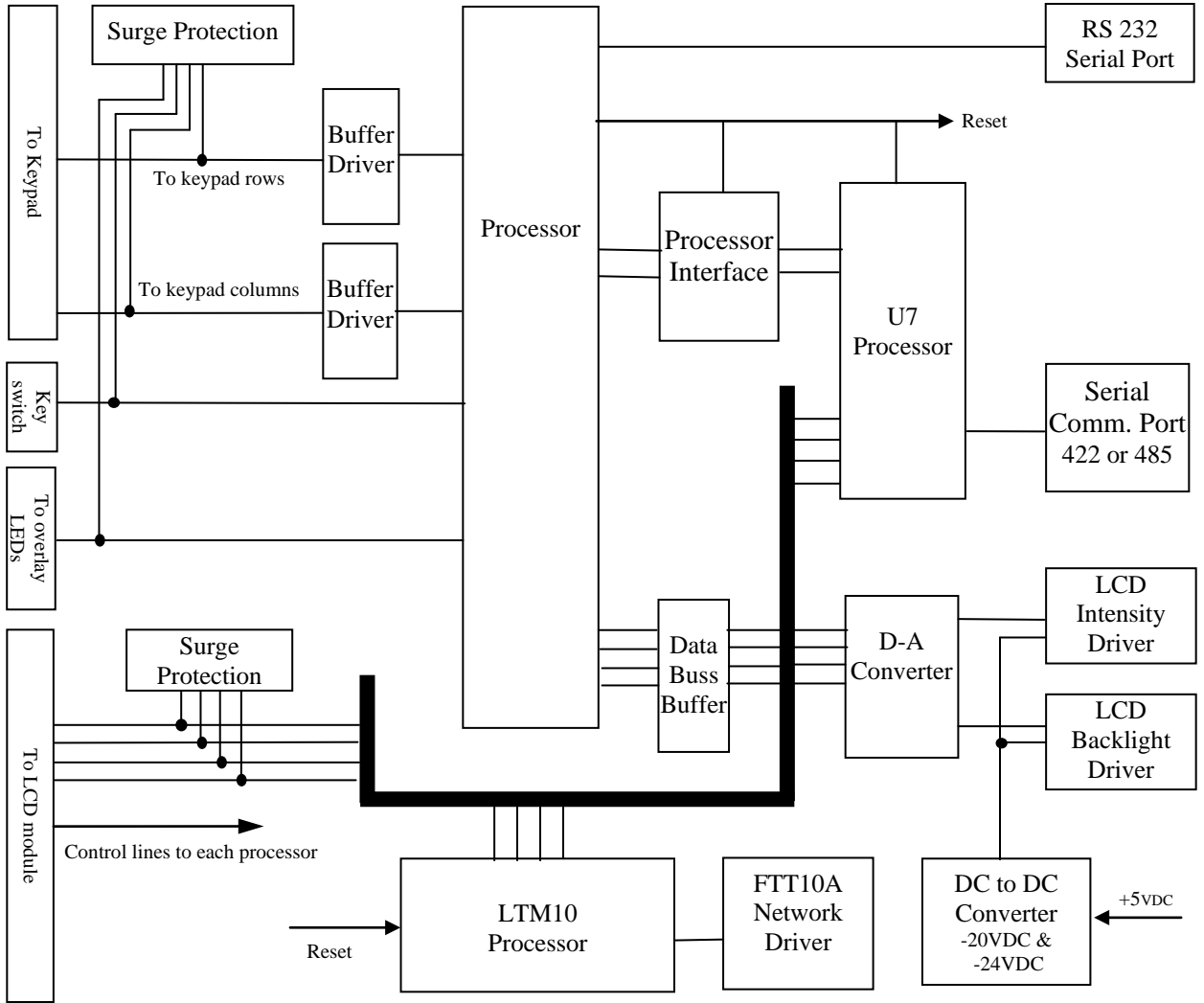


Figure 4-1
Block Diagram, Mother Board, 1803-0200

Enhanced Remote Display Mother Board Jumper Definitions

Jumper #	Selections							Functional Description
JU1	IRQ1	IRQ2	IRQ3	IRQ4	IRQ5	IRQ6	Out	Selects IRQ for reset signal
JU2	IRQ1	IRQ2	IRQ3	IRQ4	IRQ5	IRQ6	Out	RS422/485 Receive IRQ
JU3	UART			TPU				Selects where to send received data
JU4	UART			TPU				Selects UART or TPU data for transmit to J6
JU5	UART		TPU		422			Selects handshake signal or full time on
JU6	A – B = single			B – C = double				Selects single or double termination of network
JU7	A – B = terminated			B – C = not terminated				Selects if network is terminated at remote or not
JU8	-20V			-24V				Selects drive voltage for LCD contrast adjustment

68332 Processor, SBC332 Board, Jumper Definitions

Jumper #	Selections		Functional Description	
J2A	1 -- 2	2 -- 3	J2A, through J2F configure the SBC 332 board for the type of memory used. Standard settings are highlighted.	
J2B	1 – 2	2 -- 3		
J2C	1 -- 2	2 -- 3		
J2D	1 -- 2	2 -- 3		
J2E	1 -- 2	2 -- 3		
J2F	1 -- 2	2 -- 3		
J3	1 – 2 = Enabled	2 – 3 = Disabled	J3 enables or disables the 68332's watchdog timer	
J9	1 -- 2	2 -- 3	1-2 = 1200 _{ms} timeout	J9 selects the length of time the watchdog timer waits
J7	IN	Out	J7 puts in or takes out the RAM supercap for backup	
J10	IN	Out	Selects the serial port outputs of the 68332	
J12	IN	Out	Selects the serial port outputs of the 68332	

NOTES: 1. J1, J4, J5A, J5B, J6, and J11 on the SBC332 board are actually connectors.
NEVER jumper together any of the pins on these headers.

2. Bold print or shading indicates the standard selection.

4.3.2.9 Multi I/O Board (Hardware)

The Multi I/O Board is a peripheral hardware interface. It communicates with the other devices in the system via a network interface. It gathers information from the Optical Head and Enhanced Remote Display via the network. It processes this information together with its digital inputs and site specific configuration to control its outputs.

The Multi I/O is capable of driving eight digital outputs (dry relay contacts) and four analog outputs. It can read up to eight digital inputs. The digital inputs are jumper configurable to be either dry contacts or 0 – 5 VDC signals. Dry contacts are standard. The analog outputs are jumper configurable to be 0 – 20 mA, 4 – 20 mA, or 0 – 24 mA current loop signals. (0 – 20 mA) is standard. Test points are provided for measuring output current. See Jumper and Test Point tables.

Multi I/O Jumper Definitions

Jumper #	Selections								Functional Description
	4 – 20 mA (not used)		0 – 20 mA		0 – 24 mA (not used)				
JU1	1		0						Jumpers JU1 and JU2 configure the range of the analog outputs for channel #1. Configures the range of analog output #2 Configures the range of analog output #3 Configures the range of analog output #4
JU2	0		1						
JU3	1		0						
JU4	0		1						
JU5	1		0						
JU6	0		1						
JU7	1		0						
JU8	0		1						
	Dry Contact				5_{vdc} Digital				
JU9	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #1 hardware to work with dry contact or 5_{vdc} logic signals
JU10	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #2 hardware.
JU11	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #3 hardware.
JU12	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #4 hardware.
JU13	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #5 hardware.
JU14	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #6 hardware.
JU15	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #7 hardware.
JU16	1-2-3		1-2-3		1-2-3		1-2-3		Configures digital input #8 hardware.
	Ram 128K	Ram 32K	ROM 128K	ROM 64K	ROM 32K	Flash 128K	Flash 64K	Flash 32K	
JU17	1-2	1-2	3-4	3-4	3-4	3-4	3-4	3-4	Jumpers JU17 and JU18 together, select the type of memory chips to be used.
JU18	7-8	7-8	5-6	5-6	3-4	5-6	5-6	1-2	
JU19	IN-----OUT Double terminated				IN-----OUT Single terminated				Selects whether the network termination will be single or double termination. This is usually done elsewhere
JU20	IN-----OUT Out = unterminated				IN-----OUT IN = terminated				Terminates the network if necessary. This is usually done elsewhere.
JU21	1 2 3				2 3				K1 Contact: 2 3 = NO 1 2 = NC
JU22	1 2 3				2 3				K2 Contact: 2 3 = NO 1 2 = NC
JU23	1 2 3				2 3				K3 Contact: 2 3 = NO 1 2 = NC
JU24	1 2 3				2 3				K4 Contact: 2 3 = NO 1 2 = NC
JU25	1 2 3				2 3				K5 Contact: 2 3 = NO 1 2 = NC
JU26	1 2 3				2 3				K6 Contact: 2 3 = NO 1 2 = NC
JU27	1 2 3				2 3				K7 Contact: 2 3 = NO 1 2 = NC
JU28	1 2 3				2 3				K8 Contact: 2 3 = NO 1 2 = NC

- NOTES:**
1. For exact jumper positions *as shipped* see “Site Specification Data Sheets” in Appendix A.
 2. Bold print indicates the standard selection.

Multi I/O Test Point Descriptions

Test Point #	Functional Description	Output
TP1	24vdc isolated drive voltage for analog output #1. Referenced to TP2	Output #1
TP2	GND reference for TP1 and all points within #1 output circuit	
TP3	TP3 & TP4 are on opposite sides of a 100Ω resistor that is in series with the output #1 current loop. Measure the DC voltage across these test points and divide by 100 to calculate the actual output current of channel #1.	
TP4		
TP5	24vdc isolated drive voltage for analog output #2. Referenced to TP6	Output #2
TP6	GND reference for TP5 and all points within #2 output circuit	
TP7	TP7 & TP8 are on opposite sides of a 100Ω resistor that is in series with the output #2 current loop. Measure the DC voltage across these test points and divide by 100 to calculate the actual output current of channel #2.	
TP8		
TP9	24vdc isolated drive voltage for analog output #3. Referenced to TP10	Output #3
TP10	GND reference for TP9 and all points within #3 output circuit	
TP11	TP11 & TP12 are on opposite sides of a 100Ω resistor that is in series with the output #3 current loop. Measure the DC voltage across these test points and divide by 100 to calculate the actual output current of channel #3.	
TP12		
TP13	24vdc isolated drive voltage for analog output #4. Referenced to TP14	Output #4
TP14	GND reference for TP13 and all points within #4 output circuit	
TP15	TP15 & TP16 are on opposite sides of a 100Ω resistor that is in series with the output #4 current loop. Measure the DC voltage across these test points and divide by 100 to calculate the actual output current of channel #4.	
TP16		

4.3.2.10 Multi I/O Software

The four analog outputs of the Multi I/O Board can be configured to carry any one of twenty-seven parameters. See “Parameters for Analog Output” table. Scaling for each of these four outputs is configurable and completely independent of the parameter selected. Both zero and full scale may be chosen for each output. Also each output may be configured to allow calibration cycles to appear on it regardless of the parameter selected with the exception of full-time Upscale, Zero, Dust Compensation, PLCF and Service Data selections. See “Multi I/O Output Modes” table for calibration mode scaling. Please note that all opacity data is PLCF corrected.

The Multi I/O can issue mode change commands to the Optical Head Assembly. These commands typically control the state of the Calibration Mechanism. They are issued under user command only via the Isolator Inputs #1 through #5. These Inputs are referred to as the Optical Head Mode Change Isolators and their operation is described in the “Optical Head Mode Change Isolators” table.

The Multi I/O analog outputs can be forced to diagnostic states (TEST FULL SCALE, TEST ZERO SCALE, etc.) from two sources: the Enhanced Remote Display keypad and its own Isolator Inputs (Inputs #7 and #8). These Isolator Inputs are referred to as the Analog Output Isolators and their operation is described in the “Analog Output Isolators” table. If the Multi I/O receives conflicting or overlapping requests for output, its priority handler will assign requests from the Isolator Inputs top priority and the keypad requests from the Enhanced Remote Display second priority.

The Optical Head Mode Change and Analog Output Isolators operate independently. If an Optical Head Mode Change Isolator is actuated simultaneously with an Analog Output Isolator, both commands will be issued without interference with the other. For interpretation of simultaneous actuation of Isolator Inputs of the same type, consult both isolator tables.

The Multi I/O Board's eight digital outputs (relays) can be configured to activate on any one of thirty parameters. These are listed in the "Parameters for Relay Assignment" table. They fall into three categories: alarm indicators, malfunction indicators, and output mode indicators. Standard practice is to assign a relay to each of the four cal modes. These signals will then indicate when and what data is present on the analog outputs for data logging purposes. A functional description of the thirteen output modes including analog output and relay timing is contained in the "Multi I/O Output Modes" table. For more information on software function see Section 4.4 Operational Description.

The malfunction indicator selections are listed in the System Trouble column of the "Parameters for Relay Assignment" table. All are self-explanatory but the Data Valid and Fault selections.

A Data Valid condition implies that the opacity monitor data is valid. A Fault condition arises when *any* abnormal situation exists regardless of data validity. Practically speaking, a Fault will exist when the Multi I/O detects *any* non-zero Optical Head status code regardless of analog output mode. The Data Valid condition will be FALSE when the Multi I/O detects *any* non-zero Optical Head status code or when the analog outputs are in TEST FULL SCALE, TEST MID SCALE or TEST ZERO SCALE modes.

Data Valid and Fault are fail-safe in nature: they are energized during normal operation and de-energized during instrument failure conditions.

Optical Head Mode Change Isolators Table

Input #1	Input #2	Input #3	Input #4	Input #5	Command
0	0	0	0	0	No action results. No command request recognized.
1	0	0	0	0	FORCE UPSCALE
0	1	0	0	0	FORCE ZERO
1	1	0	0	0	DUMP DUST COMPENSATION
0	0	1	0	0	DUMP PLCF
0	0	0	1	0	DUMP DUST COMPENSATION
0	0	0	0	1	FORCE CAL CYCLE
All other combinations of Inputs #1 through #5.					No action results. These are considered invalid command requests.

NOTE: In the above table, a “1” designates actuation of an Isolator Input and “0” designates de-actuation.

Analog Output Isolators Table

Input #7	Input #8	Command
0	0	No action results. No command request recognized.
1	0	TEST ZERO SCALE
0	1	TEST FULL SCALE
1	1	TEST MID SCALE

NOTE: In the above table, a “1” designates actuation of an Isolator Input and “0” designates de-actuation.

Parameters for Relay Assignment (Digital Output Closure Conditions)

Opacity Exceedence	Optical Density Exceedence	Mass Loading Exceedence	System Trouble	Calibration Control
Inst. Opacity Level #1	Inst. Opt Density Level #1	Inst. Mass load Level #1	Cal Failure	Normal
Inst. Opacity Level #2	Inst. Opt Density Level #2	Inst. Mass load Level #2	Excess Dust Compensation Comp	Cal on A.O.
Min Opacity Level #1	Min Opt Density Level #1	Min Mass load Level #1	Fault	Dust Compensation on A.O.
Min Opacity Level #2	Min Opt Density Level #2	Min Mass load Level #2	Data Valid	PLCF on A.O.
Ave Opacity Level #1	Ave Opt Density Level #1	Ave Mass load Level #1	Purge Failure	Zero on A.O.
Ave Opacity Level #2	Ave Opt Density Level #2	Ave Mass load Level #2	No Selection	Upscale on A.O.

Parameters for Analog Output

Parameter Name	Functional Description
Instant Opacity	Instantaneous opacity corrected for the system's PLCF. Update time is 6-8 seconds.
Minute Ave Opacity	A one minute average of the instantaneous opacity reading. This value is PLCF corrected. The period is minute to minute according to the real time clock in the Optical Head.
Selectable Ave Opacity	An average opacity reading whose time period is selectable in one-minute increments. The time selected should divide evenly into 60 minutes. 1,2,4,6,10,12,15,30 and 60-minute averages are possible. Six minutes is the standard selection.
Instant Opt Density	Instantaneous optical density corrected for the system's PLCF. Update time is 6-8 seconds. This is a mathematical conversion of the opacity reading.
Minute Ave Opt Density	A one minute average of the instantaneous Optical Density reading. This value is PLCF corrected. The period is minute to minute according to the real time clock in the Optical Head.
Select Ave Opt Density	An average Optical Density reading whose time period is selectable in one-minute increments. The time selected should divide evenly into 60 minutes. 1, 2, 4, 6, 10, 12, 15, 30, and 60-minute averages are possible. Six minutes is the standard selection.
Instant Particulate Mass	Instantaneous Particulate Mass loading in mg/m ³ . Update time is 6-8 seconds. This is a mathematical correlation from the opacity reading by a curve that is developed through extractive testing. This is not available for output until the correlation testing is done and the results entered into the 560's software.
Minute Ave Particulate Mass	A one minute average of the instantaneous Particulate Mass loading reading. The period is minute to minute according to the real time clock in the Optical Head. Not available for output until testing results are entered.
Select Ave Particulate Mass	An average Particulate Mass loading reading whose time period is selectable in one-minute increments. The time selected should divide evenly into 60 minutes. 1, 2, 4, 6, 10, 12, 15, 30, and 60-minute averages are possible. Six minutes is the standard selection. Not available for output until testing results are entered.
Dust Compensation Output	The amount of Dust Compensation build up. The Dust Compensation factor applied to the NORMAL and UPSCALE mode readings is limited to ±4% PLCF-corrected opacity. However, the Dust Compensation reading is unbounded.
Zero Output	The calibration Zero value.
Upscale Output	The calibration Upscale value.
PLCF Output	The Path Length Correction Factor being applied to the readings.
Signal Voltage	Signal Voltage from the Optical Head in VDC. (Service Data selection).
Reference Voltage	Reference Voltage from the Optical Head in VDC. (Service Data selection).
LED Current	LED Current reading in mA. (Service Data selection).
Clear Stack Set Voltage	Clear Stack Set Voltage in VDC. (Service Data selection).
Cal Zero Set Voltage	Cal Zero Set Voltage in VDC. (Service Data selection).
Background Set Voltage	Background Set Voltage in VDC. (Service Data selection).
Optical Head Temperature	Optical Head Temperature in degrees Centigrade. (Service Data selection).
Calibration Mechanism Position	Calibration Mechanism Position. Dimensionless integer units equal to the Calibration Mechanism quadrature encoder value. (Service Data selection).
+15V Power Supply	Optical Head +15V Power Supply in VDC. (Service Data selection) (+/-5%)
-15V Power Supply	Optical Head -15V Power Supply in VDC. (Service Data selection) (+/-5%)
+5V Analog Power Supply	Optical Head +5V Analog Power Supply in VDC (Service Data selection) (+/-5%)
-5V Analog Power Supply	Optical Head -5V Analog Power Supply in VDC. (Service Data selection) (+/-5%)
+5V Digital Power Supply	Optical Head +5V Digital Power Supply in VDC. (Service Data selection) (+/-5%)
No Selection	Deactivates output.

Multi I/O Output Modes

Mode	Analog Output Function	Digital Output Function
NORMAL MODE <i>Initiated by:</i> <i>Enhanced Remote Display & Optical Head Keypads or System Clock</i>	Causes the analog outputs to display the data that they are configured for under normal operation.	Any relay configured for one of the calibration modes will drop out if already actuated.
UPSCALE <i>Initiated by:</i> <i>Input #1, Enhanced Remote Display & Optical Head Keypads or System Clock</i>	Forced UPSCALE output. This will cause the Optical Head Calibration Mechanism to go the UPSCALE position. If the Optical Head accepts the command, any or all of the four analog outputs will indicate the current instantaneous Upscale value if they are configured to allow calibrations on them. The scaling of this Cal UPSCALE value equals the NORMAL mode scaling.	If a relay is configured as “UPSCALE ON AO” or “CAL ON AO” it will actuate when the calibration mechanism is in the UPSCALE position.
ZERO <i>Initiated by:</i> <i>Input #2 or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	Forced ZERO output. This will cause any or all of the four analog outputs to indicate the current zero value if they are configured to allow calibrations on them. For the scaling of the ZERO cal output see the “Zero and Dust Compensation Calibration Scaling Table”.	If a relay is configured as “ZERO ON AO” or “CAL ON AO” it will actuate when the calibration mechanism is in the ZERO position.
PLCF <i>Initiated by:</i> <i>Input #3 or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	Forced PLCF output. This will cause any or all of the four analog outputs to indicate the current PLCF value if they are configured to allow calibrations on them. The scaling of PLCF cal output is 0—5 unless configured for full time PLCF output. Note: The Calibration Mechanism must be in NORMAL position for this command to be accepted.	If a relay is configured as “PLCF ON AO” or “CAL ON AO” it will actuate when the command is sent.
DUST COMPENSATION <i>Initiated by:</i> <i>Input #4 or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	Forced DUST COMPENSATION output. This will cause any or all of the four analog outputs to indicate the current DUST COMPENSATION value if they are configured to allow calibrations on them. For the scaling of the DUST COMPENSATION cal output see the “Zero and Dust Compensation Calibration Scaling Table”. Note: The Calibration Mechanism must be in NORMAL position for this command to be accepted.	If a relay is configured as “DUST COMPENSATION ON AO” or “CAL ON AO” it will actuate when the command is sent.
FORCE CAL CYCLE <i>Initiated by:</i> <i>Input #5 or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	This test initiates an internally controlled cal sequence. This sequence is fixed in software. It consists of four parameters each posted to the outputs for 0-720 sec. (user selectable). The sequence of the parameters is: 1 st ZERO: See “Zero & Dust....Scaling Table”. 2 nd UPSCALE: NORMAL mode scaling (0-100% typ.) 3 rd PLCF: 0 -----5 4 th DUST COMP.: See “Zero & Dust....Scaling Table”.	If a relay is configured as “CAL ON AO”, during a cal cycle it will actuate when the calibration mechanism is in UPSCALE or ZERO positions or the Optical Head is in PLCF or DUST COMP mode. It will drop out when the cal mechanism is between positions during a cal cycle.
TEST ZERO SCALE <i>Initiated by: Input #7 or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	This test will drive all analog outputs regardless of configuration to their zero scale.	Any mode relays already actuated will drop out.
TEST MID SCALE <i>Initiated by: Inputs #7 & #8 together or Enhanced Remote Display & Optical Head Keypads or System Clock</i>	This test will drive all analog outputs regardless of configuration to their mid scale value (12mA).	Any mode relays already actuated will drop out
TEST FULL SCALE <i>Initiated by: Input #8 Enhanced Remote Display & Optical Head Keypads or System Clock</i>	This test will drive all analog outputs regardless of configuration to their full scale.	Any mode relays already actuated will drop out

NOTE: Digital input #6 is not used. Digital inputs 1 through 5, 7 and 8 require actuation for 5 seconds before the software will recognize the input as a valid request. This is intended to prevent mode changes due to external transients.

Zero and Dust Compensation Calibration Scaling Table

“WITH” Field in Output Module Configuration	Value at ZERO SCALE (4mA) During Zero and Dust Compensation Modes			Value at FULL SCALE (20mA) During Zero and Dust Comp. Modes		
YES	Equal to NORMAL mode ZERO SCALE (typically 0% opacity)			Equal to NORMAL mode FULL SCALE (typically 100% opacity)		
EXP	-5% Opacity Outputs	-0.025 Optical Density Outputs	-25mg/m ³ Particulate Mass Outputs	+5% Opacity Outputs	+0.025 Optical Density Outputs	+25mg/m ³ Particulate Mass Outputs

NOTE: This table does not apply to full-time Zero and Dust Compensation outputs, in which case scaling is to the ZERO and FULL SCALE values and is independent of mode. This table applies only to outputs configured for opacity, optical density and particulate mass that are selected to contain time-multiplexed calibration data.

4.4 OPERATIONAL DESCRIPTION

The Enhanced Remote Panel is menu driven. Operational and configuration parameters are viewed and changed through the display menu screens. The system configuration parameters are password protected. They can be accessed with the supervisor password or the security key switch. Operational and test parameters may be viewed and/or changed by scrolling through the menus using the “↑”, “↓”, “Page Up”, “Page Down”, “ESC”, and “↵” keys. The functions of these keys are described on each menu screen. The “ESC” key will return you to the previous menu. Password protected screens will prompt for the password before displaying the screen. To use the SECURITY key switch it must be in the ON position when that screen is selected.

4.4.1 Main Display Screen

This is the screen that is typically displayed during normal operation. The screen has six pages accessed by the Page Up and Page Down keys. No parameters displayed can be changed from this screen. Page #1 is the display screen default on power up and reset. It is at the top of the menu structure. All other screens can be accessed through these pages by moving down through the menu choices.

This information is updated continuously. The opacity, optical density and particulate mass readings update at the instantaneous sample rate of about 2 seconds. The Upscale and Zero readings update with average values at the conclusion of Upscale and Zero modes.

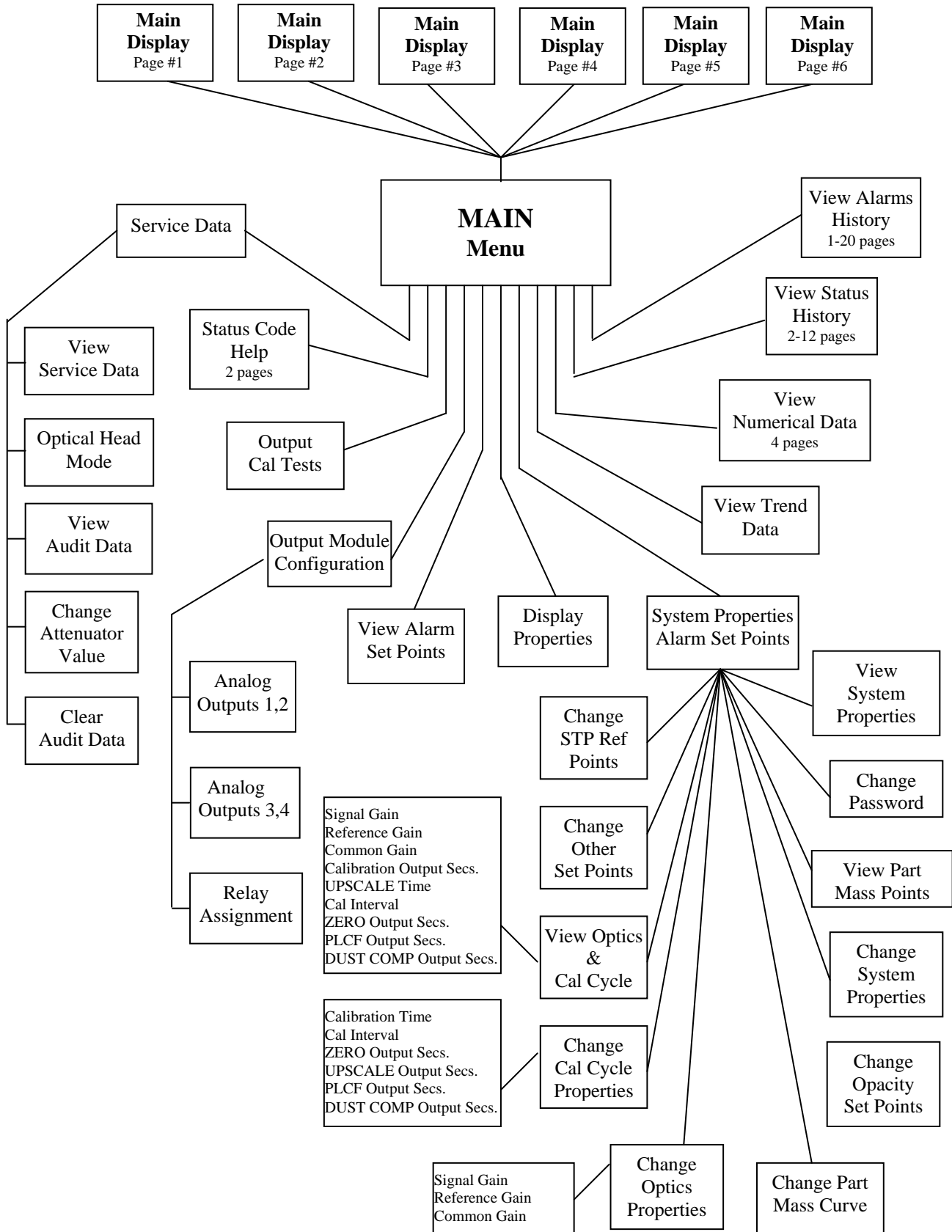
The status text and code fields are updated immediately on any change in the monitor status. If multiple malfunctions are indicated, the status text field can be made to scroll through the list of errors by pressing either arrow button (↓ or ↑) once. After scrolling is completed the status text field will stop and continuously display the most significant error. The Net Status field will display the status of network communication between the Optical Head and the display node. The Head Mode field will display the operational mode of the Optical Head.

From any one of the six pages of this display press the “↵” key to view the first level “Main” menu. The “ESC” key will bring you back up to this screen.

4.4.1.1 Memory Test

The memory test runs at power up before the logo screen is displayed. It tests all the used areas of the RAM ICs. If they pass, a message is briefly displayed on the screen before the logo. If either one fails, a message indicating which chip failed remains on the screen and the CPU halts.

LightHawk® 560ES Menu Tree



4.4.2 Main Menu Screen

This is the first level of the menu structure. From this screen you can choose one of the submenus that lead to the information of interest. For a detailed description of the information available under a particular sub menu refer to the section about that submenu. To choose a submenu press the arrow buttons (↓ or ↑) until your selection is highlighted, then press the “↵” key to select. The “ESC” key will take you back to the previous screen.

4.4.3 Service Data Menu

This menu presents the user with choices for performing maintenance and troubleshooting operations. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.4 View Service Data

This screen is view only. The information displayed is useful in determining the status of the Optical Head assembly. Use the “ESC” or “↵” key to exit the screen when you are done. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

NOTE: *This screen corresponds to parts of the Service Data Bank of the Optical Head. See the Optical Head Assembly section of this manual for further details.*

4.4.5 View Head Mode

This screen is view only. The information displayed is useful in determining the mode of the Optical Head Assembly. The Calibration Mechanism, Audit Mode and Filter Value states can be viewed. For further details, consult the Optical Head Assembly section of this manual. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.6 View Audit Data

This screen is view only. The information displayed is useful in determining the success of a neutral density attenuator audit of the Optical Head Assembly. All opacity data on this screen is PLCF corrected. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

CAUTION: *All users are cautioned that the data displayed on this screen does not necessarily equal the data recorded on the final recording device if analog outputs are used to convey analyzer data for compliance reporting. Depending on regulatory requirements, the data values present at the final recording device may be required for a valid quarterly audit. In these instances, the data on this*

screen is for assistance and reference during the audit process and is not suitable as actual quarterly audit data.

Audits are typically conducted using three values of attenuators: LOW, MID and HIGH. Five runs of each attenuator are typically performed. As each analyzer response to an attenuator is received from the Optical Head Assembly, it is displayed in the appropriate row and column. As each data point is received, the Enhanced Remote Display software compares received values to Target Values and calculates Arithmetic Mean, Confidence Coefficient and Calibration Error according to 40CFR60 Appendix B, Performance Specification 1. For further details on the pertinent mathematics, consult 40CFR Part 60.

For further details on performing an audit, consult the Optical Head Assembly section of this manual.

4.4.7 Change Attenuator Values

This screen is password protected. Either password entry or Security key actuation is needed to enter.

To choose between LOW, MID and HIGH attenuators, press the arrow buttons (↓ or ↑) until the selection is highlighted. Once highlighted, attenuator values are to be entered **without** PLCF correction using the numeric section of the keypad and registered by pressing “↵”. After entry, the attenuator values may be stored by highlighting "SAVE ATTEN. VALUES" and pressing “↵”. To display PLCF corrected values, highlight "PLCF CORRECT THE VALUES" and press “↵”. The software will subsequently calculate the PLCF corrected value and display it on the screen. The PLCF corrected value of each attenuator is subsequently used in the VIEW AUDIT DATA screen. (*Consult the 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.8 Clear Audit Data

This screen is password protected. Either password entry or Security key actuation is needed to enter.

This screen is useful to clear analyzer data from previous audits. Typically it is used before beginning a new audit.

Pressing ↵ after entering the CLEAR AUDIT DATA screen will clear, i.e., erase, all audit data. To leave the screen without performing an erasure of audit data, press “ESC”.

4.4.9 Status Codes Help

This screen has two pages. Both are view only. The information on both pages is reference only with the exception of CURRENT STATUS word that updates

continuously. The CURRENT STATUS word will be equal to the sum of the active codes on both pages. For example a “7” in any status word digit would mean that three errors were present, the 1, 2, and 4 errors of that digit. Use the “Page Up” or “Page Down” key to move between pages. Press the “↵” to return to the exit screen when you are done. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

NOTE: *The Enhanced Remote Display CURRENT STATUS word on this screen is the combination of the Primary Status and Extended Status words on the Optical Head Assembly (U3 and U4, respectively, of the User Bank). The 4 least significant digits of the status word on this screen map to the Primary Status word. The most significant digit of the status word on this screen maps to the least and only significant digit of the Extended Status word.*

4.4.10 Output & Cal Tests

This screen allows the user to send commands to the Optical Head and the Multi I/O Board analog outputs. The current values for INST. OPACITY, OPTICAL HEAD MODE and Multi I/O Board mode (displayed as “OUTPUT MODULE MODE”) are displayed in the top half of the screen. User interface is via the highlighted command line displayed under the COMMAND MODE: heading.

While the mode line is highlighted, press the “Page Up” or “Page Down” key to choose the command you want, then press “↵”. The highlight bar will then move down to the SEND THIS COMMAND line for confirmation. Press “↵” and the command will be sent to the Optical Head and Multi I/O Board. The highlight bar will move back to the mode line so you may enter another test.

Commands that invoke calibration modes (ZERO MODE, FORCE CAL CYCLE, etc.) will initiate calibrations on the Optical Head. In these cases, only Multi I/O Board analog outputs that have been configured “WITH CAL.” will respond. TEST ZERO SCALE, TEST MID SCALE and TEST FULL SCALE affect all four analog outputs. See “Multi I/O Output Modes” table on how each mode works.

NOTE: *When this screen is exited the Enhanced Remote Display will automatically send a “Normal” mode command to the Optical Head and Multi I/O Board.*

4.4.11 Output Module Configuration Menu

This screen is password protected. To get to this screen you must have the security key or supervisor password. If using the key, it must be turned before selecting the OUTPUT MODULE CONFIG menu or you will be prompted for the password. Enter the password on the keypad and press “↵”.

This menu allows you to choose between the four configuration menus of the output module. The menus titled ANALOG OUTPUTS 1, 2 and ANALOG OUTPUTS 3, 4 configure their respective analog output parameter mapping and scaling. The Relay Assignment menu configures the conditions for closure of the eight output relays. Use the arrow keys to select the menu you want then press “↵”. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.12 Analog Outputs 1,2

This screen is password protected. This screen configures the Multi I/O Board’s #1 and #2 analog outputs. It chooses the parameter for display, whether or not cal values can be dumped to the output, the numerical value at zero scale, and the numerical value at full scale. As described in previous sections, the physical properties of the outputs are configured with hardware jumpers on the Multi I/O Board. For a list of possible output parameters refer to the “Parameters for Analog Output” table.

When this screen comes up, the parameter for display on output #1 will be highlighted. Use the “Page Up” and “Page Down” keys to find the parameter you want. Press “↵” to choose and move to the next property.

The field labeled VALUE AT ZERO SCALE: is the numerical value that will correspond to 4mA output. VALUE AT FULL SCALE: is the numerical value at full-scale (20mA) output. These values are what you would change to rescale the output if needed. Enter the numbers desired through the keypad. Press “↵” to move to the next field.

The WITH CAL. field can be "YES", "NO" or "EXP". If "YES", calibration cycle data will be sent to that output. Calibration data scaling for Upscale, Zero and Dust Compensation will be the same as the Normal mode scaling entered in VALUE AT ZERO SCALE and VALUE AT FULL SCALE. If "NO", the output will not have calibration values on it. If "EXP" (EXPANDED SCALING) is selected, calibration data will be present on the analog output but Zero and Dust Compensation scaling will be expanded for better resolution. Consult the “Zero and Dust Compensation Calibration Scaling Table” for further details. Make your selection and press “↵”. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

NOTE: *No changes are accepted by the Multi I/O configuration until the last field, SAVE THIS CONFIG is entered. This field confirms that you want to implement the changes entered. If one of the fields is not correct, use the ↑ or ↓ key to scroll to it. Once corrected move to “SAVE THIS CONFIG. and press the enter “↵” key.*

4.4.13 Analog Outputs 3,4

This screen is password protected. The ANALOG OUTPUTS 3,4 menu screen functions exactly the same as the ANALOG OUTPUTS 1,2 menu screen. Only the output # references have changed. Refer to the Analog Outputs 1,2 section for a functional description. (Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)

4.4.14 Relay Assignments

This screen is password protected. This menu screen sets the condition for closure for each of the eight output relays on the Multi I/O Board. While the assignment for a particular relay is highlighted, scroll to the desired condition using the “Page Up” and “Page Down” keys. Press “↵” to select. The “ESC” key will take you back to the I/O configuration menu.

NOTE: *No changes are accepted in the Multi I/O configuration until the last field, SAVE THIS CONFIG. is entered. This field confirms that you want to implement the changes entered. If one of the fields is not correct, use the “↑” or “↓” key to scroll to it. Once corrected move to SAVE THIS CONFIG. and press the “↵” key. (Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.15 System Properties Menu

This menu allows you to chose a group of system level properties to view or alter. The screens labeled “VIEW” are not password protected. Screens labeled “CHANGE” require either the security key or supervisor password to access. Use the “↑” and “↓” keys to select the screen and “↵” to enter. (Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)

4.4.16 Change STP Ref Points

This screen is password protected. (Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 find the menu/submenu location of individual screens.)

This screen is for entering the pressure and temperature reference points used by the Optical Head in the conversion of Particulate Mass data to standard pressure and temperature (STP) conditions.

Pressure units are in Pascals absolute. One atmosphere (101.5 KPascals) is the typical reference pressure value. The temperature unit is degrees Celsius. Twenty degrees Celsius is the typical value.

To keep the existing value, press “↵” or “ESC” back to the previous menu. To make a change, type in the new value, press “↵”, then move to “SAVE THIS

CONFIG. with the “↑” or “↓” keys and press “↵”. Press ESC to leave this screen when you are done.

4.4.17 View System Properties

This screen is provided to view the opacity system set points. It is view only. No set point changes are permitted from this screen. The “ESC” key will take you back to the SYSTEM PROPERTIES menu. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.18 View Optics & Cal Properties

This screen displays current Optical Amplifier board gains (Signal, Reference and Common) and the calibration cycle parameters (Calibration Time, Cal Interval, Cal Upscale, Zero, PLCF and Dust Comp Output Seconds). It is view only. No changes can be made. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.19 Change Cal Properties

This screen is password protected. The menu sets the start time for the internally controlled calibration output cycle and the interval, in hours, between successive cycles. This allows from 0 to 24 calibration cycles per day.

NOTE: *Calibration data will appear only on analog output channels selected WITH CAL on the analog output configuration menu. The internal sequence, (Zero, Upscale, PLCF, and Dust Compensation from first to last), is fixed in firmware. It is made up of four selectable duration Calibration Cycle modes.*

To disable the internal sequence, set the hour value of the CALIBRATION TIME field to 24 or larger. Since such hour values are invalid, the cycle will never start.

To enable the internal sequence, set the hour value of the CALIBRATION TIME field to 0-23 and the minute value to 0 to 59. If the CAL INTERVAL value is set to 0 or to 24 or greater, the internal sequence will occur once a day. CAL INTERVAL value of 1 will cause the internal sequence to occur once an hour starting from the CALIBRATION TIME value until the CALIBRATION TIME hour and minute values occur again; a value of 2 will initiate an internal sequence every 2 hours from the “CALIBRATION TIME value; etc.

Calibration cycle mode durations (CAL. XX OUTPUT SECS.) can be set from 0 – 720 seconds. Entering a zero will disable that calibration mode. If all mode durations are set to zero, all cycle mode durations will default to 90 seconds.

NOTE: *No changes are made to the configuration until the last field, SAVE THIS CONFIG., is entered. (Consult the LightHawk® 560ES Menu Tree*

diagram of Section 4.0 to find the menu/submenu location of individual screens.)

4.4.20 Change Optics Properties

This screen is password protected. (Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)

There are three parameters available on the screen: SIGNAL GAIN, REFERENCE GAIN and COMMON GAIN. These parameters set amplifier gains on the Optical Amplifier Board on the Optical Head Assembly.

NOTE: *Adjustment of these values is NOT required during NORMAL operation. Enhanced Remote access to these parameters would only be required during a complete off-stack calibration. For additional information, consult the Optical Head Assembly section of this manual.*

To keep the existing value, press “↵” or “ESC” back to the previous menu. To make a change type in the new value, press “↵”, then move to SAVE THIS CONFIG. with the “↑” or “↓” keys and press “↵”. Press “ESC” to leave this screen when you are done.

4.4.21 Change System Properties

This screen is password protected. You must have the security key or supervisor password to gain access. This screen can be used to change the following parameters:

1. DATE/TIME
2. AVERAGING INTERVAL, MIN
3. CAL ZERO SET POINT
4. CAL UPSCALE SET POINT
5. CAL FAIL LEVEL (tolerable error for Zero and Upscale)

NOTE: *Although PLCF is displayed on this screen, it cannot be changed after initial calibration. As a result of regulatory agency security restrictions, **the PLCF can only be factory adjusted.***

All parameter data is in numerical format with the exception of the month field of the date, which is displayed using the first three letters of the English spelling of the month. The date is displayed in the European style: day, month and year

respectively. Year is displayed as a two-digit field but four-digit entry, i.e.,2000, 2001, etc. is supported and encouraged.

Use the "↑" and "↓" keys to select a field and the numerical keys to enter the values for all data fields except month, which is changed by the "Page Up" and "Page Down" keys. It is not necessary to use leading zeroes for single digits. The "←" key can be used to correct mistakes within a field. Hit the "↵" key to register a value on the screen.

To save a DATE/TIME change, use the "↑" or "↓" key to highlight SAVE DATE/TIME and press "↵". To save the other parameters in this screen use the "↑", "↓" keys to highlight the SAVE THIS CONFIG. and then press "↵". Press "ESC" to leave this screen when finished. Any changes will be applied after leaving the screen. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.22 Change Password

This screen is password protected. This screen permits the supervisor password to be changed. In order to access this screen you must have the security key or the current supervisor password.

Once you have gained access, the CHANGE PASSWORD screen will appear. It prompts you to enter a new password of at least four digits but not more than six digits. Enter by pressing the "↵" key. You must then confirm your selection by typing the new password again in the CONFIRM PASSWORD field. Enter by pressing the "↵" key. Exit out of this screen by pressing the "ESC" key.

4.4.23 Change Opacity Set Points

This screen is password protected. The opacity alarm levels are changed using this screen. These are maximum allowed settings. An opacity reading higher than these levels will trigger an alarm. To keep the existing value, press "↵" or "ESC" back to the previous menu. To make a change type in the new value, press "↵", then move to SAVE THIS CONFIG. with the "↑" or "↓" keys and press "↵". Press "ESC" to exit this screen. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.24 Change Other Set Points

This screen is password protected. The Optical Density and Particulate Mass alarm levels are changed using this screen. These are maximum allowed settings. A higher value will trigger an alarm. To keep the existing value, press "↵" or "ESC" back to the previous menu. To make a change type in the new value, enter, move to SAVE THIS CONFIG. with the "↑" or "↓" keys and enter. Press

“ESC” to exit this screen. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.25 View Part. Mass Points

This screen is for viewing the points used to develop the correlation curve that converts Optical Density into Particulate Mass loading. It is not password protected. These points are derived through extractive testing and entered on a different screen. Each point consists of an Optical Density value and an associated Particulate Mass value. Press the “ESC” or enter key to exit. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.26 Change Part. Mass Curve

This screen is password protected. The data points used to develop the correlation curve that converts Optical Density into Particulate Mass loading are entered via this screen. These points must be derived by monitoring the instrument’s Optical Density output while simultaneously performing extractive testing to determine the user’s source Particulate Mass. Each point consists of an Optical Density value and a correlating Particulate Mass value. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

Optical Density (O.D.) is calculated with this formula:

$$\text{O.D.} = \log \frac{1}{1 - \text{opacity}}$$

Particulate Mass is then derived from O.D. as a straight-line approximation, using up to three line segments. The first segment has zero as its origin and ends at the first O.D./Particulate Mass pair of numbers entered on the Particulate Mass Curve screen. The second segment is a line from the first number pair (x1, y1) to the second O.D./Particulate Mass pair of numbers (x2, y2). The third segment runs from the second number pair (x2, y2) to the third O.D./Particulate Mass pair of numbers (x3, y3). If a segment is not used, “-1” is entered for the terminal point O.D. Thus if “-1” is entered for the last O.D. point only two lines are used for the curve fit. If the second and third O.D. points are “-1”, only one line is calculated. If all three points are “-1”, Particulate Mass calculations are disabled.

To save the parameters in this screen use the “↑” or “↓” keys to highlight the SAVE THIS CONFIG. Field and then press “↵”. Press “ESC” to exit this screen. Any changes will be applied after leaving the screen. (*Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

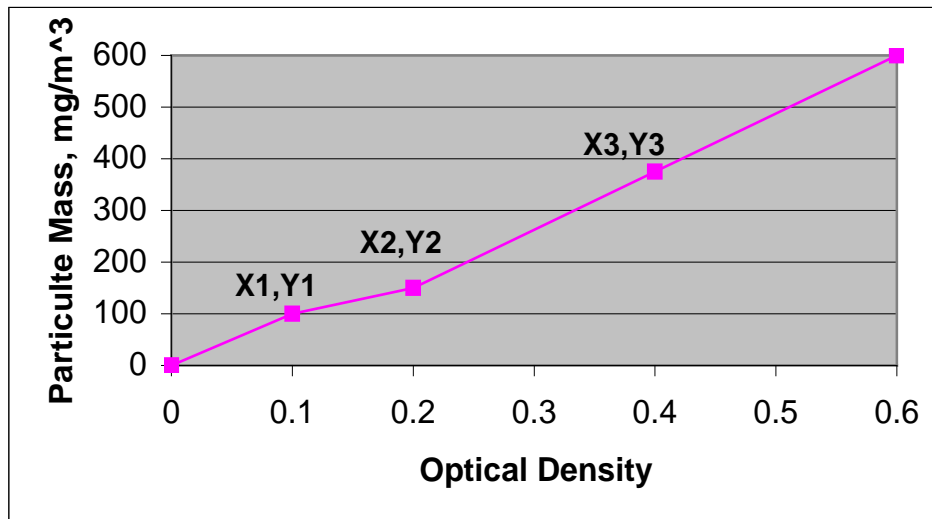


Figure 4-2 Particulate Mass / Optical Density Correlation Curve

4.4.27 Display Properties Menu

This screen permits adjustment of the Brightness and Contrast of the Display. Use the “↑” and “↓” keys to select the parameter you want to adjust. Then use the “Page Up” and “Page Down” keys to increase or decrease. The screen should visually change while pressing these keys. When the screen looks the way you want it, return to the main screen by pressing “ESC”.

An alternate method can be used to adjust the LCD display Contrast and backlight brightness:

- To increase display Contrast, press “Page Up” and hold the “↑” key.
- To decrease display Contrast, press “Page Up” and hold the “↓” key.
- To increase display backlight brightness, press “Page Down” and hold the “↑” key.
- To decrease display backlight brightness, press “Page Down” and hold the “↓” key. (*Consult the LightHawk[®] 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.*)

4.4.28 View Alarm Set Points

The current alarm set points may be viewed from this screen. These are maximum acceptable settings. A higher value will trigger an alarm. No changes can be made from here. Press “ESC” or “↵” to return to the previous screen. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.29 View Trending Data

This menu screen selects the parameter trend to be displayed. Use the “↑” and “↓” keys to select the parameter you want to display, then press “↵” to view that trend screen. “ESC” will take you back to the main menu. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.30 Trend Screen, Instantaneous Opacity

The trend screen displays the previous one hundred values of the parameter selected in the preceding menu. The units of the trend x-axis will always be number of values no matter if the parameter selected is instantaneous or six minute average. This screen actively updates as new values are received. This makes viewing process changes easier. The trend screen is capable of bar graphs only. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.31 View Numerical Data

There are four pages to the Numerical Data screen: one each for Opacity data, Optical Density data, Particulate Mass data and Network Status data. It is designed to be a place to simultaneously view all of the parameters for a given type of measurement, i.e., Opacity, Optical Density or Particulate Mass. This is a good place to do a daily check of the monitor since all values are updated concurrently. If readings are taken from multiple screens, some differences in the readings may occur due to updates occurring while you are switching screens.

The NETWORK STATUS screen contains event counters that keep a tally of the number of times each of the eight possible network errors occurs. These are specific errors defined by the network protocol. Each time one of the errors occurs at the Enhanced Remote Display node, an error message is issued and the network status log value for that error is incremented by one. These errors do not necessarily require corrective action but happen due to network contention issues that are a normal consequence of the network topology. A full description of these errors is beyond the scope of this manual. If necessary, please consult Teledyne Monitor Labs technical support for more information. The lower portion of this page shows the software versions being run by each of the systems processors. This information will always be current. It is updated on each reset.

(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)

4.4.32 View Status History

This screen has up to twelve pages depending on the number of system status changes that have taken place. It stores the previous 100 non-zero status word changes. Consecutive, identical non-zero status words cause only one entry. After one hundred entries the log is first in, first out. The most recent entries are at the top of the list on page one. Each entry consists of a code, the date, and time it occurred. Status words can be decoded as per the STATUS CODE HELP screen. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

4.4.34 View Alarms History

The View Alarms History screen can have as many as twenty pages. The "Page-Up" and "Page Down" keys move you to the next or previous page. This screen stores the previous 100 alarm events. An alarm event consists of setting or clearing any of the alarms that are defined in the SYSTEM PROPERTIES menu. Each entry stores the parameter in alarm, type of alarm, date, time, and whether the event set or cleared the alarm. If an alarm event happens while viewing the screen, the information will scroll down and the new event will be posted at the top of page #1. After one hundred entries are recorded, the oldest one gets dropped from the log. *(Consult the LightHawk® 560ES Menu Tree diagram of Section 4.0 to find the menu/submenu location of individual screens.)*

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5.0 SIX POINT I/O BOARD FOR 560DI SYSTEM

5.1 OVERVIEW

This chapter describes the Six Point I/O Board (6PIO) in the *LightHawk*[®] 560ES system. The Six Point I/O Board (P/N 1860-0700) is used in Direct Interface versions of the *LightHawk*[®] 560ES where analog output and control signals are required directly from the Optical Head Assembly. The 6PIO is packaged under the Optical Head rear cover and is mounted vertically on the left side. External connections are in the Integral Junction Box. See Wiring Diagram for connections.

Many of the configuration details of the 6PIO Board are user selectable. Some parameters may be selected using the keypad and digital display of the Optical Head Assembly. Other details are configured by placement of small jumpers located on the circuit board.

5.2 ANALOG OUTPUT DESCRIPTION

There are two independently isolated analog outputs.

DAC 1 (Channel 1 or Out 1) During the NORMAL mode, the analog output will track Instantaneous values displayed in bank U0. During any CALIBRATION mode, the analog output will hold the last NORMAL mode value. (If CB=0)

DAC 2 (Channel 2 or Out 2) During the NORMAL mode, the analog output will track Selectable Average values displayed in bank U2. During any CALIBRATION mode, the analog output will hold the last Selectable average mode value. (If CB=0)

You can add CALIBRATION mode values to the normal DAC1 or selectable average DAC2 channels. This is software selectable in the CB screen of the optical head keypad. 0=None, or no calibration values will be tracked. 1=DAC1 will collect calibration values. 2=DAC2 will collect calibration values. 3=DAC1 & DAC2 will collect calibration values. Calibration data scaling for Upscale, Zero and Dust Compensation will be the same as the Normal mode scaling.

5.2.1 Analog Output Measurement Units Selection

The DAC 1 and 2 output units may be Opacity, Optical Density or Dust Mass depending on user selection. The output units are software selectable using the keypad and digital display. The Measurement Unit parameter value will dictate both the LED display and the analog output units. For example, if Measurement Unit (F0 location) = 1, the LED display and analog outputs will be in terms of Opacity. If the Measurement Unit = 2, both will display in units of Optical Density, etc.

5.2.2 Analog Output Current Range Selection

Two output current options are available from the 6PIO Board (either 4 – 20mA or 0 – 20mA). This range will apply to any measurement unit configuration selected above.

Both analog channels are configured identically and the current range selected by the placement of jumper JU9 on the 6PIO Board. Placing the removable jumper between the two *leftmost* pins of JU9 (or the “4” position) will select the 4 – 20mA range. Placement of the jumper between the two rightmost pins of JU9 (or the “0” position) will select the 0 – 20mA range.

5.2.3 Automatic Calibration Analog Output Sequence

The order of the Automatic Calibration Analog Output Sequence is shown below. The duration of each is programmable in seconds.

Order	Description	Duration/ Parameter #	Opacity Scaling	O.D. Scaling	Dust Scaling
1 st	ZERO Calibration	Selectable/ C7	0-100	0-2	0-9999
2 nd	UPSCALE Calibration	Selectable/ C8	0-100	0-2	0-9999
3 rd	PLCF	Selectable/ C9	0-5	0-5	0-5
4 th	DUST Compensation	Selectable/ CA	-5 to +5	-0.022 to +0.022	

**Table 5-1
Automatic Calibration Sequence**

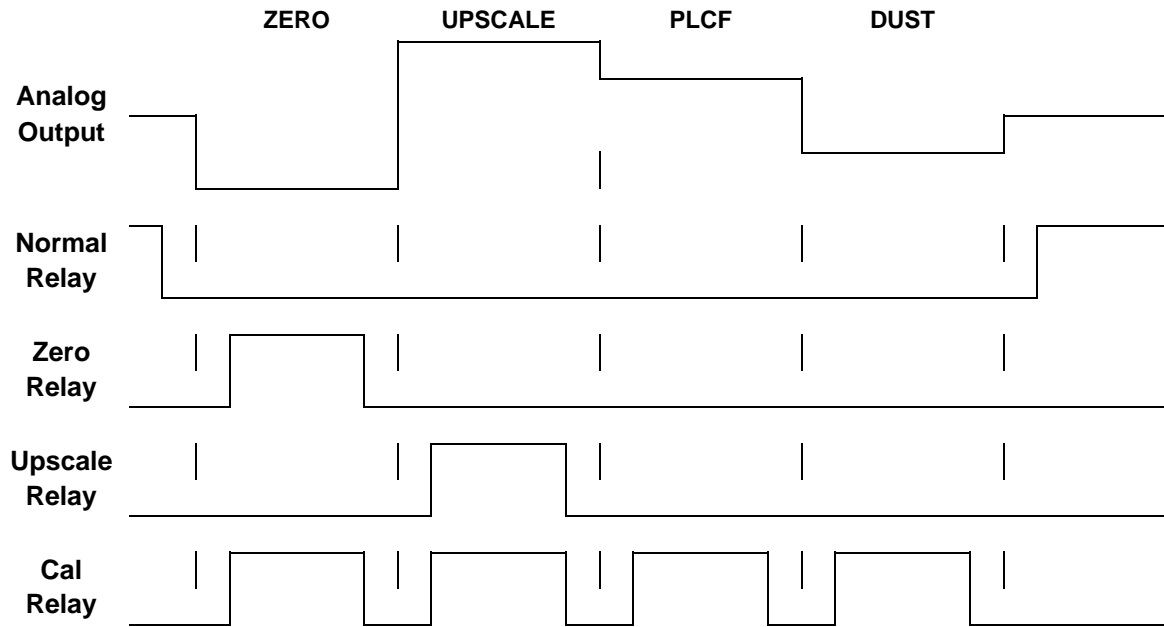


Figure 5-1
560ES Analog Output Cal Cycle Sequence

PLCF scaling for the Analog Output Cal Cycle (AOCC) is fixed and not user adjustable due to security considerations. The scaling for PLCF is always 0 – 5.

5.3 DISCRETE ISOLATOR INPUTS AND JUMPER SETTINGS EFFECT ON ANALOG OUTPUTS

There are two discrete isolator inputs on the 6PIO Board. Both can be independently configured for operation from +5Vdc or Dry contacts: Jumper JU5 for isolator #1 and JU6 for isolator #2. They are also jumper configurable to perform the following functions:

- **FORCE UPSCALE:** (JU7 in position “A” and Isolator 1 engaged): The instrument goes into calibration UPSCALE mode. The calibration mechanism moves to the UPSCALE position. Normal sampling of stack data ceases. Analog output #2 follows the UPSCALE value. Analog output #1 holds the last stack value.
- **FORCE ZERO:** (JU8 in position “A” and Isolator 2 engaged): The instrument goes into calibration ZERO mode. The calibration mechanism moves to the ZERO position. Normal sampling of stack data ceases. Analog output #2 follows the ZERO value. Analog output #1 holds the last stack value read.

- **FORCE UPSCALE and FORCE ZERO:** (JU7 in position “A”, JU8 in position “A”, Isolators 1 and 2 engaged): The calibration mechanism moves to NORMAL position. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the DUST COMPENSATION value.
- **DUMP PLCF:** (JU7 in position “B” and Isolator 1 engaged or JU8 in position “B” and Isolator 2 engaged): The calibration mechanism moves to NORMAL position. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the PLCF value with a dedicated scaling: ZERO SCALE = 0 PLCF; FULL SCALE = 5 PLCF.
- **DUMP DUST:** (JU8 in position “C” and Isolator 2 engaged): The calibration mechanism moves to NORMAL position. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the DUST COMPENSATION value.
- **FORCE CALIBRATION:** (JU7 in position “C” and Isolator 1 engaged):
 1. The instrument first goes into calibration ZERO mode. The calibration mechanism moves to ZERO position. Analog output #1 holds the last stack value read. Analog output #2 follows the ZERO value.
 2. After a configurable amount of time, the instrument goes into UPSCALE mode. The calibration mechanism moves to UPSCALE position. Analog output #1 holds the last stack value read. Analog output #2 follows the UPSCALE value.
 3. After a configurable amount of time, the instrument goes into PLCF mode. The calibration mechanism moves to NORMAL position. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the PLCF value with a dedicated scaling: ZERO SCALE = 0 PLCF; FULL SCALE = 5 PLCF.
 4. After a configurable amount of time, the instrument goes into DUST COMPENSATION mode. The calibration mechanism remains in NORMAL position. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the DUST COMPENSATION value.
 5. After a configurable amount of time, the instrument goes into NORMAL mode. Real time stack data appears on the LED readout and on analog output #1. Analog output #2 follows the selectable average stack value.

Jumper Position	Function	Available Isolator
JU7 "A"	FORCE UPSCALE	ISO1
JU8 "A"	FORCE ZERO	ISO2
JU7 "B" or JU8 "B"	DUMP PLCF	ISO1 or ISO2
JU8 "C"	DUMP DUST	ISO2
JU7 "C"	FORCE CALIBRATION CYCLE	ISO1

**Table 4-2
Isolator Configuration Jumpers**

5.3.1 Other Jumpers That Effect Analog Outputs

- **TEST ZERO SCALE (JU10):** This jumper is used to set both analog outputs to ZERO SCALE when placed in position "Z" (rightmost).
- **TEST FULL SCALE (JU11):** This jumper is used to set both analog outputs to FULL SCALE (20mA) when placed in the "FS" position (rightmost).
- **TEST ZERO SCALE AND TEST FULL SCALE:** When both of these jumpers (JU10 and JU11) are actuated simultaneously, both the analog outputs go to MID SCALE (12mA if the JU9 jumper is set to position "4", 10mA if the JU9 jumper is set to position "0").
- **JU1, JU2, JU3 and JU4:** These jumpers are used to set up internal measurement parameters for the 6PIO Board. These must remain in the positions detailed below for all 6PIO configurations.

Jumper Position	Function
JU9 "0"	Analog Outputs 0-20 mA
JU9 "4"	Analog Outputs 4-20 mA
JU10 "Z"	Test Zero Scale
JU11 "FS"	Test Full Scale
JU10 "Z" and JU11 "FS"	Test Mid Scale
JU1 & JU3 = 0	Internal Ranging (do not move)
JU2 & JU4 = 1	Internal Ranging (do not move)

**Table 4-3
Output Jumper Configuration**

5.4 RELAY OUTPUTS

Two relays are available. Contacts are SPDT Form C. The configuration of the relays is jumper selectable per the following table.

K1 (JU12 position)	K2 (JU13 position)	Function
A	A	Calibration Data on Analog Outputs
B	B	Instrument Malfunction (Not Fail-safe)
C	C	Instantaneous Alarm 1 Actuated
D	D	Selectable Average Alarm 1 Actuated
E	E	UPSCALE Data on Analog Outputs
F	F	ZERO Data on Analog Outputs
G	G	Purge Failure
H	H	Excessive Dust Compensation

Table 4-4
Relay Function Configuration Jumpers

The contacts of each relay are jumper configurable for either N.O. or N.C. operation as per the following table.

RELAY	N.O.	N.C.
K1	JU14 "A"	JU14 "B"
K2	JU15 "A"	JU15 "B"

Table 4-5
Relay Contact Configuration Jumpers

5.5 ANALOG OUTPUT ADJUSTMENT

The output current from each channel of the 6PIO may be measured at test points located on the board. The 0 – 20 or 4 – 20mA currents may be measured using a digital voltmeter to read the voltage across a 100Ω resistor at test points TP3 and TP4 for analog channel #1 (DAC1). 2.00 VDC between TP3 and TP4 indicates a 20mA output current. 0.40 VDC corresponds to a 4mA output.

To do this, wire jumpers must be installed between pins 6 & 7 (DAC1) and pins 9 & 10 (DAC2) on TB2, located on the external interface PC board which is mounted inside the junction box. JU9 on the 6PT I/O PC Board must be in the "4" position. To adjust the 4mA output current, place jumper JU10 in the "Z" (Zero scale) position. Adjust Potentiometer R11 till .40 VDC is achieved. Put JU10 back in the "OFF" position and place JU11 in the "FS" (Full Scale) position. Adjust Potentiometer R10 till 2.00 VDC is achieved. Place JU10 back into the "Z" position. You should get a voltage of 1.2 VDC. This is the mid range scale. Return both JU10 & JU11 to there off positions.

The analog channel #2 (DAC2) output is measured between test points TP10 and TP11. Voltage readings on channel #2 are the same as channel #1.

$$2.00 \text{ VDC} = 20\text{mA}$$

$$0.40 \text{ VDC} = 4\text{mA}$$

Jumpers must be moved per DAC1 instructions. Potentiometer R23 & R22 are used for adjustment.

	TEST POINTS	ZERO ADJUST	FULL SCALE ADJUST
Channel #1 (DAC1)	TP3 – TP4	R11	R10
Channel #2 (DAC2)	TP10 – TP11	R23	R22

Table 4-6
Analog Output Channel Adjustment Details

5.6 DATA CABLES

Two data cables are needed to interconnect the 6PIO to external devices. One is a 4 conductor #20 AWG (0.5 mm²) cable for connecting the contacts from the two relays. The other one Teledyne Monitor Labs recommends is a 6-pair #24 AWG (0.25 mm²) shielded cable for connection to the two analog outputs and two isolators. This would leave two pairs as spares or for future use. See Wiring Diagram in Appendix B, for details on external connections to the 6PIO PC Board.

Appendix A Six Point I/O Board Specifications

SIX POINT I/O BOARD ANALOG OUTPUTS

Number	2
Isolation Type	Optical & capacitive barriers; channel to channel, channel to circuit common & earth
Minimum Isolation Voltage	500V _{peak} *, 500VDC*
Output Type	4-20mA with live 4mA zero, OR 0-20mA w/o live zero
Maximum Load Resistance	900 ohms
Maximum Offset	±0.05% of full scale
Total Output Error	±0.30% of full scale

SIX POINT I/O BOARD DIGITAL INPUTS

Number	2
Modes	Isolated and Non-isolated
Isolated Mode Minimum Isolation Voltage	500V _{rms} *
Isolated Mode Minimum Actuation Voltage	5VDC (user supplied)
Isolated Mode Maximum Actuation Voltage	24VDC (user supplied)
Isolated Mode Maximum Input Current	50mA @ 24VDC
Non-Isolated Mode Actuation Condition	Dry contact closure
Non-Isolated Mode Internal Operating Voltage	5VDC

SIX POINT I/O BOARD RELAY OUTPUTS

Number	2 SPST, N.O. (Single Pole Single Throw, Normally Open or Normally Closed [jumper selectable])
Minimum Isolation	500V _{rms} *
Maximum Contact Voltage	250VAC
Maximum Contact Current	1Amp AC, 1Amp DC

*I/O wires with respect to earth (common mode).

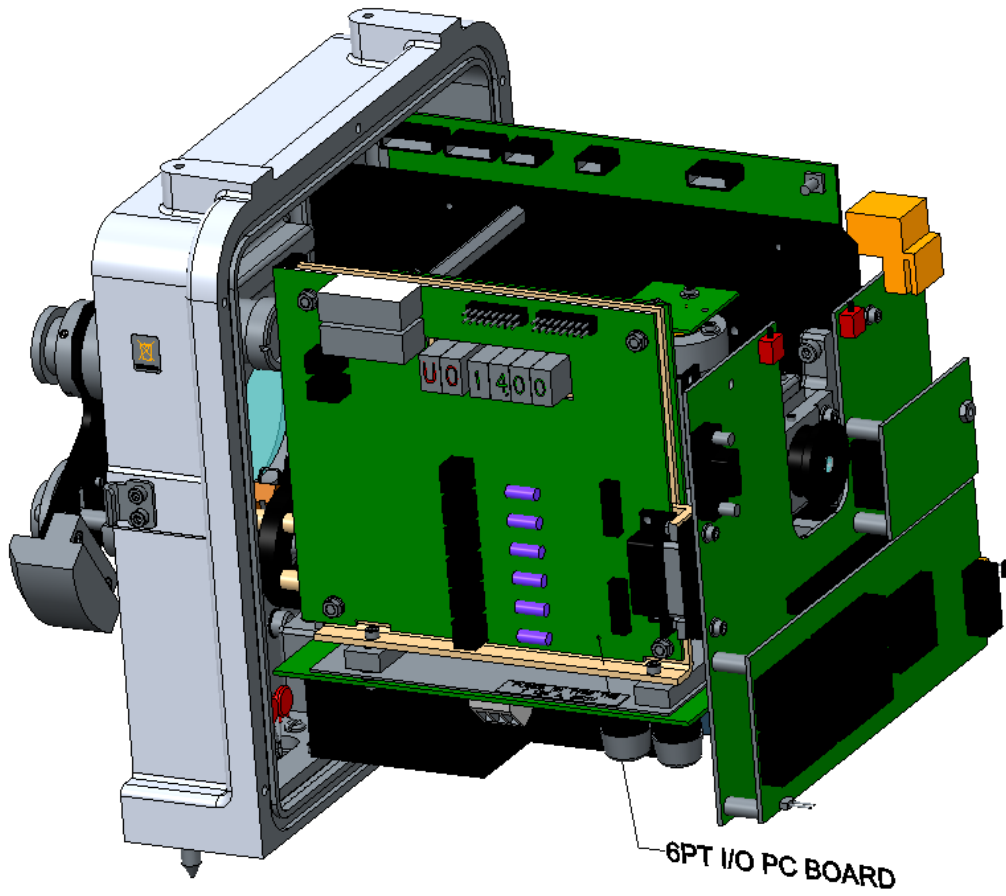
SIX POINT I/O BOARD (1860-0700) DEFAULT JUMPERS (560DI only)

JU1	0 1	0	Hardware range for analog output #1
JU2	0 1	1	
JU3	0 1	0	Hardware range for analog output #2
JU4	0 1	1	
JU5	+5V DRY	DRY	Selects input #1 type
JU6	+5V DRY	DRY	Selects input #2 type
JU7	A (TOP=Force _{upscale}) . B (MID=Dump _{PLCF}) . C (BOTTOM=Force _{cal cvcle})	BOTTOM	Selects input #1 function
JU8	A (TOP=Force _{Zero}) . B (MID=Dump _{PLCF}) . C (BOTTOM=Dump _{Dust})	TOP	Selects input #2 function
JU9	4 0	4	Software range. ma outputs
JU10	OFF ZERO	OFF	Test Zero
JU11	OFF FS	OFF	Test Full Scale
JU12	H G F E D C B A	A (Cal)	K1 relay closure condition
JU13	H G F E D C B A	B (Fault)	K2 relay closure condition
JU14	B A	A (NO)	K1 Relay operation NC/NO
JU15	B A	A (NO)	K2 Relay operation NC/NO

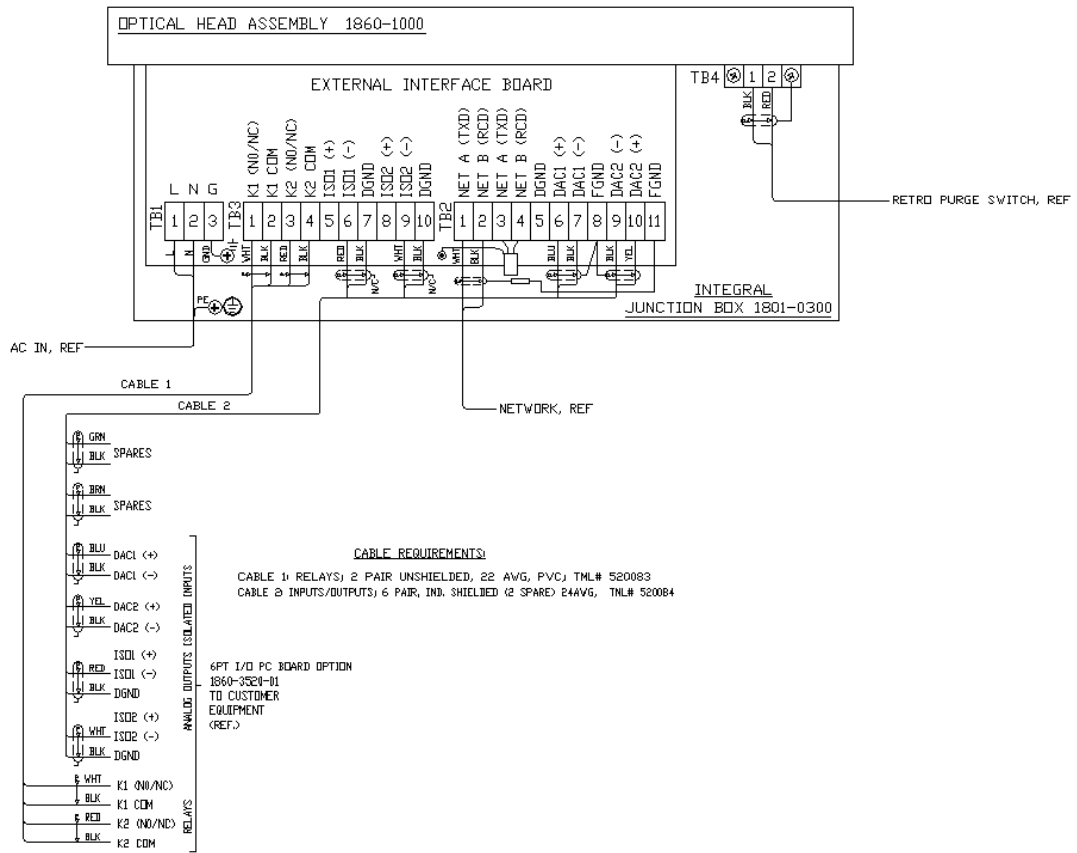
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APPENDIX B

DRAWINGS



6PT I/O PC BOARD LOCATION



6PT I/O WIRING DIAGRAM

6.0 PURGE SYSTEM OVERVIEW

The Protective Purge Air System provides clean air to both the Optical Head and Retroreflector Assemblies. The filtered air is directed in a way that prevents the sample medium from touching the optical surfaces. The purge air is injected into the stack through the nozzles of the Optical Head and Retroreflector Assemblies. The Purge System has an air intake filter that prevents ambient dust from contaminating the purge air. Filter replacement is very important to prevent contamination of the optical system. The weather cover protects the filter so that rain does not wash through the filter and allow contaminants to enter the purge blower. The outlet of the blower motor is split off and purge air is routed to each assembly through flexible hoses.

Refer to the Site Specification Data Sheets in Appendix A to determine your particular system configuration.

6.1 MECHANICAL DESCRIPTION

The Purge Air System consists of the following major components.

- Mounting Plate and Weather Cover
- Purge Blower Motor
- Blower Intake Air Filter and Associated Pipes and Hardware

These components are shown on the Opacity Single Blower System Installation drawing provided.

6.2 ELECTRICAL DESCRIPTION

The purge blower motor is connected to user supplied AC voltage source capable of supplying continuous (uninterrupted) power. The input voltage, current and phase will differ for some users. A breaker of sufficient rating to allow for motor start up current must be used.

Please consult the Site Specification Data Sheets for the specific Purge Blower motor supplied with your system.

NOTE: *One of the primary causes of blower motor failure is the location of the inlet to the Purge System. These systems must draw air that is free from corrosive gaseous pollutants so that the lubricant in the bearings of the motors is not contaminated.*

6.3 OPERATION

The air intake filter and purge system must be maintained in good working condition in order to adequately protect the Optical Head and Retroreflector Assemblies.

NOTE: *Interruption of the Protective Purge Air System requires immediate corrective action by the user. In no case should the Optical Head or Retroreflector Assembly be placed in service or mounted on the stack without the Protective Purge Air System in operation.*

6.4 PURGE STATUS

If the purge blower is providing proper airflow, two pressure sensitive switches will be closed in the Retroreflector and Optical Head. If either switch senses that the airflow is not sufficient it will open. Switch status is determined on the Optical Amplifier Board and triggers a fault when purge air is malfunctioning. The termination for the Retroreflector purge cable is made at both the Retro Purge Switch Junction Box and the Optical Head Integral Junction Box. The status of the Optical Head purge switch is internal to the Optical Head Assembly.

6.5 DUAL PROTECTIVE PURGE AIR SYSTEM (DUAL) BLOWER OPTION (REQUIRED FOR >+5" H2O STACK PRESSURES)

Please consult the Site Specification Data Sheets for the specific configuration of your system.

The system may be configured for a Dual Purge Blower option. A separate circuit powers each assembly as shown on the wiring diagrams. Each motor is mounted on the Optical Head and Retroreflector sides. The output of each blower goes to its respective assembly via a short flexible hose located under the protective hood.

6.6 PURGE SHUTTER ASSEMBLY OPTION

Please consult the Site Specification Data Sheets for the specific configuration of your system.

These shutters are located between the main casting and purge nozzles on the Optical Head and Retroreflector Assemblies. Their purpose is to prevent hot stack gases from entering the Optical Head and Retroreflector Assemblies if the purge blower or other air handling components should fail. The Purge Shutters are gravity operated and have no electrical connections. The shutters remain open as sufficient purge air volume is being supplied. If purge air is halted or reduced for any reason, the purge shutter will begin to close and drop down into the optical path of the monitor.

NOTE: *The Purge Air Shutters are designed to provide short-term protection for the optical components in the case of a purge air failure. “Purge Fail” faults must be evaluated and corrected immediately in order to prevent significant damage to the stack mounted equipment.*

6.7 INSTRUMENT AIR PURGE OPTION

Please consult the Site Specification Data Sheets for the specific configuration of your system.

This option requires that the customer must supply and install ½ inch pipe to carry the Instrument Air. The air must be delivered at a dynamic pressure of 30 PSIG (7473 PaG) minimum, at a flow rate of 25 CFM (707 LPM) minimum. Connection to the Retroreflector and Optical Head Assemblies is via 3/8 inch tube. Reference *LightHawk*® 560 Opacity w/Inst Air System Installation drawing provided. Customer must supply hardware to connect Instrument Air to both Optical Head and Retroreflector Assemblies.

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7.0 CALIBRATION KIT OVERVIEW

The Calibration Kit consists of a black external zero device fixture and a filter case. The fixture is made to mount on the Optical Head to simulate a clear path zero condition and hold the calibrated attenuators used to check system response. The case contains three attenuators and an opaque blocking plate. Each attenuator is calibrated to give a different upscale response. The external zero device has an adjustable iris.



NOTE: *The Cal Kit iris is adjusted only at the time of a clear path calibration to produce the same zero opacity response as the COMS reflector.*

7.1 OPERATION

The Calibration Kit Fixture is factory adjusted to simulate the exact amount of energy returned from the Retroreflector at the calibration distance. The Calibration Kit Fixture then becomes a standard or reference to be used to audit or completely adjust the Optical Head Assembly electronics at the stack location while the stack is in operation. Each Calibration Kit Fixture has a unique serial number that matches the serial number of the Optical Head and Retro Assemblies.

NOTE: *Only the Calibration Kit Fixture that has the same serial number as the Optical Head may be used to calibrate an individual monitor.*

CAUTION: *The Calibration Kit iris must never be readjusted unless the "clear path" or zero opacity setting has been confirmed by completion of a clear path calibration.*

The Calibration Kit without attenuators should be used for all subsequent on-stack electronics adjustment of zero opacity.

Before installing the Calibration Kit, be sure that the window that protects the iris and reflective material of the Cal Kit is clean and free of lint so that the signal returned from the fixture will not be reduced.

Install the Cal Kit Fixture on the face of the Optical Head Subassembly. There are three small holes approximately one inch apart just above the instrument exit window. The two outermost of these will accept the two 1/4-inch diameter locator pins protruding from the rear of the Cal Kit Fixture. The center hole is tapped to receive the thumbscrew that holds the fixture in place while the kit is in use. It is very important that the Cal Kit Fixture sits flat and flush against the face of the Optical Head Subassembly so that the iris and reflector fall on the optical centerline of the exit window. Since the clearances are small on the precision locator pins, it may be necessary to wiggle the test fixture a bit so that the locator

pins go into the subassembly face to their full extent before beginning to tighten the thumbscrew by hand. A small common screwdriver may be used to tighten the captive thumbscrew to hold the fixture firmly in place.

CAUTION: Take care not to over torque the thumbscrew as this may damage the threads in the instrument mounting plate.

With the Cal Kit Fixture in place and no attenuators or blocking plate installed, the Cal Kit will generate a signal equivalent to the clear path 0% opacity signal. The opaque disk is used to simulate a 100% opacity reading when inserted into the fixture. The opacity values of the three calibrated attenuators are marked on the edge of their tabs. The attenuators are used to check the linearity and system response to different values of opacity.

7.2 STORAGE

The Calibration Kit Fixture and attenuators should be stored in the protective case provided when not in use. Store the case in a location that will prevent dirt contamination of the optical surfaces and is not subject to extremes in temperature.

8.0 MAINTENANCE & ON-STACK CALIBRATION

This section contains the information needed to provide proper maintenance and on-stack recalibration.

Routine Maintenance normally consists of: •Verifying the LED operating current, •checking the condition of Purge Air System, •cleaning and aligning of the Optical Head, Retroreflector and Cal Mechanism, •performing a manual Calibration Cycle check, •checking the Dust Compensation.

An On-Stack Calibration is a more comprehensive checkout and adjustment of the entire monitoring system. Teledyne Monitor Labs recommends an On-Stack Calibration be performed quarterly, while the Routine Maintenance be performed on an “as needed” basis.

It should be noted that in performing either Routine Maintenance or an On-Stack Calibration, the monitor will be experiencing malfunctions and will not be collecting valid data. Operators and other affected personnel should be notified that the monitor will be out of service until the maintenance or calibration is complete.

8.1 ROUTINE MAINTENANCE

The conditions under which the monitoring system operates vary widely from installation to installation. Teledyne Monitor Labs recommends a Routine Maintenance check be performed approximately 30 days after initial installation and again at 30 day intervals for the first 3 months of operation. This actual site experience should indicate the frequency of future Routine Maintenance.

1. LED Drive Current

Manipulate the keypad until location S2 is displayed. The LED light source current will be displayed in milliamps on the RED 4 digit display. Typical factory settings are between 30.0 and 35.0 mA, though higher values may be used under some conditions. (Consult the Site Specification Data Sheets for the “as shipped” value.)

NOTE: *Ambient temperature and instrument conditions will strongly influence LED current levels. Although typical factory LED currents are between 30.0 and 35.0 mA, currents of up to 40.0 mA are perfectly normal for your monitor and do not require readjustment. LED currents beyond 40 mA should be investigated and Teledyne Monitor Labs recommends an Off-Stack Calibration described in Section 8.0 of this manual.*

2. Purge Air System

The Purge Air System has an air filter that prevents dust particles from entering the Optical Head area. This filter should be changed periodically so that the proper amount of purge air is provided to the system. In typical locations, replacing the filter quarterly should be adequate. The filters must be protected by the purge housing cover so that water does not wash through the filter and enter the purge blower. Refer to Appendix C of this manual for replacement filter part numbers.

Purge Shutters are optional equipment and may not be present on every *LightHawk*® 560ES. The Purge Air Shutters are not included on an upgrade from the LS541, 1100M, or MC2000. If so equipped, check the condition of Purge Shutters by looking through alignment eyepiece window on the Optical Head. The mechanical shutter plates of the Purge Shutters should **not** be visible falling into the light beam on either the retroreflector or transceiver side.

There is a desiccator in the Optical Head Assembly. It can be viewed by swinging open the Rear Optical section and looking to the upper right hand corner of the assembly. *Note: The transceiver must be in the NORMAL mode before opening the Rear Optical section.* When the desiccator is not completely spent, it will indicate a blue to blue/white color. When it indicates a pink color, it is completely spent. The desiccator will prevent moisture from condensing on the optical surfaces inside the Rear Optical section. Teledyne Monitor Labs recommends the desiccator be changed if it is **not blue**, or whenever the rear cover is removed.

3. Cleaning

During Routine Maintenance, only the exit window of the Optical Head Assembly, the surface of the Retroreflector Assembly, and the Cal Mechanism windows need to be cleaned.

NOTE: Typical *cleaning of the Cal Mechanism zero and upscale windows may be performed carefully without removal of the mechanism from the motor shaft.*

The window of the Cal Kit Fixture should also be cleaned prior to its use. The cleaning solution should be a 50% alcohol and distilled water solution. Teledyne Monitor Labs recommends the use of a reagent grade isopropyl alcohol. A quality ammonia based window cleaner may be used as a second resort; however, do not use cleaners that contain an anti-fog additive. Commercial lint free lens and glass wipes such as Kimwipes® must be used for cleaning.

4. Alignment**Optical Head Assembly**

The across stack alignment of the Optical Head is performed by observing the Retroreflector image through the eyepiece and adjusting the Optical Head mounting nuts, that rest against the swivel washers on the four mounting bolts, which support the Optical Head Assembly on the blower plate. The Optical Head alignment may be observed by placing your eye about 3cm (1 inch) from the alignment window on the rear cover.

You will notice that the eyepiece contains a cross hair and a series of concentric circles. Alignment is achieved by loosening one nut and tightening the opposing nut, pivoting the optical head around so that the cross hairs are centered on the bright green image of the Retroreflector and the eyepiece circles are concentric with the image. (Figure 8-1) The last few adjustments should be by tightening only so that the instrument is securely fastened to the port.

NOTE: A graphic depiction of the misalignment images for the user's individual monitor is permanently affixed to the Optical Head cover for easy reference.

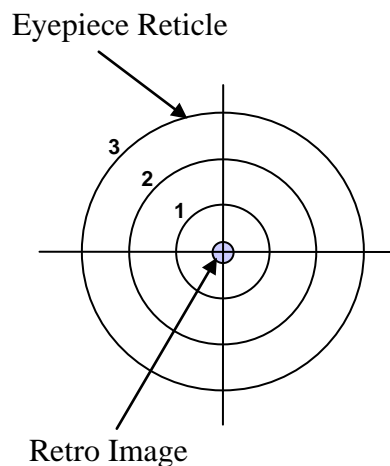


Figure 8-1

NOTE: If a multi-element retro is supplied the group should be centered on the reticle.

Retroreflector Assembly

Retroreflector Assembly alignment is achieved by use of the Integral Retro Alignment Site. The Retro Alignment Site provides a visual indication during alignment. The alignment sight protrudes from the rear of the Retro Cap and has a frosted glass screen. The frosted glass screen has a circular target etched into it and a portion of the beam from the Optical Head is projected onto the target.

- a. Preliminary adjustment of the Retro is accomplished by opening the Retro Cap and observing the green light projected from the Optical Head.
- b. Preliminary alignment is achieved by loosening one nut and tightening the opposing nut, pivoting the Retroreflector around until the bore of the Retro and purge nozzle is nominally centered on the projected beam. Close the retro cap.

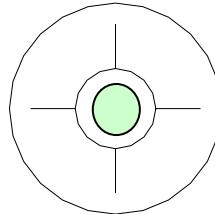


Figure 8-2

- c. Final adjustment is achieved by observing the GREEN light image on the frosted glass target. (Figure 8-2) Then readjust the 4 nuts on the mounting bolts until the projected beam is completely contained within the circular target of the alignment device. The last few adjustments should be by tightening only so that the Retroreflector Assembly is securely fastened to the port.

NOTE: *The Retro Alignment image is best viewed by keeping the eye 8 – 12 inches (20 – 30cm) back from the target and looking for the GREEN spot superimposed on the target. The spot may be difficult to see under*

bright ambient light conditions. It may be necessary to shield the ambient light from the target during adjustment under these conditions.

The Retro Alignment Site is useful for providing on-line feedback during analyzer operation of small changes in Retroreflector position once initial alignment has been performed. It is well suited for alignment indication during normal operation.

5. Manual Calibration Cycle Check

Perform a manual Calibration Cycle by simultaneously depressing the “ZERO” and “UPSCALE” keys on the keypad. When the Cal Cycle is complete, check the Dust Compensation value (location U8). If the Dust Compensation value is $0\% \pm .5\%$, the Routine Maintenance is complete. *If the Dust Compensation exceeds $\pm .5\%$, Teledyne Monitor Labs recommends an On-Stack Calibration as described in Section 8.2 below.*

8.2 ON-STACK CALIBRATION

An On-Stack Calibration is a more comprehensive checkout and adjustment of the entire monitoring system. Teledyne Monitor Labs recommends an On-Stack Calibration be performed quarterly or when the Routine Maintenance delivers unacceptable results.

Appendix B of this manual contains an On-Stack Calibration Checklist to aid the user in performing the calibration. Teledyne Monitor Labs recommends this data be retained to provide a historical record of the opacity monitoring system.

8.2.1 Procedure for On-Stack Calibration Checklist

TOOLS:

- Standard Common Screwdriver
- 3/4 Open End Wrench or Adjustable Wrench

TEST EQUIPMENT:

- Instrument Calibration Kit Fixture
- Calibrated Neutral Density Attenuators

MISCELLANEOUS:

- ❑ 50% solution of distilled water and isopropyl alcohol or a quality commercially available glass cleaner
- ❑ Lint free, untreated lens cleaning cloth (Kimwipe® or equivalent)
- ❑ Teledyne Monitor Labs On-Stack Calibration Checklist for *LightHawk*® 560ES Opacity System (Appendix B)

The checklist begins at the Enhanced Remote Display, moves to the DAS/recording device for a few readings before going to the stack mounted equipment. After the stack equipment checks are complete, the checklist moves back to the Enhanced Remote Display, then finishes at the DAS/recorder. Begin the checklist by filling in the information regarding serial number, location, date, and service person.

(1) Reason for Calibration

Place a check or an "X" in the appropriate circle to indicate the reason maintenance is being performed. Explain any important information on the lines provided

(2) Enhanced Remote Display Checks

A. Current Readings

Record the "As Found" opacity readings from the Enhanced Remote Display Fault Indicators, from Page 2 of the main display.

B. Fault Indicators

Record the status, ON or OFF, of the 2 Operational Status Indicator LEDs: Faults / Alarms.

C. Status Word

Record the five digit Status Code from the MAIN DISPLAY screen. If this is anything other than "0", increment the screen to the STATUS HELP screen and explain the status code in the space provided.

D. Current Calibration Values

Record the current calibration values in the BEFORE column of the data sheet. Obtain these values from Page 2 of the MAIN DISPLAY Screen.

E. Calibration Set Points

Increment the display to the VIEW SYSTEM PROPERTIES screen. Record the calibration set points, CAL FAIL LEVEL and PLCF in the BEFORE column.

NOTE: *To get to VIEW SYSTEM PROPERTIES from the MAIN DISPLAY, first press the enter key (↵) to go to the SYSTEM PROPERTIES, then use the down arrow (↓) to select VIEW SYSTEM PROPERTIES and press enter (↵) to select.*

F. Check the Permanent Data Record for the Results of the Last Cal.

Review the strip chart recorder, DAS or data collection device, for the last calibration values received from Enhanced Remote Display. Record these values.

G. Analog Outputs Enhanced Remote Display

NOTE: *There are two ways to verify the outputs' calibration. One is by placing a current meter in series with the output. The other is to evaluate the reading of the output device. Usually, checking them against the output device sets them up for best accuracy on that device. If a problem is suspected, use a multimeter*

From the VIEW SYSTEM PROPERTIES screen, record the AVERAGE INTERVAL MIN. This is the sampling period for the selectable average parameters.

Return to the MAIN MENU and increment the display to the OUTPUT MODULE CONFIG. screen for CH.1,2 then 3,4. This will require either the security key or the supervisor password. Record the parameter that each channel is configured to carry and if it is configured to display the calibration output.

Return to the MAIN MENU and increment to the ANALOG OUTPUT TEST screen. Select TEST ZERO SCALE. Then select SEND THIS COMMAND and enter (↵). This will drive all four outputs to Zero scale. Check the outputs for accuracy. Send the outputs a TEST FULL SCALE command and then a TEST MID SCALE command. Check for accuracy of each output at each point. Record how the outputs were checked and if adjustments were made.

(3) ON-STACK CHECKS

A. Led Current

On the Optical Head manipulate the keypad until location S2 is displayed. The LED light source current will be displayed in milliamps on the RED 4 digit display. Typical factory settings are between 30.0 and 35.0 mA, though higher values may be used under some conditions. *Consult the Site Specification Data Sheets for the “as shipped” value.*

NOTE: *Ambient temperature and instrument conditions will strongly influence LED current levels. Although typical factory LED currents are between 30.0 and 35.0 mA, currents of up to 40.0 mA are perfectly normal for your monitor and do not require readjustment. **LED currents beyond 40 mA should be investigated and Teledyne Monitor Labs recommends an Off-Stack Calibration described in Section 8.0 of this manual.***

B. Inspect

- Purge Filters - Check conditions of purge air filters and replace if necessary. Record condition.
- Flex Hoses - Check the condition of the flex hoses and replace if necessary. Record results.

NOTE: *If single blower system is in use and the Optical Head or Retroreflector is opened, the purge air valve on the **OPEN** side must be **CLOSED**.*

- Mounting Tubes - Open the latch on the Optical Head and swing it open. Close the PURGE AIR valve. Check the mounting tube for obstructions. Open the cap on the Retroreflector. Close the PURGE AIR valve. Check its mounting tube for obstructions. Record condition of the mounting tubes.
- Purge Shutters - Purge Shutters are optional equipment and may not be present on every *LightHawk*® 560ES. The Purge Air Shutters are not included on an upgrade from the LS541, 1100M, or MC2000. If so equipped, check condition of Purge Shutters by looking through alignment eyepiece window on the Optical Head. The mechanical shutter plates of the Purge Shutters should **not** be visible falling into the light beam. Record condition of Purge Shutters.
- Desiccator - To access the Optical Head’s desiccator, open the latch and swing the Optical Head Assembly open. Its desiccator is mounted on the top right of the front plate. If the desiccator is still useable, it will indicate a blue to blue/white color. When the desiccator indicates a pink color, it is completely spent. The desiccator may be reactivated by baking at 150 degrees Fahrenheit for several hours. Report condition of desiccate. Teledyne Monitor Labs recommends the

desiccator be changed if it is **not blue**, or anytime the rear cover is removed.

C. Alignment

Observe the projected beam image from the alignment eyepiece window at the rear of the Optical Head Assembly. The cross hairs of the reticule should be centered on the beam image and the outside edge of the GREEN Retro image must be inside of the # 1 ring of the eyepiece. Record the alignment condition on the data sheet. The image of the beam should also be centered on the cross hairs of the Retroreflector. Refer to Section 8.1, Step 4, for a detailed alignment procedure.

D. Cleaning

Clean Retro surface, Exit Window, and Cal Mechanism Windows. A 50/50 mix of alcohol and distilled water and a lint free cloth is recommended. Mark the data sheet to indicate that each optical surface was cleaned.

NOTE: *Clean the Cal Mechanism zero and upscale windows carefully without removal of the mechanism from the motor shaft.*

E. Install the Cal Kit Fixture

Be sure that the window of the Cal Kit is clean and free of lint so that the signal returned from the fixture will not be reduced. Install the Cal Kit Fixture on the face of the Optical Head Subassembly. It is very important that the Cal Kit Fixture sit flat and flush against the face of the Optical Head so that the iris and reflector fall on the optical centerline of the exit window. A small common screwdriver may be used to tighten the captive thumbscrew to hold the fixture firmly in place. Do not over tighten the thumbscrew as damage to the aluminum threads in the Optical Head may result.

F. Perform BACKGROUND SET

Create a 100% opacity condition by inserting the opaque blocking plate in the filter holder section of the Cal Kit. Perform a BACKGROUND SET by simultaneously pressing the “BACKGND” and “SET” keys on the keypad. The “SET” and “BACKGND” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period. The SET LED will then come on continuously and stay lit for about 6 minutes. Once the SET LED goes out, remove the opaque blocking plate creating a 0 % opacity condition.

NOTE: *The YELLOW “SET” LED will light continuously during the actual 6 minute BACKGROUND SET process. The LED display will have a value during the set that should be ignored.*

G. Perform NORMAL Set

With no filters in the Cal Kit, simultaneously press the “NORM” and “SET” keys on the keypad until the SET LED quits blinking. The “SET” and “NORM” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period. Once again the SET LED will light continuously for about 6 minutes. Leave the unit undisturbed until the set light goes out. During this period, the clear path reference is established.

NOTE: *The YELLOW “SET” LED will light continuously during the actual 6 minute NORMAL SET process. The LED display will have a value during the set that should be ignored.*

H. Perform ZERO SET

Confirm that the unit is in the NORMAL mode/position. Simultaneously press the “ZERO” and “SET” keys on the keypad until the SET LED quits blinking. The “SET” and “ZERO” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period. Once again the SET LED will light continuously for about 6 minutes. Leave the unit undisturbed until the set light goes out. During this period, the ZERO calibration value is established.

NOTE: *The YELLOW “SET” LED will light continuously during the actual 6 minute ZERO SET process. The LED display will have a value during the set that should be ignored.*

I. Check the Cal ZERO value

Check the EXTENDED STATUS CODE by reading the contents of location U4 on the Optical Head display. If the last digit of the U4 EXTENDED STATUS indicates a XXX1 malfunction (ZERO SET voltage out of range), the energy ratio returned by the Cal Zero section of the Cal Mechanism and the Cal Kit are outside the allowable range. Teledyne Monitor Labs strongly suggests an Off-Stack Calibration as

outlined in Section 8.0 of this manual to determine the source of the malfunction and correct this problem.

J. Command Cal Cycle

Run through a complete Cal Cycle by simultaneously depressing the “ZERO” and “UPSCALE” keys on the keypad. When the Cal Cycle is complete, check that the last Zero Calibration (location U6) is the same value as Dust Compensation (location U8). If they are not, recheck all the SET functions you just did. Check that the last Upscale Calibration (location U7) is within $\pm 1\%$ of the target value (location C1). The Upscale Calibration value is generated using its own reflective optical reference on the Cal Mechanism. This means that the optical signal returned from the Upscale section may vary independently from the Cal Zero reading by as much as $\pm 0.5\%$ opacity. In the short term (from week to week or month to month), the COMS response should be very repeatable and the calibration set point should be maintained at the value established during the last full calibration.

However, whenever the COMS is recalibrated (clear path) for errors in path length or after replacement of optical components, the relationship between the Upscale Cal Value and the Clear Path Zero will likely change. Since the “NORMAL SET” function will command the new across stack energy to indicate ZERO opacity, the independent optical response from the Upscale Cal Value will change with respect to the new zero. The change in the Upscale Cal response may be dealt with in two ways:

- Readjust the Upscale Calibration set point to match the new response.
- Readjust the Upscale Calibration Iris on the Cal Mechanism to, as closely as possible, produce the same response as was historically used.

K. Cal Kit Readings, Attenuator Checks

Calculate and record the PLCF corrected value of each of the three attenuators. Use the formula below (PLCF was recorded previously). Place the attenuators in the Cal Kit one at a time. Allow sufficient time for your systems average opacity reading to reach the attenuator’s value (at least two averaging periods) before removing it. Record the reading from location U2 (Selectable Average Opacity). The recorder/DAS readings will be compared with the corrected attenuator readings in a later step.

$$\text{Corrected filter value} = 1 - (1 - \text{actual value})^{\text{PLCF}}$$

Where the actual value = Labeled %opacity / 100

L. Remove the Cal Kit Fixture. Close the Optical Head Assembly.

Install the weather cover. At this time all stack checks are completed. Return to the Enhanced Remote Display.

(4) DATA COLLECTION

A. Re-Check Output Device

- Examine the recorder or data collection device for the attenuator values that were collected during the Cal Kit checks. Record them under “Output Value” in the table of Section 3. Compare these values with the corrected attenuator values for the absolute difference. Enter this difference in the table. It should be $\leq 2\%$ opacity.

B. Fill in Section 2 "AS LEFT"

- Record the instantaneous and average opacity values “**AS LEFT**” in Section 2.

8.3 ATTENUATOR AUDIT

The Enhanced Remote Panel is capable of recording, storing, and displaying an entire Attenuator Audit: Initial and final Zero, and 15 Attenuator values (5 runs of 3 attenuator values). Contact Teledyne Monitor Labs Tech Support at (800) 846-6062 for Technote #0049.opc.

9.0 OFF-STACK CALIBRATION

If the analyzer is undergoing an annual recalibration, then the actual optical zero opacity energy must be verified empirically by performing a complete clear path zero calibration. Complete recalibration is also necessary under the following conditions:

Replacement or damage to:

- ❑ LED Source Assembly
- ❑ Retro Cap Assembly
- ❑ Signal Detector Assembly
- ❑ Calibration Kit Fixture

Optical alignment of:

- ❑ LED Source Assembly
- ❑ Signal Detector Assembly
- ❑ Any Internal Optics

9.1 FACTORY SELECTION OF OPTICAL ELEMENTS

Factory calibration of the Opacity Monitoring System involves the selection of optical components that are site specific. The electronic adjustments and across stack visual alignment portions of the calibration procedure may be performed by user maintenance personnel in the normal course of maintenance and audit testing.

NOTE: *The user should not attempt the internal alignment of individual optical elements.*

Small changes ($\pm 10\%$) in the flange to flange calibration distance discovered by the user may be compensated for by performing a new clear path zero calibration. The Teledyne Monitor Labs factory should approve changes beyond the $\pm 10\%$ limit. This will insure that the appropriate optical elements are installed & refocusing of the projection lens is performed before the recalibration begins.

9.2 GENERATING AN OPTICAL CLEAR PATH OPACITY SIGNAL

To properly calibrate the opacity monitor it is necessary to generate conditions equivalent to zero percent opacity (clear) and 100 percent opacity (completely opaque). These optical signals may be produced in the following ways:

- Simulating the installation path length on test stands
- At the actual installation site under *clear stack* conditions

9.2.1 Simulating Installation Path Length on Test Stands

This method may be used to calibrate the monitor under the conditions described in Section 9.0. This method is also used to perform the factory calibration. Information must be obtained on the precise distance between the opposing faces of the mounting flanges that the user has installed for the monitor. The Optical Head and Retroreflector Assemblies are mounted on special test stands. These stands are then separated by the exact same distance as that provided by the user. This distance is referred to as the “flange to flange” calibration distance. This distance is depicted on the installation drawing and has been documented by Teledyne Monitor Labs in the Site Specification Data Sheets of this manual.

If test stands are not available, a table whose length is greater than the “flange to flange” calibration distance may be used for calibration. To use this approach, take off the Retroreflector Assembly cover and re-install it with the ends of its curved surfaces pointing upward. If the Retroreflector and Optical Head Assemblies are now both placed on the table in an upside down orientation, the optical axes of both will be close to coaxial alignment. See Figure 9-1. The Retroreflector Assembly cover is not available on an upgrade from the LS541, 1100M, or MC2000.

NOTE: *If the Optical Head and or Retroreflector is equipped with purge shutters or flange adapters, extra care must be taken when simulating the installation path length. If the purge shutters or flange adapters are not attached to the monitor during the Off-Stack Calibration, their distance must be accounted for. The Optical Path Length (the distance between the Optical Head Exit Window and the Retroreflector Surface Window) must be replicated. This Optical Path Length is sometimes referred to as the “hinge to hinge” distance.*

So long as the distance measurement supplied by the user is accurate and no obstruction of the beam occurs in the room in which the calibration occurs, these methods of calibration produce excellent results. **Note:** *Document both the “flange to flange” and “hinge to hinge” values in Table 9-1 at the end of this section.*

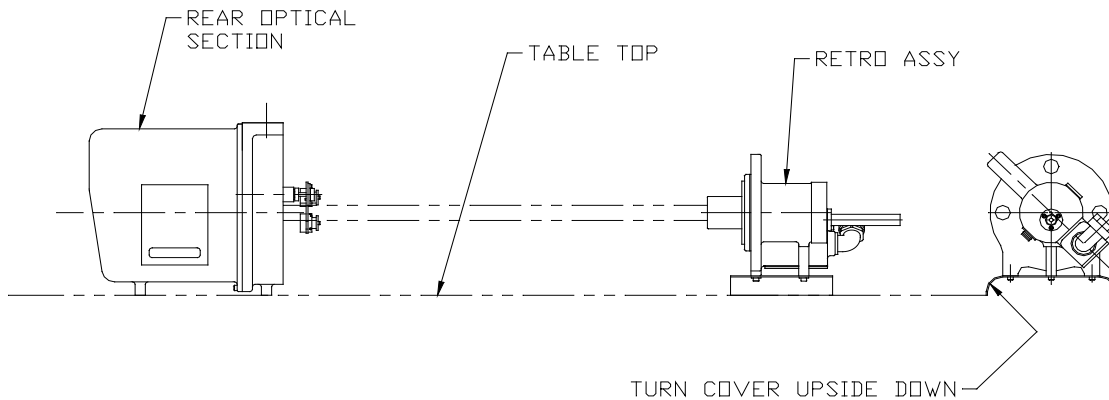


Figure 9-1

Tabletop Calibration

9.2.2 Actual Clear Path Conditions

This is done by performing the across stack calibration while the stack or duct is not in operation.

This type of calibration does not suffer from potential distance measurement errors; however, it is not uncommon for a stack that is out of service to have some circulating opacity in it. This may be a result of natural convection or maintenance work being performed somewhere in the effluent carrying duct work. *If such a condition exists while the 0% and 100% opacity adjustments are being made, it is certain that the calibration will be biased.*

9.3 ACROSS STACK ALIGNMENT

9.3.1 Optical Head Assembly

The across stack alignment of the Optical Head is performed by observing the Retroreflector image through the eyepiece and adjusting the Optical Head mounting nuts, that rest against the swivel washers on the four mounting bolts, which support the Optical Head Assembly on the blower plate. The Optical Head alignment may be observed by placing your eye about 3cm (1 inch) from the alignment window on the rear cover.

You will notice that the eyepiece contains a cross hair and a series of concentric circles. Alignment is achieved by loosening one nut and tightening the opposing nut, pivoting the optical head around so that the cross hairs are centered on the bright green image of the Retroreflector and the eyepiece circles are concentric with the image. (Figure 9-2) The last few adjustments should be by tightening only so that the instrument is securely fastened to the port.

NOTE: A graphic depiction of the misalignment images for the user's individual monitor is permanently affixed to the Optical Head cover for easy reference.

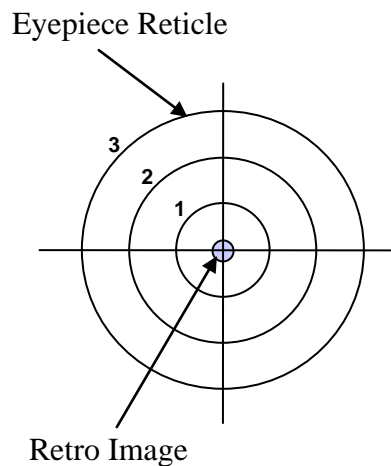


Figure 9-2

NOTE: If a multi-element retro is supplied the group should be centered on the reticle.

9.3.2 Retroreflector Assembly

Retroreflector Assembly alignment is achieved by use of the Integral Retro Alignment Site. The Retro Alignment Site provides a visual indication during alignment. The alignment sight protrudes from the rear of the Retro Cap and has a frosted glass screen. The frosted glass screen has a circular target etched into it and a portion of the beam from the Optical Head is projected onto the target.

- a. Preliminary adjustment of the Retro is accomplished by opening the Retro Cap and observing the green light projected from the Optical Head.
- b. Preliminary alignment is achieved by loosening one nut and tightening the opposing nut, pivoting the Retroreflector around until the bore of the Retro and purge nozzle is nominally centered on the projected beam. Close the retro cap.

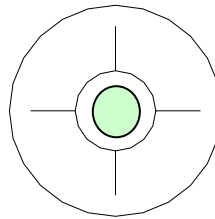


Figure 9-3

- c. Final adjustment is achieved by observing the GREEN light image on the frosted glass target. (Figure 9-3) Then readjust the 4 nuts on the mounting bolts until the projected beam is completely contained within the circular target of the alignment device. The last few adjustments should be by tightening only, so that the Retroreflector Assembly is securely fastened to the port.

NOTE: *The Retro Alignment image is best viewed by keeping the eye 8 – 12 inches (20 – 30cm) back from the target and looking for the GREEN spot superimposed on the target. The spot may be difficult to see under bright ambient light conditions. It may be necessary to shield the ambient light from the target during adjustment under these conditions.*

The Retro Alignment Site is useful for providing on-line feedback during analyzer operation of small changes in Retroreflector position once initial alignment has been performed. It is well suited for alignment indication during normal operation.

9.4 CLEANING THE OPTICAL SURFACES

Dirt that accumulates on the instrument optical surfaces will attenuate the optical energy and be detected as either increased dust compensation signal or increased opacity by the instrument. Under normal conditions, only the Exit Window of the Optical Head Assembly, the Retroreflector Surface, and the simulated zero/upscale Mechanism Windows need to be cleaned.

9.4.1 Cleaning Materials

The external optical windows and surfaces should be cleaned using a clean soft lint free cloth (Kimwipe® or equivalent) and quality commercial glass cleaning solution. Both are available from Teledyne Monitor Labs. An ammonia based window cleaner may be used so long as it does *not* contain any anti-fog additive. The anti-fog agents leave a residue on the glass surface that may react with stack gases and produce a perceptible haze on the windows. A second choice would be a mixture of 50% alcohol and 50% distilled water. Care should be taken not to use alcohol containing oily contaminants as this will leave a residue on the optical surfaces. Teledyne Monitor Labs recommends the use of a reagent grade isopropyl alcohol. Many optical surfaces are treated with an anti-reflective coating. **Strong solvents such as acetone should never be used for cleaning.**

9.4.2 Cleaning Procedure

Three surfaces must be cleaned before calibration. All of these areas must be cleaned so that the opacity monitor may properly display and compensate for any future accumulations of dust on the surfaces.

- ❑ The Optical Head Exit Window
- ❑ The Retro External Surface
- ❑ The Cal Mechanism Windows

9.4.2.1 **Optical Head Exit Window**

The Exit Window is accessible by releasing the latches on both sides of the Optical Head Assembly and opening the hinged section. **Carefully** clean the optical elements using the standard cloth and solution. Cotton cleaning swabs may be employed to clean hard to reach areas.

9.4.2.2 Cal Mechanism Sections

While the Optical Head hinged section is open, the simulated zero and upscale windows of the Calibration Assembly may be cleaned. The Cal Mechanism Arm Assembly can be removed by loosening the gear clamp and pulling it off the shaft. See Figure 9-4. **Care should be taken not to damage the guide pin.** Using the standard cloth and solution, clean both windows. Cotton cleaning swabs may be employed to clean hard to reach areas, so long as the lint-free cloth is used to remove any cotton fibers left by the swab. Return the Cal Mechanism Arm to the shaft making sure that the guide pin slides fully into the slot on the arm. Put the gear clamp back on and tighten.

9.4.2.3 Retro Assembly Surface

Access the Retro surface by releasing the latch and opening the hinged section of the Retroreflector Assembly. Clean this surface as mentioned previously, then close the hinged section and proceed to adjustment of the electronics for zero and 100% opacity as outlined in this manual.

9.5 OPTICAL HEAD ZERO AND ONE HUNDRED PERCENT OPACITY

NOTE: *Refer to the Site Specification Data Sheets before attempting any of the adjustments in this section. Information regarding the initial factory calibration of the monitor is contained therein and is especially useful as a baseline reference.*

The electronic adjustment must not be undertaken until the Optical Head and Retro Assemblies have been properly aligned and cleaned, as per Sections 9.3 and 9.4 of this manual. These adjustments are made using the Optical Head keypad. To familiarize yourself with the keypad operation read the User Interface portion of Section 3.0 of this manual.

9.5.1 Setting the LED Current Level

NOTE: *The LED current level should ONLY be adjusted while the ambient temperature of the Optical Head is between 65 and 80°F (18 - 26°C). Ambient temperature and instrument conditions will strongly influence LED current levels. Although typical factory LED currents are between 30.0 and 35.0 mA, currents of up to 40.0 mA are perfectly normal for your monitor and do not require readjustment. **LED currents beyond 40 mA should be investigated and clear path calibration during this process is highly recommended.***

1. Enter the password in the A2 location

1. While depressing the “DISP” key, increment the “←” key until an A appears in the left most green display character.

2. While depressing the “DISP” key, increment either the “↑” or “↓” key until a 2 appears in the next green display character.

A	2
---	---

n	E	E	d
---	---	---	---

The word nEEd will appear in the 4 digit red display.

3. Depress the “←” key. The 4 digit display will now contain all 0’s, with the LSD (Least Significant Digit) blinking.
4. Depress the “←” key again. The 4 digit display will still display all 0’s, but the 2nd LSD will now be blinking.
5. Depress the “↑” key until the 2nd LSD is a 6.
6. Repeat selecting and incrementing each character until the password (9860) is displayed.

A	2
---	---

9	8	6	0
---	---	---	---

7. Now depress the “SET” key. The 4 digit display will read 7200 and begin counting down. This indicates the number of seconds remaining to make adjustments before you must enter the password again.

A	2
---	---

7	2	0	0
---	---	---	---

2. Read the LED Current

1. Manipulate the keypad as above until location S2 is displayed. The LED light source current will be displayed in milliamps on the RED 4 digit display. Typical factory settings are between 30.0 and 35.0 mA, though higher values may be used under some conditions. (Consult the "Setting the Signal Gain" part of this section and the Site Specification Data Sheets.)

NOTE: *The LED current level should ONLY be adjusted while the ambient temperature of the Optical Head is between 65 and 80 °F (18 - 26 °C). Ambient temperature and instrument conditions will strongly influence LED current levels. Although typical factory LED currents are between 30.0 and 35.0 mA, currents of up to 40.0 mA are perfectly normal for your monitor and do not require readjustment. LED currents beyond 40 mA should be investigated and clear path calibration during this process is highly recommended.*

3. **Set the LED Current (Optional)**

NOTE: *If it is necessary to adjust the LED current and all of the conditions mentioned in the information above have been met, continue below. However, if the LED current is already within acceptable limits, proceed directly to Section 9.5.2 Setting the Signal Gain.*

To adjust the LED current the Reference Gain must be changed. To increase the current, decrease the Reference Gain. To decrease the current, increase the Reference Gain

1. Manipulate the keypad until the Reference Gain (location F9) is displayed.

F	9	0	0	1	5
---	---	---	---	---	---

2. Using the “←”, “↑”, and “↓” keys increase or decrease the Reference Gain setting.
3. Depress the “SET” key to enter the change. The display stops blinking when the change has been entered.
4. Once again display the LED current (location S2). Repeat Reference Gain changes until LED current is between 30.0 and 35.0 mA.
5. If the required Reference Gain is greater than 125, this may be an indication of potential LED problems. Contact Teledyne Monitor Labs Tech Support at (800) 846-6062 before proceeding.

NOTE: *Successful completion of this section indicates that the reference loop and the LED source are functioning properly. Proper reference loop control allows compensation for variations in the LED output.*

9.5.2 Setting the Signal Gain

NOTE: *The Signal Gain must be set to a nominal value before further calibration. Setting of this nominal gain is necessary only during the initial clear path calibration.*

1. To set Signal Gain, manipulate the keypad as above until location F8 is displayed
2. Using the “←”, “↑”, and “↓” keys set the Signal Gain to 25.
3. Depress the “SET” key to enter.

F	8
---	---

0	0	2	5
---	---	---	---

4. Manipulate the keypad to display the Signal Voltage at location S0. The Signal Voltage must be between 6.0 and 7.0 VDC.

NOTE: *If the voltage is not between 6.0 and 7.0 VDC, the Signal Gain will need adjustment. To adjust the Signal Voltage the Signal Gain must be changed. An increase in Signal Gain will increase the Signal Voltage, and a decrease in Signal Gain will decrease the Signal Voltage. The Signal Gain is at location F8. The following formula can be used to calculate the desired Signal Gain value.*

$$\text{New Gain} = (\text{Present Gain}) (6.5 / \text{Present Signal Voltage})$$

5. Modify the value of location F8 until the Signal Voltage (location S0) is greater than 6.0 and less than 7.0.

If the Signal Gain is less than 125, proceed to Section 9.5.3 Final Calibration SET Function Routines.

NOTE: *If the Signal Gain must be set above 125 to achieve the desired Signal Voltage, go to Step 6.*

6. Increase the LED current (location S2) by decreasing Reference Gain (location F9).
7. Then set Signal Gain (F8) again to establish the proper Signal Voltage (S0).

The maximum recommended LED current is 40 mA.

Once the proper LED Current, Signal Gain and Signal Voltage targets have been established, record the Reference and Signal Gains in Table 9-1 at the end of this section. Then continue with Section 9.5.3 Final Calibration SET Function Routines.

9.5.3 Final Calibration SET Function Routines

NOTE: *Performing the “SET” functions will configure the LightHawk® 560ES firmware to accurately output the ZERO, 100% and linear intermediate opacity values. Although these routines are simple, they must be followed carefully and be performed in the following order.*

- *BACKGROUND SET (100% opacity)*
- *NORMAL SET (ZERO opacity)*

- *Set Out of Service Marker to 1.000*
- *Read raw CAL ZERO value (adjust as necessary)*
- *Set Out of Service Marker back to 0.000*
- *Perform CAL ZERO SET*
- *Adjust Upscale Calibration Iris as necessary*

Begin Procedure

1. Create a 100% opacity condition by blocking the optical path of the instrument.
2. Perform a BACKGROUND SET by simultaneously pressing the “BACKGND” and “SET” keys on the keypad. The “SET” and “BACKGND” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period.

NOTE: *The YELLOW “SET” LED will light continuously during the actual 6 minute BACKGROUND SET process. The LED display will have a value during the set that should be ignored.*

3. Once the “SET” LED goes out, remove the blocking condition of the optical path creating a 0% opacity condition.

Perform a NORMAL SET by simultaneously pressing the “NORM” and “SET” keys on the keypad. The “SET” and “NORMAL” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period. The “SET” LED will then light continuously indicating a SET function is in progress. Once again the SET function will take about 6 minutes. Note: *The LED display will have a value during the set that should be ignored.*

NOTE: *When the NORMAL SET function is finished, it will be necessary to take the Optical Head Out of Service.*

4. Manipulate the keypad to display the Service Marker (location F6).

5. Change the Service Marker (location F6) to 1.000 for “Out of Service”.

NOTE: *When the “Out of Service” marker is on (1.000), the “Auto Zero Adjust” feature is disabled.*

6. Open the Optical Head by releasing the latches on both sides and swinging out.
7. Put the system into the Zero mode by depressing the “ZERO” key on the keypad. The Cal Mechanism will move to the Cal Zero position and the “IN CAL” LED will light. Allow the instrument to remain in the Zero mode for at least 2 minutes.
8. Manipulate the keypad to display the Instantaneous Opacity (location **U0**). The opacity must be $0\% \pm 1\%$ opacity. If it is not within these limits, the Cal Zero Iris of the Cal Mechanism must be adjusted as described in steps (a) through (h) below.

NOTE: *If the U0 reading is less than $\pm 1\%$ go to step 10.*

- a) Loosen the Allen head setscrew that locks the Zero Iris in place. See Figure 9-4.
- b) Manipulate the keypad to display the Instantaneous Opacity (location **U0**).

NOTE: *The Iris MUST be adjusted while observing the Instantaneous Opacity (location U0).*

- c) Slowly rotate the disc on the rear of the Cal Zero Iris to achieve as near as possible to 0% opacity ($\pm 1\%$ on U0). See Figure 9-4

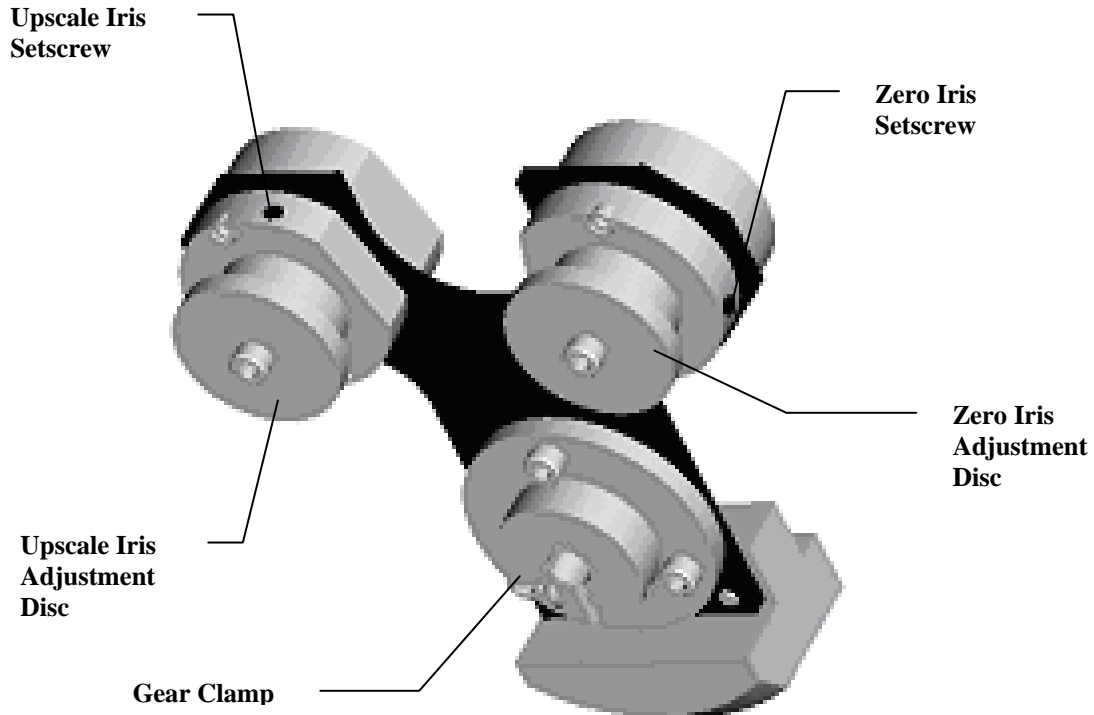


Figure 9-4

NOTE: *The Instantaneous Opacity display may have as much as $\pm 0.5\%$ variation over the period of a few seconds. Every attempt should be made to adjust the Iris carefully so that the normal variation is equally balanced around the 0% reading.*

- d) Carefully lock down the Iris setscrew. See Figure 9-4.
- e) Allow the monitor to operate in the Zero mode for an additional 2 minutes.
- f) Then manipulate the keypad to again display the Instantaneous Opacity (location **U0**).
- g) Confirm that the Instantaneous Opacity reading is less than $\pm 1\%$ opacity before continuing on with the calibration.
- h) Before proceeding, verify the Zero Iris opening is between 1/4 inch and 7/16 inch diameter. If the Zero Iris opening diameter is within limits, record the diameter in Table 9-1 at the end of this section.

Failure to obtain this specification will require the replacement of the Neutral Density window protecting the Zero Iris. Go to Section 9.8 for the Cal Mechanism Neutral Density Window Replacement procedure.

NOTE: *If the 1-Minute Opacity reading of the Calibration Zero value is NOT within the ± 1 % opacity limit, return to step a) above and readjust the Calibration Zero Iris.*

9. Go to the Normal Mode by depressing the “NORM” key on the keypad.
10. Close the Optical Head, making sure the latches on both sides are closed.
11. Change the Service Marker (location F6) to a 0.000 (“In Service”).

NOTE: *The ZERO SET must be initiated from the NORMAL mode.*

12. Perform a CAL ZERO SET by simultaneously pressing the “ZERO” and “SET” keys on the keypad. The “SET” and “ZERO” keys must be pressed continuously for about 10 seconds. The YELLOW “SET” LED will flash at a two second rate during this acknowledgement period. The “SET” LED will then light continuously indicating a “SET” function is in progress. Once again the “SET” LED will light continuously for 6 minutes while the CAL ZERO SET is completed. Note: *The LED display will have a value during the set that should be ignored*

NOTE: *Always return the Cal Mechanism to the NORMAL position before opening or closing the housing. If this is not done, the Cal Mechanism may strike the front housing and cause damage to the mechanism.*

13. Open the Optical Head by releasing the latches on both sides and swinging out the Cal Mechanism. Go to the UPSCALE mode by pressing the “UPSCALE” key on the keypad. Manipulate the keypad to display the Instantaneous Opacity (location U0). Allow the instrument to remain in the Upscale mode for several minutes. The Instantaneous Opacity should read the target value for your installation. This value can be found in location C1.
14. If U0 does not read the target value, adjust the Upscale Iris on the Cal Mechanism as described in steps (i) through (v) below.

NOTE: *If the U0 reading is equal to the target value $\pm 0.5\%$ go to step 16 below.*

- i) Loosen the Allen head setscrew that locks the Upscale Iris in place. See Figure 9-4.

- ii) Manipulate the keypad to display the Instantaneous Opacity (location **U0**).

NOTE: *The Iris MUST be adjusted while observing the Instantaneous Opacity (location U0).*

- iii) Slowly rotate the disc on the rear of the Cal Upscale Iris to achieve as near as possible to target value (location C1). See Figure 9-4.
- iv) When the proper value is obtained, carefully lock down the Upscale Iris setscrew. See Figure 9-4.
- v) Before proceeding, verify the Upscale Iris opening is between 1/4 inch and 7/16 inch diameter. If the Upscale Iris opening diameter is within limits, record the diameter in Table 9-1 at the end of this section. *Failure to obtain this specification will require the replacement of the Neutral Density Window protecting the Upscale Iris. Go to Section 9.8 for the Cal Mechanism Neutral Density Window Replacement procedure.*

15. Go to the NORMAL mode by depressing the "NORM" key on the keypad.

16. Close the Optical Head, making sure the latches on both sides are closed.

Run through a complete Cal Cycle by simultaneously depressing the "ZERO" and "UPSCALE" keys on the keypad. When the Cal Cycle is complete, check that the last Zero Calibration (location U6) is the same value as Dust Compensation (location U8). If they are not, recheck all the SET functions.

9.6 ADJUSTING CALIBRATION KIT

CAUTION: *This adjustment must not be undertaken unless complete clear path recalibration is being performed.*

After all of the adjustments have been performed with the Retro Assembly, the Calibration Kit may be adjusted.

1. Open the Optical Head Assembly and attach the Calibration Kit Fixture to the front of the housing.

NOTE: *Before installing the Calibration Kit, be sure that the window that protects the Iris and reflective material of the Cal Kit is clean and free of lint so that the signal returned from the fixture will not be reduced.*

2. Confirm that the system is in the NORMAL mode by pressing the "NORM" key on the keypad.
3. Read the instantaneous opacity (location U0). It must read 0.0% opacity $\pm 0.2\%$ opacity. If not, the Calibration Kit Fixture Iris must be adjusted.
4. Loosen the cap screws and remove the cover that protects the Iris Adjustment Mechanism. There is a reduction gear drive mechanism under the cover used to provide precise adjustment of the Iris. See Figure 9-5.

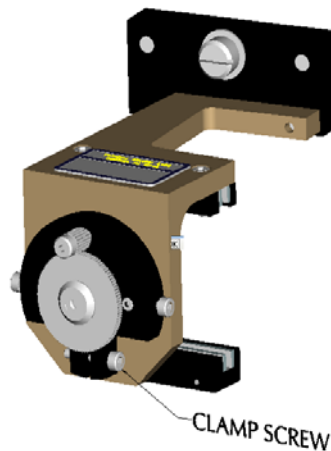


Figure 9-5

5. To unlock the Iris, loosen the small clamp screw located at the six o'clock position on the round backing plate just behind the larger gear. This will allow the gear to rotate and open and close the Iris.

6. In order to provide a fine adjustment device, temporarily place the gear clamp (an integral part of the cover previously removed) over the smaller gear and tighten the clamp. This will allow the cover to be rotated in order to move the Iris in small increments for the final adjustment. See Figure 9-6 showing the cover and gear clamp temporarily installed.

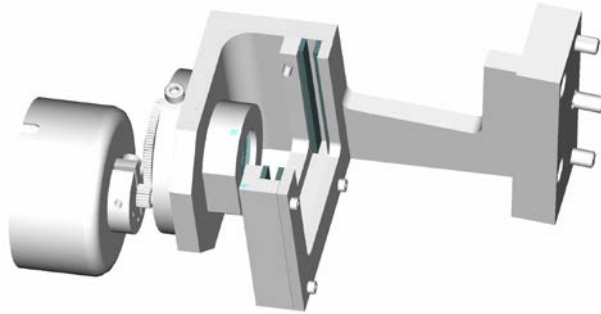


Figure 9-6

7. Rotate the cover until the analyzer U0 display value is 0.0% ($\pm 0.2\%$) opacity. If the cover is hard to turn, use a flat blade (common) screwdriver to spread the slot in the clamp.

NOTE: This adjustment must be made carefully in order for the Cal Kit to be used for subsequent testing. Be patient! There will be some natural variability in the instantaneous (U0) reading. *When the proper value is obtained, lock down the Iris with the clamp screw. While making the final adjustments it will be helpful to monitor location U1 (1-Minute Average Opacity) to be certain that the average reading stays within the $\pm 0.2\%$ tolerance.* Carefully tighten the clamp screw in the backing plate and recheck both the U0 and U1 display values to confirm the proper zero reading is maintained.

8. Before proceeding, verify the Cal Kit Iris opening is between 3/16 inch and 7/16 inch diameter. If the Cal Kit Iris opening diameter is within limits, record the diameter in Table 9-1 at the end of this section. *Failure to obtain this specification will require the replacement of the Neutral Density Window protecting the Cal Kit Iris. See Section 9.9 for the Cal Kit Neutral Density Window Replacement procedure.*
9. Carefully loosen the gear clamp and remove the cover. Reinstall the cover and tighten the cover retaining screws.

NOTE: *Some small changes in the Iris position may occur when the clamp screw is tightened or when the gear clamp is removed. Be certain that the zero opacity reading is proper after the Iris position is locked and the cover has been reinstalled.*

9.7 VERIFY THE RESPONSE OF THE OPTICAL HEAD

The neutral density attenuators in the Calibration Kit pouch have been marked to indicate their opacity at the measurement point. If a PLCF other than 1.000 has been entered in location F7, calculate the Exit value of the attenuators as follows.

$$\text{Exit value} = 1 - (1 - \text{Marked value})^{\text{PLCF}}$$

EXAMPLE: Marked value 20% opacity

$$\text{PLCF} = 0.900$$

$$\text{Exit value} = 1 - (1 - 0.20)^{0.9}$$

$$\text{Exit value} = 1 - (0.80)^{0.9}$$

$$\text{Exit value} = 1 - 0.818$$

$$\text{Exit value} = 0.182$$

$$\text{Exit value} = 18.2 \% \text{ opacity}$$

Insert each attenuator into the Calibration Kit. The values read at U0 (Instantaneous), U1 (1 minute average), and U2 (selectable average) must be within $\pm 2\%$ opacity of the attenuator's marked values.

9.8 CAL MECHANISM NEUTRAL DENSITY WINDOW REPLACEMENT

NOTE: *This procedure should only be undertaken if either the Cal Zero Iris or Cal Upscale Iris opening diameters fall outside of the specifications listed in Section 9.5.3 Step 9(h) or Section 9.5.3 Step 16(v) respectively.*

The Site Specification Data Sheets in Appendix A of this manual list the factory settings for the Iris diameters and Optical Density values for the ND windows “as shipped” in the Cal Mechanism. See Appendix C for ND window part numbers.

The Cal Mechanism Iris opening diameters must be between 1/4 inch and 7/16 inch. If during Iris adjustments these limits cannot be maintained, the ND window must be changed.

If the Iris opening is too small, the ND window must be replaced with one of a higher Optical Density value. If the Iris opening is too large, the ND window must be replaced with one of a lower optical density value.

1. Remove the Cal Mechanism Arm Assembly by loosening the gear clamp and pulling it off the shaft.
2. Remove the 2 Allen head screws holding the ND cover on the appropriate Iris. See Figure 9-7.
3. Remove the ND cover, front gasket, ND window and rear gasket. See Figure 9-7. (See note below for .2 ND windows)
4. Re-assemble the rear gasket, new ND window, front gasket and ND cover as shown in Figure 9-7. **Note: The ND window must be installed with the coating side IN toward the rear gasket.**
5. Return the Cal Mechanism Arm to the shaft making sure that the guide pin slides into the slot on the arm. Put the gear clamp back on and tighten.
6. Record the Optical Density value of the new ND window in the appropriate row of Table 9-1 at the end of this section.
7. The Iris can now be readjusted so the opening diameter is within specification. If the Zero Iris ND window was replaced, return to Section 9.5.3, Step 5. If the Upscale Iris ND window was replaced, return to Section 9.5.3, Step 16.

Note: For .2 ND filter windows a metal shim, .016 thick is needed to make up the thickness difference for this filter. This shim is to be placed in the ND window cover first, then the rest is assembled as shown. If a .2ND filter is already installed, this shim is to be removed and should not be used with any of the other windows.

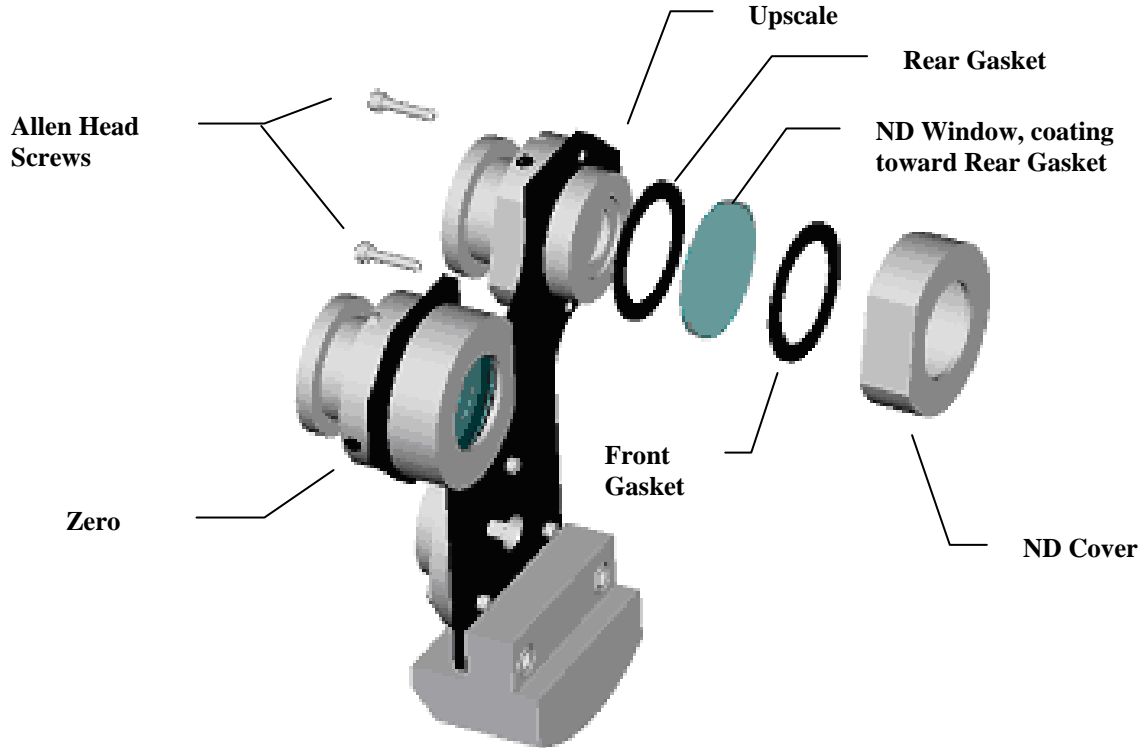


Figure 9-7

9.9 CAL KIT NEUTRAL DENSITY WINDOW REPLACEMENT

NOTE: This procedure should *only* be undertaken if the Cal Kit Iris opening diameter falls outside of the specifications listed in Section 9.6, Step 8.

The Site Specification Data Sheets in Appendix A of this manual list the factory settings for the Iris diameter and Optical Density value for the ND window “as shipped” in the Cal Kit. See Appendix C for ND window part numbers.

The Cal Kit Iris opening diameter must be between 3/16 inch and 7/16 inch. If during Iris adjustments these limits cannot be maintained, the ND window must be changed.

If the Cal Kit Iris opening is too small, the ND window must be replaced with one of a higher Optical Density value. If the Iris opening is too large, the ND Window must be replaced with one of a lower Optical Density value.

1. Loosen the cap screws and remove the cover that protects the Iris Adjustment Mechanism. See Figure 9-8.

2. Remove the gear screw, collar and gear. See Figure 9-8.
3. Remove the 2 Allen head screws holding the ND Cover. See Figure 9-8.
4. Remove the ND cover, front gasket, ND window and rear gasket. See Figure 9-8. (See note below for .2ND windows)
5. Re-assemble the rear gasket, new ND window, front gasket and ND cover as shown in Figure 9-8. **Note: The ND window must be installed with the coating side IN toward the rear gasket.**
6. Re-install the gear, collar and gear screw. See Figure 9-8.
7. Record the Optical Density value of the new ND window in Table 9-1 at the end of this section.
8. The Cal Kit Iris can now be readjusted so the opening diameter is within specification. Return to Section 9.6.

Note: For .2 ND filter windows a metal shim, .016 thick is needed to make up the thickness difference for this filter. This shim is to be placed in the ND window cover first, then the rest is assembled as shown. If a .2ND filter is already installed, this shim is to be removed and should not be used with any of the other windows.

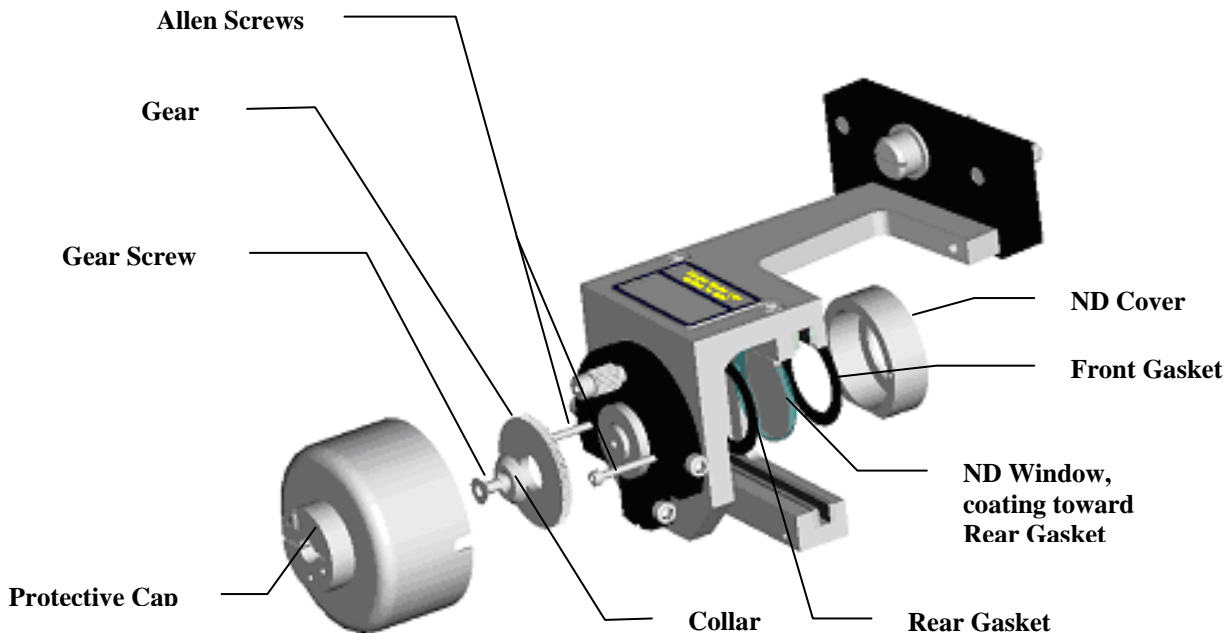


Figure 9-8

9.10 OFF-STACK CALIBRATION HISTORY

Use Table 9-1 below to record the adjustments made during the Off-Stack Calibration.

Date					
Flange to Flange¹					
Hinge to Hinge²					
Reference Gain³					
Signal Gain⁴					
Zero Iris Diameter					
Zero ND Window					
Upscale Iris Diameter					
Upscale ND Window					
Upscale Target Value⁵					
Cal Kit Iris Diameter					
Cal Kit ND Window					

¹The precise distance between the opposing faces of the mounting flanges for the monitor

²The precise distance between the Optical Exit Window and the Retroreflector Surface Window

³Parameter location F9

⁴Parameter location F8

⁵Parameter location C1

Table 9-1

(This page intentionally left blank.)

10.0 INSTALLATION

The installation overview of the *LightHawk*[®] 560ES system is shown in the Installation Drawing. It is important that the optical center line of the Optical Head and Retro be maintained so that they are capable of being pointed directly at each other.

10.1 FLANGE MOUNTING

Before the flanges can be mounted, the stack or duct must be cut so that a clear path from one side to the other can be seen. These flanges must be put up so that the mounting holes fall on vertical and horizontal lines. A distance between the flange and the stack or duct must be provided so that the mounting hardware can be accessed. This dimension must be at least 4 5/8 inches (117.5mm). The flange must be welded to a 2-inch schedule 40 (American Standard) steel pipe. The pipe in turn must be attached to the stack or duct. **The pipe on one side must be in a straight line with the pipe on the other.** (THE LIGHT BEAM **MUST NOT TOUCH THE PIPE** BETWEEN THE OPTICAL HEAD ASSEMBLY AND GAS STREAM, NOR CAN ANY PART OF THE REFLECTIVE PORTION OF THE RETROREFLECTOR ASSEMBLY BE OBSCURED.)

10.1.1 Mounting Pipe Considerations

A typical installation on a stack simply requires a short pipe to be welded or cemented to the stack. The pipe should not protrude into the stack gas stream.

In cases where there is an outer shell and an inner stack liner which are too close together to make mounting between the two impossible, or desired, a long pipe will be required. The longer the pipe, the more it will have to be stepped up to ensure that no part of the light beam is obscured. Reference the Opacity Monitor *LightHawk*[®] 560ES Flange Mtg. Method drawing.

CAUTION: The accuracy of the mounting tube alignment becomes an issue when the user's installation requires the use of long mounting tubes. See Figure 10-1. The distance "L" is the length of the mounting tube required. "D" is the inside diameter of the mounting tube and "Phi" (ϕ) is the maximum allowable misalignment angle in degrees. Determination of the angle ϕ may be made by the following formula:

$$\phi = \text{ARC SIN} \left[\frac{\{(D/2) - .5\}}{(L+1'')} \right]$$

For a typical installation where Teledyne Monitor Labs recommends a 2" diameter tube 5.5" long, the maximum misalignment calculates to 4.41°.

Example:

$$\phi = \text{ARC SIN} \left[\frac{(2/2) - .5}{(5.5+1'')} \right]$$

$$\phi = \text{ARC SIN} .5/6.5$$

$$\phi = 4.41^\circ$$

For a mounting to be 2 feet or 24" long, the maximum angle would fall to 1.15°.

To avoid very small misalignment angles the mounting tube diameter should be increased when long mounting tube lengths (L) are required.

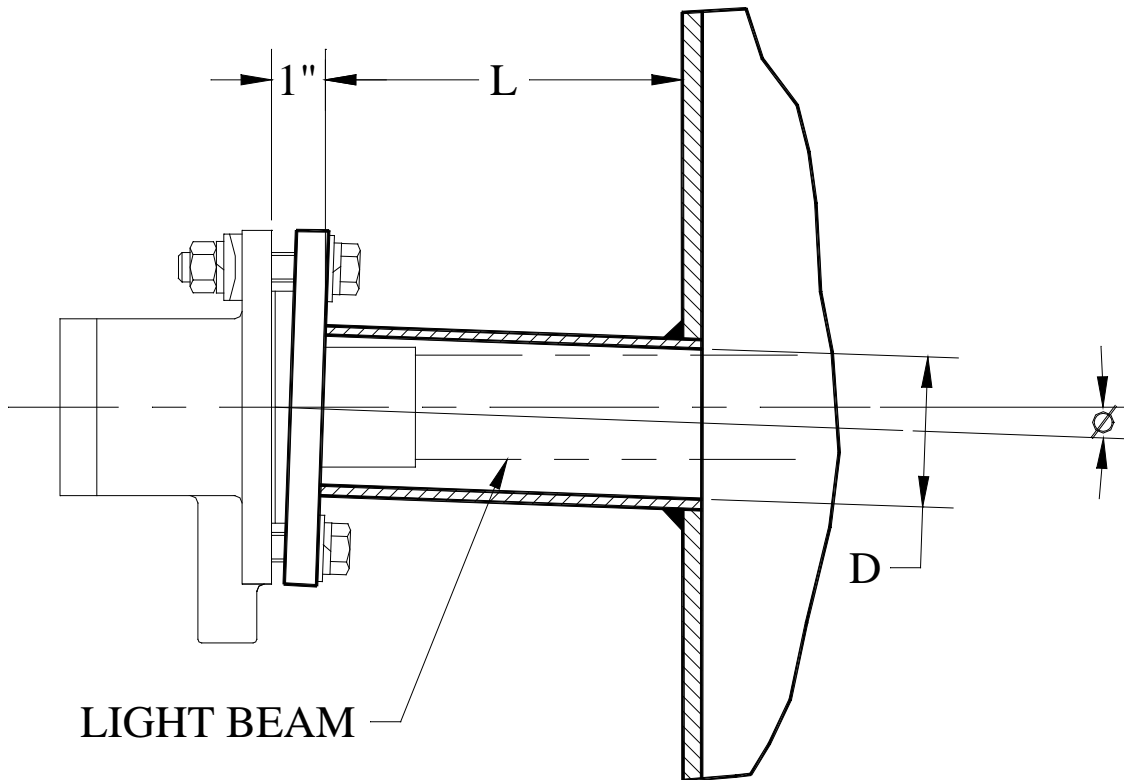


Figure 10-1

560ES Opacity Port Alignment

Teledyne Monitor Labs has a mounting plate alignment scope, which may be used to aid the user in determining the optical centerline between the two opposing ports.

CAUTION: *The pipes must not be rigidly connected to the inner and outer shell stacks since they may move differently. Ensure that the pipes will not be bent or broken as the two stacks move. (Be sure to check size at maximum and minimum stack temperature.)*

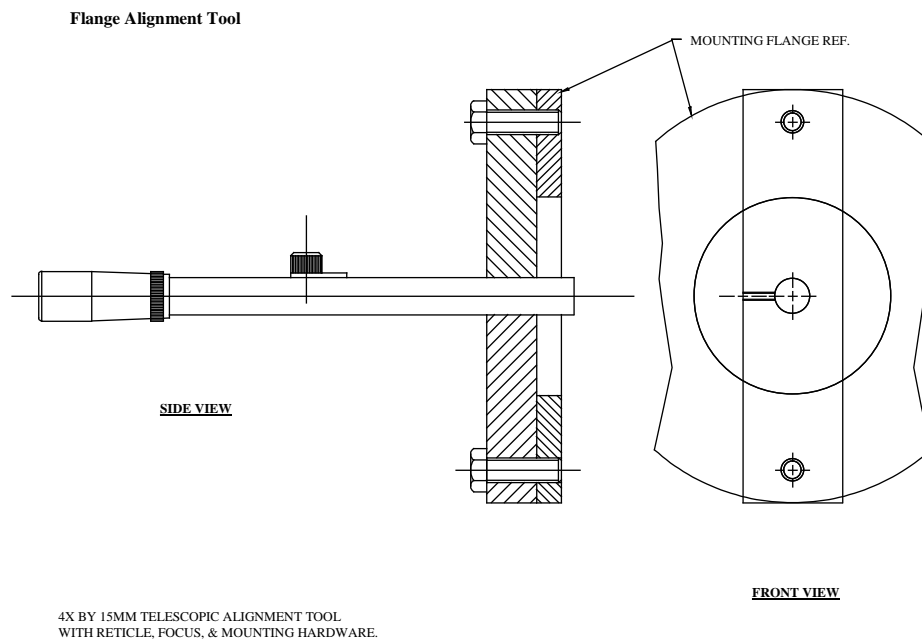


Figure 10-2

10.2 DISTANCE DETERMINATION

Once the flanges have been mounted properly, the distances required for calibration can be determined. There are three distances needed for calibration. Two of these are the inside dimension of the stack or duct in which the gas stream is flowing, both at the monitor location and at the exit. The other distance is known as the “flange to flange” distance. This distance is the distance from the

outside face of the mounting flange that is going to support the Optical Head to the outside face of the flange, which is going to support the Retroreflector. All of these distances are important in determining the calibration.

10.3 POWER REQUIREMENTS

Power requirements for the standard *Lighthawk*® 560ES system are determined primarily by the Purge System. The system power requirements are listed in Section 1.2 Specifications. Please consult the Site Specification Data Sheets for your system configuration and power mains voltage and install your system.

10.4 PURGE AIR SYSTEM

CAUTION: *Care must be taken to be certain that the purge air to both the Optical Head Assembly and the Retroreflector Assembly is in operation and connected **BEFORE** any of the optical components are mounted on the flanges. Failure to provide purge air to the system components could result in damage to the system that will not be covered under the Teledyne Monitor Labs warranty.*

Power to the Purge System should be provided via a circuit that is always activated so long as the stack is in operation. This will prevent the inadvertent deactivation of the circuit causing potential damage to the optical components.

10.5 DATA CABLE

The data cable between the Integral Junction Box and the Enhanced Remote Display should consist of a shielded twisted pair composed of 16 AWG (1.0mm²) wires and suitable jacket material. See the Wiring Diagram-Model 560ES Opacity drawing and Section 1.2 Specifications for details about maximum cable length and appropriate cable.

NOTE: *The cable shield **MUST** be terminated to earth ground using a Teledyne Monitor Labs Shield Termination Kit, Part No. 0650-0400-01, as per 560ES System Wiring Diagram.*

10.6 RETRO PURGE FAIL CABLE

The terminations for the purge cable are made at the time of installation. This cable must be terminated at both the Retro Purge Switch Junction Box and the Optical Head Integral Junction Box. Materials for the termination of these cables are contained in the Teledyne Monitor Labs hardware kit.

10.7 MOUNTING THE OPTICAL HEAD AND RETRO ASSEMBLIES

As mentioned previously, the purge air must be in operation and connected before mounting of the optical components. The mounting configuration of the Optical Head and Retro Assemblies is described in the Teledyne Monitor Labs drawings in Appendix D.

Optical alignment of the system is accomplished as described in Section 7.0 of this manual. Evaluation of the monitor output and calibration is covered in Section 8.0 of this manual.

10.8 ENHANCED REMOTE DISPLAY ASSEMBLY

The Enhanced Remote Display Assembly may be 19" (483mm) rack mounted, panel mounted, or located inside an enclosure. See Section 1.2 Specifications for ambient temperature conditions of the *Lighthawk*[®] 560ES.

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11.0 TROUBLESHOOTING

The Primary Status Code (U3) and the Extended Status Code (U4) will define almost any system problem.

Each of the digits in the status codes represents an octal number ranging from 0 to 7. A value of 0 indicates no problems for that particular digit. Three unique malfunctions are defined for each digit: 1, 2 or 4 as outlined below. Values of 3, 5, 6 and 7 represent a numerical summation for the defined malfunctions. For example: a value of 5 is defined as malfunction 1 and malfunction 4 simultaneously. If a fault is indicated or you suspect a problem, go to U3 and U4 and record the values displayed. Decode the malfunctions by using Section 11.1 and 11.2 below.

11.1 PRIMARY STATUS CODE U3

XXX1 Purge Fail Analyzer Side: Check the blower operation, blower plumbing and Optical Head side pressure switch.

XXX2 Purge Fail Retro Side: Check the blower operation, blower plumbing and Retro side pressure switch.

XXX4 Out of Service: The *LightHawk*[®] 560ES has been logged out of service. Check the value of F6. For normal operation F6 must be set to 0.

XX1X ADC Fault: Beyond the scope of this manual. Call Teledyne Monitor Labs Tech Support at (800) 846-6062.

XX2X Reference Fault: Check the Reference voltage value at location S1. Reference Voltage must be between +5VDC to +8VDC.

XX4X NORMAL Position Not Achieved: Verify the operation of the Calibration Arm on the Optical Head.

X1XX ZERO Position Not Achieved: Verify the operation of the Calibration Arm on the Optical Head.

X2XX UPSCALE Position Not Achieved: Verify the operation of the Calibration Arm on the Optical Head.

X4XX CLEAR STACK SET in Progress: Normal indication when performing a CLEAR STACK SET.

1XXX ZERO SET in Progress: Normal indication when performing a ZERO SET.

2XXX BACKGROUND SET in Progress: Normal indication when performing a BACKGROUND SET.

4XXX CLEAR STACK SET Voltage Out of Range: Check the Clear Stack Set Voltage value at location S3. The Clear Stack Set Voltage must be between +5VDC to +8VDC.

11.2 EXTENDED STATUS CODE U4

XXX1 ZERO SET Voltage Out of Range: Check the value of the ZERO SET voltage (S4) and the CLEAR STACK SET voltage (S3). S4 must be equal to S3 $\pm 10\%$.

XXX2 ZERO Calibration Bad: Check the value of the Last ZERO Calibration (U6), Calibration ZERO Set Point (C0) and the Calibration Tolerance (C3). U6 must be $\pm C3$ of C0.

XXX4 UPSCALE Calibration Bad: Check the value of the Last UPSCALE Calibration (U7), Calibration UPSCALE Set Point (C1) and the Calibration Tolerance (C3). U7 must be $\pm C3$ of C1.

XX1X Excessive Dust Compensation: Check the value of the Dust Compensation (U8) and the Dust Compensation Tolerance (C2). The absolute value of U8 must be less than C2.

XX2X Not Used

XX4X Not Used

X1XX Not Used

X2XX Not Used

X4XX Not Used

1XXX Not Used

2XXX Not Used

4XXX Not Used

11.3 ASSISTANCE

If you are unable to determine the problem, call Teledyne Monitor Labs Tech Support at (800) 846-6062. An experienced factory trained technician will handle your call.

APPENDIX A
SITE SPECIFICATION DATA SHEETS

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SITE SPECIFICATION DATA
TML Lighthawk® 560ES Opacity Monitoring System

COMPANY: _____

TML SHOP ORDER NO: _____ CAL DATE: _____

UNIT SERIAL #: _____

CAL. TECHNICIAN: _____

I. OPTICAL HEAD _____ FEET Hinge to Hinge

FLANGE TO FLANGE CALIBRATION DISTANCE: _____ FEET _____ meters

MONITOR PATH LENGTH: _____ FEET _____ meters

EXIT PATH LENGTH: _____ FEET _____ meters

PLCF: _____ 104 / F(7)

A. SIX POINT I/O:

YES	_____
NO	_____

OUTPUT UNITS _____ F(0) Opacity = 1, Optical Density = 2, Dust Mass = 3

OUTPUT FULL SCALE _____ F(E)

CAL ZERO/DUST COMP SCALING _____ F(F) 0 = NORMAL mode scaling; 1 = EXPANDED scaling

HARDWARE CURRENT RANGE

OUTPUT #1	JU1	_____	0 or 1
	JU2	_____	0 or 1
OUTPUT #2	JU3	_____	0 or 1
	JU4	_____	0 or 1

SOFTWARE RANGE FOR CURRENT OUTPUT

JU9	_____	4 or 0	4 = 4-20ma, 0 = 0-20ma
-----	-------	--------	------------------------

RELAY JUMPERS

K1: JU12	_____	A through H
K1: JU14	_____	A = NO = Normally Open or B = NC = Normally Closed
K2: JU13	_____	A through H
K2: JU15	_____	A = NO = Normally Open or B = NC = Normally Closed

ISOLATOR INPUT JUMPERS

ISO1: JU7	_____	A, B or C
ISO1: JU5	_____	DRY or +5V
ISO2: JU8	_____	A, B or C
ISO2: JU6	_____	DRY or +5V

B. CAL MECHANISM

ZERO CAL VALUE _____ % Opacity 105 / C(0)
 _____ Optical Density

UPSCALE CAL VALUE _____ % Opacity 106 / C(1)
 _____ Optical Density

N.D. WINDOWS _____ Optical Density

ZERO	_____
UPSCALE	_____

IRIS OPENING DIAMETER

ZERO	_____	decimal inches, approximate, enter 0.38" as 0.38
UPSCALE	_____	

LIGHTHAWK® 560ES COMPLIANCE OPACITY MONITOR

C. AUTO CAL CYCLE

CYCLE FREQUENCY			
CAL TIME HOUR	<input type="text"/>	HR	76 / C(4)
CAL TIME MIN.	<input type="text"/>	MIN.	77 / C(5)
CAL INTERVAL HOUR	<input type="text"/>	HR	78 / C(6)
CYCLE DURATIONS			
UPSCALE	<input type="text"/>	SEC	79 / C(8)
ZERO	<input type="text"/>	SEC	80 / C(7)
PLCF	<input type="text"/>	SEC	81 / C(9)
DUST COMP.	<input type="text"/>	SEC	82 / C(A)

D. POWER SUPPLY

+15 VDC:	<input type="text"/>	28 / S(8)
-15 VDC:	<input type="text"/>	29 / S(9)
+5 VDC analog:	<input type="text"/>	30 / S(A)
-5 VDC analog:	<input type="text"/>	31 / S(B)
+5 VDC digital:	<input type="text"/>	32 / S(C)

E. "AS SHIPPED" CONFIG.

ZERO CAL OPACITY	<input type="text"/>	17 / U(6)	DUST COMP ALARM	<input type="text"/>	39 / C(2)
UPSCALE CAL OPACITY	<input type="text"/>	18 / U(7)	CAL DELTA	<input type="text"/>	107 / C(3)
SIGNAL VOLTS	<input type="text"/>	20 / S(0)	AVG. INTERVAL	<input type="text"/>	108 / F(B)
REF. VOLTS	<input type="text"/>	21 / S(1)	STACK 332 VERSION:	<input type="text"/>	116 / U(A)
LED CURRENT	<input type="text"/>	22 / S(2)	STACK NEURON VER:	<input type="text"/>	117 / U(B)
XSTACK SET VOLTS	<input type="text"/>	23 / S(3)	SIGNAL GAIN:	<input type="text"/>	121 / F(8)
CAL ZERO SET VOLTS	<input type="text"/>	24 / S(4)	REFERENCE GAIN:	<input type="text"/>	122 / F(9)
BCK GRD SET VOLTS	<input type="text"/>	25 / S(5)	COMMON GAIN:	<input type="text"/>	123 / F(A)

II. PURGE SYSTEM

SINGLE BLOWER	<input type="text"/>	<input type="text"/>	CFM
DUAL BLOWER	<input type="text"/>		
INSTRUMENT AIR	<input type="text"/>		
AIR SHUTTERS:	YES <input type="text"/>	NO <input type="text"/>	
HEATERS:	YES <input type="text"/>	NO <input type="text"/>	

III. RETROREFLECTOR

PART NUMBER	<input type="text"/>
RETRO TYPE	<input type="text"/> mm

IV. CALIBRATION KIT

A. N.D. WINDOW	Optical Density	<input type="text"/>
----------------	-----------------	----------------------

B. IRIS OPENING DIAMETER	<input type="text"/> decimal inches, approximate, enter 0.38" as 0.38
--------------------------	---

C. ATTENUATOR VALUES:				
	O.D	OPACITY	CAL DATE	SERIAL NO.
1)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

D. NIST CALIBRATION:	<input type="text"/>
	YES <input type="text"/>
	NO <input type="text"/>

V. ENHANCED REMOTE PANEL

--

E. R. P. PROVIDED:

YES	
NO	

A. MULTI I/O PROVIDED:

YES	
NO	

B. ANALOG OUTPUT CHANNEL SELECTIONS

CHANNEL 1	DEFINITION		52
	WITH / W.O. CAL		53
	ZERO VALUE		54
	FULL SCALE		55
CHANNEL 2	DEFINITION		56
	WITH / W.O. CAL		57
	ZERO VALUE		58
	FULL SCALE		59
CHANNEL 3	DEFINITION		60
	WITH / W.O. CAL		61
	ZERO VALUE		62
	FULL SCALE		63
CHANNEL 4	DEFINITION		64
	WITH / W.O. CAL		65
	ZERO VALUE		66
	FULL SCALE		67

C. DIGITAL OUTPUT (Relay) SELECTIONS

DIGITAL OUTPUT 1		68
DIGITAL OUTPUT 2		69
DIGITAL OUTPUT 3		70
DIGITAL OUTPUT 4		71
DIGITAL OUTPUT 5		72
DIGITAL OUTPUT 6		73
DIGITAL OUTPUT 7		74
DIGITAL OUTPUT 8		75

D. "AS SHIPPED" CONFIG.

MIO VERSION		118
PANEL332 VERSION		119
PANEL NEURON VERSION		120
REF. TEMP		124
REF. PRESSURE		125

Ethernet Module

Static IP information

Static IP Address	
SubNet Mask	
Default Gateway	

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APPENDIX B
MAINTENANCE CHECK SHEETS

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TELEDYNE MONITOR LABS
ON-STACK CALIBRATION CHECKLIST for *LightHawk*® 560ES OPACITY SYSTEM

PLANT NAME _____ LOCATION _____

SERVICE PERSON _____ SERIAL # _____

DATE _____ TIME _____

(1)

A. REASON FOR CALIBRATION QUARTERLY <input type="radio"/> EMERGENCY <input type="radio"/> INSTALL <input type="radio"/> OTHER <input type="radio"/> EXPLAIN: _____

(2) **Enhanced Remote Display Checks**

A. Current Opacity Readings (MAIN DISPLAY)

	INST OPACITY	AVG OPACITY
AS FOUND	_____ %	_____ %
AS LEFT	_____ %	_____ %

B. FAULT INDICATOR'S (LED's)

	FAULTS	ALARM
ON	<input type="radio"/>	<input type="radio"/>
OFF	<input type="radio"/>	<input type="radio"/>

C. STATUS WORD _____ (MAIN DISPLAY SCREEN)

EXPLAIN _____

D. CURRENT CALIBRATION VALUES (From MAIN DISPLAY page 2)

	BEFORE	AFTER	
1. CURRENT CAL ZERO	_____	_____	OPACITY
2. UPSCALE CAL	_____	_____	OPACITY
3. DUST COMP	_____	_____	OPACITY

E. CALIBRATION SET POINTS (from the VIEW SYSTEM PROPERTIES screen)

	BEFORE	AFTER	
1. CAL ZERO SET POINT	_____	_____	% OPACITY
2. UPSCALE SET POINT	_____	_____	% OPACITY
3. CAL FAIL LEVEL	_____	_____	% OPACITY
4 P. L. C. F.	_____	_____	

F. CHECK THE PERMANENT DATA RECORD FOR THE LAST CAL RESULTS

ZERO CAL = _____ % OPACITY DUST COMP= _____ % OPACITY
 UPSCALE CAL = _____ % OPACITY P. L. C. F. = _____

G. ANALOG OUTPUTS ENHANCED REMOTE DISPLAY

CHECKED WITH

MULTIMETER ○	OUTPUT DEVICE (DAS) ○
-------------------	----------------------------

AVERAGING INTERVAL MIN _____ MIN ("VIEW SYSTEM PROPERTIES" screen)

	*SELECTION	*WITH CAL? (Y/N/EXP)	ADJUSTED? (Y/N)
CHANNEL 1			
CHANNEL 2			
CHANNEL 3			
CHANNEL 4			

* Viewed on "ANALOG OUTPUT 1,2" and "ANALOG OUTPUT 3,4" screens

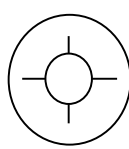
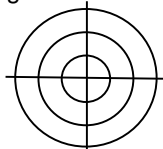
(3) On-Stack Checks

A. LED CURRENT _____ (S2) OK ≤ 40mA

B. INSPECT

	PURGE AIR FILTERS	FLEX HOSES	MOUNTING TUBES	PURGE SHUTTERS	DESIC- CATOR
OK	○	○	○	○	○
CLEANED	○	○	○	○	○
REPLACED	○	○	○	○	○

C. Optical Head Retro
 Alignment as found Alignment as found



	OPTICAL ALIGNMENT	
	HEAD	RETRO
OK	○	○
ADJUSTED	○	○

COMMENTS: _____

D. CLEAN: RETRO EXIT WINDOW CAL MECH CAL KIT

E. **INSTALL** CAL KIT FIXTURE **OK**

F. PERFORM BACKGROUND SET **OK**

G. PERFORM NORMAL SET **OK**

H. PERFORM ZERO SET **OK**

I. CHECK CAL ZERO VALUE _____ U4 Extended Status Code

OK

J. COMMAND CAL CYCLE **OK**

CAL CYCLE RESULTS ZERO _____ UPSCALE _____

OK

K. CAL KIT READINGS **PLCF =** _____ (F7)

	ZERO	LOW	MID	HIGH	FS
ATTENUATOR VALUE					
CORRECTED VALUE					
<i>LightHawk</i> ® READING					
OUTPUT VALUE (DAS)					
DIFFERENCE (+/- 2.0 %)					

L. **REMOVE** CAL KIT FIXTURE **OK**

(4) DATA COLLECTION

A. RE-CHECK OUTPUT DEVICE **OK**
VALUES ABOVE

B. FILL IN OPACITY READINGS SECTION 2A "AS LEFT" **OK**

NOTES OR RECOMMENDATIONS :

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APPENDIX C
SPARE PARTS

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RECOMMENDED SPARE PARTS

Recommended spare parts for the *LightHawk*[®] 560ES are organized into four categories. User can stock the appropriate parts for their level of maintenance. The four lists do not overlap. For the highest level of maintenance the first three lists should be stocked. The “Recalibration” list is for reference only in the event that major path length or optical changes are necessary. For normal maintenance the “Start Up/Operational” and “Normal Wear and Maintenance” lists should be stocked. The four levels are:

- ❑ Start Up/Operational
 - Parts and supplies that may be used during start up and daily operation.
- ❑ Normal Wear and Maintenance
 - Parts that may be required as a result of normal wear over time.
- ❑ Emergency/Quick Response
 - Parts that will facilitate the fastest possible repair time in failure situations such as power surges, lightning strikes, etc.
- ❑ Recalibration
 - Neutral Density Windows for the Calibration Mechanism and Calibration Kit

“Start Up/Operational” Spare Parts

The following table represents a selection of parts and supplies that may be required during start up and normal operation.

This is the least comprehensive list. These parts will support only a minimal maintenance level.

TELEDYNE MONITOR LABS (TML) <i>LIGHTHAWK</i> ® 560ES “START UP/OPERATIONAL” RECOMMENDED SPARE PARTS								
<u>Part Name</u>	<u>TML Part #</u>	<u>System Location</u>	<u>Stocking</u>	<u>Stocking</u>	<u>Stocking</u>	<u>Cal Kit</u>	<u>Off-Stack</u>	<u>Mean Time</u>
			<u>Quantity</u>	<u>Quantity</u>	<u>Quantity</u>	<u>Recal</u>	<u>Recal</u>	
			<u>1 on Site</u>	<u>2 – 5 on Site</u>	<u>5 – 10 on Site</u>	<u>Required After Replacement</u>	<u>Required After Replacement</u>	<u>Between Replacement</u>
Fuse (1.25A)	527441	Optical Head Power Supply Board	5	5	5	No	No	N/A
Fuse (5.0 A)	527418	Optical Head	5	5	5	No	No	N/A
* Fuse, 2 amp	527438	Enhanced Remote and Multi I/O	6	6	12	No	No	N/A
** Purge Filters	528873	Purge System	12	24	48	No	No	N/A
Wipes	550026	General	1 Box	1 Box	2 Boxes	N/A	N/A	N/A
Lens Cleaning Fluid	530023	General	1 Bottle	1 Bottle	1 Bottle	N/A	N/A	N/A
Dessicator (Head)	997788	Optical Head Assembly	1	2	3	No	No	N/A
Alignment Scope Mounting Flange	1007-0000-01	General	1	1	1	No	No	N/A
Multi I/O Connector Kit	1803-0006-01	Enhanced Remote Panel	1	1	1	No	No	N/A

NOTES: * Not needed if Direct Interface option is chosen.

** Not needed if Instrument Air Purge option is chosen.

“Normal Wear and Maintenance” Spare Parts

These are parts that may be used as a result of normal wear over time.

TELEDYNE MONITOR LABS (TML) <i>LIGHTHAWK</i> [®] 560ES "MAINTENANCE" RECOMMENDED SPARE PARTS								
<u>Part Name</u>	<u>TML Part #</u>	<u>System Location</u>	<u>Stocking</u> <u>Quantity</u>	<u>Stocking</u> <u>Quantity</u>	<u>Stocking</u> <u>Quantity</u>	<u>Cal Kit</u> <u>Recal</u> <u>Required</u> <u>After</u> <u>Replacement</u>	<u>Off-Stack</u> <u>Recal</u> <u>Required</u> <u>After</u> <u>Replacement</u>	<u>Estimated</u> <u>Mean Time</u> <u>Between</u> <u>Failures</u>
			<u>1 on Site</u>	<u>2 - 5 on</u> <u>Site</u>	<u>5 - 10 on</u> <u>Site</u>			
Purge Switch	528312SP	Optical Head & Retro	1	2	4	No	No	3-5 Yrs
** Purge Hose 1" Dia. ***	980536	Purge System	2 Ft.	6 Ft.	10 Ft.	No	No	2-5 Yrs
** Hose Clamp	980537	Purge System	2	4	6	No	No	N/A
Battery	550047	Optical Head Mother Board	1	2	3	No	No	3-5 Yrs
* Key Switch	525414	Remote Display with Multi I/O	1	1	2	No	No	N/A
Tubing Seal & Adhesive Epoxy	528553 & 530007	Optical Head & Retro	1	1	2	No	No	N/A

NOTES: * Not needed if Direct Interface option is chosen.

** Not needed if Instrument Air Purge option is chosen.

*** 980539 for Hi-Temperature or if purge air heaters are supplied.

“Emergency/Quick Response” Spare Parts

The following is a list of spares that the user may wish to keep on hand in order to minimize system downtime in the event of an unforeseen failure such as power surges, lightning strikes, etc.

TELEDYNE MONITOR LABS (TML) LIGHTHAWK® 560ES "EMERGENCY/QUICK RESPONSE" RECOMMENDED SPARE PARTS								
<u>Part Name</u>	<u>TML Part #</u>	<u>System Location</u>	<u>Stocking</u>	<u>Stocking</u>	<u>Stocking</u>	<u>Cal Kit</u>	<u>Off-Stack</u>	<u>Estimated</u>
			<u>Quantity</u> 1 on Site	<u>Quantity</u> 2 - 5 on Site	<u>Quantity</u> 5 - 10 on Site	<u>Recal</u> <u>Required</u> <u>After</u> <u>Replacement</u>	<u>Recal</u> <u>Required</u> <u>After</u> <u>Replacement</u>	<u>Mean Time</u> <u>Between</u> <u>Replacement</u>
Optical Amplifier PCB	1860-0400-05	Optical Head	1	1	1	Yes	No	N/A
## 560ES Mother Board PCB	1860-0500-07	Optical Head	1	1	1	Yes	No	N/A
Display/Control PCB	1860-0600-01	Optical Head	1	1	1	Yes	No	N/A
** 6 Point I/O PCB	1860-0700-01	Optical Head	1	1	1	No	No	N/A
## Control Module PCB	515441	Optical Head	1	1	1	No	No	N/A
Power Supply PCB	1860-1100-02	Optical Head	1	1	1	No	No	N/A
Keypad	1860-0190-01	Optical Head	1	1	1	No	No	N/A
Keypad Panel Gasket	1860-0193-01	Optical Head	1	1	1	No	No	N/A
* Retro Cap	1802-0200-02 1802-0400-01 1802-0700-01 1802-0700-02	Retro Assembly	1	1	2	No	Yes	N/A
Cal Mechanism Drive Assembly	1860-0125-01	Optical Head	1	1	1	Yes	No	4-6 Yrs.
# Blower Motor	980142	Purge System	1	1	1	No	No	3-5 Yrs.
Exit Window	0601-0123-01	Optical Head	1	1	1	Yes	No	N/A
LED Source	1860-0244-01	Optical Head	1	2-5	5-10	No	Yes	N/A
Signal Detector Assy	1860-0290-01	Optical Head	1	2-5	5-10	No	Yes	N/A
Reference Detector Assembly	0601-1000-02	Optical Head	1	2-5	5-10	Yes	No	N/A
*** Enhanced Remote Mother Board PCB	1803-2200-02	Enhanced Remote Panel	1	1	2	No	No	N/A
*** Multi I/O PCB	1803-2500-03	Enhanced Remote Panel	1	1	2	No	No	N/A
*** Enhanced Remote LCD Display	1803-1400-02	Enhanced Remote Panel	1	1	2	No	No	N/A
*** Power Supply PCB	1803-0300-02SP	Enhanced Remote Panel	1	1	2	No	No	N/A
Viton O-ring	700233	Optical Head	1	1	2	No	No	N/A

NOTES: * Each monitor at a particular site may have a different Retro Cap. Review the site specification data for each monitor to insure that the proper Retro Cap is ordered.

** Only needed when Direct Interface option is chosen.

*** Not needed if Direct Interface option is chosen.

Not required if Instrument Air Purge option is chosen.

Mother Board (1860-0500-07) includes one Control Module (515441).

“Recalibration” Parts

The following is a list of neutral density windows used in the Calibration Mechanism and Calibration Kit. These windows only need changed if directed by the Off-Stack Calibration procedure outlined in Section 8.0 of this manual.

TELEDYNE MONITOR LABS (TML) <i>LIGHTHAWK</i> [®] 560ES “RECALIBRATION” PART NOS.						
<u>Part Name</u>	<u>TML Part #</u>	<u>System Location</u>	<u>Stocking Quantity 1 on Site</u>	<u>Cal Kit Recal Required After Replacement</u>	<u>Off-Stack Recal Required After Replacement</u>	<u>Estimated Mean Ttime Between Replacement</u>
Clear Window	528470	Cal Mechanism	* 2	No	No	N/A
0.2 Optical Density Window	528471 & 530183 Shim	Cal Mechanism				
0.4 Optical Density Window	528474	Cal Mechanism				
0.5 Optical Density Window	528472	Cal Mechanism				
0.6 Optical Density Window	528475	Cal Mechanism				
0.7 Optical Density Window	528473	Cal mechanism				

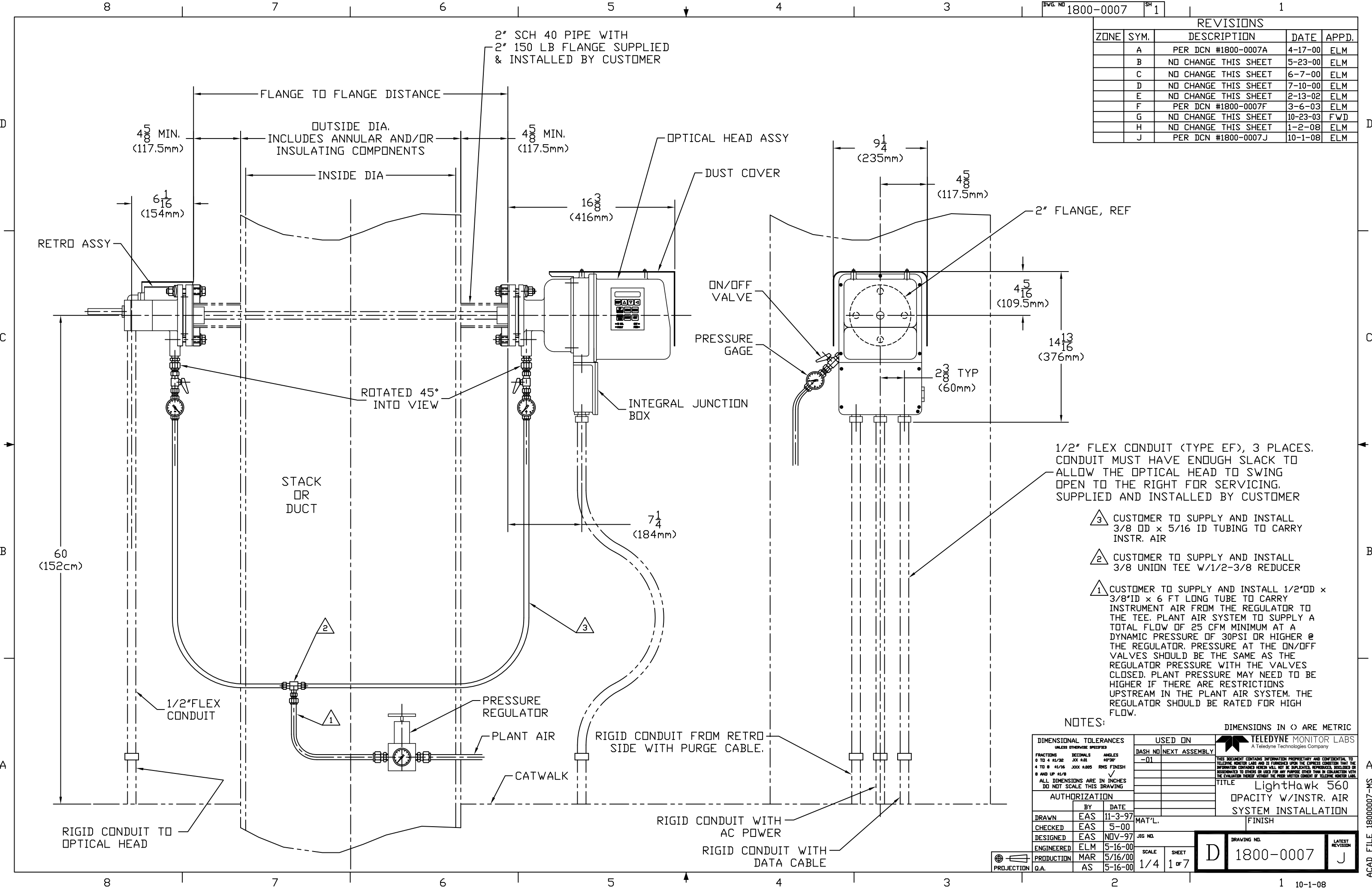
NOTE: * The appropriate part no. can only be determined during the Off-Stack Calibration procedure outlined in Section. 8.0.

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APPENDIX D
DRAWINGS

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REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER DCN #1800-0007A	4-17-00	ELM
	B	NO CHANGE THIS SHEET	5-23-00	ELM
	C	NO CHANGE THIS SHEET	6-7-00	ELM
	D	NO CHANGE THIS SHEET	7-10-00	ELM
	E	NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



- 3 CUSTOMER TO SUPPLY AND INSTALL 3/8 OD x 5/16 ID TUBING TO CARRY INSTR. AIR
- 2 CUSTOMER TO SUPPLY AND INSTALL 3/8 UNION TEE W/1/2-3/8 REDUCER
- 1 CUSTOMER TO SUPPLY AND INSTALL 1/2"OD x 3/8"ID x 6 FT LONG TUBE TO CARRY INSTRUMENT AIR FROM THE REGULATOR TO THE TEE. PLANT AIR SYSTEM TO SUPPLY A TOTAL FLOW OF 25 CFM MINIMUM AT A DYNAMIC PRESSURE OF 30PSI OR HIGHER @ THE REGULATOR. PRESSURE AT THE ON/OFF VALVES SHOULD BE THE SAME AS THE REGULATOR PRESSURE WITH THE VALVES CLOSED. PLANT PRESSURE MAY NEED TO BE HIGHER IF THERE ARE RESTRICTIONS UPSTREAM IN THE PLANT AIR SYSTEM. THE REGULATOR SHOULD BE RATED FOR HIGH FLOW.

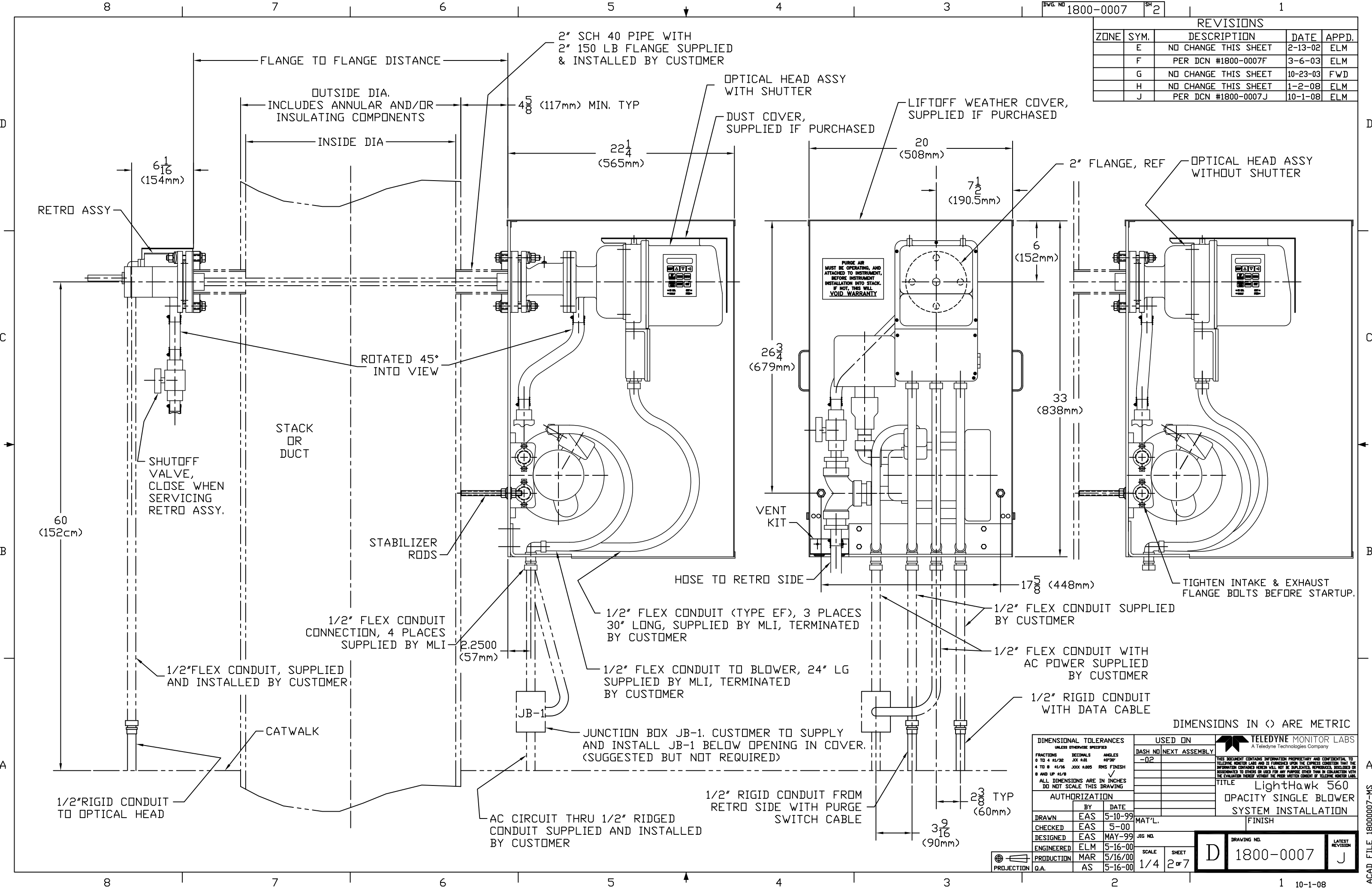
NOTES:

DIMENSIONS IN () ARE METRIC

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		 TELEDYNE MONITOR LABS A Teledyne Technologies Company
FRACTIONS	DECIMALS	ANGLES	DASH NO/NEXT ASSEMBLY	
0 TO 4 41/32	.001	45°	-01	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPHRASED, COPIED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.
4 TO 8 41/16	.002	RHS FINISH		
8 AND UP 41/8	.005			
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING				
AUTHORIZATION		TITLE		LightHawk 560 OPACITY W/INSTR. AIR SYSTEM INSTALLATION
BY	DATE	FINISH		
DRAWN	EAS 11-3-97	MAT'L.		DRAWING NO. 1800-0007 LATEST REVISION J
CHECKED	EAS 5-00	SCALE		
DESIGNED	EAS NOV-97	SHEET		
ENGINEERED	ELM 5-16-00	1 OF 7		
PRODUCTION	MAR 5/16/00			
Q.A.	AS 5-16-00			



REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	E	NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



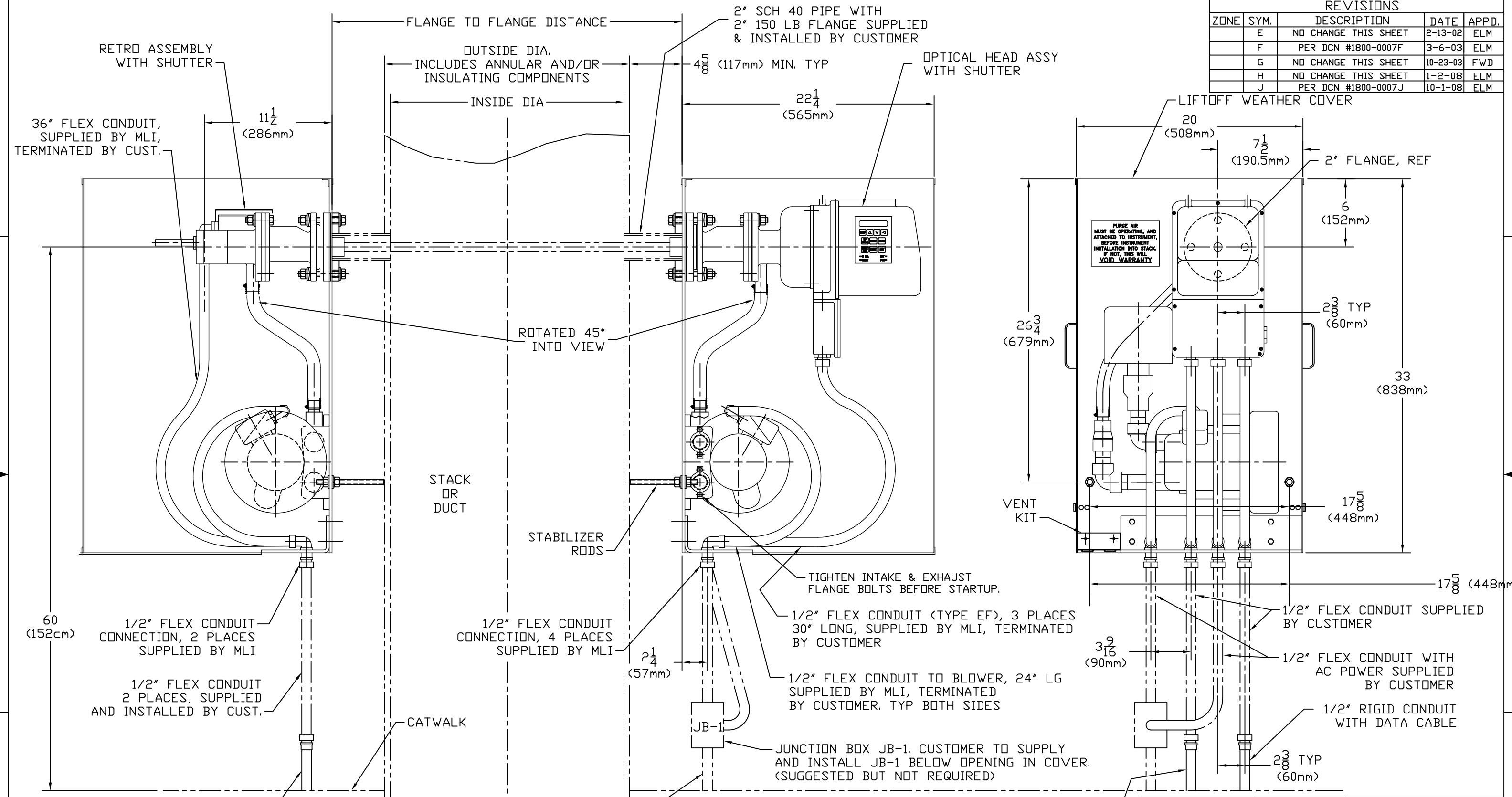
DIMENSIONS IN () ARE METRIC

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			USED ON		TELEDYNE MONITOR LABS A Teledyne Technologies Company
FRACTIONS	DECIMALS	ANGLES	DASH NO	NEXT ASSEMBLY	
0 TO 4 31/32	.XX .XXX	±30"	-02		THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, COPIED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.
4 TO 8 31/16	.XX .XXX	±30"			
8 AND UP 31/8	.XX .XXX	±30"			TITLE
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING					LightHawk 560
AUTHORIZATION					OPACITY SINGLE BLOWER
DRAWN EAS 5-10-99					SYSTEM INSTALLATION
CHECKED EAS 5-00					FINISH
DESIGNED EAS MAY-99					
ENGINEERED ELM 5-16-00					
PRODUCTION MAR 5/16/00					
Q.A. AS 5-16-00					



SCALE	SHEET	DRAWING NO.	LATEST REVISION
1/4	2 OF 7	1800-0007	J

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
		NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



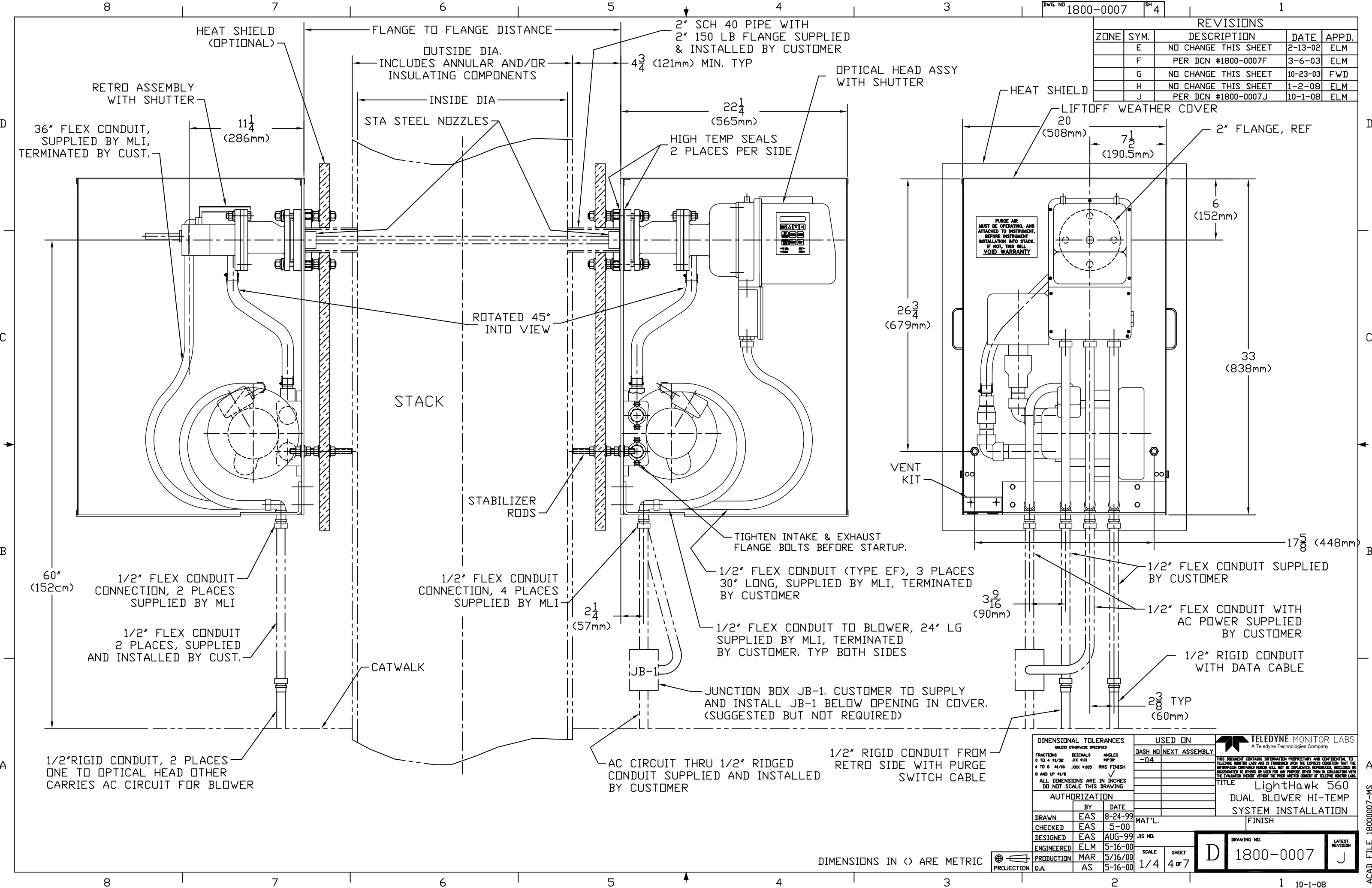
<p>DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED</p> <p>FRACTIONS: DECIMALS ANGLES 0 TO 4 41/32 .001 4:1</p> <p>4 TO 8 41/64 .002 4:005 RHS FINISH</p> <p>8 AND UP 41/8 .003</p> <p>ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING</p>		<p>USED ON</p> <p>DASH NO NEXT ASSEMBLY</p>	<p>TELEDYNE MONITOR LABS A Teledyne Technologies Company</p> <p>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPAIRED, COPIED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.</p> <p>TITLE: LightHawk 560 OPACITY DUAL BLOWER SYSTEM INSTALLATION</p>														
<p>AUTHORIZATION</p> <table border="1"> <tr> <th>BY</th> <th>DATE</th> </tr> <tr> <td>DRAWN EAS</td> <td>8-19-99</td> </tr> <tr> <td>CHECKED EAS</td> <td>5-00</td> </tr> <tr> <td>DESIGNED EAS</td> <td>AUG-99</td> </tr> <tr> <td>ENGINEERED ELM</td> <td>5-16-00</td> </tr> <tr> <td>PRODUCTION MAR</td> <td>5/16/00</td> </tr> <tr> <td>Q.A. AS</td> <td>5-16-00</td> </tr> </table>		BY		DATE	DRAWN EAS	8-19-99	CHECKED EAS	5-00	DESIGNED EAS	AUG-99	ENGINEERED ELM	5-16-00	PRODUCTION MAR	5/16/00	Q.A. AS	5-16-00	<p>MAT'L.</p> <p>JIG NO.</p> <p>SCALE: 1/4"</p> <p>SHEET: 3 OF 7</p>
BY	DATE																
DRAWN EAS	8-19-99																
CHECKED EAS	5-00																
DESIGNED EAS	AUG-99																
ENGINEERED ELM	5-16-00																
PRODUCTION MAR	5/16/00																
Q.A. AS	5-16-00																

DIMENSIONS IN () ARE METRIC

ACAD FILE 18000007-MS

ACAD FILE 18000007-MS

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	E	NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



8
7
6
5
4
3
2
1

D
C
B
A

60" (152cm)

36" FLEX CONDUIT, SUPPLIED BY MLI, TERMINATED BY CUST.

11 1/4 (286mm)

HEAT SHIELD (OPTIONAL)

RETRO ASSEMBLY WITH SHUTTER

FLANGE TO FLANGE DISTANCE

OUTSIDE DIA. INCLUDES ANNULAR AND/OR INSULATING COMPONENTS

INSIDE DIA.

STA STEEL NOZZLES

2" SCH 40 PIPE WITH 2" 150 LB FLANGE SUPPLIED & INSTALLED BY CUSTOMER

4 3/4 (121mm) MIN. TYP

OPTICAL HEAD ASSY WITH SHUTTER

22 1/4 (565mm)

HIGH TEMP SEALS 2 PLACES PER SIDE

HEAT SHIELD

LIFTOFF WEATHER COVER

20 (508mm)

7 1/2 (190.5mm)

2" FLANGE, REF

6 (152mm)

26 3/4 (679mm)

33 (838mm)

17 5/8 (448mm)

3 9/16 (90mm)

2 3/8 (60mm)

1 1/2" FLEX CONDUIT CONNECTION, 2 PLACES SUPPLIED BY MLI

1 1/2" FLEX CONDUIT 2 PLACES, SUPPLIED AND INSTALLED BY CUST.

CATWALK

1 1/2" FLEX CONDUIT CONNECTION, 4 PLACES SUPPLIED BY MLI

2 1/4 (57mm)

1 1/2" FLEX CONDUIT (TYPE EF), 3 PLACES 30" LONG, SUPPLIED BY MLI, TERMINATED BY CUSTOMER

1 1/2" FLEX CONDUIT TO BLOWER, 24" LG SUPPLIED BY MLI, TERMINATED BY CUSTOMER. TYP BOTH SIDES

JUNCTION BOX JB-1. CUSTOMER TO SUPPLY AND INSTALL JB-1 BELOW OPENING IN COVER. (SUGGESTED BUT NOT REQUIRED)

1 1/2" RIGID CONDUIT FROM RETRO SIDE WITH PURGE SWITCH CABLE

1 1/2" RIGID CONDUIT, 2 PLACES ONE TO OPTICAL HEAD OTHER CARRIES AC CIRCUIT FOR BLOWER

AC CIRCUIT THRU 1 1/2" RIDGED CONDUIT SUPPLIED AND INSTALLED BY CUSTOMER

TIGHTEN INTAKE & EXHAUST FLANGE BOLTS BEFORE STARTUP.

VENT KIT

PURGE AIR MUST BE OPERATING, AND ATTACHED TO INSTRUMENT, BEFORE INSTRUMENT INSTALLATION INTO STACK. IF NOT, THIS WILL VOID WARRANTY

ROTATED 45° INTO VIEW

STABILIZER RODS

STACK

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
0 TO 4 31/32	.005	±.005
4 TO 8 31/16	.005	RHS FINISH
8 AND UP 31/8	.005	

USED ON	
DASH NO	NEXT ASSEMBLY
-04	
TITLE	
LightHawk 560	
DUAL BLOWER HI-TEMP	
SYSTEM INSTALLATION	
FINISH	

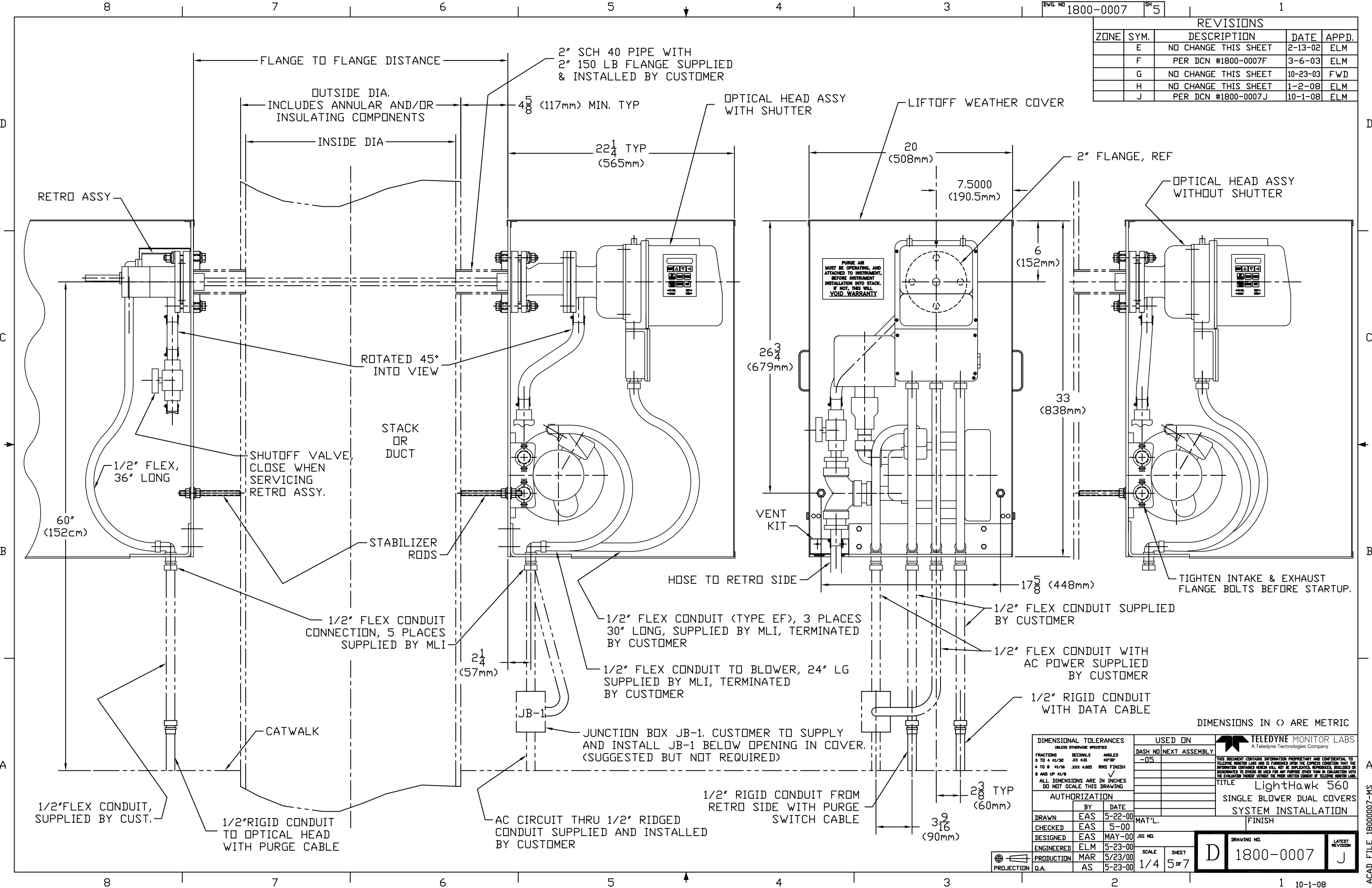
AUTHORIZATION	
BY	DATE
EAS	8-24-99
CHECKED	5-00
DESIGNED	AUG-99
ENGINEERED	5-16-00
PRODUCTION	5/16/00
Q.A.	AS 5-16-00

SCALE	SHEET
1/4	4 OF 7

DRAWING NO.	LATEST REVISION
D 1800-0007	J

DIMENSIONS IN () ARE METRIC

REVISIONS			
ZONE	SYM.	DESCRIPTION	DATE APPD.
	E	NO CHANGE THIS SHEET	2-13-02 ELM
	F	PER DCN #1800-0007F	3-6-03 ELM
	G	NO CHANGE THIS SHEET	10-23-03 FWD
	H	NO CHANGE THIS SHEET	1-2-08 ELM
	J	PER DCN #1800-0007J	10-1-08 ELM



DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
0 TO 4 41/32	.XX .XX	±.005"
4 TO 8 41/16	.XX .XX	±.005"
8 AND UP 41/8	.XX .XX	±.005"

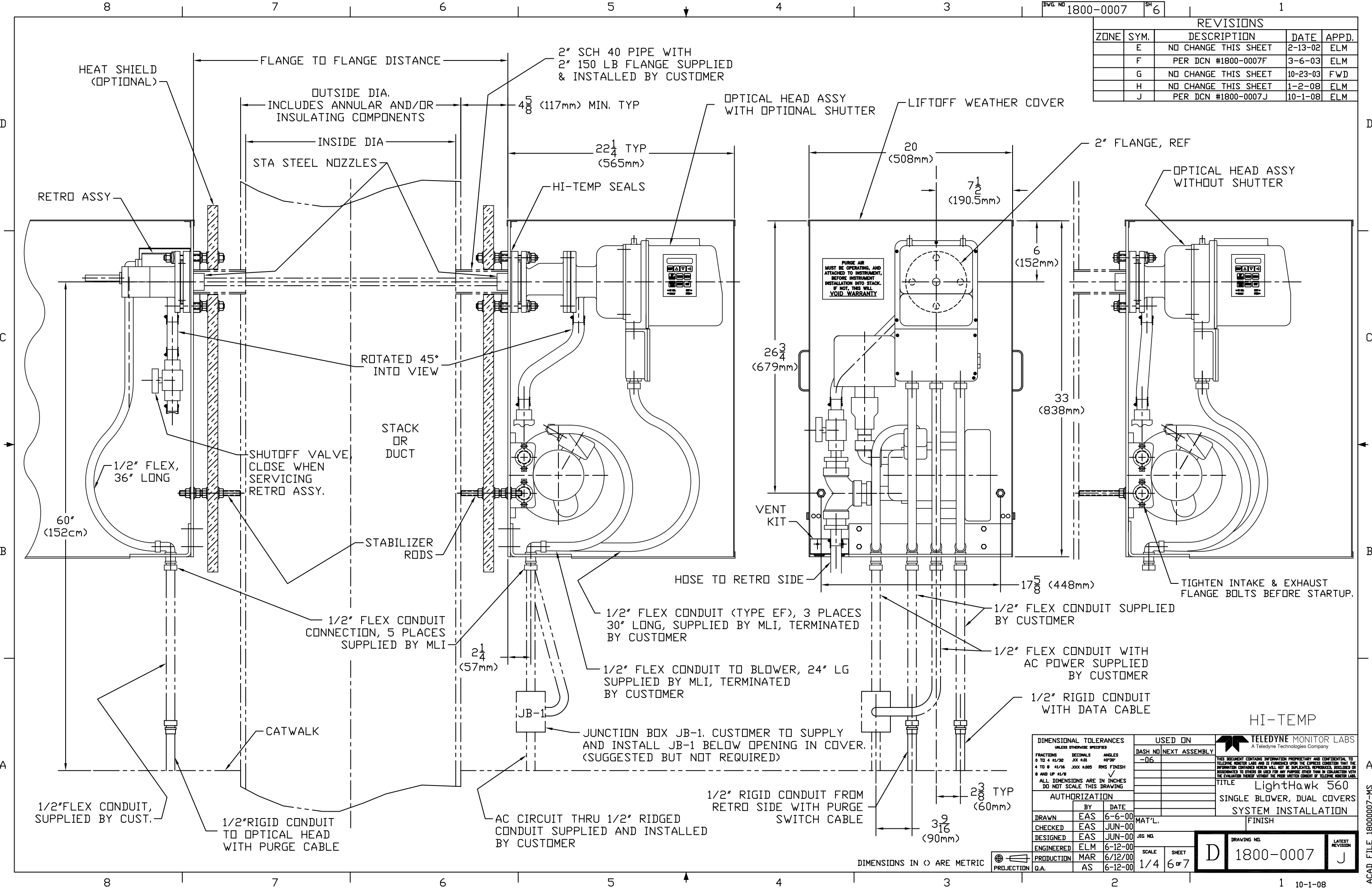
USED ON	
DASH NO	NEXT ASSEMBLY
-05	

TELEDYNE MONITOR LABS	
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TITLE LightHawk 560	
SINGLE BLOWER DUAL COVERS	
SYSTEM INSTALLATION	
FINISH	
BY	DATE
EAS	5-22-00
DESIGNED	MAY-00
ENGINEERED	ELM 5-23-00
PRODUCTION	MAR 5/23/00
Q.A.	AS 5-23-00

SCALE	SHEET
1/4	5 OF 7

DRAWING NO.	LATEST REVISION
1800-0007	J

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	E	NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
0 TO 4 31/32	.XX ±.01	±30°
4 TO 8 31/16	.XX ±.005	RMS FINISH
8 AND UP 31/8	.XX ±.005	

USED ON	
DASH NO	NEXT ASSEMBLY
-06	

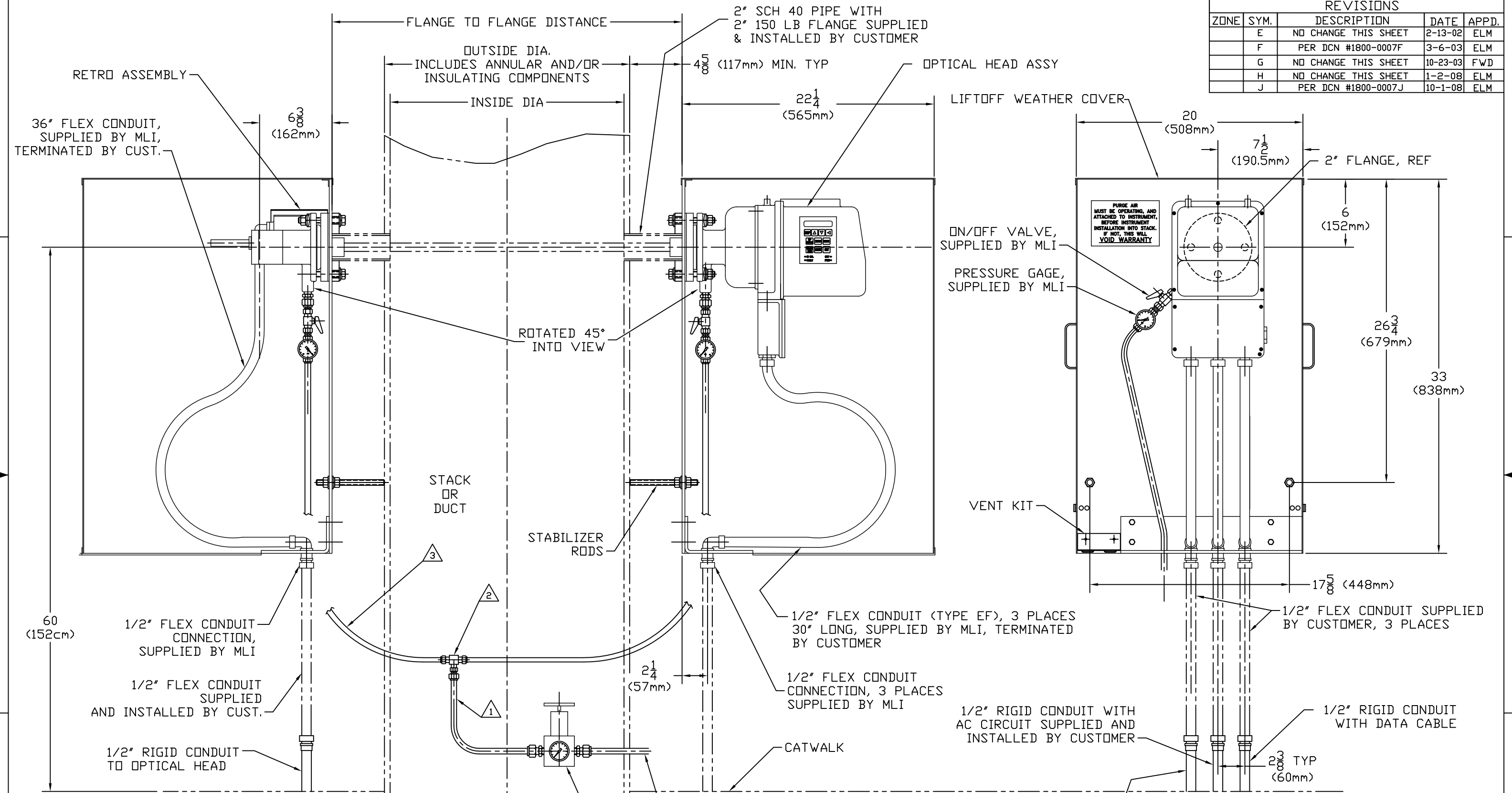
TELEDYNE MONITOR LABS	
A Teledyne Technologies Company	
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TITLE LightHawk 560	
SINGLE BLOWER, DUAL COVERS	
SYSTEM INSTALLATION	
FINISH	
AUTHORIZATION	
BY	DATE
EAS	6-6-00
CHECKED	EAS JUN-00
DESIGNED	EAS JUN-00
ENGINEERED	ELM 6-12-00
PRODUCTION	MAR 6/12/00
Q.A.	AS 6-12-00

SCALE	SHEET
1/4	6 OF 7

DRAWING NO.	LATEST REVISION
D 1800-0007	J

DIMENSIONS IN ◊ ARE METRIC

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	E	NO CHANGE THIS SHEET	2-13-02	ELM
	F	PER DCN #1800-0007F	3-6-03	ELM
	G	NO CHANGE THIS SHEET	10-23-03	FWD
	H	NO CHANGE THIS SHEET	1-2-08	ELM
	J	PER DCN #1800-0007J	10-1-08	ELM



1 CUSTOMER TO SUPPLY AND INSTALL 1/2"OD x 3/8"ID x 6 FT LONG TUBE TO CARRY INSTRUMENT AIR FROM THE REGULATOR TO THE TEE. PLANT AIR SYSTEM TO SUPPLY A TOTAL FLOW OF 25 CFM MINIMUM AT A DYNAMIC PRESSURE OF 30PSI OR HIGHER @ THE REGULATOR. PRESSURE AT THE ON/OFF VALVES SHOULD BE THE SAME AS THE REGULATOR PRESSURE WITH THE VALVES CLOSED. PLANT PRESSURE MAY NEED TO BE HIGHER IF THERE ARE RESTRICTIONS UPSTREAM IN THE PLANT AIR SYSTEM. THE REGULATOR SHOULD BE RATED FOR HIGH FLOW.

2 CUSTOMER TO SUPPLY AND INSTALL 3/8" OD x 5/16" ID TUBING TO CARRY INSTR. AIR

3 CUSTOMER TO SUPPLY AND INSTALL 3/8" UNION TEE W/REDUCER

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
0 TO 4 41/32	.XX 4:1	± .005"
4 TO 8 41/16	.XX 4:1	RHS FINISH
8 AND UP 41/8		
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING		
AUTHORIZATION		
BY	DATE	
DRAWN	EAS	2-13-02
CHECKED	EAS	FEB-02
DESIGNED	EAS	FEB-02
ENGINEERED	ELM	5-15-02
PRODUCTION	PD	5-15-02
Q.A.	AS	5-15-02

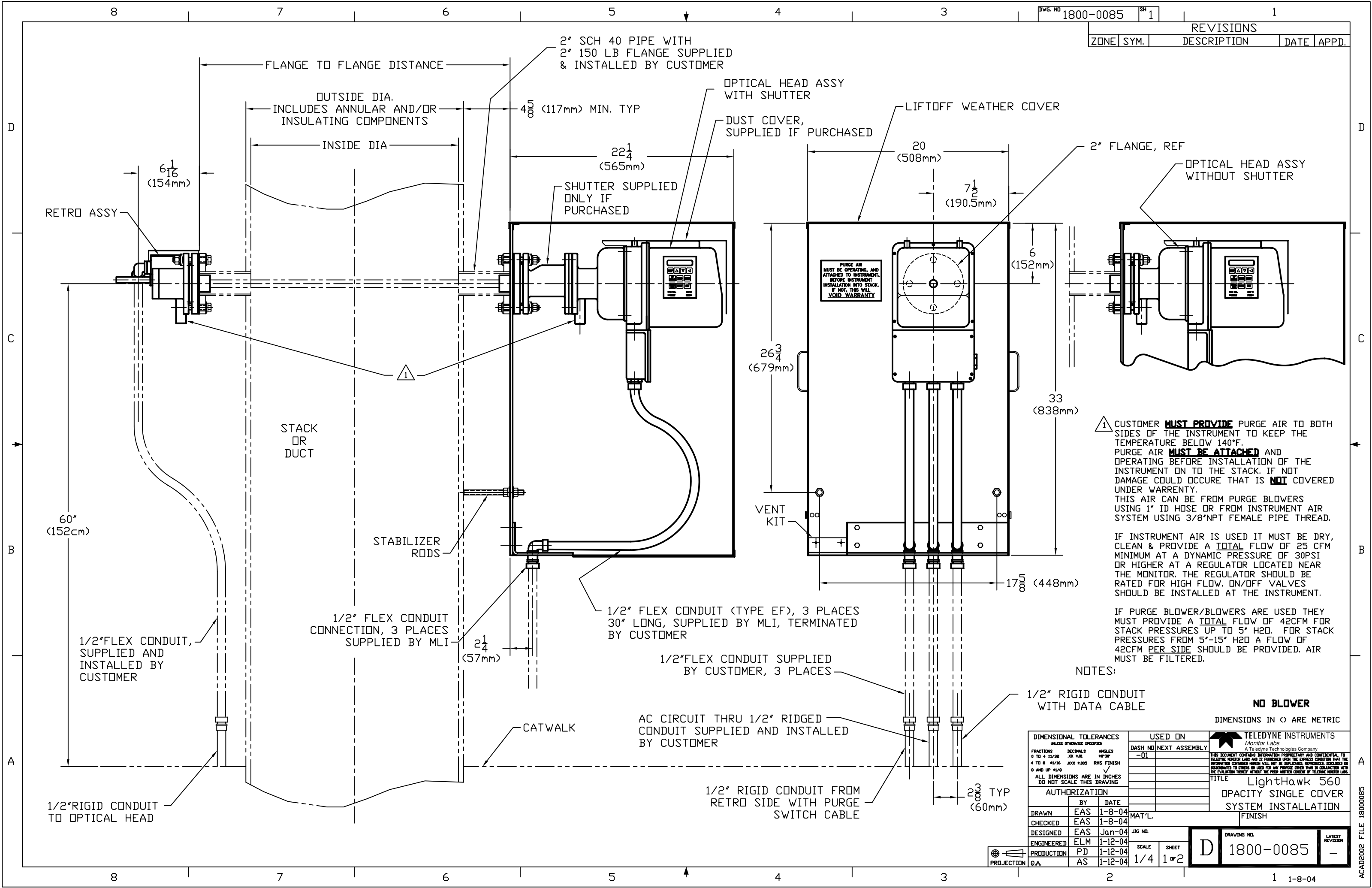
USED ON		TELEDYNE MONITOR LABS A Teledyne Technologies Company	
DASH NO	NEXT ASSEMBLY	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELETYPE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REFINISHED, COPIED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELETYPE MONITOR LABS.	
-07		TITLE	
		LightHawk 560	
		OPACITY DUAL COVERS	
		INSTR AIR SYS INSTALL	
		FINISH	
		DRAWING NO.	
		1800-0007	
		LATEST REVISION	
		J	

DIMENSIONS IN () ARE METRIC

PROJECTION	SCALE	SHEET
1/4	1/4	7 OF 7

D 1800-0007 **J**

REVISIONS			
ZONE	SYM.	DESCRIPTION	DATE APPD.



1 CUSTOMER **MUST PROVIDE** PURGE AIR TO BOTH SIDES OF THE INSTRUMENT TO KEEP THE TEMPERATURE BELOW 140°F. PURGE AIR **MUST BE ATTACHED** AND OPERATING BEFORE INSTALLATION OF THE INSTRUMENT ON TO THE STACK. IF NOT DAMAGE COULD OCCURE THAT IS **NOT** COVERED UNDER WARRENTY. THIS AIR CAN BE FROM PURGE BLOWERS USING 1" ID HOSE OR FROM INSTRUMENT AIR SYSTEM USING 3/8"NPT FEMALE PIPE THREAD.

IF INSTRUMENT AIR IS USED IT MUST BE DRY, CLEAN & PROVIDE A TOTAL FLOW OF 25 CFM MINIMUM AT A DYNAMIC PRESSURE OF 30PSI OR HIGHER AT A REGULATOR LOCATED NEAR THE MONITOR. THE REGULATOR SHOULD BE RATED FOR HIGH FLOW. ON/OFF VALVES SHOULD BE INSTALLED AT THE INSTRUMENT.

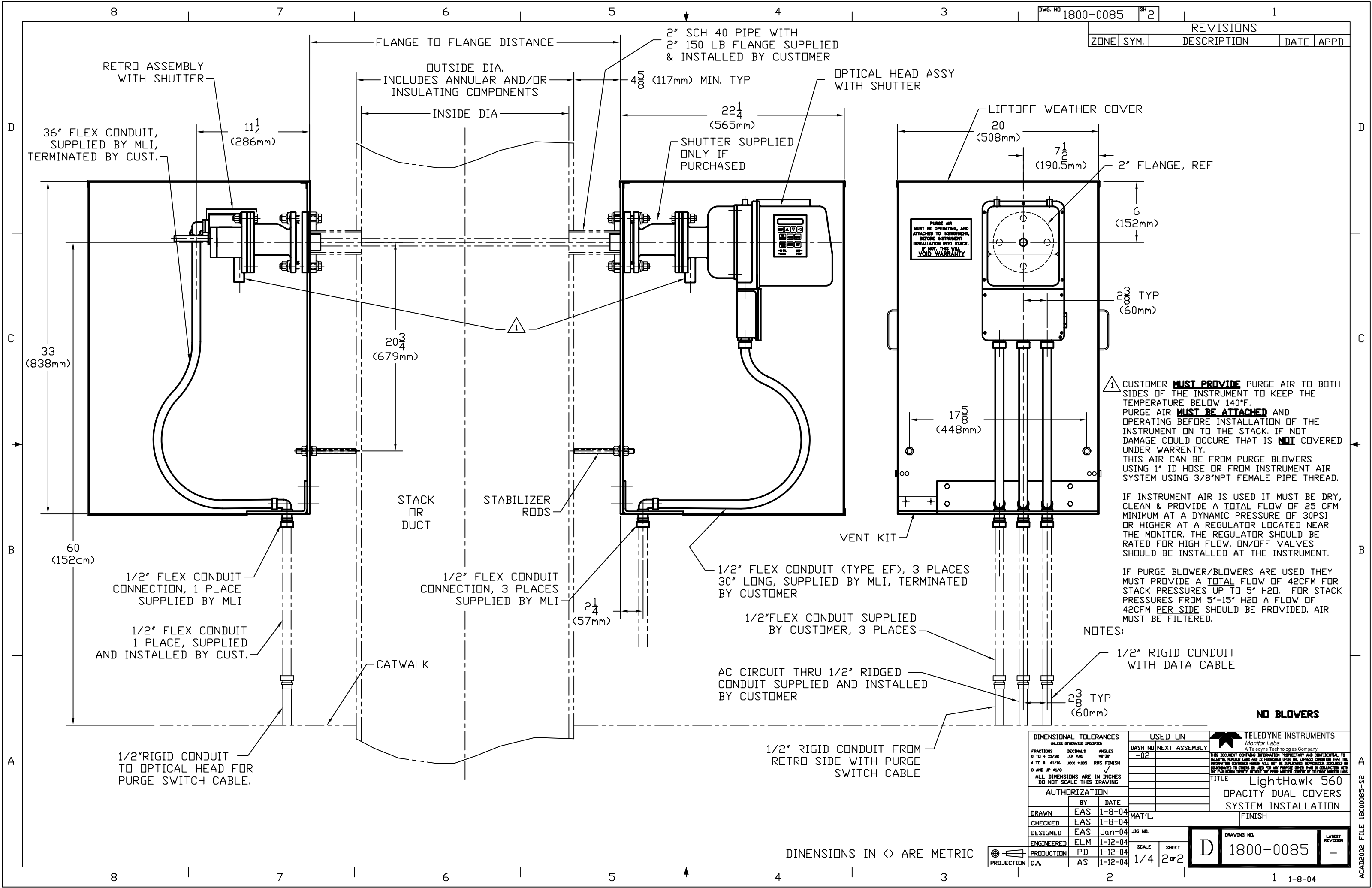
IF PURGE BLOWER/BLOWERS ARE USED THEY MUST PROVIDE A TOTAL FLOW OF 42CFM FOR STACK PRESSURES UP TO 5' H2O. FOR STACK PRESSURES FROM 5'-15' H2O A FLOW OF 42CFM PER SIDE SHOULD BE PROVIDED. AIR MUST BE FILTERED.

NOTES:

NO BLOWER
DIMENSIONS IN () ARE METRIC

<p>DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED</p> <p>FRACTIONS DECIMALS ANGLES</p> <p>0 TO 4 41/32 100 0.01 40°30'</p> <p>4 TO 8 41/16 1000 0.005 RMS FINISH</p> <p>8 AND UP 41/8</p> <p>ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING</p>		<p>USED ON</p> <p>DASH NO/NEXT ASSEMBLY</p> <p>-01</p>		<p>TELEDYNE INSTRUMENTS Monitor Labs A Teledyne Technologies Company</p> <p>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELETYPE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRINTERED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION HEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELETYPE MONITOR LABS.</p>	
<p>AUTHORIZATION</p> <p>BY DATE</p> <p>DRAWN EAS 1-8-04</p> <p>CHECKED EAS 1-8-04</p> <p>DESIGNED EAS Jan-04</p> <p>ENGINEERED ELM 1-12-04</p> <p>PRODUCTION PD 1-12-04</p> <p>Q.A. AS 1-12-04</p>		<p>MAT'L.</p> <p>FINISH</p>		<p>TITLE</p> <p>LightHawk 560 OPACITY SINGLE COVER SYSTEM INSTALLATION</p>	
<p>SCALE SHEET</p> <p>1/4 1 of 2</p>		<p>DRAWING NO.</p> <p>D 1800-0085</p>		<p>LATEST REVISION</p> <p>-</p>	

REVISIONS			
ZONE	SYM.	DESCRIPTION	DATE APPD.



1 CUSTOMER **MUST PROVIDE** PURGE AIR TO BOTH SIDES OF THE INSTRUMENT TO KEEP THE TEMPERATURE BELOW 140°F. PURGE AIR **MUST BE ATTACHED** AND OPERATING BEFORE INSTALLATION OF THE INSTRUMENT ON TO THE STACK. IF NOT DAMAGE COULD OCCURE THAT IS **NOT** COVERED UNDER WARRENTY. THIS AIR CAN BE FROM PURGE BLOWERS USING 1" ID HOSE OR FROM INSTRUMENT AIR SYSTEM USING 3/8"NPT FEMALE PIPE THREAD.

IF INSTRUMENT AIR IS USED IT MUST BE DRY, CLEAN & PROVIDE A TOTAL FLOW OF 25 CFM MINIMUM AT A DYNAMIC PRESSURE OF 30PSI OR HIGHER AT A REGULATOR LOCATED NEAR THE MONITOR. THE REGULATOR SHOULD BE RATED FOR HIGH FLOW. ON/OFF VALVES SHOULD BE INSTALLED AT THE INSTRUMENT.

IF PURGE BLOWER/BLOWERS ARE USED THEY MUST PROVIDE A TOTAL FLOW OF 42CFM FOR STACK PRESSURES UP TO 5" H2O. FOR STACK PRESSURES FROM 5"-15" H2O A FLOW OF 42CFM PER SIDE SHOULD BE PROVIDED. AIR MUST BE FILTERED.

NOTES:

1/2" RIGID CONDUIT WITH DATA CABLE

NO BLOWERS

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
0 TO 4 41/32	.005	±30"
4 TO 8 41/16	.005	RHS FINISH
8 AND UP 41/8		

ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING

USED ON	
DASH NO	NEXT ASSEMBLY
-02	

TELEDYNE INSTRUMENTS
Monitor Labs
A Teledyne Technologies Company

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TITLE: LightHawk 560
OPACITY DUAL COVERS
SYSTEM INSTALLATION

FINISH

AUTHORIZATION		
BY	DATE	
DRAWN EAS	1-8-04	
CHECKED EAS	1-8-04	
DESIGNED EAS	Jan-04	
ENGINEERED ELM	1-12-04	
PRODUCTION PD	1-12-04	
Q.A. AS	1-12-04	

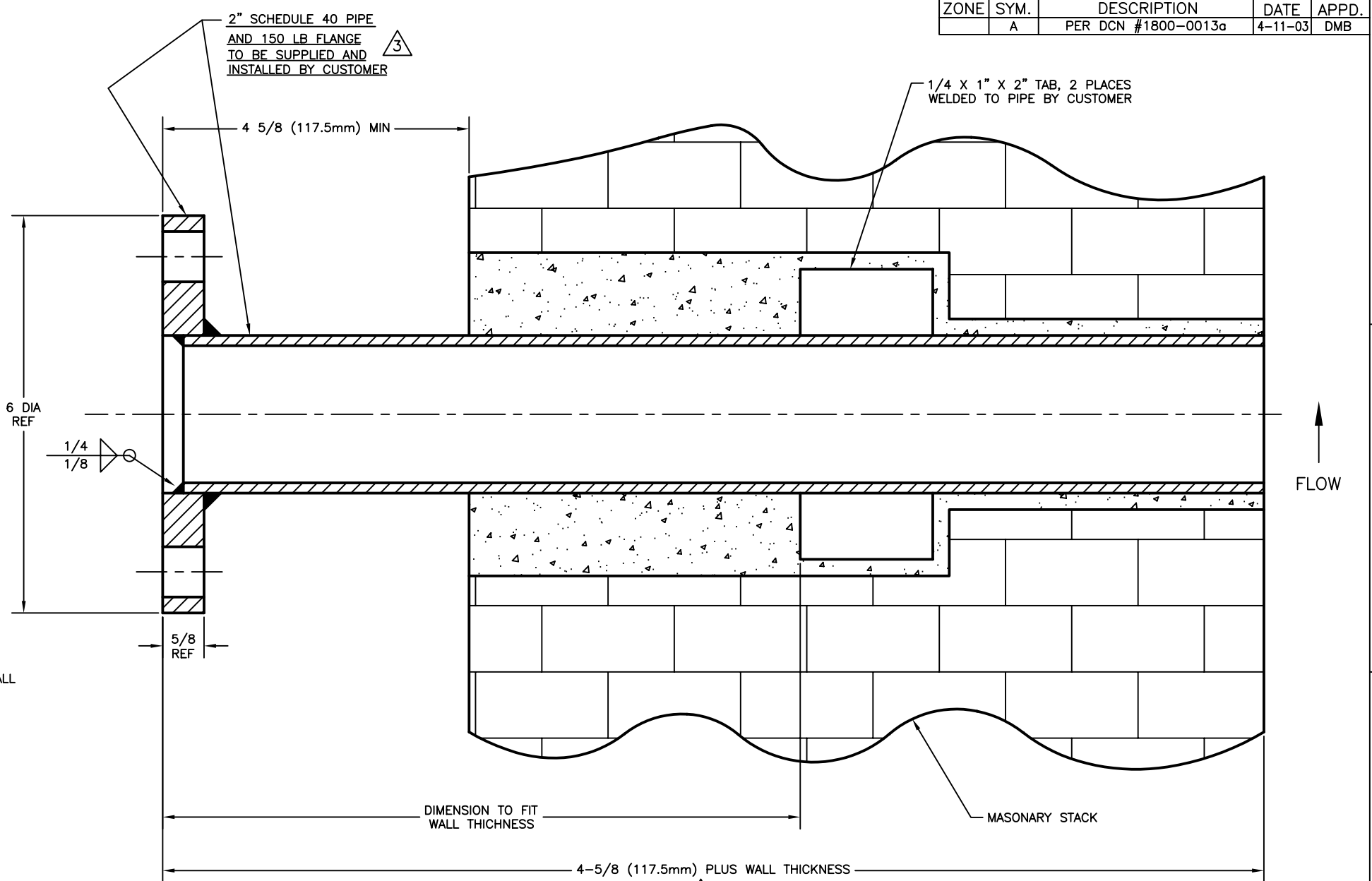
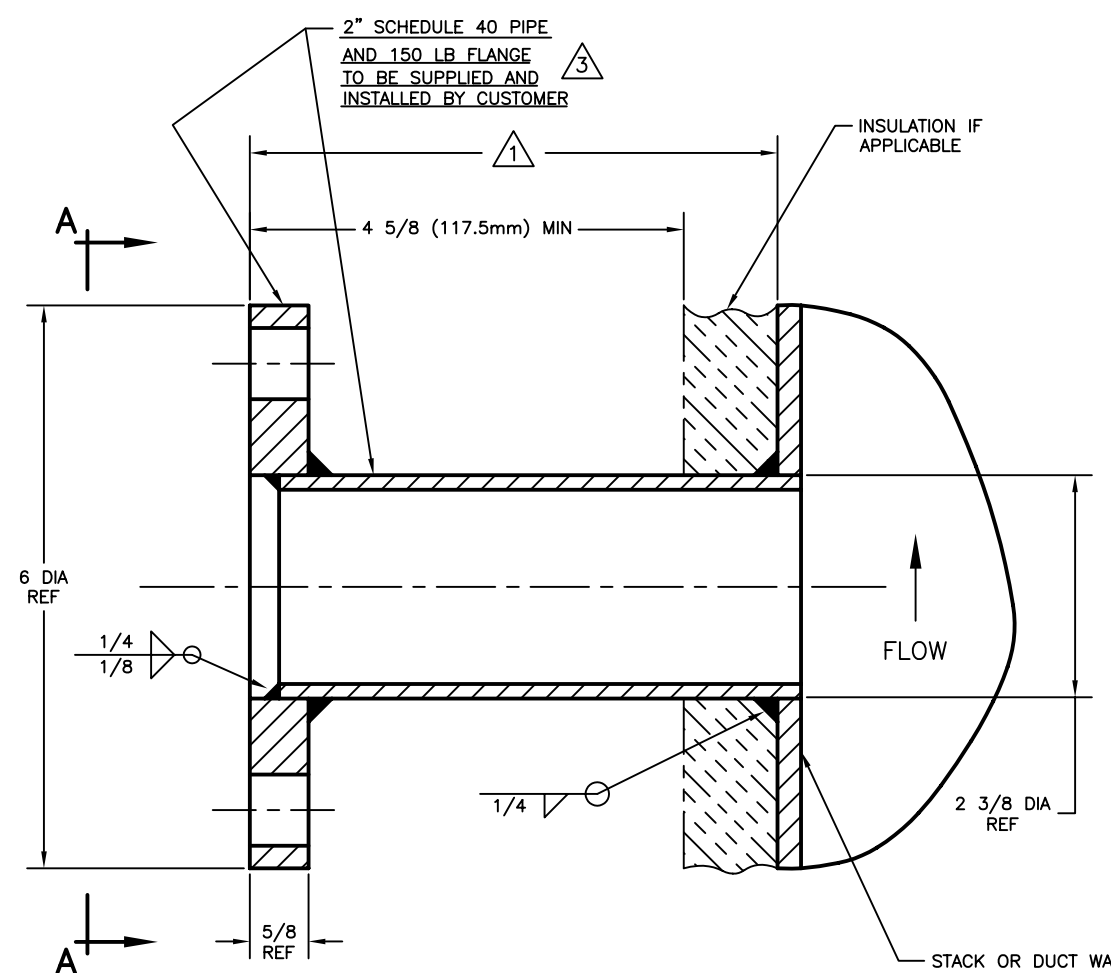
SCALE	SHEET
1/4	2 OF 2

DRAWING NO.	LATEST REVISION
D 1800-0085	-

DIMENSIONS IN () ARE METRIC

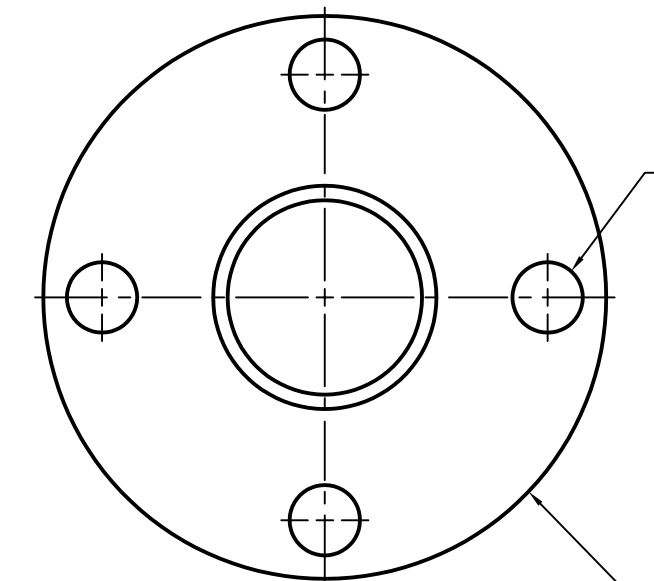


REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
A		PER DCN #1800-0013a	4-11-03	DMB



MAX. ANGULAR MISALIGNMENT PORT TO PORT
FOR PORT LENGTH OF 4-5/8" IS 5°
FOR PORT LENGTH OF 12" IS 2.5°

MAX. ANGULAR MISALIGNMENT PORT TO PORT
FOR PORT LENGTH OF 18" IS 1.7°



HOLES MUST BE ORIENTED AS SHOWN FOR INSTRUMENT TO SIT LEVEL

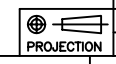
2" 150 LB FLANGE SUPPLIED & INSTALLED BY CUSTOMER

VERTICAL VIEW "A-A"

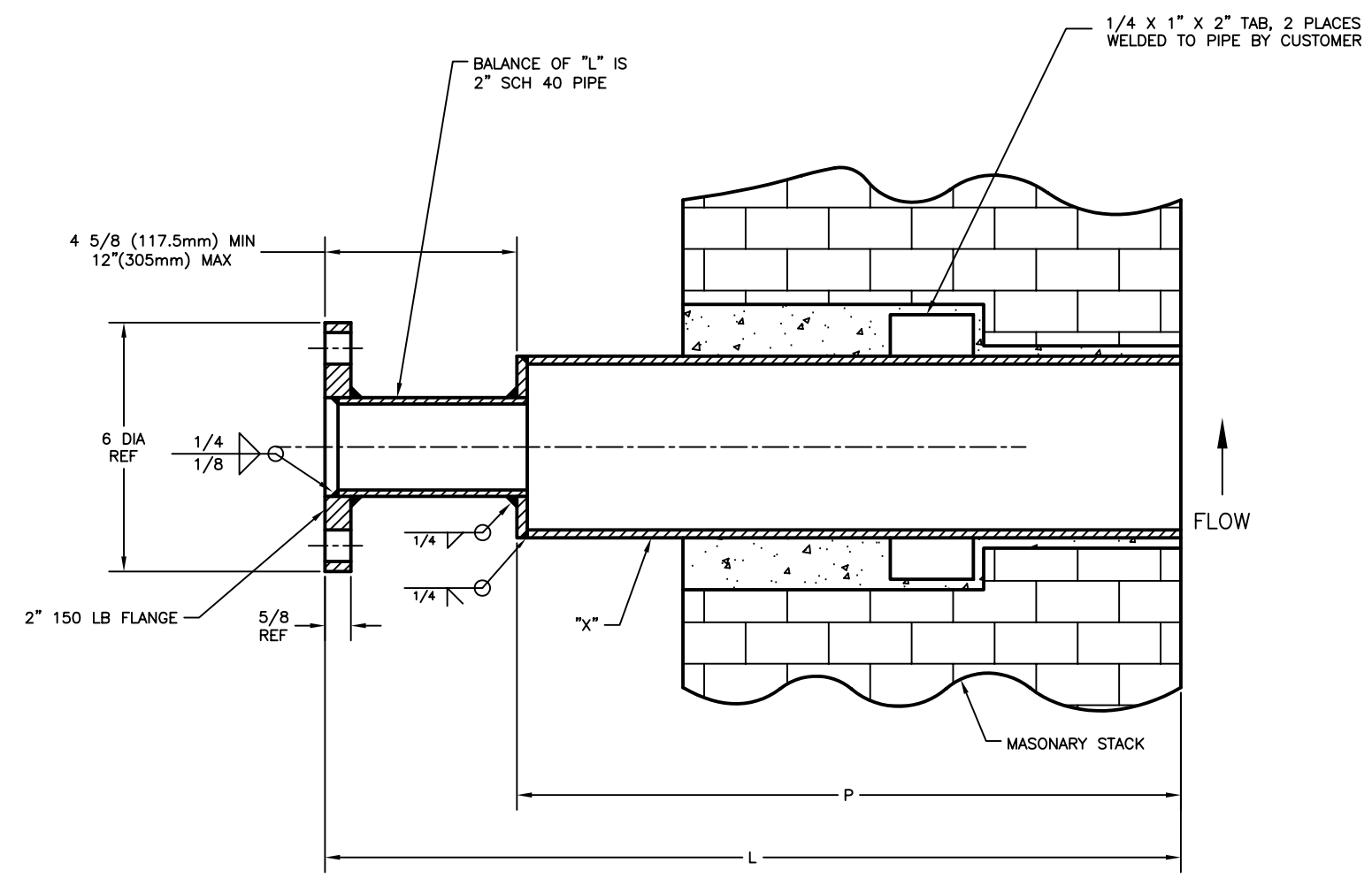
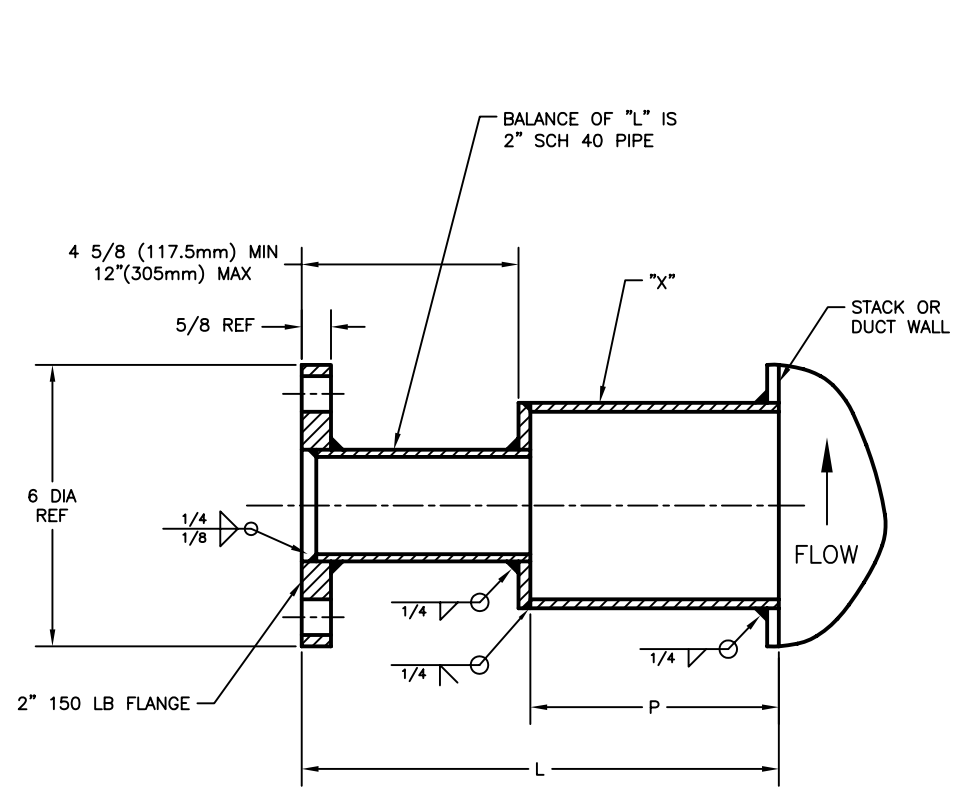
- 4. ADAPTER PLATES ARE AVAILABLE FOR 3" THRU 6" PIPE WITH 150# FLANGES.
- ③ PIPE SIZES ARE AMERICAN STANDARD.
- ② SEE SHEET 2 IF THIS DISTANCE EXCEEDS 18" (457mm).
- ① SEE SHEET 2 IF THIS DISTANCE EXCEEDS 12" (305mm).

NOTES:

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE INSTRUMENTS MONITOR LABS	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEMONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPROCESSED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EQUIPMENT THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEMONITOR LABS.	
0 TO 4 ±1/32	.XX ±.01	-01	1860-0000	TITLE LightHawk 560 OPACITY MONITOR FLANGE MTG. METHODS	
4 TO 8 ±1/16	.XXX ±.005			FINISH	
8 AND UP ±1/8				DRAWING NO. 1800-0013	
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING		AUTHORIZATION		LATEST REVISION A	
		BY	DATE	SCALE 1:1	
		EAS	9-30-99	SHEET 1 OF 2	
		CHECKED	EAS	DATE 4-11-03	
		DESIGNED	EAS		
		ENGINEERED	ELM		
		PRODUCTION	MAR		
		Q.A.	AS		



REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	NO CHANGE THIS SHEET	4-11-03	DMB



3

L	P	L (METRIC)	P (METRIC)	SIZE OF "X"	MAX. ANGULAR MISALIGNMENT PORT TO PORT
13"-19"	7"	320.2mm-482.6mm	177.8mm	3"SCH. 40	2.50°
20"-26"	14"	508.0mm-660.4mm	335.6mm	3"SCH. 40	2.17°
27"-33"	21"	685.8mm-838.2mm	533.4mm	4"SCH 40	2.50°
34"-40"	28"	86.36cm-101.60cm	711.2mm	4"SCH. 40	2.12°
41"-47"	35"	104.14cm-119.38cm	889.0mm	5"SCH. 40	2.40°
48"-54"	42"	121.92cm-137.16cm	106.68cm	5"SCH 40	2.12°
55"-61"	49"	139.70cm-154.94cm	124.46cm	6"SCH. 40	2.34°
62"-68"	56"	157.48cm-172.72cm	142.24cm	6"SCH. 40	2.06°
69"-75"	63"	175.26cm-190.50cm	160.02cm	8"SCH 40	2.50°
76"-82"	70"	193.04cm-208.28cm	177.80cm	8"SCH 40	2.46°
83"-89"	77"	210.82cm-226.06cm	195.58cm	8"SCH 40	2.23°
90"-96"	84"	228.60cm-243.84cm	213.36cm	8"SCH 40	2.06°
97"-103"	91"	246.38cm-261.62cm	231.14cm	10"SCH 40	2.50°
104"-109"	97"	264.16cm-276.86cm	246.38cm	10"SCH 40	2.35°
110"-116"	104"	279.40cm-294.64cm	264.16cm	10"SCH 40	2.23°

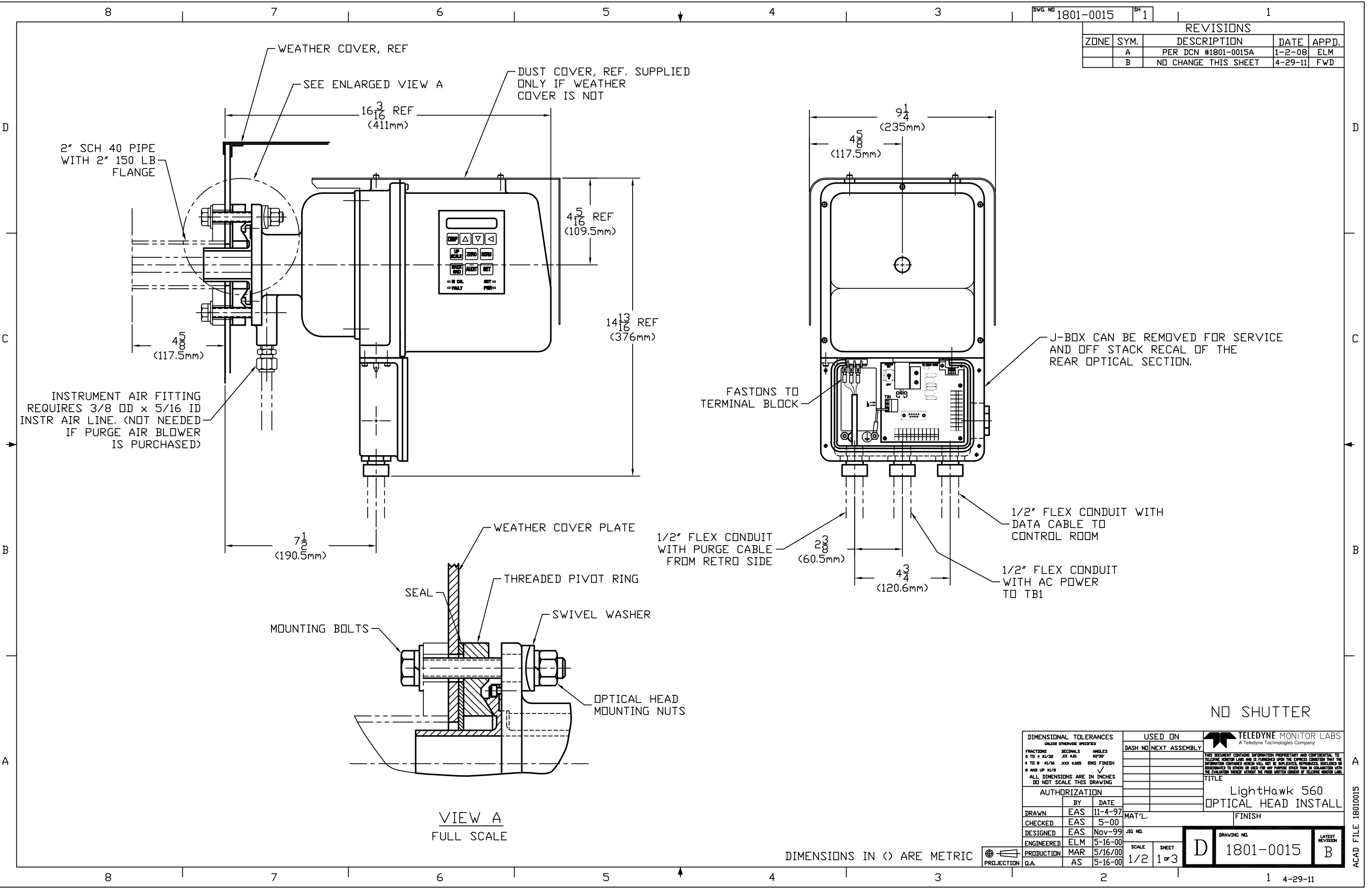
THIS CHART IS SUGGESTED PIPE SIZES FOR PORTS OVER 12" IN LENGTH. THIS WILL ALLOW A REASONABLE PORT TO PORT MISALIGNMENT. IF TIGHTER TOLERANCES CAN BE MET, PIPE SIZES CAN BE DECREASED. CONSULT FACTORY IF ASSISTANCE IS NEEDED

SEE SHEET 1 FOR NOTES

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE INSTRUMENTS MONITOR LABS	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEPHONE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPROCESSED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EQUIPMENT THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEPHONE MONITOR LABS.	
0 TO 4 ±1/32	.001 ±.01	-01	1860-0000	TITLE LightHawk 560 OPACITY MONITOR FLANGE MTG. METHODS	
4 TO 8 ±1/16	.002 ±.005			FINISH	
8 AND UP ±1/8	.005			MAT'L.	
AUTHORIZATION					
		BY	DATE		
DRAWN		EAS	9-30-99		
CHECKED		EAS	5-00		
DESIGNED		EAS	Sept-99		
ENGINEERED		ELM	5-16-00		
PRODUCTION		MAR	5/16/00		
Q.A.		AS	5-16-00		
		SCALE	SHEET	DRAWING NO.	
		1/2	2 OF 2	D 1800-0013	
				LATEST REVISION A	

PROJECTION

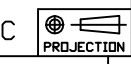
REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER DCN #1801-0015A	1-2-08	ELM
	B	NO CHANGE THIS SHEET	4-29-11	FWD



NO SHUTTER

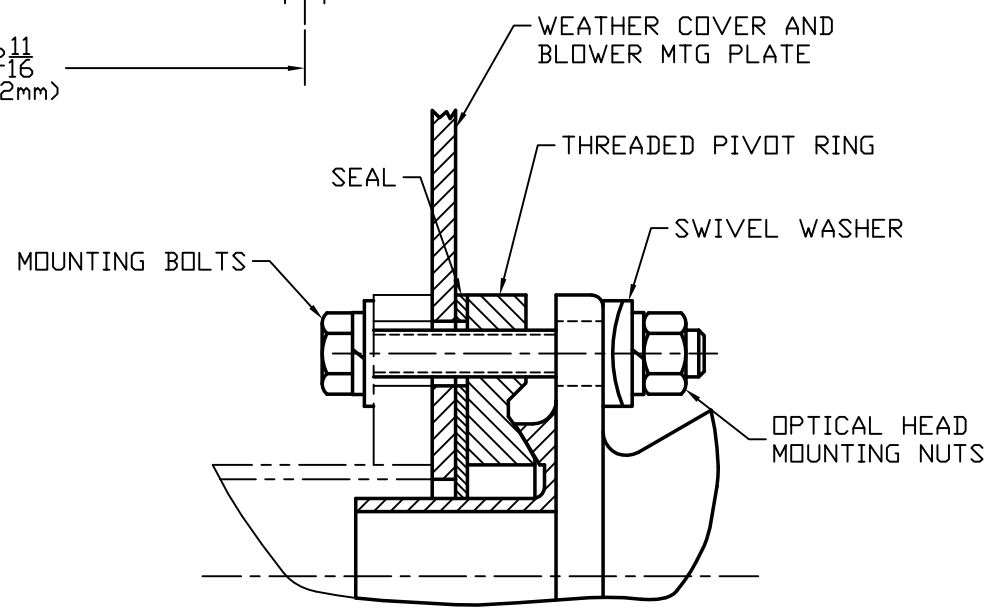
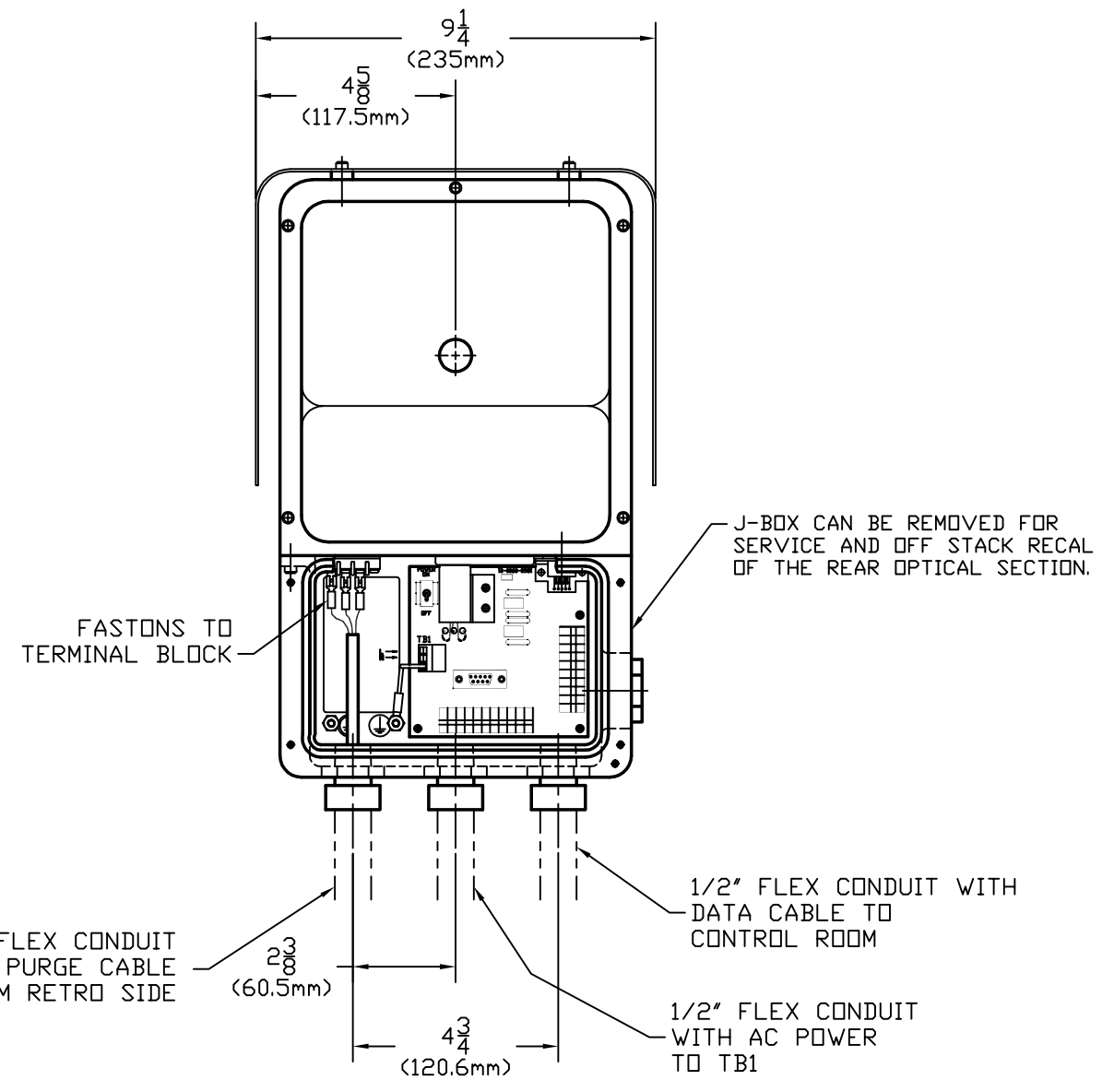
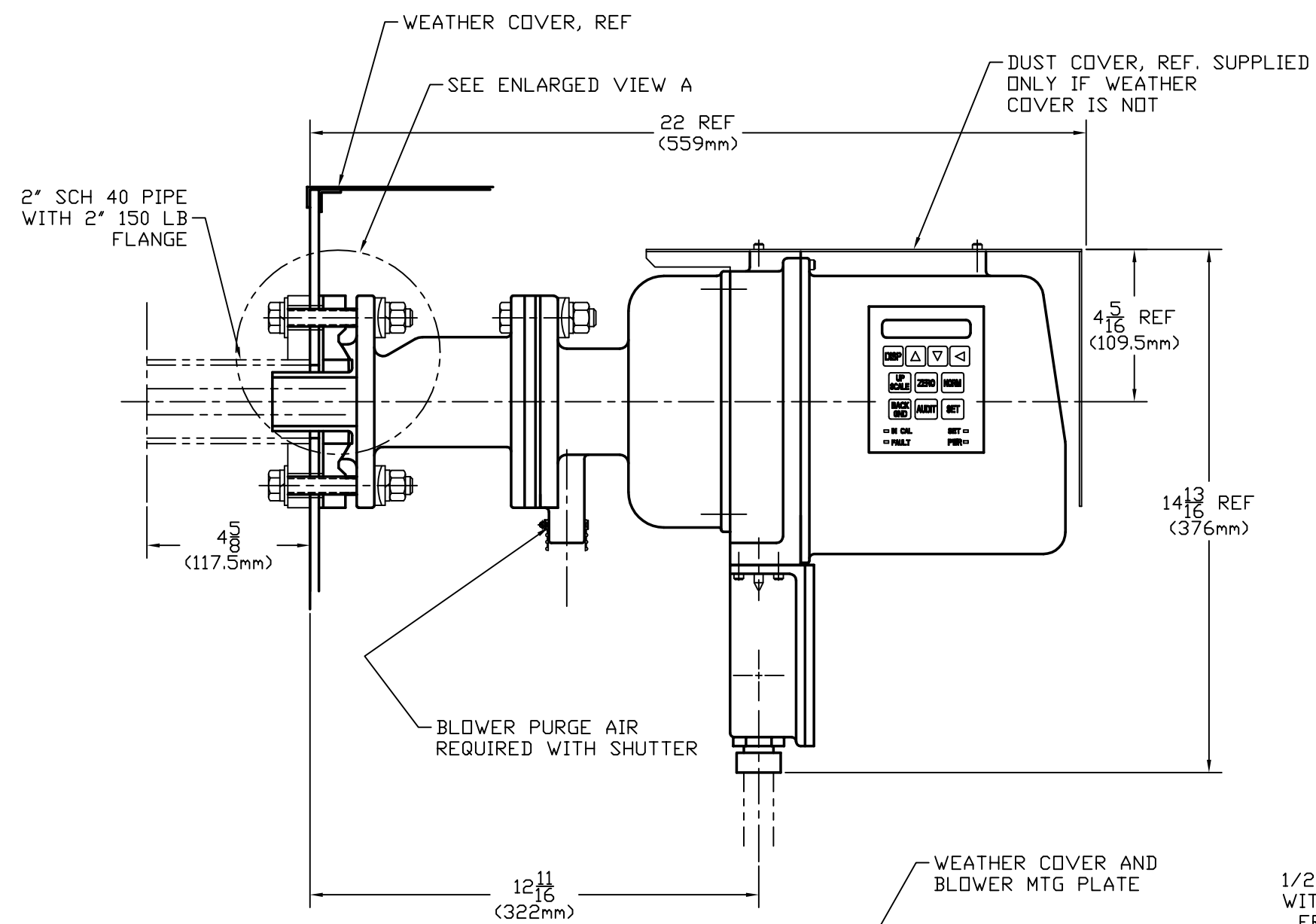
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DECIMALS ANGLES 0 TO 4 ±1/32 XX ±01 90°/30° 4 TO 8 ±1/16 XXX ±.005 RMS FINISH 8 AND UP ±1/8 ✓ ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING			USED ON DASH NO NEXT ASSEMBLY		TELEDYNE MONITOR LABS A Teledyne Technologies Company <small>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED WITH THE EXPRESS UNDERSTANDING THAT INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRODUCED, DISCLOSED OR REPRODUCED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.</small> TITLE LightHawk 560 OPTICAL HEAD INSTALL
AUTHORIZATION BY DATE DRAWN EAS 11-4-97 CHECKED EAS 5-00 DESIGNED EAS Nov-99 ENGINEERED ELM 5-16-00 PRODUCTION MAR 5/16/00 Q.A. AS 5-16-00			MAT'L. FINISH JIG NO. SCALE SHEET 1/2 1 of 3		
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DECIMALS ANGLES 0 TO 4 ±1/32 XX ±01 90°/30° 4 TO 8 ±1/16 XXX ±.005 RMS FINISH 8 AND UP ±1/8 ✓ ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING			DRAWING NO. D 1801-0015		LATEST REVISION B

DIMENSIONS IN () ARE METRIC



ACAD FILE 18010015

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER DCN #1801-0015A	1-2-08	ELM
	B	PER DCN #1801-0015B	4-29-11	FWD



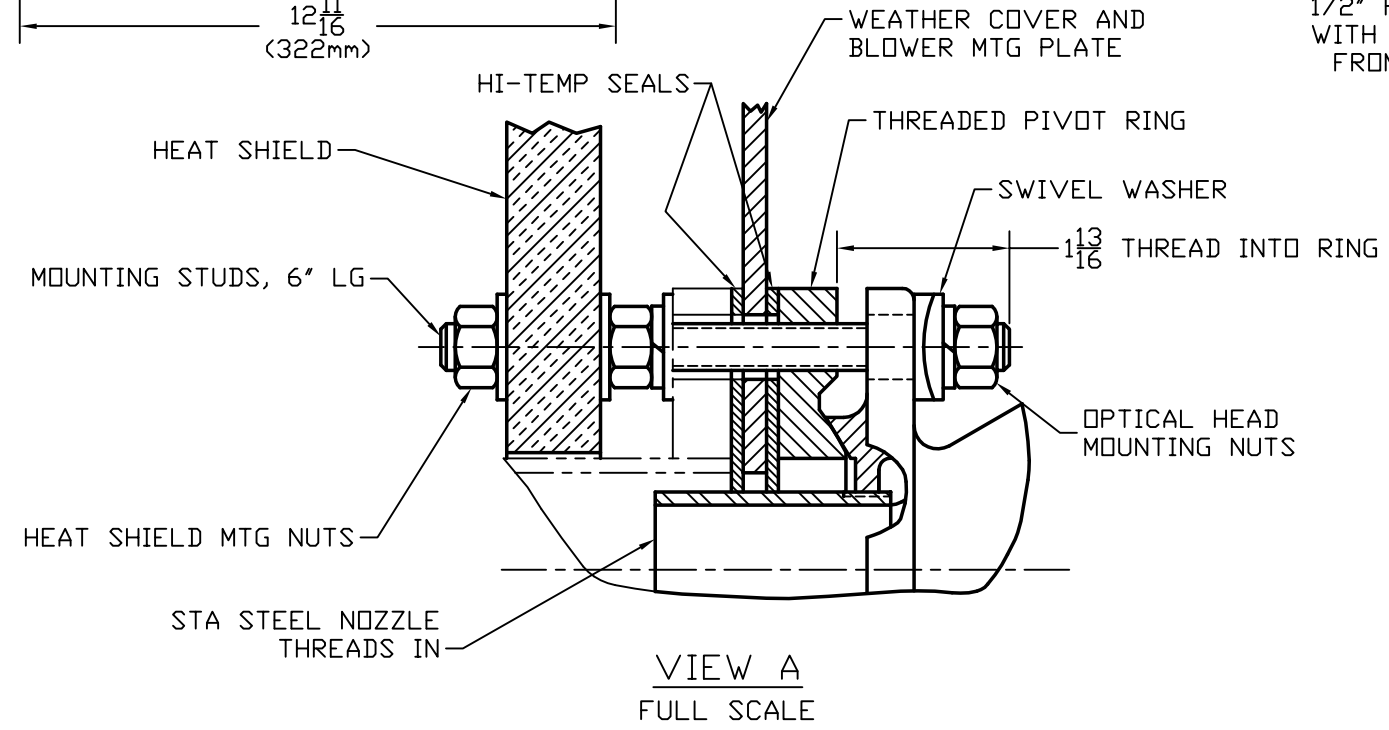
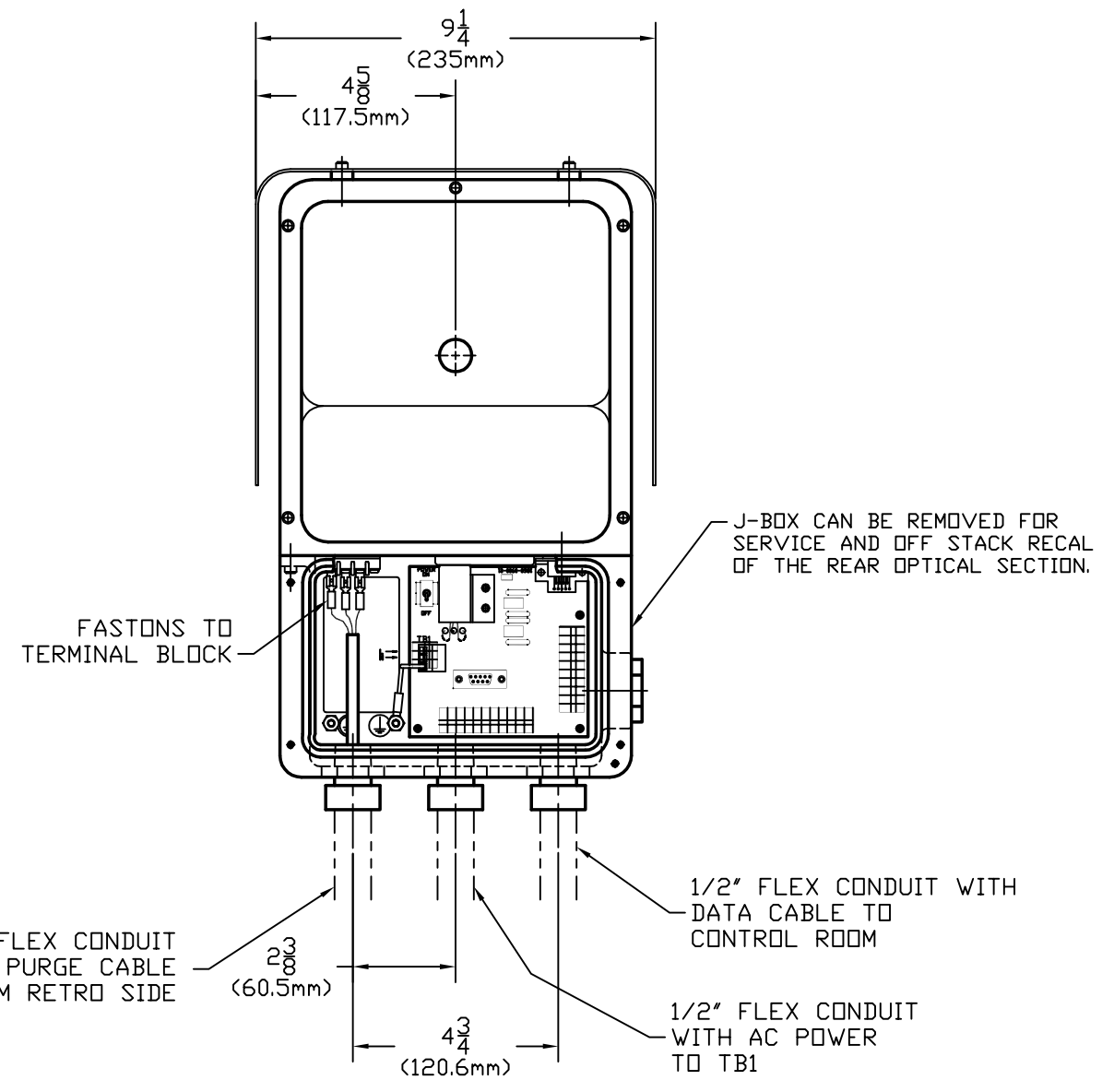
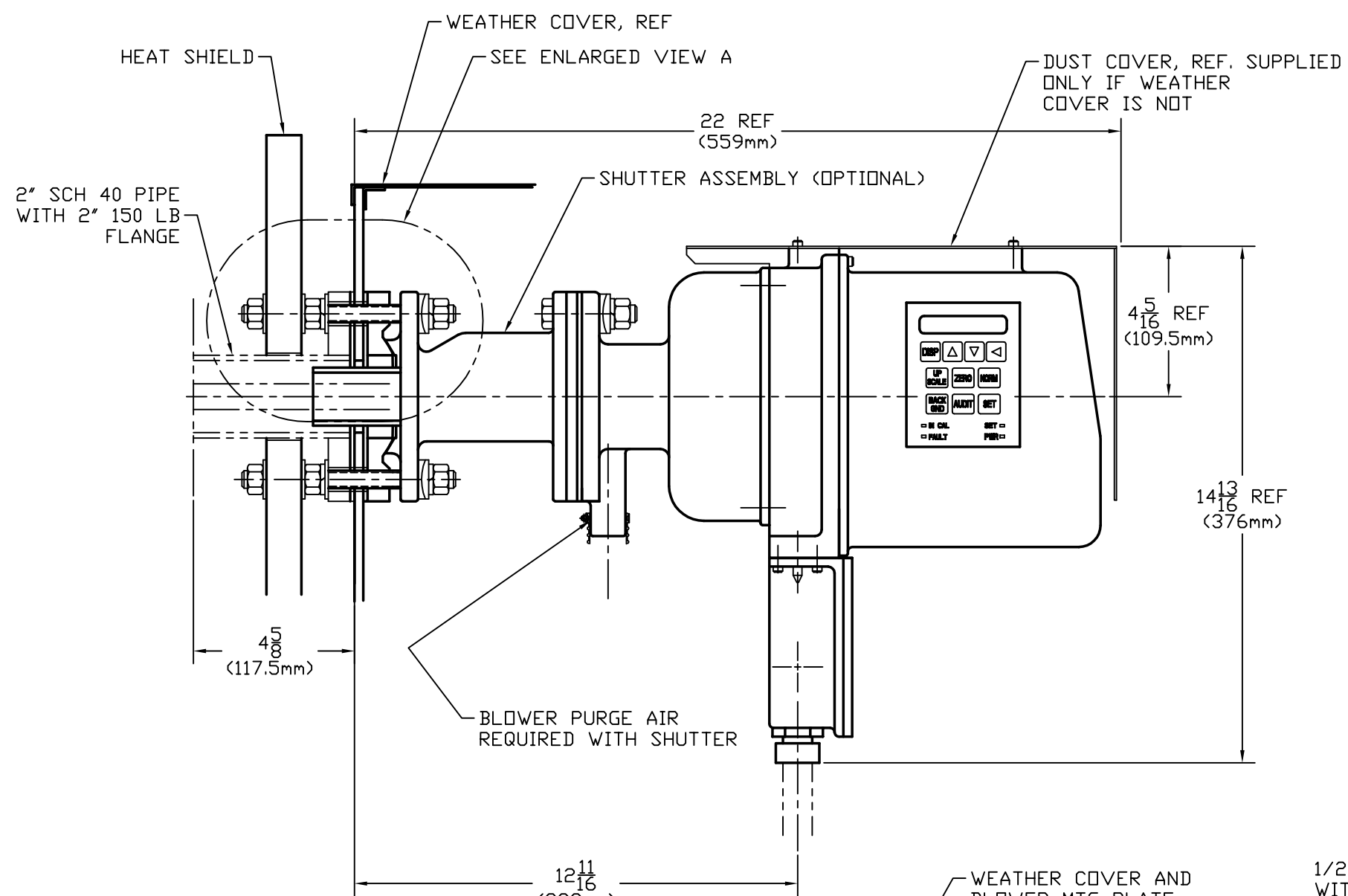
VIEW A
FULL SCALE

DIMENSIONS IN () ARE METRIC

WITH SHUTTER

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DECIMALS ANGLES 0 TO 4 ±1/32 .001 .01 4 TO 8 ±1/62 .0005 .005 RMS FINISH 8 AND UP ±1/8 .015 ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING			USED ON DASH NO NEXT ASSEMBLY		TELEDYNE INSTRUMENTS Monitor Labs A Teledyne Technologies Company <small>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE INSTRUMENTS LABS AND IS FURNISHED WITH THE EXPRESS UNDERSTANDING THAT INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, COPIED, DISCLOSED OR TRANSMITTED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE INSTRUMENTS LABS.</small>
AUTHORIZATION BY DATE DRAWN EAS 8-19-99 CHECKED EAS 5-00 DESIGNED EAS Aug-99 ENGINEERED ELM 5-16-00 PRODUCTION MAR 5/16/00 Q.A. AS 5-16-00			MAT'L. FINISH JIG NO. SCALE SHEET 1/2 2 OF 3		
DRAWING NO. 1801-0015 SHEET 2 OF 3			LATEST REVISION B		DATE 4-29-11

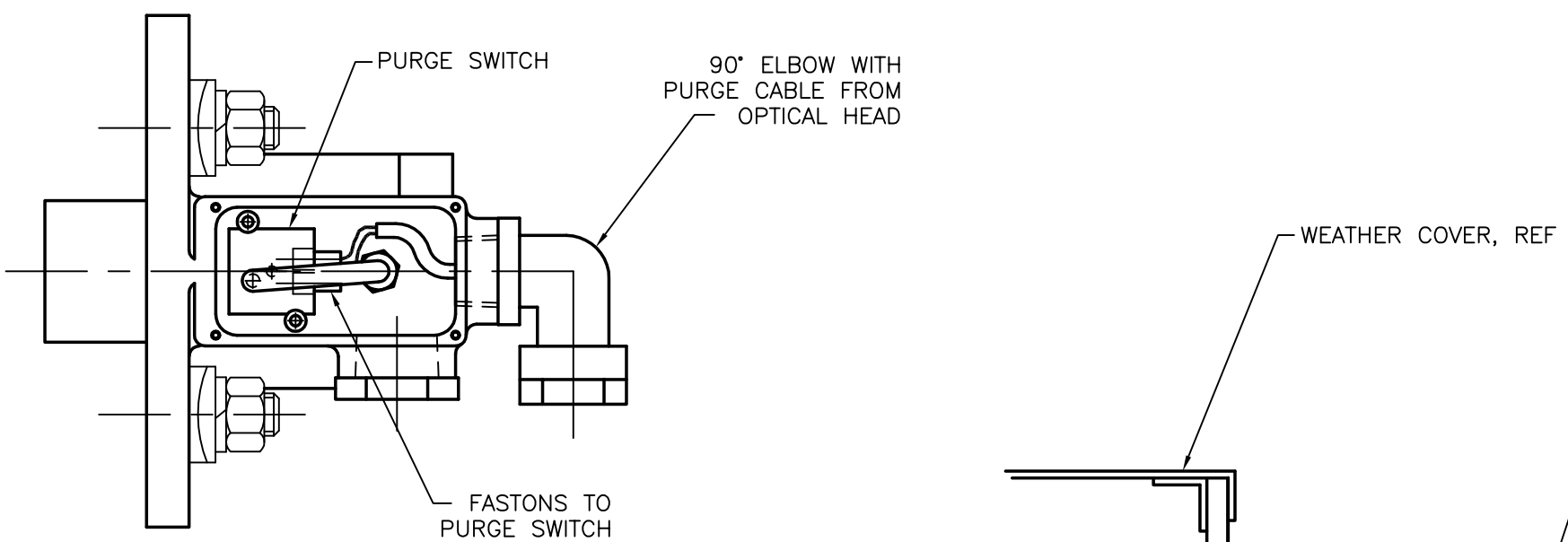
REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER DCN #1801-0015A	1-2-08	ELM
	B	PER DCN #1801-0015B	4-29-11	FWD



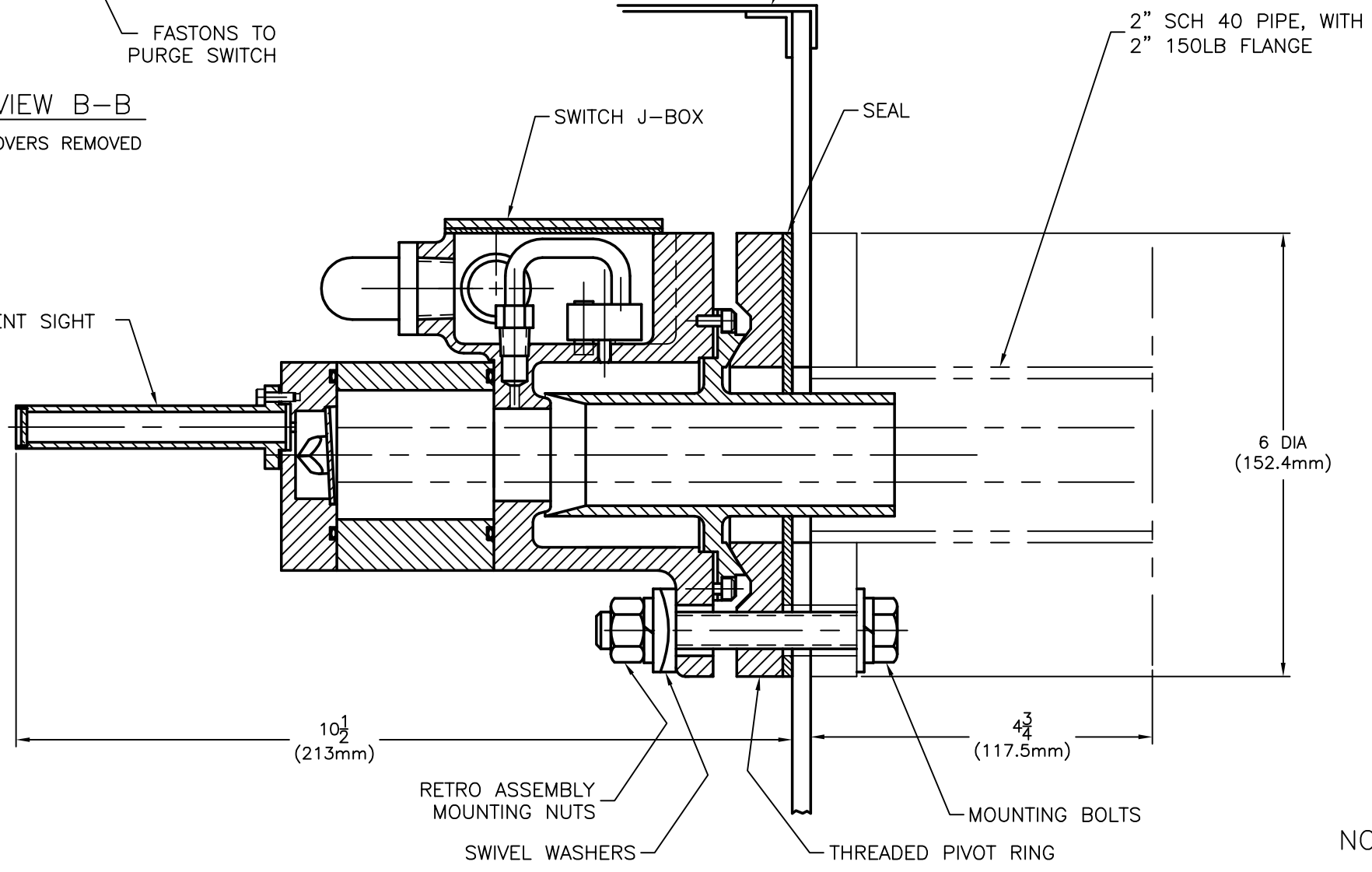
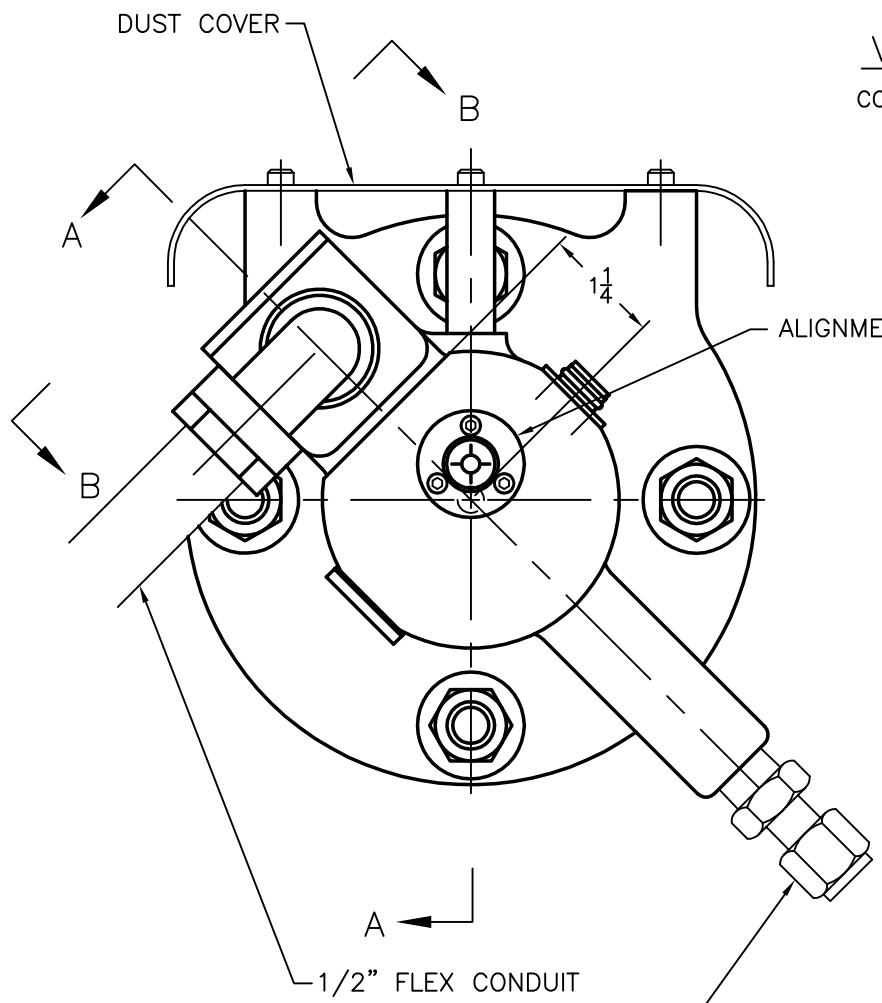
DIMENSIONS IN () ARE METRIC

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DECIMALS ANGLES 0 TO 4 ±1/32 .005 ±.01 90°/30° 4 TO 8 ±1/16 .005 ±.005 RMS FINISH 8 AND UP ±1/8 .010 ±.010 RMS FINISH ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING		USED ON DASH NO NEXT ASSEMBLY		TELEDYNE INSTRUMENTS Monitor Labs A Teledyne Technologies Company <small>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE INSTRUMENTS LABS AND IS FURNISHED HEREIN UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN SHALL NOT BE REPRODUCED, REPAIRED, DISCLOSED OR TRANSMITTED IN ANY MANNER OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE INSTRUMENTS LABS.</small>	
AUTHORIZATION BY DATE DRAWN EAS 8-19-99 CHECKED EAS 5-00 DESIGNED EAS Aug-99 ENGINEERED ELM 5-16-00 PRODUCTION MAR 5/16/00 Q.A. AS 5-16-00		MAT'L. FINISH JIG NO. SCALE SHEET 1/2 3 OF 3		LightHawk 560 OPTICAL HEAD INSTALL DRAWING NO. 1801-0015 LATEST REVISION B	

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
A		PER DCN #1802-0015A	4-14-00	ELM
B		PER DCN #1802-0015B	1-2-08	ELM
C		PER DCN #1802-0015C	10-01-08	ELM
D		NO CHANGE THIS SHEET	4-28-11	FWD



VIEW B-B
COVERS REMOVED



SECTION A-A

NO SHUTTER

PURGE AIR FITTING, REQUIRES 3/8 OD x 1/4 ID INSTR AIR LINE. (NOT NEEDED IF PURGE AIR BLOWER IS PURCHASED)

DIMENSIONS IN () ARE METRIC

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DECIMALS	ANGLES
9 TO 4 ±1/32	JXX ±.01	±30°
4 TO 8 ±1/16	JXX ±.005	RMS FINISH
8 AND UP ±1/8		
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING		

USED ON	
DASH NO	NEXT ASSEMBLY
-01	

TELEDYNE MONITOR LABS
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TITLE
**LIGHTHAWK 560
RETRO INSTALLATION**

FINISH

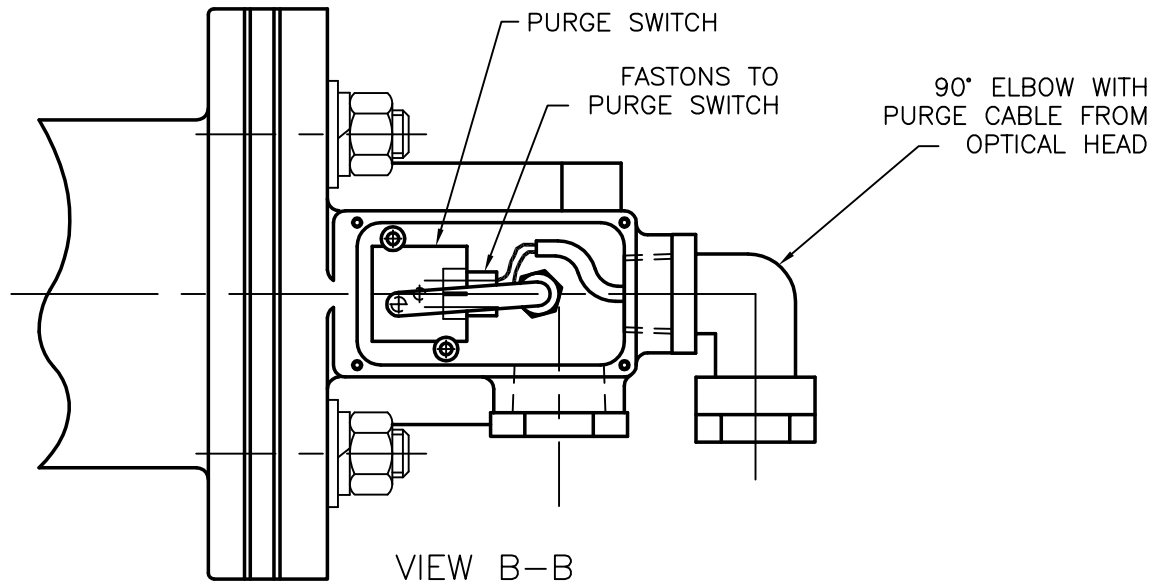
DRAWING NO. **D 1802-0015** LATEST REVISION **D**

AUTHORIZATION		
BY	DATE	
DRAWN EAS	11-4-97	
CHECKED EAS	5-00	
DESIGNED EAS	NOV-99	
ENGINEERED ELM	5-16-00	
PRODUCTION MAR	5/16/00	
Q.A. AS	5-16-00	

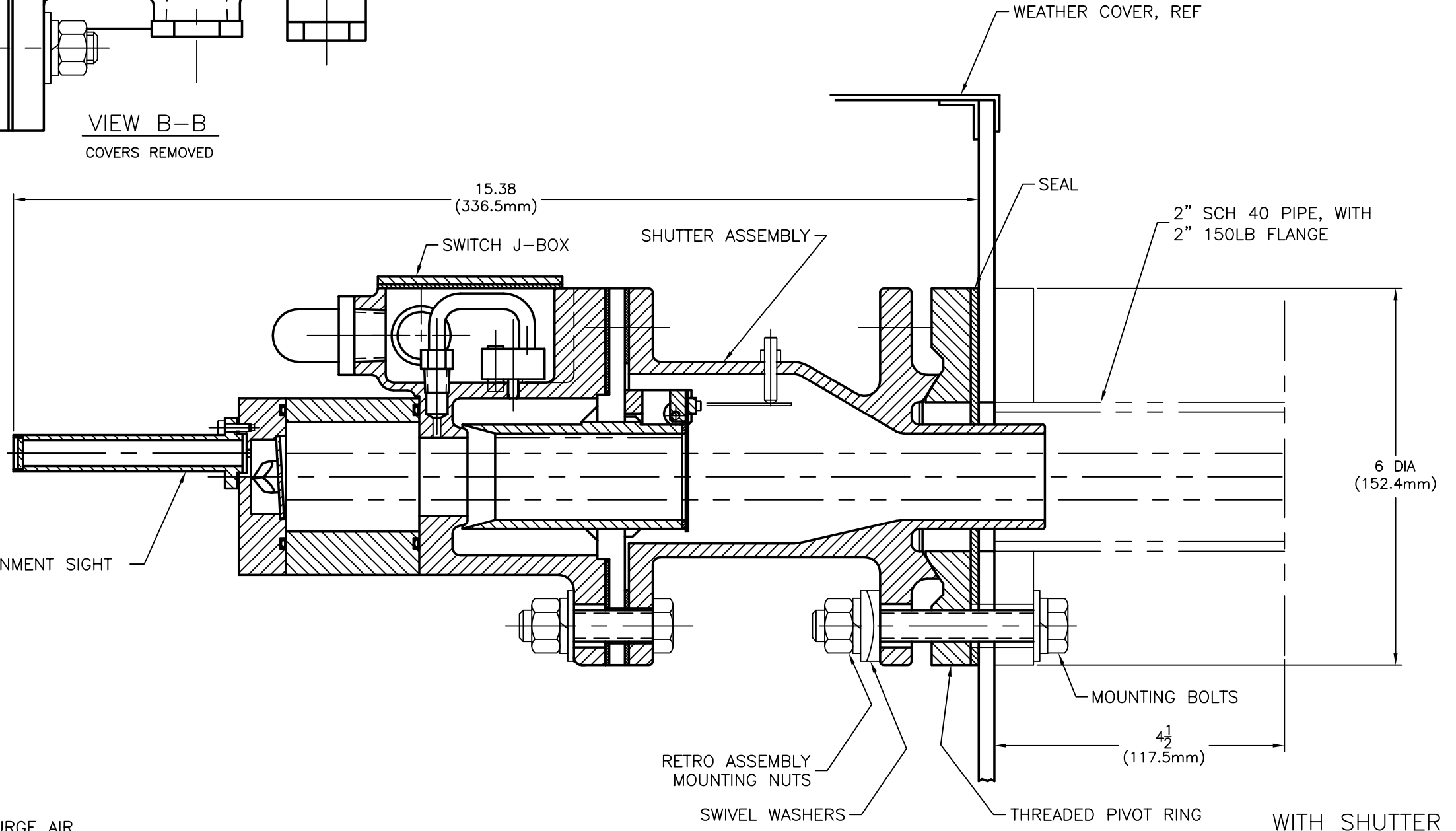
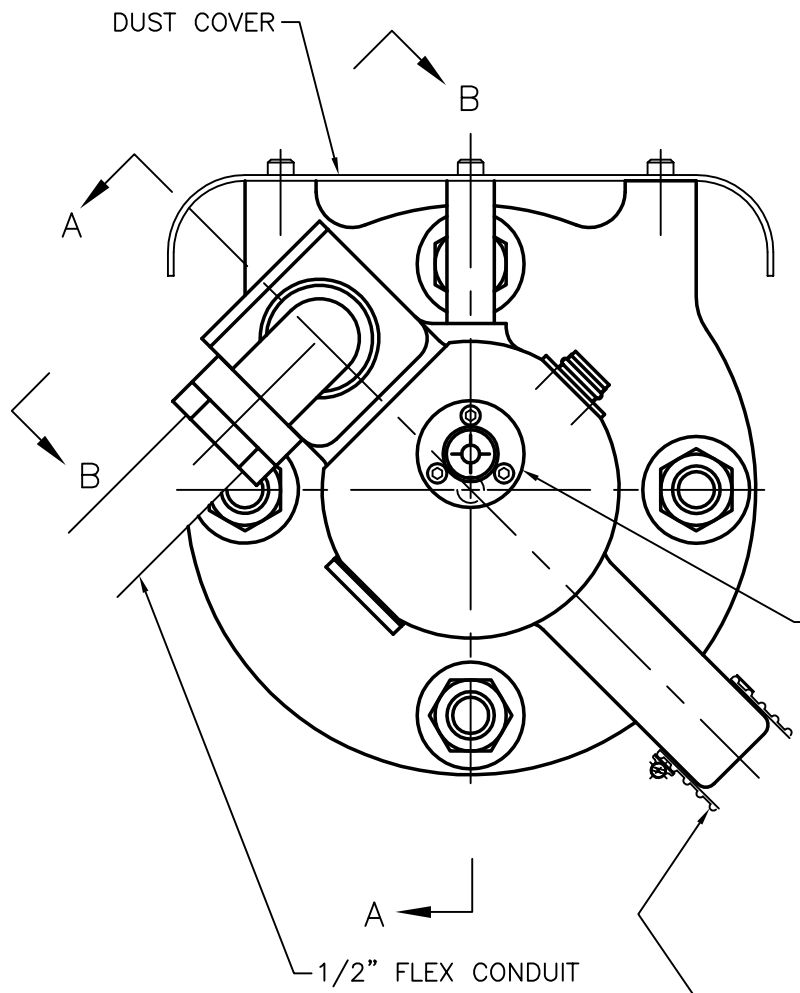
SCALE	SHEET
1:1	1 OF 3



REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
A		PER DCN #1802-0015A	4-14-00	ELM
B		PER DCN #1802-0015B	1-2-08	ELM
C		PER DCN #1802-0015C	10-01-08	ELM
D		NO CHANGE THIS SHEET	4-28-11	FWD



VIEW B-B
COVERS REMOVED



SECTION A-A

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			USED ON	
FRACTIONS	DECIMALS	ANGLES	DASH NO	NEXT ASSEMBLY
9 TO 4 ±1/32	JXX ±.01	±30°	-01	
4 TO 8 ±1/16	JXX ±.005	RMS FINISH		
8 AND UP ±1/8				
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING				
AUTHORIZATION				
BY	DATE			
DRAWN	EAS	11-4-97		
CHECKED	EAS	5-00		
DESIGNED	EAS	NOV-99		
ENGINEERED	ELM	5-16-00		
PRODUCTION	MAR	5/16/00		
Q.A.	AS	5-16-00		
MATERIAL			FINISH	
SCALE			SHEET	
1:1			2 OF 3	

TELEDYNE MONITOR LABS
A Teledyne Technologies Company

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TITLE
**LIGHTHAWK 560
RETRO INSTALLATION**

DRAWING NO. **1802-0015** LATEST REVISION **D**

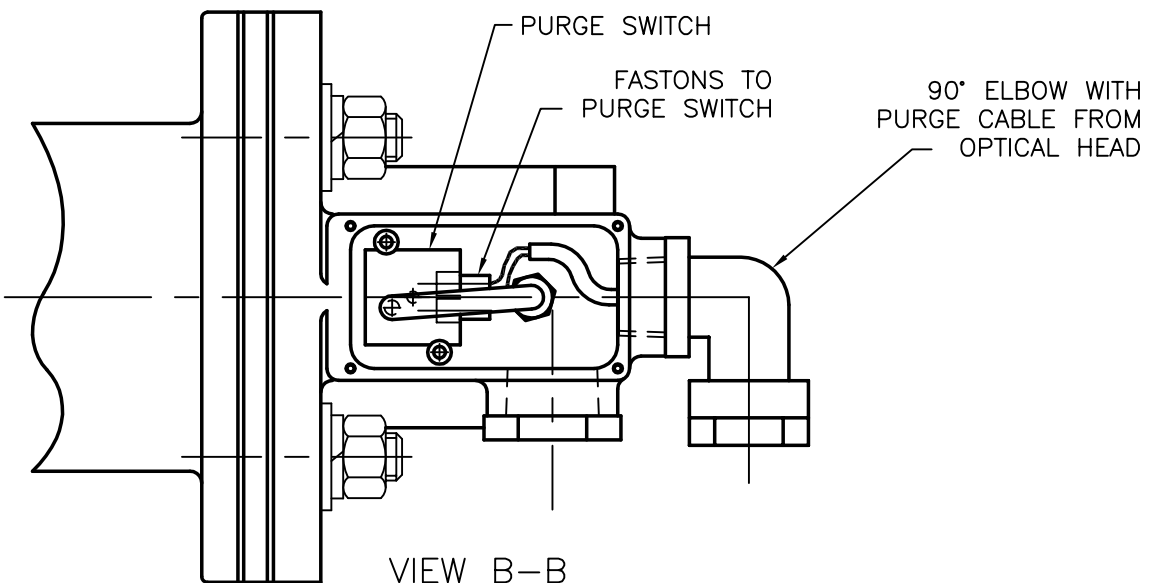
DIMENSIONS IN () ARE METRIC



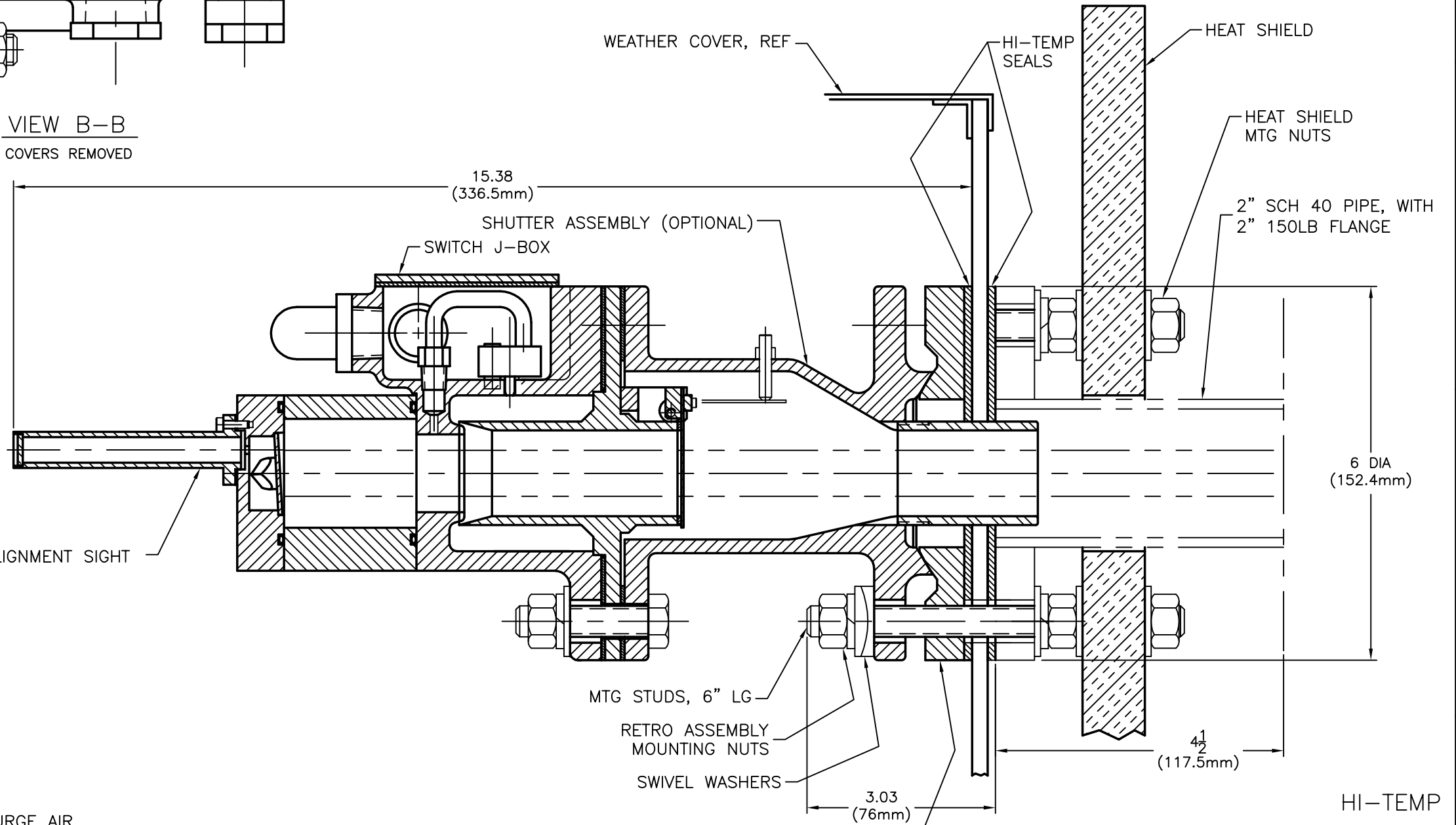
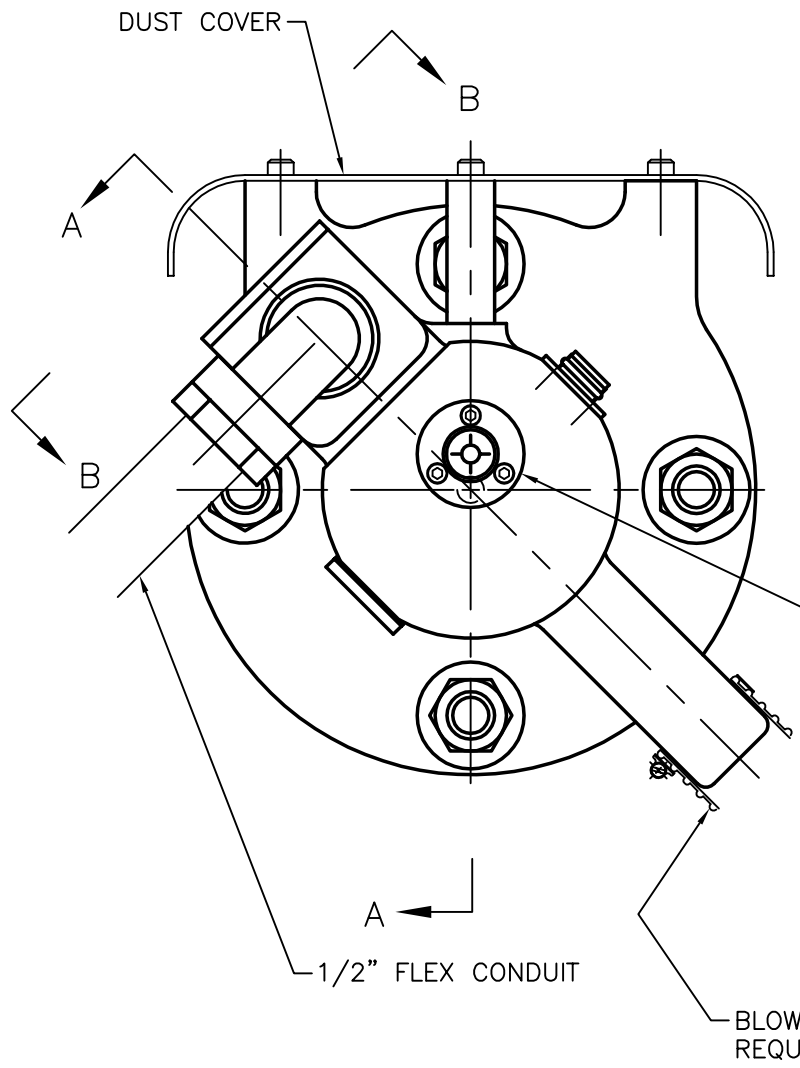
PROJECTION

ACAD 18020015-MS

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
A		PER DCN #1802-0015A	4-14-00	ELM
B		PER DCN #1802-0015B	1-2-08	ELM
C		PER DCN #1802-0015C	10-01-08	ELM
D		PER DCN #1802-0015D	4-28-11	FWD



VIEW B-B
COVERS REMOVED



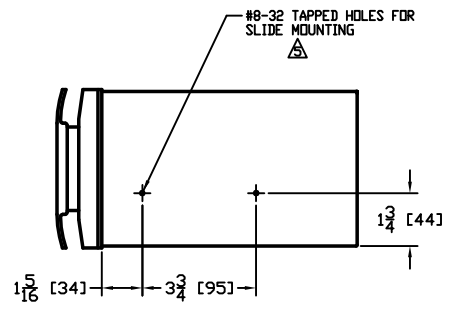
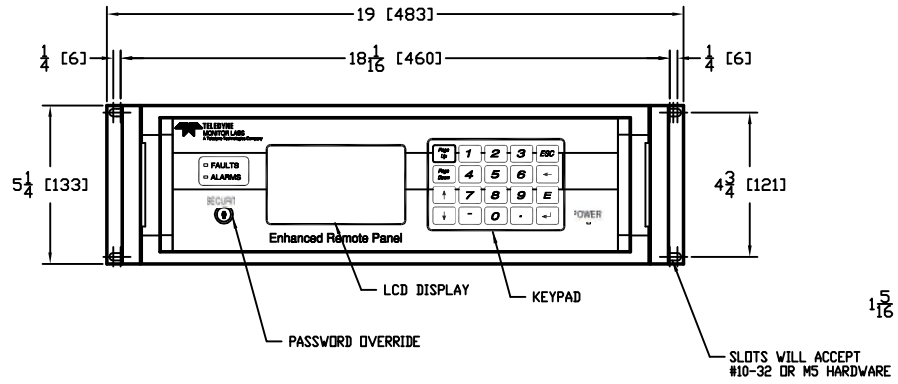
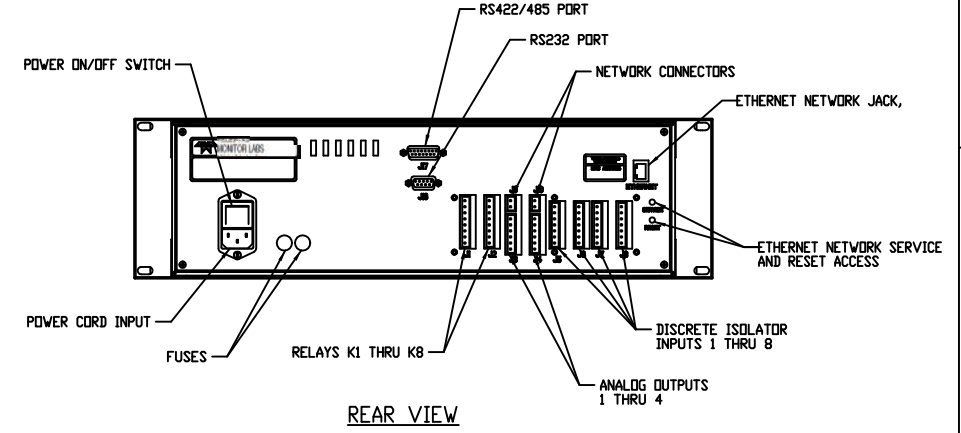
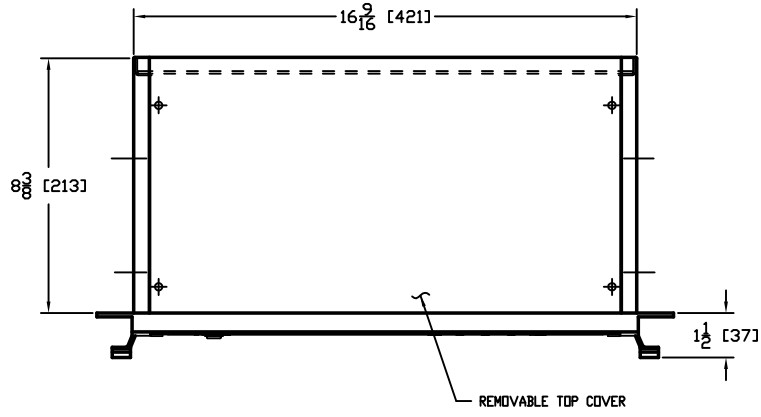
SECTION A-A

DIMENSIONS IN () ARE METRIC

<p>DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED</p> <p>FRACTIONS 9 TO 4 ±1/32 JOC ±.01 ANGLES 45°/30°</p> <p>4 TO 8 ±1/16 JOC ±.005 RMS FINISH</p> <p>8 AND UP ±1/8</p> <p>ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING</p>		<p>USED ON</p> <p>DASH NO NEXT ASSEMBLY</p> <p>-01</p>		<p>TELEDYNE MONITOR LABS A Teledyne Technologies Company</p> <p>THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UPON THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE EMPLOYED, REPRODUCED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION THEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.</p>															
<p>AUTHORIZATION</p> <table border="1"> <tr> <th>BY</th> <th>DATE</th> </tr> <tr> <td>EAS</td> <td>11-4-97</td> </tr> <tr> <td>EAS</td> <td>5-00</td> </tr> <tr> <td>EAS</td> <td>NOV-99</td> </tr> <tr> <td>ELM</td> <td>5-16-00</td> </tr> <tr> <td>MAR</td> <td>5/16/00</td> </tr> <tr> <td>AS</td> <td>5-16-00</td> </tr> </table>		BY	DATE	EAS	11-4-97	EAS	5-00	EAS	NOV-99	ELM	5-16-00	MAR	5/16/00	AS	5-16-00	<p>TITLE</p> <p>LIGHTHAWK 560 RETRO INSTALLATION</p>		<p>MAT'L. FINISH</p>	
BY	DATE																		
EAS	11-4-97																		
EAS	5-00																		
EAS	NOV-99																		
ELM	5-16-00																		
MAR	5/16/00																		
AS	5-16-00																		
<p>DRAWN</p>		<p>JIG NO.</p>		<p>SCALE</p>															
<p>CHECKED</p>		<p>SCALE</p>		<p>SHEET</p>															
<p>DESIGNED</p>		<p>SCALE</p>		<p>3 OF 3</p>															
<p>ENGINEERED</p>		<p>SCALE</p>		<p>1:1</p>															
<p>PRODUCTION</p>		<p>SCALE</p>		<p>1:1</p>															
<p>Q.A.</p>		<p>SCALE</p>		<p>1:1</p>															

DRAWING NO.	LATEST REVISION
1802-0015	D

REVISONS		DATE	APPD.
B	PER DCN #1803-2003B	7-16-02	ELM
C	PER DCN 1803-2003C	4-1-03	DMB
D	PER DCN 1803-2003D	12-4-06	DMB
E	PER DCN 1803-2003E	6-1-07	ELM
F	PER DCN 1803-2003F	10-7-08	ELM
G	PER DCN 1803-2003G	9-6-11	ELM

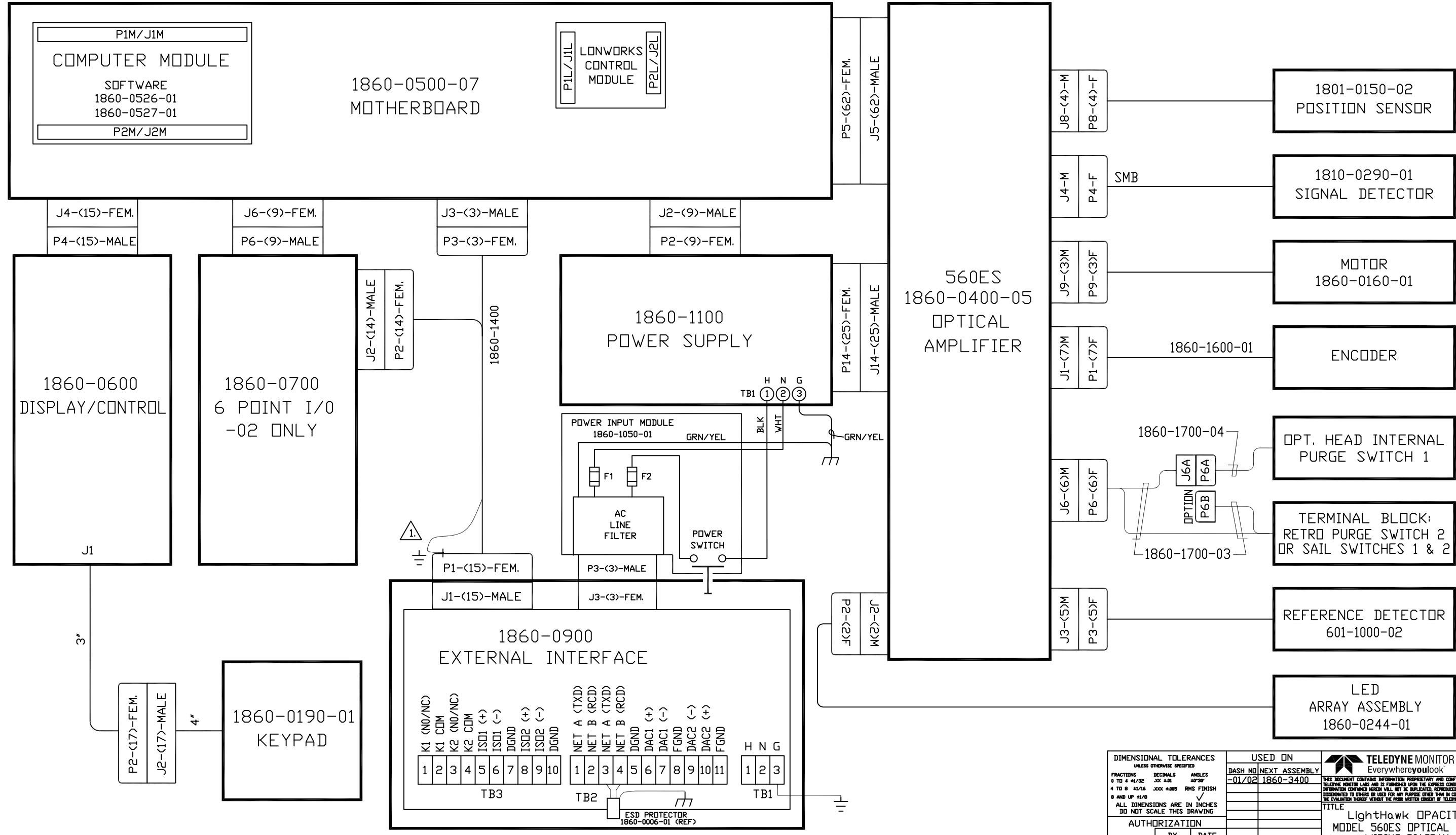


- △ SLIDES ARE AVAILABLE AS AN OPTION. CONSULT FACTORY
 - 4
 - 3 MINIMUM REAR CLEARANCE 5"(127mm)
 - 2 DIMENSIONS IN Ø ARE METRIC
 - 1 DISPLAY FITS IN STANDARD 19"(482.6mm) RACK MOUNT, 5-1/4" (3U) HIGH CHASSIS
- NOTE:

CUSTOMER OUTLINE DRAWING

TELEDYNE MONITOR LABS A Teledyne Technologies Company		
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRACTIONS DECIMALS ANGLES 0 TO 4 0.005 0.012 0.005 4 TO 10 0.010 0.015 0.005 10 TO 30 0.015 0.020 0.005 30 TO 100 0.020 0.025 0.005 100 TO 300 0.030 0.035 0.005 300 TO 1000 0.040 0.045 0.005 ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THESE DRAWINGS	USED ON DASH NO. NEXT ASSEMBLY -02	
AUTHORIZATION BY DATE EAS 16-JUL-02 EAS 7-18-02 EAS JUL-02 ELM 7-24-02 PD 7-24-02 AS 7-24-02		TITLE TML ENHANCED REMOTE PANEL ASSEMBLY, W/NEW CASE FINISH
DRAWN EAS 16-JUL-02 CHECKED EAS 7-18-02 DESIGNED EAS JUL-02 ENGINEERED ELM 7-24-02 PRODUCTION PD 7-24-02 PQA AS 7-24-02	SCALE SHEET 1/2 2 OF 2	DRAWING NO. 1803-2003 SHEET NO. G

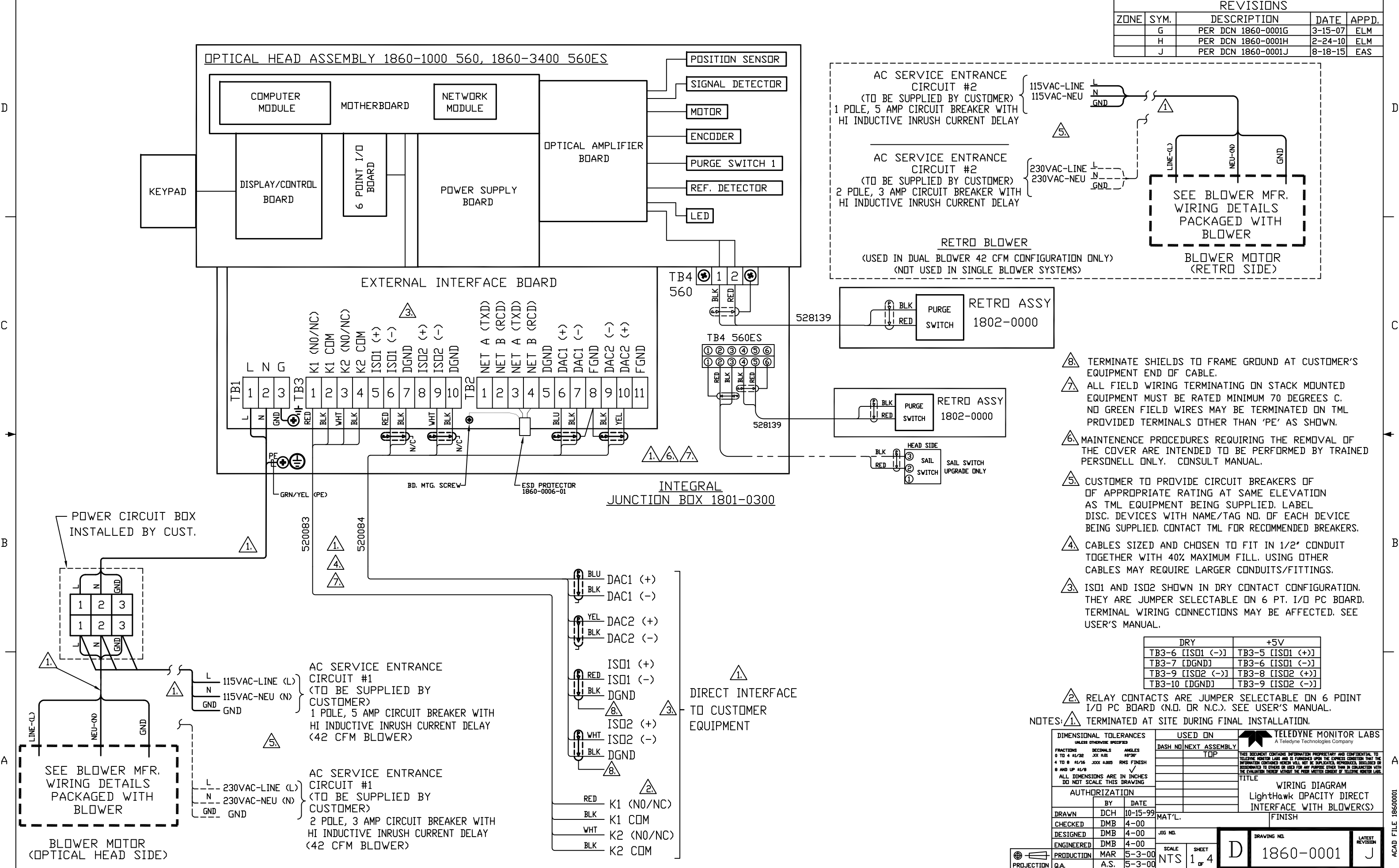
REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	RELEASE FOR PRODUCTION PER ECO# 1330	9/24/14	EAS



NOTES: 1. TERMINATE DRAIN WIRE(S) TO LONGER MOUNTING SCREW OF THIS CONNECTOR, WITH NUT AND WASHER.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE MONITOR LABS Everywhere you look	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELE-DYNE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRINTER, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION HEREOF WITHOUT THE WRITTEN CONSENT OF TELE-DYNE MONITOR LABS.	
0 TO 4 41/32	.001	-01/02	1860-3400	TITLE	
4 TO 8 1/16	.002			LightHawk OPACITY	
8 AND UP 1/8	.005			MODEL 560ES OPTICAL HEAD	
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING				WIRING DIAGRAM	
AUTHORIZATION				FINISH	
DRAWN	DCH	DATE	8-16-13		
CHECKED	EAS	DATE	Oct-14		
DESIGNED	DCH	DATE	8-16-13		
ENGINEERED	EAS	DATE	Oct-14		
PRODUCTION	NA				
Q.A.	NA				
SCALE		SHEET		DRAWING NO.	
N/A		2 of 2		1860-3450	
				LATEST REVISION	
				A	

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	G	PER DCN 1860-0001G	3-15-07	ELM
	H	PER DCN 1860-0001H	2-24-10	ELM
	J	PER DCN 1860-0001J	8-18-15	EAS



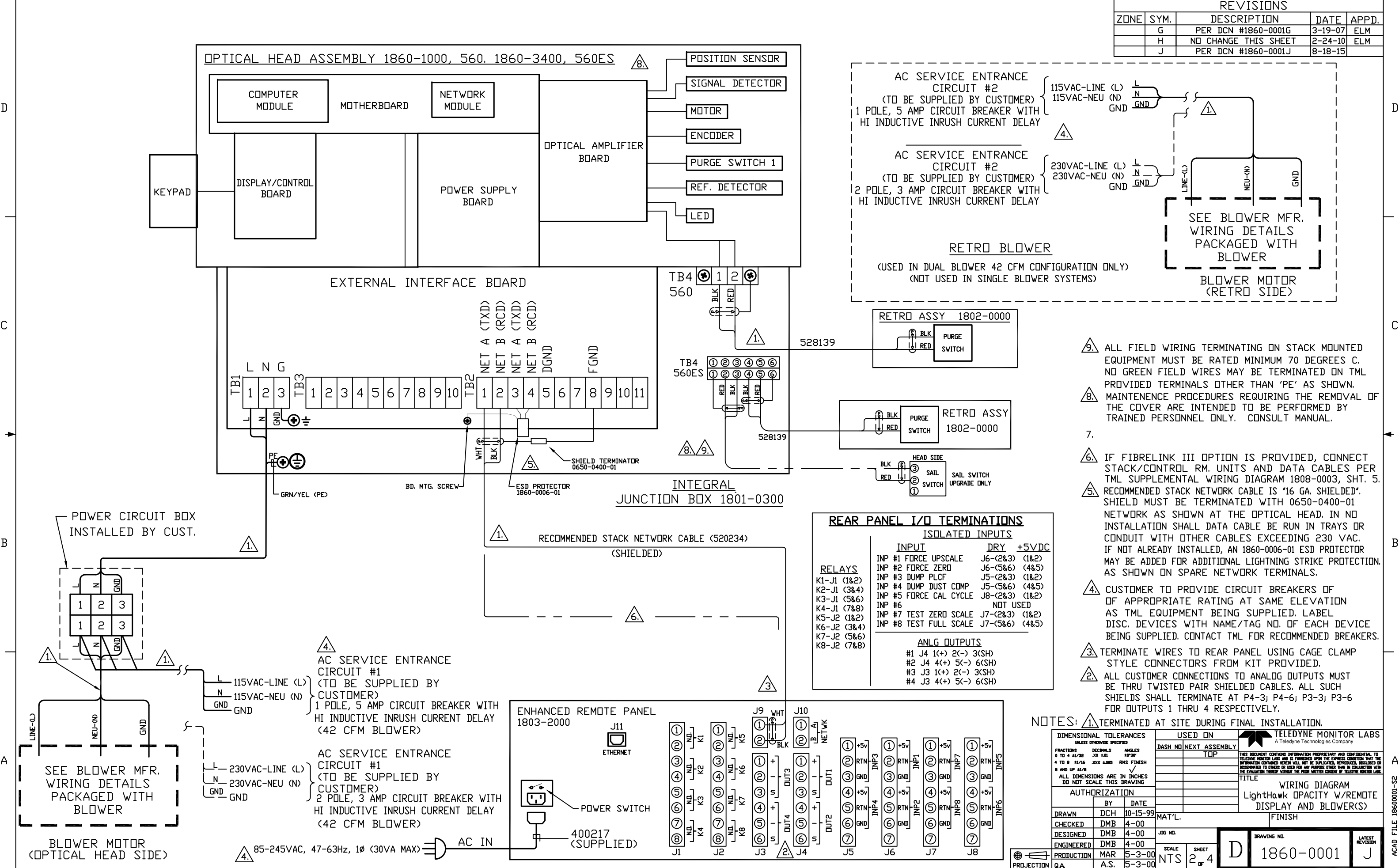
- Ⓐ TERMINATE SHIELDS TO FRAME GROUND AT CUSTOMER'S EQUIPMENT END OF CABLE.
- Ⓙ ALL FIELD WIRING TERMINATING ON STACK MOUNTED EQUIPMENT MUST BE RATED MINIMUM 70 DEGREES C. NO GREEN FIELD WIRES MAY BE TERMINATED ON TML PROVIDED TERMINALS OTHER THAN 'PE' AS SHOWN.
- Ⓜ MAINTENANCE PROCEDURES REQUIRING THE REMOVAL OF THE COVER ARE INTENDED TO BE PERFORMED BY TRAINED PERSONNEL ONLY. CONSULT MANUAL.
- Ⓝ CUSTOMER TO PROVIDE CIRCUIT BREAKERS OF APPROPRIATE RATING AT SAME ELEVATION AS TML EQUIPMENT BEING SUPPLIED. LABEL DISC. DEVICES WITH NAME/TAG NO. OF EACH DEVICE BEING SUPPLIED. CONTACT TML FOR RECOMMENDED BREAKERS.
- Ⓓ CABLES SIZED AND CHOSEN TO FIT IN 1/2" CONDUIT TOGETHER WITH 40% MAXIMUM FILL. USING OTHER CABLES MAY REQUIRE LARGER CONDUITS/FITTINGS.
- Ⓜ ISO1 AND ISO2 SHOWN IN DRY CONTACT CONFIGURATION. THEY ARE JUMPER SELECTABLE ON 6 PT. I/O PC BOARD. TERMINAL WIRING CONNECTIONS MAY BE AFFECTED. SEE USER'S MANUAL.

DRY	+5V
TB3-6 [ISO1 (-)]	TB3-5 [ISO1 (+)]
TB3-7 [DGND]	TB3-6 [ISO1 (-)]
TB3-9 [ISO2 (-)]	TB3-8 [ISO2 (+)]
TB3-10 [DGND]	TB3-9 [ISO2 (-)]

NOTES: Ⓐ RELAY CONTACTS ARE JUMPER SELECTABLE ON 6 POINT I/O PC BOARD (N.O. OR N.C.). SEE USER'S MANUAL.
 Ⓜ TERMINATED AT SITE DURING FINAL INSTALLATION.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE MONITOR LABS A Teledyne Technologies Company	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	TOP	
0 TO 4 41/32	.XX .01			THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRICED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN BY CONTRACTOR WITH THE EVALUATION HEREBY WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.	
4 TO 8 41/16	.XX .005			TITLE	
8 AND UP 41/8	.XX .0025			WIRING DIAGRAM	
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING					
AUTHORIZATION					
DRAWN BY DCH DATE 10-15-99					
CHECKED BY DMB DATE 4-00					
DESIGNED BY DMB DATE 4-00					
ENGINEERED BY DMB DATE 4-00					
PRODUCTION BY MAR DATE 5-3-00					
Q.A. BY A.S. DATE 5-3-00					
SCALE NTS				SHEET 1 OF 4	
DRAWING NO. 1860-0001				LATEST REVISION J	

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	G	PER DCN #1860-0001G	3-19-07	ELM
	H	NO CHANGE THIS SHEET	2-24-10	ELM
	J	PER DCN #1860-0001J	8-18-15	



- 9. ALL FIELD WIRING TERMINATING ON STACK MOUNTED EQUIPMENT MUST BE RATED MINIMUM 70 DEGREES C. NO GREEN FIELD WIRES MAY BE TERMINATED ON TML PROVIDED TERMINALS OTHER THAN 'PE' AS SHOWN.
- 8. MAINTENANCE PROCEDURES REQUIRING THE REMOVAL OF THE COVER ARE INTENDED TO BE PERFORMED BY TRAINED PERSONNEL ONLY. CONSULT MANUAL.
- 7.
- 6. IF FIBRELINK III OPTION IS PROVIDED, CONNECT STACK/CONTROL RM. UNITS AND DATA CABLES PER TML SUPPLEMENTAL WIRING DIAGRAM 1808-0003, SHT. 5.
- 5. RECOMMENDED STACK NETWORK CABLE IS '16 GA. SHIELDED'. SHIELD MUST BE TERMINATED WITH 0650-0400-01 NETWORK AS SHOWN AT THE OPTICAL HEAD. IN NO INSTALLATION SHALL DATA CABLE BE RUN IN TRAYS OR CONDUIT WITH OTHER CABLES EXCEEDING 230 VAC. IF NOT ALREADY INSTALLED, AN 1860-0006-01 ESD PROTECTOR MAY BE ADDED FOR ADDITIONAL LIGHTNING STRIKE PROTECTION. AS SHOWN ON SPARE NETWORK TERMINALS.
- 4. CUSTOMER TO PROVIDE CIRCUIT BREAKERS OF APPROPRIATE RATING AT SAME ELEVATION AS TML EQUIPMENT BEING SUPPLIED. LABEL DISC. DEVICES WITH NAME/TAG NO. OF EACH DEVICE BEING SUPPLIED. CONTACT TML FOR RECOMMENDED BREAKERS.
- 3. TERMINATE WIRES TO REAR PANEL USING CAGE CLAMP STYLE CONNECTORS FROM KIT PROVIDED.
- 2. ALL CUSTOMER CONNECTIONS TO ANALOG OUTPUTS MUST BE THRU TWISTED PAIR SHIELDED CABLES. ALL SUCH SHIELDS SHALL TERMINATE AT P4-3; P4-6; P3-3; P3-6 FOR OUTPUTS 1 THRU 4 RESPECTIVELY.

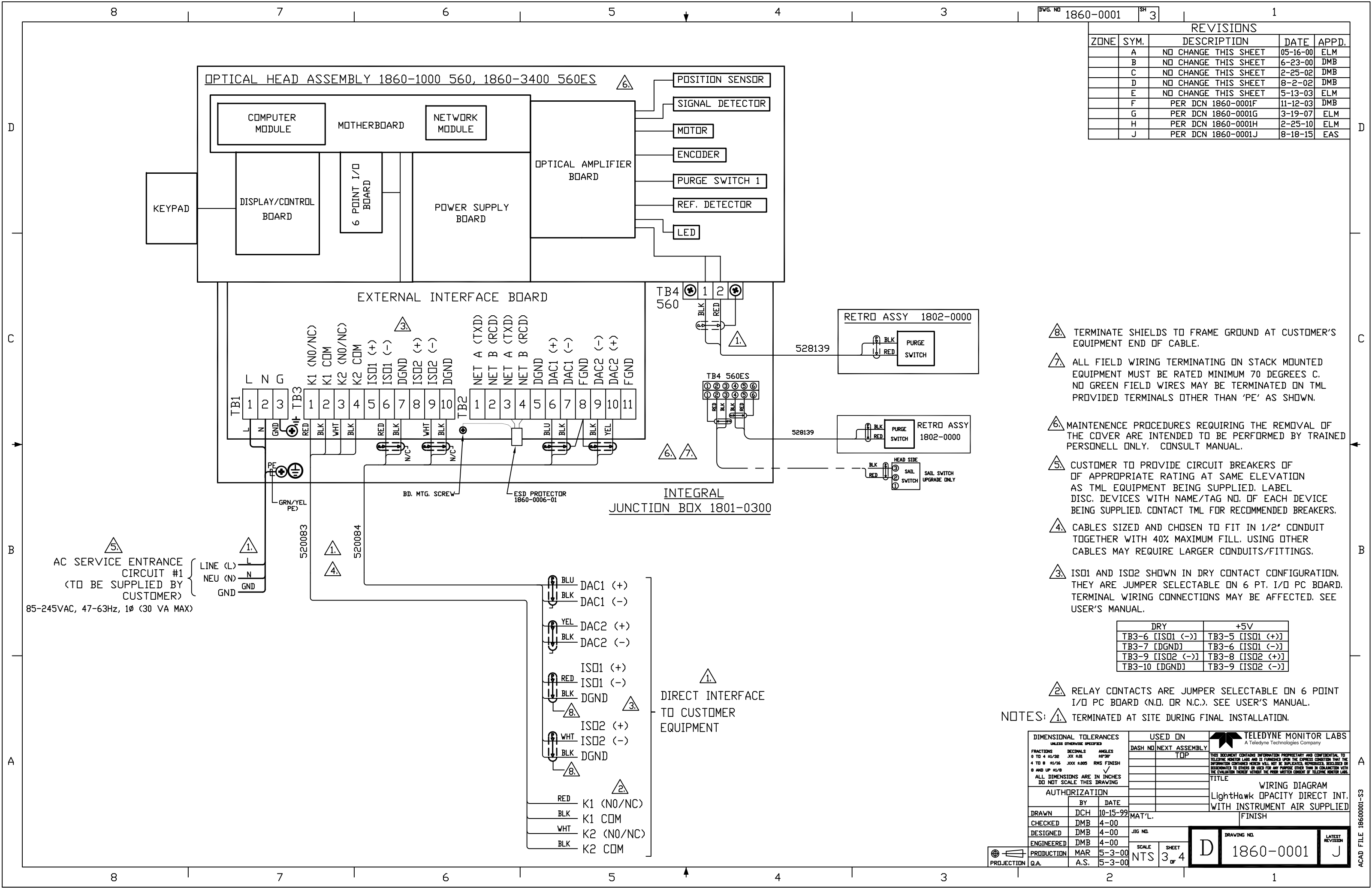
NOTES:

- TERMINATED AT SITE DURING FINAL INSTALLATION.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE MONITOR LABS	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	A Teledyne Technologies Company	
0 TO 4 41/32	.001		TOP	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPAIRED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN THAT AUTHORIZED BY THE EVALUATION RECEIPT WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.	
4 TO 8 1/16	.002			TITLE	
8 AND UP 1/8	.005			WIRING DIAGRAM	
				LightHawk OPACITY W/REMOTE DISPLAY AND BLOWER(S)	
AUTHORIZATION				FINISH	
DRAWN	DCH	DATE	10-15-99	DRAWING NO.	
CHECKED	DMB	DATE	4-00	1860-0001	
DESIGNED	DMB	DATE	4-00	LATEST REVISION	
ENGINEERED	DMB	DATE	4-00	J	
PRODUCTION	MAR	DATE	5-3-00		
Q.A.	A.S.	DATE	5-3-00		

SCALE: NTS 2 OF 4

REVISIONS				
ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	NO CHANGE THIS SHEET	05-16-00	ELM
	B	NO CHANGE THIS SHEET	6-23-00	DMB
	C	NO CHANGE THIS SHEET	2-25-02	DMB
	D	NO CHANGE THIS SHEET	8-2-02	DMB
	E	NO CHANGE THIS SHEET	5-13-03	ELM
	F	PER DCN 1860-0001F	11-12-03	DMB
	G	PER DCN 1860-0001G	3-19-07	ELM
	H	PER DCN 1860-0001H	2-25-10	ELM
	J	PER DCN 1860-0001J	8-18-15	EAS



DRY		+5V	
TB3-6 [ISD1 (-)]	TB3-5 [ISD1 (+)]		
TB3-7 [DGND]	TB3-6 [ISD1 (-)]		
TB3-9 [ISD2 (-)]	TB3-8 [ISD2 (+)]		
TB3-10 [DGND]	TB3-9 [ISD2 (-)]		

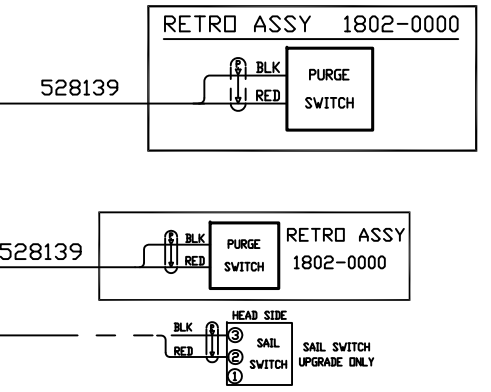
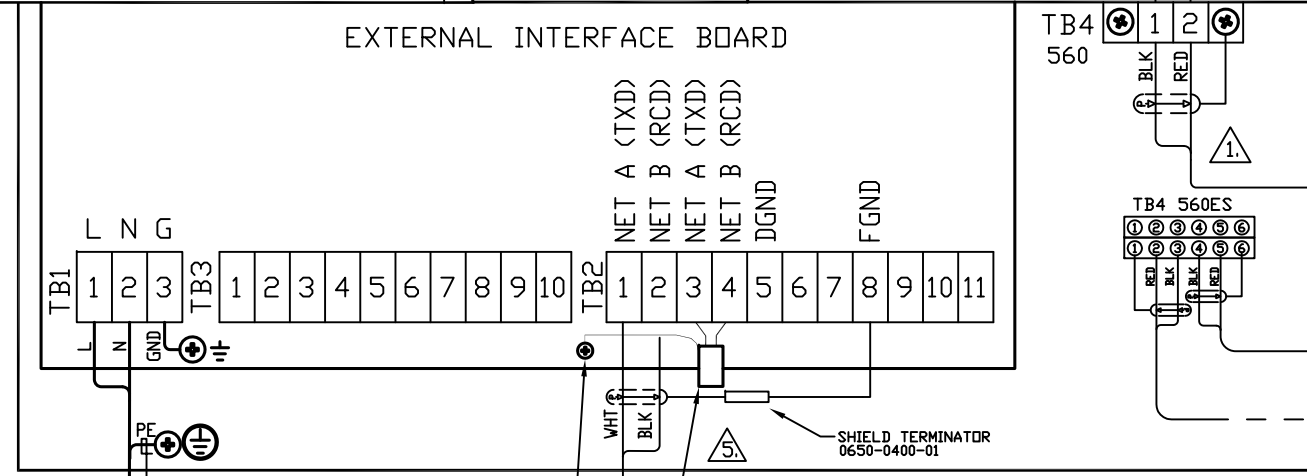
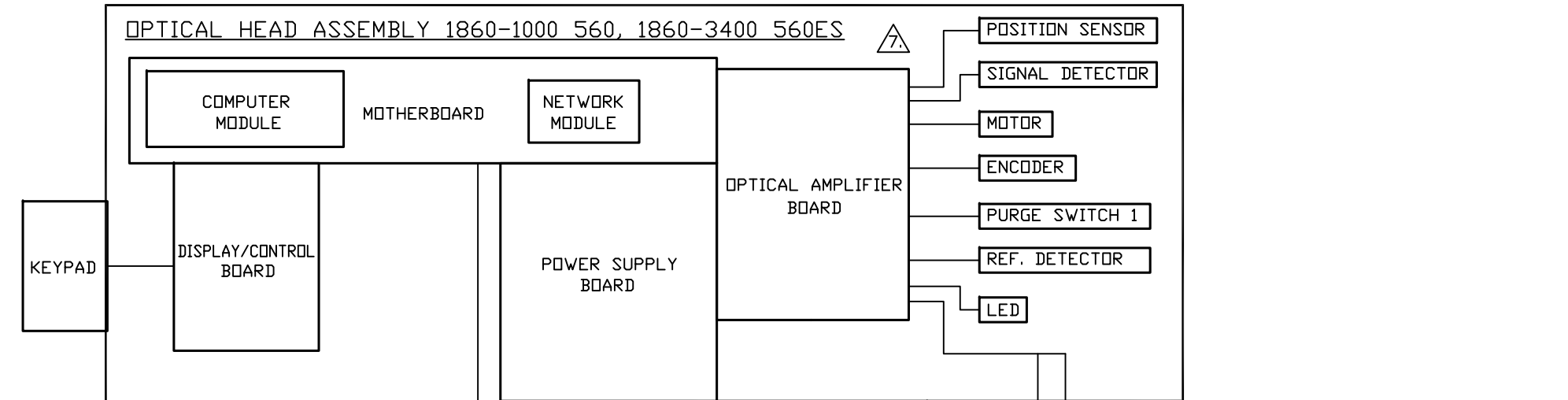
NOTES: 1. TERMINATED AT SITE DURING FINAL INSTALLATION.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE MONITOR LABS	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	A Teledyne Technologies Company	
0 TO 4 1/32	.005		TOP	THIS DOCUMENT CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION. IT IS THE PROPERTY OF TELETYPE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRICED, REPRODUCED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN THAT AUTHORIZED BY TELETYPE MONITOR LABS.	
4 TO 8 1/16	.010			TITLE	
8 AND UP 1/8	.015			WIRING DIAGRAM	
ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING				LightHawk OPACITY DIRECT INT. WITH INSTRUMENT AIR SUPPLIED	
AUTHORIZATION				FINISH	
BY DATE		JIG NO.		DRAWING NO.	
DRAWN DCH 10-15-99		MAT'L.		1860-0001	
CHECKED DMB 4-00		SCALE		LATEST REVISION	
DESIGNED DMB 4-00		NTS		J	
ENGINEERED DMB 4-00		SHEET			
PRODUCTION MAR 5-3-00		3 OF 4			
Q.A. A.S. 5-3-00					



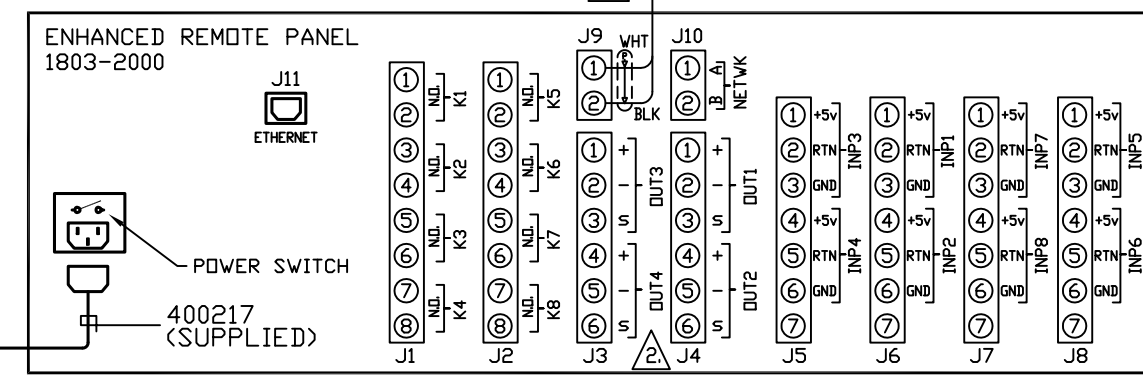
REVISIONS

ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER ECN #1860-0001A	05-16-00	ELM
	B	PER ECN #1860-0001B	6-23-00	DMB
	C	PER ECN #1860-0001C	2-25-02	DMB
	D	PER ECN #1860-0001D	8-2-02	DMB
	E	PER ECN #1860-0001E	5-13-03	ELM
	F	PER ECN #1860-0001F	11-13-03	DMB
	G	PER ECN #1860-0001G	3-19-07	ELM
	H	NO CHANGE THIS SHEET	2-25-10	ELM
	J	PER ECN #1860-0001J	8-18-15	EAS



AC SERVICE ENTRANCE CIRCUIT #1 (TO BE SUPPLIED BY CUSTOMER) 85-245VAC, 47-63Hz, 1Ø (30 VA MAX)

INTEGRAL JUNCTION BOX 1801-0300 (SHIELDED) RECOMMENDED STACK NETWORK CABLE (520234)



- ⚠ ALL FIELD WIRING TERMINATING ON STACK MOUNTED EQUIPMENT MUST BE RATED MINIMUM 70 DEGREES C. NO GREEN FIELD WIRES MAY BE TERMINATED ON TML PROVIDED TERMINALS OTHER THAN 'PE' AS SHOWN.
- ⚠ MAINTENANCE PROCEDURES REQUIRING THE REMOVAL OF THE COVER ARE INTENDED TO BE PERFORMED BY TRAINED PERSONNEL ONLY. CONSULT MANUAL.
- ⚠ IF FIBRELINK III OPTION IS PROVIDED, CONNECT STACK/CONTROL RM. UNITS AND DATA CABLES PER TML SUPPLEMENTAL WIRING DIAGRAM 1808-0003, SHT. 5. RECOMMENDED STACK NETWORK CABLE IS '16 GA. SHIELDED'. SHIELD MUST BE TERMINATED WITH 0650-0400-01 RC NETWORK AS SHOWN AT THE OPTICAL HEAD. IN NO INSTALLATION SHALL DATA CABLE BE RUN IN TRAYS OR CONDUIT WITH OTHER CABLES EXCEEDING 230 VAC. IF NOT ALREADY INSTALLED, AN 1860-0006-01 ESD PROTECTOR MAY BE ADDED FOR ADDITIONAL LIGHTNING STRIKE PROTECTION, AS SHOWN ON SPARE NETWORK TERMINALS.
- ⚠ CUSTOMER TO PROVIDE CIRCUIT BREAKERS OF OF APPROPRIATE RATING AT SAME ELEVATION AS TML EQUIPMENT BEING SUPPLIED. LABEL DISC. DEVICES WITH NAME/TAG NO. OF EACH DEVICE BEING SUPPLIED. CONTACT TML FOR RECOMMENDED BREAKERS.
- ⚠ TERMINATE WIRES TO REAR PANEL USING CAGE CLAMP STYLE CONNECTORS FROM KIT PROVIDED.
- ⚠ ALL CUSTOMER CONNECTIONS TO ANALOG OUTPUTS MUST BE THRU TWISTED PAIR SHIELDED CABLES. ALL SUCH SHIELDS SHALL TERMINATE AT P4-3; P4-6; P3-3; P3-6 FOR OUTPUTS 1 THRU 4 RESPECTIVELY.

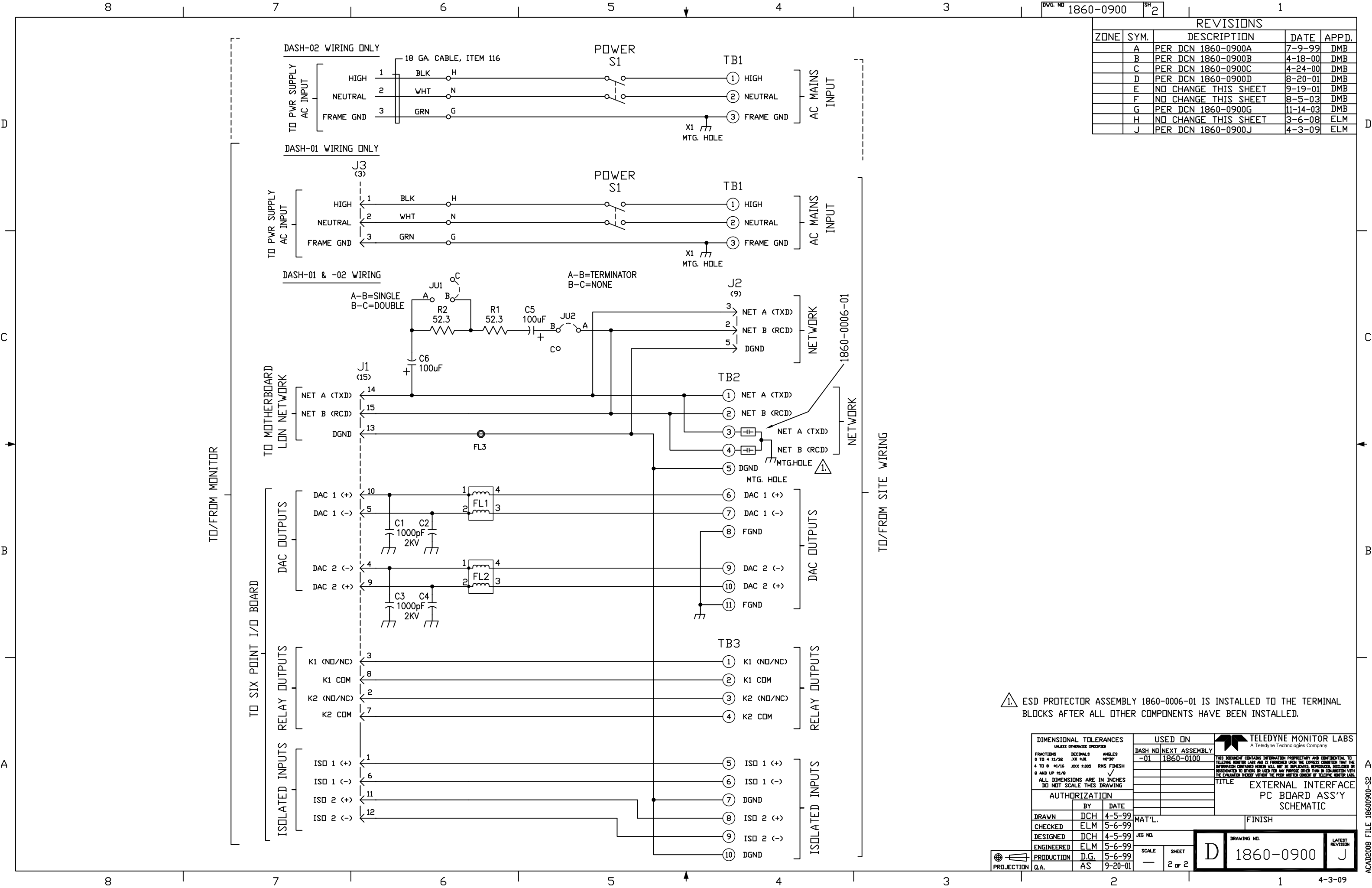
NOTES: 1. TERMINATED AT SITE DURING FINAL INSTALLATION.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		USED ON		TELEDYNE MONITOR LABS	
FRACTIONS	DECIMALS	DASH NO	NEXT ASSEMBLY	A Teledyne Technologies Company	
0 TO 4 1/32	.005		TOP	THIS DOCUMENT CONTAINS INFORMATION PROPRIETARY AND CONFIDENTIAL TO TELEDYNE MONITOR LABS AND IS FURNISHED UNDER THE EXPRESS CONDITION THAT THE INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPARATED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN THAT AUTHORIZED BY THE EVALUATION RECEIPT WITHOUT THE PRIOR WRITTEN CONSENT OF TELEDYNE MONITOR LABS.	
4 TO 8 1/16	.010			TITLE	
8 AND UP 1/8	.015			WIRING DIAGRAM-LightHawk OPACITY W/REM DISPLAY & INSTRUMENT AIR SUPPLIED	
AUTHORIZATION				FINISH	
DRAWN	DCH	DATE	10-15-99	DRAWING NO. 1860-0001	
CHECKED	DMB	DATE	4-00	LATEST REVISION J	
DESIGNED	DMB	DATE	4-00	SCALE NTS	
ENGINEERED	DMB	DATE	4-00	SHEET 4 OF 4	
PRODUCTION	MAR	DATE	5-3-00	D	
Q.A.	A.S.	DATE	5-3-00		

⚠ 85-245VAC, 47-63Hz, 1Ø (30VA MAX)

REVISIONS

ZONE	SYM.	DESCRIPTION	DATE	APPD.
	A	PER DCN 1860-0900A	7-9-99	DMB
	B	PER DCN 1860-0900B	4-18-00	DMB
	C	PER DCN 1860-0900C	4-24-00	DMB
	D	PER DCN 1860-0900D	8-20-01	DMB
	E	NO CHANGE THIS SHEET	9-19-01	DMB
	F	NO CHANGE THIS SHEET	8-5-03	DMB
	G	PER DCN 1860-0900G	11-14-03	DMB
	H	NO CHANGE THIS SHEET	3-6-08	ELM
	J	PER DCN 1860-0900J	4-3-09	ELM



⚠ ESD PROTECTOR ASSEMBLY 1860-0006-01 IS INSTALLED TO THE TERMINAL BLOCKS AFTER ALL OTHER COMPONENTS HAVE BEEN INSTALLED.

<p>DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED</p> <p>FRACTIONS DECIMALS ANGLES 0 TO 4 1/32 .001 4.0 16°/30° 4 TO 8 1/16 .002 4.005 RMS FINISH 8 AND UP 1/8 .005</p> <p>ALL DIMENSIONS ARE IN INCHES DO NOT SCALE THIS DRAWING</p>		<p>USED ON</p> <p>DASH NO / NEXT ASSEMBLY -01 / 1860-0100</p>		<p>TELEDYNE MONITOR LABS A Teledyne Technologies Company</p> <p>THIS DOCUMENT CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION CONTAINED HEREIN WILL NOT BE REPRODUCED, REPRICED, DISCLOSED OR DISSEMINATED TO OTHERS OR USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH THE EVALUATION HEREOF WITHOUT THE PRIOR WRITTEN CONSENT OF TELETYPE MONITOR LABS.</p>	
<p>AUTHORIZATION</p> <p>BY DATE DCH 4-5-99</p> <p>CHECKED ELM 5-6-99</p> <p>DESIGNED DCH 4-5-99</p> <p>ENGINEERED ELM 5-6-99</p> <p>PRODUCTION D.G. 5-6-99</p> <p>Q.A. AS 9-20-01</p>		<p>TITLE</p> <p>EXTERNAL INTERFACE PC BOARD ASS'Y SCHEMATIC</p>		<p>FINISH</p>	
<p>PROJECTION</p>		<p>MAT'L.</p>		<p>JIG NO.</p>	
<p>SCALE</p>		<p>SHEET</p> <p>2 of 2</p>		<p>DRAWING NO.</p> <p>1860-0900</p>	
<p>Q.A.</p>		<p>SCALE</p>		<p>LATEST REVISION</p> <p>J</p>	

APPENDIX E

ENHANCED SERIAL PORT COMMUNICATION PROTOCOL

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ENHANCED SERIAL PORT COMMUNICATION PROTOCOL

This enhanced serial port protocol is only available with Enhanced Remote Panel 332 version 1.13 or later.

A short description of the original communication is described in the Enhanced Remote Display section of the manual. It explains how to use the simple commands that utilize the question mark (?) to request information from the RS232 or RS422/485 ports of the Enhanced Remote Panel. This is still a valid form of communication with either of these ports.

The configuration of the serial ports are still fixed at:

9600, 8 data bits, no parity, two stop bits*.

NOTE: *The RS232 will also work with one stop bit.

Although the original communication is very simple, it has some drawbacks. One of these is the fact that there is no data validation within the structure of the protocol and as a result, characters could be lost or corrupted from time to time.

In order to add flexibility for users that need the ability to acquire data serially from our instruments for their Data Acquisition and Handling Systems, we have included an optional serial communication format used on some of our legacy equipment.

It consists of four values separated by commas ending in a 'Carriage-Return' and 'Line-Feed'. The first and third values must match exactly. The second and fourth values must also match exactly. If **either** of these two conditions is not met, then the Enhanced Remote Panel will ignore the data stream as an input. In a similar manner, a DAS should ignore any data streams that do not have matching pairs.

A typical command or data stream would look like the following:

“first value”, “second value”, “first value repeated”, “second value repeated”<CR><LF>

There are two types of functions that can be sent to the Enhanced Remote Panel using this format. One function is a more robust and error free way in which to request data. The other function has the ability to command and control calibrations and initiate other modes of operation. It is important to note that program parameters **CANNOT** be modified from the serial ports.

MATCHED PAIR DATA REQUEST PROTOCOL FOR A DAS

To request data in the matched pair format, use the following command line:

990 “variable number”, 990, “variable number”<CR><LF>

The “variable number” is the same number designation used to number the variables in the original protocol. A list of the variable numbers can be obtained from the Enhanced Remote Panel by using the original 255? command. An example is included later in this appendix.

INITIATION AND CONTROL OF CALIBRATIONS AND MODES OF OPERATION

The system calibration may be initiated and controlled from the serial port.

The command string is as follows: 998, "command", 998, "command" <CR><LF>

The value for "command" is chosen from the following list of commands.

Command Number	Action resulting from specified Command Number
1	NORMAL
2	ZERO
3	UPSCALE
4	PLCF
5	DUST COMP
6	FORCE_CAL_CYCLE (the Optical Head will complete a full calibration cycle typically consisting of <u>at least</u> both Zero and Span High modes and then returning to Normal operation.
7	TEST_ZERO_SCALE (for MIO 4 to 20 mA outputs)
8	TEST_MID_SCALE (for MIO 4 to 20 mA outputs)
9	TEST_FULL_SCALE (for MIO 4 to 20 mA outputs)
10	PUT_IN_SERVICE (may be used to indicate when the monitor is finished having maintenance done on it)
11	PUT_OUT_OF_SERVICE (may be used to indicate when maintenance is done on the monitor)
12	RESET (sends a command to reset the Optical Head)
13	Not Used

- MIO stands for the printed circuit board (Multi Input Output) commonly used to interface with computers via isolator inputs, relay outputs and analog outputs)

For example to request the OPTICAL HEAD to go into the UPSCALE mode the following command line would be used.

998, 2, 998, 2 <CR><LF>

If the following command line is given to the ENHANCED REMOTE PANEL, it will list the commands available for the calibration input command line such as shown in the above table.

997 ? <CR><LF>

A SUMMARY OF THE ENHANCED COMMANDS AVAILABLE

The program variables are listed later in this appendix. The 990 and 998 commands described below are used with the matched-pair format.

990 This variable is used to request variables in the matched-pair format.

The following is the proper way to use this variable:

990, "VAR#",990,"VAR#"<cr> where "VAR#" is the variable number desired.

After receiving this input the ERP will respond with the following output:

"VAR#","VALUE of VAR#","VAR#","VALUE of VAR#"

<cr>

991 This variable is used to request the STATUS HISTORY

Proper usage is: 991?<cr>

The ERP will respond by printing the STATUS HISTORY in a similar format as on the ERP screen display.

992 This variable is not used

993 This variable is used to request the ALARM HISTORY

Proper usage is: 993?<cr>

The ERP will respond by printing the ALARM HISTORY in a similar format as on the ERP screen display.

994 This variable is not used

995 This variable is not used

996 This variable is not used

997 This variable may be used to request a printout of the enumerations used for calibration.

Proper usage is: 997?<cr>

998 This variable is used to request a calibration mode for the Optical Head from the serial port.

Proper usage is as follows: 998,"DESIRED MODE",998,"DESIRED MODE"

<cr>

999 This variable is not used

BROADCAST MODE

A screen on the Enhanced Remote Panel can be used to output data on a periodic basis. This allows a technician to log data without the need to request each data point independently. This serial transmission is only available on the RS-232 port and will only be in the matched-pair protocol.

There are two groups of data variables. They are called the FAST Access group and the SLOW Access group. Each group may contain 0 to 8 variables for output as entered on the Enhanced Remote Panel screen. A common time base may be entered on the screen to control the serial output rate for each group. The time base for the FAST group is in multiples of seconds and the time base for the SLOW group is in multiples of minutes. This means that if the value of 10 is entered for the FAST group rate, then ALL of the variables in the FAST list will be transmitted every 10 seconds. If a value of 6 is entered for the SLOW group rate then ALL of the variables in the SLOW list will be transmitted every 6 minutes. Each group rate may be independently entered by the technician.

The technician may enter the desired variable numbers into either list using the keyboard of the Enhanced Remote Panel. The variable numbers are listed later in this appendix. A value of 0, (zero) would indicate that no-selection is made.

A common ENABLE / DISABLE is provided to turn the group serial transmission on or off.

The screen is located under VIEW NUMERICAL DATA\ SERIAL DATA from the Main Menu. The screen looks something like the following picture:

SERIAL DATA	
FAST ACCESS	SLOW ACCESS
VAR 1: 0	VAR 1: 0
VAR 2: 0	VAR 2: 0
VAR 3: 0	VAR 3: 0
VAR 4: 0	VAR 4: 0
VAR 5: 0	VAR 5: 0
VAR 6: 0	VAR 6: 0
VAR 7: 0	VAR 7: 0
VAR 8: 0	VAR 8: 0
TIME SEC: 0	TIME MIN: 0
VAR = 0 NO SELECTION	
TIME = 0 NO BROADCAST	
← TO ENTER, ESC TO CANCEL	

MECHANICAL CONNECTIONS

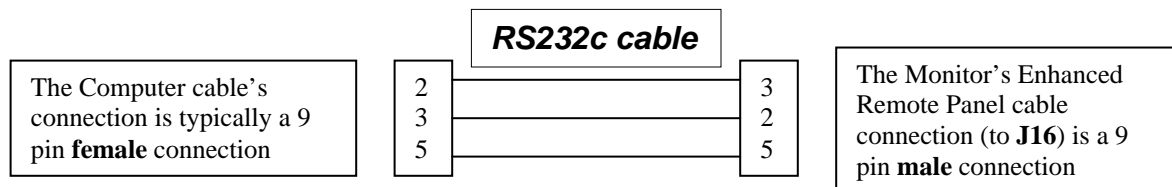
To fasten a laptop or other computer running a standard serial program to the serial port of the ENHANCED REMOTE PANEL you must use following hardware connections.

RS-232 MECHANICAL CONNECTIONS

The connections to the ENHANCED REMOTE PANEL are at the rear of the unit on a standard 9-pin "D" connector labeled J16. Only a 3-wire protocol is supported. It uses 9600 baud, 8 data bits, no parity, and can use one or two stop bits.

- J16 - pin - 3 = Transmit
- J16 - pin - 2 = Receive
- J16 - pin - 5 = Ground

A null modem cable is required to connect between the Computer's RS232 serial port and the Monitor's Enhanced Remote Panel. The following diagram shows how to construct the RS232 cable used to connect with the Enhanced Remote Panel's J16. J16 is a DB9 female connection on the back of the Enhanced Remote Panel.



RS-422 MECHANICAL CONNECTIONS

The connections to the ENHANCED REMOTE PANEL are at the rear of the unit on a standard 15-pin "D" connector labeled J17. Only a 4-wire protocol is supported. It uses 9600 baud, 8 data bits, no parity, and can use two stop bits.

- J17 - pin - 3 = Receive-A
- J17 - pin - 15 = Receive-B
- J17 - pin - 2 = Transmit-A
- J17 - pin - 14 = Transmit-B
- J17 - pin - 1 = Shield Ground

Note that RS-422 communication is also at 9600 baud and it requires using 2 stop bits.

ENHANCED REMOTE MOTHERBOARD JUMPERS for Serial Communication

Jumper	Options	RS-232	RS-422	RS-485
JU3	UART TPU	UART	UART	UART
JU4	UART TPU	UART	UART	UART
JU5	UART TPU 422	UART	422	UART

VARIABLE LIST

The following is a list of variables available from the Enhanced Remote Panel RS232 serial port. TML reserves the right to modify this list at any time. It is best to request a list from the Enhanced Remote Panel with 255? command.

Status and time:

1 Head Status:3
 2 System Date: 4-May-2005
 3 System Time:13:58:56

Latest Alarm data:

4 Alm:AVE OPACITY : HI LEV 2 CLEAR

LonWorks® Network data:

5 MIO Status:1
 6 Net Xmit Errors:2
 7 Net Trans Timeouts:30
 8 Net Rcv Trans Full:0
 9 Net Lost Msgs:0
 10 OptD Alarm State:1
 11 Net Reset Cause:1
 12 Net Node State:4
 13 Net Error Log:0

Opacity data:

14 Inst Opacity:0.40
 15 Ave Opacity:0.40
 16 Min Opacity:0.40
 17 Zero Opac Cal.:0.01
 18 Upscale Opac Cal.:35.19
 19 Dust Comp Value:-0.10

Service data:

20 Signal Voltage:6.52
 21 Reference Voltage:6.85
 22 LED Current mA:5.52
 23 Clear Stack SET Volt:6.46
 24 CAL ZERO SET VOLTAGE:6.39
 25 BACKGROUND SET Volts:0.10
 26 Optical Head Temp:27.30
 27 Calib Mech Posit:168
 28 +15V Supply Voltage:14.92
 29 -15V Supply Voltage:-14.96
 30 +5V Analog Supply:5.00
 31 -5V Analog Supply:-5.05
 32 +5V Digital Supply:4.95

Alarm Configuration data:

33 Inst Opac Level1:50.00
34 Inst Opac Level2:55.00
35 Min Opac Level1:40.00
36 Min Opac Level2:45.00
37 Avg Opac Level1:30.00
38 Avg Opac Level2:35.00
39 Dust Comp Alarm:4.00
40 Inst Dust Level1:9999
41 Inst Dust Level2:9999
42 Min Dust Level1:9999
43 Min Dust Level2:9999
44 Avg Dust Level1:9999
45 Avg Dust Level2:9999
46 Inst OptD Level1:2.0000
47 Inst OptD Level2:2.0000
48 Min OptD Level1:2.0000
49 Min OptD Level2:2.0000
50 Avg OptD Level1:2.0000
51 Avg OptD Level2:2.0000

MIO Configuration data:

52 MIO Ch 1:INSTANT OPACITY
53 MIO Ch 1 With Calib:NO
54 MIO Ch 1 Zero Scale:0.00
55 MIO Ch 1 Full Scale:100.00
56 MIO Ch 2:INSTANT OPACITY
57 MIO Ch 2 With Calib:NO
58 MIO Ch 2 Zero Scale:0.00
59 MIO Ch 2 Full Scale:100.00
60 MIO Ch 3:SELECTABLE AVG OPACITY
61 MIO Ch 3 With Calib:YES
62 MIO Ch 3 Zero Scale:0.00
63 MIO Ch 3 Full Scale:100.00
64 MIO Ch 4:DUST COMP OUTPUT
65 MIO Ch 4 With Calib:NO
66 MIO Ch 4 Zero Scale:-5.00
67 MIO Ch 4 Full Scale:5.00
68 Dig Out 1:CAL ON AO
69 Dig Out 2:UPSCALE ON AO
70 Dig Out 3:ZERO ON AO
71 Dig Out 4:INST OPAC LEVEL1
72 Dig Out 5:AVG OPAC LEVEL1
73 Dig Out 6:PURGE FAILURE
74 Dig Out 7:DATA VALID
75 Dig Out 8:FAULT

Calibration Configuration data:

76 Cal Time Hour: 0
 77 Cal Time Min:0
 78 Cal Interval Hour: 0
 79 Upscale Secs:90
 80 Zero Secs:90
 81 Plcf Secs:90
 82 Dust Secs:90

Particulate Mass correlation curve data:

83 MassLoad_X1:0.0000
 84 MassLoad_Y1:0
 85 MassLoad_X2:1.0000
 86 MassLoad_Y2:0
 87 MassLoad_X3:2.0000
 88 MassLoad_Y3:0

Optical Density data:

89 Inst Opt Density:0.0017
 90 Min Opt Density:0.0018
 91 Ave Opt Density:0.0018
 92 Zero OptD Cal.:0.0000
 93 Upscale OptD Cal.:0.1884
 94 Dust Comp OptD:-0.0004

Particulate Mass data:

95 Inst Mass Load:0
 96 Min Mass Load:0
 97 Ave Mass Load:0
 98 Zero Mass Cal:0
 99 Upscale Mass Cal:0
 100 Dust Comp Mass:-0

Correction and other data:

101 Stack Temp:0.0
 102 Baro Press:0
 103 Correct Factor:1.000
 104 PLCF:0.935
 105 Zero Cal Setpoint:0.00
 106 Upscale Cal Setpoint:35.22
 107 Cal Delta:2.00
 108 Averaging Interval:6
 109 Opac Alarm State:1
 110 OptD Alarm State:1
 111 Part Mass Alrm state:1
 112 Cal Mechanism Mode:NORMAL MODE
 113 Six PIO Mode:NORMAL MODE
 114 Audit Mode:NOT IN AUDIT
 115 Filter Value:NO FILTER

Firmware versions:

116 Stack332 Version:1.11
117 StackNeuron Version:1.50
118 MIO Version:1.50
119 Panel332 Version:1.13
120 PanelNeuron Version:1.51

Gains and References:

121 Signal Gain:15
122 Ref Gain:30
123 Common Gain:0
124 Ref Temp:20.00
125 Ref Pressure:101.30

AUDIT DATA Information (see 114 and 115):

126 ALL DATA PLCF CORR:
127 RUN1 LowValue:0.000
128 RUN2 LowValue:0.000
129 RUN3 LowValue:0.000
130 RUN4 LowValue:0.000
131 RUN5 LowValue:0.000
132 RUN1 MidValue:0.000
133 RUN2 MidValue:0.000
134 RUN3 MidValue:0.000
135 RUN4 MidValue:0.000
136 RUN5 MidValue:0.000
137 RUN1 HighValue:0.000
138 RUN2 HighValue:0.000
139 RUN3 HighValue:0.000
140 RUN4 HighValue:0.000
141 RUN5 HighValue:0.000
142 Low TargetValue:0.00
143 Mid TargetValue:0.00
144 High TargetValue:0.00
145 Low ArithMean:0.000
146 Mid ArithMean:0.000
147 High ArithMean:0.000
148 Low ConCoeff:0.000
149 Mid ConCoeff:0.000
150 High ConCoeff:0.000
151 Low CalError:0.00
152 Mid CalError:0.00
153 High CalError:0.00