121406-P1
Rev A, 1/99
Instruction Manual

MKS Type 186B
Process Controller

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WARRANTY

Type 186B Equipment

MKS Instruments, Inc. (**MKS**) warrants that for two years from the date of shipment the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship and will correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

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MKS Type 186B
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Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning 

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution 

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note 

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

Definition of Symbols Found on the Unit			
On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified for your product.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

HIGH VOLTAGE DANGER

High voltage is present in the cable, and in the sensor when the controller is turned on.

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

Definition der mit WARNUNG!, VORSICHT! und HINWEIS überschriebenen Abschnitte in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahrenquelle hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Körperverletzung führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. Ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Produkts oder von Teilen des Produkts führen kann.

Hinweis

Das Symbol HINWEIS weist auf eine wichtige Mitteilung hin, die auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit von besonderer Wichtigkeit aufmerksam macht.

Am Gerät angebrachte Symbole

Der untenstehenden Tabelle sind die Bedeutungen der Symbole zu entnehmen, die an dem Gerät angebracht sind.

Definitionen der am Gerät angebrachten Symbole			
Ein (Netz) IEC 417, Nr. 5007	 Aus (Netz) IEC 417, Nr. 5008	 Erde IEC 417, Nr. 5017	 Schutzleiter IEC 417, Nr. 5019
 Rahmen oder Chassis IEC 417, Nr. 5020	 Äquipotentialanschluß IEC 417, Nr. 5021	 Gleichstrom IEC 417, Nr. 5031	 Wechselstrom IEC 417, Nr. 5032
 Wechselstrom und Gleichstrom IEC 417, Nr. 5033-a	 Geräteklasse II IEC 417, Nr. 5172-a	 Drehstrom IEC 617-2 Nr. 020206	
 Vorsicht! Bitte Begleitdokumente lesen! ISO 3864, Nr. B.3.1	 Vorsicht! Stromschlaggefahr! ISO 3864, Nr. B.3.6	 Vorsicht! Heiße Fläche! IEC 417, Nr. 5041	

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Die untenstehenden allgemeinen Sicherheitsvorschriften sind bei allen Betriebs-phasen dieses Instruments zu befolgen. Jede Mißachtung dieser Sicherheits-vorschriften oder sonstiger spezifischer Warnhinweise in dieser Betriebsanleitung stellt eine Zuwiderhandlung der für dieses Instrument geltenden Sicherheits-standards dar und kann die an diesem Instrument vorgesehenen Schutzvor-richtungen unwirksam machen. MKS Instruments, Inc. haftet nicht für eine Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Keine Teile austauschen und keine Veränderungen vornehmen!

Bauen Sie in das Instrument keine Ersatzteile ein, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor! Schicken Sie das Instrument zu Wartungs- und Reparatur-zwecken an einen MKS-Kalibrierungs- und -Kundendienst ein! Dadurch wird sicher-gestellt, daß alle Sicherheitseinrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Gehäuse des Instruments darf vom Bedienpersonal nicht geöffnet werden. Das Auswechseln von Bauteilen und das Vornehmen von internen Einstellungen ist nur von qualifizierten Fachleuten durchzuführen.

Produkt erden!

Dieses Produkt ist mit einer Erdleitung und einem Schutzkontakt am Netzstecker versehen. Um der Gefahr eines elektrischen Schlages vorzubeugen, ist das Netzkabel an einer vorschriftsmäßig geerdeten Schutzkontaktsteckdose anzuschließen, bevor es an den Eingangs- bzw. Ausgangsklemmen des Produkts angeschlossen wird. Das Instrument kann nur sicher betrieben werden, wenn es über den Erdleiter des Netzkabels und einen Schutzkontakt geerdet wird.

Gefährdung durch Verlust der Schutzerdung!

Geht die Verbindung zum Schutzleiter verloren, besteht an sämtlichen zugänglichen Teilen aus stromleitendem Material die Gefahr eines elektrischen Schlages. Dies gilt auch für Knöpfe und andere Bedienelemente, die dem Anschein nach isoliert sind.

Erdung und Verwendung geeigneter elektrischer Armaturen!

In diesem Instrument liegen gefährliche Spannungen an. Alle verwendeten elektrischen Armaturen und Kabel müssen dem angegebenen Typ entsprechen und sich in einwand-freiem Zustand befinden. Alle elektrischen Armaturen sind vorschriftsmäßig anzubringen und zu erden.

Richtiges Netzkabel verwenden!

Das verwendete Netzkabel muß sich in einwandfreiem Zustand befinden und den in der Betriebsanleitung enthaltenen Anschlußwerten entsprechen.

Das Netzkabel muß abnehmbar sein. Der Querschnitt der einzelnen Leiter darf nicht weniger als 0,75 mm^2 betragen. Das Netzkabel sollte einen Prüfvermerk einer zuständigen Prüfstelle tragen, z.B. VDE, Semko oder SEV.

Richtige Stromquelle verwenden!

Dieses Produkt ist für eine Stromquelle vorgesehen, bei der die zwischen den Leitern bzw. zwischen jedem der Leiter und dem Masseleiter anliegende Spannung den in dieser Betriebsanleitung angegebenen Wert nicht überschreitet.

Richtige Sicherung benutzen!

Es ist eine Sicherung zu verwenden, deren Typ, Nennspannung und Nennstromstärke den Angaben für dieses Produkt entsprechen.

Gerät nicht in explosiver Atmosphäre benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät nicht in der Nähe explosiver Stoffe eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zertifiziert worden ist.

Hochspannungsgefahr!

Bei eingeschaltetem Steuerteil liegt im Kabel und im Sensor Hochspannung an.

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

Définition des indications AVERTISSEMENT, ATTENTION et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque de blessure en cas d'exécution incorrecte ou de non-respect des consignes.

Attention

L'indication ATTENTION signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque d'endommagement ou de dégât d'une partie ou de la totalité de l'appareil en cas d'exécution incorrecte ou de non-respect des consignes.

Remarque

L'indication REMARQUE signale des informations importantes. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un intérêt particulier.

Symboles apparaissant sur l'appareil

Le tableau suivant décrit les symboles apparaissant sur l'appareil.

Définition des symboles apparaissant sur l'appareil			
Marche (sous tension) IEC 417, No. 5007	 Arrêt (hors tension) IEC 417, No. 5008	 Terre (masse) IEC 417, No. 5017	 Terre de protection (masse) IEC 417, No. 5019
 Masse IEC 417, No. 5020	 Equipotentialité IEC 417, No. 5021	 Courant continu IEC 417, No. 5031	 Courant alternatif IEC 417, No. 5032
 Courant continu et alternatif IEC 417, No. 5033-a	 Matériel de classe II IEC 417, No. 5172-a	 Courant alternatif triphasé IEC 617-2 No. 020206	
 Attention : se reporter à la documentation ISO 3864, No. B.3.1	 Attention : risque de secousse électrique ISO 3864, No. B.3.6	 Attention : surface brûlante IEC 417, No. 5041	

Tableau 3: Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

Prendre toutes les précautions générales suivantes pendant toutes les phases d'utilisation de cet appareil. Le non-respect de ces précautions ou des avertissements contenus dans ce manuel entraîne une violation des normes de sécurité relatives à l'utilisation de l'appareil et le risque de réduire le niveau de protection fourni par l'appareil. MKS Instruments, Inc. ne prend aucune responsabilité pour les conséquences de tout non-respect des consignes de la part de ses clients.

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

Ne pas utiliser de pièces détachées autres que celles vendues par MKS Instruments, Inc. ou modifier l'appareil sans l'autorisation préalable de MKS Instruments, Inc. Renvoyer l'appareil à un centre d'étalonnage et de dépannage MKS pour tout dépannage ou réparation afin de s'assurer que tous les dispositifs de sécurité sont maintenus.

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

L'opérateur de l'appareil ne doit pas enlever le capot de l'appareil. Le remplacement des composants et les réglages internes doivent être effectués uniquement par un personnel d'entretien qualifié.

MISE À LA TERRE DE L'APPAREIL

Cet appareil est mis à la terre à l'aide du fil de terre du cordon d'alimentation. Pour éviter tout risque de secousse électrique, brancher le cordon d'alimentation sur une prise de courant correctement câblée avant de le brancher sur les bornes d'entrée ou de sortie de l'appareil. Une mise à la terre de protection à l'aide du fil de terre du cordon d'alimentation est indispensable pour une utilisation sans danger de l'appareil.

DANGER LIÉ À UN DÉFAUT DE TERRE

En cas de défaut de terre, toutes les pièces conductrices accessibles (y compris les boutons de commande ou de réglage qui semblent être isolés) peuvent être source d'une secousse électrique.

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

Des tensions dangereuses existent à l'intérieur de l'appareil. Tous les accessoires et les câbles électriques doivent être conformes au type spécifié et être en bon état. Tous les accessoires électriques doivent être correctement connectés et mis à la terre.

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

Utiliser uniquement un cordon d'alimentation en bon état et conforme aux exigences de puissance d'entrée spécifiées dans le manuel.

Utiliser uniquement un cordon d'alimentation amovible avec des conducteurs dont la section est égale ou supérieure à 0,75 mm^2. Le cordon d'alimentation doit être approuvé par un organisme compétent tel que VDE, Semko ou SEV.

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

Cet appareil est conçu pour fonctionner en s'alimentant sur une source de courant électrique n'appliquant pas une tension entre les conducteurs d'alimentation, ou entre les conducteurs d'alimentation et le conducteur de terre, supérieure à celle spécifiée dans le manuel.

UTILISATION D'UN FUSIBLE APPROPRIÉ

Utiliser uniquement un fusible conforme au type, à la tension nominale et au courant nominal spécifiés pour l'appareil.

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

Pour éviter tout risque d'explosion, ne pas utiliser l'appareil dans une atmosphère explosive à moins qu'il n'ait été approuvé pour une telle utilisation.

DANGER DE HAUTE TENSION

Une haute tension est présente dans le câble et dans le capteur lorsque le contrôleur est sous tension.

Información sobre seguridad

Símbolos usados en el manual de instrucciones

Definiciones de los mensajes de ADVERTENCIA, PRECAUCIÓN Y OBSERVACIÓN usados en el manual.

Advertencia

El símbolo de ADVERTENCIA indica un riesgo. Pone de relieve un procedimiento, práctica, condición, etc., que, de no realizarse u observarse correctamente, podría causar lesiones a los empleados.

Precaución

El símbolo de PRECAUCIÓN indica un riesgo. Pone de relieve un procedimiento, práctica, etc., de tipo operativo que, de no realizarse u observarse correctamente, podría causar desperfectos al instrumento, o llegar incluso a causar su destrucción total o parcial.

Observación

El símbolo de OBSERVACIÓN indica información de importancia. Pone de relieve un procedimiento, práctica, condición, etc., cuyo conocimiento resulta esencial.

Símbolos que aparecen en la unidad

En la tabla que figura a continuación se indican los símbolos que aparecen en la unidad.

Definición de los símbolos que aparecen en la unidad			
Encendido (alimentación eléctrica) IEC 417, N.° 5007	 Apagado (alimentación eléctrica) IEC 417, N.° 5008	 Puesta a tierra IEC 417, N.° 5017	 Protección a tierra IEC 417, N.° 5019
 Caja o chasis IEC 417, N.° 5020	 Equipotencialidad IEC 417, N.° 5021	 Corriente continua IEC 417, N.° 5031	 Corriente alterna IEC 417, N.° 5032
 Corriente continua y alterna IEC 417, N.° 5033-a	 Equipo de clase II IEC 417, N.° 5172-a	 Corriente alterna trifásica IEC 617-2 N.° 020206	
 Precaución. Consultar los documentos adjuntos ISO 3864, N.° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N.° B.3.6	 Precaución. Superficie caliente IEC 417, N.° 5041	

Tabla 4: Definición de los símbolos que aparecen en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad que figuran a continuación deben observarse durante todas las fases de funcionamiento del presente instrumento. La no observancia de dichas precauciones, o de las advertencias específicas a las que se hace referencia en el manual, contraviene las normas de seguridad referentes al uso previsto del instrumento y podría impedir la protección que proporciona el instrumento. MKS Instruments, Inc., no asume responsabilidad alguna en caso de que el cliente haga caso omiso de estos requerimientos.

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

No se debe instalar piezas que no sean originales ni modificar el instrumento sin autorización. Para garantizar que las prestaciones de seguridad se observen en todo momento, enviar el instrumento al Centro de servicio y calibración de MKS cuando sea necesaria su reparación y servicio de mantenimiento.

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

Los operarios no deben retirar las cubiertas del instrumento. El cambio de piezas y los reajustes internos deben efectuarlos únicamente técnicos especializados.

PUESTA A TIERRA DEL INSTRUMENTO

Este instrumento está puesto a tierra por medio del conductor de tierra del cable eléctrico. Para evitar descargas eléctricas, enchufar el cable eléctrico en una toma debidamente instalada, antes de conectarlo a las terminales de entrada o salida del instrumento. Para garantizar el uso sin riesgos del instrumento resulta esencial que se encuentre puesto a tierra por medio del conductor de tierra del cable eléctrico.

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

Si se pierde la conexión protectora de puesta a tierra, todas las piezas conductoras a las que se tiene acceso (incluidos los botones y mandos que pudieran parecer estar aislados) podrían producir descargar eléctricas.

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

Este instrumento funciona con voltajes peligrosos. Todos los accesorios y cables eléctricos deben ser del tipo especificado y mantenerse en buenas condiciones. Todos los accesorios eléctricos deben estar conectados y puestos a tierra del modo adecuado.

USAR EL CABLE ELÉCTRICO ADECUADO

Usar únicamente un cable eléctrico que se encuentre en buenas condiciones y que cumpla los requisitos de alimentación de entrada indicados en el manual.

Usar únicamente un cable desmontable instalado con conductores que tengan un área de sección transversal equivalente o superior a 0,75mm². El cable eléctrico debe estar aprobado por una entidad autorizada como, por ejemplo, VDE, Semko o SEV.

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

Este instrumento debe funcionar a partir de una fuente de alimentación eléctrica que no aplique más voltaje entre los conductores de suministro, o entre uno de los conductores de suministro y la puesta a tierra, que el que se especifica en el manual.

USAR EL FUSIBLE ADECUADO

Usar únicamente un fusible del tipo, clase de voltaje y de corriente adecuados, según lo que se especifica para el instrumento.

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

Para evitar el riesgo de explosión, no usar este instrumento o en un entorno explosivo, a no ser que haya sido certificado para tal uso.

PELIGRO POR ALTO VOLTAJE

Cuando el controlador está encendido, se registra alto voltaje en el cable y en el sensor.

Chapter One: General Information

Introduction

The MKS Type 186B Process Controller can power and read up to ten different input channels, and four control channels. The unit holds up to eight plug-in boards. The input channels include Pirani/convection gauges, capacitance manometers, mass flow controllers, cold cathode gauges, and up to four hot cathode gauges. The hot cathode gauges can be either the high or low power variety, or a combination of both types. The control channel functionality can support up to four Control boards. The 186 unit supports up to eight Auxiliary Output boards; each board supplies two alarm relays. (A maximum of two alarm relays can be assigned to each input channel.) In addition, the 186 instrument provides one analog output. The 186 instrument requires a remote power supply and conveniently fits into a standard ½ rack.

The Control board enables the 186 instrument to perform closed-loop process control. The 186 instrument uses a Proportional-Integral-Derivative (PID) control algorithm to adjust the output of the Control, or Mass Flow Controller, board based on a pressure input signal. The 186 instrument reads the pressure input signal from an input channel, compares the reading to the user-defined set point, and calculates the output signal necessary to position the valve to achieve, or maintain, the desired set point pressure. It repeats this cycle every time it samples the pressure input channel.

The 186 instrument communicates through an RS-232 interface, rather than a front panel, so it can be incorporated into a larger process system. The rear panel of the 186 instrument contains a standard 9-pin male Type “D” connector for serial communications. The front panel of the 186 instrument contains a 25-pin female Type “D” connector that allows you to connect a computer to program the 186 instrument directly (and override the rear panel communications).

The 186 instrument offers several features to protect ion gauges. One feature monitors the rate of rise of pressure experienced by the hot cathode gauge. Another feature allows you to define a high pressure shutoff value. If the hot cathode senses a pressure that exceeds the high pressure shutoff value, the 186 instrument automatically powers off the hot cathode gauge. A third feature controls the power to the hot cathode gauge based on the pressure reading from a reference channel. If the pressure of the reference channel exceeds the preset upper limit, the 186 instrument powers off the hot cathode gauge. When the pressure of the reference channel drops below the preset limit, the 186 instrument restores power to the hot cathode gauge.

The 186 instrument offers one standard analog output signal with a range of 0 to +10 Volts (DC).

How This Manual is Organized

This manual is designed to provide instructions on how to set up and install a Type 186 unit.

Before installing your Type 186 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One: General Information, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three: Overview, gives a brief description of the instrument and its functionality. This chapter includes connector pinout and interface cabling information.

Chapter Four: Operation, describes how to use the instrument and explains all the functions and features.

Chapter Five: Sensor Board Command Summary, presents the RS-232 messages arranged by board type.

Chapter Six: Operation of the Control Board, explains how to configure a Control board so that the 186 instrument can control your process using closed-loop control.

Chapter Seven: Maintenance, offers several tips to help you maintain your 186 instrument.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Model Code Explanation, describes the model code assigned to each unit.

Appendix C: Pressure Range, states the default pressures for various sensors.

Appendix D: Power Supply Requirements, outlines the specifications for the power supply you must provide to operate the 186 instrument.

Appendix E: RS-232 Message Summary, lists the RS-232 commands in tables for reference.

Manual Conventions

Function A function is a task the 186 instrument can perform. For example, spanning a sensor with a reference is a task the 186 instrument can perform. Other tasks include adjusting set point values and zeroing a transducer. Refer to the *Table of Contents* for a complete list of all functions the 186 instrument can perform.

Parameter A parameter is a value or option you add or alter when you give a command or execute a function. The result is that the command or function accomplishes its task in the way that you want. If you do not enter a parameter, the 186 unit operates according to its default values. For example, the 186 instrument reports the pressure reading in Torr, initially. Unless you issue the command to change the pressure unit, the 186 instrument will continue to use Torr.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 186 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning  **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

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Chapter Two: Installation

How To Unpack the Type 186 Unit

MKS has carefully packed the Type 186 unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment

- Type 186 Unit
- Type 186 Instruction Manual (this book)
- Power cord (CB186S-7-M1) refer to *Power Connector*, page 59, for details

Optional Accessories

- Electrical Connector Accessories Kit, 186B-K1 (contains mating connectors)
- Gauges
- Typw 260 PS-3 power supply
- Interface Cables (refer to *Inside the Type 186 Unit*, page 37, for details)
- Type 186A to 186B adapter cable (p/n 121984-G1)
- RS-232 Interface Cable (MKS p/n CB146-21)
- Rear panel connector cable (MKS p/n CB-146-2 or CB-146-4)
- Labels for rear panel board identification (MKS p/n LB-1141011)
- RM-6 Rack Mount (MKS p/n RM6)
- MKS *Remote User Interface* software program to communicate with the 186 unit

Plug-In Boards

All or some of the following boards may have been ordered with your basic 186 instrument. Examine the rear panel of the 186 unit to make sure your unit conforms to your model code. Refer to Figure 1, page 23, to identify these boards by their connectors on the rear panel. *Appendix B: Model Code Explanation*, page 147, provides an explanation of the model code.

The order form also contains specific configuration instructions. For example, the unit can be set up for a single channel Pirani board (the default is a dual channel board), or for a low power HPS hot cathode gauge (the default is for a high power gauge).

Labels are placed at each occupied board slot on the rear panel of the 186 unit. The labels identify the channel number(s) and type of board installed in the slot.

Your 186 instrument supports the following boards:

- Pirani/Convection
- Hot Cathode
- Cold Cathode
- Capacitance Manometer
- Mass Flow Controller
- Control
- Auxiliary Output

Figure 1, page 23, shows the rear panel of the 186 instrument with a Capacitance Manometer board, four Hot Cathode boards, and two Pirani boards. The rear panel on your instrument will conform to the ordering code used to purchase the instrument. Figure 2, page 23, shows the connectors on each board.

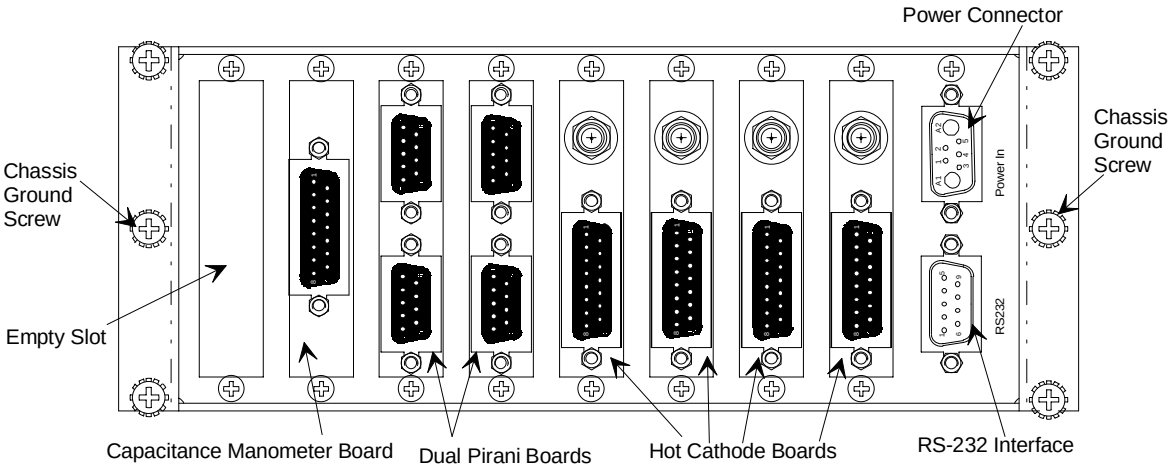


Figure 1: Rear Panel of the Type 186 Unit

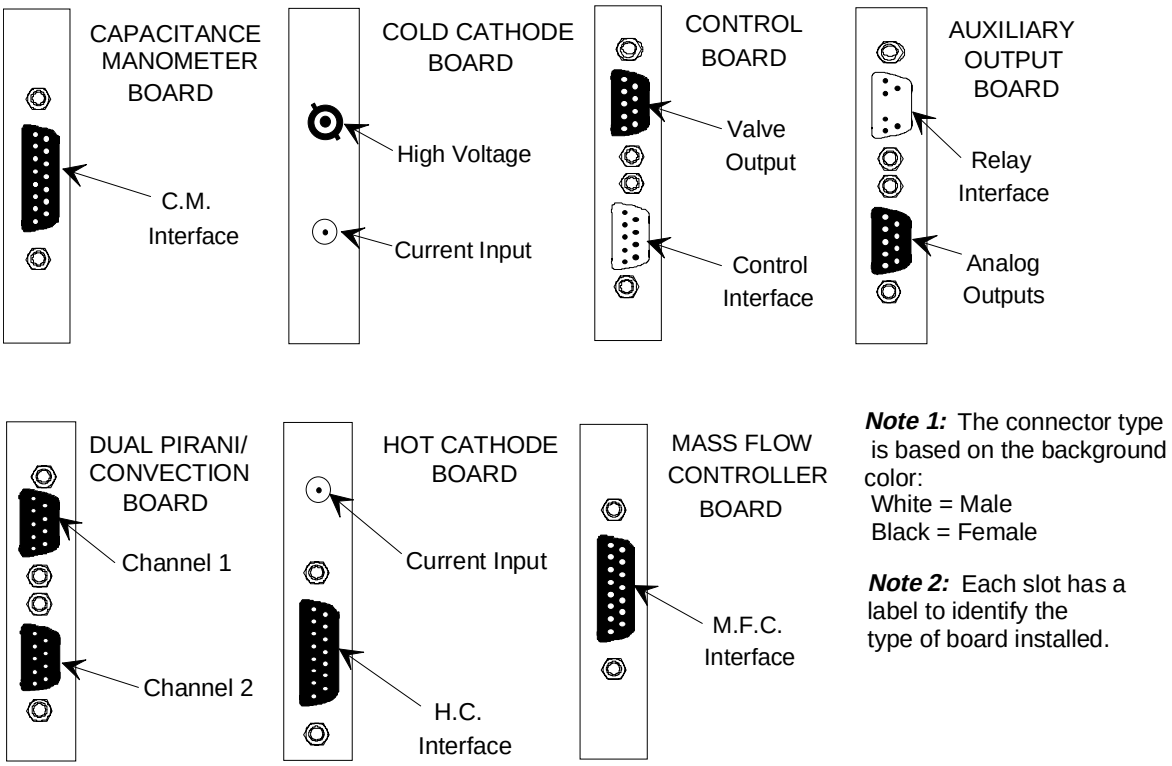


Figure 2: Plug-In Boards

Product Location and Requirements

Environmental Requirements

- Ambient Operating Temperature: 15° to 40° C (59° to 104° F)
- Ventilation requirements include sufficient air circulation
- Operating humidity range is between 0 and 95%, non-condensing

Mounting

- The 186 unit fits into panel cutout or in a 19 inch rack when supplied with the RM-6 Rack Mount option

Safety Conditions

The 186 unit poses no safety risk under the following environmental conditions.

- Altitude: up to 2000 m
- Maximum relative humidity: 80% for temperatures up to 31° C, decreasing linearly to 50% at 40° C

System Requirements

Pressure Transducer Selection

Refer to the description of each transducer board in *Inside the Type 186 Unit*, page 37, for details such as connector pinouts.

Note

The Capacitance Manometer board supports any capacitance manometer that delivers up to ±10 Volts full scale. If your capacitance manometer delivers *less than* ±10 Volts full scale, the 186 instrument *may not read the pressure correctly.*

If you are using a transducer with a ±5 Volt output, you must set the full scale range correctly. For example, if you have a 20 Torr full scale transducer with a 5 VDC output, set the full scale setting on the 186 unit to 40 Torr, the equivalent of a 10 VDC output.

The Pirani-type gauges that are compatible with the 186 instrument are the HPS Pirani and Convection-Enhanced Pirani (CEP) gauges, and the Granville-Phillips Convectron® gauge.

The HPS inverted magnetron cold cathode gauge is compatible.

The 186 instrument supports all Bayard-Alpert hot cathode gauges. This includes both the thoriated iridium and tungsten filament gauges in nude or glass envelope configuration (where available), and the HPS low power, nude, Bayard-Alpert hot cathode. You can use up to four hot cathode gauges, of either power type, with each 186 unit.

Valve Selection

The types of control valves supported include proportional current driven, and exhaust throttling valves.

Mass Flow Controller Selection

The 186 instrument supports all MKS mass flow controllers, and equivalent controllers.

Dimensions

Note All dimensions are listed in inches with millimeters (mm) referenced in parentheses.

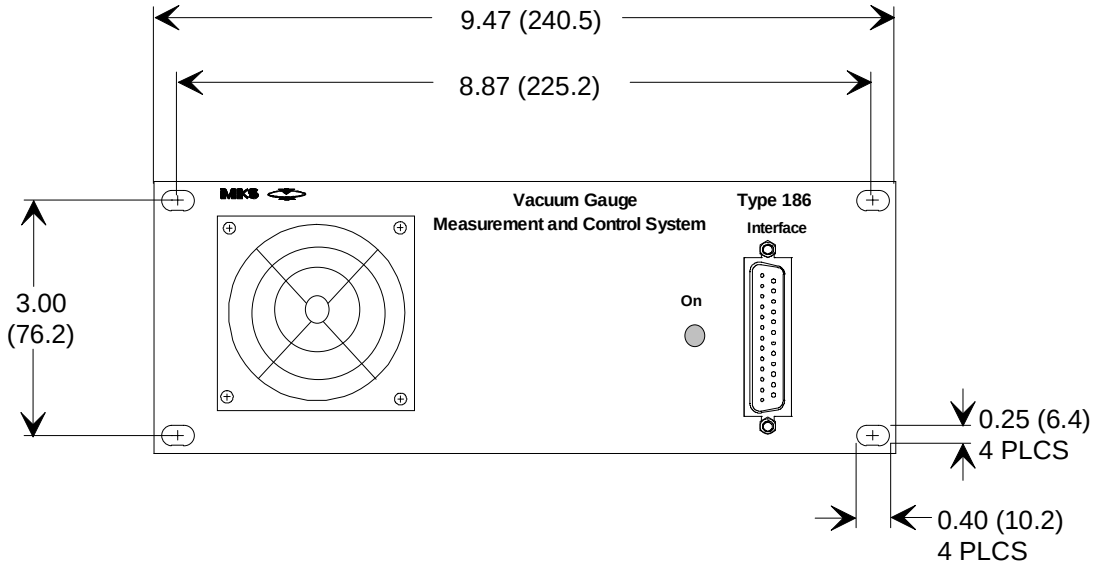


Figure 3: Front Panel Dimensions

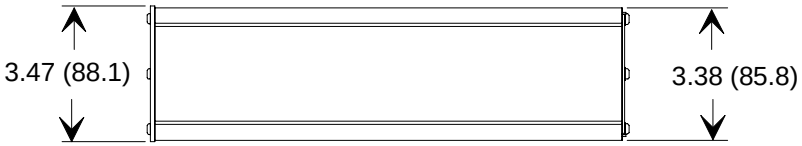


Figure 4: Side Panel Dimensions

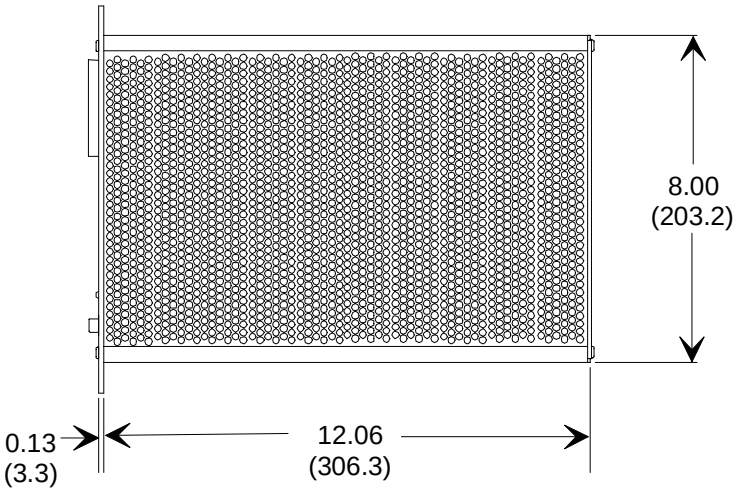


Figure 5: Top Panel Dimensions

Set Up

Caution **Provide proper clearance so that the 186 unit operates within the product environmental specifications (refer to *Appendix A, Product Specifications,* page 145).**

General

- Employ proper grounding

  Power, and the analog and digital commons, are all tied together in the 186 instrument. The transducer signal common and power common are usually tied together internally at the sensor. Although these commons are connected together internally, it is important that each ground be used only for its stated purpose to minimize ground noise and ground-loop errors.

- Connect to chassis ground

  Mount the 186 instrument securely and use a grounding lug to connect the 186 instrument to a chassis ground source. If the mounting position does not provide a chassis ground source, run a cable from a known, good chassis ground to either middle screw on the rear panel of the 186 instrument. Refer to Figure 1, page 23, for the location of the middle screws.

Transducer and Mass Flow Controller Connections

Please refer to the installation instructions that came with your particular transducer or mass flow controller.

- Connect the gauge or MFC interface cable to the appropriate 186 instrument connector

  Refer to Figure 1, page 23, to identify the appropriate connector.

Communication and Power Connections

1. Connect the power supply cable to the Power connector, located on the rear panel.

   Refer to Figure 1, page 23, for the location of the Power connector, and Table 28, page 59, for a description of the power cable.

2. Connect the RS-232 communications cable to the RS232 connector on the rear panel.

   The RS232 connector, shown in Figure 1, page 23, is a standard 9-pin male Type “D” connector.

3. Connect the other end of the communications cable to the serial port on your computer.

4. If a Control board(s) is installed, use the correct interface cable to connect the appropriate valve or controller to the top connector (Valve Output connector) on the Control board.

   Table 21, page 55, lists the valves and controllers supported, and their interface cables. The bottom connector (Control connector) provides remote function control. Connect a PC or other remote equipment to this connector, with the appropriate cable.

5. If an Auxiliary Output board is installed, use an appropriate interface cable to connect the 186 unit to a device which can be activated through the relays on the top connector (the relay interface), and another cable to connect an analog output device to the bottom connector (the analog output interface) on the Auxiliary Output board.

   Refer to Table 23 and Table 24, page 56, for the pinouts of each connector on the Auxiliary Output board. MKS does not offer an interface cable for the Auxiliary Output board.

Installing Boards in the 186 Unit

This section describes how to install boards that have been ordered after the 186 unit has arrived.

Warning  **The 186 unit has lethal voltages inside. To avoid the danger of electrical shock, disconnect the Power connector cable *before* opening the unit.**

1. Be sure that the Power connector cable is disconnected.
2. Remove the four Phillips head screws on the outside corners of the rear panel.
3. Remove the seven (7) screws that fasten the top cover.
4. Remove the top cover by firmly pulling it towards the back of the unit.
5. Carefully turn the unit over so that it is bottom-side up.
6. Remove the seven (7) screws that fasten the bottom cover.
7. Remove the bottom cover by firmly pulling it towards the back of the unit.
8. Place the unit on a flat surface in its normal orientation, with the rear panel facing you.
9. Decide where the board will go.

   We recommend that you do not move any boards already installed in the 186 unit. Instead, install a new board in an unused slot. This prevents the 186 unit from changing user-defined parameters to default parameters. Refer to *How To Check the Power Up Status*, page 112, for additional information.

Caution  **Place high powered boards, such as Hot Cathode boards, in higher numbered slots, close to the cooling fan. Insufficient cooling can damage a Hot Cathode board.**

10. Unscrew the two small screws holding the slot cover which corresponds to the board slot you intend to use.
11. If your board has two Type “D” connectors (Pirani or Control board), remove the top connector’s fastening screw.

    Refer to Figure 6, page 30, for placement of the top connector’s fastening screw.

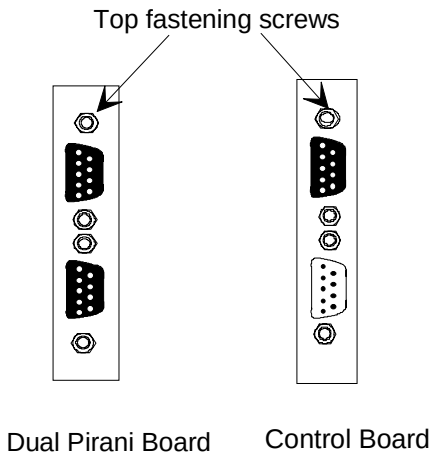


Figure 6: Fastening Screw Positions

12. Slide the board inside the unit so that the connector(s) protrude through the opening in the rear panel.

13. Line the board up so that the female connector on the board is directly over the male connector on the motherboard.

14. Carefully push the board onto the male connector.

15. If your board has two Type “D” connectors (Pirani or Control board), replace the top connector’s fastening screw.

16. Turn the unit over so that it is bottom-side up.

17. Use the screw which came with the board, to fasten the board to the bottom of the unit.

18. Replace the bottom cover by inserting it into the grooves provided and firmly sliding it towards the front of the unit.

    The center screw on the bottom cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

19. Replace the seven (7) screws that fasten the bottom cover.

20. Carefully turn the unit right-side up.

21. Grasp the top cover, which is fully perforated, and insert it into the grooves provided. Firmly slide it towards the front of the unit.

22. Replace the seven (7) screws that fasten the top cover.

    The center screw on the top cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

23. Replace the four Phillips head screws on the outside corners of the rear panel.

24. Replace all the cables which were disconnected from the 186 unit.

Start-up

1. Plug in the Power connector cable to connect the 186 instrument to the external power supply.

   The 186 instrument responds by illuminating the LED on the front panel. The LED is red initially, then it turns to green a few seconds after power up. Within 5 seconds the 186 instrument is fully initialized. Refer to *How To Check the Power Up Status*, page 112, if the LED remains red.

2. Allow the system to warm up.

   Allow the 186 instrument to warm up for 5 minutes to achieve the rated accuracy. Refer to the start up instructions that came with your particular transducer(s) for additional start up procedure and warm up time information. A hot cathode gauge must be turned on since it is off when the 186 instrument powers up.

3. Initiate gas flow in a manner appropriate to your system.

   The system is now operational. If your 186 instrument has a Control board, you can configure it to control the system. Refer to *Chapter Six: Operation of the Control Board*, page 129, for information on configuring and operating the Control board.

Communicating with the 186 Unit

The 186 unit has an Interface connector, located on the front panel, and an RS-232 connector, located on the rear panel. Both connectors support RS-232 communication between the 186 unit and a computer. However, the 186 unit only accepts messages through one port at a time, though it reports status information on both ports simultaneously. The 186 unit determines which port takes precedence based on the state of pin 4 of the Interface connector. (Refer to Table 6, page 36.)

Pin 4 left open: The rear panel connector (RS-232) is active; the front panel connector (Interface) is passive. The RS-232 connector takes precedence. It will accept command messages and respond to query messages. The device connected to the Interface connector can only monitor RS-232 communications that are currently being issued *from* the 186 unit, through the rear panel. The 186 unit sends out its responses on both connectors, however, it will only acknowledge messages on the active connector.

Pin 4 grounded: The front panel connector (Interface) is active; the rear panel connector (RS-232) is passive. The Interface connector takes precedence so that the device connected to the front panel can communicate fully with the 186 unit. Any device connected to the rear panel RS-232 connector can only monitor messages that are currently being issued *from* the 186 unit, through the front panel. The 186 unit sends out its responses on both connectors, however, it will only acknowledge messages on the active connector.

For regular operation, use the RS-232 connector on the rear panel to connect the 186 unit to your system. The Interface connector provides a convenient port to connect a portable computer to the 186 unit should you need to troubleshoot the unit.

Chapter Three: Overview

General Information

The 186 unit is controlled through remote RS-232 communications. Refer to *Chapter Four: Operation,* page 61, for information on establishing communication with a remote computer.

The Front Panel

The 186 unit has a status LED, cooling fan, and a 25-pin female Type "D" connector to connect to a computer via RS-232 communications.

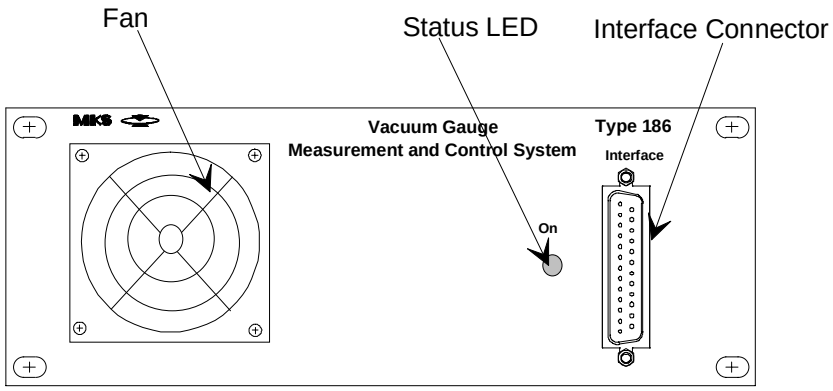


Figure 7: The Front Panel

Status LED

Upon power up, the LED indicates the status of the unit. Proceed *slowly* because the 186 instrument uses the color of the LED to communicate important diagnostic information.

- *The LED turns red, then changes to green within a few seconds*

  This indicates that all systems are operating properly. You may proceed to use the instrument.

- *The LED turns red and stays red*

  The 186 unit has detected a non fatal error, or several non fatal errors, during power up. You must address the cause of each error before using the instrument. One possible cause of this error is a configuration change, such as adding or removing a plug-in board. Refer to *How To Check the Power Up Status*, page 112, to determine the cause of the error. Cycle power to the unit. The unit will turn on properly if the problem was caused by adding or removing a board, however, all settings will revert to the default values. If a hardware problem caused the failure, the 186 unit may not be able to communicate.

- *After cycling power to the 186 unit several times, the LED still remains red*

  The 186 unit has detected a fatal error condition. You must power down the unit and send it back to MKS for service. Refer to *Customer Support*, page 19, for details.

Fan

The fan draws in air into the 186 unit to cool the internal components. Be sure that the area in front of the fan is kept clear for free air flow. Refer to *How To Clean the Fan Filter*, page 141, for maintenance information.

Interface Connector

The 25-pin female Type "D" Interface connector allows you to connect an RS-232 communications source to the front panel of the 186 unit. The pinout of the connector is listed in Table 6, page 36. As stated above, the front panel connector is a 25-pin female Type "D" whereas the RS232 connector, located on the rear panel, is a 9-pin male Type "D" connector. Refer to *Communicating with the 186 Unit*, page 32, for a complete description of the function of each communications connector.

Note 

The RS-232 cable for the front panel connector differs from the RS-232 cable used for rear panel communications. Refer to *Communicating with the 186 Unit*, page 32, for a description of how the 186 communicates.

Cable for the Interface Connector	
Interface Connector cable for RS-232 communication	CB146-21

Table 5: Cable for the Interface Connector

Table 6, page 36, lists the pinout information for the Interface connector.

Note 

The "No Connection" pin assignment refers to a pin with no internal connection.

Interface Connector Pinout	
Pin Number	**Assignment**
1	Chassis Ground
2	RS-232 Transmit Data (TXD)
3	RS-232 Receive Data (RXD)
4	$\overline{\text{RS-232 Receive Enable}}$ *
5	RS-232 Clear to Send (CTS)
6	Spare
7	Digital Ground
8	Filtered +5 Volts (50 mA maximum capacity)*
9	No Connection
10	No Connection
11	No Connection
12	No Connection
13	No Connection
14	No Connection
15	No Connection
16	No Connection
17	No Connection
18	No Connection
19	No Connection
20	RS-232 Request to Send (RTS)
21	No Connection
22	No Connection
23	No Connection
24	No Connection
25	No Connection
Connect pin 4 to pin 7 to override rear connector RS-232 ** The +5V signal that can be used to power one of several types of remote terminals.*	

Table 6: Interface Connector Pinout

Inside the Type 186 Unit

The 186 unit can house up to eight boards, as shown in Figure 1, page 23.

Caution **Position the high powered Hot Cathode boards in the higher numbered slots to provide the maximum air circulation from the cooling fan. Insufficient air circulation can damage a Hot Cathode board.**

Labels are placed on the rear panel to mark the channel number and board type of each board installed in the unit when it leaves the factory. A complete set of labels is supplied if an unconfigured base unit is ordered. Additional labels are available (MKS p/n LB-1141011).

Capacitance Manometer Board

The Capacitance Manometer board has one 15-pin female Type "D" connector. Table 7 lists the pinout of the connector. Refer to Table 8, page 39, for a list of the MKS capacitance manometers supported, along with their cables.

Capacitance Manometer Board Connector Pinout	
Pin Number	**Assignment**
1	+15 Volts
2	Signal+
3	$\overline{\text{Remote Zero}}$
4*	$\overline{\text{PROM Clock}}$ (120 x 10)
5	Power Ground
6	-15 Volts
7	+15 Volts
8	Remote Zero Out-of-Range
9	-15 Volts
10*	PROM Write
11	Digital Ground
12	Signal-
13*	$\overline{\text{PROM Read}}$ (120 x 10)
14	$\overline{\text{Bypass Remote Zero}}$
15	Chassis Ground
*See *Function of Pins 4, 10, and 13*, for more information	

Table 7: Capacitance Manometer Board Connector Pinout

Function of Pins 4, 10, and 13

Linear Capacitance Manometers: Pins 4, 10, and 13 are not used.

Type 120 Capacitance Manometer: Pins 4, 10, and 13 enable you to apply a gain of 10 to the transducer. The 120 transducer pulls pin 13 low when it changes range.

Note 

Neither the x0.1 nor the x10 range on the 120 transducer is supported. Use only the x1 range.

MKS Capacitance Manometers and Cables		
Type	**Description**	**Cable Number**
120	Highest Accuracy Standalone	CB120-1-xx
122A	General Purpose	CB112-2-xx
127A	Heated General Purpose	CB259-5-xx
128	High Temperature General Purpose	CB259-5-xx
220	NEMA Case	CB112-10-xx
221	Remote Sensor	CB112-14-xx
223	Differential Sensor	CB112-2-xx
124, 224, 225	General Purpose with Alarms	CB112-2-xx
390/690 with a 270	Highest Accuracy	CB112-6-xx
622	Absolute Transducer	CB112-2-xx
623	Absolute Transducer	CB112-2-xx
624	Absolute Transducer (heated)	CB112-2-xx
625	Absolute Transducer (heated)	CB112-2-xx
626	Absolute Transducer	CB259-5-xx
627	Absolute Transducer (heated)	CB259-5-xx
628	Absolute Transducer (heated)	CB259-5-xx
700 Series	Mini-Baratron® Absolute and Gage Pressure Transducers	consult factory
800 Series	Ultraclean Mini-Baratron Absolute and Gage Pressure Transducers	consult factory
where -xx is the length; standard length is 10 ft.		

Table 8: MKS Capacitance Manometers Supported by the 186 Instrument

Dual Pirani/Convection Board

On the end of the Pirani/Convection board are two 9-pin female Type “D” connectors, since the board can support up to two gauges. Table 9 shows the pinout for each connector. For each Pirani/Convection board, the top connector is the lower numbered channel, and the bottom connector is the higher numbered channel. For example, if this board is installed in slot 1, the top connector is channel 1 and the bottom connector is channel 2; if a second Pirani/Convection board is installed in slot 2, the top connector channel is channel 3 and the bottom connector is channel 4, and so forth.

Refer to Table 10, page 41, for a list of MKS Pirani sensors, along with their associated cables.

Pirani/Convection Board Connector Pinout	
Pin Number	**Assignment**
1	Drive +
2	Chassis Ground
3	Signal +
4	Signal -
5	Power Ground
6	Drive +
7	Bridge Delta +
8	Bridge Delta -
9	Power Ground

Table 9: Pirani/Convection Board Connector Pinout

Pirani Sensors and Cables	
Sensor Type	**Part Number**
Pirani Tube with KF-16	103150010
Pirani Tube with 1/8" NPT	103150011
Pirani Tube with ½" VCR	103150012
Pirani Tube with 1 1/3" CF	103150013
Pirani Tube with 2¾" CF	103150014
Cable Type	**Cable Number**
10 foot cable for all HPS Pirani sensors	CB146-15
186 to HPS CEP gauge	CB146-37
186 to G.P. Convectron®	CB146-14
186 cable adapter for G.P. Convectron® cable	CB146-1

Table 10: Pirani Sensors and Cables

Configuring the Dual Pirani/Convection Board as Single Channel Board

The Dual Pirani/Convection board can function as a single channel board. MKS will have configured the board as a single channel board, if you requested it when you placed the order. The board will be configured for dual channel operation if you did not specify single channel operation. If you did not request the single channel configuration, but wish to configure the board for single channel operation, follow these instructions.

Warning  **The 186 unit has lethal voltages inside. To avoid the danger of electrical shock, disconnect the Power connector cable *before* opening the unit.**

1. Be sure the Power connector cable is disconnected.
2. Disconnect all cables from the 186 unit.
3. Remove the four Phillips head screws on the outside corners of the rear panel.
4. Remove the seven (7) screws that fasten the top cover.
5. Remove the top cover by firmly pulling it towards the back of the unit.
6. Carefully turn the unit over so that it is bottom-side up.

7. Remove the seven (7) screws that fasten the bottom cover.

8. Remove the bottom cover by firmly pulling it towards the back of the unit.

9. Remove the Phillips screw that is securing the Pirani/Convection board to the bottom of the 186 unit.

10. Carefully turn the unit right-side up.

11. Unscrew the two small screws holding the slot cover on the Pirani/Convection board.

12. Remove the top fastening screw which is above the top connector.

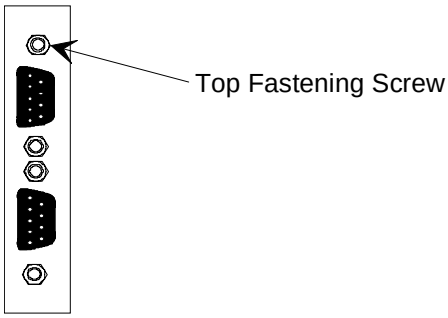


Figure 8: Pirani/Convection Board Connectors

13. Carefully but firmly pull the Pirani/Convection board out of the unit.

14. Remove the jumper that is currently on the jumper pack numbered JP2 through JP8 (typically the jumper is stored on JP2).

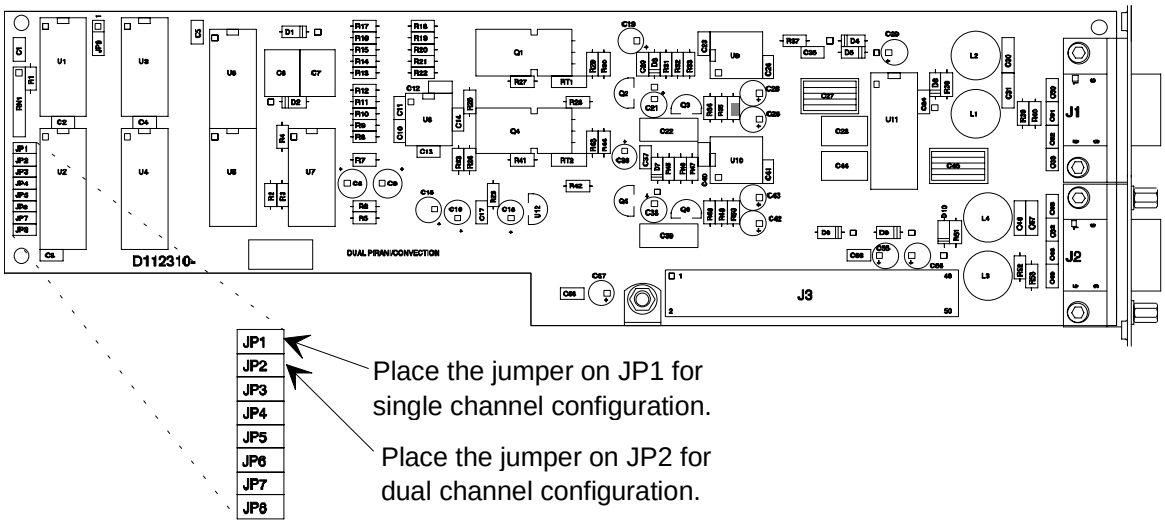


Figure 9: Jumper Placement on a Pirani/Convection Board

15. Place the jumper on JP1.

    The board is now configured as a single channel Pirani/Convection board. The upper connector becomes the only active channel.

16. Slide the board back inside the unit so that the connectors protrude through the opening in the rear panel.

17. Line the board up so that the female connector on the board is directly over the male connector on the motherboard.

18. Gently push the board onto the male connector.

19. Replace the top connector's fastening screw.

20. Turn the unit over so that it is bottom-side up.

21. Replace the Phillips head screw that fastens the board to the 186 unit.

22. Replace the bottom cover by inserting it into the grooves provided and firmly sliding it towards the front of the unit.

    The center screw on the bottom cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

23. Replace the seven (7) screws that fasten the bottom cover.

24. Carefully turn the unit right-side up.

25. Grasp the top cover with the silkscreening visible and insert it into the grooves provided. Firmly slide it towards the front of the unit.

    The back of the top cover is labeled so that the vent holes are positioned properly.

26. Replace the seven (7) screws that fasten the top cover.

    The center screw on the top cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

27. Replace the four Phillips head screws on the outside corners of the rear panel.

28. Replace all the cables which had been disconnected from the 186 unit.

29. Plug in the power cord.

Hot Cathode Board

Caution  **Position the high powered Hot Cathode boards in the higher numbered slots to provide the maximum air circulation from the cooling fan. Insufficient air circulation could damage a Hot Cathode board.**

Located on the end of the Hot Cathode board is one coaxial connector and one 15-pin female Type "D" connector. Table 11 shows the connector pinout of the coaxial connector and Table 13, page 45, shows the Type "D" connector pinout. A list of MKS hot cathode sensors, along with their cables, is shown in Table 12.

The 186 instrument offers several power control features designed for use with hot cathode gauges. If the 186 instrument detects a disconnected hot cathode, a tube short, or an open filament in the HC gauge, it automatically turns off power to the gauge. To restore power to the gauge, toggle the HC channel off and on again. This feature is always enabled. Refer to *Power Control Messages*, page 68, and *Ion Gauge Protection Features*, page 60, for a complete list of the protection features offered.

Hot Cathode Coaxial Connector Pinout	
Ion Current SMA	
Ion Current	Center
Chassis Ground	Shield

Table 11: Hot Cathode Coaxial Connector Pinout

Hot Cathode Sensors and Cables	
Sensor Type	**Part Number**
All MKS Hot Cathode Gauges, Types IG-xx, RG75, and NRC563	consult factory
HPS low power, nude, Bayard-Alpert (B/A) hot cathode KF40	100005987
HPS low power, nude, Bayard-Alpert (B/A) hot cathode 2¾ CF	100005980
Other nude or B/A tubes - thoriated iridium or tungsten filament	consult factory

Table 12: Hot Cathode Sensors and Cables
(Continued on next page)

Hot Cathode Sensors and Cables (*Continued*)	
Cable Type	**Part Number**
Cable for glass envelope tubes	CB146-13
Cable for glass envelope tubes and external power	CB146-16
Cable for nude hot cathode tube	CB146-19

Table 12: Hot Cathode Sensors and Cables

Hot Cathode Board Connector Pinout	
Pin Number	**Assignment**
1	Filament +
2	Chassis Ground
3	Filament -
4	+15 Volt Output
5	115 Volt Output
6	Grid/Degas -
7	External -15 Volts (high power)
8	Grid/Degas +
9	Filament +
10	External +15 Volts
11	Filament -
12	Power Ground
13	Grid/Degas -
14	External -15 Volts (Current limited)
15	Grid/Degas +

Table 13: Hot Cathode Board Connector Pinout

Note

One characteristic common to all ion gauges is an inability to establish an ion current at high pressures (low vacuum). The gauge may, therefore, respond as if the pressure is extremely low. Keep this characteristic in mind when you set a disconnect pressure, alarm trip points, or if you plan to use an ion gauge as a reference channel.

Configuring the Hot Cathode Board for a Low Power Hot Cathode

The Hot Cathode board can be configured for a low power hot cathode gauge (the default is for a high power gauge). MKS will configure the board for a low power gauge at the factory, if specified on the order. If you did not request the low power configuration, but wish to use the board with a low power hot cathode, follow these instructions.

Caution 

Be sure to have the correct setting for your hot cathode. Damage may occur to a low power hot cathode gauge if you operate it with the high power gauge configuration because excessive power would be applied to the grid during degas.

1. Be sure the Power connector cable is disconnected.

Warning 

The 186 unit has lethal voltages inside. To avoid the danger of electrical shock, disconnect the Power connector cable *before* opening the unit.

2. Disconnect all cables from the 186 unit.
3. Remove the four Phillips head screws on the outside corners of the rear panel.
4. Remove the seven (7) screws that fasten the top cover.
5. Remove the top cover by firmly pulling it towards the back of the unit.
6. Carefully turn the unit over so that it is bottom-side up.
7. Remove the seven (7) screws that fasten the bottom cover.
8. Remove the bottom cover by firmly pulling it towards the back of the unit.
9. Remove the Phillips head screw that is securing the Hot Cathode board to the bottom of the 186 unit.
10. Carefully turn the unit right-side up.
11. Unscrew the two small screws holding the slot cover on the Hot Cathode board.
12. Carefully but firmly pull the Hot Cathode board out of the unit.
13. Remove one of the shorting jumpers that is currently stored on JP4.

14. Place the shorting jumper on JP3.

    The board is now configured for a low power hot cathode gauge.

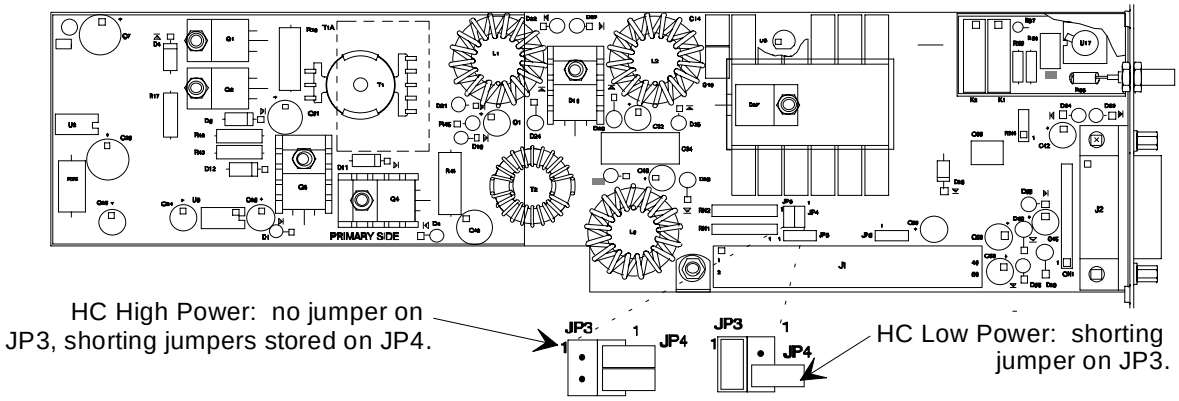


Figure 10: Jumper Placement on a Hot Cathode Board

15. Slide the board back inside the unit so that the connectors protrude through the opening in the rear panel.

16. Line the board up so that the female connector on the board is directly over the male connector on the motherboard.

17. Gently push the board onto the male connector.

18. Turn the unit over so that it is bottom-side up.

19. Replace the Phillips screw that fastens the board to the 186 unit.

20. Replace the bottom cover by inserting it into the grooves provided and firmly sliding it towards the front of the unit.

    The center screw on the bottom cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

21. Replace the seven (7) screws that fasten the bottom cover.

22. Carefully turn the unit right-side up.

23. Grasp the top cover with the silkscreening visible and insert it into the grooves provided. Firmly slide it towards the front of the unit.

    The back of the top cover is labeled so that the vent holes are positioned properly.

24. Replace the seven (7) screws that fasten the top cover.

    The center screw on the top cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

25. Replace the four Phillips head screws on the outside corners of the rear panel.

Cold Cathode Board

Located on the end of the Cold Cathode board are two coaxial connectors. Table 14 shows the pinout of each connector. Table 15 lists the MKS sensors supported, along with their cables.

Cold Cathode I/O Connectors	
High Voltage - High Voltage BNC	
High Voltage	Center
Chassis Ground	Shield
Ion Current SMA	
Ion Current	Center
Chassis Ground	Shield

Table 14: Cold Cathode I/O Connectors

Cold Cathode Sensors And Cables	
Sensor Type	**Part Number**
Cold Cathode with NW-40-KF	104210001
Cold Cathode with 2-3/4" CF	104210002
Cold Cathode with 1" tube	104210003
Cold Cathode with NW-25-KF	104210004
Cable	**Part Number**
Cold Cathode Cable (10 ft.)	100006171

Table 15: Cold Cathode Sensors and Cables

Note 

One characteristic common to all ion gauges is an inability to establish an ion current at high pressures (low vacuum). The gauge may, therefore, respond as if the pressure is extremely low. Keep this characteristic in mind when setting a disconnect pressure, alarm trip points, or if you designate an ion gauge as a reference channel.

Mass Flow Controller Board

On the end of the Mass Flow Controller (MFC) board is a 15-pin female Type “D” connector.

Mass Flow Controller Board Connector Pinout	
Pin Number	**Assignment**
1	No Connection
2	Signal In +
3	Valve Close output (active low open collector)
4	Valve Open output (active low open collector)
5	Power Ground
6	-15 Volts
7	+15 Volts
8	Set Point Signal Output
9	Fault Input (active low TTL): Reserved
10	Reserved
11	Set Point Remote Sense
12	Signal In -
13	No Connection
14	No Connection
15	Chassis Ground

Table 16: Mass Flow Controller Board Connector Pinout

Note 

The “No Connection” pin assignment refers to a pin with no internal connection.

Mass Flow Controllers and Cables	
MFC Type	**Part Number**
All MKS Mass Flow Controllers except Types 1749/1759	Consult the factory for a complete list of MFC types, ranges, and part numbers
Cable Type	**Part Number**
Cable for MFCs w/ Edge Card connector	CB147-7
Cable for MFCs w/ 15-pin Type “D” connector	CB147-1
Cable for MFCs w/ 9-pin Type “D” connector	CB147-12

Table 17: Mass Flow Controllers and Cables

Note

You must use the appropriate CB147-X cable to enable the MFC override commands. The CB259-5 and CB259-10 cables do not support the open and close override commands. However, using these cables will not damage either unit.

Control Board

The optional Control board has two connectors; a Valve Output connector and a Control Interface connector.

Valve Output Connector

The Valve Output connector, the upper connector on the board, uses a 9-pin female Type "D" connector. This connector carries valve drive lines, and the PCS (Pressure Control Signal) output used for throttle valves and ratio controllers. Refer to Table 18 for the Valve Output connector pinout.

Valve Output (Upper) Connector Pinout	
Pin Number	**Assignment**
1	Power Ground
2	+15 Volts
3	Reserved
4	Reserved
5	PCS (Pressure Control Signal) *an analog output signal (voltage)*
6	Valve Drive + *an analog output signal (current)*
7	Valve Drive - *an analog output signal (current)*
8	PCS Common (Signal Ground)
9	Chassis Ground

Table 18: Valve Output (Upper) Connector Pinout

Note 

The "Reserved" pin assignment refers to a pin with an internal connection, that may be assigned a function in the future.

The analog output signal is available as a voltage (pins 5 and 8) and a current (pins 6 and 7). When using the Valve Drive + and - outputs (pins 6 and 7), you must use the proper jumpers to select the full scale valve drive current (140 or 200 mA), and the compliance voltage (14 or 26 Volts) as listed in Table 19, page 52. For the Type 186 unit, compliance voltage is the voltage needed to sustain a given constant current throughout a range of valve types. The default jumper packs are JP3 and JP5. This default enables the 186 unit to drive a Type 148 or 248 Valve. Refer to *How To Configure the Control Board to Drive Different Valves*, page 53, to configure the 186 instrument to drive different valves.

Jumpers on the Control Board		
Jumper	**Voltage/Current**	**Jumpered for . . .**
JP1	200 mA	154 valve
JP2	Reserved	N/A
JP3	140 mA	148 and 248 valves
JP4	26 Volts	154 valve
JP5	14 Volts	148 and 248 valves

Table 19: Jumpers on the Control Board

How To Configure the Control Board to Drive Different Valves

1. Be sure the power cord is disconnected.

Warning **The 186 unit has lethal voltages inside. To avoid the danger of electrical shock, disconnect the power line before opening the unit.**

2. Disconnect all cables from the 186 unit.
3. Remove the top two (2) Phillips head screws on the outside corners of the rear panel.
4. Remove the seven (7) screws that fasten the top cover.
5. Remove the top cover by firmly pulling it towards the back of the unit.
6. Remove the shorting jumpers that are currently placed on and jumper packs numbered JP1 through JP5.

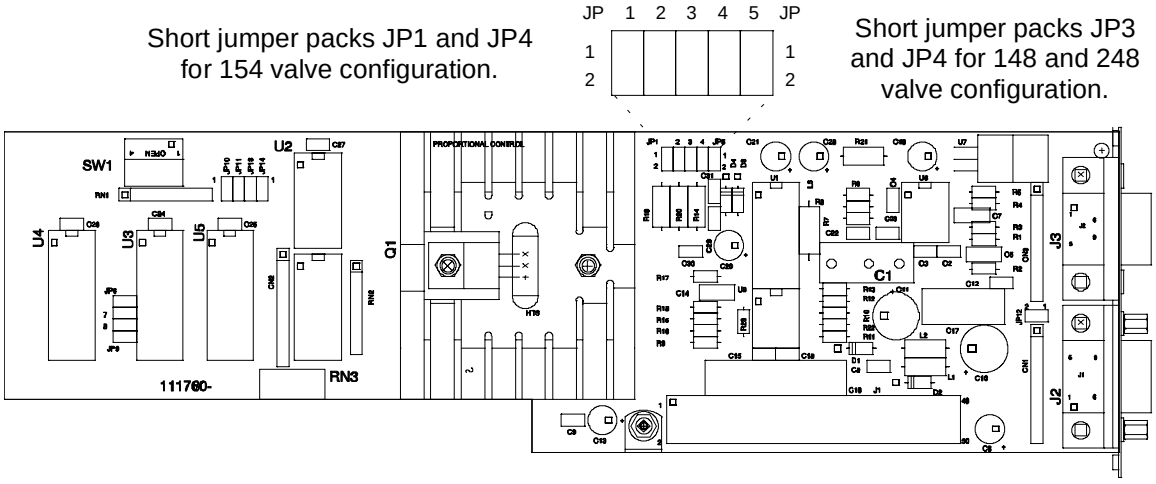


Figure 11: Jumper Placement on a Control Board

7. Place the shorting jumpers on JP1 and JP4 (for a Type 154 valve) or place the jumpers on JP3 and JP5 (for Type a 148, 248 or 153 valve).
8. Grasp the top cover with the silkscreening visible and insert it into the grooves provided. Firmly slide it towards the front of the unit.

   The back of the top cover is labeled so that the vent holes are positioned properly.

9. Replace the seven (7) screws that fasten the top cover.

   The center screw on the top cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

10. Replace the top two Phillips head screws on the outside corners of the rear panel.

11. Replace all cables which had been disconnected from the 186 unit.

12. Plug in the power cord.

Control Interface Connector

The Control Interface connector uses a 9-pin male Type "D" connector and is the lower connector on the board. The Control Interface connector includes the open, close, manual, and set point recipe select digital control lines.

Control Interface (Lower) Connector Pinout	
Pin Number	**Assignment**
1	Reserved
2	Select Recipe 2 (active low)*
3	Select Recipe 3 (active low)*
4	Select Recipe 4 (active low)*
5	Digital Ground
6	Reserved
7	Open (active low)**
8	Manual (active low)**
9	Close (active low)**
** Recipe 1 is used unless one pin (either 2, 3, or 4) is pulled low* *** The control mode defaults to Auto unless one pin (either 7, 8, or 9) is pulled low*	

Table 20: Control Interface (Lower) Connector Pinout

Note A "Reserved" pin assignment means that the pin has an internal connection and may be assigned a function in the future.

Control Valves and Cables		
Valve Type	**MKS Valve Type Number**	**Cable Number**
Solenoid	148, 248	CB251-2-10
Smart Throttle (not powered by the 186 unit)	153	CB153-4-10
Smart Throttle (powered by the 186 unit)	153	CB153-13-10
High Flow Solenoid	154	CB251-2-10 with CB-248-1-5 adapter

Table 21: Control Valves and Cables

Power Supply/Readouts and Cables		
Power Supply/Readout Type	**MKS Type Number**	**Cable Number**
Four Channel Flow, with CRT	147	CB147-3
Single Channel Flow	246	CB246-3
Four Channel Flow	247	CB247-9

Table 22: Power Supply/Readouts and Cables

Auxiliary Output Board

The Auxiliary Output board contains two relays. The modified, male 9-pin Type "D" connector at the top of the board allows operation of 120 VAC devices. The 9-pin female Type "D" connector at the bottom of the board carries relay status.

Auxiliary Output (Top) Connector Pinout	
Pin Number	**Assignment**
1, 2, 6	Relay A (NO, NC, C) *
4, 5, 9	Relay B (NO, NC, C) *
3, 7, 8	Reserved
* *NO = Normally Open, NC = Normally Closed, C = Common to both*	

Table 23: Auxiliary Output (Top) Connector Pinout

Auxiliary Output (Bottom) Connector Pinout	
Pin Number	**Assignment**
1	Relay A Status (high = energized)
2	Relay B Status (high = energized)
3	Reserved
4	Reserved
5	Reserved
6	Reserved
7	Reserved
8	Reserved
9	Digital Ground

Table 24: Auxiliary Output (Bottom) Connector Pinout

Note A "Reserved" pin assignment means that the pin has an internal connection and may be assigned a function in the future.

Auxiliary Output Board - Fail-Safe Feature

The relays on the Auxiliary Output board are associated with the 186 instrument's Fail-Safe feature. When the 186 unit is powered on, this feature is activated. The processor waits until pressure readings are stable before activating any of the relays in the 186 unit.

The Fail-Safe feature includes a watchdog timer (in hardware) which causes the relays to go to default positions. The processor in the 186 unit prevents the watchdog from triggering by issuing a timer reset pulse every 10 milliseconds. If the 186 unit fails, the interrupt pulse stops and the timed hardware reset executes, which causes the relays to go to default positions. The relays go to the default position (de-energized state) whenever the 186 unit is powered down.

Rear Panel

In addition to the plug-in board connectors, the rear panel contains the RS-232 connector, and the Power connector. Refer to Figure 1, page 23.

RS-232 Connector

The standard 9-pin male Type "D" connector, used for serial communications, is located on the rear panel. Table 25 lists the pinout of this connector, and Table 26 lists the cable (and its part number) to connect to your computer. *Chapter Four: Operation*, page 61, describes the RS-232 protocol used in the 186 instrument, and provides an interconnect diagram for IBM XT® and AT® compatibles.

RS-232 Connector Pinout	
Pin Number	**Assignment**
1	Reserved
2	Transmit Data (TXD)
3	Receive Data (RXD)
4	Reserved
5	Digital Ground
6	Data Terminal Ready (DTR)
7	Clear To Send (CTS)
8	Request to Send (RTS)
9	Reserved
A "Reserved" pin assignment means that the pin has an internal connection and may be assigned a function in the future.	

Table 25: RS-232 Connector Pinout

RS-232 Cables	
Cable	**Part Number**
Cable for AT® or compatible	CB146-2
Cable for XT® or compatible	CB146-4

Table 26: RS-232 Cables

Power Connector

The Power connector is a 7-pin coaxial high current metal shell connector that is the size of a standard 15-pin Type "D" connector. You must furnish a power supply to provide ±15 Volt ±5% @ 10 Amperes maximum to power the 186 instrument.

Power Connector Pinout	
Pin Number	**Assignment**
A1	+15 Volts
A2	-15 Volts
1	Analog Output
2	Analog Return
3	±15 Volt Power Common
4	±15 Volt Power Common
5	±15 Volt Power Common

Table 27: Power Connector Pinout

Refer to Table 28 for a description of the Y-cable, CB186S-7-M1, that connects the 186 unit to your power supply. The standard cable length is 10 feet; consult factory for other lengths.

Description of the Power Connector Y-Cable		
Power Connector End		**Flying Lead End**
Pin Number	**Assignment**	**Wire Color**
A1	+15 V	Red
A2	-15 V	White
3, 4, 5	Ground	Black
	Drain	Metal Braided Shield
1	Analog Output	Red
2	Analog Return	Black
	Drain	Metal Braided Shield

Table 28: Description of the Power Connector Y-Cable

Note 

For installations where the 186B is replacing a 186A unit, an adapter cable (121984-G1) is available. This type of connection *violates* the CE marking of the 186B if the power cable remains unshielded.

Ion Gauge Protection Features

A characteristic of either hot or cold cathode gauges is that they may provide invalid pressure readings when the pressure is above 1 x 10^{-2} Torr. In addition, hot cathode tubes may be damaged at high pressures (low vacuum). Because of these gauge limitations, the 186 unit has some high pressure and pressure rate-of-rise protection built into its hardware, and provides user-editable protection parameters as well. Refer to *Chapter Four, Operation*, page 61, for more information on RS-232 commands.

Ion Gauge Auto Power Control *RS-232 Command:* Channel Auto Control, page 68

When the pressure reading of the selected reference channel exceeds a user-defined pressure limit, the ion gauge is powered off. When the pressure drops below the preset limit, the ion gauge turns back on. If a hot cathode gauge had been degassing when it was auto powered off, the degas function will *not* turn back on when the hot cathode is auto powered on.

HC High Pressure Shutoff *RS-232 Command:* HC High Pressure Shutoff, page 74

When the pressure reading of a hot cathode gauge exceeds a user-defined pressure limit, the gauge is powered off. The gauge will *not* auto power on again even if the pressure drops below the shutoff pressure. To power the gauge again, the pressure must be below the shutoff limit, *and* the HC channel must be turned off and then on again.

Ion Gauge Disconnect Pressure *RS-232 Command:* Ion Gauge Disconnect Pressure, page 74

The ion gauge disconnect pressure feature sounds an alarm and changes the gauge's reading to DISCONNECTED when the detected pressure drops below the threshold pressure. Set the disconnect pressure to a value one decade below the system base pressure for a reliable disconnect alarm. You can also set the threshold pressure to the highest pressure reading the ion gauge can reliably measure. To disable this feature, set the disconnect pressure to -1.0. Refer to Table 34, page 74.

Internal Fast Rate of Rise Shutoff *RS-232 Command:* Internal Fast Rate of Rise Shutoff, page 74

This feature is built into the hardware of the 186 unit. If pressure rises rapidly to a level that potentially could harm a hot cathode's filament, the gauge is turned off. The response to a channel status command will indicate a disconnected sensor. For more information on the channel status command, refer the *Read Only Messages*, page 108. The exact pressure limit is dependent upon the type of gauge, but for most Bayard-Alpert tubes it is around 10 to 100 mTorr. To power on the gauge again, the hot cathode channel must be turned off and then on again. The initial setting for this feature is disabled.

Internal Sensing of HC disconnect/tube shorts/open filament *This feature is always enabled, it cannot be disabled.*

This feature is built into the hardware of the 186 unit. If the 186 unit detects a disconnected hot cathode gauge, or a tube short or open filament, the gauge is immediately turned off. To power the gauge again, the hot cathode channel must be turned off and then on again.

Chapter Four: Operation

General Information

The 186 unit can communicate with any host computer equipped with an RS-232 serial port and an appropriate cable. The 186 instrument operates as a DTE (Data Terminal Equipment) device, and uses a standard 9-pin male Type "D" connector (IBM AT® configuration). The RS-232 messages allow you to fully control all 186 functions remotely. The messages include commands that set parameters, and requests that query the status of the parameters or the pressure reading.

Chapter Four: Operation, this chapter, organizes the commands by *functional* type, and provides a complete description of each command.

Chapter Five: Sensor Board Command Summary, page 117, organizes the commands by *sensor board* type.

Chapter Six: Operation of the Control Board, page 129, discusses operating a Control board.

RS-232 Communication Parameters

Refer to Table 29 for a list of the RS-232 communication parameters.

Note The 186 communication parameters are permanent. You cannot change the setting of any of the communication parameters.

RS-232 Communication Parameters	
Parameter	**Setting**
Baud Rate	9600
Parity	Even
Number of Data Bits	7
Number of Stop Bits	1
End-of-Line Delimiter	CR

Table 29: RS-232 Communication Parameters

How To Establish RS-232 Communications

Connect the computer to the 186 unit with the correct RS-232 cable. Use the RS-232 connector on the rear panel to connect the 186 to your system. Note that the RS-232 cable used for rear panel communications (refer to Table 26, page 58, for the proper MKS part number) is not the same as the RS-232 cable used for the front panel (MKS p/n CB146-21). Refer to *Communicating with the 186 Unit*, page 32, for the difference between the front and rear panel connectors.

Channel Numbering

The 186 unit can hold up to eight plug-in boards, and supports up to 10 input channels, 4 control channels, and up to 16 relays. Each input channel can have a maximum of 2 relays assigned to it. Therefore, you can use twice as many relays as input channels.) The input channels include capacitance manometers, Pirani gauges, convection gauges, hot cathode gauges (maximum of 4), cold cathode gauges, and mass flow controllers. The output channels include process control outputs (maximum of 4). The unit also supports 1 analog output. The channel numbering sequence depends on the position of the plug-in board in the 186 unit. Boards are identified by their slot position in the unit, starting from the left (when the unit is viewed from the back). The input and output channels are numbered separately.

Note 

The analog output is provided by the motherboard so it does not require a separate plug-in board. It is assigned channel number 1.

For example, using the board configuration shown in Figure 1, page 23, the Capacitance Manometer board in slot 2 would be assigned input channel 1. The Pirani board in slot 3 would be assigned input channel 2 (upper connector) and input channel 3 (lower connector). The second Pirani board in the adjacent slot would use input channel 4 (upper connector) and input channel 5 (lower connector). The four Hot Cathode boards, in slots 5 through 8, would be assigned input channels 6 through 9. This configuration does not use any output channels.

If the four Hot Cathode boards were replaced with 4 Control boards, the sequence of the input channels would remain the same, for channels 1 through 5. The Control board in slot 5 would have output channel 1, the Control board in slot 6 would have output channel 2, and so forth.

Note 

The ten input channels are numbered in sequence from 1 through 9; the tenth channel is channel 0.

RS-232 Protocol

Message Syntax

The information presented in this section applies to all RS-232 messages. The RS-232 message syntax uses the following conventions:

bold	Messages that you must enter exactly as shown in the manual. Do not include any spaces in the message string.
italics	Placeholder that represents text or numeric values that you must supply.
`response`	Format of message sent from the 186 instrument.
[ENTER]	Represents Carriage Return that must be configured as the end-of-line delimiter (in your communications software).

- All commands are sent and received as ASCII strings.
- All commands *must* include an ID byte. If the ID byte has no significance, any character, except [ENTER] can be supplied in its place.
- All messages must use a carriage return as the end-of-line delimiter. Use your communications software on the host computer to assign a CR to the [ENTER] key.
- Use UPPERCASE letters for all command messages.

Format of the Messages

You may enter either scientific notation or fixed notation for floating point data fields. For example, to set the full scale range to 1000 Torr (1×10^3) on channel 1, you can enter either:

For Fixed Notation: **@0611:1000** [ENTER]

or

For Scientific Notation: **@0611: 1E3** [ENTER]

For information on the full scale range command, refer to *Sensor Configuration Messages*, page 73.

To specify the format that the 186 instrument will use for its *response* messages, use the 508 response format command message. The factory setting is fixed notation. Refer to *RS-232 Response Messages Sent By the 186* Unit, page 65, for more information.

Note 

All examples in this manual will use fixed notation for both command and response messages.

Format of Messages Sent By the Host Computer

Messages sent by the host computer to the 186 unit are either *commands* that instruct the instrument to change an operating parameter, or *requests* that prompt the instrument to report status information. Use UPPERCASE letters in all command messages.

The following table shows the format of RS-232 command messages that are sent by the host computer to the 186 unit. Specific command bytes are described in this chapter.

RS-232 Command Message Format								
Type of Message	**@**	**Command Category**		**Command Number**	**ID**	**Data (one of the following)**		
Data Input		**Byte 1**	**Byte 2**	**Byte 1**		**:**	**up to 20 data bytes**	ENTER
Request						**?**	ENTER	
Command							ENTER	

@	The "@" character is always the first character in a message.
Command Category	2 ASCII Bytes
Command Number	1 ASCII Byte
ID	1 ASCII Byte. It may be one of the following: input channel number (1 - 0); analog output number (1); control channel number (0 - 4); alarms A – P; blank space or any character.
Data	This can be variable length ASCII data up to 20 bytes. For data input, use a colon (:) followed by the data, terminated with ENTER. For a data request, use a question mark (?) followed by ENTER. For no data, press ENTER by itself.

Table 30: RS-232 Command Message Format

How To Query the Status of a Parameter

You can request the status of any user-defined parameter by entering the RS-232 command with a "?" inserted for the value. For example, to request the sensor full scale range value on channel 1, enter:

@0611? ENTER

The 186 unit will send the following response (if the response format is set to fixed notation):

@0611:1000ENTER

RS-232 Response Messages Sent By the 186 Unit

Format of the Response Messages

You can specify the format for all RS-232 responses, by sending the following command:

@508•:<option> ENTER

where:

- • represents a blank space

<option> is E (for scientific notation) or D (for fixed notation)

The 186 instrument uses fixed notation by default.

Note

1. You must re-issue the response format command after each power up since it is not stored at power down.
2. The error responses are discussed in *Error Messages*, page 66.

Response to a Command

When you issue a command, the 186 instrument returns the command category, command number, and the ID, followed by a colon and the acknowledgement, ":OK." Using the example above, to issue the command to specify scientific notation, enter:

@508*x*:E ENTER

The 186 instrument returns:

@508*x*:OK<CR>

Note

The "OK" response indicates that the command syntax was correct and the command did not generate an error response. This response does not mean that the command was implemented. For example, the command to power on a channel with a disconnected sensor will be accepted but not implemented. To verify that the command was implemented, issue a query message. The 186 unit will report the current value.

Response to a Request

When you issue a request, the 186 unit returns the query message, except the actual data replaces the "?" in the data field. Following the example above, to query the response format enter:

@508*x*? ENTER

The 186 instrument returns:

@508*x*:E<CR>

Error Messages

If the 186 instrument cannot execute a command, it will respond with an error message.

Error Code Summary	
Error Code	**Description**
E111	Unrecognized command
E112	Inappropriate command
E122	Invalid data field

Table 31: Error Code Summary

E111: Unrecognized Command

An "unrecognized command" error message will occur if the command syntax is incorrect. The 186 instrument cannot interpret the command string. The syntax error is located in the first four bytes of the command. Also, if you are converting from a 146 unit to a 186 unit, some commands, such as the front panel lock out, do not apply and will generate an unrecognized command message. Refer to Table 30, page 64, for a description of the command message format.

E112: Inappropriate Command

The 186 unit will return an "inappropriate command" error message if the command cannot be executed on the selected channel (the command is not supported for the type of channel); the command is supported but cannot be executed at this time; or a request only message is sent as a command message. Inappropriate commands include attempting to:

- Read a channel that is turned off
- Zero an ion gauge (*ion gauges cannot be zeroed*)
- Zero or span a channel when the zero or span function, respectively, is turned off
- Read a channel that is out-of-range
- Read a hot cathode gauge that is performing a high power degas
- Perform a degas procedure on a channel that is not connected to a hot cathode gauge
- Span a Pirani gauge that has the gas type set to argon or helium (*Pirani gauges can only be spanned if the gas type is set to nitrogen.)*
- Enter the Auto (or PID) control mode with the recipe select command set to "none"

E122: Invalid Data Field

An "invalid data field" error message indicates a problem with the data field of the command string. The data field can contain a maximum of 26 characters. If your data field exceeds 26 characters, the 186 instrument will return an invalid command error message. Other possible causes of an invalid command error message include entries in lowercase letters, an invalid data range, or a data field that contains numbers instead of letters, or vice versa.

Getting Started

This section is designed to help you initiate communications with the 186 instrument. Once you have established communications, refer to *Power Control Messages*, page 68, and *Sensor Configuration Messages*, page 73, to complete the system configuration.

Note 

You must turn on power to a channel before it can accept messages. If you attempt to change a parameter of a channel that is powered off, an E112, inappropriate command error message will result.

How To Verify Instrument Configuration

You can query the 186 instrument to report all of the boards currently installed. Refer to *Diagnostic Messages*, page 114, for a detailed description of this message.

To query the 186 instrument for its configuration, enter:

@992•?[ENTER]

where • = represents a blank space

The 186 instrument will respond with the same command except the "?" will be replaced with:

0 = Empty slot
1 = Pirani board (configured as a single channel board)
2 = Pirani board (configured for dual channel operation)
3 = Hot Cathode board
4 = Capacitance Manometer board
5 = Mass Flow Controller board
6 = Control board
7 = Cold Cathode board
8 = Auxiliary Output board

Note 

The instrument configuration command reports the type of board installed in each slot; it does not report channel information. Refer to *Channel Numbering*, page 62, for information on how channel numbers are assigned.

How To Turn On Power to a Channel

Before you can read the value of any channel, you must turn on power to the channel.

@081<id>:<state> [ENTER]

where <id> = the channel number (1, 2, . . .9, 0)

<state> = OFF
ON

For more information on powering channels, refer to *Power Control Messages*, page 68.

Power Control Messages

The power control messages enable you to turn the power to a channel on or off, to activate the Auto Power feature, and to perform a hot cathode degas procedure. Table 32 lists the power control messages.

Power Control Messages								
Message Description	**Message Format**							
	@	**Command Category**		**command number**	**ID**		**Data**	
Channel Power	@	0	8	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ON = On OFF = Off *Sensor must be attached*	ENTER
Channel Auto Power Control (ion gauges only)	@	0	8	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	E = Enable D = Disable	ENTER
Auto Power Reference Channel	@	0	8	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	Channel # in ASCII	ENTER
Auto Power Shutoff Pressure	@	0	8	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value	ENTER
Hot Cathode Degas	@	0	8	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	L = Lo power H = Hi power O = Off	ENTER

Table 32: Power Control Messages

Channel Power

The ability to turn off power to sensors is a useful function in several situations. For example, it is a safety procedure against explosion during cryo-pump regeneration with all sensors except capacitance manometers (the danger of explosion does not exist with capacitance manometers). A cold cathode gauge should be powered off above 1 x 10^{-2} Torr, otherwise false readings may occur. Generally this is also true for hot cathode gauges. In addition, a hot cathode gauge may experience damage to its filament at high pressures (low vacuum). Pirani type gauges may need to be powered off if there is a chance their filaments may ignite, or induce a reaction in backfilled gases.

Warning 

Turn off all gauges (except capacitance manometers), that are in contact with a cryo-pump, during regeneration procedures. The gauges may cause an explosion if they are not powered down.

To turn on or off a mass flow controller (MFC) channel, follow the exact same procedure as described for a sensor channel. Note, however, that power is still supplied to an MFC or capacitance manometer when the channel is off.

To turn off the power to channel 2, issue the following command:

@0812:OFF ENTER

Note 

1. A sensor must be attached to the channel. Otherwise, the 186 unit will accept the command if the format is correct (so the response will be "OK"), but be unable to implement it. A subsequent query of the channel power will report "OFF."
2. This command does not turn off power to MFCs or capacitance manometers.
3. The 186 unit will accept and implement ion gauges messages during the gauge initialization procedure.

Ion Gauge Auto Power Control

The Ion Gauge Auto Power Control enables you to control the state of the ion gauge based on the pressure reading from a reference channel. When the pressure reading on the reference channel exceeds a user-defined pressure limit, the 186 instrument will power off an ion gauge. When the pressure reading on the reference channel drops below the preset limit, the 186 instrument powers on the ion gauge. If a hot cathode gauge had been degassing when it was auto powered off, the degas function will *not* turn back on when the hot cathode gauge is auto powered on.

When an ion gauge is in an auto powered off condition, the gauge will not be powered back on until the reference channel measurement is less than 90% of the auto power shutoff threshold setting.

The default setting is off for this feature.

To activate the Auto Power Control on channel 5, issue the following command:

@0825:E ENTER

To define the pressure limit, enter the following command:

@084<chan>:<pres> ENTER

where <chan> = the channel number (1,2,...9,0)

<pres> = pressure limit value, in ASCII

To define the reference channel, issue the following command:

@083<chan>:<ref> ENTER

where <chan> = the channel number (1,2,...9,0)

<ref> = channel number of the reference channel (1,2,...9,0)

How To Perform a Hot Cathode Degas Procedure

Note 

The 186 instrument can only perform the degassing procedure on *one* hot cathode gauge at a time. All other channels will continue to function during the degassing procedure.

The 186 instrument can perform either a low or high power degassing procedure. The hot cathode channel must be on (power on) in order to degas it. A hot cathode channel configured for high power can undergo either a high or low power degas. If the hot cathode channel is configured for low power, only use the low power degas. For information on configuring the Hot Cathode board, refer to *Hot Cathode Board*, page 44.

Caution 

Damage to a hot cathode gauge can occur if pressure is allowed to get too high. To avoid any damage, monitor the pressure and control it within the specifications stated for the hot cathode gauge.

Degas is only effective if the pressure remains less than 1 x 10^{-5} Torr.

During a low power degas, the filament inside the hot cathode stays on and the 186 unit continues to collect valid pressure readings. During low power degas (I^2R resistance heating), all the power remaining (after powering the filament) is delivered to the grid inside the tube.

During a high power degas, the filament inside the hot cathode is turned off and all power is delivered to the grid inside the tube. The 186 instrument will *not* report pressure readings during a high power degas.

Initiating a Low Power Degas:

To perform a low power hot cathode degas procedure:

1. To power on the hot cathode channel, issue the command:

   @081<chan>:ON ENTER

   where <chan> = the channel number (1,2,...9,0)

2. The following command starts the low power degas procedure:

   @085C:L ENTER

   where <chan> = the channel number (1,2,...9,0)

3. To stop the low power degas procedure, enter:

   @085C:O ENTER

   where <chan> = the channel number (1,2,...9,0)

Initiating a High Power Degas:

Caution **Only perform the high power degas procedure on a high power hot cathode gauge. Performing a high power degas procedure on a low power gauge may damage the grid within the gauge.**

Follow the steps below to configure the 186 instrument to perform a high power hot cathode degas procedure.

1. To power on the hot cathode channel, issue the command:

   @081<chan>:ON ENTER

   where <chan> = the channel number (1,2,...9,0)

2. To verify that the 186 instrument has correctly identified the sensor type, enter:

   @069<chan>? ENTER

   where <chan> = the channel number (1,2,...9,0)

   The 186 instrument will respond with the same string, except the "?" will be replaced with a number to indicate the type of sensor:

   6 for high power hot cathode gauge

   7 for a low power hot cathode gauge

   For more information on the sensor identification command, refer to *Sensor Configuration Messages,* page 73.

3. To start the high power degas procedure, issue the following command:

   @085<chan>:H ENTER

   where <chan> = the channel number (1,2,...9,0)

   H =selects a high power degas procedure

4. To stop the high power degas procedure, enter:

   @085<chan>:O ENTER

   where <chan> = the channel number (1,2,...9,0)

Sensor Configuration Messages

Sensor configuration is used to adjust parameters that are specific to different gauge types or to a mass flow controller (MFC). This group also contains the commands to set the alarms, provided by the Auxiliary Output board. The 186 unit automatically determines the type of sensor attached to each channel during power up.

Table 33 lists the parameters included in the sensor configuration group as they apply to the different gauges.

Sensor Configuration Parameters	
Gauge Type	**Adjustable Parameters**
Capacitance Manometer	Sensor range Resolution Units (Torr*, mTorr, mbar, Pascal)
Pirani or Convection	Gas type (N_2, Ar, or He) Convection gauge type (HPS or GP) Units (Torr*, mTorr, mbar, Pascal)
Hot Cathode	Sensitivity Disconnect Pressure High Pressure Shutoff Internal Fast Rate of Rise Shutoff Units (Torr*, mTorr, mbar, Pascal)
Cold Cathode	Gauge Correction Factor Disconnect Pressure Units (Torr*, mTorr, mbar, Pascal)
Mass Flow Controller	Range Units (sccm*, slm)
Alarms	Assign channel
** denotes the default value*	

Table 33: Sensor Configuration Parameters

Refer to Table 34, page 74, for a complete list of the sensor configuration messages.

Refer to *Chapter Five: Sensor Board Command Summary,* page 117, for a complete list of commands for each board type.

Sensor Configuration Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Channel Range	@	0	6	1	1, 2, 3, 4, 5, 6, 7, 8, 9 ,0 (channel #)	:	ASCII value indicating full scale range	ENTER
Channel Resolution	@	0	6	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value that represents resolution as a power of 10	ENTER
Channel Gas Type	@	0	6	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	N = Nitrogen A = Argon H = Helium	ENTER
Channel Gauge Factor/Sensitivity	@	0	6	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value	ENTER
Ion Gauge Disconnect Pressure	@	0	6	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value of the disconnect pressure, from -1.0 to +0.001	ENTER
Hot Cathode High Pressure Shutoff	@	0	6	6	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value of the shutoff pressure	ENTER
Internal Fast Rate of Rise Shutoff (Hot Cathode)	@	0	6	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	E = Enable D = Disable	ENTER
Convection Gauge Type	@	0	6	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	4 = GP Convectron 5 = HPS CEP	ENTER

Table 34: Sensor Configuration Messages
(Continued on next page)

Sensor Configuration Messages *(Continued)*								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Sensor Identification	@	0	6	9	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	? *(Request only)* 0 = Type 120 2 = linear capacitance manometer 3 = HPS Pirani 4 = GP Convectron 5 = HPS CEP 6 = high power hot cathode 7 = low power hot cathode 8 = cold cathode 9 = mass flow controller	ENTER
Assign Alarm 1	@	0	6	A	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #, one per alarm relay)	:	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M , N, O, P) The query will return an X if no alarm is assigned	ENTER
Assign Alarm 2	@	0	6	B	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel ##, one per alarm relay)	:	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M , N, O, P) The query will return an X if no alarm is assigned	ENTER
Select units for an individual channel	@	0	6	C	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm C = Celsius	ENTER

Table 34: Sensor Configuration Messages

Capacitance Manometer Configuration Messages

The sensor configuration messages for a capacitance manometer include the sensor range and resolution entries. Refer *Calibration Messages*, page 85, for information on zero and span adjustments.

Sensor Identification

To verify that the 186 instrument has correctly identified the sensor type, send the command:

@069<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument will respond with the same string, except the "?" will be replaced with a number to indicate the type of sensor:

0 for a Type 120 capacitance manometer

2 for a linear capacitance manometer

Sensor Full Scale

The default full scale range for all capacitance manometers is 1000 Torr. To set the sensor full scale, issue the command:

@061<chan>:<fs> ENTER

where <chan> = the channel number (1,2,...9,0)

<fs> = the full scale of the sensor, 0.0009 to 100,000 Torr

Sensor Resolution

Sensor resolution is the number of significant digits displayed to the left or right of the decimal point. The range of the sensor resolution setting for a Type 120 gauge or linear capacitance manometer is ±7 decades (from 10^{-7} to 10^{+7}) The default resolution, for all capacitance manometers, is 1×10^{-1}. The resolution value must be entered as the power of 10; the range is from -7 to +7.

For example, to display 3 digits to the right of the decimal point (the resolution would be 1×10^{-3}) on channel 2, enter the following command:

@0622:-3 ENTER

Channel Units

You can set the units for each individual channel using the units command:

@06C<chan>:<units> ENTER

where <chan> = the channel number (1,2,...9,0)

<units> = a letter representing units (MT = mTorr; T = Torr; PA = Pascal; MB = mbar)

Pirani and Convection Gauge Configuration Messages

The 186 unit determines whether a Pirani or convection type gauge is connected when the channel is powered on. However, the 186 unit *cannot* distinguish between an HPS Convection Enhanced Pirani (CEP) and a Granville-Phillips (GP) Convectron gauge. The default selection for a convection gauge is the Convectron gauge. Therefore, if you are using an HPS CEP gauge, you must issue an additional command to select the convection gauge type.

Sensor Identification

To verify that the 186 instrument has correctly identified the sensor type, ensure that the sensor is powered on, and enter:

@069<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument will respond with the same string, except the "?" will be replaced with a number to indicate the type of sensor:

3 for Pirani gauge

4 for Convectron

5 for HPS convection gauge

Selecting the Gas Type

You must select the gas type for both Pirani and convection gauges. Nitrogen is the default gas type for all gauges. To select the gas type, enter the following command:

@063<chan>:<gas> ENTER

where <chan> = the channel number (1,2,...9,0)

<gas> = N for nitrogen; A for argon; H for helium

Selecting the Type of Convection Gauge

The 186 unit cannot distinguish between a GP Convectron and an HPS Convection-Enhanced Pirani (CEP) gauge. Therefore, you must issue this command to select the type convection gauge (the gauge does not need to be on). This command is not necessary if you have a Pirani gauge.

@068<chan>:<gauge> ENTER

where <chan> = the channel number (1,2,...9,0)

<gauge> = 4 for GP Convectron; 5 for HPS CEP gauge

Channel Units

You can set the units for each individual channel using the units command:

@06C<chan>:<units> ENTER

where <chan> = the channel number (1,2,...9,0)

<units> = a letter representing units (MT = mTorr; T = Torr; PA = Pascal; MB = mbar)

Hot Cathode Configuration Messages

The Hot Cathode board is configured for a high power hot cathode gauge, by default. If you are using a low power hot cathode gauge, refer to *Configuring the Hot Cathode Board for a Low Power Hot Cathode*, page 46, for instructions on how to change the default setting and accommodate a low power hot cathode.

To configure the 186 unit to operate a hot cathode gauge you need to set the ion gauge disconnect pressure, and the sensitivity. In addition, the 186 instrument offers two shutoff commands as safety features.

Note  The 186 unit will accept and implement hot cathode specific RS-232 messages during the initialization procedure.

Sensor Identification

To verify that the 186 instrument has correctly identified the sensor type, enter:

@069<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument will respond with the same string, except the "?" will be replaced with a number to indicate the type of sensor:

6 for high power hot cathode gauge
7 for a low power hot cathode gauge

Sensitivity

The sensitivity value can range from 0.01 to 100, inclusive; the units are 1/Torr. The default value for the sensitivity is 10. Increasing the sensitivity value *decreases* the slope of the actual pressure versus the apparent pressure curve. Therefore, a smaller change in the apparent pressure (what the hot cathode gauge reads) results in a measurable change in the actual pressure value (what the 186 unit reports).

To enter the sensitivity parameter, issue the following command:

@064<chan>:<value> ENTER

where <chan> = the channel number (1,2,...9,0)
<value> = the sensitivity value, in ASCII

Ion Gauge Disconnect Pressure

The ion gauge disconnect pressure is set at base pressure so that if the detected pressure drops below this limit (often the result of a disconnected sensor), the response to a channel status command will indicate a disconnected sensor. For more information on the channel status command, refer to *Read Only Messages*, page 108.

Another use for this entry is to detect when the pressure has exceeded the limit at which an ion gauge can reliably measure. A characteristic of all ion gauges is that when measuring at high pressures (low vacuum), an ion current cannot be established. The gauge may, therefore, respond as if the pressure is extremely low. This situation is detected by setting the shutoff limit at base pressure.

To enter the disconnect pressure value, enter the following command:

@065<chan>:<pres> ENTER

where <chan> = the channel number (1,2,...9,0)

<pres> = the disconnect pressure value, in ASCII, ranging from -1.0 to +0.001

To disable this feature, set the disconnect pressure value to -1.0.

Note

1. The factory configuration disables the ion gauge disconnect pressure feature (the value for the disconnect pressure is -1). If you enable this feature, ensure that your pressure signal is not excessively noisy in the low end of its range. A noisy pressure signal may drop below the disconnect pressure briefly causing the 186 unit to disconnect the sensor.
2. The 186 unit assumes that a gauge is disconnected if the pressure reading is below the disconnect pressure value for three consecutive readings.

Hot Cathode High Pressure Shutoff

This feature allows you to define a high pressure limit for a hot cathode gauge. The 186 unit will power off a hot cathode gauge if its pressure exceeds the pressure limit. The gauge will *not* auto power on again even if the pressure drops below the shutoff pressure. (Since the gauge is powered off, it cannot detect when the pressure drops below the shutoff pressure.) To power on the gauge again, the pressure must be below the shutoff limit, *and* the hot cathode channel must be turned off and then on again.

Caution

Valid pressure limits for a hot cathode gauge range from 1 x 10^{-5} Torr to 1 Torr. Select the high pressure limit carefully since a hot cathode gauge can be permanently damaged if oxygen is present at pressures above 0.01 Torr.

Enter the following command to define the pressure limit:

@066<chan>:<pres> ENTER

where <chan> = the channel number (1,2,...9,0)

<pres> = the pressure limit value, in ASCII (range 1 x 10^{-5} Torr to 1 Torr)

Internal Fast Rate of Rise Shutoff

This feature is built into the hardware of the 186 unit. If pressure rises rapidly to a level that potentially could harm a hot cathode's filament, the gauge is turned off and the response to a channel status command will indicate a "bad sensor" status. For more information on the channel status command, refer to *Read Only Messages,* page 108. The exact pressure limit is dependent upon the type of gauge, but for most Bayard-Alpert tubes it is around 10 to 100 mTorr. To power the gauge again, toggle the hot cathode channel off and then on again.

The initial setting for this feature is disabled.

Note 

The factory configuration disables the internal fast rate of rise shutoff feature (the value for the disconnect pressure is -1). If you enable this feature, ensure that your pressure signal is not excessively noisy. A fast pressure increase due to noise may activate this feature and cause the 186 unit to turn off the gauge.

The following command sets the internal fast rate of rise shutoff:

@067<chan>:<state> ENTER

where <chan> = the channel number (1,2,...9,0)

<state>= E for enabled; D for disabled

Channel Units

You can set the units for each individual channel using the units command:

@06C<chan>:<units> ENTER

where <chan> = the channel number (1,2,...9,0)

<units> = a letter representing units(MT = mTorr; T = Torr; PA = Pascal; MB = mbar)

Cold Cathode Configuration Messages

The sensor configuration messages for a cold cathode gauge include setting the gauge correction factor and the ion gauge disconnect pressure.

The 186 unit will accept and implement cold cathode specific RS-232 messages during the initialization procedure.

Sensor Identification

To verify that the 186 instrument has correctly identified the sensor type, enter:

@069<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument will respond with the same string, except the "?" will be replaced with a number to indicate the type of sensor:

8 for a cold cathode

Gauge Correction Factor

The cold cathode gauge requires that you enter a combined gauge and gas correction factor. This factor is used as a multiplier, so it acts like a span adjustment factor. Increasing the gauge correction factor increases the pressure reading. The gauge correction factor can range from 0.01 to 100. The default value is 1.00.

To enter the gauge correction factor, issue the following command:

@064<chan>:<factor> ENTER

where <chan> = the channel number (1,2,...9,0)

<factor> = the gauge correction factor, in ASCII

Ion Gauge Disconnect Pressure

The ion gauge disconnect pressure is set at base pressure so that if the detected pressure drops below this limit (often the result of a disconnected sensor), the response to a channel status command will indicate a disconnected sensor. For more information on the channel status command, refer to *Read Only Messages*, page 108.

Another use for this entry is to detect when the pressure has exceeded the limit at which an ion gauge can reliably measure. A characteristic of all ion gauges is that when measuring at high pressures (low vacuum), an ion current cannot be established. The gauge may therefore respond as if the pressure is extremely low. This situation is detected by setting the disconnect pressure at base pressure.

To enter the disconnect pressure value, enter the following command:

@065<chan>:<pres> ENTER

where <chan> = the channel number (1,2,...9,0)

<pres> = the disconnect pressure value, in ASCII

To disable this feature, set the disconnect pressure value to -1.0.

Note

1. The factory configuration disables the ion gauge disconnect pressure feature (the value for the disconnect pressure is -1). If you enable this feature, ensure that your pressure signal is not excessively noisy in the low end of its range. A noisy pressure signal may drop below the disconnect pressure briefly causing the 186 unit to disconnect the sensor.
2. The 186 unit assumes that a gauge is disconnected if it receives a below threshold value for three consecutive readings.

Channel Units

You can set the units for each individual channel using the units command:

@06C<chan>:<units> ENTER

where <chan> = the channel number (1,2,...9,0)

<units> = a letter representing units(MT = mTorr; T = Torr; PA = Pascal; MB = mbar)

Mass Flow Controller Configuration Messages

The range selection is the only sensor configuration command necessary for a mass flow controller (MFC). Refer to *Mass Flow Controller (MFC) Specific Messages*, page 101, for more information.

Sensor Identification

To verify that the 186 instrument has correctly identified the sensor type, enter:

@069<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument will respond with:

```
@069C:9
```

Range

Mass flow controllers are available in a variety of full scale ranges. The range is usually listed on the serial number label. Use this entry to select MFC range; from 0.0002 sccm to 1 x 10^5 sccm. The default range is 1000 sccm.

To change the MFC range, issue the following command:

@061<chan>:<range> ENTER

where <chan> = the channel number (1,2,...9,0)

<range> = full scale range of the MFC

Refer to *Mass Flow Controller (MFC) Specific Messages*, page 101, for a complete list of commands.

Channel Units

This command allows you to set the units for each individual channel. The flow unit sccm (standard cubic centimeters per second) is default setting for an MFC channel.

@06C<chan>:<units> ENTER

where <chan> = the channel number (1,2,...9,0)

<units> = a letter representing units (S = sccm; L = slm; C = Celsius)

As an alternate, the MFC board can be used with some temperature gauges to report temperature in degrees Celsius (° C) instead of a flow rate. Enter a “C” in the <units> data field.

Alarm Assignment Messages

Each input channel can have up to two alarm relays assigned to it. The alarms assigned to each channel are referred to as alarm 1 and alarm 2 for that channel. Two alarm relays are provided on the Auxiliary Output board. Refer to *Alarm Messages*, page 95, for more information on alarms.

Note Each alarm relay (A through P) can only be assigned one input channel since the input channel reading determines the relay state.

To assign a alarm relay to a channel as alarm 1, enter:

@06A<chan>:<relay> ENTER

where <chan> = the channel number (1,2,...9,0)

<relay> = the alarm relay (A through P)

To assign an alarm relay to a channel as alarm 2, enter:

@06B<chan>:<relay> ENTER

where <chan> = the channel number (1,2,...9,0)

where <relay> = the alarm relay (A through P)

Note The query will return an “X” if there is no alarm assigned to the channel.

Calibration Messages

Depending upon the type of sensor, calibration may involve adjusting the zero, the span, or both the zero and span.

Sensor Calibration Parameters			
Type of Sensor	**Zero**	**Span to Reference.**	**Span to Atmosphere**
Capacitance Manometer	Yes	No	No
Pirani/Convection	Yes	Yes	Yes
Cold Cathode	No	Yes	No
Hot Cathode	No	No	No
MFC	Yes	No	No

Table 35: Sensor Calibration Parameters

Calibration Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID (channel #)**		**Data**	
Zero Channel *(command only)*	@	0	5	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 0			ENTER
Span Channel to Atmosphere *(command only)*	@	0	5	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 0		Sensor type must be a Pirani/Convection gauge.	ENTER
Span with Reference *(command only)*	@	0	5	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 0	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (reference channel #)	ENTER
Zero On/Off	@	0	5	6	1, 2, 3, 4, 5, 6, 7, 8, 9, 0	:	ON = On OFF = Off	ENTER
Span On/Off	@	0	5	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 0	:	ON = On OFF = Off	ENTER
Enable Auto Zero	@	0	5	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 0	:	E = Enable D = Disable	ENTER
Select Auto Zero Reference Channel	@	0	5	9	1, 2, 3, 4, 5, 6, 7, 8, 9, 0	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (reference channel #)	ENTER

Table 36: Calibration Messages

How To Zero a Sensor

For pressure sensors, zeroing means adjusting the readout for the sensor. The zero point is the pressure at which the instrument displays zero pressure. For Pirani type gauges and capacitance manometers, the zero point is the output voltage at which zero pressure is referenced. Ion gauges cannot be zeroed.

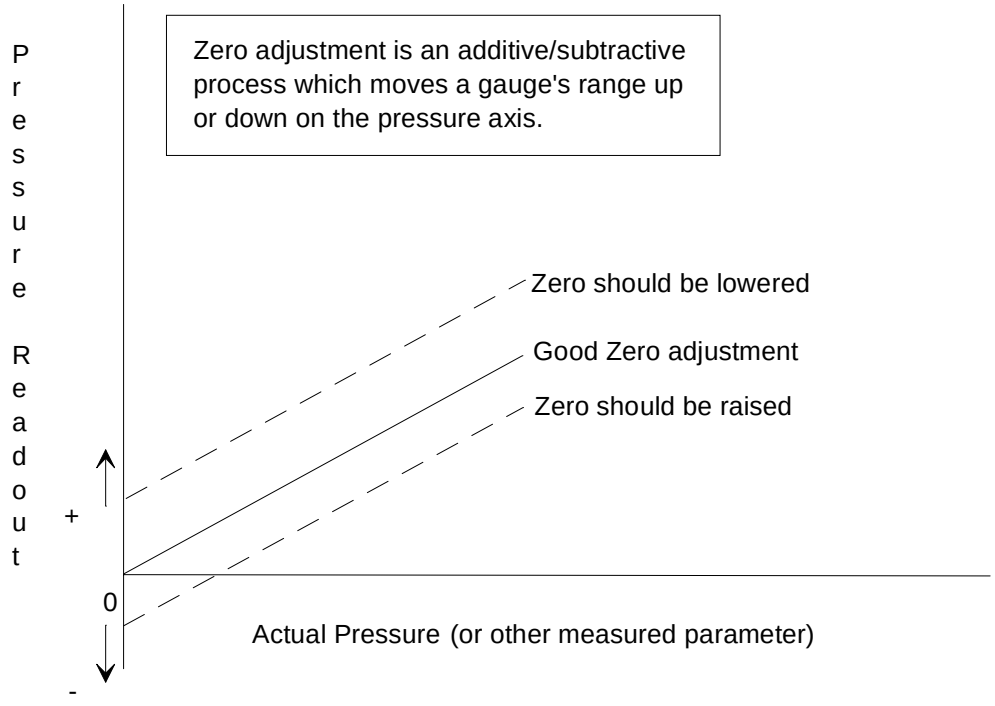


Figure 12: Zeroing a Sensor

For mass flow controllers (MFC), the zero offset is subtracted from the MFC reading and added to the set point output voltage. This is done to accommodate the internal PID control loop in an MFC.

Note

1. Before zeroing an MFC, verify that there is no gas flow through the unit. Two ways to accomplish this involve an upstream valve, or a digital override (refer to *Mass Flow Controller (MFC) Specific Messages,* page 101, for more information).
2. To zero an MFC, the reading must be close to 0.0. The 186 instrument will not perform the zero function if the reading deviates from 0.0 by more than ±10% of the full scale range of the MFC. For example, for a 10 sccm unit, the reading must be 0.0 ±1.0 sccm.

1. Verify that the sensor is reading a value within the range listed in Table 37. To zero a sensor, issue the following command:

   @051<chan> ENTER

   where <chan> = the channel number (1,2,...9,0)

   The system responds by zeroing the sensor on the selected channel. The reading of the selected channel goes to zero.

Ranges for Zeroing a Sensor	
Sensor Type	**Zero Range***
Pirani and convection gauges	Gauges can always be zeroed
Type 120 Capacitance Manometer	-0.8 to +0.8 Volts
Linear Capacitance Manometer	-0.3 to +0.3 Volts
Ion gauges (Hot Cathode and Cold Cathode gauges)	Cannot be zeroed
Mass Flow Controller	-0.5 to +0.5 Volts
**Use the Sensor Voltage (@603) command to read the voltage values; refer to* Read Only Messages, *page 108*	

Table 37: Ranges for Zeroing a Sensor

Note

1. Zeroing any sensor preempts the factory set zero. To return to the factory set zero, use the command to toggle the zero on/off, described on page 88.
2. If there is no sensor for the channel number selected, the system will respond to a channel status command to indicate a disconnected sensor. For more information on the channel status command, refer to *Read Only Messages*, page 108.
3. If a sensor's zero goes out of its normal range, the 186 unit will respond to a channel status command to indicate an underranged or overranged sensor. For more information on the channel status command, refer to *Read Only Messages*, page 108.
4. Ion gauges cannot be zeroed since they are high vacuum gauges.
5. For the MKS Type 120 gauge, the zeroing occurs in both the sensor and in the 186 unit. If the Type 120 gauge cannot complete the zeroing itself, the 186 unit completes the zeroing, provided the 120 gauge is within ±0.8 V of zero.
6. If the zero channel command (@051) is sent while the zero on/off command (@056) is off, the zero is performed and the zero on/off function is turned on.

How To Turn the Zero On/Off

Once a sensor or MFC has been zeroed, use this procedure to toggle between using the factory-defined zero value and the user-defined zero value. When the zero is toggled off, the 186 instrument does not apply the user-defined zero correction to the sensor/MFC reading. Toggling a sensor's zero on and off is useful as a diagnostic aid, or as a transducer calibration check.

1. Issue the following command to disable (toggle off) the user-defined zero:

   @056<chan>:OFF ENTER

   where <chan> = the channel number (1,2,...9,0)

   The system bypassed the user-defined zero of the sensor on the selected channel.

Note

1. For Pirani gauges, the factory-set zero becomes effective.
2. For Type 120 capacitance manometers, the zero is bypassed in both the sensor and the 186 unit.

2. To enable (toggle on) the user-defined zero, issue the following command:

   @056<chan>:ON ENTER

   where <chan> = the channel number (1,2,...9,0)

   The system restores the channel's user-defined zero.

Note

1. For Pirani gauges, the 186 unit restores the user-defined zero when the sensor zero is toggled on.
2. For Type 120 capacitance manometers, the zero is restored in both the sensor and the 186 unit.

How To Span a Pirani-Type Sensor to Atmosphere

Spanning a Pirani-type sensor should only be done at atmosphere. Spanning is done to adjust the upper range of the gauge which may have drifted due to contamination or aging of the sensor. Figure 13 shows the effect of spanning a Pirani-type sensor. The span adjustment requires the gas type to be nitrogen and assumes a pressure of 760 Torr (atmospheric pressure), as its reference. The gauge will report 760 Torr when spanned. The spanning method is usually sufficient to bring the spanned gauge's readings within its stated measurement accuracy. If this is not the case, span the gauge with a reference (refer to *How To Span a Sensor with a Reference,* page 90).

Note

1. Spanning a Pirani sensor preempts the factory set span. To return to the factory set span, turn off the span function. Refer to *How To Turn the Span On/Off,* page 91.
2. A Pirani sensor cannot be spanned if helium (He) or argon (Ar) is the gas type chosen. The gas must be nitrogen (N_2).

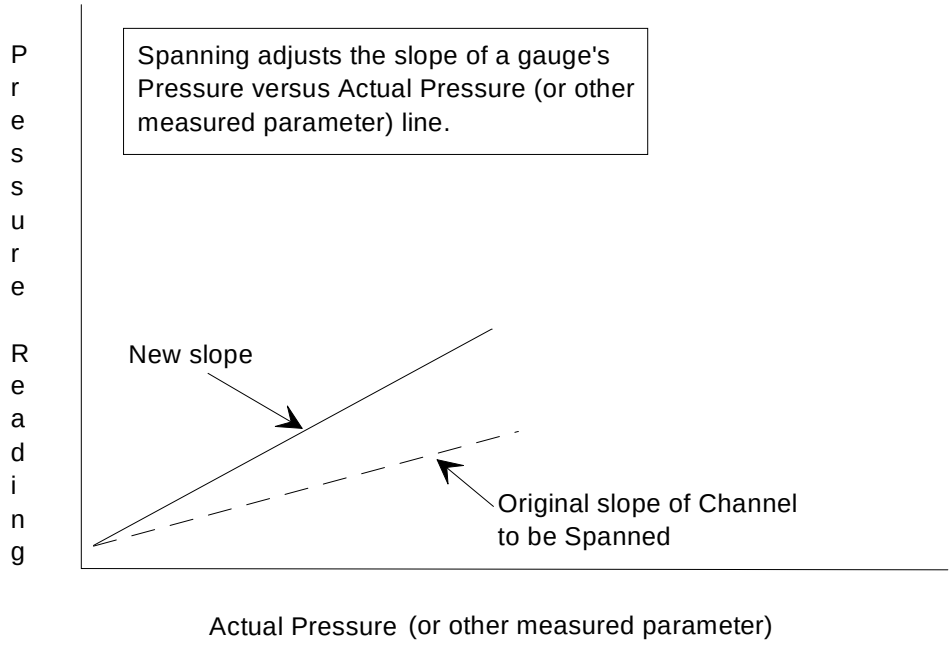


Figure 13: Spanning a Pirani-Type Sensor

- To span a Pirani-type sensor, issue the following command:

  @053<chan> ENTER

  where <chan> = the channel number (1,2,...9,0)

  The system responds by spanning the Pirani-type sensor on the selected channel.

How To Span a Sensor with a Reference

This procedure spans one sensor based on the reading of a reference sensor. This makes the upper pressure reading of the spanned gauge agree with the pressure reading of the referenced gauge. Spanning is done with two sensors that are well within their measurement ranges.

Caution **This command is not supported in firmware version 1.2x.**

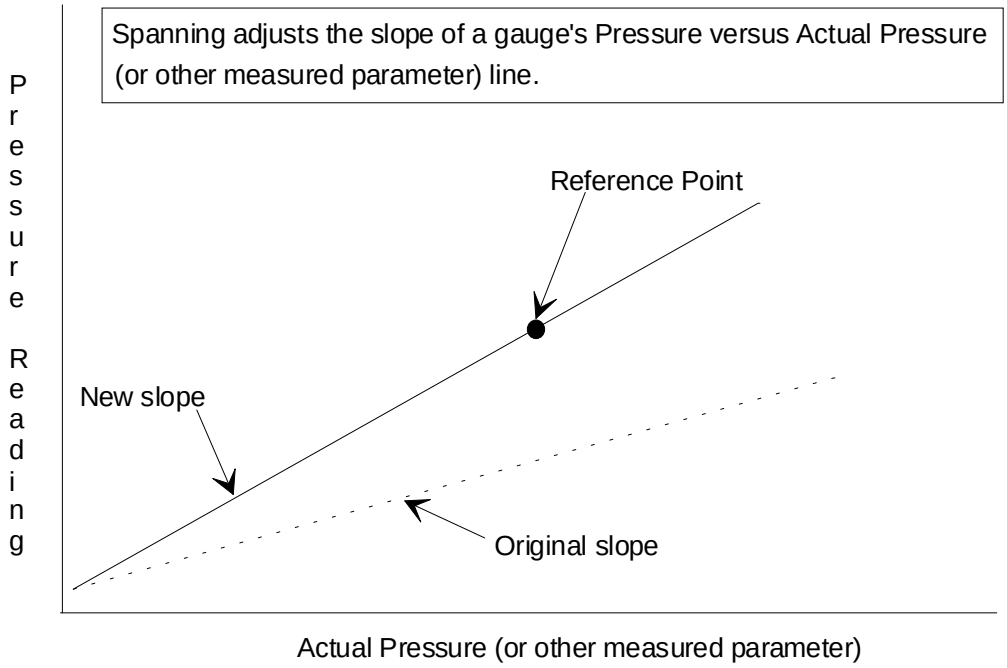


Figure 14: Spanning a Sensor with a Reference

Note

1. Pirani gauges must be reading above 100 Torr, and the reference channel must be within a decade of the Pirani channel for a valid span.
2. When spanning a Pirani gauge, the reference sensor can be anything except an ion gauge. This includes another Pirani.
3. For a successful span of an ion gauge, the reference must be a capacitance manometer. The capacitance manometer must be at least a decade above its zero, reading within one decade (±) of the unspanned ion gauge, and reading at or below 10 mTorr.
4. This procedure does not apply to capacitance manometers.

1. Issue the following command to span a sensor to a reference sensor:

   @055<chan>:<ref> ENTER

   where <chan> = the channel number (1,2,...9,0)

   <ref> = the reference channel number (1,2,...9,0)

   The system responds by spanning the sensor on the first channel to the reading of the sensor on the second channel.

How To Turn the Span On/Off

Once a sensor has been spanned, use this procedure to toggle between using the factory-defined span value and the user-defined span value. When the span is toggled off, the factory-defined span is used. Table 35, page 85, lists the sensor types that support the span command.

Note This procedure does not apply to capacitance manometers.

1. Issue the following command to toggle off the span. This will disable the user-defined span value and use the factory-defined span value.

   @057<chan>:OFF ENTER

   where <chan> = the channel number (1,2,...9,0)

   The system bypasses the user-defined span for the sensor on the channel selected.

2. To use the user-defined span value (toggle on the span) issue the following command:

   @057<chan>:ON ENTER

   where <chan> = the channel number (1,2,...9,0)

   The system restores the channel's user-defined span.

How To Turn Auto Zeroing On/Off

The Auto Zero feature uses one channel (defined as the reference channel) to automatically zero a second channel (defined as the selected channel). The 186 unit continually zeros the selected channel as long as the reference channel's pressure is below the selected channel's minimum resolution. The 186 unit suspends the zeroing operation during the first 10 seconds after the reference channel is turned on, and whenever the reference channel's condition is not measuring.

The Auto Zero function overrides any user-defined zero previously set. Entering a new user-defined zero overrides the effects of the Auto Zero function. The 186 unit uses the last zero defined (by Auto Zero or user-defined) when the Auto Zero feature is disabled.

Configuring the Auto Zero function is a two step process. First, you must select the channel to be auto zeroed and the reference channel. A second command enables or disables the Auto Zero function.

1. The following command selects the Auto Zero and reference channels:

   @059<chan>:<ref> ENTER

   where <chan> = the channel number (1,2,...9,0)

   <ref> = the reference channel number (1,2,...9,0)

2. To enable the Auto Zero function, issue the following command:

   @058<chan>:E ENTER

   where <chan> = the channel number (1,2,...9,0)

   E = Enable (D = Disable)

   The system responds by enabling the Auto Zero function.

Analog Output Messages

The 186 instrument provides one built-in analog output, available on the Power connector. The analog output is referred to as analog output 1; it does not occupy a channel number. Refer to Table 27, page 59, for the Power connector pinout.

You can program the output as either linearly scaled (LN), logarithmically scaled (LO1 - LO9), or as a set point (SP). Table 38, page 94, lists the analog output command messages.

Linear Scaling

In linear scaling, the 0 to 10 Volt output is directly proportional to the pressure of the selected input channel. The voltage versus pressure curve is linear over its entire length. Refer to Figure 15 for a scalar representation of voltage versus pressure for a 1000 Torr transducer.

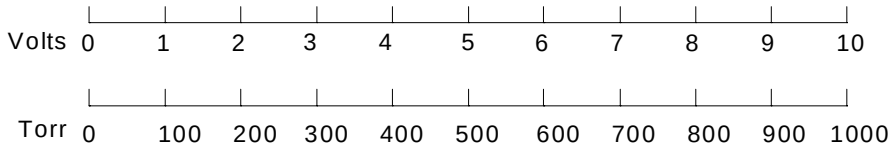


Figure 15: Voltage versus Pressure

Logarithmic Scaling

In logarithmic scaling, as in linear scaling, the full scale output of 10 V is made to correspond to the pressure of the input channel. The voltage versus pressure curve is logarithmic over its upper portion, and linear over its lower portion. The boundary between linear and logarithmic scaling is determined by the selection of LO1 through LO9. The *numerals 1 through 9* represent the number of logarithmic decades in the output. Each logarithmic decade is equal to 1 Volt. As an example, you want the full scale voltage of 10 Volts to correspond to 20 Torr, and you want three decades of logarithmic output. To accomplish this, select LO3. Refer to Figure 16 for a scalar representation of voltage versus pressure with three decades of logarithmic output.

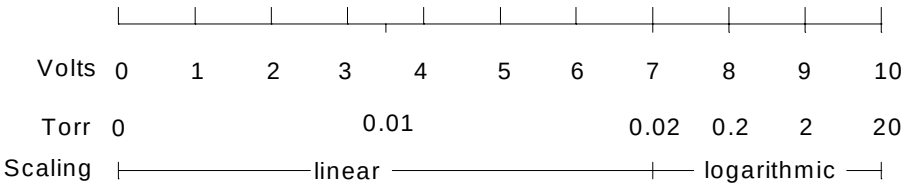


Figure 16: Linear and Logarithmic: Voltage versus Pressure

Set Point

In the case of a set point, a fixed voltage is output from the 186 unit. The value remains constant, regardless of the pressure reading on the input channel. The set point voltage can range from -10.5 through 10.5 Volts.

Analog Output Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Channel Output Type	@	0	7	1	1 (analog output #)	:	LN = Linear LO1 to LO9 = Log 1 to Log 9 SP = Set Point	ENTER
Input Channel Selection	@	0	7	2	1 (analog output #)	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #'s)	ENTER
Full Scale Pressure at 10 V output *or* set point output voltage	@	0	7	3	1 (analog output #)	:	Value in ASCII (using the units of the input channel) Range: 0.001 to 1000 Torr *or* -10.5 to 10.5 Volts	ENTER

Table 38: Analog Output Messages

How To Configure the Analog Output

1. Enter the pressure value corresponding to full scale voltage, ***OR,*** if you are using a set point, the voltage for the set point (-10.5 to 10.5 Volts). Use the following command:

   @0731:<pres> ENTER

   where <pres> = an ASCII number representing either:

   the full scale pressure (0.001 to 1000 Torr), ***or***
   the set point voltage (-10.5 to 10.5 Volts)

2. To select the output scaling method, issue the following command:

   @071:<scale> ENTER

   where <scale> = LN for linear
   LO1 to LO9 for Log 1 to Log 9
   SP for Set Point

   The system defaults to 5 Volts if the set point is greater than 10.

3. Select the input channel that supplies the input signal for scaling.

   @0721:<input> ENTER

   where <input> = the channel number (1,2,...9,0)

Alarm Messages

The Auxiliary Output board provides two relays that can be used as alarms. The 186 unit supports up to eight Auxiliary Output boards (or sixteen relays). Refer to Table 34, page 74, for the command to assign the alarm to a channel. Up to two alarms can be assigned to a sensor channel, which allows you to define an upper and lower operating range.

Overview of Alarms

From a design viewpoint, the alarms provided by the Auxiliary Output board consists of several, single pole, double throw relays.

From an operational viewpoint, the alarm system consists of user-defined *alarm trip points*, and user-defined relay *actuation states*. Alarm trip points are set, and individual alarms can be enabled or disabled. To understand how to configure the alarm relay system in the 186 unit, it is necessary to understand what an *alarm condition* means. In the 186 instrument, **an alarm condition exists when pressure rises above the alarm trip point pressure**.

The first alarm relay parameter to set up is the relay *actuation state*. Actuation and deactuation simply refer to how an alarm relay is configured during a non-alarm condition. Individual alarms must be assigned an actuated or deactuated state. If a relay is set up as a deactuated relay and an alarm condition arises, the relay will respond as shown in Figure 17.

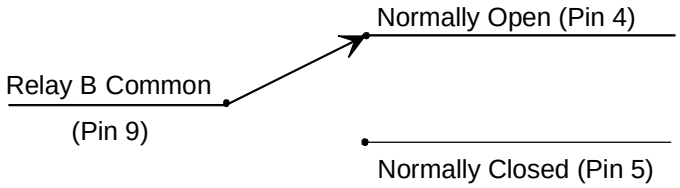


Figure 17: Relay B During an Alarm Condition, when configured as a Deactuated Relay

If a relay is set up as an actuated relay and an alarm condition arises, the relay will be configured as shown in Figure 18.

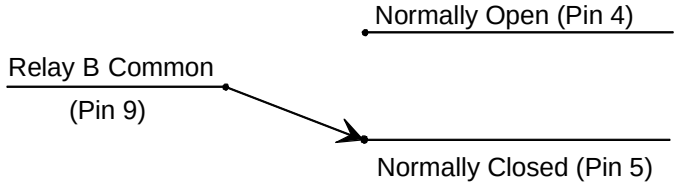


Figure 18: Relay B During an Alarm Condition, when configured as an Actuated Relay

Note

The relays in the 186 unit do not support latching!

The relays in the MKS Type 146 Cluster Gauge Vacuum Measurement and Control System, differ from those in the 186 unit in that they support a latching feature. A relay with the latch feature enabled will hold the alarmed position after the alarm condition no longer exists. The relay must be manually unlatched to assume the non-alarm position.

Refer to Tables 23 and 24, page 56, for the pinout of the relay connectors.

Default Settings of the Trip Point Alarms	
Parameter	**Default Setting**
Alarm State	Disabled
Trip Point Value	0 Torr
Hysteresis Value	10%
Input Channel	1
Actuation State	Actuated

Table 39: Default Settings of the Trip Point Alarms

Alarm Condition

An alarm condition occurs when a channel's pressure reading goes over the alarm trip point plus hysteresis. When an alarm condition arises, the alarm relay condition changes. That is, if the relay contact was open, it changes to closed.

Hysteresis

Hysteresis is built into the operation of the alarm relays to help compensate for the noise inherent in all systems. Without hysteresis, the noise may cause the relays to repeatedly switch states, a condition known as "relay chatter." The hysteresis value is specified as a percentage of the trip point pressure, and can be adjusted separately for each relay.

Setting the hysteresis too high creates a *deadband* around the trip point. The deadband prevents the alarm relay from responding to changes in the pressure signal around the trip point. Ideally, the hysteresis should be close to, but not less than, the peak-to-peak noise to provide maximum immunity from relay chatter while providing the best possible accuracy. It may take some trial and error efforts to determine the best hysteresis setting for your system.

When an alarm is enabled, the pressure of the sensor on the input channel must rise above the trip point value *plus* the hysteresis value before an alarm condition occurs. The pressure of the sensor must fall below the trip point value *minus* the hysteresis value before the alarm condition clears.

Figure 19, page 97, shows how noise effects a system. The figure uses a system in which the relay is actuated when the pressure falls *below* the trip point setting.

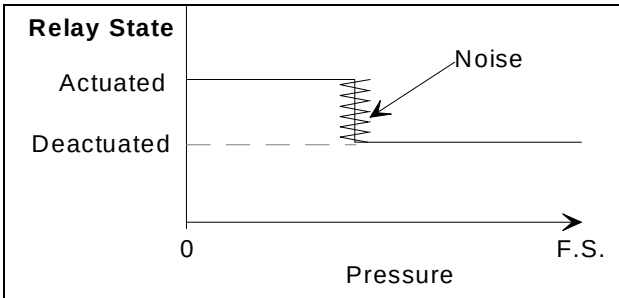
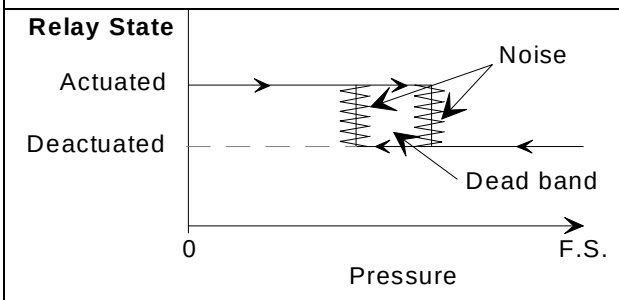
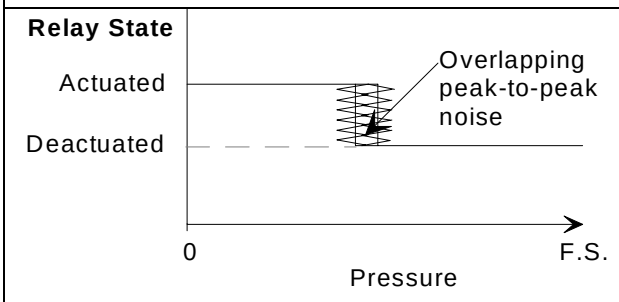
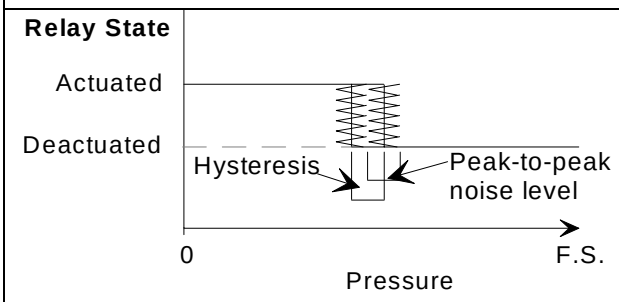
	The noise in a system can cause the pressure signal to vary back and forth across an alarm trip point, causing the relay to repeatedly change state. This condition is known as relay chatter.
	By incorporating hysteresis in the control loop, relay chatter can be eliminated. If the hysteresis is too great, however, a deadband develops where changes in the pressure signal around the trip point do not trigger a change of relay state.
	To avoid the inaccuracy which results from too much hysteresis, the hysteresis may be reduced. Too little hysteresis, however, may not be enough to overcome relay chatter.
	Ideally, the hysteresis should be as close to, but no less than, the peak-to-peak noise. This setting will provide maximum immunity from relay chatter while providing the best possible accuracy.

Figure 19: Examples of Noise in a System

Example: How To Configure An Alarm to Trip Low

Assume that you must configure an alarm to trip when the pressure drops atmospheric pressure (typically 760 Torr); at pressures above one atmosphere the alarm should be off. Enter 760 as the trip point pressure. With the hysteresis set at 1% the deadband region is from 752 to 768 Torr. This means that the pressure must drop below 752 Torr before the alarm will trip. Conversely, the pressure must rise above 768 Torr before it will turn off. Set the relay actuation state to deactuated so that the alarm will be off when the pressure is above 760 Torr. Once the pressure drops below 752 Torr, the alarm state changes to actuated.

Alarm Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Alarm Enable/Disable	@	0	1	1	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P)	:	E = Enabled D = Disabled Default setting is disabled	ENTER
Trip Point Value	@	0	1	2	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P)	:	-100000 to +100000 Torr inclusive Default value is 0.0	ENTER
Hysteresis Value	@	0	1	3	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P)	:	0 to 10% inclusive Default value is 10%	ENTER
Relay Actuation State	@	0	1	4	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P)	:	A = Actuated D = Deactuated Default setting is actuated	ENTER

Table 40: Alarm Messages

Note

1. Be sure the both the sensor and the input channel to the alarm are turned on. You will not be able to configure the alarm unless the input channel is turned on.
2. Refer to *Sensor Configuration Messages*, page 73, to assign an alarm to a channel.
3. Each alarm relay (A through P) can only be assigned one input channel since the input channel reading determines the relay state.

How To Configure an Alarm

1. Assign the alarm to an input channel. Each channel can have two alarms, alarm 1 and alarm 2, set by independent commands.

Note  Each alarm relay (A through P) can only be assigned one input channel since the input channel reading determines the relay state.

Alarm 1: **@06A<chan>:<alarm>** ENTER

Alarm 2: **@06B<chan>:<alarm>** ENTER

where <chan> = the channel number (1,2,...9,0)

<alarm> = the alarm letter (A through P)

Note  The query to these commands will return an "X" if no alarm is assigned to the channel.

Refer to *Sensor Configuration Messages*, page 73, for more information.

2. Enable the alarm by sending the following command:

@011<alarm>:<state> ENTER

where <alarm> = the channel number (1,2,...9,0)

<chan> = E for enabled; D for disabled

3. Issue the following command to set the trip point value:

@012<alarm>:<pres> ENTER

where <alarm> = the channel number (1,2,...9,0)

where <pres> = the pressure value, in Torr

4. Set the hysteresis value for each relay, with the command:

@013<alarm>:<hyst> ENTER

where <alarm> = the alarm letter (A through P)

<hyst> = the hysteresis value (0 to 10%, inclusive)

5. Set the relay actuation state with the following command:

@014<alarm>:<state> ENTER

where <alarm> = the alarm letter (A through P)

where <state> = the actuation state, either A for actuated or D for deactuated

Example: Assigning Two Alarms to One Channel

Assume you need to set an upper and lower operating range for a capacitance manometer reading pressure in your process. The upper range is 80 Torr and the lower range is 50 Torr. You have one Auxiliary Output board, which provides the two relays. When the pressure deviates from the operating range, the appropriate alarm must be activated.

1. Assign alarm A as alarm 1 for to input channel 1:

   @06A1:A ENTER

2. Assign alarm B as alarm 2 for to input channel 1:

   @06B1:B ENTER

3. Enable the alarms by sending the following commands:

   @011A:E ENTER

   @011B:E ENTER

4. Alarm A will monitor the upper operating limit, in this case, 80 Torr. Issue the following command to set the trip point value for alarm A:

   @012A:80 ENTER

5. Alarm B will monitor the lower operating limit, in this case, 50 Torr. Issue the following command to set the trip point value for alarm B:

   @012B:50 ENTER

6. Set the relay actuation state for alarm A. This alarm monitors the upper limit, so we want the relay to be actuated when the alarm is tripped. Send the following command:

   @014A:A ENTER

7. Set the relay actuation state for alarm B. This alarm monitors the lower limit, so the normal operating range requires that pressure remain above this trip point value. Therefore, we want the relay to be deactuated when the alarm is tripped (since the alarm is tripped when the pressure exceeds the trip point value). The alarm will actuate if the pressure drops below the trip point value. Send the following command:

   @014B:D ENTER

Mass Flow Controller (MFC) Specific Messages

The MFC board allows the 186 instrument to communicate with mass flow controllers (MFCs) to regulate the flow of gas into a system. The 186 instrument can operate in either set point, totaling, or ratio flow control mode.

Set Point Mode of Operation

When using the Set Point mode of operation, the 186 instrument sends out a voltage corresponding to a user-defined set point (in sccm). The set point voltage takes into account any zero offset which may have resulted from zeroing the MFC, to ensure that the MFC controls to the desired flow rate. Up to eight MFCs can be operated by the 186 instrument. Each MFC operating in Set Point mode has a set point value assigned to it; the range is from -10 to +220% of full scale. Refer to *How To Use the Set Point Mode*, page 103, for configuration instructions.

Totaling Mode of Operation

When using the Totaling mode of operation, two MFCs operate in conjunction with each other. One MFC (defined as the co-channel), operates according to a fixed set point. The other MFC, defined as the totaling MFC, adjusts its output voltage to maintain a user-defined total flow rate (set point) for the system. The set point can range from -10 to +220% of full scale. For example, you want to maintain a flow rate of 100 sccm. Enter a set point of 100 sccm and set the co-channel to a fixed flow rate of 20 sccm. The totaling MFC will subtract 20 (flow rate of the co-channel) from 100 (the set point) and adjust its voltage to produce a flow rate of 80 sccm. Therefore, the total flow rate will be 100 (20 + 80). As with the Set Point mode of operation, the 186 instrument accounts for any zero offset. Refer to *How To Use the Totaling Mode*, page 104, for more information.

Ratio Flow Control Mode of Operation

In Ratio control mode, the 186 instrument is capable of controlling up to seven MFCs. The Ratio mode uses a virtual control channel to execute the PID control algorithm and achieve the desired gas ratio. The virtual control channel (control channel 0) is present even if no Control Board is installed. The 186 instrument calculates the control signal to correct the gas ratio and sends the signal to all MFCs configured for Ratio control.

Two possible control methods exist within Ratio mode: control with a *pressure* measuring control channel, and control with a *flow* measuring (MFC) control channel.

The ratio controllers maintain the *gas ratio,* and the 186 instrument maintains the absolute *pressure* by controlling the *total flow*.

Essentially, the Ratio mode of operation scales and proportions the 0 to 10 Volt control signal among the MFCs configured for Ratio mode, based on their chosen ratio set points. The set points can range from 0 to 200%. Since most MFCs accept a 0 to 5 Volt signal, the control signal for a given MFC is always scaled by ½, then multiplied by the ratio set point percent:

$$\text{MFC control signal} = \tfrac{1}{2}\,(\text{control signal})(\text{ratio set point \%}/100)$$

Example 1: Assume you have two MFCs configured for ratio control and you change the control set point (in the designated recipe) to 100%. Each MFC has a set point of 50%. The PID control algorithm determines that full scale flow is required to meet the new set point, so the equation becomes:

MFC control signal = ½ (10 Volts)(50%/100) = 2.5 Volts

Each MFC would receive a 2.5 Volt control signal.

Example 2: If the control algorithm determined that the change necessitates a 60% flow rate, the equation becomes:

MFC control signal = ½ (6 Volts)(50%) = 1.5 Volts

Each MFC would receive a 1.5 Volt control signal.

Example 3: Assume that you have three MFCs with ratio set points of 10%, 30%, and 60%. The PID algorithm determines that a 75% control signal is required to meet the control set point. The 186 instrument calculates the control signal for each MFC:

MFC 1 = ½ (7.5 Volts)(10%) = 0.375 Volts

MFC 2 = ½ (7.5 Volts)(30%) = 1.125 Volts

MFC 3= ½ (7.5 Volts)(60%) = 2.25 Volts

The total control signal is 3.75 Volts (75% of 5 Volts).

Refer to *How To Use the Ratio Flow Control Mode*, page 105, for more information.

Pressure Measuring Control

When using a pressure measuring control channel, up to three MFCs can be configured to function in a pressure control loop. In this case, the total flow of the three MFCs determines the pressure, however, the percent of gas through each MFC remains constant. For example, if the ratio set points for the three MFCs are 30%, 30%, and 40% and pressure rises in the system, the gas flow through each MFC decreases but the 30%, 30%, 40% relationship remains intact.

Flow Measuring Control

When using a flow measuring control channel, an MFC channel is selected as the control input channel. The Ratio mode MFCs follow the controlling MFC with their respective proportions of flow as set by their Ratio mode set points.

Mass Flow Controller Specific Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Mode of Operation	@	1	0	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	S = Set Point T = Totaling R = Ratio	ENTER
Adjust Set Point (analog output)	@	1	0	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	ASCII value SP & Totaling: -10 to 220% FS Ratio: 0 to 200% FS	ENTER
Totaling Co-channel	@	1	0	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (co-channel #)	ENTER
Open/Close/Cancel Override	@	1	0	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	:	O = Open C = Close N = Cancel	ENTER

Table 41: Mass Flow Controller Specific Messages

How To Use the Set Point Mode

To configure the 186 instrument to operate in the set point mode, you must specify set point control, and enter the set point value.

1. To operate in the set point mode, enter the following command:

   @101<chan>:<mode> ENTER

   where <chan> = the channel number (1,2,...9,0)

   <mode> = the operating mode (S = set point; T = totaling; R = ratio)

2. To enter the set point value, issue the following command:

   @102<chan>:<mode> ENTER

   where <chan> = the channel number (1,2,...9,0)

   <value> = the set point value, -10 to 220% full scale

   The set point signal is sent out on pin 8 of the MFC connector. Refer to Table 16, page 49, for the complete pinout of the MFC connector.

How To Use the Totaling Mode

To operate in totaling mode, you must select the totaling mode, assign a co-channel, and specify set point values for both the totaling channel and the co-channel. The channel entered as the parameter in the command string is assigned as the totaling channel. Refer to *Totaling Mode of Operation*, page 101, for more information.

1. To select the totaling mode, enter the following command:

   @101<chan>:T ENTER

   where <chan> = the channel number of the totaling channel (1,2,...9,0)

2. To select the co-channel, enter the following command:

   @103<chan>:<cochan> ENTER

   where <chan> = the channel number of the totaling channel (1,2,...9,0)

   <cochan> = the co-channel number (1,2,...9,0)

3. To set the set point value of the totaling channel, issue the following command:

   @102<chan>:<value> ENTER

   where <chan> = the channel number of the totaling channel (1,2,...9,0)

   <value> = the set point value, -10 to 220% full scale

3. To set the set point value of the co-channel, issue the following command:

   @102<cochan>:<value> ENTER

   where <cochan> =the channel number of the co-channel (1,2,...9,0)

   <value> = the set point value, -10 to 220% full scale

How To Use the Ratio Flow Control Mode

Configuring the 186 instrument to operate under ratio control is a two step process. First, you must select ratio control and configure all the desired MFC channels to use ratio flow control. Use the MFC set point entry to enter the ratio for each flow controller. Second, to implement PID control you must configure the parameters for Control channel 0. (Use the set point entry in the designated recipe to set the overall flow rate as the control set point.) Control channel 0 functions as a virtual channel because it does not require an actual Control board. The 186 controller reserves Control channel 0 as the controller for ratio control.

1. To select the ratio control, enter the following command:

   @101<chan>:R ENTER

   where <chan> = the channel number (1,2,...9,0)

2. Enter the ratio for each MFC using the set point entry using the following command:

   @102<chan>:<value> ENTER

   where <chan> = the channel number (1,2,...9,0)

   <value> = the set point value, 0 to 200% full scale

3. Enter all the control parameters (such as the input channel and the control set point) described in *Chapter Six: Operation of the Control Board*, page 129, using Control channel 0. Control channel 0 sends the control signals to all the MFCs in ratio mode.

MFC Override Commands

You can command the MFC to either the full open or full closed position. The MFC moves to the commanded position within two seconds. This command overrides any mode (ratio, set point or totaling). Issue a cancel command to resume operating under the previous mode.

To issue an open override command, enter:

@104<chan>:<over> ENTER

where <chan> = the channel number (1,2,...9,0)

<over> = defines the action (C = Close; O = Open; N = Cancel)

Note 

The close override provides a fully closed position, and in most cases, it can be used to zero the MFC (since it results in zero flow).

To Cancel An MFC Override Command

When you issue a cancel override command, the system responds by removing the open or close override for the MFC on the selected channel. The MFC then performs as if no override had been issued.

Miscellaneous Messages

Table 42 lists the miscellaneous messages available.

Miscellaneous Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Select Pressure Units	@	5	0	3	*	:	T = Torr P = Pascal B = mbar The initial setting is Torr.	ENTER
Leak Rate Period	@	5	0	7	*	:	1 to 60 seconds Default is 1 second.	ENTER
Response Format	@	5	0	8	*	:	E = Scientific D = Fixed The default is fixed.	ENTER
** indicates any character, including a blank space*								

Table 42: Miscellaneous Messages

Note All commands *must* include an ID byte, even if it has no significance. You can enter any character, including a blank space, in its place.

How To Set the Pressure Units

To set the pressure units to mbar, enter the following command:

@503•:B ENTER

where • = represents a blank space
B = mbar; P = Pascal

The factory setting is Torr.

How To Set the Leak Rate Period

The 186 instrument can calculate the leak rate of a system to which a sensor is attached. The leak rate reflects the change in pressure over a user-defined time period, expressed as pressure units per second. For example, if the pressure is measured in Torr and you have selected a time base of 30 seconds, the leak rate will be reported as Torr per 30 seconds. The leak rate period entry is global and applies to all channels.

The leak rate is calculated as a moving average using the most recent measurements. The 186 instrument continually replaces the oldest value with the latest value and recalculates the new leak rate. Initially, when you enter the leak rate period, you must wait until the time period has elapsed before querying the 186 instrument to report the leak rate.

The range is from 1 to 60 seconds; the default value is 1.

To determine the leak rate, you must first specify the time period, for example, 30 seconds:

@507•:30 ENTER

where • = represents a blank space

To request the leak rate on channel 5, enter:

@6065? ENTER

Following the example above, the 186 instrument responds with:

`@6065:2` ENTER

This response indicates that a 2 Torr difference in pressure has occurred over 30 seconds.

How To Select the Response Format

The 186 instrument can send its response messages in either scientific notation or fixed notation. The factory setting is fixed notation. To configure the 186 unit to respond in scientific notation, issue the command:

@508•:E ENTER

where • = represents a blank space
E = for scientific notation (D selects fixed notation)

The factory setting is fixed notation.

Note 

You must re-issue this command after each power up since it is not stored at power down.

Read Only Messages

Read only messages, listed in Table 43, request information from the 186 instrument. You cannot change the value or setting of any read only parameters.

When the 186 unit accepts a read only message it will report the last value read. If the gauge has been turned off, the request will return the last value reading performed. If no measurement has been made (for example, the gauge was never turned on) the request will return 0.0.

Read Only Messages							
Message Description	**Message Format**						
	@	**Command Category**		**Command Number**	**ID**	**Reported Data**	
Channel Reading – *gauge must be on* *(reports reading only)*	@	6	0	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value of the channel reading	ENTER
Channel Reading with Time Stamp– *gauge must be on*	@	6	0	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value of the time stamp (the number of milliseconds since the sensor was turned on) and the channel reading	ENTER
Sensor Voltage *(not valid for hot cathode gauges)*	@	6	0	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value, in Volts	ENTER
Sensor Ion Current *(only applies to hot and cold cathode gauges)*	@	6	0	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value, in Amps	ENTER
Sensor Emission Current *(only applies to hot cathode gauges)*	@	6	0	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value, in Amps	ENTER
Pressure Leak Rate– *gauge must be on*	@	6	0	6	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	ASCII value, in pressure units per seconds	ENTER

Table 43: Read Only Messages
(Continued on next page)

Read Only Messages *(Continued)*							
Message Description	**Message Format**						
	@	**Command Category**		**Command Number**	**ID**	**Data**	
Channel Status	@	6	0	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #)	A = On B = Low power degas C = Underranged D = Overranged E = Manually off F = Auto off G = High power degas H = Initializing I = Zeroing J = Bad sensor K = Disconnected L = Channel not installed	ENTER
Power Up Status	@	6	0	9	*Any character*	Refer to Table 44, page 112.	ENTER
Alarm Status	@	6	0	B	Alarm ID (A to P)	E = Enabled D = Disabled T = Tripped	ENTER

Table 43: Read Only Messages

How To Report the Channel Reading

The report channel reading (@601) command reports the current pressure reading. If the gauge has been turned off, the request will return an error (E112). It is better practice to use the Channel Status command (@608) to report the channel's pressure since it reports the status of the channel as well.

How To Report the Channel Reading with Time Stamp

The 186 instrument can report the channel's reading with a time stamp. A 16-bit counter tracks the elapsed time in milliseconds, with a resolution of 10 milliseconds. The counter increments by ten counts every 10 milliseconds, until it reaches a count of approximately 24 days. To calculate the elapsed time between readings, subtract the time stamp of the first reading from the time stamp of the second reading.

If the pressure reading is within range, the response reports the pressure reading and the time stamp. When the pressure reading is out of range, the response reports the time stamp only.

To report the channel reading on channel 3 with time stamp, enter:

@6023? ENTER

the 186 instrument responds with:

```
@6023:[4261]+133 <CR>
```

to indicate a pressure of 133 at the time equivalent to 4261 counts.

The next time you check the reading with time stamp, the 186 instrument responds with:

```
@6023:[18784]+129 <CR>
```

The time between the readings is:

18784 - 4261 = 14523 counts

Therefore, the time elapsed between readings is approximately 14.5 seconds.

How To Check the Sensor Parameters (Voltage, Ion Current, and Emission Current)

The channel voltage (@603), ion current (@604), and emission current (@605) messages are provided for diagnostic purposes. These commands enable you to verify that the sensor is working since the 186 instrument reports the actual value of the parameter at the measured pressure.

Assume you have a capacitance manometer with a 0 to 10 Volt full scale output, connected to channel 3. To report the sensor voltage, enter:

@6033? ENTER

Assuming the sensor was at 50% of full scale, the response would be:

```
@6033:5<CR>
```

How To Query the Pressure Leak Rate

The 186 unit can report the pressure leak rate for any sensor. Refer to *Miscellaneous Messages*, page 106, for a description of the leak rate period and report leak rate messages.

How To Check the Channel Status

Note 

This request is the recommended method to use to check the channel reading since the response indicates whether the gauge is working.

The channel status message reports the channel's status. If the channel is currently on or currently performing a low power degas, it will report the pressure. The response will indicate one of several sensor conditions. Use the channel status message to check the channel pressure:

@608<chan>? ENTER

where <chan> = the channel number (1,2,...9,0)

The 186 instrument responds with:

`@608C:<status><reading><CR>`

where <`status`> is: = A for On
B for Low power degas
C for Underranged
D for Overranged
E for Manually off
F for Auto off
G for High power degas
H for Initializing
I for Zeroing
J for Bad sensor
K for Disconnected
L for Chan not installed

<`reading`> is: = an empty field unless <status> is A (on) or B (low power degas), then this field contains an ASCII string representing the channel's reading

How To Check the Power Up Status

The LED on the front panel will remain red should the 186 instrument encounter a power up problem. Use the power up status message to report the cause; either a configuration, calibration, or memory problem. To query the power up status enter:

@609•? ENTER

where • = represents a blank space

the 186 instrument responds with:

@609•:<XX><CR>

where • = represents a blank space
<XX> = represents the status, in a hexadecimal number, as described in Table 44

Response to a Power Up Status Message		
Bit	**Value (in Hexadecimal)**	**Cause**
—	00	No Errors
0	01	Bad Factory Calibration
1	02	Bad User Configuration
2	04	Bad Power Down Values
3	08	New Configuration
4	10	Bad ROM (Read Only memory)
5	20	Bad RAM (Random Access memory)
6	40	Reserved
7	80	Reserved

Table 44: Response to a Power Up Status Message

The response values are additive, so that one response reports all power up problems. The response consists of two Hex digits such that each bit corresponds to a specific status message. For example, a response of 28 (hexadecimal) indicates that the unit has detected a new configuration (08) *and* a RAM problem (20). If bad power down values (04) were detected as well, the response would be 2C (hexadecimal).

Bad Factory Calibration: Cycle the power to restart the 186 unit. If the error re-occurs, return the unit to MKS for service.

Bad User Configuration: Cycle the power to restart the 186 unit. If the error re-occurs, you must reprogram the unit. All the user-defined entries have assumed the default values.

Bad Power Down Values: Cycle the power to restart the 186 unit. This error indicates that the 186 unit did not save the information upon power down. You may need to reprogram the unit.

New Configuration: This error occurs whenever the configuration of the unit changes, such as adding or removing a board. Power down the 186 unit so that it stores the new configuration. When you restart the 186 unit the error should not reappear.

Bad ROM: This error reports a problem with the Read Only Memory. Send the unit back to MKS for service

Bad RAM: This error detects a problem with the Random Access Memory. Send the unit back to MKS for service.

How To Check the Alarm Status

The 186 instrument will report the status of an alarm in response to the following request:

@60B<alarm>? ENTER

where <alarm> = the alarm letter (A through P)

the 186 instrument responds with:

`@60B<alarm>:<state><CR>`

where <alarm> = the alarm letter (A through P)

<state>= D if the alarm is disabled
A if the alarm is enabled but not tripped
T if the alarm is enabled and tripped

Diagnostic Messages

If you encounter a problem operating the 186 unit, the first step you should take is to issue a power up status query. Refer to *How To Check the Power Up Status*, page 112, for more information.

The messages in this category provide diagnostic information about the 186 instrument. These messages consist of requests only; there are no commands associated with these messages.

Diagnostic Messages							
Message Description	**Message Format**						
	@	**Command Category**		**Command Number**	**ID**	**Data**	
Software Version	@	9	9	1	x	xx = software version	ENTER
Instrument Configuration	@	9	9	2	x	0 = Empty slot 1 = Pirani board (configured as a single channel board) 2 = Pirani board (configured for dual channel operation) 3 = Hot Cathode board 4 = Capacitance Manometer board 5 = Mass Flow Controller board 6 = Control board 7 = Cold Cathode board 8 = Auxiliary Output board	ENTER
where the x in the ID field is any ASCII character, including a space							

Table 45: Diagnostic Messages

How To Check the Software Version

The 186 instrument will report the software version when it receives the following request:

@991•? ENTER

the 186 instrument responds with:

@991•:x.xx.xx<CR>

where • = is the channel number (1,2,...9,0)

x.xx.xx = is the software version number

How To Identify the Type of Boards Installed

To verify the type of boards installed in your 186 instrument, enter:

@992•? ENTER

where • = represents a blank space

The 186 instrument will respond with the same command except the "?" will be replaced with:

0 = Empty slot
1 = Pirani board (configured as a single channel board)
2 = Pirani board (configured for dual channel operation)
3 = Hot Cathode board
4 = Capacitance Manometer board
5 = Mass Flow Controller board
6 = Control board
7 = Cold Cathode board
8 = Auxiliary Output board

For example, if you have a Pirani board installed in slot 2 and two Hot Cathode boards installed in slots 7 and 8, the response would be:

@992•:01000033 ENTER

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Chapter Five: Sensor Board Command Summary

General Information

This chapter organizes the RS-232 messages by the *plug-in board* type. It lists all the commands necessary to operate each type of sensor. The plug-in boards covered include:

- Capacitance Manometer
- Pirani/Convection
- Cold Cathode
- Hot Cathode
- Mass Flow Controller
- Auxiliary Output

The commands in this chapter are arranged in four groups: power, configuration, calibration, and status. A page reference for the section that describes each group, is also included. Refer to *RS-232 Protocol*, page 63, for an explanation of the message format. All messages, both commands and requests, must end with a carriage return.

Note 

The page references included in the following tables refer to the section which describes the group of commands. Each command is discussed individually within that section.

Chapter Four: Operation, page 61, organizes the commands by *functional* type, and provides a complete description of each command.

Chapter Six: Operation of the Control Board, page 129, discusses operating a Control board.

Capacitance Manometer Messages

The 186 unit supports Type 120 and linear capacitance manometers.

Note The <id> parameter in all messages, identifies the channel number (1, 2, ...9, 0).

Capacitance Manometer Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Power	Channel Power	@081<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	68
Configuration	Sensor Type	@069<id>?	*Request only* reports: 0 = Type 120 2 = linear cap. Manometer Sensor must be powered on.	73
	Capacitance Manometer Range	@061<id>:<fs>	<fs> From 0.001 to 100,000 Torr equivalent. Sensor must be installed.	
	Sensor Resolution	@062<id>:<res>	<res> ASCII value that represents the resolution as a power of 10. Valid range is from +7 to -7. Sensor type must be linear or Type 120.	
	Units for Channel	@06C<id>:<units>	<units> MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm	

Table 46: Capacitance Manometer Messages
(Continued on next page)

Capacitance Manometer Messages *(Continued)*				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Calibration	User Zero Enable	@056<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	85
	Zero Channel	@051<id>	*Command only*	
	Auto Zero Function	@058<id>:<state>	<state> is E for enabled D for disabled	
	Auto Zero Reference Sensor	@059<id>:<ref>	<ref> is the reference channel number Both sensors must be installed.	
Status	Report Channel Reading	@601<id>?	*Request only* Sensor must be powered on and within range.	108
	Report Reading With Time Stamp	@602<id>?	*Request only* Sensor must be powered on and within range.	
	Report Sensor Voltage	@603<id>?	*Request only* Sensor must be installed.	
	Report Pressure Leak Rate	@606<id>?	*Request only* Sensor must be installed.	
	Report Channel Status	@608<id>?	*Request only* Sensor must be installed.	

Table 46: Capacitance Manometer Messages

Pirani/Convection Messages

The 186 unit can identify the gauge as a Pirani or convection gauge. If the gauge is identified as a convection gauge, you must issue a command to further identify the gauge as either a Granville-Phillips Convectron gauge or an HPS Convection Enhanced Pirani (CEP) gauge.

Note The <id> parameter identifies the channel number (1, 2, ...9, 0).

Pirani/Convection Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Power	Channel Power	@081<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	68
Configuration	Sensor Type	@069<id>?	*Request only* reports: 3 = Pirani gauge 4 = GP Convectron gauge 5 = HPS CEP gauge Sensor must be powered on and within range.	73
	Gas Type	@063<id>:<gas>	<gas> is N for nitrogen H for helium A for argon Nitrogen is the default.	
	Convection Gauge Type	@068<id>:<type>	<type>4 for GP Convectron 5 for HPS convection Convectron is the default.	
	Units for Channel	@06C<id>:<units>	<units> MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm	
Calibration	User Zero Enable	@056<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	85

Table 47: Pirani/Convection Messages
(Continued on next page)

Pirani/Convection Messages *(Continued)*				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Calibration *(Continued)*	Zero Channel	@051<id>	*Command only* Sensor must be in range or underrange.	85
	Auto Zero Reference Sensor	@059<id>:<ref>	<ref> is the reference channel number Sensors must be installed.	
	Auto Zero Function	@058<id>:<state>	<state> is E for enabled D for disabled	
	Span Function	@057<id>:<state>	<state> is ON for on OFF for off	
	Span Channel to Atmosphere	@053<id>	*Command only* Command will turn on the span function (if off)	
	Span With Reference	@055<id>:<ref> *This command is not supported in firmware 1.2x.*	<ref> is the reference channel number Command will turn on the span function (if off).	
Status	Report Channel Status	@608<id>?	*Request only* Sensor must be powered on and within range.	108
	Report Channel Reading	@601<id>?	*Request only* Sensor must be powered on and within range.	
	Report Reading With Time Stamp	@602<id>?	*Request only* Sensor must be powered on and within range.	
	Report Sensor Voltage	@603<id>?	*Request only* Sensor must be installed and powered on. Value in Volts.	
	Report Pressure Leak Rate	@606<id>?	*Request only* Sensor must be installed.	

Table 47: Pirani/Convection Messages

Cold Cathode Messages

The 186 unit supports up to eight cold cathode gauges.

Note The <id> parameter in all messages, identifies the channel number (1, 2, ...9, 0).

Cold Cathode Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Power	Channel Power	@081<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	68
	Auto Power Function	@082<id>:<state>	<state> is E for enabled D for disabled	
	Auto Power Reference	@083<id>:<ref>	<ref> is the reference channel number	
	Auto Power Shutoff Pressure	@084<id>:<pres>	<pres> is the shutoff pressure, in ASCII	
Configuration	Sensor Type	@069<id>?	*Request only* reports: 8 = cold cathode gauge Sensor must be powered on.	81
	Select Gauge Factor	@064<id>:<factor>	<factor> is a numeric ASCII string	
	Specify Disconnect Pressure	@065<id>:<pres>	<pres> is the disconnect pressure, in ASCII, range -1 to 0.001 (default -1)	
	Units for Channel	@06C<id>:<units>	<units> MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm	

Table 48: Cold Cathode Messages
(Continued on the next page)

Cold Cathode Messages *(Continued)*				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Calibration	Span With Reference	@055<id>:<ref> *This command is not supported in firmware 1.2x.*	<ref is the reference channel number Span function must be on.	85
Status	Report Channel Status	@608<id>?	*Request only* Sensor must be installed.	108
	Report Channel Reading	@601<id>?	*Request only* Sensor must be powered on and within range.	
	Report Reading With Time Stamp	@602<id>?	*Request only* Sensor must be powered on and within range.	
	Report Sensor Voltage	@603<id>?	*Request only* Sensor must be installed. Value in Volts.	
	Report Sensor Ion Current	@604<id>?	*Request only* Sensor must be installed. Value in Amps.	
	Report Pressure Leak Rate	@606<id>?	*Request only* Sensor must be installed.	

Table 48: Cold Cathode Messages

Hot Cathode Messages

The 186 unit supports up to four hot cathode gauges.

Note The <id> parameter in all messages, identifies the channel number (1, 2, ...9, 0).

Hot Cathode Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Power	Channel Power	@081<id>:<state>	<state> is ON for on OFF for off Sensor must be installed.	68
	Auto Power Function	@082<id>:<state>	<state> is E for enabled D for disabled Default is off.	
	Auto Power Reference	@083<id>:<ref>	<ref> is the reference channel number	
	Auto Power Shutoff Pressure	@084<id>:<pres>	<pres> is the shutoff pressure, in ASCII, range +1 to -1 Torr. Default is 10^{-3} Torr.	
	Degas	@085<id>:<degas>	<degas> is: H = high power degas L = low power degas O = degas function off	
Configuration	Sensor Type	@069<id>?	*Request only* reports: 6 = high powered HC gauge 7 = low powered HC gauge Sensor must be powered on.	78
	Sensitivity/ Gauge Factor	@064<id>:<factor>	<factor>is an ASCII string Default value is 10.	
	Disconnect Pressure	@065<id>:<pres>	<pres> is the disconnect pressure, in ASCII, from -1.0 to +0.001 Default is -1 (disconnected).	

Table 49: Hot Cathode Messages
(Continued on next page)

Hot Cathode Messages *(Continued)*				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Configuration *(Continued)*	High Pressure Shutoff	@066<id>:<pres>	<pres> is the shutoff pressure, in ASCII. Default pressure is 10^{-3} Torr.	78
	Internal Fast Rate of Rise Shutoff	@067<id>:<state>	<state> E = enabled D = disabled Initial setting is disabled.	
	Units for Channel	@06C<id>:<units>	<units> MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm	
Calibration	Span Function	@057<id>:<state>	<state> ON = user span OFF = factory value Sensor must be installed.	85
	Span With Reference	@055<id>:<ref> *Not supported in firmware 1.2x.*	<ref is the reference channel number Span function must be on.	
Status	Report Channel Status	@608<id>?	*Request only* Sensor must be installed.	108
	Report Channel Reading	@601<id>?	*Request only* Sensor must be powered on and within range	
	Report Reading With Time Stamp	@602<id>?	*Request only* Sensor must be powered on and within range.	
	Report Sensor Ion Current	@604<id>?	*Request only* Sensor must be installed. Value in Amps.	
	Report Sensor Emission Current	@605<id>?	*Request only* Sensor must be installed. Value in Amps.	
	Report Pressure Leak Rate	@060<id>?	*Request only* Sensor must be installed.	

Table 49: Hot Cathode Messages

Mass Flow Controller Messages

The 186 instrument supports all MKS mass flow controllers, and equivalent flow controllers. *Mass Flow Controller (MFC) Specific Messages*, page 101, provides instructions on operating an MFC.

Note The <id> parameter in all messages, identifies the channel number (1, 2, ...9, 0).

Mass Flow Controller Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Power	Channel Power	@081<id>:<state>	<state> ON for on OFF for off MFC must be installed.	68
Configuration	Report Sensor Identification	@069<id>?	*Request only* MFC must be installed.	83
	MFC FS Range	@061<id>:<range>	<range> from 0.0002 sccm to 1 x 10^5 sccm	
	Operating Mode	@101<id>:<mode>	<mode> R = Ratio S = Set Point T = Totaling	103
	Set Point Value	@102<id>:<value>	<value> is -10 to 220% FS for Set Point and Totaling, and 0 to 200% FS for Ratio	
	Totaling Co-Channel	@103<id>:<cochan>	<cochan>is the co-channel number	
	Override	@104<id>:<cmd>	<cmd> O = Open C = Close N = Cancel	
	Units for channel	@06C<id>:<units>	<units> S = sccm L = slm C = temperature	

Table 50: Mass Flow Controller Messages
(Continued on next page)

Mass Flow Controller Messages *(Continued)*				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Calibration	User Zero Enable	@056<id>:<state>	<state> ON for on OFF for off Sensor must be installed.	85
	Zero Channel	@051<id>	*Command only*	
Status	Report MFC Status	@608<id>?	*Request only* MFC must be installed.	108
	Report MFC Flow Rate	@601<id>?	*Request only* MFC must be installed.	
	Report MFC Flow Rate With Time Stamp	@602<id>?	*Request only* MFC must be installed.	
	Report MFC Voltage	@603<id>?	*Request only* MFC must be installed.	

Table 50: Mass Flow Controller Messages

Auxiliary Output Messages

The Auxiliary Output board provides two alarm relays. For more information, refer to *Alarm Messages*, page 95.

Note The <id> parameter in all messages, identifies the channel number (1, 2, ...9, 0).

Auxiliary Output Messages				
Function	**Description**	**Command**	**Range and Restrictions**	**Page Ref**
Configuration	Input Channel Alarm 1	@06A<id>:<A>	<id> is the input channel number <A> is the alarm letter (A through P; X no alarm assigned)	84
	Input Channel Alarm 2	@06B<id>:<A>	<id> is the input channel number <A> is the alarm letter (A through P; X no alarm assigned)	
	Alarm Enable/Disable	@011<id>:<data>	<id> is the alarm letter (A through P) <data> is E for enabled; D for disabled	98
	Trip Point Value	@012<id>:<data>	<id> is the alarm letter (A through P) <data> is the trip point pressure, from -100000 to 100000 Torr, inclusive	
	Hysteresis	@013<id>:<data>	<id> is the alarm letter (A through P) <data> is the hysteresis value from 0 to 10%, inclusive	
	Relay Actuation State	@014<id>:<data>	<id> is the alarm letter (A through P) <data> is A for activated; D for deactivated	

Table 51: Auxiliary Output Messages

Chapter Six: Operation of the Control Board

System Design Elements

This section discusses, in a general way, how the 186 instrument can be used to control a pressure/vacuum system. A Control board must be installed in the 186 instrument for the control capabilities to function. The 186 instrument utilizes three parameters of control (gain, lead, and integral), and these are discussed in some detail. This section also provides basic information about pressure control, and explains how to recognize and correct pump choking.

General Control Theory

The 186 instrument can control a gas system via mass flow control with an MFC. Refer to *Mass Flow Controller (MFC) Specific Messages,* page 101, for information. The more typical source of control is with pressure sensors. Only one sensor can control the gas system at any one time. That is, the pressure reading from only one sensor is compared to a set point and used to create a valve drive signal. To change which sensor is being used to control the system, you change the channel designated as the control channel. The 186 instrument supports up to four control boards. The control parameters for each Control board can be stored in a "control recipe." Each control recipe can be associated with a different channel by selecting a different control channel. The 186 instrument supports up to eight control recipes.

The control system for a 186 instrument typically consists of six parts:

- the sensor(s)
- a gas supply
- a control valve (gas inlet or exhaust throttle valve)
- a process chamber
- a pumping system
- the 186 instrument itself

The system may also include one or more ratio flow controllers, or mass flow controllers if controlling via mass flow.

Normally, gas pressure is controlled by altering the pumping speed of a pump that removes gas from the system (less frequently, it is regulated by controlling gas flow into the system via a control valve). The 186 instrument can regulate the control valve, be it a downstream throttle valve or an upstream solenoid valve, or control one or more ratio flow controllers. If a Control board is not installed in the 186 instrument, a separate controller must be used to control gas pressure.

When controlling gas pressure, the 186 instrument obtains a pressure reading from a sensor operating on the control input channel, and compares the reading with a set point. The difference between the set point and the actual pressure is called the error.

Error = Set Point - Actual Reading

When the actual pressure reading is less than the set point value, the error term is a positive value. Therefore, if the valve is configured for direct polarity, the signal to the valve increases to close the valve. (Refer to *How To Select the Polarity*, page 136, for more information.) As the valve closes, less gas is pumped out of the process chamber, so the pressure rises. Eventually, the pressure rises to meet the set point value. (With reverse polarity, the signal to the valve decreases when the pressure rises.)

When the actual pressure reading exceeds the set point value, the error term is a negative value. Therefore, if the valve is configured for direct polarity, the signal to the valve decreases to open the valve. As the valve opens, the pressure in the system is reduced because more gas is pumped out of the process chamber. Eventually, the pressure decreases to meet the set point value. (With reverse polarity, the signal to the valve increases when the pressure drops.)

The gas system is continuously regulated to ensure that the actual pressure reaches, and is maintained at, the set point pressure.

The 186 instrument utilizes Proportional-Integral-Derivative (PID) control found in most industrial controllers today. The P-I-D parameters operate according to an equation. These parameters are:

1. ***Proportional control action*** (***Gain)*** is used as a constant to create a valve drive signal that is proportional to the error signal, (the error signal is the result of comparing actual pressure with the set point). The error signal is then multiplied by a *gain* setting, thus creating a proportional valve drive signal. The higher the gain, the greater the change in the valve drive signal. Thus, the response is proportional to the gain.

   Provided that the gain is not set too high, adjusting it allows the system to approach set point more quickly than if a lower gain setting is used. The best tuned gain is maximized without promoting overshoot.

   $$\textbf{Valve Drive Signal} = K_1 \times \textbf{Error Signal}$$

   (K_1 is adjusted by changing the gain setting)

2. ***Integral control action*** creates a valve drive signal which is proportional to the magnitude and sign of the area under the error signal curve (error signal with respect to time).

   $$\textbf{Valve Drive Signal} = K_2 \times \int (\textbf{Error Signal})\, dt$$

   As time passes the valve position is changed. Due to integration (and good control), the error signal approaches and is reduced to zero. An increase in the integral value increases the period of time over which the error signal is generated, and system response gets slower. This helps offset potential oscillation caused by a high gain setting.

3. ***Derivative control action*** (Phase Lead) creates a valve drive signal that is proportional to the *rate of change* of the sensor pressure reading. Derivative is the lead, or anticipation factor.

   $$\textbf{Valve Drive Signal} = K_3 \times \frac{d(\text{pressure})}{dt}$$

   (K_3 is adjusted by changing the lead setting)

   Part of the lag in a control system is caused by the fact that the current pressure reading is no longer accurate by the time it is used in the PID calculations. To overcome this, the current reading is compared with a previous reading, and then the rate of change is extrapolated to arrive at a new pressure reading. The new reading more accurately represents the true pressure. The new pressure reading is substituted for the current reading in PID calculations. Thus, the derivative control mode provides an anticipation element. The valve drive signal then causes the control valve to approach its steady state position sooner than it would if there was no derivative in the above equation.

Pressure Control

The speed of pressure response is relative, and depends on chamber size and the pressure range in which the system is operating. Lower pressures (less than 10 mTorr) are usually slower because of the slower molecular flow (and reduced pumping speed). The maximum rate of rise (or fall) of pressure is determined by the following formula:

$$\frac{dP}{dt} = \frac{F_{in} - F_{out}}{V}$$

where:

$\frac{dP}{dt}$ = rate of pressure rise (or fall) in Torr/second

F_{in} = gas flow into the chamber in Torr-liters/second

F_{out} = gas flow out of the chamber (to the pump) in Torr-liters/second

V = chamber volume in liters

In systems with small flows and relatively large chamber volumes, the pressure rises (or falls) slowly. This occurs even when the control valve is fully opened or closed. With a fast upstream control valve, the maximum rate of pressure *drop* is a function of pump speed, and the chamber volume, but the maximum rate of pressure *rise* is a function of the pump speed, chamber volume, and valve size.

Pump Choking

Choking is a situation that sometimes occurs, and is the result of a peculiarity of all *diffusion* pumps. If too much gas is introduced at too high a pressure (that is, too great a flow rate), the pumping speed can change radically and erratically. This occurs for several reasons. For example, the pump can fill up (since the evacuation rate is less than the incoming flow rate), and as a result it momentarily cannot take up any more gas. Also, it may be that the pumping mechanism is slowed down by high friction.

In any case, the situation is easily recognized by lack of stability at the set point, and by pneumatic noise. Closing down the inlet to the pump is the only solution. Diffusion pumps should never be operated at pump inlet pressures higher than the maximum pressure set by the pump manufacturer. Refer to the specifications for your pump to determine the maximum allowable inlet pressure. A restriction between the pump and chamber may be necessary to prevent pump choking.

Process Control Messages

Note This section only applies when either an optional Control or Mass Flow Controller board is installed in your 186 instrument.

A Control board enables your 186 instrument to perform closed-loop process control. The 186 instrument can support up to four Control boards. The 186 instrument can store up to eight control recipes. The eight recipes can be assigned to any Control board.

The 186 instrument uses a Proportional - Integral - Derivative (PID) algorithm for process control. The gain, lead, and set point parameters are stored in a control recipe. The default settings are:

- Gain of 10
- Lead of 1.5 seconds
- Set Point of 0

For more information on PID control, refer to *System Design Elements,* page 129.

Board-Specific Control Messages

You must configure the parameters covered in this section for *each* Control board installed in your 186 instrument. The Control board uses these parameters for every recipe assigned to it. The control parameters covered in this section are not stored as part of a control recipe.

Note

The Board-Specific Control messages support Control Channel 0, which is a "virtual" control channel used by the MFC board for Ratio flow control. A "virtual" channel exists in software only; it does not require a physical board to work. Refer to *Mass Flow Controller (MFC) Specific Messages*, page 101, for information on Ratio control for flow controllers.

Board-Specific Control Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Select Control Mode	@	0	2	1	0*, 1, 2, 3, 4 (Control Bd number)	:	A = Auto O = Open C = Close H = Hold M = Manual Default is close.	ENTER
Select Active Recipe	@	0	2	2	0*, 1, 2, 3, 4 (Control Bd number)	:	0 through 8 (recipe #) where 0 = no recipe	ENTER
Select Controller Polarity	@	0	2	3	0*, 1, 2, 3, 4 (Control Bd number)	:	D = Direct R = Reverse	ENTER
Adjust Integral	@	0	3	1	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value from 0.01 to 100 (seconds)	ENTER
Adjust Base	@	0	3	2	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value from 0.00 to 103 (%)	ENTER

Table 52: Board-Specific Control Messages

(Continued on next page)

Board-Specific Control Messages *(Continued)*								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Adjust Start	@	0	3	3	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value, 0.00 to 103 (%)	ENTER
Adjust Alpha	@	0	3	4	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value, 5 to 99, inclusive	ENTER
Adjust Preset	@	0	3	5	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value, 0.00 to 103 (%)	ENTER
Adjust Position/Output *(for Manual and Hold modes only)*	@	0	3	6	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value, 0.00 to 100 (% Open), inclusive	ENTER
Adjust Softstart Speed	@	0	3	7	0*, 1, 2, 3, 4 (Control Bd number)	:	ASCII value, 1.0 to 100 seconds	ENTER
** Control channel 0 is a virtual control channel used in conjunction with Mass Flow Controllers*								

Table 52: Board-Specific Control Messages

How To Select the Control Mode

The Control mode allows you to select the operating mode used to control the valve: either open, close, hold, manual, or auto. Close is the default mode.

Control Modes	
Mode	**Action**
Open	The valve output signal is set to 100%.
Close	The valve output signal is set to 0%. Default setting.
Hold	The valve freezes in its current position.
Manual	The valve is moved to a user-defined preset position.
Auto*	The valve is controlled according to a selected control recipe.
** To enter the Auto mode a recipe must be selected as "Active"*	

Table 53: Control Modes

For example, to select the Auto control mode on Control board 4, issue the command:

@0214:A ENTER

The 186 instrument will operate Control board 4 based on the active control recipe.

How To Select the Active Recipe

When operating in the Auto mode, the 186 instrument controls the valve based on the parameters specified in the active recipe.

Note A recipe must be selected as "Active" to enter the Auto mode.

For example, to select recipe 2 as the active recipe for Control board 3, issue the command:

@0223:2 ENTER

The default setting is no recipe.

How To Select the Polarity

The polarity determines the action of the valve, either direct or reverse. Choose direct polarity for downstream control to increase the output of the downstream valve as pressure rises in the process chamber. Choose reverse polarity for upstream control to decrease the output of the upstream valve as pressure rises in the process chamber.

Note Although you can change the polarity within any recipe, only the last entered polarity is saved and used for all recipes.

For example, to select direct polarity for Control board 1, enter the following command:

@0231:D ENTER

The polarity setting applies to all control recipes.

The default setting is Direct.

How To Adjust the Integral

The integral parameter selects the time constant used for the integral term of the PID control. Enter a number between 0.01 (exclusive) and 100 (inclusive). The default is 0.3 seconds.

To enter 10 as the integral term on Control board 3, enter the following command:

@0313:10 ENTER

For more information on PID control, refer to *System Design Elements,* page 129.

How To Adjust the Base

The base is defined as the smallest user-defined value for the valve control signal output. It is expressed as percent of the valve control signal output. A base setting of 20 means that the valve control signal should not go below 20% of the full open output. Stated another way, the valve should remain at least 20% open. In effect, the base parameter limits how closed the valve can become. The base parameter can override the softstart parameter.

To change the base to 10 on Control board 2, enter the following command:

@0322:10 ENTER

The base parameter can range from 0.00 to 103% of full open. The default base is 0%.

How To Adjust the Start

The start parameter is a valve position, expressed as a percent of the valve control signal output. It determines the initial position of the valve when the Auto mode is evoked. The start value only applies if the valve was at full open or full close just prior to evoking the Auto feature. If softstart is enabled, it can override the start parameter.

To change Control board 1 to start at 20% full open, enter the following command:

@0331:20 ENTER

The start parameter can range from 0.00 to 103% of full open. The default start is 0%.

How To Adjust the Alpha

The alpha control parameter reduces the amplification of noise in the system. Noise is an inherent problem in process control systems. With a low alpha setting, the response time of the lead is slower. With a higher alpha setting, the lead may be overly sensitive to noise. Do not change the alpha setting from the default value of 20, unless you have a clear reason to do so.

To set the alpha to 15 on Control board 2, enter the following command:

@0342:15 ENTER

The alpha parameter can range from 5 to 99, inclusive.

How To Adjust the Preset

The 186 instrument moves the valve to the preset position when the Manual mode is evoked. The preset valve position is expressed as a percent of the valve control signal output.

To set the preset position to 45% on Control board 1, issue the following command:

@0351:45 ENTER

The preset parameter can range from 0.00 to 103% of full open. The default base is 98.8%.

How To Adjust the Valve Position/Output

This command allows you to change the position of the valve while operating in either the Manual or Hold modes. Initially, when you select the Manual mode, the valve moves to the position defined by the preset entry. Use this command to change the valve position from the preset position. When you select the Hold mode, the valve freezes in its current position. This command allows you to change the position of the valve while in the Hold mode.

To move the valve to 50% on Control board 2, enter:

@0362:50 ENTER

Valid output entries range from 0.00 to 100% (inclusive).

How To Adjust the Softstart Speed

The softstart entry defines the period of time required for the valve position to move from 0% to 100% open. It is advantageous to open a valve slowly in some systems to minimize turbulence of the gas. When the softstart parameter is turned off the valve moves at full speed. The softstart speed can range from 1.0 to 100 seconds. The default speed is 10 seconds.

To set the softstart rate to 30 seconds on Control board 1, enter the following command:

@0371:30 ENTER

Note  The softstart speed is common to all control recipes.

Recipe-Specific Parameters

This section lists the parameters of a control recipe. The 186 instrument can store up to eight control recipes. Each Control board can have a recipe designated as its active recipe, which is used when the Control board is operating in the Auto mode.

Recipe-Specific Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Adjust Set Point	@	0	4	1	1 through 8 (recipe #)	:	ASCII value ±100,000 Default is 0.0	ENTER
Adjust Lead	@	0	4	2	1 through 8 (recipe #)	:	ASCII value from 0.001 to 10,000 seconds. Default is 1.5.	ENTER
Adjust Gain	@	0	4	3	1 through 8 (recipe #)	:	ASCII value from 0.002 to 10,000. Default is 10.0.	ENTER
Select Softstart	@	0	4	4	1 through 8 (recipe #)	:	E = Enable D = Disable	ENTER
Select Input Channel	@	0	4	7	1 through 8 (recipe #)	:	Input channel, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0	ENTER

Table 54: Recipe-Specific Messages

How To Adjust the Set Point

Use this command to enter the set point value for each recipe. For example, the input channel is reading pressure in Torr, and you want to enter a set point value of 50 Torr in recipe 2. Enter the command:

@0412:50 ENTER

Note 

The set point value must be entered in the units selected for the input channel. The maximum value that can be entered is 100,000.

If the input channel is reading pressure in Pascal, and you want to enter a set point value of 1333 Pascal in recipe 3. Enter the command:

@0413:1333 ENTER

How To Adjust the Lead

The lead parameter is the derivative term in PID control. The lead is proportional to the rate of change of the error signal (up to some maximum value).

The derivative term anticipates the effect of the valve action on the system. It acts to achieve the set point pressure with minimal overshoot or undershoot. The effect of the derivative term is to cancel out the build-up of lags inherent in the system.

For example, to set the lead parameter to 10 in recipe 3, enter the command:

@0423:10 ENTER

For more information on PID control, refer to *System Design Elements,* page 129.

How To Adjust the Gain

The gain parameter is the proportional term in PID control. The proportional term is a linear function of the error signal. Typically, a higher gain setting results in a smaller dead band and yields the most accurate control.

To set the gain to 30 in recipe 1, enter the command:

@0431:30 ENTER

For more information on PID control, refer to *System Design Elements,* page 129.

How To Enable/Disable Softstart

When softstart is enabled, the valve moves at the rate set by the softstart speed parameter. Refer to *How To Adjust the Softstart Speed,* page 138, for more information.

To enable softstart for recipe 1, enter:

@0441:E ENTER

How To Select the Input Channel

Use this command to select the input channel for each recipe. In the closed-loop control the 186 instrument reads the pressure from the input channel, performs the PID control calculations, and outputs the appropriate voltage to the valve through the Control channel, to adjust the pressure accordingly.

To use channel 5 as the input channel for recipe 3, enter the command:

@0473:5 ENTER

Chapter Seven: Maintenance

General Information

The two maintenance tasks, cleaning the fan filter and replacing the fuses, are discussed in this chapter. A few common sense maintenance notes are included here:

- Locate the 186 instrument in a dust-free environment
- Check the potential difference between grounds if you change the gas system substantially
- Periodically check for wear on the cables and inspect the enclosure for visible signs of damage

How To Clean the Fan Filter

The cooling fan, located on the front panel, contains a replaceable filter. Refer to Figure 7, page 33, for the location of the fan. This filter is designed to capture airborne particulates. The replaceable filter (part number 09250-F/30) is available from Qualtek Electronics Corporation, Mentor, OH (216) 951-3300.

1. Turn off the power to the 186 instrument.
2. Insert a blunt instrument, such as a small screw driver, under the plastic facing and gently pull towards you.

   The plastic facing should pop out and expose the mesh.
3. Insert the new mesh and replace the plastic facing.

How To Replace the Fuses

The 186 instrument has two printed circuit-type miniature, fast-acting, 10 Ampere fuses soldered onto the bottom side of the main CPU board.

Under normal operating conditions, these fuses should last indefinitely. Should you need to replace the fuses, you can either replace them yourself, or send the unit back to an authorized MKS Calibration and Service Center. Please refer to *Customer Support*, page 19, for information on returning the unit. Table 55 lists the various manufacturers of replacement fuses.

Replacement Fuses	
Manufacturer	**Type**
Littelfuse	255010 Fast Acting 10 Ampere
Buss	MCR-10 Fast Acting 10 Ampere
BEL	MQ10 Fast Acting 10 Ampere

Table 55: Replacement Fuses

1. Ensure that the Power connector cable is disconnected.

Warning  **The 186 unit has lethal voltages inside. To avoid the danger of electrical shock, disconnect the Power connector cable *before* opening the unit.**

2. Disconnect all other cables attached to the 186 instrument.
3. Remove the four Phillips head screws on the outside corners of the rear panel.
4. Carefully turn the unit over so that it is bottom-side up.
5. Remove the seven (7) screws that fasten the bottom cover.
6. Remove the bottom cover by firmly pulling it towards the back of the unit.
7. Carefully turn the unit over so that it is right-side up.
8. Locate the fuses.

   The fuses are located on the bottom side of the main PC board, as shown in Figure 20, page 143.

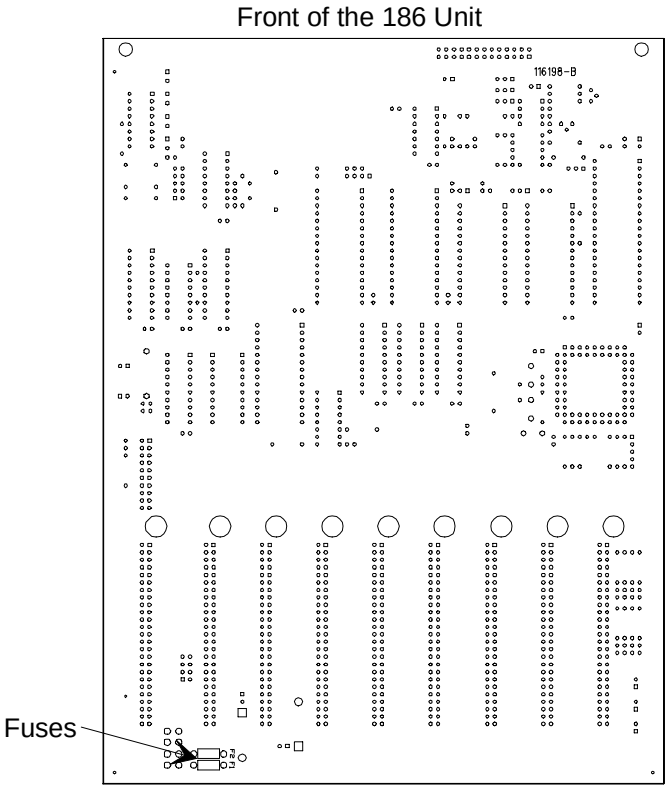

Figure 20: Location of the Fuses

9. Remove the old fuses by cutting the leads.

10. Carefully clean out the soldering holes with water or alcohol.

11. Solder on the new fuses.

    The 186 instrument uses two printed circuit-type miniature, fast-acting, 10 Ampere fuses. Replacement fuses are listed in Table 55, page 142.

12. Replace the bottom cover by inserting it into the grooves provided and firmly sliding it towards the front of the unit.

    The center screw on the bottom cover is slightly off center to avoid interfering with a connector if a board is positioned in slot 5. Be sure to align the cover correctly.

13. Replace the seven (7) screws that fasten the bottom cover.

14. Carefully turn the unit right-side up.

15. Replace the seven (7) screws that fasten the top cover.

16. Replace the two (2) Phillips head screws on the outside corners of the rear panel.

17. Replace all the cables which had been disconnected from the 186 unit.

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Appendix A: Product Specifications

Type 186 Unit

Ambient Operating Temperature	15° to 40° C (59° to 104° F)
Analog Output	Standard: 0 to +10 VDC on single channel, linear or log; set point ±10.5 Volts
Compatible Sensors	Pirani/Convection gauges: HPS Division Pirani gauges HPS Convection Enhanced Pirani (CEP) gauge Granville-Phillips Convectron® gauge HPS convection gauge Capacitance Manometers MKS Type 120 capacitance manometers Linear capacitance manometer Hot Cathode Gauge Tubes HPS Division Hot Cathode Gauge Tubes including thoriated iridium and tungsten filament gauges in nude or glass envelope configuration, the HPS low power, nude, Bayard-Alpert Tube
Digital Communications	RS-232C
Baud Rate	9600
Parity	Even
Data Bits	7
Stop Bit	1
Dimensions	9½" W x 3½" H x 12" D (½ rack) 24.1 cm x 8.9 cm x 30.5 cm
Humidity Storage Range	0 to 95%, non-condensing
Input Power Required	User provided ±15 VDC ±5% @ 10 Amperes maximum through a 15-pin coaxial high current metal shell connector Refer to *Appendix D: Power Supply Requirements*, page 151, for more information.

Due to continuing research and development activities, these product specifications are subject to change without notice.

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Appendix B: Model Code Explanation

Model Code

The plug-in boards installed in your 186 unit are identified in the model code.

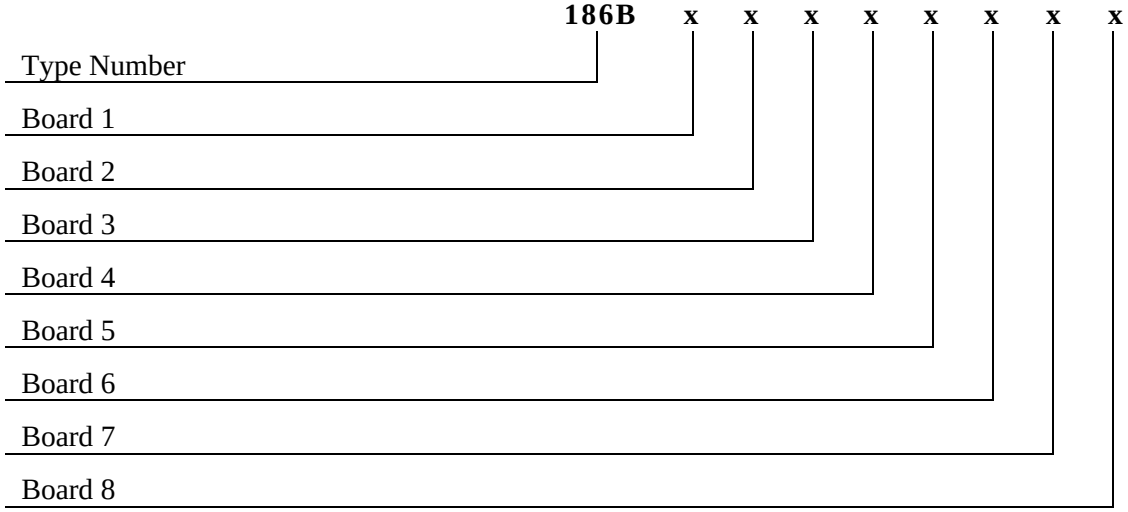

Table 56: Model Code

Letter Designation for the Plug-In Boards	
Letter	**Board**
A	Capacitance Manometer
B	Pirani/Convection
C	Cold Cathode
D	Hot Cathode
F	Mass Flow Controller
M	Control
N	Auxiliary Output
O	No board installed (covered slot)

Table 57: Letter Designation for the Plug-In Boards

Special ordering information and restrictions for certain boards are listed in Table 58, page 148.

Special Instructions for Positioning Plug-In Boards	
Plug-In Board	**Note**
Hot Cathode	Maximum number 4 Position in higher numbered slots to provide the maximum air circulation from the cooling fan. Insufficient air circulation could damage a Hot Cathode board.
Control	Maximum number 4

Table 58: Special Instructions for Positioning Plug-In Boards

Additional Notes

1. Channel numbers are determined by the sequence of boards. For example, a single board installed in slot 1 becomes channel 1. If a dual channel board is then installed in slot 2, it becomes both channels 2 and 3.
2. Input channels are sequenced separately from output channels. Therefore, you can have input channel 1 and output channel 1.

Appendix C: Pressure Range for Supported Sensors

General Information

Table 59 lists the pressure range for each type of sensor supported by the 186 unit. You must enter the full scale range of each capacitance manometer; the other type of sensors have a defined pressure range.

Pressure Range for Supported Sensors			
Sensor Type	**Gas Type**	**Overrange Pressure (Torr)**	**Underrange Pressure (Torr)**
Cold Cathode		1.05×10^{-2}	1.05×10^{-12}
Hot Cathode		1.05×10^{-2}	1.05×10^{-12}
HPS Pirani	nitrogen	1050	1.05×10^{-5}
	helium	57.75	1.05×10^{-5}
	argon	1108.8	1.05×10^{-5}
Convection	nitrogen	1060.5	1.05×10^{-5}
	helium	57.75	1.05×10^{-5}
	argon	1108.8	1.05×10^{-5}
MKS Type 120 Capacitance Manometer		105% of sensor range	-105% of sensor range
All other Linear Capacitance Manometers		105% of sensor range	-105% of sensor range

Table 59: Pressure Range for Supported Sensors

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Appendix D: Power Supply Requirements

Power Supply Specifications

You must provide a ±15 VDC power supply to operate the 186 instrument. The 186 instrument contains a DC-to-DC converter that converts the +15 Volts to +5 Volts to power the logic circuits of the instrument.

Specifications for the Power Supply	
Specification	**Requirement**
Voltage	
Positive Output Voltage	+15 VDC
Negative Output Voltage	-15 VDC
Current	
Minimum Current Out (each supply)	250 mA
Maximum Current Out (each supply)	10 A (maximum for the internal fuses; the actual maximum current depends on the type of boards installed)
Output Accuracy (Line + Load + Temp)	±3%
Line Regulation	±1%
Load Regulation (balanced)	±2%
Maximum Ripple and Noise	
DC to 1 MHz	45 mV
DC to 20 MHz	60 mV

Table 60: Specifications for the Power Supply

Power Required by the Plug-In Boards

Each 186 instrument is custom configured with the plug-in boards specified on the order. The power drawn by each plug-in board varies. Therefore, the overall power consumption of the instrument depends on the board configuration. To calculate the total power consumption, add the power requirement of each board to the power requirement of the 186 base unit.

Individual Board Power Consumption		
Board Type	**Model Code Letter**	**Power Consumption**
186 Base Unit	N/A	±15 Volts @ 200 mA
Capacitance Manometer	A	±15 Volts @ 25 mA*
Pirani/Convection	B	±15 Volts @ 100 mA**
Cold Cathode	C	±15 Volts @ 50 mA
Hot Cathode	D	±15 Volts @ 1000 mA, nominal 2200 mA, during degas
Mass Flow Controller	F	±15 Volts @ 50 mA*
Control	M	±15 Volts @ 200 mA
Auxiliary Output	N	±15 Volts @ 75 mA
** Does not include power drawn by the transducer, or MFC, connected to the board* *** Value per channel*		

Table 61: Individual Board Power Consumption

Appendix E: RS-232 Message Summary

Command Messages

Command messages allow you to change an operating parameter of the 186 instrument. Request messages report the status or value of a parameter.

Note  Use UPPERCASE letters in all command messages.

Calibration Messages

Calibration Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Zero Channel	@	0	5	1	*		*Command only*	ENTER
Span Pirani-Type Sensor to Atmosphere	@	0	5	3	*		*Command only*	ENTER
Span with Reference *Not supported in firmware 1.2x.*	@	0	5	5	*	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (reference channel #)	ENTER
User Zero Enable	@	0	5	6	*	:	ON = User OFF = Factory	ENTER
Span Function	@	0	5	7	*	:	ON = User OFF = Factory	ENTER
Enable Auto Zero	@	0	5	8	*	:	E = Enable D = Disable	ENTER
Select Auto Zero Reference Channel	@	0	5	9	*	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (reference channel #)	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0*								

Table 62: Calibration Message Summary

Sensor Configuration Messages

Sensor Configuration Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Channel Range	@	0	6	1	*	:	ASCII value indicating full scale range	ENTER
Channel Resolution	@	0	6	2	*	:	ASCII value that represents resolution as a power of 10	ENTER
Channel Gas Type	@	0	6	3	*	:	N = Nitrogen A = Argon H = Helium	ENTER
Channel Gauge Factor/Sensitivity	@	0	6	4	*	:	ASCII value	ENTER
Ion Gauge Disconnect Pressure	@	0	6	5	*	:	ASCII value, from -1.0 to +0.001	ENTER
Hot Cathode High Pressure Shutoff	@	0	6	6	*	:	ASCII value	ENTER
Internal Fast Rate-of-Rise Shutoff (Hot Cathode)	@	0	6	7	*	:	E = Enable D = Disable	ENTER
Convection Gauge Type	@	0	6	8	*	:	4 = GP Convectron 5 = HPS CEP	ENTER
Report Sensor Type	@	0	6	9	*		*Request only* response is: 0 = Type 120 2 = linear capacitance manometer 3 = HPS Pirani 4 = GP Convectron 5 = HPS CEP 6 = high power hot cathode 7 = low power hot cathode 8 = cold cathode 9 = MFC Sensor must be powered on	ENTER

Table 63: Sensor Configuration Message Summary
(Continued on next page)

Sensor Configuration Message Summary *(Continued)*								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Assign Alarm 1	@	0	6	A	*	:	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M , N, O, P) Query returns an "X" if no alarm is assigned.	ENTER
Assign Alarm 2	@	0	6	B	*	:	Alarm letter (A, B, C, D, E, F, G, H, I, J, K, L, M , N, O, P) Query returns an "X" if no alarm is assigned.	ENTER
Select units for an individual channel	@	0	6	C	*	:	MT = mTorr T = Torr PA = Pascal MB = mbar SC = sccm SL = slm C = Celsius	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0*								

Table 63: Sensor Configuration Message Summary

Power Control Messages

Power Control Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Channel Power	@	0	8	1	*	:	ON = On OFF = Off	ENTER
Channel Auto Control (ion gauges only)	@	0	8	2	*	:	E = Enable D = Disable	ENTER
Auto Power Reference Channel	@	0	8	3	*	:	Channel number	ENTER
Auto Power Shutoff Pressure	@	0	8	4	*	:	ASCII value	ENTER
Hot Cathode Degas	@	0	8	5	*	:	L = Lo power H = Hi power O = Off	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0*								

Table 64: Power Control Message Summary

Analog Output Messages

Analog Output Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Channel Output Type	@	0	7	1	*	:	LN = Linear LO1 - LO9 = Log 1 - Log 9 SP = Set Point	ENTER
Input Channel Selection	@	0	7	2	*	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (channel #'s)	ENTER
Full Scale Pressure at 10 V output *or* set point output voltage	@	0	7	3	*	:	Value in ASCII (using the units of the input channel) Range: 0.001 to 1000 Torr *or* -10.5 to 10.5 Volts	ENTER
** where ID field is the analog output number 1*								

Table 65: Analog Output Message Summary

Mass Flow Controller-Specific Messages

Mass Flow Controller -Specific Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Mode of Operation	@	1	0	1	*	:	S = Set Point T = Totaling R = Ratio	ENTER
Adjust Set Point	@	1	0	2	*	:	ASCII value, -10 to 220% FS for Set Point and Totaling, and 0 to 200% FS for Ratio	ENTER
Totaling Co-channel	@	1	0	3	*	:	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (co-channel #)	ENTER
Open/Close/Cancel Override	@	1	0	4	*	:	O = Open C = Close N = Cancel	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0*								

Table 66: Mass Flow Controller-Specific Message Summary

Alarm Messages

Alarm Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Alarm Enable/Disable	@	0	1	1	*	:	E = Enabled D = Disabled	ENTER
Trip Point Value	@	0	1	2	*	:	-100000 to +100000 Torr, inclusive	ENTER
Hysteresis Value	@	0	1	3	*	:	0 to 10% inclusive	ENTER
Relay Actuation State	@	0	1	4	*	:	A = Actuated D = Deactuated	ENTER
** where ID field is the alarm letter, A through P*								

Table 67: Alarm Message Summary

Miscellaneous Messages

Miscellaneous Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Select Pressure Units for All Channels	@	5	0	3	*	:	T = Torr P = Pascal B = mbar	ENTER
Leak Rate Period	@	5	0	7	*	:	ASCII value	ENTER
Response Format	@	5	0	8	*	:	E = Scientific D = Fixed	ENTER
*where the * in the ID field is any ASCII character, including a blank space*								

Table 68: Miscellaneous Message Summary

Recipe Specific Messages

Recipe-Specific Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Adjust Set Point	@	0	4	1	*	:	ASCII value from ±100,000	ENTER
Adjust Lead	@	0	4	2	*	:	ASCII value from 0.001 to 10,000 seconds	ENTER
Adjust Gain	@	0	4	3	*	:	ASCII value from 0.002 to 10,000	ENTER
Select Softstart	@	0	4	4	*	:	E = Enable D = Disable	ENTER
Select Input Channel	@	0	4	7	*	:	Input channel number, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0	ENTER
** where ID field is the recipe number, 1 through 8*								

Table 69: Recipe-Specific Message Summary

Board Specific Control Messages

Board-Specific Control Messages								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**		**Data**	
Select Control Mode	@	0	2	1	#	:	M = Manual O = Open C = Close H = Hold A = Auto (PID) - must have a recipe assigned	ENTER
Select Active Recipe	@	0	2	2	#	:	1 through 8 (recipe #) or 0 = No recipe	ENTER
Select Controller Polarity	@	0	2	3	#	:	D = Direct R = Reverse	ENTER
Adjust Integral	@	0	3	1	#	:	ASCII value from 0.02 to 100 (seconds)	ENTER
Adjust Base	@	0	3	2	#	:	ASCII value from 0 to 103 (%)	ENTER
Adjust Start	@	0	3	3	#	:	ASCII value from 0 to 103 (% open)	ENTER
Adjust Alpha	@	0	3	4	#	:	ASCII value from 5 to 99, inclusive	ENTER
Adjust Preset	@	0	3	5	#	:	ASCII value from 0 to 103 (%)	ENTER
Adjust Position/ Output (Manual and Hold modes only)	@	0	3	6	#	:	ASCII value from 0 to 100 (%), inclusive	ENTER
Adjust Softstart Speed	@	0	3	7	#	:	ASCII value from 1.0 to 100 seconds	ENTER
# Indicates the Control board channel number , 0, 1, 2, 3, 4, where control channel 0 is a virtual control channel used in conjunction with Mass Flow Controllers								

Table 70: Board Specific Control Message Summary

Read Only Messages

Read only messages allow you to query the 186 instrument for status information.

Read Only Messages

Read Only Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Channel Reading *(reports reading only)*	@	6	0	1	*	?	ASCII value of the channel reading	ENTER
Channel Reading with Time Stamp	@	6	0	2	*	?	ASCII value of the channel reading and the number of milliseconds since the sensor was turned on.	ENTER
Sensor Voltage *(not valid for hot cathode gauges)*	@	6	0	3	*	?	ASCII value	ENTER
Sensor Ion Current *(only applies to hot and cold cathode gauges)*	@	6	0	4	*	?	ASCII value	ENTER
Sensor Emission Current *(only applies to hot cathode gauges)*	@	6	0	5	*	?	ASCII value	ENTER
Pressure Leak Rate	@	6	0	6	*	?	ASCII value Sensor must be measuring	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0*								

Table 71: Read-Only Message Summary
(Continued on next page)

Read Only Message Summary *(Continued)*								
Message Description	**Message Format**							
	@	**command category**		**command number**	**ID**	**Data**		
Channel Status	@	6	0	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 0 (chan #)	?	A = On B = Low power degas C = Underranged D = Overranged E = Manually off F = Auto off G = High power degas H = Initializing I = Zeroing J = Bad sensor K = Disconnected L = Chan not installed	ENTER
Power Up Status	@	6	0	9	x	?	Refer to Table 44, page 112.	ENTER
Alarm Status	@	6	0	B	Alarm ID (A - P)	?	E = Enabled D = Disabled T = Tripped	ENTER
Report Sensor Type	@	0	6	9	*	?	0 = Type 120 2 = linear capacitance manometer 3 = HPS Pirani 4 = GP Convectron 5 = HPS CEP 6 = high power hot cathode 7 = low power hot cathode 8 = cold cathode 9 = MFC	ENTER
** where ID field is the channel number: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0* *x indicates any ASCII character, including a blank space*								

Table 71: Read-Only Message Summary

Diagnostic Messages

Diagnostic Message Summary								
Message Description	**Message Format**							
	@	**Command Category**		**Command Number**	**ID**	**Data**		
Software Version	@	9	9	1	x	?	xx = software version	ENTER
Instrument Configuration	@	9	9	2	x	?	0 = Empty slot 1 = Pirani board (configured as a single channel board) 2 = Pirani board (configured for dual channel operation) 3 = Hot Cathode board 4 = Capacitance Manometer board 5 = Mass Flow Controller board 6 = Control board 7 = Cold Cathode board 8 = Auxiliary Output board	ENTER
where the x in the ID field is any ASCII character, including a space								

Table 72: Diagnostic Message Summary

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