120715-P1
Rev A, 2/98
Instruction Manual

MKS Type 246C
Single Channel
Power Supply/Readout

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WARRANTY

Type 246C Equipment

MKS Instruments, Inc. (**MKS**) warrants that the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment and will for a period of two years from the date of shipment, 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.

For the period commencing with the date of shipment of this equipment and ending one year later in the case of defects in materials and workmanship, but two years later in the case of failure to comply with the date-related operations warranty, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

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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 II equipment IEC 417, No.5172-a	3~ 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.

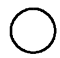
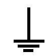
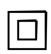
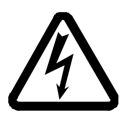
Definitionen der am Gerät angebrachten Symbole			
 Ein (Netz) IEC 417, Nr. 5007	 Aus (Netz) IEC 417, Nr. 5008	 Erde IEC 417, Nr. 5017	 Schutzleiter IEC 417, Nr. 5019
 Rahmen oder Chassis IEC 417, Nr. 5020	 Äquipotentialanschluß IEC 417, Nr. 5021	 Gleichstrom IEC 417, Nr. 5031	 Wechselstrom IEC 417, Nr. 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.

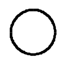
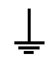
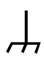
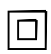
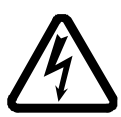
Definición de los símbolos que aparecen en la unidad			
 Encendido (alimentación eléctrica) IEC 417, N.° 5007	 Apagado (alimentación eléctrica) IEC 417, N.° 5008	 Puesta a tierra IEC 417, N.° 5017	 Protección a tierra IEC 417, N.° 5019
 Caja o chasis IEC 417, N.° 5020	 Equipotencialidad IEC 417, N.° 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 246C Single Channel Power Supply/Readout is designed as a power supply/readout and set point source for one analog mass flow controller (MFC). The unit can also power and monitor the flow rate through an analog mass flow meter (MFM).

The 246 unit consists of a ±15 VDC power supply, a set point circuit (MFC only), and a digital panel meter (DPM) to display the flow rate of the mass flow device. It may also be used to monitor and provide a set point level for an MFC and to provide ratioed set points for multiple gas control.

The 246 unit is a versatile instrument that may be used separately or as part of a larger control system. Multiple units can be mounted in a unique 19" full rack which holds up to five units, or in a half-rack which holds up to two units. The 246 readout can be operated manually via the front panel controls, through an external controller, or through remote TTL logic control.

The 246 readout is primarily designed to interface with MKS mass flow controllers; however, with the proper interface cables, you can use most major MFCs. Refer to Table 5, page 20, for a list of MKS interface cables.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 246 unit.

Before installing your Type 246 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.

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

Chapter Five: Maintenance and Troubleshooting, describes basic maintenance procedures required to keep the instrument in good working condition, and provides a checklist for reference should the instrument malfunction.

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

Appendix B: Model Code Explanation, describes the instrument's ordering code.

Appendix C: Gas Correction Factors for Commonly Used Pure Gases, lists the gas correction factors for some commonly used pure gases.

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 246 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.

Chapter Two: Installation

How To Unpack the Type 246 Unit

MKS has carefully packed the Type 246 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 a 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 246 Unit
- Type 246 Instruction Manual (this book)
- Power cord

Optional Equipment:

- Electrical Connector Accessories Kit - 246C-K1
- Mounting Accessories

Half-Rack Main Frame	246MF-1
Full-Rack Main Frame	246MF-2
Blank Panel	246P-1

- Interface Cables (refer to Table 5, page 20)

Interface Cables

As of January 1, 1996, most products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE mark.

To ensure compliance with EMC Directive 89/336/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. Overall metal braided shielded cables, properly grounded at both ends, are required to meet CE specifications.
2. To order metal braided shielded cables, add an "S" after the cable type designation. For example, to order a standard cable to connect the 246 unit to a 1679 MFC with a 15-pin Type "D" commector, use part number CB259-5-10; for a metal braided shielded cable, use part number CB259S-5-10.

System Interface Cables

Use the system interface cables to connect the 246 unit to a mass flow device, an external controller, or another 246 unit.

System Interface Cables		
To Connect the 246 Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
258, 358, 558, 1150*, 1151*, 1152*, 1159, 1162, 1259, 1261, 1359, 1449, 1459, 1559, 1562, 1661, 1678, 2159, 2162, 2259 MFC 1179, 1479, or 1679 MFC with 15-pin Type "D" connector (Model Code B)	CB259-5-10	CB259S-5-10
1160, 1163, 1461, 2160, 2163 MFC 1179, 1479, or 1679 MFC with Edge Card connector (Model Code C)	CB259-10-10	CB147S-7-10**
1462, 1661 MFC 1179, 1479, or 1679 with 9-pin Type "D" connector (Model Code A), M200, M331	CB147-12-10	CB147S-12-10

Table 5: System Interface Cables

(Continued on next page)

System Interface Cables *(Continued)*		
To Connect the 246 Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
250 Controller (PCS)	CB246-2-3	CB246S-2-3
1250 Controller (PCS)	---	CB246-3-3
246 Readout	---	CB396-1-2
* *To connect the 246 unit to a 1150, 1151, or 1152 MFC, cable CB260S-3-10 or CB260S-3-10 is also required along with the 260 PS-1 or 260 PS-3 Power Supply.* ***Products shipped with Edge Card connectors are not CE compliant.*		

Table 5: System Interface Cables

Generic Shielded Cables

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.
2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.
3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.
4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:
   A. The voltage ratings;
   B. The cumulative I^2R heating of all the conductors (keep them safely cool);
   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;
   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and
   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Product Location and Requirements

The Type 246 unit meets the following criteria:

- POLLUTION DEGREE 2 in accordance with IEC 664
- INSTALLATION CATEGORY II, for transient overvoltages, according to EN 61010-1

Operating Environmental Requirements

- Ambient Operating Temperature: 15° to 40° C (59° to 104° F)
- Main supply voltage fluctuations must not exceed ±10% of the nominal voltage
- Ventilation requirements include sufficient air circulation
- Connect the power cord into a grounded outlet

Safety Conditions

The 246 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

Setup

Dimensions

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

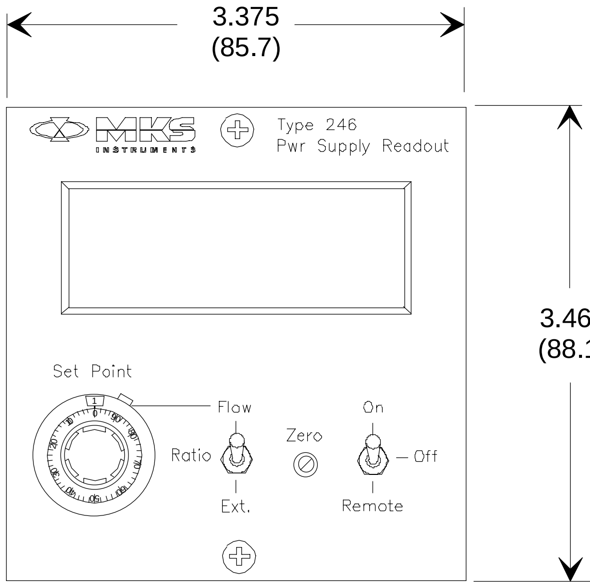


Figure 1: Front Panel Dimensions

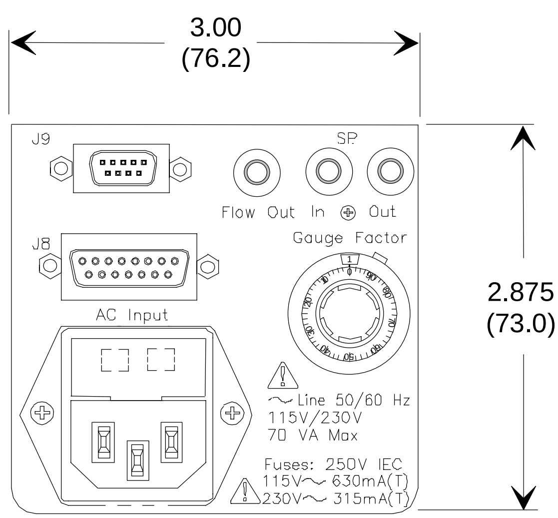


Figure 2: Rear Panel Dimensions

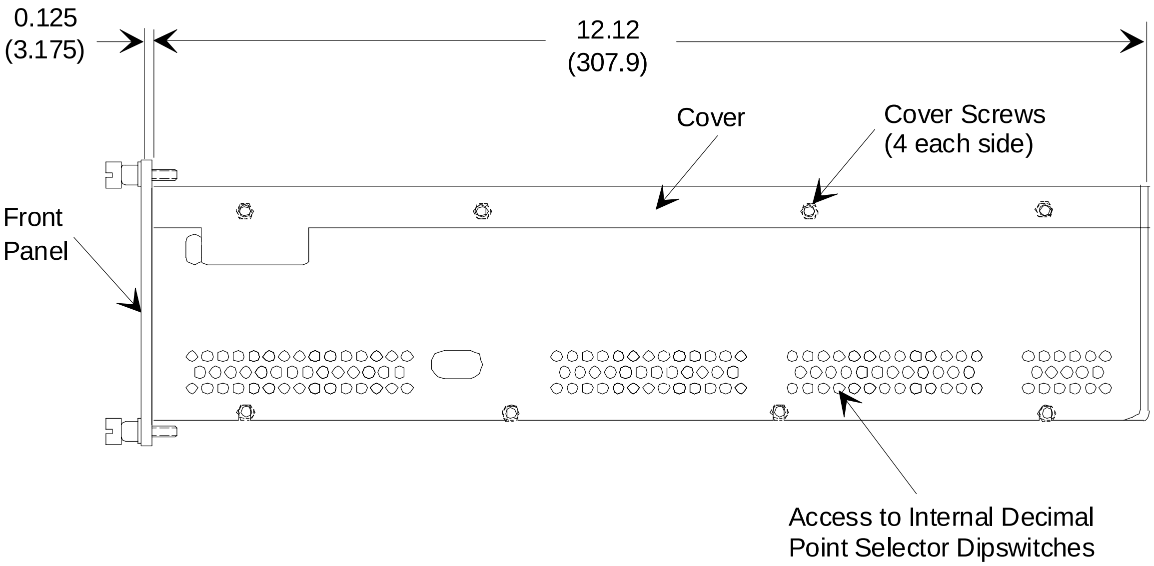


Figure 3: Side Panel Dimensions

Power Requirements

The power requirements for the 246 unit are:

- 115 VAC Setting: 100 to 120 VAC nominal, 50/60 Hz
- 230 VAC Setting: 200 to 240 VAC nominal, 50/60 Hz

The power consumption for the 246 unit is:

- 70 VA (maximum)

Mounting Instructions

Type 246 Unit

The 246 unit can be used as a bench top instrument, or can be mounted in a panel cutout, in a half-rack holding up to 2 units, or in a 19" full-rack holding up to 5 units. Part numbers for these accessories are listed in *Unpacking Checklist*, page 19.

However the unit is mounted, leave adequate space around it for proper ventilation. Refer to *Dimensions,* page 23, for dimensional drawings of the 246 unit. Refer to *System Configurations*, page 26, for more information.

Mass Flow Device

Caution

Install the mass flow device (MFC or MFM) in the gas stream so that the flow direction corresponds to the flow marking on the base of the equipment.

Allow enough space for connector clearance, access to the zero adjustment, and access to the seat adjustment in the control valve. Refer to the appropriate instruction manual as needed for complete installation instructions.

System Configurations

The 246 unit can be configured for manual (internal) set point control, external set point control, or remote operation. All connections are made using the connectors on the rear panel (refer to Figure 8, page 41). The system interface cables are listed in Table 5, page 20.

Manual Set Point Control

Manual set point control of the flow rate through MFCs is accomplished using either individual 246 units or multiple units connected for ratio operation. In either case, the gas flow is based on the unit's internal +5 V reference and the unit's front panel Set Point Control.

Individual Flow Control

For individual flow control, the system requires only the 246 unit, the MFC, and the appropriate cables. The flow rate is controlled with the front panel SET POINT CONTROL, which is connected to an internal +5 V reference. Since the +5 V corresponds to full rated flow, the SET POINT CONTROL can be adjusted up to a maximum of 100% of the rated flow for the attached MFC. Refer to *How To Manually Control Individual Gas Flows*, page 60, for operating instructions.

Ratio Flow Control

For ratio flow control, the system requires two or more 246 units connected together, the MFCs, and the appropriate cables.

To connect multiple 246 units together for ratio operation (refer to Figure 4, page 27):

1. Connect the FLOW OUT jack on the master 246 unit to the SP IN (Set Point In) jack on the first 246 slave unit.

2. Connect the first slave (Channel 2) 246 unit's SP OUT (Set Point Out) jack to the next 246 unit's SP IN jack (Channel 3).

   The Set Point In and Set Point Out jacks are internally connected in parallel.

3. Continue to join the slave 246 units together by connecting the SP OUT jack on one unit to the next 246 unit's SP IN jack until all of the units are connected.

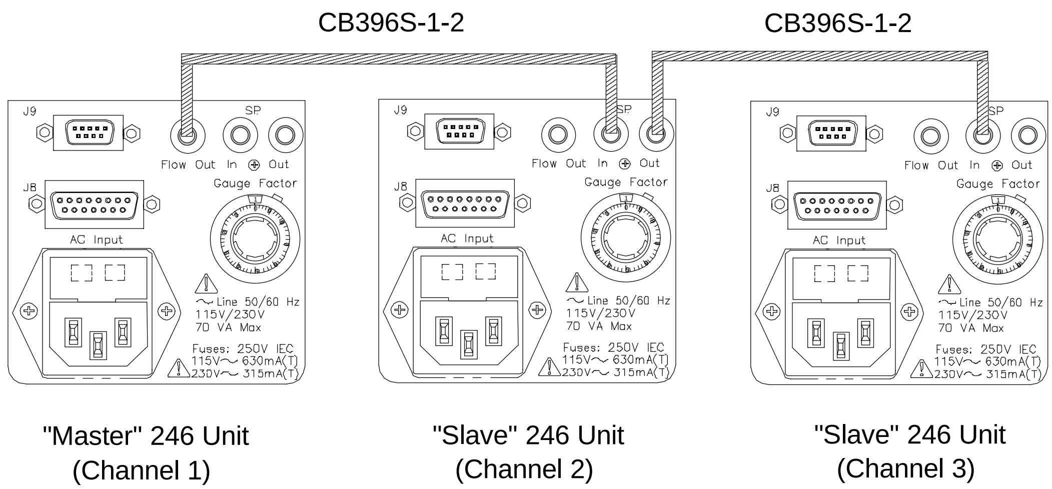


Figure 4: Internal Set Point Control Setup - Ratio Flow Control

The flow rate for the first unit in the string (the *"master"*) is controlled with its front panel SET POINT CONTROL, which is connected to an internal +5 V reference. Since the +5 V corresponds to full rated flow, the master's SET POINT CONTROL can be adjusted up to a maximum of 100% of the rated flow for the attached MFC. The flow rates for each of the *"slave"* 246 units are set using their front panel SET POINT CONTROLS, as a fraction (ratio) of the output flow from the master 246 unit. The ratio is maintained while the total flow is adjusted to maintain the desired pressure. Refer to *How To Manually Control Ratioed Gas Flows*, page 61, for operating instructions.

External Set Point Control

External set point control of the flow rate through MFCs is accomplished using either individual 246 units with an external pressure controller, or multiple units connected for ratio operation with an external pressure controller and a pressure transducer.

Note The 246 unit can operate with any controller or pressure transducer provided the signal that enters the 246 unit goes *positive* with increasing flow (correct polarity). Throughout this manual, the MKS Type 250 Pressure/Flow Controller is used for example only.

Individual Flow Control

For individual flow control, the system requires the 246 unit, the MFC, an external pressure controller, and the appropriate cables. To connect the 246 unit to an external controller, connect the proper interface cable from the external controller to the SP IN jack on the 246 unit (refer to Figure 5).

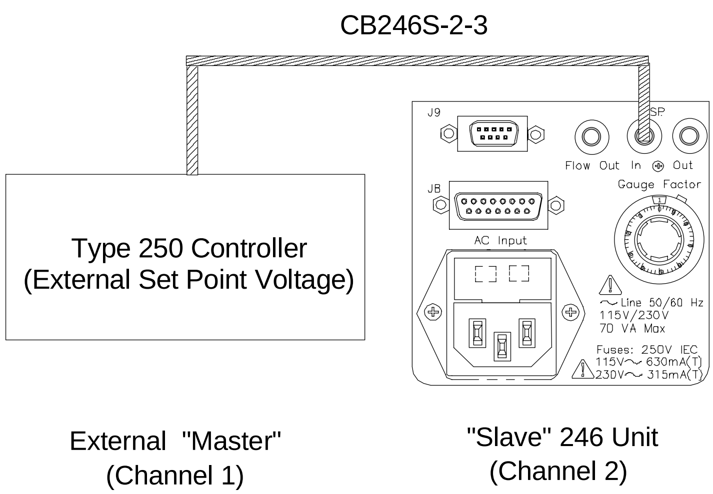


Figure 5: External Set Point Control Setup - Individual Flow Control

Note The drawing in Figure 5 is not drawn to scale.

The flow rate is controlled using a set point signal from the external controller. The external set point voltage bypasses the 246 unit's SET POINT CONTROL, and the flow signal is sent directly to the MFC. Refer to *How To Control Individual Gas Flows with an External Set Point*, page 62, for operating instructions.

Ratio Flow Control

For ratio flow control, the system requires two or more 246 units connected together, the MFCs, an external pressure controller, a pressure transducer, and the appropriate cables.

To connect multiple 246 units together with an external controller (refer to Figure 6):

1. Connect the proper interface cable from the external controller to the SP IN jack on the first slave 246 unit.

2. Connect the SP OUT jack on the first slave 246 unit to the SP IN (Set Point In) jack on the second slave 246 unit.

3. Connect the second slave (Channel 2) 246 unit's SP OUT (Set Point Out) jack to the next 246 unit's SP IN jack (Channel 3).

   The Set Point In and Set Point Out jacks are internally connected in parallel.

4. Continue to join the 246 slave units together by connecting the SP OUT jack on one unit to the next 246 unit's SP IN jack until all of the units are connected.

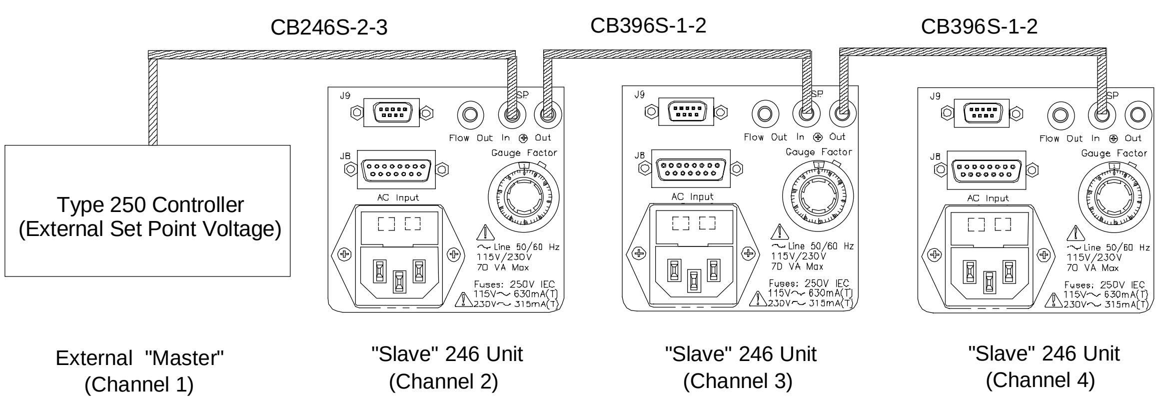


Figure 6: External Set Point Control Setup - Ratio Flow Control

Note The drawing in Figure 6 is not drawn to scale.

The pressure in a chamber is maintained by controlling the ratio of gas flows, based on the set point signal from an external controller and measurements from a pressure transducer.

The controller (the "*master*") provides a pressure control signal (PCS) that is applied to the SET POINT CONTROL on the first slave 246 unit. The external set point voltage bypasses the first slave 246 unit's SET POINT CONTROL and the flow signal is sent directly to the MFC. The flow rates for the remaining slave 246 units are set using their front panel SET POINT CONTROL, as a fraction (ratio) of the output from the first slave 246 unit. The ratio is maintained while the total flow is adjusted to maintain the desired pressure. Refer to *How To Control Ratioed Gas Flows with an External Set Point*, page 63 for operating instructions.

Remote Flow Control

Remote flow control can be accomplished using TTL logic control. The MFC Interface connector J8 provides the means to remotely turn the flow on/off and to adjust and monitor the flow rate using a set point signal from an external voltage. Refer to Table 8, page 34, for the MFC Interface connector pinout. Refer to *How To Control Gas Flow with TTL Logic*, page 66, for more information.

Electrical Information

Power Up

Caution

The 246 unit uses the AC line cord as its power switch, that is, the unit is *ALWAYS ON* when it is connected to a line source.

Grounding

For protective earthing, plug the power (AC line) cord into a properly grounded outlet.

Fuses

The line fuses protect the internal circuitry; both sides of the line are fused. The fuse values are listed in Table 6.

Fuse Information		
Voltage Setting	**Fuse Type**	**MKS Part Number**
115 VAC	630 mA (T) / 250 V	024-0009
230 VAC	315 mA (T) / 250 V	024-0444

Table 6: Fuse Information

Caution

Disconnect the AC line cord from the 246 unit *before* you replace the fuse, to avoid any damage.

Ensure that the fuse type is appropriate for your voltage setting, and that the voltage setting is correct for your local electrical source.

Line Voltage

The Line Voltage Selector Switch, located on the underside of the 246 unit, configures the unit to accept either 115 or 230 VAC input voltage. The voltage selected is visible through the window in the panel cutout.

Caution **The Line Voltage Selector must be set to the proper input voltage *before* you connect the AC line cord. Otherwise, the unit will be severely damaged.**

To set the line voltage:

1. Ensure that the power cord and all interface cables are disconnected from the 246 instrument.

2. Use a blunt instrument, such as a flat head screw driver, to change the position of the switch.

   The value of the selected line voltage is visible in the panel cutout.

Connectors

The 246 unit's two interface connectors and three microjack connectors are located on the rear panel of the unit (refer to Figure 8, page 41). The system interface cables are listed in Table 5, page 20.

Interface Connector J9

This 9-pin male Type "D" connector provides the communication link to and from the unit including the connection to the scaled transducer outputs, the lines to turn the flow on and off, and the set point input lines which remotely set the flow rate of the MFC.

Interface Connector J9 Pinout		
Pin	**Assignment**	**Description**
1	Analog Return	
2	0 to 1 V (nominal) Corrected Output	Flow output corrected by rear panel Gauge Factor Scaling Control
3	Analog Return	
4	Remote ON/OFF	Line used for an external (remote) control of flow controller. Compatible with all 5 V logic, this line is held high (or left unconnected), causing a flow "off" condition when the SET POINT SOURCE SWITCH is in the EXT position.
5	No Connection	
6	0 to 5 V Output	MFC output voltage, after being zero corrected by the front panel ZERO CONTROL circuitry
7	Set Point Input	Line used to input an external set point signal for direct control (EXT position) or ratio control (RATIO position)
8	Digital Ground	Return for remote ON/OFF line (pin 4)
9	Chassis Common	

Table 7: Interface Connector J9 Pinout

Note

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

MFC Connector J8

This 15-pin female Type "D" connector provides the connection for the mass flow device. The connector provides the necessary power and set point voltages, and receives the flow output signal.

MFC Connector J8 Pinout		
Pin	**Assignment**	**Description**
1	No Connection	
2	Flow Input Signal	The output from the MFC is applied here
3	No Connection	
4	No Connection	
5	Power Ground	
6	-15 Volts	Supplied by the 246 unit
7	+15 Volts	Supplied by the 246 unit
8	Set Point Output Signal	From the 246 unit to the MFC
9	No Connection	
10	Flow Out	A 0 to 5 V zero-corrected output sent back to the MFC for use with the set point circuitry to ensure that set point matches the actual flow
11	No Connection	
12	Analog Return	
13	No Connection	
14	No Connection	
15	Chassis Common	

Table 8: MFC Connector J8 Pinout

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

Microjack Connectors

Three microjack connectors are located on the rear panel of the 246 unit (refer to Figure 8, page 41).

Flow Out Connector

The Flow Out jack is used for data acquisition purposes, or for providing a master flow set point voltage to other slave 246 units.

This connector provides the same function as pin 6 on the Interface connector J9, providing a 0 to 5 V sensor output voltage which is corrected by the front panel ZERO CONTROL.

Set Point In/Out Connectors

The Set Point In and Set Point Out jacks are internally connected in parallel and are used to accept an external set point voltage.

When used with other 246 units for ratio set point operation, the FLOW OUT jack from the master unit must be connected to the SP IN jack on the first slave 246 unit, then parallel connected from the slave SP OUT jack to the next 246 unit's SP IN jack, and so on. Refer to Figure 4, page 27, and Figure 6, page 29.

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Chapter Three: Overview

General Information

The 246 readout can be connected to a single MFC or MFM through MFC connector J8 on the rear panel of the unit (refer to Figure 8, page 41). Communication to and from the unit occurs through Interface connector J9. The microjack connectors are used to join multiple 246 units or to connect a 246 unit to an external controller.

Flow Signal Path

The main power supply provides ±15 Volts to power the MFC. The voltage corresponding to the flow rate, +5 VDC at full rated flow, is received at the input amplifier where the fine zero correction is made.

The flow signal from the MFC (0 to 5 V) enters the 246 unit at pin 2 of the J8 connector. The signal is buffered and the system injects a zero correction signal, if necessary, using the front panel ZERO CONTROL. This signal is sent to three places:

1. To an output pin on Interface connector J9.

   This is a 0 to 5 Volt, non-gas-corrected output. This output is zero-corrected and is wired to microjack J10 (flow output). The zero and scaled signal is sent to J9.

2. To the MFC connector J8.

   This zero-corrected signal is used by MKS flow controllers for comparison against incoming set point voltages.

3. To a second amplifier stage.

The second amplifier stage amplifies the incoming 0 to 5 V signal times two, making it a 0 to 10 V signal which is applied to the scaling control, the output of which is buffered to become the scaled output. The output is labeled as a "0 to 1 V corrected output" but in fact, the output voltage range is 0 to 1 V only when the Gauge Factor Scaling Control potentiometer is set to 1.00 (refer to *Gauge Factor Scaling Control*, page 44, for more information). Otherwise it is possible for the output to be as high as 0 to 10 V.

Set Point Signal

The set point circuitry operates independently of the flow circuitry. The source of the set point signal is selected by the three position SET POINT SOURCE SWITCH on the front panel (refer to Figure 7, page 39), as either FLOW, RATIO, or EXT. The FLOW and RATIO positions of this switch are driven by the output of the SET POINT CONTROL; the EXT position is driven by a externally applied voltage. Refer to *Set Point Source Switch*, page 40, for more information.

The set point signal can be generated by:

- An internal +5 V reference

  Use the internal reference to manually control individual gas flows based on the 246 unit's Set Point, or to ratio the gas flow from multiple 246 units to the flow from a master 246 unit.

- A voltage signal from an external controller

  Use an external voltage signal to control individual gas flows, or to ratio the gas flow from multiple 246 units, using the external signal for the master unit and the Set Point Controls for the slave 246 units.

- An externally applied voltage

The set point signal flows through a switch circuit, which is controlled by the front panel FLOW CONTROL SWITCH or a TTL logic level on connector J9, and is applied to the MFC. When the circuit is turned on, the set point signal is applied to the MFC and flow begins. The flow rate is determined by the magnitude of the set point signal with +5 V corresponding to full flow. When the switch circuit is turned off, the flow stops.

Front Panel Controls

Figure 7 shows the location of the controls on the front panel of the 246 unit.

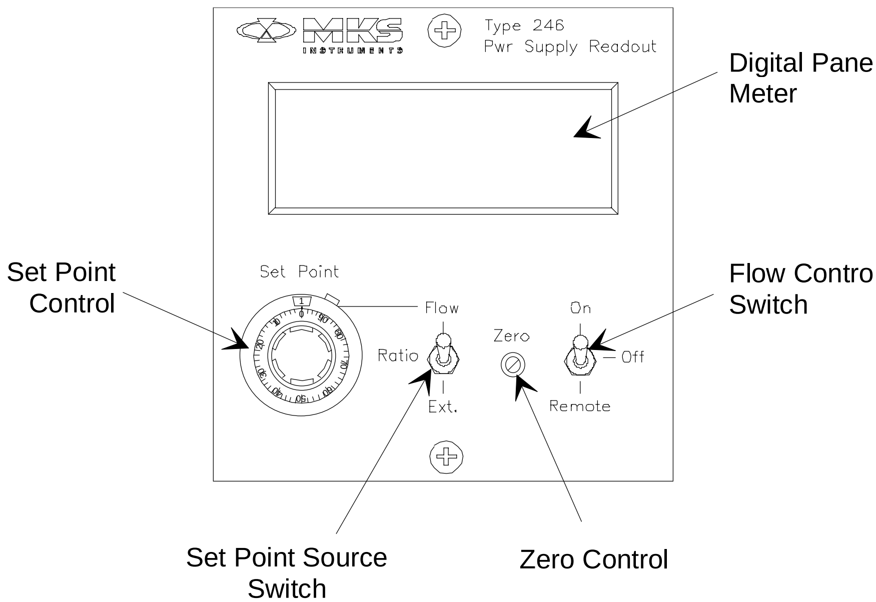

Figure 7: Front Panel Controls

Digital Panel Meter

This 3½ digit panel meter (DPM), set to read 1 VDC as 1000 counts full scale, displays the flow rate. In order for the meter to display a *direct* flow reading, in sccm or slm, the Gauge Factor Scaling Control potentiometer on the rear panel (refer to Figure 8, page 41) must be properly set. Refer to *Gauge Factor Scaling Control*, page 44, for more information.

Flow Control Switch

This 3-position toggle switch controls the circuit which applies the set point signal to the MFC as follows:

ON: Allows flow control via the 246 set point voltage.

OFF: Shuts off flow (overrides the 246 unit’s set point voltage). The switch places a small negative voltage on the set output line so that the control valve will be closed positively.

REMOTE: Provides for external command of ON/OFF flow control.

A logic signal coming in through Interface connector J9 (pin 4) may be used to gate the set point signal to the MFC. Flow may be turned ON/OFF by an external TTL signal; a logic low turns the flow ON, a logic high or open turns the flow OFF. Refer to Table 7, page 33, for the Interface connector J9 pinout.

Zero Control

This 20-turn potentiometer is used for fine zero adjustment. It has a limited range of ±3% of FS; therefore, larger adjustments must be made with the zero control on the MFC.

Set Point Source Switch

This 3-position toggle switch selects the source of the set point signal to be sent to the MFC. The FLOW and RATIO positions are driven by the output of the SET POINT CONTROL; the EXT position is driven by an externally applied voltage level.

FLOW Position: Selects the set point signal from the front panel Set Point Control.

The signal is driven from the +5 V internal reference.

RATIO Position: Selects the set point signal from the front panel Set Point Control.

The signal is driven from an external controller (the external set point input at pin 7 in Interface connector J9). This setting provides for the set point voltage to be the ratio of an external source where the ratio is set by the front panel Set Point Control.

EXT Position: Selects the set point signal from a pin on Interface connector J9, allowing the flow rate to be controlled directly from an external 0 to +5 V signal.

Set Point Control

This 10-turn potentiometer sets the set point level as a *percentage of full scale* when the Set Point Source Switch is in the FLOW or RATIO position.

When the Set Point Source Switch is in the:

FLOW Position: Determines the set point voltage from ± 0.1 to 100% of full rated flow

RATIO Position: Determines the ratio of an incoming set point voltage from ± 0.1 to 100% of Channel 1 Flow Signal

Note

The Set Point Control is the same type of 10-turn potentiometer used to set the Scaling Control Factor. For detailed information on how to adjust the potentiometer, refer to *Scaling Control Potentiometer*, page 46.

Refer to *How To Setup the System*, step 8, page 57, for an example Set Point Control calculation.

Rear Panel Controls

Figure 8 shows the location of the controls on the rear panel of the 246 unit.

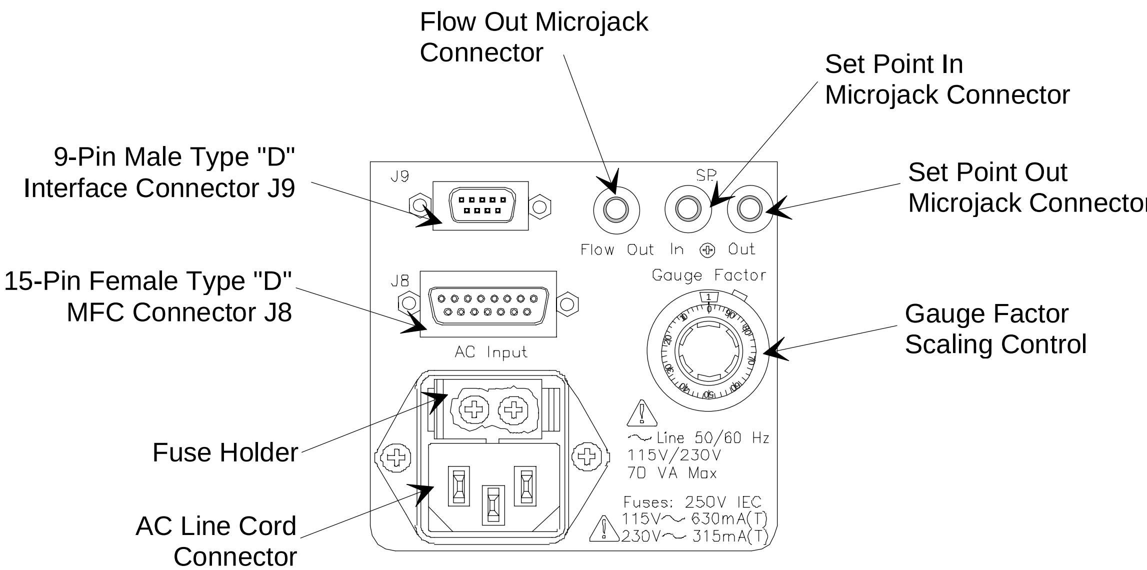

Figure 8: Rear Panel Controls

Gauge Factor Scaling Control Potentiometer

This 10-turn potentiometer is used to enter the scaling factor, which scales down the +5 VDC transducer output signal so that the Digital Panel Meter displays the flow rate directly in sccm or slm. Normally set to “1/00”, it can be raised or lowered for use with a particular gas.

Note

It is ***critical*** for proper system operation that the scaling control factor is calculated properly and that the potentiometer is set correctly. Refer to *Gauge Factor Scaling Control*, page 44, for more information.

AC Line Cord Connector

The AC Line Cord provides 115 or 230 VAC power to the 246 unit. For protective earthing, plug the power cord into a properly grounded outlet.

Caution

The 246 unit uses the AC line cord as its power switch, that is, the unit is *ALWAYS ON* when connected to a line source.

Fuse Holder

This housing holds the unit's two fuses. The fuse values are listed in Table 6, page 31. Refer to *How To Replace the Fuses,* page 67, for more information.

Caution **Disconnect the AC line cord from the 246 controller *before* you replace the fuses, to avoid any damage.**

MFC Connector J8

This 15-pin female Type "D" connector provides the connection for the mass flow device. The connector provides the necessary power and set point voltages, and receives the flow output signal.

Refer to Table 8, page 34, for the MFC Connector J8 pinout.

Interface Connector J9

This 9-pin female Type "D" connector provides the connection for a pressure transducer. The connector provides the communications link to and from the unit including the connection to the scaled transducer outputs, the lines to turn the flow on and off, and the set point input lines which remotely set the flow rate of the MFC.

Refer to Table 7, page 33, for the Interface Connector J9 pinout.

Flow Out Microjack Connector

This connector provides a 0 to 5 V sensor output voltage which is corrected by the front panel ZERO CONTROL; this connector provides the same function as pin 6 in Interface connector J9. Refer to Table 7, page 33, for the Interface connector J9 pinout.

When operating the 246 unit with ratio control, this jack provides a master flow set point voltage for the slave 246 units, and can also be used for data acquisition purposes.

Set Point In/Out Microjack Connector

The set point in and out connectors receive an external set point voltage; they are internally connected in parallel. These connectors are used to connect a 246 unit to an external pressure controller or to connect two 246 units together, as shown in Figure 6, page 29.

Underside Control

Line Voltage Selector Switch

The Line Voltage Selector Switch, located on the underside of the 246 unit, configures the unit to accept either 115 or 230 VAC input voltage. The value of the selected line voltage is visible in the panel cutout. Refer to *Line Voltage*, page 32, for more information.

Caution

The Line Voltage Selector switch must be set to the proper input voltage *before* you connect the AC line cord. Otherwise, the unit will be severely damaged.

Side Panel Control

Decimal Point Selector Dipswitches

This 4-position dipswitch, located inside the unit on the edge of the Main PC board, sets the decimal point position for the Digital Panel Meter. The dipswitch is accessible through the vent holes in the side of the unit (refer to Figure 3, page 24).

The position of the decimal point is determined by the full scale range of the MFC in use. A 100 sccm mass flow controller requires the decimal point to be positioned as “100.0” (display at full rated flow).

Refer to Table 9, page 45, for a list of the correct displays at full scale for various range MFCs.

Gauge Factor Scaling Control

There is one Gauge Factor Scaling Control potentiometer on the rear panel of the 246 unit (refer to Figure 8, page 41). This 10-turn potentiometer is used to adjust the full scale voltage signal from the MFC, which corresponds to the flow rate, to a level that enables the digital panel meter (DPM) to display the flow rate directly, in sccm or slm.

The 246 unit uses a digital panel meter that reads 1 VDC as 1000 counts full scale (FS). Although the DPM can accommodate a *maximum* of 2 VDC and can read up to 1999 counts, it cannot be adjusted to the 5000 counts needed to accommodate the +5 VDC full scale output signals from the MFC. Therefore, the +5 VDC output voltage from the MFC must be scaled down so that the full scale counts (1000) read on the meter represent the full scale voltage from the MFCs. When the adjustment is properly made, flow can be read directly from the meter.

The amount by which the +5 VDC output signal is scaled down, the *Scaling Control Factor,* is application dependent and must be calculated for each MFC in use. The Scaling Control Factor for the MFC is set with the Scaling Control potentiometer.

Note It is ***critical*** for proper system operation that the scaling control factor is calculated properly and that the potentiometer is set correctly.

Scaling Control Factor

The Scaling Control Factor is the *product* of the Gauge Factor for the MFC in use and the Gas Correction Factor for the gas in use:

SCALING CONTROL FACTOR = GAUGE FACTOR x GAS CORRECTION FACTOR

Gauge Factor

The Gauge Factor is a factory set value which scales the +5 VDC output signal to the appropriate full scale range for the MFC, so that the digital panel meter reads 1000 counts. The gauge factors for various flow ranges are listed in Table 9.

MFC Gauge Factors		
5 V Full Scale Input (sccm)	**Gauge Factor**	**Display at Full Scale**
10	100	10.00 sccm
20	200	19.99 sccm
50	50	50.0 sccm
100	100	100.0 sccm
200	200	199.9 sccm
500	50	500 sccm
1000	100	1000 sccm
2000	200	1999 sccm
5000	50	5.00 slm
10000	100	10.00 slm
20000	200	19.99 slm
50000	50	50.0 slm

Table 9: MFC Gauge Factors

Gas Correction Factor

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). Refer to Table 12, page 77, for a list of GCFs for commonly used pure gases.

If the pure gas you are using is not listed in Table 12, page 77, or you are using a gas mixture, you must calculate its GCF. Refer to *Gas Correction Factor*, page 47, for more information.

Note Refer to *How To Setup the System*, step 6, page 54, for an example Scaling Control Factor calculation.

Scaling Control Potentiometer

The Scaling Control (refer to Figure 9) is a 10-turn potentiometer that serves as a voltage divider for the +5 VDC output signal from the MFC; the control has a full scale setting of 1000.

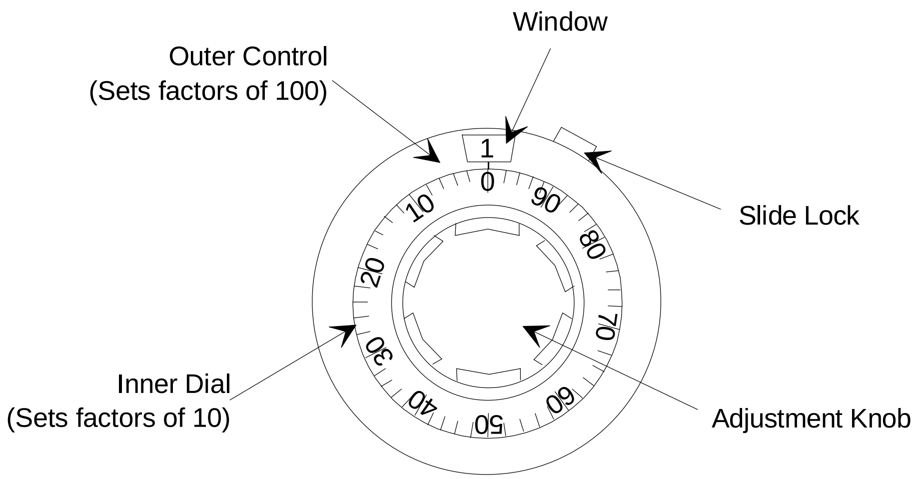

Figure 9: Scaling Control Potentiometer - Initial Setting

The outer control represents factors of 100; indicated by the numbers 0 to 10 which display in the window at the top of the potentiometer. The numbers on the inner dial represent factors of 10, in divisions of 2; these values are set when the appropriate value is aligned with the vertical line beneath the window. The adjustment knob cannot be turned below 0 or above the full scale setting of 1000.

Note The maximum number of counts the meter can read is 1999, therefore the voltage cannot exceed 2 VDC. Ensure that the scaling control potentiometer is never set higher than “2/00”, that is a “2” in the window and “0” on the dial. This ensures that the voltage is never set higher than 2 VDC, and that the meter is not be set beyond its capacity.

To adjust the Scaling Control Potentiometer:

- Unlock the slide lock on the right side of the control by pushing it up (counterclockwise)
- Turn the adjustment knob *clockwise* to increase the value represented on the control

  The 246 unit is typically shipped with the control set to “1 / 00”, as shown in Figure 9.
- Turn the adjustment knob *counterclockwise* to decrease the value represented on the control
- Lock the position of the control by pushing the slide lock on the right side of the control down (clockwise)

Refer to *How To Setup the System*, step 7, page 56, for an example of how to adjust the Scaling Control potentiometer.

Gas Correction Factor

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1).

Table 12, page 77, lists the gas correction factors for some commonly used pure gases. If the gas you are using is not listed in Table 12, you must calculate its GCF. The equations for calculating gas correction factors are listed in *How To Calculate the GCF for Pure Gases*, page 48, and *How To Calculate the GCF for Gas Mixtures*, page 49.

The equations for calculating the GCF assume that the MFC was calibrated at a reference temperature of 0° C (~273° K). If you want the 246 unit to read the mass flow as if the MFC was calibrated at a different reference temperature, adjust the calculated GCF value using the following equation:

$$\text{Temperature Corrected GCF} = \text{GCF} \times \frac{T_x}{T_s}$$

where:

T_X = Reference temperature (° K)

T_S = 273.15° K (~ equal to 0° C)

Note

1. When using the GCF, the accuracy of the flow reading may vary by ±5%, however, the repeatability will remain ±0.2% of FS.
2. All MKS readouts have Gas Correction Adjustment controls to provide direct readout.

How To Calculate the GCF for Pure Gases

To calculate the Gas Correction Factor for *pure* gases, use the following equation:

$$GCF_x = \frac{(0.3106)\ (s)}{(d_x)\ (cp_x)}$$

where:

GCF_X = Gas Correction Factor for gas X

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

s = Molecular Structure correction factor where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_X = Standard Density of gas X, in g/l (at 0° C and 760 mm Hg)

cp_X = Specific Heat of gas X, in cal/g° C

How To Calculate the GCF for Gas Mixtures

For gas mixtures, the calculated Gas Correction Factor is not simply the weighted average of each component's GCF. Instead, the GCF (relative to nitrogen) is calculated by the following equation:

$$GCF_M = \frac{(0.3106)\ (a_1 s_1 + a_2 s_2 + \dots a_n s_n)}{(a_1 d_1 cp_1 + a_2 d_2 cp_2 + \dots a_n d_n cp_n)}$$

where:

GCF_M = Gas Correction Factor for a gas mixture

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

a_1 through a_n = Fractional Flow of gases 1 through n
Note: a_1 through a_n must add up to 1.0

s_1 through s_n = Molecular Structure correction factor for gases 1 through n where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

d_1 through d_n = Standard Densities for gases 1 through n, in g/l (at 0° C and 760 mmHg)

cp_1 through cp_n = Specific Heat of gases 1 through n, cal/g° C

Note

The values for s, d, and cp_x are available for most gases, refer to Table 12, page 77.

The values for a_1 through a_n (which must add up to 1.0) are application dependent.

Example:

Calculate the GCF for a gas mixture of argon (gas 1) flowing at 150 sccm and nitrogen (gas 2) flowing at 50 sccm, where:

Argon (Ar)	Nitrogen (N_2)
$a_1 = \frac{150}{200} = 0.75$	$a_2 = \frac{50}{200} = 0.25$
$s_1 = 1.030$	$s_2 = 1.000$
$d_1 = 1.782$ g/l	$d_2 = 1.250$ g/l
$cp_1 = 0.1244$ cal/g ° C	$cp_2 = 0.2485$ cal/g ° C

then:

$$GCF_M = \frac{(0.3106)\ [(0.75)(1.030) + (0.25)(1.000)]}{(0.75)(1.782)(0.1244) + (0.25)(1.250)(0.2485)}$$

$$= \frac{(0.3106)\ [(0.7725) + (0.25)]}{(0.1663) + (0.0777)}$$

$$= \frac{(0.3106)\ (1.0225)}{0.244}$$

$$= \frac{0.3176}{0.244}$$

$$GCF_M = 1.302$$

Labels

Serial Number Label

The Serial Number Label, located on the side of the instrument, lists the serial number and the product model code, and displays the CE mark signifying compliance with the European CE regulations.

Figure 10: Serial Number Label

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Chapter Four: Operation

How To Setup the System

1. Verify that the LINE VOLTAGE SELECTOR switch on the underside of the 246 unit is set to the proper input voltage, and ensure that the fuse type is appropriate for your voltage setting.

   Refer to Table 6, page 31, and *Line Voltage*, page 32, for more information.

Caution **The Line Voltage Selector Switch must be set to the proper input voltage *before* you connect the AC line cord. Otherwise, the unit will be severely damaged.**

2. ***Before*** connecting any cables or a mass flow controller to the 246 unit, apply power to the unit by connecting the AC LINE CORD and check that the DIGITAL PANEL METER on the 246 unit reads 000, ±1 count.

   For protective earthing, plug the power cord into a properly grounded outlet.

Caution **The 246 unit uses the AC line cord as its power switch, that is, the unit is *ALWAYS ON* when connected to a line source.**

   If the DPM does not read 000, adjust the ZERO CONTROL on the front panel of the 246 unit until it does. Note that the zero control potentiometer is sensitive when no MFC is attached to the unit.

3. Disconnect the AC LINE CORD to turn off power to the unit.

4. Set the front panel controls on the 246 unit as listed in Table 10.

Type 246 Unit Setup - Front Panel Controls	
Control	**Switch Position**
Flow Control Switch	OFF
Set Point Source Switch	FLOW

Table 10: Type 246 Unit Setup - Front Panel Controls

5. Connect the MFCs to connector J8 on the rear panel of the 246 units in use and, if necessary, connect multiple units together using the proper interface cables.

   Refer to *System Configurations*, page 26, for setup information.

Note If you are using a 1259A/2259A MFC, *do not connect* the 2-pin connector to the control valve at this time. If the 1259A/2259A MFC has the control valve connector plugged in, separate the plug to break the connection.

6. Calculate the SCALING CONTROL FACTOR for each MFC in use.

   The Scaling Control Factor specifies how much the +5 VDC output signal from the MFC will be scaled down so that the flow rate can be read directly from the digital panel meter, which reads 1 VDC as 1000 counts full scale.

Note It is ***critical*** for proper system operation that the Scaling Control Factors are calculated properly. Refer to *Gauge Factor Scaling Control*, page 44, for more information.

   a. The *Scaling Control Factor* is the product of the Gauge Factor for the MFC in use and the Gas Correction Factor for the gas in use:

      SCALING CONTROL FACTOR = GAUGE FACTOR x GAS CORRECTION FACTOR

   b. The *Gauge Factor* is a factory set value which scales the 5 VDC signal to the appropriate full scale range for the MFC, so that the digital panel meter reads 1000 counts. The gauge factors for various flow ranges are listed in Table 9, page 45.

   c. The *Gas Correction Factor (GCF)* is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). Refer to Table 12, page 77, for a list of GCFs for commonly used pure gases.

      If the pure gas you are using is not listed in Table 12, page 77, or you are using a gas mixture, you must calculate its GCF. Refer to *Gas Correction Factor*, page 47, for more information.

Example:

To calculate the Scaling Control Factor for a 20 sccm MFC, which is flowing pure argon gas, multiply the Gauge Factor for argon (200), listed in Table 9, page 45, times the Gas Correction Factor for argon (1.39), listed in Table 12, page 77:

SCALING CONTROL FACTOR	=	GAUGE FACTOR x GAS CORRECTION FACTOR
	=	200 x 1.39
	=	278

Since the full scale setting of the Scaling Control Potentiometer is 1000, the Scaling Control Factor of 278 is 27.8% of FS.

7. Adjust the GAUGE FACTOR SCALING CONTROL potentiometer for each MFC in use.

   The Scaling Control potentiometer sets the value of the Scaling Control Factor.

Note It is ***critical*** for proper system operation that the Scaling Control Potentiometer is set correctly. Refer to *Gauge Factor Scaling Control*, page 44, for more information.

The outer control represents factors of 100; indicated by the numbers 0 to 10 which display in the window at the top of the potentiometer. The inner dial represents factors of 10, in divisions of 2; these values are set when the appropriate value is aligned with the vertical line beneath the window. The adjustment knob cannot be turned below 0 or above the full scale setting of 1000.

To adjust the Scaling Control Potentiometer to the setting of "278" calculated in the example in step 6, page 54:

a. Unlock the slide lock on the right side of the control by pushing it up (counterclockwise).
b. Turn the adjustment knob clockwise until the "2" appears in the window.
c. Continue turning the adjustment knob until the line on the dial which represents "78" is aligned with the vertical line beneath the window, as shown in Figure 11.
d. Lock the position of the control by pushing the slide lock on the right side of the control down (clockwise).

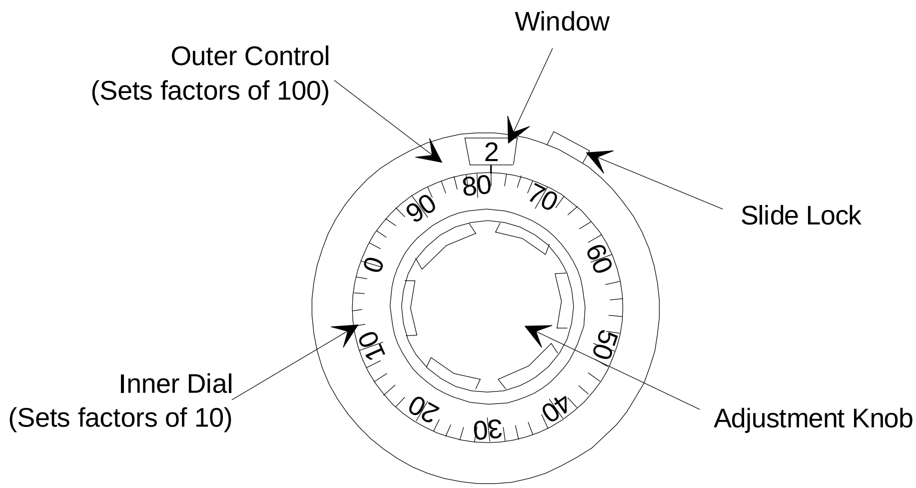

Figure 11: Gauge Factor Scaling Control Potentiometer - Example Setting
(Set to "2/78")

8. Calculate and adjust the SET POINT CONTROL setting for each 246 unit in use.

Note

The Set Point Control is bypassed when using an external set point voltage for individual gas flow control. If you are using this type of operation, this step is not required. Proceed to step 9, page 58.

Refer to *How To Control Individual Gas Flows with an External Set Point*, page 62,for more information.

The Set Point Control allows gross adjustment of the set point voltage. Fine adjustment is done under actual operating conditions by watching the front panel readout and adjusting the Set Point Control for the desired flow reading.

The SET POINT CONTROL setting is calculated as follows, based on the desired set point level as a *percentage of full scale*, and the GCF for the gas in use:

$$\text{Set Point Control Setting} = \frac{\%\text{ of FS } \times 10}{\text{Gas Correction Factor}}$$

Example 1:

Calculate the Set Point Control setting for a 100 sccm MFC which is flowing pure nitrogen (N_2), if the desired set point value is 85 sccm.

a. Calculate the desired set point as a *percentage of full scale*.

$$\%\text{ Full Scale} = \frac{85\text{ sccm}}{100\text{ sccm}}$$

$$= 0.85$$

$$= 85\%$$

b. Calculate the Set Point Control setting.

$$\text{Set Point Control Setting} = \frac{85\% \times 10}{1.0\ (\text{GCF for } N_2)}$$

$$= 850$$

Since N_2 has a correction factor of 1.00 (refer to Table 12, page 77), the rear panel Gauge Factor Scaling Control is set to “1/00”, and the set point is directly applied without needing any gas correction. In this case, the front panel SET POINT CONTROL should be set to “8/50”; that is, an “8” should appear in the window and the dial should be set to “50.”

Example 2:

Calculate the Set Point Control setting for a 500 sccm MFC which is flowing pure argon (Ar), if the flow must be maintained at 375 sccm.

a. Calculate the desired set point as a *percentage of full scale*.

$$\text{\% FULL SCALE} = \frac{375 \text{ sccm}}{500 \text{ sccm}}$$

$$= 0.75$$

$$= 75\%$$

b. Calculate the Set Point Control setting.

$$\text{SET POINT CONTROL SETTING} = \frac{75\% \times 10}{1.39 \text{ (GCF for argon)}}$$

$$= 540$$

The GCF for argon is 1.39 (refer to Table 12, page 77). In this case, the SET POINT CONTROL should be set to "5/40"; that is, an "5" should appear in the window and the dial should be set to "40."

9. Reconnect the AC LINE CORD to power the 246 unit; allow it to warm up and stabilize for at least 15 minutes.

Caution

The 246 unit uses the AC line cord as its power switch, that is, the unit is *ALWAYS ON* when connected to a line source.

Note

Allow a minimum of 1½ hours for the MFC to reach control temperature and stabilize. Refer to the appropriate MFC Instruction Manual for information concerning turn-on drift characteristics.

10. Set the DECIMAL POINT for the digital panel meter to the appropriate location for the MFC being used by adjusting the dipswitches on the side of the 246 unit.

    The position of the decimal point is determined by the full scale range of the MFC in use. For example, a 100 sccm mass flow controller requires the decimal point to be positioned as "100.0" (display at full rated flow).

    The correct display at full scale for various flow ranges are listed in Table 9, page 45. Refer to *Decimal Point Selector Dipswitches*, page 43, for more information.

11. Recheck the DIGITAL PANEL METER on the 246 unit to ensure that it reads 000, ±1 count, as described in step 2, page 53.

    If you are using a 1259A/2259A MFC:

    Adjust out any zero offset by the ZERO CONTROL *on the MFC*. This ensures that the flow will match the set point.

    For all other MFCs:

    Adjust out any zero offset using the ZERO CONTROL *on the 246 unit*. If you are unable to adjust the zero, use the Zero Control pot on the MFC.

12. Ensure that the unit's front panel FLOW CONTROL SWITCH is in the OFF position, and then (if applicable) re-connect the 2-pin control valve connector at the MFC which was disconnected in step 5, page 54.

Note

In general, the control valve of the MFC should be set to the OFF position, whenever a no gas flow condition exists. This can be done either manually with the FLOW CONTROL SWITCH on the 246 unit, or by an incoming digital signal.

Manual Flow Control

Manual (internal) set point control of the flow rate through MFCs is accomplished using either individual 246 units or multiple units connected for ratio operation. In either case, the gas flow is based on the unit's internal +5 V reference and the unit's front panel Set Point Control. Refer to *System Configurations*, page 26, for installation information.

Note Ensure that the MFC(s) and the 246 unit(s) are properly configured as described in *How To Setup the System*, page 53.

How To Manually Control Individual Gas Flows

This type of operation enables you to manually control individual gas flows based on the unit's internal +5 V set point signal.

1. Set the SET POINT SOURCE SWITCH to the FLOW position.

   This connects an internal +5 V reference to the top of the SET POINT CONTROL. Since the +5 V corresponds to full rated flow, the Set Point Control can be adjusted up to a maximum of 100% for the attached MFC's rated flow.

2. Ensure that the SET POINT CONTROL is properly calculated and adjusted for the MFC in use.

   Refer to step 8, page 57, for an example calculation. The 246 unit is now set to control the flow of the MFC.

3. Turn the flow ON by placing the FLOW CONTROL SWITCH to the ON position.

   The set point signal is applied to the MFC and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

4. Turn the flow OFF by placing the FLOW CONTROL SWITCH to the OFF position.

How To Manually Control Ratioed Gas Flows

This type of operation enables you to control the flow rates of multiple 246 units as a fraction (ratio) of the flow a master 246 unit, using an internal set point signal (refer to Figure 4, page 27). The master unit uses the internal +5V set point signal; the set point signals for the slave units are controlled by the output of the master unit.

Note The MFC that is set to control at the highest percentage of its rated flow should be connected to the master 246 unit.

In the following example, we will assume a system with four 246 units, each with a 100 sccm MFC flowing nitrogen (N_2) gas. Units (Channels) 2 to 4 will be set to a ratio of 75, 50, and 25% of the flow in unit (Channel) 1.

1. Set the SET POINT SOURCE SWITCHES for Channels 1 to 4 to the FLOW position.

   This connects an internal +5 V reference to the top of the SET POINT CONTROL. Since the +5 V corresponds to full rated flow, each Set Point Control can be adjusted up to a maximum of 100% for the attached MFCs rated flow.

2. Ensure that the SET POINT CONTROL is properly calculated and adjusted for each MFC in use.

   Refer to step 8, page 57, for an example calculation. In this example, the SET POINT CONTROLS for Channels 1 to 4 should be set to 100, 75, 50, and 25 respectively.

3. Leave the SET POINT SOURCE SWITCH for the master 246 unit (Channel 1) in the FLOW position and move the switches for Channels 2 to 4 to the RATIO position.

   The 246 unit is now adjusted to control the MFCs connected to Channels 2 through 4 to 75, 50, and 25% of the flow rate through Channel 1.

4. Turn the flow ON by placing the FLOW CONTROL SWITCH for all channels to the ON position.

   The set point signal is applied to the MFC, and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

5. Turn the flow OFF by placing the FLOW CONTROL SWITCH for all channels to the OFF position.

External Set Point Control

External set point control of the flow rate through MFCs is accomplished using either individual 246 units with an external pressure controller, or multiple units connected for ratio operation with an external pressure controller and a pressure transducer. Refer to *System Configurations*, page 26, for installation information.

Note Ensure that the MFCs and the 246 unit are properly configured as described in *How To Setup the System*, page 53.

How To Control Individual Gas Flows with an External Set Point

This type of operation enables you to control individual gas flows using a set point (voltage) signal from an external controller. The 0 to 5 VDC full scale set point signal is received at the SET POINT IN microjack connector, *bypasses* the unit's SET POINT CONTROL, and is routed by the SET POINT SOURCE SWITCH to the MFC.

1. Calculate and apply the external set point voltage for the MFC in use.

   The external set point voltage is calculated as follows, based on the desired set point level as a *percentage of full scale*, and the GCF for the gas in use:

   $$\text{External Set Point Voltage} = \frac{\text{\% of FS x 5 V (set point FS voltage)}}{\text{Gas Correction Factor}}$$

   For example, to calculate the external set point voltage for a 100 sccm MFC which is flowing pure nitrogen (N_2), if the desired set point value is 85 sccm:

   a. Calculate the desired set point as a *percentage of full scale*.

   $$\text{\% Full Scale} = \frac{\text{85 sccm}}{\text{100 sccm}}$$

   $$= 0.85 = 85\%$$

   b. Calculate the external set point voltage.

   $$\text{External Set Point Voltage} = \frac{85\% \text{ x } 5 \text{ V}}{1.0 \text{ (GCF for } N_2)}$$

   $$= 4.25 \text{ V}$$

2. Turn the flow ON by placing the FLOW CONTROL SWITCH to the ON position.

   The set point signal is applied to the MFC and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

3. Turn the flow OFF by placing the FLOW CONTROL SWITCH to the OFF position.

How To Control Ratioed Gas Flows with an External Set Point

This type of operation enables you to control the flow rates of multiple 246 units based on a set point (voltage) signal from an external controller and measurements from a pressure transducer. The set point signal for the first slave 246 unit is controlled by the output of the controller; the set point signals for all other slave 246 units are controlled by the output of the first slave unit.

Note The MFC that is set to control at the highest percentage of its rated flow should be connected to the master 246 unit.

In the following example, we will assume a system with four 246 units, each with a 100 sccm MFC flowing nitrogen (N_2) gas. Units (channels) 2 to 4 will be set to a ratio of 75, 50, and 25% of the flow in unit (channel) 1.

1. Verify that the LINE VOLTAGE SELECTOR SWITCH on the 250 controller is set to the proper voltage.

Note The 246 unit can operate with any controller or pressure transducer provided the signal that enters the 246 unit goes *positive* with increasing flow (correct polarity). Throughout this manual, the MKS Type 250 Pressure/Flow Controller is used for example only.

2. Set the FRONT PANEL CONTROLS on the 250 controller as listed in Table 11.

External Controller - Front Panel Controls			
Control	**Position**	**Control**	**Position**
Power Switch	OFF	Bias	Fully CCW
INT/EXT	INT	CMAE	Manual
10V/1V/.1V	10V	Manual Control	500 out of 1000
Phase Lead	1.5 SEC	Set Point Level	Required pressure level
Gain	20%		

Table 11: External Controller - Front Panel Controls

The settings in Table 11 configure the controller to deliver a constant Pressure Control Signal (PCS) of approximately +5 V to the 246 unit. This manually produced signal is used to determine if the required pressure and flow rates can be achieved using a PCS with a nominal value of +5 V. *Best control performance is achieved when the PCS is kept high for a good signal to noise ratio*.

3. Plug the controller's AC LINE CORD into the power line and turn on the power switch.

Note Allow the controller to warmup for at least 1½ hours before adjusting the zero.

4. Pump the chamber down below the resolution of the transducer and adjust the zero for a reading of ±0000 on the controller's digital panel meter (DPM).

   On controllers without a DPM, adjust the Set Point Control to zero and adjust for a zero reading on the Error Meter.

5. Place the SET POINT SOURCE SWITCH on each 246 unit to the RATIO position.

6. Ensure that the SET POINT CONTROL is properly calculated and adjusted for each MFC in use.

   Refer to step 8, page 57, for an example calculation. Adjust the flow rate with the 246 unit's SET POINT CONTROL to achieve the desired flow rate and ratio between the units and the desired pressure (within a factor of 2) in the chamber.

7. Turn the flow ON by placing the FLOW CONTROL SWITCH on each 246 unit to the ON position.

   The set point signal is applied to the MFC and flow begins after a slight delay. The correct flow is realized within approximately 1.5 seconds, depending on the type of MFC being used.

8. Read the chamber pressure on the controller's digital panel meter.

   To read pressure on a controller without a meter, adjust the controller's set point until the error meter reads zero, then multiply the Set Point reading times the Full Scale of the transducer (1000 counts = full scale). When the pressure is within the desired 2 to 1 range, the system is ready for automatic control.

   If the pressure cannot be adjusted to within the factor of 2, then modification of the system may be necessary.

   - Too high of a pressure requires increased pumping capacity or smaller MFCs for less total flow
   - Too low of a pressure requires reduced pumping capacity or larger MFCs for greater total flow

9. Move the CMAE switch on the controller to the AUTO position.

Note The controller will vary the pressure control signal to adjust the total flow to achieve the control pressure. Although the total flow rate will change, the *ratio* between the gases will remain constant.

10. Adjust the controller's GAIN and PHASE LEAD settings as needed.

    The controller settings listed in Table 11, page 63, are used as a starting point for control. These settings should be properly tuned to provide accurate control, free from oscillations. Refer to the appropriate controller instruction manual for complete tuning information.

Remote Flow Control

Remote control of the flow through MFCs is accomplished using TTL logic control. Interface connector J9 provides the means to remotely turn the flow on and off, and to adjust and monitor the flow rate in any channel using a set point signal from a voltage applied to J9. Refer to Table 7, page 33, for the Interface connector J9 pinout.

If an external voltage source is to be used for Ratio or External set point control, it can be applied via either the "SP IN" microjack connector, or through pins 7 (+) and 3 (-) on Interface connector J9.

How To Control Gas Flow with TTL Logic

TTL logic control provides a way to use only a simple voltage level to control the flow rate. You can create a custom interface by wiring the required control signals to the appropriate pins on connector J9. Refer to Table 7, page 33, for the Interface connector J9 pinout.

When the FLOW CONTROL SWITCH (refer to Figure 7, page 39) is placed in the REMOTE position, a logic signal coming in through the Interface connector J9 may be used to gate the set point signal to the MFC. A logic low turns the flow ON; a logic high turns the flow OFF.

To use TTL logic control:

1. Follow the instructions in *How To Setup the System,* page 53, to prepare the 246 unit and the MFCs for flow control.

2. Place the SET POINT SOURCE SWITCH on all 246 units in use to the EXT position.

3. Place the FLOW CONTROL SWITCH on all 246 units in use to the REMOTE position.

4. Apply the control signals through Interface connector J9.

   For example:

   a. To produce a flow of 50 sccm through a 100 sccm MFC, apply a +2.5 V signal to pin 7 on connector J9.

      Reference this voltage to pin 8 (digital ground) on connector J9.

   b. Attach a TTL signal to pin 4 on connector J9.

      Reference this signal to pin 8 (digital ground) on connector P6.

   c. Turn the flow ON by applying a TTL low (0.4 to 0.8 V) to pin 4 on connector J9.

   d. Turn the flow OFF by applying a TTL high (2.4 to 5 V) to pin 4 on connector J9 or an open circuit.

Chapter Five: Maintenance and Troubleshooting

General Information

If the 246 controller fails to operate properly upon receipt, check for shipping damage, and check the cables for proper continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If it is necessary to return the unit to MKS, obtain an ERA number (Equipment Return Authorization Number) from a MKS Service Center before shipping. Please refer to the inside back cover of this manual for a list of MKS Calibration and Service Centers.

Maintenance

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage.

How To Clean the Unit

Periodically wipe down the unit with a damp cloth.

How To Replace the Fuses

The line fuses protect the internal circuitry; both sides of the line are fused.

Caution **Disconnect the power cord from the 246 unit *before* you replace the fuses, to avoid any damage.**

1. Select the proper fuses.

   The fuse values are listed in Table 6, page 31.

2. Disconnect the power cord from the 246 instrument.

Warning **To avoid an electrical shock, be sure to disconnect the power cord *before* proceeding.**

3. Disconnect all cables from the connectors located on the rear panel of the unit.

4. Insert a small device, such as a flat head screwdriver in the fuse holder clip on the right side of the fuse holder.

   Refer to Figure 12 for the location of the fuse holder clip.

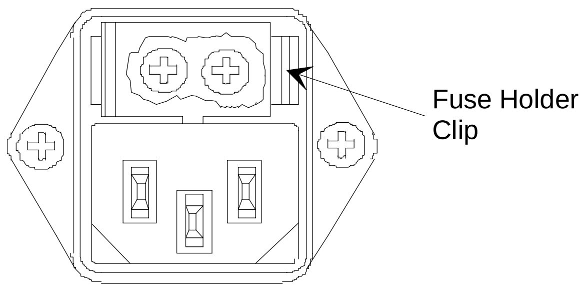

Figure 12: Fuse Holder Clip

5. Gerntly press against the clip and push up with the screwdriver until the plastic fuse holder pops out.

   It may be necessary to repeat steps 4 and 5 on the left side in order to get the fuse holder to release.

6. Remove the existing fuses.

7. Place the new fuses into the unit.

8. Gently snap the fuse holder back into place.

9. Connect any cables removed from the back of the 246 instrument in step 3.

10. Connect the power cord.

Troubleshooting

The first approach when dealing with a problem with the 246 unit is to isolate the section of the instrument where the fault lies. The 246 readout can be separated into the following sections:

- Power Supply
- Flow Amplifier String
- Internal +5 V Voltage Reference
- Digital Panel Meter
- Set Point Buffer and Flow Switching Circuit

When troubleshooting, it is always best to measure the power supply voltages first, since a problem in the Power Supply will effect the performance of all sections. Therefore, it is important to begin troubleshooting at this location. Jumpers are available on the Main PC board to easily disconnect the supplies from other circuitry, if a faulty supply is discovered.

Power Supply

1. Measure the ±15 V supplies at the power supply jumpers on the PC board, or across diodes CR2 and CR3.

   The voltages should be within the range of 14.8 and 15.2 Volts and the AC ripple should be < 10 mV P-P. If the voltages are within range, proceed to step 4. If the voltages are not within the acceptable range, proceed to step 2.

2. Disconnect the MFC from the 246 unit.

   Should the supplies recover when an MFC is removed, then either the cable or the MFC is defective. If the supply still fails, proceed to step 3.

3. Isolate the power supply jumpers from the circuits in the 246 unit by disconnecting the ±15 V power supply jumpers E3-E4 and E5-E6 and the 5 V jumper E1-E2, and measure the supplies on the supply side.

Caution ***Disconnect BOTH SUPPLIES*** **to perform this test. Do not run the circuits with only one supply operative.**

   If the supplies output the proper voltages, the problem lies with the 246 unit electronics. If not, the supply itself is faulty. Contact MKS for assistance.

4. Test the 5 V supply at the jumper, or across diode CR1.

   The voltage should be between the range of 4.9 and 5.1 Volts.

   If the power supply is operating normally, proceed to *Flow Amplifiers,* page 70, to examine the signal path through the channel amplifiers.

Flow Amplifiers

Failure of the 246 unit to work properly with an external voltage being used as a ratio signal may be caused by a defective amplifier.

To check the output of the SET POINT CONTROL:

1. Prepare a 15 pin "D" connector (which will mate with J8) by placing a jumper from pin 2 to pin 8.

   This allows the 5 V set point voltage to be used to simulate an input. Refer to Table 8, page 34, for the pinout for connector J8.

2. Connect a digital voltmeter (DVM) to this jumper and analog ground and adjust the front panel SET POINT CONTROL until the DVM reads 5.000 Volts.

3. Set the SET POINT SOURCE SWITCH to FLOW and the FLOW CONTROL SWITCH to ON.

   The DVM should read approximately 5 Volts on pin 10 in connector J8, and on pin 6 in connector J9.

To check the output of the ZERO CONTROL:

1. Verify that the ZERO CONTROL works by using it to set the voltage on pin 10 in connector J8 to 5.000 Volts.

   If you cannot achieve the voltage, the problem most likely is with the first stage amplifier (U4A). Contact MKS Instruments for assistance.

2. Check the output of the second amplifier stage (U5).

   The output should be twice the output voltage measured at pin 10 in connector J8, and at pin 6 in connector J9. This can be found easily on the input pin of the gas correction pot R11 (J7-3).

3. Turn pot R11 to "1" and verify that approximately 1 Volt appears at pin 2 in connector J9 and in the microjack connector J10 (Flow Output).

   If you cannot achieve the correct voltage, check R11 and U6 for problems.

Internal +5 V Voltage Reference

In the event that the voltage output from the internal +5 V source is not correct, measure the input to the source.

1. Connect a digital voltmeter between TP4 and TP5 on the Main PC board.

   The voltage should read between 4.999 and 5.001 Volts. If the voltage is out of the acceptable range but is close and stable, proceed to step 2. If a gross error exists, proceed to step 3.

2. Adjust R26 (REF ADJ pot) on the Main PC board.

   Repeat step 1.

3. Check across on the Main PC board.

   The voltage should read between 1.23 and 1.25 Volts. An incorrect input voltage may be caused by a defective reference VR1. An incorrect output may be caused by a defective amplifier U7, also located on the rear of the Main PC board. Contact MKS Instruments for assistance.

Digital Panel Meter

The digital panel meter (DPM) is a 3½ digit, 2 V full scale device. The meter is powered by a +5 V supply located on the Main PC board.

To measure the supply voltage to the meter:

1. Measure the output of pin 2 in Interface connector J9.

   The voltage on the DPM should match the voltmeter reading from pin 2 of Interface connector J9, ±1 count. If it does not, you must adjust the span pot on the right rear of the DPM until the readings agree. To access the span pot you must remove the top cover of the 246 unit; proceed to step 2.

2. Remove the four (4) Phillips head screws from the top of the unit’s right side panel (refer to Figure 3, page 24).

3. Loosen the four (4) Phillips head screws on the bottom of the unit’s left side panel, and lift the cover off.

4. Adjust the span pot on the rear of the digital panel meter box (located directly behind the DPM) with a small flathead screwdriver until the meter reading agrees with the voltmeter reading from pin 2 of Interface connector J9, ±1 count.

   If the range of this adjustment is insufficient to bring the two meter readings into agreement, the DPM must be replaced.

5. Place the top cover back into position and replace or tighten the four screws on each side panel to secure it in place.

Set Point Buffer and Flow Switching Circuit

If, with switches set for FLOW and ON, the maximum set point voltages is different from the 5 V reference TP4 and TP5, it may be possible to adjust the offset of U7A by using R25 (OFFSET ADJ) for 5.000 Volts out exactly. If not, suspect either U7 or possibly Q2.

With no REMOTE ON/OFF signal and either OFF or REMOTE selected on switch S2, the voltage on the gate of Q2 should be approximately +15 V, and the drain voltage should equal the source voltage at around -0.08 ±.02 Volts. If not, determine which voltage is in error and then why. With S2 in the ON state, Q2's gate should be at -15 Volts and drain should be at the set point voltage (measure with high impedance probes). If not, Q2 may be the problem. Contact MKS Instruments for assistance.

Appendix A: Product Specifications

CE Compliance
Electromagnetic Compatibility[1]
Low-Voltage Requirements
  Installation Category
  Pollution Degree
Product Safety and Liability
	
	EMC Directive 89/336/EEC
	Low-Voltage Directive 73/23/EEC
	II, according to EN 61010-1
	2, according to IEC 664
	Product Safety Directive 92/59/EEC

Display Accuracy	±0.1% ±1 digit
Flow Display	3½ Digit Display (+1.999 maximum) 0.56” Red LED display

Fuse Ratings
  115 VAC
  230 VAC
	
	630 mA (T) / 250 V
	315 mA (T) / 250 V

Operating Temperature	15° to 40° C (59° to 104° F)
Power Consumption	70 VA (maximum)

Power Requirement
  115 VAC Setting
  230 VAC Setting
	
	100 to 120 VAC nominal, 50/60 Hz
	200 to 240 VAC nominal, 50/60 Hz

Power Supply Output Capacity	±15 VDC @ 500 milliamps Maximum ripple < 10 mV P-P

Set Point Adjust
  Flow Control
  Ratio Control
	
	0.1 to 100% of Full Scale
	0.1 to 100% of Input Level

[1]An overall metal braided shielded cable, properly grounded at both ends, is required during use.

Signal Inputs	
MFC	0 to +5 VDC (5.5 V maximum)
Scaling (GCF) Control	0.1 to 4.0; allows display in actual engineering units for a specific gas
External Set Point (bypasses on-board set point controls)	0 to 5 VDC
External ON/OFF	TTL Compatible
Signal Outputs	
MFC Output(s)	Minimum load impedance; 10K ohm/channel
Unscaled (Uncorrected) Transducer (MFC) Output	0 to +5 VDC
Scaled (Corrected) Transducer (MFC) Output	0 to +1 VDC Nominal (scaled with a rear panel scaling control); ±1 VDC corresponds to a 1000 count reading on the DPM; 0 to 2 VDC maximum
Weight	4 lbs. 2 oz (2.1 kg)
Zero Correction	± 3% of Full Scale

Due to continuing research and development activities, these product specifications are subject to change without notice.

Appendix B: Model Code Explanation

Model Code

The model code for the 246 single channel power supply/readout is identified as follows:

246C

Type Number (246C)

The type number 246C designates the model number of the instrument.

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Appendix C: Gas Correction Factors for Commonly Used Pure Gases

Table 12 lists the gas correction factors for some commonly used pure gases. If the GCF for your gas is not listed, or you are using a gas mixture, you must calculate the GCF. Refer to *Gas Correction Factor*, page 47, for more information.

Gas Correction Factors for Pure Gases

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Air	- - -	0.240	1.293	1.00
Ammonia	NH_3	0.492	0.760	0.73
Argon	Ar	0.1244	1.782	1.39[1]
Arsine	AsH_3	0.1167	3.478	0.67
Boron Trichloride	BCl_3	0.1279	5.227	0.41
Bromine	Br_2	0.0539	7.130	0.81
Carbon Dioxide	CO_2	0.2016	1.964	0.70[1]
Carbon Monoxide	CO	0.2488	1.250	1.00
Carbon Tetrachloride	CCl_4	0.1655	6.86	0.31
Carbon Tetraflouride (Freon - 14)	CF_4	0.1654	3.926	0.42
Chlorine	Cl_2	0.1144	3.163	0.86
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	0.1544	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	0.153	4.660	0.38
Cyanogen	C_2N_2	0.2613	2.322	0.61
Deuterium	D_2	1.722	0.1799	1.00
Diborane	B_2H_6	0.508	1.235	0.44
Dibromodifluoromethane	CBr_2F_2	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	0.1432	5.395	0.35

Table 12: Gas Correction Factors for Pure Gases
(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g^{o}C**	**DENSITY g/l @ 0^{o}C**	**CONVERSION FACTOR**
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	0.140	4.592	0.42
Dichloromethysilane	$(CH_3)_2SiCl_2$	0.1882	5.758	0.25
Dichlorosilane	SiH_2Cl_2	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	0.224	2.857	0.43
2,2-Dimethylpropane	C_5H_{12}	0.3914	3.219	0.22
Ethane	C_2H_6	0.4097	1.342	0.50
Fluorine	F_2	0.1873	1.695	0.98
Fluoroform (Freon - 23)	CHF_3	0.176	3.127	0.50
Freon - 11	CCl_3F	0.1357	6.129	0.33
Freon - 12	CCl_2F_2	0.1432	5.395	0.35
Freon - 13	$CClF_3$	0.153	4.660	0.38
Freon - 13 B1	$CBrF_3$	0.1113	6.644	0.37
Freon - 14	CF_4	0.1654	3.926	0.42
Freon - 21	$CHCl_2F$	0.140	4.592	0.42
Freon - 22	$CHClF_2$	0.1544	3.858	0.46
Freon - 23	CHF_3	0.176	3.127	0.50
Freon - 113	$C_2Cl_3F_3$	0.161	8.360	0.20
Freon - 114	$C_2Cl_2F_4$	0.160	7.626	0.22
Freon - 115	C_2ClF_5	0.164	6.892	0.24
Freon - 116	C_2F_6	0.1843	6.157	0.24
Freon - C318	C_4F_8	0.185	8.397	0.17
Freon - 1132A	$C_2H_2F_2$	0.224	2.857	0.43
Helium	He	1.241	0.1786	.- - -2
Hexafluoroethane (Freon - 116)	C_2F_6	0.1843	6.157	0.24

Table 12: Gas Correction Factors for Pure Gases
(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g^{o}C**	**DENSITY g/l @ 0^{o}C**	**CONVERSION FACTOR**
Hydrogen	H_2	3.419	0.0899	.- - -2
Hydrogen Bromide	HBr	0.0861	3.610	1.00
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C_4H_8	0.3701	2.503	0.29
Krypton	Kr	0.0593	3.739	1.543
Methane	CH_4	0.5328	0.715	0.72
Methyl Fluoride	CH_3F	0.3221	1.518	0.56
Molybdenum Hexafluoride	MoF_6	0.1373	9.366	0.21
Neon	Ne	0.246	0.900	1.46
Nitric Oxide	NO	0.2328	1.339	0.99
Nitrogen	N_2	0.2485	1.250	1.00
Nitrogen Dioxide	NO_2	0.1933	2.052	- -[2]
Nitrogen Trifluoride	NF_3	0.1797	3.168	0.48
Nitrous Oxide	N_2O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C_4F_8	0.185	8.937	0.17
Oxygen	O_2	0.2193	1.427	1.00[3]
Pentane	C_5H_{12}	0.398	3.219	0.21
Perfluoropropane	C_3F_8	0.194	8.388	0.17
Phosgene	$COCl_2$	0.1394	4.418	0.44
Phosphine	PH_3	0.2374	1.517	0.76
Propane	C_3H_8	0.3885	1.967	0.36
Propylene	C_3H_6	0.3541	1.877	0.41
Silane	SiH_4	0.3189	1.433	0.60
Silicon Tetrachloride	$SiCl_4$	0.1270	7.580	0.28
Silicon Tetrafluoride	SiF_4	0.1691	4.643	0.35
Sulfur Dioxide	SO_2	0.1488	2.858	0.69

Table 12: Gas Correction Factors for Pure Gases
(Continued on next page)

Gas Correction Factors for Pure Gases *(Continued)*				
GAS	**SYMBOL**	**SPECIFIC HEAT, Cp cal/g°C**	**DENSITY g/l @ 0°C**	**CONVERSION FACTOR**
Sulfur Hexafluoride	SF_6	0.1592	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl_3F	0.1357	6.129	0.33
Trichlorosilane	$SiHCl_3$	0.1380	6.043	0.33
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl_2FCClF_2 or ($C_2Cl_3F_3$)	0.161	8.360	0.20
Tungsten Hexafluoride	WF_6	0.0810	13.28	0.25
Xenon	Xe	0.0378	5.858	1.32

[1]Empirically defined.

[2]Consult MKS Instruments, Inc. for special applications.

[3]The GCF for Oxygen is 0.993 when using *thermal* MFCs such as the Type 1179, 1479, 1679, 1159, and 1259 units, and related products. The GCF for Oxygen is 1.000, as listed in the table, for pressure based MFCs such as the Type 1640, 1150, 1151, 1152, and 1153 units.

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia).
Standard Temperature is defined as 0°C

Table 12: Gas Correction Factors for Pure Gases

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