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Instruction Manual

MKS Type GBR3A
GBROR® In Situ
Flow Verifier

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WARRANTY

Type GBR3A Equipment

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

For the period commencing with the date of shipment of this equipment and ending two years later, **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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Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning 

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

Caution 

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

Note 

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

Symbols Found on the Unit

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

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

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

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

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

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

SERVICE BY QUALIFIED PERSONNEL ONLY

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

GROUNDING THE PRODUCT

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

DANGER ARISING FROM LOSS OF GROUND

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

GROUND AND USE PROPER ELECTRICAL FITTINGS

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

USE THE PROPER POWER CORD

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

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

USE THE PROPER POWER SOURCE

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

USE THE PROPER FUSE

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

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

HIGH VOLTAGE DANGER

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

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

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

Warnung!

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

Vorsicht!

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

Hinweis

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

Am Gerät angebrachte Symbole

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

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

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

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

Keine Teile austauschen und keine Veränderungen vornehmen!

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

Wartung nur durch qualifizierte Fachleute!

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

Produkt erden!

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

Gefährdung durch Verlust der Schutzerdung!

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

Erdung und Verwendung geeigneter elektrischer Armaturen!

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

Richtiges Netzkabel verwenden!

Das verwendete Netzkabel muß sich in einwandfreiem Zustand befinden und den in der Betriebsanleitung enthaltenen Anschlußwerten entsprechen.
Das Netzkabel muß abnehmbar sein. Der Querschnitt der einzelnen Leiter darf nicht weniger als 0,75 mm^2 betragen. Das Netzkabel sollte einen Prüfvermerk einer zuständigen Prüfstelle tragen, z.B. VDE, Semko oder SEV.

Richtige Stromquelle verwenden!

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

Richtige Sicherung benutzen!

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

Gerät nicht in explosiver Atmosphäre benutzen!

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

Hochspannungsgefahr!

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

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

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

Avertissement 

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

Attention 

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

Remarque 

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

Symboles apparaissant sur l'appareil

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

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

Tableau 3 : Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

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

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

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

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

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

MISE À LA TERRE DE L'APPAREIL

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

DANGER LIÉ À UN DÉFAUT DE TERRE

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

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

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

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

Utiliser uniquement un cordon d'alimentation en bon état et conforme aux exigences de puissance d'entrée spécifiées dans le manuel.
Utiliser uniquement un cordon d'alimentation amovible avec des conducteurs dont la section est égale ou supérieure à 0,75 mm^2. Le cordon d'alimentation doit être approuvé par un organisme compétent tel que VDE, Semko ou SEV.

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

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

UTILISATION D'UN FUSIBLE APPROPRIÉ

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

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

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

DANGER DE HAUTE TENSION

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

Información sobre seguridad

Símbolos usados en el manual de instrucciones

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

Advertencia 

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

Precaución 

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

Observación 

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

Símbolos que aparecen en la unidad

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

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

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

Procedimientos y precauciones de seguridad

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

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

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

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

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

PUESTA A TIERRA DEL INSTRUMENTO

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

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

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

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

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

USAR EL CABLE ELÉCTRICO ADECUADO

Usar únicamente un cable eléctrico que se encuentre en buenas condiciones y que cumpla los requisitos de alimentación de entrada indicados en el manual.
Usar únicamente un cable desmontable instalado con conductores que tengan un área de sección transversal equivalente o superior a 0,75mm². El cable eléctrico debe estar aprobado por una entidad autorizada como, por ejemplo, VDE, Semko o SEV.

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

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

USAR EL FUSIBLE ADECUADO

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

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

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

PELIGRO POR ALTO VOLTAJE

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

Chapter One: General Information

Introduction

The MKS Type GBR3A Series In Situ Flow Verifiers measure and verify gas flow rates in gas lines using a pressure rate-of-rise method. They are tightly packaged, integrated systems which consist of both mechanical and electrical elements and appear similar to a large mass flow controller. All GBR3A units meet European CE directives that cover electromagnetic compatibility and product safety issues.

The mechanical plumbing of the GBR3A includes a volume, a pressure transducer (a modified MKS Type 800 Series Baratron), two pneumatically actuated isolation valves, and solenoid air pilot valves which are controlled by the electronics. The volume size and pressure transducer range vary with configuration, allowing optimized performance over various flow ranges. Wetted materials in the plumbing include Inconel, Elgiloy, Kel-F, and electropolished 316L stainless steel.

The best location for the GBR3A is in a process by-pass line between the gas manifold and the vacuum pump. Although your system may include mass flow controllers and vacuum pumps, the GBR3A does not control these devices.

GBR3A flow verifiers are remotely controlled with RS-232 communications through a 9-pin D connector on the unit. A visual interface program is available for operation from a personal computer using the Windows 95/98 operating system.

The Gas Box Rate-of-Rise (GBROR®) flow verification technique used by the GBR3A is largely independent of gas type, eliminating the need for gas correction factors common to other flow measurement techniques. It can handle gas mixtures as well as pure gases. The GBROR measurement technique is also tolerant of corrosive gases, contamination, and coating films. Unwanted deposits are not introduced into the process chamber since the verification is performed in the gas line, not the process chamber.

The isolation valves in the GBR3A are closed during idle, preventing the flow of gas between flow verification runs. When a run is initiated, the valves open, allowing flow through the unit, via the MFC under investigation. Once flow has stabilized, the downstream valve is closed and the pressure begins to rise in the volume. The Baratron measures the pressure rise, and the electronics monitor the rate of rise over the length of the run and use it to calculate the flow rate.

How This Manual is Organized

This manual provides instructions on how to set up, install, and operate a Type GBR3A verifier unit.

Before installing your GBR3A verifier unit in a system or operating it, familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. Obey all WARNING and CAUTION notes provided in 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, *Visual Interface Operation*, describes how to operate the unit through the GBR3A visual interface controls. It also explains all the functions and features.

Chapter Five, *Remote Communication*, describes how to operate the unit remotely using RS-232 commands to communicate with the GBR3A.

Chapter Six, *Maintenance and Troubleshooting*, lists any maintenance 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 model code used to order the instrument.

Appendix C, *Calibration Data Sheet*, includes an example calibration data sheet, shipped with every unit.

Appendix D, *Error Messages*, provides a list of errors reported through RS-232 communication.

Appendix E, *Gas Condensation Reference*, lists condensation data for various common substances.

Customer Support

Standard maintenance and repair services are available at all regional MKS Calibration and Service Centers, listed on the inside back cover of this manual. MKS also accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. If any difficulties arise in the use of your GBR3A 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 Equipment Return Authorization (ERA) 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 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, and toxic materials.**

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Chapter Two: Installation

How To Unpack the Type GBR3A Unit

MKS has carefully packed the Type GBR3A unit to reach you in perfect operating order. On receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to make sure that the unit was not damaged in 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 Equipment Return Authorization (ERA) Number from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution 

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

Unpacking Checklist

Below is the unpacking checklist.

Standard Equipment:

- In Situ GBR3A Flow Verifier
- In Situ GBR3A Flow Verifier Instruction Manual (this book)
- Visual interface software for use with Windows 95/98 PC
- One two foot length of polyurethane tubing
- One adapter tee

Optional Equipment:

- RS-232 communications cable CBROR-5-Mx

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.

The GBR3A system requires an RS-232 cable to connect a PC to the GBR3A.

Note

1. An overall metal braided, shielded cable, properly grounded at both ends, is required during use to meet CE specifications.
2. The “S” after the cable type designation indicates an overall metal braided shielded cable.

Generic Shielded Cable Guidelines

If you choose to manufacture your own cables, follow these guidelines:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding is 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 (6.35 mm) 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 is 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).
   E. Some cables may need internal shielding between specific wires; please see the instruction manual for details regarding this matter.

Product Location and Requirements

GBR3A Electrical Requirements

The GBR3A flow verifier meets the following criteria:

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

Environmental Requirements

- Ambient operating temperature must be between 15° and 40° C (59° to 104° F)
- Storage humidity range: 0 to 95% relative humidity, non-condensing
- Position the controller with proper clearance to allow air cooling
- Ventilation requirements include sufficient air circulation
- Main supply voltage fluctuations must not exceed ±10% of the nominal voltage

Electrical Requirements

- Power requirements: 24 to 30 VDC, nominal
- Maintain a solid system ground for proper and safe operation

Safety Conditions

The GBR3A 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

GBR3A Mechanical Requirements

The mechanical requirements are the following:

- Ambient operating temperature must be in the range of 0° to 50° C (32° to 122° F)
- Clean instrument air supply, regulated at 70 to 100 psig for 23° C/53° C
- A vacuum pump capable of maintaining a pressure of less than 50 Torr at the maximum measurement flow rate of the GBR3A

Dimensions

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

GBR3A Dimensions

The following three figures show the dimensions of the unit.

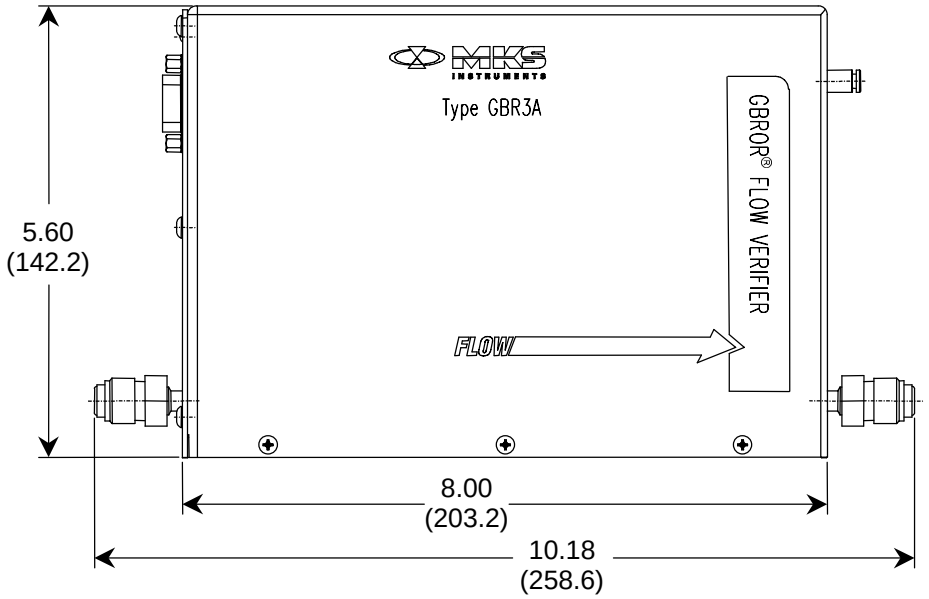

Figure 1: GBR3A Side View Dimensions

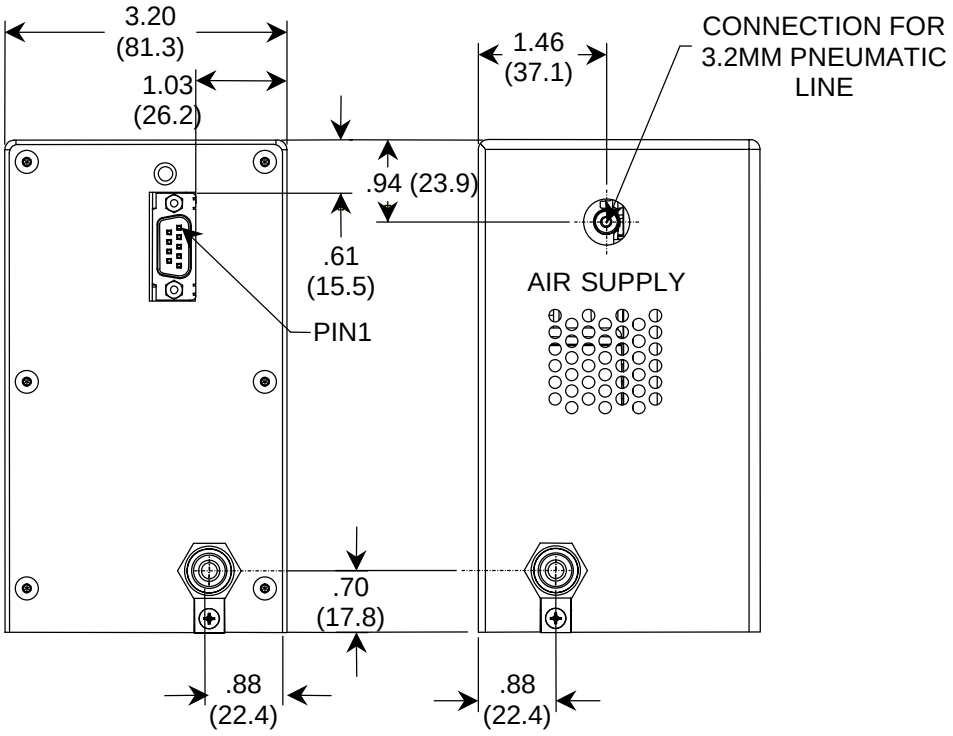

Figure 2: GBR3A End View Dimensions

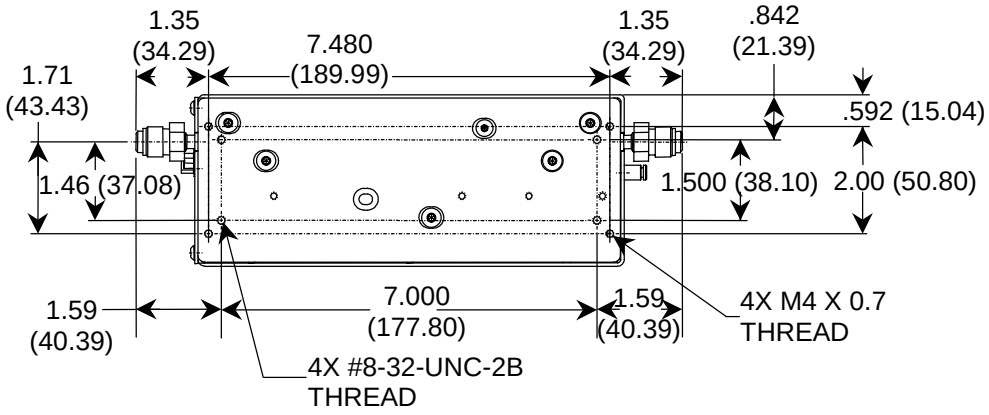

Figure 3: GBR3A Bottom View Dimensions

Setup

Setup involves installing and mounting the GBR3A in your process. One recommended location for the GBR3A is the purge or “dump” line that connects your gas manifold to the vacuum pump. This location enables you to verify the flow of each MFC in a system using either an inert purge gas or the actual process gases, without flowing gas into your process chamber.

Warning **Severe hazards may exist when mixing different gases. You must be aware of the hazards associated with the gases you are using BEFORE installing the GBR3A Flow Verifier.**

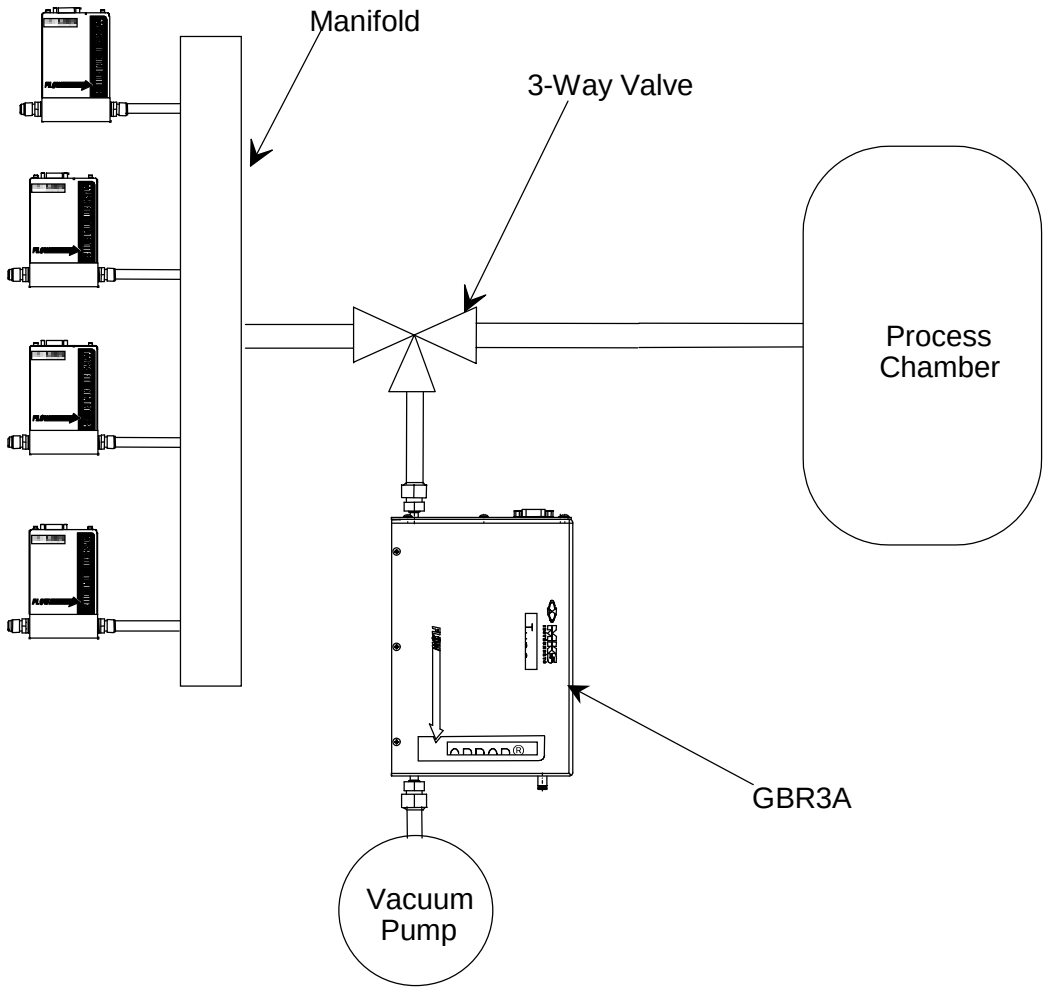

Figure 4: Recommended Location for the GBR3A

Installing the GBR3A

Locate the GBR3A as close to the process tool as possible. Locate it no farther than 20 feet with ¼" tubing. The volume of the tubing leading to the GBR3A system must not exceed the volume of the GBROR volume, or flow verification will be affected.

Note You may need to create and install a mounting bracket to support the GBR3A, depending upon its location and the surrounding piping.

1. Remove the two (2) protective endcaps from the VCR fittings on the GBR3A.
2. Mount the GBR3A into your system.

   The gas inlet and outlet fittings are 4-VCR male.
3. Secure the GBR3A using the mounting holes on the base plate.

   Refer to Figure 3 on page 26 for the dimensions of the mounting plate and mounting holes.
4. Connect the solenoid air supply to the quick connect pneumatic fittings on the GBR3A.

   Depending on the design of your gas box, you should tap into the pneumatic supply for either the diverter valve, gas box isolation valve, or the main vacuum valve. This ensures that gas is available to operate the GBR3A valves if there is a power outage . Depending on the configuration, the fittings on the GBR3A accept either $^1/_8$" or 4 mm O.D. polyethylene or soft nylon tubing.

Warning **Connect the air supply of the process tool to the air supply inlet of the GBR3A unit. If a power loss in the facility, or a process tool safety alarm condition occurs, the air supply to the GBR3A shuts off. This moves the valves in the GBR3A unit to their normal default positions, isolating the GBR3A from your system.**

Electrical Information

Serial Interface Connector

The Serial Interface, or RS-232, connector is a 9-pin male Type “D” connector. Unlisted pins on this connector are *not compatible* with the current Type “D” 9-pin industry-standard cable.

Serial Interface Connector Pinout	
Pin No.	**Assignment**
1	Chassis Ground
2	RS-232 Transmit Data
3	RS-232 Receive Data
4	Power Input
5	System Ground
6	Power Ground
7	Reserved
8	Reserved
9	Power Ground

Table 1: Serial Interface Connector Pinout

Cable Numbers for RS-232 Serial Communications		
Serial Port	**Serial Interface Cable**	**Cable Number**
9-pin	RS-232 Power/Communications	CBROR-5-Mx

Table 2: Cable Numbers for RS-232 Serial Communications

Caution 

The MKS RS-232 Power/Communications cable (CBROR-5-Mx) *must* be used for the GBR3A’s 9-pin connector. Unlisted pins on this connector are NOT COMPATIBLE with the current Type “D” 9-pin industry-standard cable. The CBROR-5Mx cable does mate with standard cables for connection with the host PC.

Power Supply Connection

Two of the three ends of the CBROR-5-Mx cable terminate in Type “D” connectors; the third end terminates in three pig-tail wires. Connect these wires to a 24 VDC power supply to power the GBR3A by doing the following:

- Connect the black wire to power return
- Connect the red wire to the positive terminal on the power supply
- Connect the drain wire to earth ground.

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Chapter Three: Overview

General Information

The GBR3A Flow Verifier consists of a GBROR volume, GBROR transducer, a controller, and two isolation valves, all housed in an enclosure. When the GBR3A verifier performs a measurement, the controller closes the isolation valves in sequence to allow the GBROR volume to fill with gas. The GBROR transducer monitors the pressure rate-of-rise as gas flows into the GBROR volume. The controller calculates the flow rate using a pressure rate-of-rise algorithm. A flow verification timeout feature monitors the pressure rate-of-rise and aborts the procedure if a pressure rise is not detected. When the verifier is not measuring the flow rate, the isolation valves are closed, and no gas flows through the GBR3A. Flow restriction introduced by the GBR3A is negligible, and the GBR3A can be permanently mounted in a gas line to provide periodic flow rate verification.

The measurement technique handles gas mixtures as well as pure gases. There are no gas correction factors to enter. Flow verification calculations also take gas temperature into consideration.

GBR3A

The GBR3A contains all the hardware necessary to verify the flow of gas using a gas box rate-of-rise (GBROR®) technique. The GBR3A includes a GBROR volume, which is a nominal 250 cc (2 slm version), 316L stainless steel vessel, a GBROR transducer, two isolation valves, and solenoid valves. The design interrupts gas flow when the GBR3A verifier is not verifying the flow. In this state, the two isolation valves close off the GBROR volume and GBROR transducer. When a flow verification procedure is started, the GBR3A opens the two isolation valves. A typical two-valve configuration is shown in Figure 5.

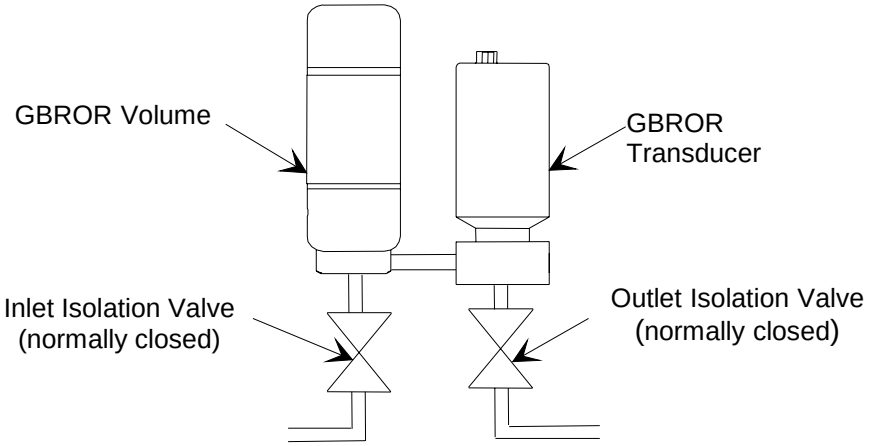


Figure 5: A Simplified Drawing of Typical GBR3A Plumbing

Labels

The serial number of the GBR3A is on the enclosure. The label identifies the product type, the serial number of the GBR3A verifier, and the flow range. A duplicate label is on the GBROR volume inside the enclosure.

Figure 6: GBR#A Serial Label

Chapter Four: Visual Interface Operation via RS-232

Introduction

The Visual Interface (VI) is a software package that controls the GBR3A from a standard Windows 95/98 personal computer, using RS-232 communication. The VI features a virtual controller front panel, shown in Figure 7.

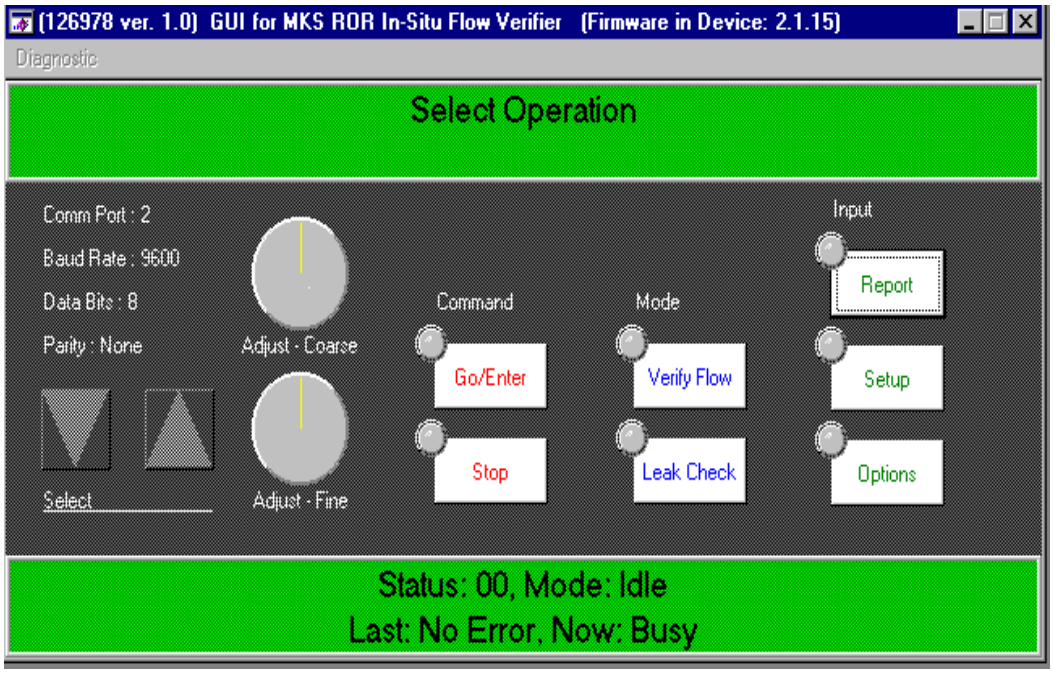


Figure 7: Visual Interface of the GBR3A Control Software

Table 3 on page 34 summarizes the types of information and the controls displayed in the visual interface.

Summary of Visual Interface Displays	
Display	**Description**
Title Bar • Software Name • Software Version • Version of Firmware in GBROR	• Indicates Software Name • Indicates Software Version • Indicates Firmware Version
Menu Bar • Diagnostics	• Permits user to manipulate the position of valves
Upper Frame • Select Operation	• Indicates the operation selected with the controls in the middle frame
Middle Frame • Comm Port • Baud Rate • Data Bits and Parity	• Shows the port on the computer used for communication with the GBR3A (automatically detected) • Baud rate selected with the Setup menu of either 1200, 2400, 4800 or 9600 • Data bits and parity are selected together, in the Setup menu
Lower Frame • Status/Mode • Last/Now	• Current mode of the GBR3A • Describes the last error condition and current state (See Table 21.)

Table 3: Summary of Visual Interface Displays

Summary of Visual Interface Controls	
Controls (in middle frame)	**Function**
Arrow Buttons	Scroll through the displays associated with control buttons: [▽] scrolls down (forward), and [△] scrolls up (backward).
Adjust Knobs	Increment parameter values. “Turn“ the knobs using the mouse cursor while holding down mouse button.
Command Buttons • Go/Enter • Stop	 • Initiates an operation. • Terminates an operation
Mode Buttons • Verify Flow • Leak Check	 • Performs the flow verification function • Measures leak integrity of either the GBR3A alone, or the whole system
Input Buttons • Report • Setup • Options	 • Reports the settings and conditions shown in Table 19 • Sets GBR3A operating parameters • Calculates the external volume of the system or allows purging of the system
Indicator lights in Command, Mode, and Input buttons	• Illuminate to indicate active function

Table 4: Summary of Visual Interface Controls

Note

Be sure to exit each menu when you finish editing a parameter. Otherwise, you could change the parameter by inadvertently moving the Adjust knob. You must click the mode or input button to exit a menu.

Definition of the Idle State

The GBR3A verifier is in an “idle state” when it is not performing a verification or measurement. The two isolation valves in the unit assume their normal closed positions. (The normal state of the valve is the state it assumes when electrical power is removed.) There is no gas flow, because the valves are closed.

Operation of the Isolation Valves

The GBR3A includes two isolation valves. Figure 5 on page 32 shows the typical GBR3A configuration. The GBR3A positions the valves during various functions. The two isolation valves are normally closed valves.

Gas flow goes through the GBR3A volume. When the unit is idle, the valves close, and no flow is possible between runs.

Visual Interface Controls

On power-up, the visual interface display prompts you to select an operation.

Arrow Buttons

The down arrow button, [▽] selects the previous display in the display list.

The up arrow button, [△] scrolls to the next display in the display sequence.

Adjust Knobs

The knobs on the VI increment values up and down. The *Adjust-Coarse* knob increments values rapidly; the *Adjust-Fine* knob increments slowly. Use the mouse cursor to "turn" a knob: click near the edge of the knob and drag to turn it.

Note 

To enter *and exit* a menu you must click a mode or input button. Clicking another button does not exit the menu.

Input Buttons

The Input buttons, color coded green, are the *Report*, *Setup*, and *Options* buttons.

Note 

You must configure the parameters in the Setup and calculate volume in the Options screens *before* you attempt to use any of the mode functions.

Report Button

When clicked, the *Report* button opens a window that displays a menu of settings and conditions that can be reported. These are the same items listed in Table 19. To move from one type of report to another, click the arrow buttons.

Setup Button

The *Setup* button menu enables you to select operating parameters for your GBR3A verifier. Use the arrow buttons to cycle through the menu entries. This section describes each screen in detail.

- **Total purge cycles:** This entry defines the number of purge cycles executed during purging. The range is from 1 to 50; the default is 5.
- **Maximum system pressure:** This value is used during the flow verification and purging procedures. During the flow verification procedure, when the system pressure reaches the value specified in this entry, the GBR3A verifier stops collecting the gas sample and performs the math calculations. For greatest accuracy, set this value as high as possible. However, when working with a condensable gas or gas mixture, set this entry below the condensation point.

Full Scale Range of Model	Maximum Pressure	Default Maximum	Minimum Pressure	Default Minimum	Base Pressure	Default Base
0.5 slm	20 to 98 Torr	98 Torr	1 to 19 Torr	10 Torr	1-19	10
2 slm	200 to 980 Torr	980 Torr	1 to 199 Torr	20 Torr	1-199	20
5 slm	200 to 980 Torr	980 Torr	1 to 199 Torr	20 Torr	1-199	20

Table 5: Maximum System, Minimum System and Base Pressure

- **Minimum system pressure:** Several GBR3A procedures, including the external volume calculation and purging sequences, require system pumpdown. It is better to keep the pumpdown pressure as low as possible. The GBR3A compares the minimum system pressure entry with the actual system pressure to verify that the system has been pumped down properly. The optimum setting depends on the particular pumping system and plumbing between the GBR3A and pump.
- **Flow verification timeout:** This entry defines the maximum length of time for gas to flow into the GBROR volume. The value also defines the duration of the leak check function. The entry can range from 6 to 600 seconds. During the flow verification procedure, when the time exceeds this value, the GBR3A verifier stops collecting the gas sample and performs math calculations. For best performance, set this value as high as possible. The initial value is 600 seconds.

Note

During a flow verification procedure, the GBROR verifier stops collecting gas when *either* the maximum system pressure is reached or the flow verification timeout period has elapsed, whichever occurs first. To ensure the most accurate measurement, set the maximum system pressure value to maximum value or just below the condensation point (or vapor pressure) of the gas.

- **Known volume:** This entry defines the nominal size (in cubic centimeters) of the GBROR volume in the GBR3A. The setting is 100 or 250 cc. Although the GBROR volume is the largest contributor, the known volume value used in calculations also includes the volume in the two GBR3A isolation valves. Figures 8 and Figures 9 identify the known, stray, and external volumes. This parameter is set at the factory. It can be viewed by the user. This value cannot be changed.

- **Stray volume:** This is the volume (in cubic centimeters) in the gas line between the control valve in the MFC and any optional downstream isolation valve. The stray volume is typically less than 5 cubic centimeters; the range is from 0 to 10.0; the default is 0. If your system does not include an isolation valve, or it is not used to stop flow, use a stray volume entry of 0. Figure 8 and Figure 9 identify the stray, known, and external volumes.
- **Baud Rate Code**: This code sets the baud rate for RS232 communication. The default setting is zero, which sets the rate to 9600 baud. See Table 17 for Baud Rate codes. Changes to this setting take effect at the next startup of the GBR3A.
- **RS-232 Bit Mode:** This command sets the communication parity and number of data bits. The default is 5. Changes to this setting take effect at the next startup of the GBR3A.
- **Flow Stabilization Time:** The system flow must be stable for a specified time before beginning a flow verification. This command sets the time. Stability is defined as: the flow varies by less than 0.02% of full scale for the specified time. The range is 1-99 and the default is 10 sec.
- **Base Pressure Prior to Flow Verification:** At the start of flow verification, both valves are opened allowing the system to reach a stable base pressure which in turn indicates a stable flow rate. The GBROR must maintain stable flow below the set base pressure for the duration set by flow stability time in order to proceed with flow verification. The range and default values are listed in Table 9.

Options Button

The *Options* button performs two functions:

- Calculates the external volume
- Purges the GBR3A verifier.

Use the arrow buttons to toggle between the entries. You must press the [ENTER] key to initiate either function.

- **Calculating the external volume:** The external volume is the volume of the gas line between the isolation valve of MFC device being tested and the inlet fitting of the GBR3A. The active volume of the GBR3A verifier includes the external volume, the stray volume, and the known volume. The GBR3A performs a sequence to determine the external volume.

  The external volume is automatically added to the known volume and stray volume to calculate the total volume, which is used during the flow rate calibrations:

  $V_{external(calculated)} + V_{known(specified)} + V_{stray(specified)} = V_{total}$

  See "How To Calculate the External Volume" on page 49 for instructions on using this function.

- **Purging the system:** This function fills and evacuates the GBR3A to purge the components of any residual gases. Entries in the setup menu allow you to specify the number of purge cycles, pump down pressure, and the maximum system pressure. See "How To Purge the System" on page 71 for instructions on using this function.

Command Buttons

The GBR3A has two command buttons: *Go/Enter* and *Stop*. These buttons have red letters for easy identification.

Go/Enter Button
The *Go/Enter* button initiates an operation. The display prompts you to click this button to start an operation.

Stop Button
The *Stop* button causes the instrument to halt the current operation at the next appropriate time. You may notice a slight delay while an operation is completed. The GBR3A verifier returns to an idle state. (Operationally, the status shows it in the aborted state until the next execution.)Mode Buttons

Mode Buttons

Note 

The GBR3A must be configured (using the *Setup* and *Options* buttons) *before* running any of the mode functions.

The GBR3A has two mode buttons: *Verify Flow* and *Leak Check*. These buttons are colored coded blue for easy identification.

Verify Flow Button
The flow verification screen appears when you click the *Verify Flow* button. This function calculates the current flow rate of an MFC in the system. To initiate this function, press the [ENTER] key.

Note 

Allow sufficient time for the system to establish a stable flow rate *before* you start the flow verification function. Erratic flow rates cause unreliable results.

The GBR3A closes the isolation valves in a precise sequence to allow gas to flow into the GBROR volume for a known amount of time. The GBROR transducer measures the gas quantity and the controller monitors the rate-of-rise and then calculates the flow rate. When the flow verification function is complete, the controller opens the isolation valves to restore flow through the system. In addition, the controller evaluates the statistical variation of the flow rate during the rate-of-rise portion of the flow calculation process. The rate-of-rise stability value is useful for diagnostic purposes only, since it is a relative number. A value of less than 1 indicates a stable system; a value between 1 and 5 indicates some instability; a value above 5 indicates stability problems in the system. Once the flow verification is complete, the screen displays both the flow rate and the statistical variation.

Leak Check Button
The *Leak Check* button enables you to perform a leak check in one of two modes: isolated or connected. Both procedures check for leaks coming from the outside *into* an evacuated system. In each leak check procedure, the GBR3A monitors the pressure for the amount of time specified in the flow verification timeout entry. For maximum resolution, set the flow timeout entry to 600 seconds (the maximum value). The resolution of the reading is approximately 0.025 sccm.

- **Isolated Leak Check***:* An isolated leak check determines the leak integrity of the GBR3A only. The procedure closes the isolation valves to seal off the GBR3A from the rest of the system. The controller then monitors the pressure of the GBR3A for the time specified by
- **Connected Leak Check***:* A connected leak check determines the leak integrity of the GBR3A plus the connected upstream plumbing. If the upstream plumbing includes a direct connection to the MFC (either no isolation valve or an open isolation valve), the leak check function reports the leak rate through the MFC. This function opens the upstream isolation valve and closes the downstream isolation valve. The controller then monitors the pressure of the GBR3A plus the connected upstream plumbing for the time specified by the flow verification timeout entry.

How To Configure RS-232 Baud Rate

1. Click the Setup button to enter the setup menu.

   The corner ot the setup button illuminates, indicating that the setup menu is active.

2. Repeatedly, click an arrow button until the Baud Rate screen appears.

Baud Rate: 9600

3. Turn the Adjust knobs to select the baud rate, either 1200, 2400, 4800, or 9600.
4. Click the down arrow button nce to display the communication settings screen.

Comm Settings 8 Bit NO Parity

5. Turn the *Adjust* knobs to set the data bits and parity settings. The data bits can be set to either 7 or 8; the parity can be set to NO, EVEN or ODD.

   Turning the Adjust knobs enables you to scroll through all combinations of data bits and parity settings. Continue turning the *Adjusts* knobs until the correct combination appears.

How to Configure the Operating Parameters

The *Setup* button displays most of the operating parameters you must set before operating the GBR3A verifier. Refer to "Setup Button", on page 36, for a description of each entry. The operating parameters include the following:

1. Maximum System Pressure
2. Minimum System Pressure
3. Flow Verification Timeout Period
4. Known Volume
5. Stray Volume
6. Total Purge Cycles
7. Flow Stabilization Time
8. Base Pressure
9. Baud Rate Code
10. RS-232 Bit Mode

Note

You can configure the operating parameters in any order. This sequence of steps presents the screens in the order in which they appear when you click the down arrow [▽] button to scroll through the menus. Clicking the up arrow button [△] reverses the order. You must click the mode or input button again to exit a menu.

These parameters can be configured in any order. Below is an example of parameters that are used for a sample unit. Use the operating parameters that you need.

1. Click the *Setup* button to enter the setup menu.
   The corner of the *Setup* button illuminates, indicating that the setup menu is active.
2. Click an arrow button until the maximum system pressure screen appears.

Maximum System Pressure: 980 Torr

3. Turn the *Adjust* knobs to set the maximum system pressure.
   Since the highest maximum pressure entry yields the best accuracy, do not lower the pressure entry without a valid reason, such as when the condensation point of the gas or gas mixture is less than the maximum value for maximum system pressure.
4. Click the down arrow button until the minimum system pressure screen appears.

Minimum System Pressure: 20 Torr

5. Turn the *Adjust* knobs to set the minimum system pressure.

   The allowable range and initial value are listed in Table 9.

6. Click the down arrow button to display the flow verification timeout screen.

   Flow Verification
   Timeout: 600 seconds

7. Turn the *Adjust* knobs to set the timeout value. The allowable range is from 6 to 600 seconds; the initial value is 600 seconds. The longest flow verification timeout entry yields the best accuracy.
8. Click the down arrow button to display the known volume screen.

   Known Volume
   250 CC's

9. The default value does not change. It is set at the factory.
10. Click the down arrow button to display the stray volume screen.

    Stray Volume
    0 cc

11. Turn the *Adjust* knobs to set the value. The allowable range is from 0 to 10 cubic centimeters (cc); the default value is 0.

    This value should be 0 if your system does not have an isolation valve installed between the MFC and the GBR3A, or if the isolation valve is not used to stop flow. If you have an isolation valve, you must calculate the stray volume and enter the correct value.

12. Repeatedly click the down arrow button to display the total purge cycles screen.

    Total Purge Cycles
    5

13. Turn the *Adjust* knobs to set the value.

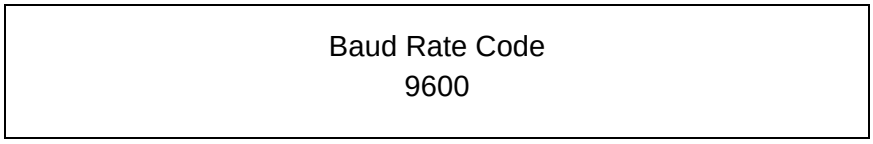
    The allowable range is from 1 to 50 cycles; the default is 5.

14. Repeatedly, click the down arrow button to display the flow stabilization time screen.

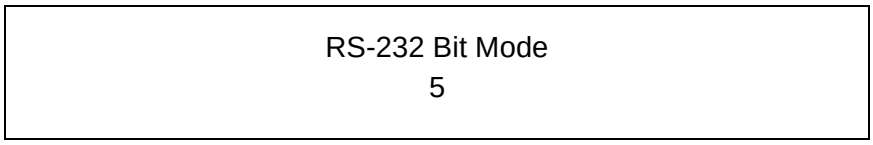
    Flow Stabilization Time
    10 sec

15. Turn the Adjust knobs to set the time duration. The allowable range is from 1 to 99 seconds; the initial value is 10 seconds.
16. Click the down arrow to display the (Pre-Flow Verification) base pressure screen.

17. Turn the *adjust* knobs to set the minimum system pressure.
18. Repeatedly, click the down arrow button to display the Baud Rate Code screen..



19. Turn the Adjust knobs to set one of the following baud rates: 1200, 2400, 4800, or 9600.
20. Click the down arrow to display the RS-232 Bit Mode screen.



21. Turn the Adjust knobs to set the value. The default is 5. Changes to this setting take effect at the next startup of the GBR3A.
22. Click the *Setup* button to leave the setup menu.

How To Calculate the Stray Volume

Note

Calculating the stray volume is only necessary if your system includes an isolation valve between the MFC and the GBR3A. Otherwise, you should enter zero for the stray volume entry.

The stray volume entry accounts for the volume of gas between the middle of the isolation valve and the middle of the control valve within the MFC. Use the shortest length of tubing possible to connect the isolation valve to the MFC. The stray volume is limited to 10 cc.

1. Determine the contribution to the stray volume for the type of tubing used to connect the isolation valve and the tubing length. Use the data in Table 6 and Table 7.

Tubing Size Contribution to the Stray Volume			
Nominal Tube Size (inch)	**Tube O.D.**	**Tube Wall**	**Volume Contribution per Inch (cc)**
1/4	0.250	0.035	0.42
3/8	0.375	0.035	1.20
1/2	0.500	0.049	2.08

Table 6: Tubing Size Contribution to the Stray Volume

Volume Contribution for Tubing Lengths			
Tubing Length (inches)	**1/4 Inch**	**3/8 Inch**	**1/2 Inch**
1	0.42	1.20	2.08
2	0.83	2.39	4.16
3	1.25	3.59	6.24
4	1.67	4.79	8.32
5	2.08	5.99	—
6	2.50	7.18	—
7	2.92	8.38	—
8	3.34	9.58	—
9	3.75	—	—
10	4.17	—	—
20	8.34	—	—
— indicates the combination of tubing diameter and length exceeds the 10 cc limit			

Table 7: Volume Contribution for Various Tubing Lengths

2. Determine the volume of the isolation valve.

   For a typical isolation valve installed in the proper direction, use a 0.4 cc volume. Most of the internal volume of the isolation valve is included in the "external volume" calculated by the GBR3A unit. Only the porting between the inlet VCR bead and the valve seat contributes to the stray volume.

3. Determine the volume of the MFC.

   A typical value for the volume between the MFC control valve seat and the outlet VCR bead is 1.2 cc (for example an MKS Type 1179 or 1479 MFC). This value applies only to MFCs that have the control valve positioned on the outlet end. The MFC volume is quite variable with manufacturer and model.

***Example**:* The system consists of an 18-inch piece of ¼ inch O. D. tubing connecting the isolation valve to an 1179 MFC.

Component	Volume Contribution
Tubing: one 10 inch and one 8 inch	4.17 3.34
Isolation Valve	0.40
Type 1179 MFC	1.20
Total Stray Volume:	9.11

How To Purge the System

The purge function removes contamination from the GBR3A verifier by repeatedly flowing clean purge gas and then evacuating the system. Use the setup menu entries to specify the minimum system pressure, the maximum system pressure, and the number of purge cycles.

You must determine when the system requires purging. Purging is especially important when using different, reactive gases. The purge requirements vary greatly depending upon the type of gas used and the process requirements.

Note

- These instructions assume that you have configured the setup menu parameters to define the number of purge cycles, minimum system pressure, and the maximum system pressure. The GBR3A is factory configured with initial values for these parameters.
- The system must be capable of reaching the minimum system pressure. If the system fails to reach the minimum system pressure, an error condition results.

1. Set the MFC to the desired flow rate.

   The 100 cc GBROR volume (in a 2 slm version) requires a value of at least 30 sccm.

Warning

Severe hazards may exist when mixing different gases. You must be aware of the hazards associated with the gases you are using BEFORE installing the GBR3A Flow Verifier.

2. Click the *Setup* button to enter the setup menu.

   The light in the upper left-hand corner of the [SETUP] button illuminates, indicating that the setup menu is active.

3. Repeatedly click an arrow button until the total purge cycles screen appears.

Total Purge Cycles 5

4. Enter the correct number of purge cycles.

   The number of purge cycles can range from 1 to 50; the default is 5.

5. Click the *Setup* button to leave the setup menu.
6. Click the *Options* button to enter the options menu.

   The corner of the *Options* button illuminates, indicating that the option menu is active.

7. Repeatedly click an arrow button until the purge screen appears.

Start Flow, Press GO To Purge System

8. Ensure that gas is flowing through the system, then press the [ENTER] key to start purging the system.

The GBR3A fills the system to the pressure specified as the maximum system pressure. After it reaches this pressure, the downstream valve opens to allow the system to be pumped down to a pressure specified as the minimum system pressure. During this procedure the message “PURGE CYCLE #1” flashes on the display. The GBR3A repeats this procedure as many times as specified in the “Total Purge Cycles” entry. Once the GBR3A verifier has completed the purge function, it enters the idle state.

How To Calculate the External Volume

Note

The calculate volume function, which calculates the external volume of the system, must be run *before* the GBR3A can verify the flow rate accurately.

The “calculate volume” function, accessible through the *Options* button, calculates the external volume in the system. The external volume is added to the known volume and stray volume, producing the total volume used to calculate the flow rate. The external volume value is stored in non-volatile memory so the value is saved even when the unit is powered down.

Note

- Run the Purge function before you calculate the external volume.
- Position the computer monitor so it is visible. The visual interface prompts you to change the flow rate during this procedure.

- *Stray volume:* includes the volume between the downstream half of the control valve in the MFC to the upstream half of the isolation valve.
- *External volume:* includes the volume from the downstream half of the isolation valve to the upstream half of the upstream isolation valve (valve 1) in the GBR3A.
- *Known volume:* includes most of the volumes in the GBR3A, the downstream half of valve 1, the downstream isolation valve (value 3), and the GBROR volume.

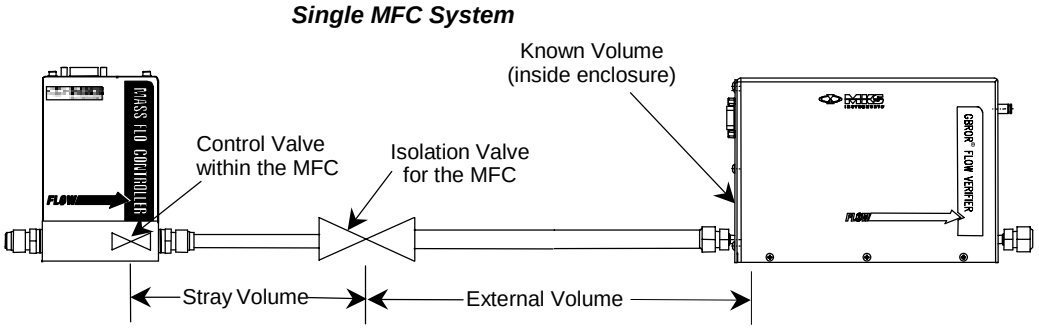


Figure 8: Identification of Volumes on a Single MFC System

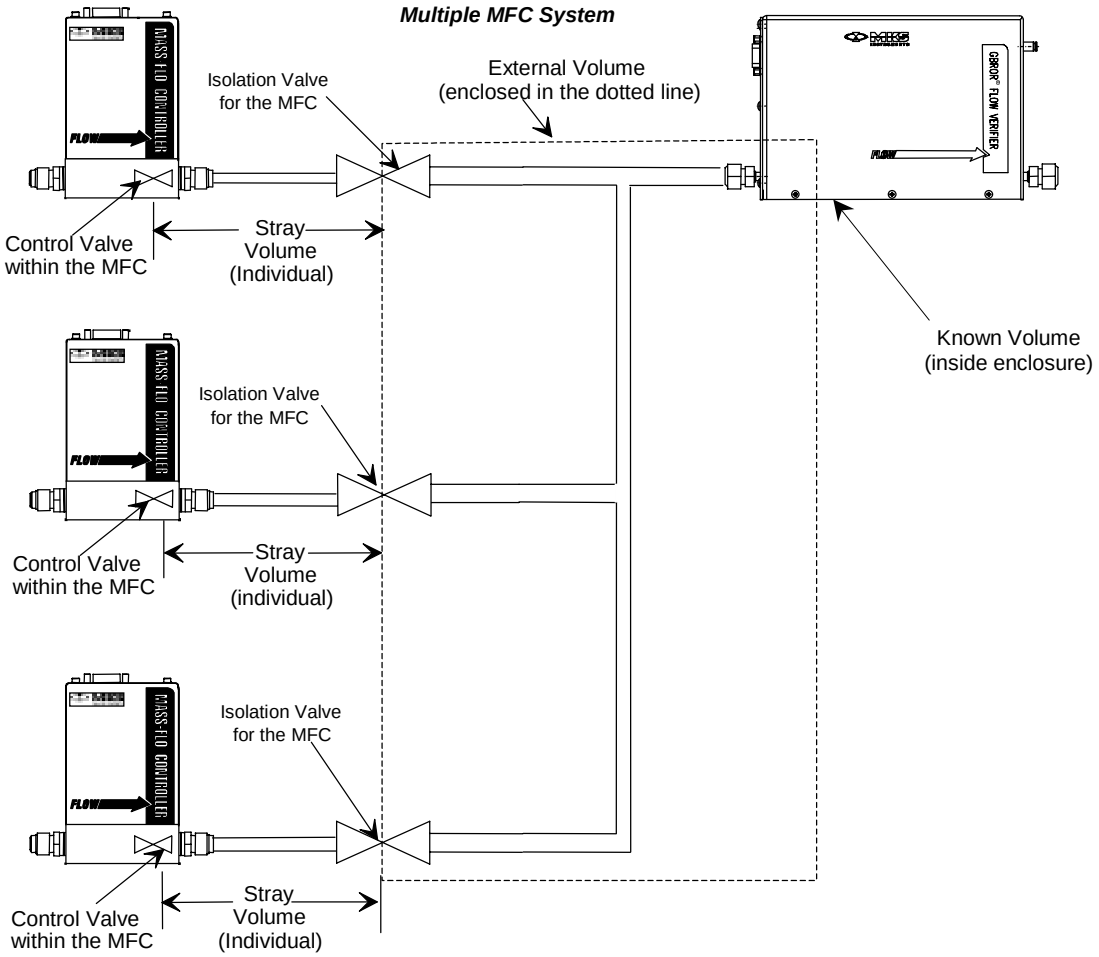


Figure 9: Identification of Volumes on a Multiple MFC System

1. Purge the system, following the steps outlined in “How To Purge the System”.
2. Set the MFC to the desired flow rate.

   The 100 cc GBROR volume in a 2 slm version requires a minimum flow rate of approximately 30 sccm; the maximum flow rate is approximately 500 sccm.

Note

External volume calculation is independent of gas type. Use a purge gas if possible.

Since the flow rate is system dependent, it can be in the range of 30 to 500 sccm.

3. Click the *Options* button to enter the options menu.

   The corner of the *Options* button illuminates, indicating that the option menu is active.

4. Repeatedly click an arrow button until the calculate volume screen appears.

Start Flow, Press GO To Calculate Volume

5. Ensure that gas is flowing through the system. Then, press the [ENTER] key to calculate the volume of the system.
6. Watch the display for the prompt. Then stop gas flowing through the system.

   Use an isolation valve immediately downstream of the MFC to stop the flow. Refer to Figure 8 and Figure 9, for the location of an isolation valve. You must be certain that the volume between the MFC and the isolation valve is entered in the stray volume field in the setup menu.

Note Failure to completely stop the gas flow when prompted will result in a system error and/or an erroneous calculation.

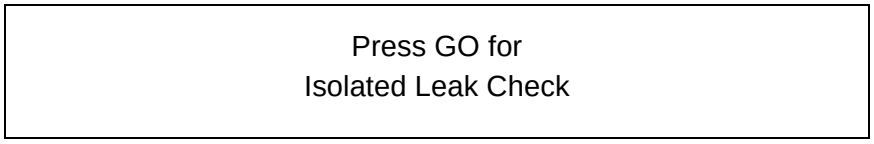
7. Click the *Go/Enter* button to complete the calculation.

   The system finishes the valve sequence, calculates the external volume, and enters the idle state. The value for the external volume are displayed and stored in non-volatile memory for use in flow calculations.

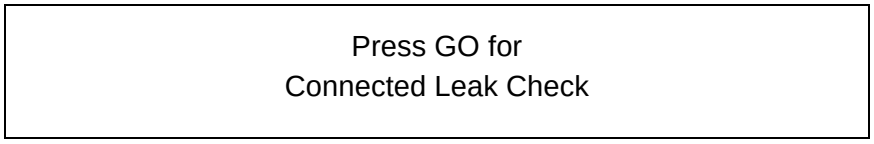
How To Perform a Leak Check

The procedure is the same whether the GBR3A performs an isolated or connected leak check. See "Mode Buttons" for a description of the leak check function.

1. Stop the gas flow through the MFC.
2. Click the *Leak Check* button to enter the leak check mode.
3. Use the arrow buttons to select the type of leak check to perform.



or



4. Click GO to start the desired leak check.

   The GBR3A monitors the pressure in the system for the time specified by the flow verification timeout entry (through the setup menu). To achieve the maximum resolution, set the flow verification timeout to 60 seconds (the maximum value). The display lists the leak check value, in sccm. The resolution of the reading is approximately 0.025 sccm.

How To Verify the Flow Rate

Note

- You must have entered the configuration parameters in the setup menu, purged the system, and performed the calculate volume function *before* you start the flow verification function.
- Allow sufficient time for the system to establish a stable flow rate *before* you start the flow verification function. Erratic flow rates result in unreliable results.
- The GBR3A verifies and reports flow rates outside its stated range. However, the accuracy of such measurements may not meet the stated accuracy specification of <1% of reading.

1. Click the *Verify Flow* button to enter the calibration menu. The calibration screen appears.

   The light in the upper left-hand corner of the [CAL] button illuminates, indicating that the calibration menu is active.

   Start Flow Press GO
   To Verify Flow

2. Ensure that gas is flowing through the system. Then press the [ENTER] key to begin the flow verification function.

   During the flow verification process, the message “VERIFYING FLOW RATE” blinks on the display.

   When the flow verification is complete, the screen display lists the flow rate and the flow statistical variation (listed as “dev”). The GBR3A system returns to the idle state.

   Select Operation
   +99.63 SCCM .70 Devs

Chapter Five: Remote Communication

Overview

The GBR3A communicates with a host computer via RS-232 communication through the serial port.

Note

The instrument is in an “idle state” when the GBR3A verifier is not performing a verification. In the idle state, the upstream and downstream isolation valves are closed, and gas does not flow through the GBR3A.

Master-Slave Operation

The host computer must initiate all communication to the GBR3A controller. The software is designed using a master-slave protocol, with the GBR3A controller acting as the slave. The slave simply responds to requests made by the master; it cannot initiate communication. The master or host computer must initiate an action and then poll the status register to determine when the action is complete. When the action is complete, the host can then request the output information. For example, the host first initiates a flow verification, then polls the status register to determine when the measurement is complete, and finally requests the flow value.

How To Communicate with the GBR3A Flow Verifier

The GBR3A visual interface provides the controls to operate the verifier through RS-232 communication. The GBR3A waits for the host computer to initiate the communication; it never sends a message unless prompted by the host computer. The host computer must wait until the GBR3A has responded to any previous message before sending another message.

Caution

Do not program the host computer to continuously send messages to the GBR3A. The host computer must wait until the GBR3A has responded to the previous message before sending another message. Continuously sending messages without waiting for a response may cause the GBR3A to lock up.

Communication Settings

The GBR3A is initially configured with the communication parameters shown in Table 12.

RS-232 Communication Parameters		
Parameter	**Initial Setting**	**Optional Settings**
Baud Rate	9600	4800, 2400, 1200
Data Bits	8	7
Parity	No	Even, Odd
Stop Bits	1	Cannot be changed
End-of-Line Delimiter	CR	Cannot be changed

Table 8: RS-232 Communication Parameters

RS-232 Protocol

Messages sent to the GBR3A can instruct the instrument to change an operating parameter, or prompt the instrument to report status information.

Responses sent by the GBR3A either return a command message to acknowledge receipt of the message or report status information.

All messages must use a carriage return (CR) as the end-of-line delimiter. Use your host computer's communications software to assign the CR action to the [ENTER] key.

Note 

Use UPPERCASE letters in all messages. Messages entered in lowercase are not recognized and result in error messages.

Contents of a Message

An RS-232 message consists of four components:

- Sync character
- Header
- Data
- Terminator

This section discusses each of the components in detail.

Sync Character

The sync character is the first character in the message, regardless of whether the message came from the host computer or the GBR3A. Messages sent by the host computer must always use "@" as the sync character. Messages sent by the GBR3A use the sync character to indicate the status of a message, as described in Table 13.

Description of the Sync Character		
Sync Character	**Hexadecimal Equivalent**	**Description**
=	3DH	Command cannot be performed at this time
>	3EH	Command was unrecognized (syntax error)
?	3FH	Command contained invalid data
@	40H	Command was successful

Table 9: Description of the Sync Character

Header

The header component is a two byte field that defines the type of message. There are three categories of messages. See Table 14.

Categories of Messages	
Category	**Description**
0x	Select the operating mode
1x, 4x	Configure the operating parameters
2x, 3x	Report the current status of the instrument
9x	Report diagnostic information
The "x" represents the specific message	

Table 10: Categories of Messages

Data

The data field is a variable length field, ranging from 0 (some commands do not require a data field entry) to several characters in length. If the data field contains numeric characters, the GBR3A sets the parameter specified by the header field to the value listed in the data field. If the data field contains a single question mark (?), the GBR3A returns the present value of the parameter specified in the header field.

Terminator

All messages must end with the terminator character, which is a carriage return (CR). You cannot change the terminator character. Use your communications software to assign a carriage return to the [ENTER] key.

How To Query the Status of a Parameter

You can request the status of any user-defined parameter by entering the appropriate RS-232 command with a "?" inserted for the value. For example, send the following message to request the value of the maximum system pressure entry:

@10?

Message Syntax

The information presented in this section applies to all RS-232 messages. The RS-232 messages in this manual use the following typographical conventions:

bold	Commands and requests that you must enter exactly as shown in the manual.
italics	Placeholder that represents text or numeric values that you must supply.
response	Format of messages sent from the GBR3A.
[ENTER]	Represents carriage return-line feed combination that you have configured as the end-of-line delimiter.

RS-232 Messages

Note To instruct the GBR3A controller to report the value of any parameter, send the related command with a question mark (?) inserted in the data field.

Operating Mode Messages

The messages in this category allow you to change the operating mode of the GBR3A.

Note All messages must end with a carriage return (CR) as the termination character. Use your communications software to assign a carriage return to the [ENTER] key.

Operating Mode Messages			
Command	**Action**	**Response**	**Description**
@00	Verify Flow	@00 =00	Command was accepted Command is inappropriate; the GBR3A is currently performing another operation or the external volume has not been calculated yet.
@01	Calculate External Volume	@01 =01	Command was accepted Command is inappropriate; the GBR3A is currently performing another operation.
@03	Purge	@03 =03	Command was accepted Command is inappropriate; the GBR3A is currently performing another operation.
@04	Continue	@04 =04	Command was accepted Command is inappropriate; the GBR3A was not expecting the Continue command.
@05	Abort	@05 =05	Command was accepted Command is inappropriate; the GBR3A is not currently performing an operation.
@06	Isolated Leak Check	@06 =06	Command was accepted Command is inappropriate; the GBR3A is performing an operation.
@07	Connected Leak Check	@07 =07	Command was accepted Command is inappropriate; the GBR3A is performing an operation.

Table 11: Operating Mode Messages

Verify Flow Command

This command calculates the current flow rate of an MFC in the system. The controller closes the isolation valves in a precise sequence to allow gas to flow into the GBROR volume for a known amount of time. The GBROR transducer measures the gas quantity and the controller monitors the rate-of-rise and then calculates the flow rate. When the flow verification function is completed, the controller opens the isolation valves to restore flow through the system. In addition, the controller evaluates the statistical variation of the flow rate during the rate-of-rise portion of the flow calculation process. See “How to Verify the Flow Rate” for information on how run the flow verification operation.

Calculate the External Volume Command

The active volume of the GBR3A verifier includes the external volume, the stray volume, and the known volume. The three volumes are identified in Figure 8 and Figure 9. The external volume is automatically added to the known volume and stray volume to calculate the total volume, which is used during the flow rate calibrations:

$V_{external(calculated)} + V_{known(specified)} + V_{stray(specified)} = V_{total}$

This calculation involves starting and stopping the gas flow at specific times, so you must monitor the GBR3A verifier status to determine when to change the gas flow. See "How To Perform a Calculate Volume Function" on page 72 for detailed instructions.

Purge Command

The purge command fills and evacuates the GBR3A the selected number of times. This action purges the internal surfaces of any residual gases. Select the number of times the purge sequence is repeated; ranging from 1 to 50. The default is 5. See "How To Purge the System" on page 71 for detailed instructions on how to purge the system.

Continue Command

The continue command instructs the GBR3A to continue with its operation. Use this command in conjunction with the report status command (@20) to coordinate the GBR3A verifier and the MFC.

Abort Command

The abort command causes the instrument to halt the current operation. The GBR3A verifier returns to an idle state. Note: When the abort command is executed successfully, the unit is functionally idle. The status indicates Aborted (until a new command is entered).

Isolated Leak Check Command

An isolated leak check determines the leak integrity of the GBR3A only. The procedure closes the isolation valves to seal off the GBR3A from the rest of the system. The controller then monitors the pressure of the GBR3A for the amount of time specified by the flow verification timeout entry. To achieve the maximum resolution, set the flow verification timeout to 60 seconds (the maximum value). See Table 15 on page 65 for information on the report message for the leak check operation.

Connected Leak Check Command

A connected leak check determines the leak integrity of the GBR3A plus the connected upstream plumbing. If the upstream plumbing includes a direct connection to the MFC (either no isolation valve or an open isolation valve), the leak check function reports the leak rate through the MFC. This function opens the upstream isolation valve and closes the downstream isolation valve. The controller then monitors the pressure of the GBR3A plus the connected upstream plumbing for the

time specified by the flow verification timeout entry. To achieve the maximum resolution, set the flow verification timeout to 60seconds (the maximum value). Refer to Table 19 for information on the report message for the leak check operation.

The following steps setup messages configure the operating parameters of the GBRA3A.

Note 

All messages must end with a carriage return (CR) as the termination character.

Setup Messages					
Command	**Action**	**Range**	**Response**	**Data Type**	**Description**
@10<pres>	Maximum system pressure (Torr)	<pres> is an ASCII string. Ranges and defaults are listed in Table 9.	@10 ?10	Integer	Command was accepted Invalid data field
@11<time>	Flow verification timeout period (seconds)	<time> is an ASCII string between 6 to 600, inclusive. Default is 600 sec.	@11 ?11	Integer	Command was accepted Invalid data field
@14<pres>	Minimum system pressure (Torr)	<pres> is an ASCII string. Ranges and defaults are listed in Table 9.	@14 ?14	Integer	Command was accepted Invalid data field
@15<baud>	Baud rate code	<baud> is an ASCII string between 0 and 3. Default is 0.	@15 ?15	Integer	Command was accepted Invalid data field
@16<vol>	Stray volume (cc)	<vol> is an ASCII string between 0 and 10. Default is 0	@16 ?16	Float	Command was accepted Invalid data field
@17<cycles>	Total purge cycles	<cycles> is an ASCII string, between 1 and 50, inclusive. Default is 5.	@17 ?17	Integer	Command was accepted Invalid data field

@18<stable>	Flow stabilization time	<stable> is an ASCII string between 1 and 99. Default is 10.	@18 ?18	Integer	Command was accepted Invalid data field
@19<bit>	RS-232 Bit Mode	<bit>is an ASCII string between 0 and 5. Ranges and defaults are listed in Table12.	@19 ?19	Integer	Command was accepted Invalid data field
@40<press>	Base pressure prior to flow verification	<press> is an ASCII string. Ranges and defaults are listed in Table 9.	?40	Integer	Command was accepted Invalid data field
@12?	GBROR (known) volume (cc)	Read only. Not able to set by user.	@12 ?12	Integer	Command was accepted Invalid data field

Table 12: Setup Messages

Maximum System Pressure

Use this command to enter the maximum absolute pressure allowable during flow verification and purging. When the pressure reaches the value specified in this field, the GBR3A verifier stops collecting a gas sample and begins calculating the flow value. For greatest accuracy, set this value as high as possible. However, when working with a condensable gas or gas mixture, set this entry below the condensation point. Ranges and defaults are listed in Table 9. The default setting yields the best accuracy.

Flow Verification Timeout Period

This command specifies the maximum time that may elapse during a flow verification operation. The value also defines the duration of the leak check function. When the elapsed time reaches the value specified in this field, the GBR3A verifier stops collecting a gas sample, and begins calculating the flow value. The timeout period can range from 6 to 600 seconds; the initial value is 600 seconds. During the flow verification procedure, when the time exceeds this value, the GBR3A verifier stops collecting the gas sample and performs math calculations. For best performance, set this value as high as possible.

Note

During a flow verification procedure, the GBR3A verifier stops collecting gas when *either* the maximum system pressure is reached or the flow verification timeout period has elapsed, whichever occurs first. To ensure the most accurate measurement, set the maximum system pressure value to 980 Torr, or just below the condensation point (or vapor pressure) of the gas.

Known Value

This entry defines the nominal size (in cubic centimeters) of the GBROR volume in the GBR3A. The setting is 100 or 250 cc. Although the GBROR volume is the largest contributor, the known volume used in calculations also includes the volume in the two GBR3A isolation valves. This

parameter is set at the factory. It can be viewed by the user. This value can not change.

Minimum System Pressure

This entry defines the minimum pressure that the system must achieve during an external volume calculation while purging the system. Ranges and defaults are listed in Table 9.

Baud Rate Code

This code sets the baud rate for RS231 communication. The default setting is zero, which sets the rate to 9600 baud. See Table 17. Changes to this setting take effect at the next startup of the GBR3A.

Baud Rate	Code
9600	0
4800	1
2400	2
1200	3

Table 13: Baud Rate Codes

Stray Volume

This is the volume in the gas line between the control valve in the MFC and the downstream isolation valve. It is typically less than 5 cubic centimeters; the range is from 0 to 10.0; the default is 0. If either your system does not include an isolation valve or it is not used to stop flow, make sure that the stray volume entry is 0. Figure 8 and Figure 9 identify the GBR3A, stay, and external volumes.

Total Purge Cycles

This defines the number of purge cycles executed during purging. The range is from 1 to 50; the default is 5. See "How To Purge the System" on page 47 for more information.

Pressure Stabilization Time

Stabilization refers to the requirement that the system pressure remains stable for a specified time before beginning a flow verification. Stability is defined as the pressure varying by less than 0.02% of full scale for the specified time.

RS-232 Bit Mode

This command sets the communication parity and number of data bits. The default is 5. Changes to this setting take effect at the next startup of the GBR3A

.

RS-232 Parity and Bits

Bits	Parity
7	Even
7	Odd
7	None
8	Even
8	Odd
8	None

Table 14: RS-232 Parity and Bits

Base Pressure Prior to Flow Verification

This command sets the minimum pressure required for a flow verification to begin. If the pressure does not reach this level and stabilize for the Flow Stabilization time, flow verification does not begin.

Report Messages

The report messages on the following page cause the GBR3A to report specific information.

Note 

All messages must end with a carriage return (CR) as the termination character.

Report Messages				
Command	**Action**	**Responses**	**Data Type**	**Description**
@20?	Report status	@20<status>	Hexadecimal Integer	status = a hexadecimal representation of an 8-bit status word.
@21?	Report flow	@21<flow>	Float	flow = an ASCII string representing the last flow rate measured, in sccm. Flow = -1 if the last flow verification was unsuccessful.
@22?	Report statistical variation of flow	@22<dev>	Float	dev = is an ASCII string related to the mean deviation of the last flow rate measured. The value reported is -1 if the last flow verification was unsuccessful.
@23?	Report external volume	@23<vol>	Float	vol = is an ASCII string representing the last external volume measured, in cubic centimeters (cc). The vol is -1 if the last volume calculation was unsuccessful.
@25<id>?	Report log entry	@25<id>:<log>	Integer	id = is an ASCII string representing the desired log entry number. log = is an ASCII string representing the pressure reading entry, in millivolts. A value of -1 indicates there is no pressure reading available for that entry number.
		?25<id>?	String	Data field is invalid; the data field must be between 0 to 3000 inclusive.
@26?	Firmware version	@26<fw>	String	fw = is an ASCII string representing the version of the GBR3A firmware
@27?	Report answer-back	@27<ans>	String	ans = is the ASCII string “U*U*U*U*U*”
@28?	Report voltage reading	@28<v>	Float	v = is an ASCII string representing the last reading taken from the GBROR transducer, in volts.
@29?	Report leak rate	@29<leak>	Float	leak = is an ASCII string representing the last leak rate measured (in sccm). A value of -1 is reported if the last leak check was unsuccessful.

Table 15: Report Messages

Report Status

This command reports the current status of the GBR3A. The response includes a hexadecimal representation of an 8-bit status word, such as:

$$D_7\ D_6\ D_5\ D_4\ D_3\ D_2\ D_1\ D_0$$

Note 

Tables 16, 21, and 18 explain the response in sections. An “x” appears as a bit value when the actual bit value is explained in another table.

Bits D_2 D_1 D_0

These bits describe the current operating mode of the GBR3A.

Status of Bits D_2, D_1, and D_0								
D_7	**D_6**	**D_5**	**D_4**	**D_3**	**D_2**	**D_1**	**D_0**	**Operation**
x	x	x	x	x	0	0	0	Idle
x	x	x	x	x	0	0	1	Verify flow
x	x	x	x	x	0	1	0	Calculate volume
x	x	x	x	x	0	1	1	Reserved
x	x	x	x	x	1	0	0	Purge
x	x	x	x	x	1	0	1	Setup
x	x	x	x	x	1	1	0	Isolated Leak Check
x	x	x	x	x	1	1	1	Connected Leak Check

Table 16: Status of Bits D_2, D_1, and D_0

Bit D_3

This bit describes the status of the current operation, whether the instrument is busy or waiting for a continue command.

Status of Bit D_3								
D_7	**D_6**	**D_5**	**D_4**	**D_3**	**D_2**	**D_1**	**D_0**	**Operation**
x	x	x	x	0	x	x	x	Busy
0	x	x	x	1	x	x	x	Waiting for Flow Off
1	x	x	x	1	x	x	x	Waiting for Flow On

Table 17: Status of Bit D_3

Bit D_6 D_5 D_4

These bits indicate the results of the last operation.

Status of Bits D_6, D_5, and D_4								
D_7	**D_6**	**D_5**	**D_4**	**D_3**	**D_2**	**D_1**	**D_0**	**Operation**
x	0	0	0	x	x	x	x	No error
x	0	0	1	x	x	x	x	Valve not responding
x	0	1	0	x	x	x	x	Unstable pressure
x	0	1	1	x	x	x	x	Pressure not rising
x	1	0	0	x	x	x	x	Pressure not falling
x	1	0	1	x	x	x	x	Flow not stable
x	1	1	0	x	x	x	x	Operation aborted
x	1	1	1	x	x	x	x	Volume unknown

Table 18: Status of Bits D_6, D_5, and D_4

Report Flow

This command reports the last flow rate measured during the flow verification operation. This value is saved in non-volatile memory so that it can be retrieved after a power loss. See "Operating Mode Messages" on page 59 for a complete description of the flow verification operation.

Example: To check the last flow rate, enter:

@21? [ENTER]

The GBR3A accepts the message and responds with:

```
@21+100.0
```

where the flow rate is listed in sccm; in the example, 100 sccm.

A response of “-1” indicates that the last flow verification was unsuccessful. An inappropriate command error message indicates that the GBR3A verifier is performing another function**.**

Report Statistical Variation of the Flow Rate

This command reports the statistical variation of the flow rate during the rate-of-rise portion of the flow verification process. Refer to Table 15 *Operating Mode Messages*, for a complete description of the flow verification operation. For example, to query for the statistical variation during the last flow verification operation, enter:

@22? [ENTER]

The GBR3A accepts the message and responds with:

`@22+.6729812`

In this example, the statistical variation is 0.67.

A value of less than 1 indicates a stable system; a value between 1 and 5 indicates some instability; a value above 5 indicates stability problems in the system.

Note The statistical variation value is useful for diagnostic purposes only, since it is a relative number.

This command reports "-1" if the last flow verification was unsuccessful. An inappropriate command error message indicates that the GBR3A verifier is currently performing another function.

Report External Volume

This command reports the last external volume calculated during the volume calculation operation. The volume is reported in cubic centimeters (cc). Refer to Table 15 *Operating Mode Messages*, for an explanation of the external volume calculation.

A response of "-1" indicates that the last volume calculation was unsuccessful. An inappropriate command error message indicates that the GBR3A verifier is performing another function.

Report Log Entry

The GBR3A maintains a log of data collected during a stability analysis, flow verification, or leak check operation. The data log can contain up to 3000 entries, each of which contains an average value of pressure readings taken over a 20 millisecond period. These readings are listed in millivolts, and are stored in a fist in-first out (FIFO) order. The GBR3A updates the log every time one of the logged operations is performed.

Use the report log entry command to request the value of an entry in the data log. The response does not indicate what type of operation created the entry.

Example: The pressure reading 10 seconds into a stability analysis operation is number 500 in the log (the 500th 20-millisecond period). To check the pressure at that time, enter:

@25500?[ENTER]

The GBR3A accepts the input and responds:

@25500:3678

The response indicates a pressure reading of 3678 millivolts at 10 seconds into the operation.

A response of @25500:-1 indicates that there is no pressure reading available for that time period.

An inappropriate command response indicates that the GBR3A is performing another function.

In the example above, the inappropriate command response would be: ?25500.

An invalid command error message indicates that the entered data field is invalid. The data field can be between 0 and 3000.

Report Firmware Version

This command reports the version of the software running the GBR3A.

Report Answerback

The report answerback command prompts the GBR3A to return the following string:

U*U*U*U*U*

This command is useful as a diagnostic tool since it determines whether your host computer can establish communications with the GBR3A.

Report Voltage Reading

This command reports the last measurement taken from GBROR transducer. The value is in volts.

Report Leak Rate

Use this command to report the leak rate value (in sccm) determined during the last isolated or connected leak check operation. The response reports the value only, it does not indicate which type of leak check was performed. For example, to query for the last leak check value, enter:

@29? [ENTER]

The GBR3A accepts the message and responds with:

```
@29+.0431196
```

The response indicates the leak integrity of the system; in this example, 0.04 sccm. The resolution of the reading is approximately 0.025 sccm.

Diagnostic Commands

The diagnostic commands allow you to command a relay to position a valve in a specified position. These commands test the communication between the GBR3A and the relay only, but not the link between the relay and the valve. A mechanical failure may prevent the valve from actually moving to the specified position even though the relay may change state and indicate that the valve has position changed.

Warning

The diagnostic commands change the state of the relay, which causes the valve to change position; these commands *do not* directly control the position of the valve. A mechanical failure between the relay and the valve may cause the valve to remain in its original position even though the relay may indicate a change in state.

You must verify the position of each valve manually before disconnecting the GBR3A from your system.

Note

All messages must end with a carriage return (CR) as the termination character.

Diagnostic Commands					
Command	**Action**	**Range**	**Responses**	**Data Type**	**Description**
@91<pos>	Upstream valve position	<pos> is: 0 for open 1 for close	@91 ?91	Integer	Command was accepted Invalid data field
@92<pos>	Downstream valve position	<pos> is: 0 for open 1 for close	@92 ?92	Integer	Command was accepted Invalid data field

Table 19: Diagnostic Commands

How To Purge the System

The purge function removes contamination from the GBR3A verifier by repeatedly flowing clean purge gas and then evacuating the system. Before purging the system, check the setup command parameters that specify the minimum system pressure, the maximum system pressure, and the number of purge cycles, to ensure that the values are correct.

You must determine when the system requires purging. Purging is especially important when using different gases. The purge requirements vary greatly depending upon the type of gas used and the process requirements.

Note

- These instructions assume that you have configured the setup menu parameters to define the number of purge cycles, minimum system pressure, and the maximum system pressure. The GBR3A is factory configured with initial values for these parameters.
- The system must be capable of reading the minimum system pressure. If the system fails to reach the minimum system pressure, an error condition results.

1. Set the MFC to the desired flow rate.

   The 100 cc GBROR volume (in a 2 slm version) requires a value of at least 30 sccm.

Warning

Severe hazards may exist when mixing different gases. You must be aware of the hazards associated with the gases you are using BEFORE installing the GBR3A Flow Verifier.

2. Make sure that gas is flowing through the system.
3. Send the purge command message:

   @03 [ENTER]

   The GBR3A accepts the message and responds with:

   ```
   @03
   ```

   and initiates the purge procedure. The GBR3A fills the system to the pressure specified as the maximum system pressure. After it reaches this pressure, the downstream valve opens to allow the system to be pumped down to a pressure specified as the minimum system pressure. The GBR3A repeats this procedure as many times as specified in the total purge cycles entry. Once the GBR3A verifier has completed the purge function, it enters the idle state.

How To Perform a Calculate Volume Function

Note 

The external volume must be calculated before the GBR3A can verify the flow rate accurately.

The external volume is defined as the volume of the gas line and manifold between the shutoff valve(s) MFC and the GBR3A. The “calculate volume” function calculates this external volume. This volume added to the known volume and stray volume, produces the total volume used to calculate the flow rate. Figure 8 and Figure 9 identify the external, stray, and known volumes.

Note 

Run the Purge function before you calculate the external volume.

You must monitor the status of the GBR3A verifier since this procedure requires that you change the flow rate.

1. Purge the system, following the steps outlined in "How To Purge the System", on page 71.

Note 

Run the Purge function before you calculate the external volume.

You must monitor the status of the GBR3A verifier since this procedure requires that you change the flow rate.

2. Set the MFC to the desired flow rate.

   The 100 cc GBROR volume (in a 2 slm version) requires a minimum flow rate of approximately 30 sccm; the maximum flow rate is approximately 500 sccm.

Note 

External volume calculation is independent of gas type. Use a purge gas if possible.

Since the flow rate is system dependent, it can be in the range of 30 to 500 sccm. The 2 slm version requires a minimum of 30 sccm.

3. Initiate the calculate volume function by sending the message:

   @01 [ENTER]

   The GBR3A accepts the message and responds with:

   ```
   @01
   ```

4. Monitor the status of the GBR3A verifier by sending the report status message:

   @20? [ENTER]

   See the RS-232 Bit Mode message for a description of the response. The GBR3A accepts the message. If the GBR3A verifier is busy, it reports:

   ```
   @02
   ```

5. Periodically send the report status message until the response changes to indicate that the GBR3A verifier is ready for the next step.

   When the GBR3A verifier is ready to have you stop the gas flow, it responds:

   ```
   @0A
   ```

   This response indicates that bit D_3 is high so the GBR3A verifier is waiting for operator intervention.

6. Stop the gas flow through the system.

   For best results use an isolation valve immediately downstream of the MFC to stop the flow. You must be certain that the volume between the MFC and the isolation valve is entered in as stray volume (@16<vol> message).

Note 

Failure to completely stop the gas flow when prompted will result in a system fault and/or an erroneous calculation.

7. Send the continue message to complete the calculation.

   @04 [ENTER]

   The GBR3A accepts the message and returns:

   ```
   @04
   ```

   The system finishes the valve sequence to calculate the external volume and enters the idle state.

How To Verify the Flow Rate

Note

You must have entered the configuration parameters, performed the calculate external volume function, and purged the system *before* you can verify the flow rate.

Allow sufficient time for the system to establish a stable flow rate *before* you start the flow verification function. Erratic flow rates result in unreliable results.

The GBR3A system verifies and reports flow rates outside its stated range. However, the accuracy of such measurements may not meet the stated accuracy specification of <1% of reading.

1. Ensure that gas is flowing through the system.
2. Begin the flow verification function by sending the command:

   @00 [ENTER]

   The GBR3A accepts the message and responds with:

   `@00`
3. Monitor the status of the GBR3A verifier by sending the report status message:

   @20? [ENTER]

   Refer to *Report Messages* for a description of the response. If the GBR3A accepts the message and it is busy, it responds:

   `@02`
4. When the flow verification is complete, the response to the report status message is:

   `@00`
5. To determine the results of the flow verification, send:

   @21? [ENTER]

   The GBR3A accepts the message and responds with:

   `@21200`

   where the flow rate is listed in sccm; in the example, 200 sccm.

Chapter Six: Maintenance and Troubleshooting

Maintenance

Periodically check for wear on the cables and inspect the controller and GBR3A for visible signs of damage.

How To Clean the Unit

Periodically wipe down the enclosure with a damp cloth**.**

Troubleshooting

This section describes the most common problems encountered with the GBR3A verifier and offers possible solution.

Note  If possible, operate another similar MFC to verify that the problem involves the GBR3A verifier before proceeding.

Troubleshooting Chart		
Symptom	**Cause**	**Solution**
Unable to perform the purge function	1. GBROR transducer zero has shifted. 2. No purge gas supply. 3. Insufficient pumping speed.	1. Return the GBR3A to MKS for service. 2. Connect a supply of inert gas to the GBR3A verifier. 3. Increase effective pumping speed of the system.
Unable to perform the external volume function	1. GBROR transducer zero has shifted. 2. No gas flow when requested. 3. No stop flow condition.	1. Return the GBR3A to MKS for service. 2. Verify gas flow through the GBR3A. 3. The GBR3A prompts you to stop the gas flow during the external volume function. Verify gas flow through the GBR3A.
Valve Not Responding	1. No air supply to a pneumatic valve. 2. Bad solenoid. 3. Bad connection to solenoid. 4. Bad indicator switch on valve.	1. Connect an air supply to the valves. 2.Turn off, then turn-on power after connected. 3. Replace solenoid value. 4.Check solenoid connection.
“Pressure Not Rising” message	1. No gas flow into the GBR3A verifier. 2. Flow rate set too low during the external volume calculation. 3. GBROR transducer not operating properly.	1. Ensure that gas is flowing into the GBR3A verifier. 2. Increase the flow rate, to a minimum of 30 sccm, during the external valve calculation. 3. Call MKS for assistance. The unit may need to be returned for service.
“Pressure Not Falling” message	1. Minimum system pressure entry set too low. 2. Vacuum pump not on. 3. Vacuum system lines are closed.	1. Raise setting. 2. Check vacuum pump. 3. Open vacuum lines.

Appendix A: Product Specifications

Performance Specifications

Accuracy (flow measurement)[a]	**<1% of Reading (over design range)**
CE Compliance Electromagnetic Compatibility[b] 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
Leak Integrity	$<4 \times 10^{-9}$ sccm/second helium
Verification Time (typical)	<1 minute for single point verification

a. When operated at maximum settings for pressure and time.
b. An overall metal braided shielded cable, properly grounded at both ends, is required during use.

Environmental Specifications

Operating Temperature Range Controller GBR3A	 15° to 40° C (59° to 104° F) 0° to 50° C (32° to 122° F)
Storage Humidity Range	0 to 95% Relative Humidity, non-condensing

Electrical Specifications

Input Power	24 VDC to 30 VDC, nominal (±10%)

Physical Specifications

Air pressure (for valves)	Regulated at 70 to 100 psig
Burst Pressure	1500 psi
RS-232 Communications	9-pin male Type “D”
Dimensions for all versions	5.6” H x 3.2” W x 10.18” L (142 mm H x 81.3 mm D x 258.6 mm L)
Fittings	(custom configurations available) 4-VCR compatible, male
Flow Range 500 sccm Version 2 slm Version 5 slm Version	 1-500 sccm 2-2000 sccm 5-5000 sccm
GBROR Volume (nominal) 500 slm Version 2 slm Version 5 slm Version	 250 cc 100 cc 250 cc
Internal Finish (GBR3A)	<10 µinch Ra, electropolished
Maximum System Pressure 500 slm Version 2 slm Version 5 slm Version	 98 Torr 980 Torr 980 Torr
Weight GBR3A *(varies with configuration)*	 3.26 kg (7 lbs 3 oz)
Wetted Materials	Inconel®, Elgiloy®, 316L SST, Kel-F®

Due to continuing research and development activities, these product specifications are subject to change without notice.Appendix B: Model Code Explanation

Appendix B: Model Code

Mode Code

The options of your GBR3A verifier are identified in the model code when you order the unit. The model code is identified as follows:

Type Number (GBR3A)

This designates the model number of the instrument, GBR3A.

Full Scale Range (XX) and Engineering Units (Y)

The full scale range is indicated by a two digit code (XX) and the engineering units have a one letter code (Y). The standard engineering unit used is sccm. The GBR3A verifier is available in two sizes, designated by a two digit one letter code.

Full Scale Range and Units Ordering Code

0.002 to 2 slm	23C

Fittings (Z)

The fitting style is indicated by a single letter code (Z). The letter “R” represents a Swagelok VCR compatible fittings.

I**nlet Fitting Ordering Code:** The 2 slm GBR3A has a 4-VCR male inlet.

Outlet Fitting Ordering Code: The 2 slm GBR3A has a 4-VCR female outlet.

Swagelok VCR compatible fittings	R

Options (00)

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Appendix C: Typical Calibration Data Sheet

Each GBR3A verifier is shipped with a Calibration Data Sheet, as shown below. This sheet contains important information on the specific application for which the GBR3A verifier was designed.

MKS INSTRUMENTS

Calibration Data Sheet - Type GBR3A - 2,000 sccm

Customer Name: _____ P.O. Number: _____

GBR3A S/N: _____ Order #/ERA #: _____

Test Conditions: Temp (C) _____ Humidity (R/H) _____ Pressure (Torr) _____

Calibration Gas: N2 MKS Calibration /Test Procedure: A120842 Rev. _____

Nominal Flow Rate, sccm	Corrected Output, Transfer Std, sccm	UUT Reading, sccm	Error, % Rdg.
10			
100			
2,000			

Notes:

1. For maximum accuracy, each flow rate is obtained with a different MFC transfer standard, operating at 100% of full scale.

Transfer Std. Range, sccm	Transfer Std. S/N	Primary Std. Type and S/N
10		
100		
2,000		

2. Standards used in these measurements are traceable to the National Institute of Standards and Technology (NIST) and documented in MKS standard NIST (STDNN) sets #2, 3, or 4.

3. The measurements recorded on this sheet were performed in compliance with ISO10012-1; 1994.

4. Due to limitations in state of the art, the combined measurement uncertainty of the primary and transfer standards yields a 1:2.5 accuracy to specifications ratio.

5. The stated accuracy of the UUT is 1.0% of reading.

Test Operator _____

Calibration Date: _____

MKS Drawing: A120867

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Appendix D: Error Messages

Description of the Error Messages

This section describes the error messages used by the GBR3A in RS-232 communications. The error conditions are reported in response to the report status (@20?) request. See "." on page 64 for more information on the report messaging capability.

Description of the Error Messages	
Error Message	**Description**
Valve Not Responding	One of the isolation valves did not respond to a command to change its position. Verify that the connections to the valves are secure.
Pressure Not Stable	This error appears if the pressure signal fluctuates excessively during a flow verification or volume calculation.
Pressure Not Rising	The GBR3A system expects the pressure in the GBROR volume to rise during the flow verification, volume calculation, and purge functions. Make sure that the gas is flowing through the system.
Pressure Not Falling	The GBR3A system expects the pressure in the GBROR volume to drop during the flow verification, volume calculation, and purge functions.
Flow Not Stable	This error occurs during a volume calculation if the system cannot achieve zero flow. This may occur in a system which does not contain a positive shutoff valve between the MFC and the GBR3A. The valve within the MFC may not be a positive shutoff valve so some leakage occurs.
Operation Aborted	The [STOP] button was pressed or the RS-232 abort command was sent during a procedure.
Ext Volume Unknown	You must run the external volume calculation before performing a flow verification. Once the external volume is calculated it is stored in non-volatile memory. This error only occurs if the external volume has never been calculated or the non-volatile memory failed.

Table 20: Description of Error Messages

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Appendix E: Gas Condensation Reference

General Information

The GBR3A system works with a variety of different gases. Table 21 lists gases with special considerations or limitations. Table 22 on page 86 lists common gases that do not have any operational restrictions. If the gas you intend to use is not included in one of these tables, contact our Applications group for assistance before using the GBR3A system.

Gases With Restrictions or Limitations				
Material	**Symbol**	**Vapor Pressure (Torr)**	**Temper-ature (°C)**	**Comments**
Boron Trichloride	BCl_3	820	20	Limit P_{max} < 600 Torr
Chlorine Trifluoride	ClF_3	1,064	20	Limit P_{max} < 800 Torr
Dichlorosilane (known as DCS)	SiH_2Cl_2	1,250	20	Limit P_{max} < 800 Torr
Hydrogen Fluoride	HF	780	20	Limit P_{max} < 600 Torr
Phosgene	$COCl_2$	1,200	20	Limit P_{max} < 800 Torr
TEOS		1	20	Not suitable
Tungsten Hexafluoride	WF_6	~900	20	Limit P_{max} < 600 Torr
Water	H_2O	17	20	Special GBR3A only

Table 21: Gases With Restrictions or Limitations

Gases Without Restrictions or Limitations			
Name	**Symbol**	**Name**	**Symbol**
Acetylene	C_2H_2	Hydrogen Bromide	HBr
Air	---	Hydrogen Chloride	HCl
Ammonia	NH_3	Isobutylene	C_4H_8
Argon	Ar	Krypton	Kr
Arsine	AsH_3	Methane	CH_4
Boron Trifluoride	BF_3	Methyl Fluoride	CH_3F
Butane	C_4H_{10}	Neon	Ne
Carbon Dioxide	CO_2	Nitric Oxide	NO
Carbon Monoxide	CO	Nitrogen	N_2
Carbon Tetrafluoride	CF_4	Nitrogen Trifluoride	NF_3

Chlorine	Cl_2	Nitrous Oxide	N_2O
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	Oxygen	O_2
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	Perfluoropropane	C_3F_8
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	Phosphine	PH_3
Cyanogen	C_2N_2	Propane	C_3H_8
Deuterium	D_2	Propylene	C_3H_6
Diborane	B_2H_6	R-14	CF_4
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	R-116	C_2F_6
Ethane	C_2H_6	Silane	SiH_4
Ethylene	C_2H_4	Silicon Tetrachloride	$SiCl_4$
Fluorine	F_2	Silicon Tetrafluoride	SiF_4
Germane	GeH_4	Sulfur Dioxide	SO_2
Helium	He	Sulfur Hexafluoride	SF_6
Hexafluoroethane (Freon - 116)	C_2F_6	Xenon	Xe
Hydrogen	H_2		

Table 22: Gases Without Restrictions or Limitations

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