VERSION 8

GAGETRAK PRO

Intro Guide

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M-F 6:00 a.m. to 4:00 p.m., MST.
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CHAPTER 1: INTRODUCTION

Overview

We're proud to welcome you to GAGEtrak Pro for Windows, a database software program that automates your calibration information, saving you time and giving you precise control over the tools you use to do your job. The program is designed for quality control professionals who need a convenient, easy-to-use and powerful method for documenting, tracking and retrieving calibration information. Once you've mastered its essentials, GAGEtrak will become a vital tool for managing your calibration records.

This guide is intended to get you started using GAGEtrak Pro and we will cover all of the areas of the application that will be essential to its operation. Below, we will begin with a hypothetical example of how you could use GAGEtrak Pro day-to-day. This example will familiarize you with the program's major functions and features while giving you a look at some optional accessories.

Let's look at how your calibration lab might use GAGEtrak on a typical day. Please note that this story is merely hypothetical; it's not meant to be prescriptive. You'll notice that all of the program's features and reports are in **bold** print and all of the optional accessories are in *italic* print.

A Typical Day in the Calibration Lab

It's Monday morning and it's time to plan the day. The QC manager asks you for the weekly update on gages coming due for the month. You anticipated this request and you've already created a **Calibration Due** report to be sent to him automatically each Monday using the **Notification Manager**, so your first task of the day is finished almost effortlessly.

Next, you pour your coffee, turn on your computer and start up GAGEtrak Pro to help you plan the rest of your day. The **Due Lists** displays all of the upcoming due items, such as the **Calibrations Due** and **All Gage Schedules Due** as a handy reference so that you can be sure that all required work is finished today. While you are viewing the **Calendar**, you note a critical gage that is coming due on Friday will not be calibrated in time, so you reschedule it to an earlier date with the **Calendar's** drag-and-drop functionality.

Now it's time to organize the work for your calibration crew. First, you assemble the reports that you printed last Friday. Because you have several calibration technicians and you have some gages that you must send off-site for calibration, you printed a separate **Calibration** report for each of these people or sites.

Along with each of these lists, you include the **Calibration Work Order** for each gage that needs to be calibrated. The **Calibration Work Order** includes a list of all of the **Calibration Standards** used, along with the minimum, nominal and maximum measurements for each standard. You've also been thorough enough to include the **Calibration Procedures** needed for each **Work Order**. Now, you're ready to send your technicians off to work. You can also close out the **Reminders** you set for certain gages that need to be collected ahead of time for shipping to your vendors.

Later in the morning, you finally receive the new gages that you ordered last week. Since you already have a gage of the same type as one of these new gages, you use the **Clone Gage** feature to copy the common information about this gage into a new gage record. When you clone the gage, GAGEtrak Pro copies all of the calibration standards, parts and procedures to the clone. All you have to do is enter the gage's unique information, like its serial number, purchase date and next calibration date.

After you clone the first gage, it's time to enter a record for a completely new and different type of gage. Since you know you will be receiving more of this gage type in the future, and it has a complex set of test points, you decide to create a new **Gage Template**. The **Gage Template**, like **Clone** feature, will allow you to create new gage records using the information stored in the template, such as test points, master standards and procedures. You also know that since this is a new gage type, you may need to update information on it in the future and the **Gage Templates** you create can be linked to gage records that are created by each template you define. Therefore, when you make a change to the template, you can update all of the records that are linked to it. Because you will electronically check this gage at incremental intervals during calibration, you use GAGEtrak Pro's **Test Point Prefill** feature to automatically create the eight calibration checkpoints required. You'll need a new procedure for calibrating, too. You use *CalPro*, a database of step-by-step calibration procedures that covers everything from gage blocks to micrometers and calipers. Thanks to *CalPro*, you don't have to waste time researching or creating calibration procedures. You can simply import the procedures directly into GAGEtrak Pro. Using *CalPro* also helps your company comply with ISO 9001, IATF 16949 and many more quality standards.

After lunch, you spend the afternoon calibrating some gages yourself. One of the gages you calibrate is the new electronic gage you received this morning. The output from this gage is transmitted through one of the serial ports on your PC. You're using the Software Wedge program to capture this real-time data and automatically insert the gage's measurements into GAGEtrak's **Measurements** screen.

Once you've finished, you use the *Calibration Label Printer* to print out a calibration label for each gage calibrated today. These laminated, durable labels are resistant to oil and water and they're easy to print and apply to your gages.

Now one of your lab technicians tells you that another department needs to borrow a gage and asks if he can just give it to them. You reply, "No, we need to provide accurate issue tracking each time someone uses our gages." You ask him for the **Gage ID** and use the **Gage Transfer** option so that you have an accurate **Location** and **Custodian** assigned to the gage record's **History**. You may have lost this gage if it had gone off to the other department unchecked.

Later in the afternoon, you check on the GAGEtrak **Crib**. Some gages used for manufacturing today are being returned. An employee with a bar code reader is quickly scanning the bar-coded labels on each gage. A second scan across bar-coded department identification completes the gage return information.

Because you expect your auditor to arrive tomorrow, you print the **Calibration Performance By Gage Type** report for the last three months, for all of your gages. You also print the **Standards Traceability** report, which shows all of the reference standards associated with your calibration standards for every calibration. Using GAGEtrak Pro's **Ad-hoc Reporting** capability, you create a quick listing of all of your active gages with only the specific columns you want to display.

Now you have documented proof as to exactly which instrument or standard you used to calibrate each gage. If your auditor asks for more information about your reference standards, you can quickly generate reports showing each one's NIST number, uncertainty, calibration schedule, calibration history, calibration certificate numbers and even the exact calibration measurements, since you've entered this much detail into your GAGEtrak Pro records.

It's time to go home now, and as you leave, you try to remember what your workday was like before you had GAGEtrak Pro. How did you ever manage?

The Result

As you can see, using GAGEtrak Pro and its accessories saved you a lot of time, effort and stress.

1. You easily and quickly generated an accurate **Calibration Schedule**.
2. The **Due List** displayed all calibrations due for the day. Plus, you were able to give your technicians the **Calibration Work Orders** and **Calibration Procedures** they needed for their assigned calibrations.
3. The **Clone Gage** and **Gage Template** feature saved you time. Without it, entering the new gage's information would have taken much longer, not to mention that it would have been a redundant task. These features also ensure more accurate data entry, since you didn't have to worry about as many potential errors.
4. The Software Wedge program instantly inserted your calibration measurements into GAGEtrak Pro; you didn't have to enter anything.
5. *CalPro* gave you proven calibration procedures that were already researched and documented.
6. The *Calibration Label Printer* helped you speedily print durable, easy-to-read calibration labels for each gage that you calibrated.
7. Using **Crib**, you were able to quickly transfer a gage out to another department and avoid the problem of not knowing where the gage is located. Most importantly, you now have an easy way to provide traceable gage usage history for each of your gages.
8. Thanks to GAGEtrak Pro's large variety of detailed reports and ad-hoc reporting capabilities, you can rest assured that you'll be able to quickly and accurately retrieve any calibration information that your auditor asks to see.
9. Finally, GAGEtrak Pro's features and optional accessories helped you with one extremely important task - ensuring your company's standards compliance.

CHAPTER 2: INSTALL & LAUNCH

Now that you've seen how GAGEtrak Pro works, it's time to install your software.

How to Install

Whether you have downloaded your software or requested it on physical media, launch the GAGEtrak Pro executable (.exe) file. It is recommended to install GAGEtrak under computer or domain administrative permissions. Once launched, the **GAGEtrak Pro Setup** screen will open; simply click **Install** to begin. Follow the on- screen instructions to complete the installation.

During installation, the **Data Utility** will open in order to create the database option you select (empty for new customers or sample for demo and training). In the **Connection Name** field, name your database connection; this will make the database connection easier to identify, especially if you plan to have multiple databases e.g., *Fixtures and Assembly Data* or by a location *Memphis Assembly No7*. Select the appropriate **Data Source Type** (use Standard SQLite option unless instructed by your IT team to select one of the other DBMS options provided). The **Database File Name** field is automatically populated; use the default value unless otherwise instructed. Click **Next**. When this process is complete, click **Finish** to close the **Data Utility** window.

If Installation Fails

If you are unable to install or you receive any error messages during installation, please run Windows Update if possible, restart your systems and try again. If installation fails again, please write down any error messages and call tech support at +1 (480) 212-1257 for assistance.

How to Uninstall

To uninstall, go to the **Windows Control Panel -> Programs and Features -> Uninstall or change a program**, select GAGEtrak Pro and click **Uninstall**. Once it has been uninstalled, simply remove the program group from the Start menu and delete the GAGEtrak Pro directories. Note: The database may be stored locally, so please ensure there are no database files that you want to keep before deleting the GAGEtrak Pro directory, i.e., the *Gtdata840.db3* and *Gtdata84_Archive.db3* database files can contain gage and calibration records. Windows 10 and 11 users: by default, GAGEtrak Pro installs to C:\Program Files (x86)\CyberMetrics...

Database Files

GAGEtrak Pro requires two database files to run properly: one for data and another for archived data. These can be created during installation on the first computer and once created, any other installs can use the **Connect to existing** option during installation. The default naming conventions created by the **Data Utility** are **GtData8x.db3** and **GtData8x_Archive.db3**. The archive database is created automatically whenever a primary database is created and this database is utilized solely by the **Archive Manager** application. The archive database file must have the same name as the primary database file. Additionally, the *_Archive* must precede the file database file extension. You can create a database with any name you prefer, but we recommend you keep at least some portion of the default naming convention, i.e., *GtData840_ACME.db3* and *GtData840_ACME_Archive.db3*. Further, do not change the file name once it's created, as you risk losing

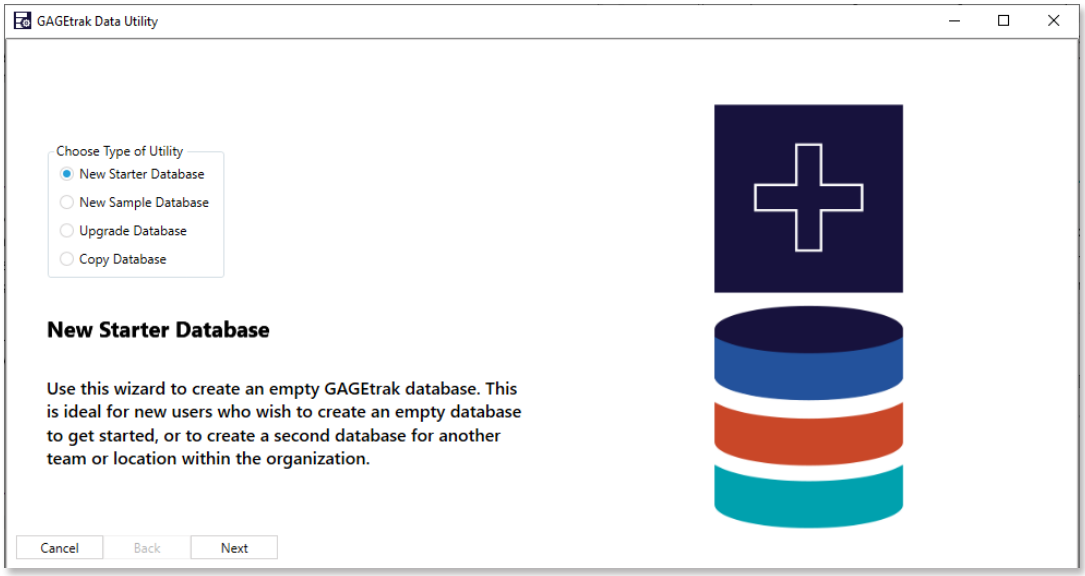
your archive connections or adversely affecting any stored data connections for your GAGEtrak Pro users. If you are utilizing the SQLite option for your GAGEtrak database, the file extension is *.db3*. If using a Microsoft SQL Server, file extensions will be *.MDF* and if PostgreSQL, you will have multiple files, one for each table in the database, with the extension *.mkd*.

Client-server Option

While GAGEtrak Pro can run with a local database, it is designed for client-server environments. The client-server option is ideal if you intend to have several GAGEtrak Pro users share a database. This means that you can place the SQLite database files created during installation on your network share where all users have equal access. As stated in the System Requirements however, GAGEtrak Pro can also take advantage of a Microsoft SQL Server or PostgreSQL Database Management System (DBMS). These options provide a more robust database option for GAGEtrak users who wish to share data more securely or to integrate with other database applications. The **Data Utility** provided with your GAGEtrak Pro installation can be pointed to your specific database host server and it will create the databases required to run GAGEtrak Pro, if you provide a server account with sufficient credentials to do so.

Data Utility

The **Data Utility** is a wizard-driven application used to create GAGEtrak Pro back-end databases for data storage. In most cases, you will only ever need one database for your gage data. Some companies, however, may employ multiple databases to separate operations, such as a separate in-house tooling database and another specifically for production gages. You may also want to create a sample database or copy your existing database for a sandbox or training database. The **Data Utility** can be used to create, upgrade or copy databases, so it is a useful tool to have in your GAGEtrak Pro arsenal. After installation, the **Data Utility** shortcut is available in your GAGEtrak Pro Windows Program Group.



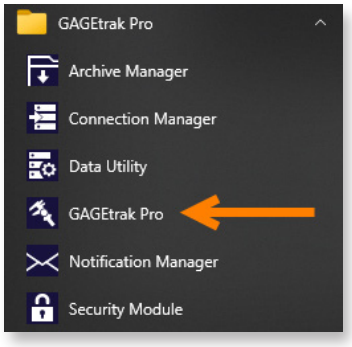
Upgrade Database

The **Upgrade Database** option in the **Data Utility** allows you to browse to and select your existing GAGEtrak databases from previous versions and transfer the data to one of the GAGEtrak Pro databases installed on your system or network.

To transfer and migrate your data from previous versions of GAGEtrak, open the **Data Utility** from the GAGEtrak Pro program group in your Windows Start menu (see **Launching GAGEtrak** instructions below), click the **Upgrade Database** radio button and then click **Next**. Follow the on-screen instructions.

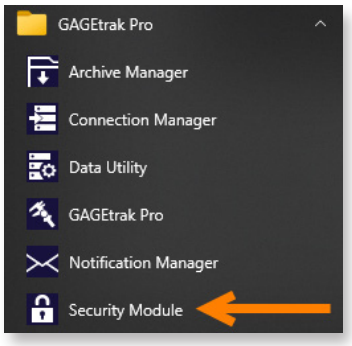
Launching GAGEtrak

Locate the GAGEtrak Pro program group in your Windows Start menu; this contains shortcuts to the GAGEtrak Pro application along with several other utilities and functions. Please do not modify the properties of these shortcuts, as this may affect the program's ability to correctly launch.



Security Manager and Login

GAGEtrak Pro provides a group-level security option, which can be managed and enabled with the **Security Manager**, located in the GAGEtrak Pro Windows program group. If security is activated through the **Security Manager**, the **Login** window will appear upon launch. Enter your User ID and Password in the appropriate fields and then click **OK** to log in.



License Registration and Management

A **License Code** is required to run GAGEtrak Pro. Once launched, the **Register License** dialog will appear and give you the opportunity to enter and validate your **License Code**. Enter the code provided by CyberMetrics or your authorized distributor and click **Check License** to verify and register your account.

GAGEtrak versions 8.2 and higher require a persistent Internet connection for product activation and for on-going license management. Once activated, you will not be prompted for this code again, unless you completely uninstall and reinstall the product. You can view your license code and other registration information in the **About** window within your GAGEtrak software.

Please Note: Your GAGEtrak Pro application requires a persistent Internet connection. Without Internet, the application cannot verify your license and it will not run.

Troubleshooting License Issues

If you are having trouble registering your license code, then you are likely restricted in some way from reaching our license host. A simple test can be performed to determine if you are blocked by going to my.nalpeiron.com. If you can access this site, then our software is being prohibited in some other way from validating your license. Proxy servers and firewalls can restrict certain inbound and outbound traffic and for certain ports or URLs.

Firewalls

In the case of a firewall restriction, you will need to ask your help desk or IT provider if they are restricting this site and if so, request that they whitelist these sites.

- **License Activation and Validation**
  URL: my.nalpeiron.com
  Port 443

Proxy Servers

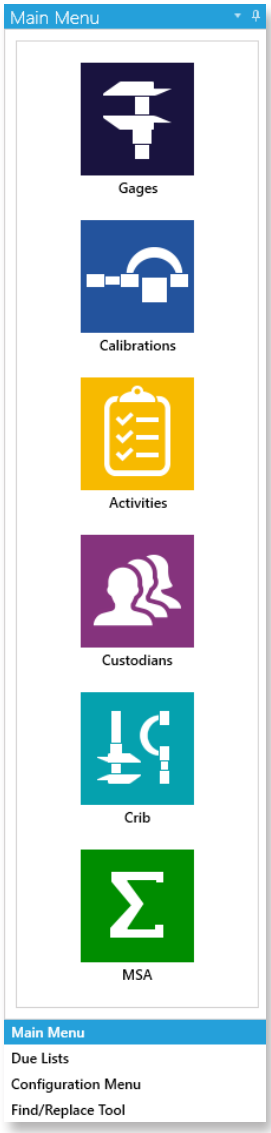
If a proxy server is employed at your location, go to the **About** window (**Help -> About -> License Management -> License Proxy** tab) to enter proxy host and authentication information. This will allow our application to negotiate access to our license host.

CHAPTER 3: CONVENTIONS

To save time and ensure consistency, GAGEtrak Pro uses program conventions, which are standard commands and design elements that make the different windows and forms operate in the same way throughout the application. You should become familiar with these conventions before you begin using GAGEtrak Pro.

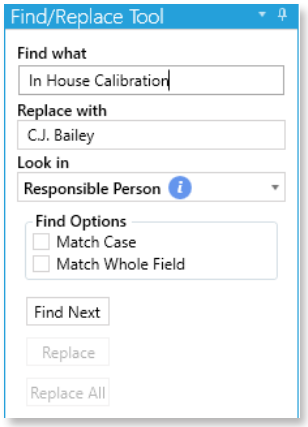
Navigation Menu

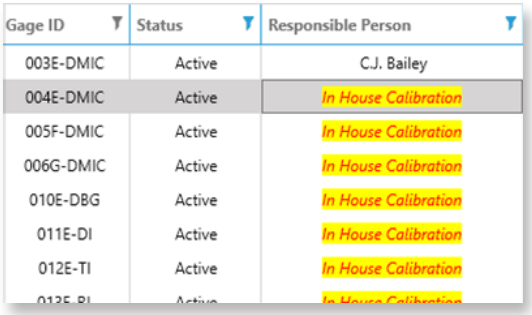
At the bottom of the **Navigation Menu**, you can access the **Main**, **Configuration** and **Due Lists** menus and the **Find/Replace Tool**. The menu pane can stay visible at all times or it can be undocked (by clicking the pushpin icon) to access it only when needed, which opens up more workspace. This menu system gives you the flexibility to quickly navigate to each area of the application without having to close out previously opened forms or losing your place while seeking information from other areas.



Find and Replace Tool

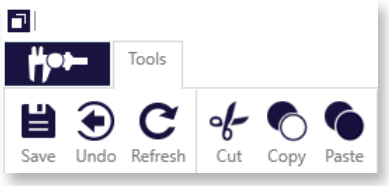
Located at the bottom of the **Navigation Menu**, the **Find/Replace Tool** is very useful for locating and highlighting items in **Grid Views**. This is also a very useful tool for locating and replacing large amounts of data in fields that cannot be managed by the **List Management** capability. Please note, however, that while the **Find/Replace Tool** can be very useful in your data clean-up efforts, you will want to be extremely careful with mass changes, as they cannot be reverted once they are applied and saved to the database. Therefore, it is recommended that you make only small changes at first, until you become more accustomed to its capabilities. Additionally, if you use the **Replace** option in a list-managed field, you can only replace with existing items in that list. Further, the **Find/Replace Tool** is only capable of locating what is currently visible, so filtered records will not be located and the **Find/Replace Tool** or its options will be grayed out or unavailable if the selected items are not applicable to its use.



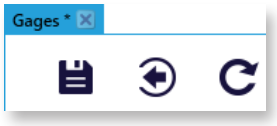


Tools Menu

Available in all entry screens, the **Tools** menu (in the Ribbon) contains common program functions and by default, is minimized. Click **Tools** to temporarily access the menu, or to make it remain open, right-click anywhere in the bar that contains the **Tools** menu and deselect **Minimize the Ribbon**. Use the **Save** function here (or Ctrl + S) to save all record modifications.



Some **Tools** menu items, like **Save**, **Refresh** and **Undo** are also visible in the header of most data entry views. The **Save** and **Undo** icons will be grayed out until a record is modified. Changes to records will activate these icons and an asterisk will appear on tabs or drop-downs to indicate unsaved changes as well. If you attempt to leave a view with unsaved changes, you will receive a prompt to do so before you can exit.



Infotips

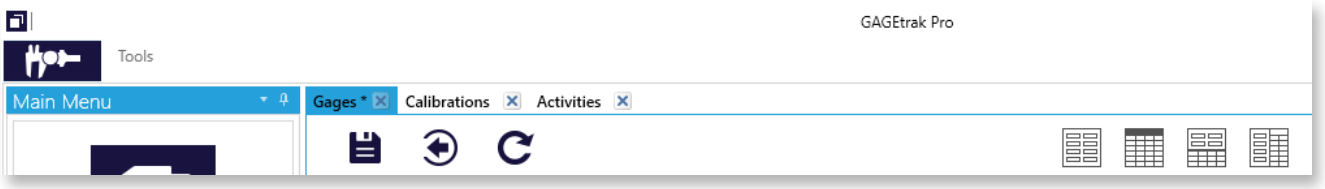
Infotips provide useful information about various features and functions throughout GAGEtrak Pro. Hover your mouse cursor over an infotip icon to get context-related information for that field's purpose or capability.

Backstage Menu

Click the caliper icon to access the backstage menu area from the upper-left hand side of the Main Menu. Available in all entry screens, the backstage menu provides specific application settings, unique to this computer install. From here, you can control settings such as themes and application performance, as well as manage your database connections, email configuration and access license and help information.

Master Tabs

The **Master Tab** feature permits multiple forms to be simultaneously open, so that you can quickly switch back and forth between them. You can even have multiple instances of the same tab open at once, like **Gages**, to compare gage records or view the records in different formats. In the image below, the tab highlighted is the active tab and the asterisk next to the tab name indicates an unsaved record.



Record Navigation Bar

From left to right, the record navigation buttons perform the following functions:

- Go to the first record in the data set.
- Go to the previous record in the data set.
- Go to the next record in the data set.
- Go to the last record in the data set.
- Add a new record.
- Delete the current record (deletion confirmation will ensue).

Record View Options

GAGEtrak Pro provides various options for viewing records: details view, grid view and split-screen views (horizontal or vertical) which simultaneously display record details and a data grid. The details view displays one record at a time; the grid view displays several.

The type of view (details, grid or split) that was most recently used will be retained as the default view the next time you open that entry screen; the default view cannot be deleted.

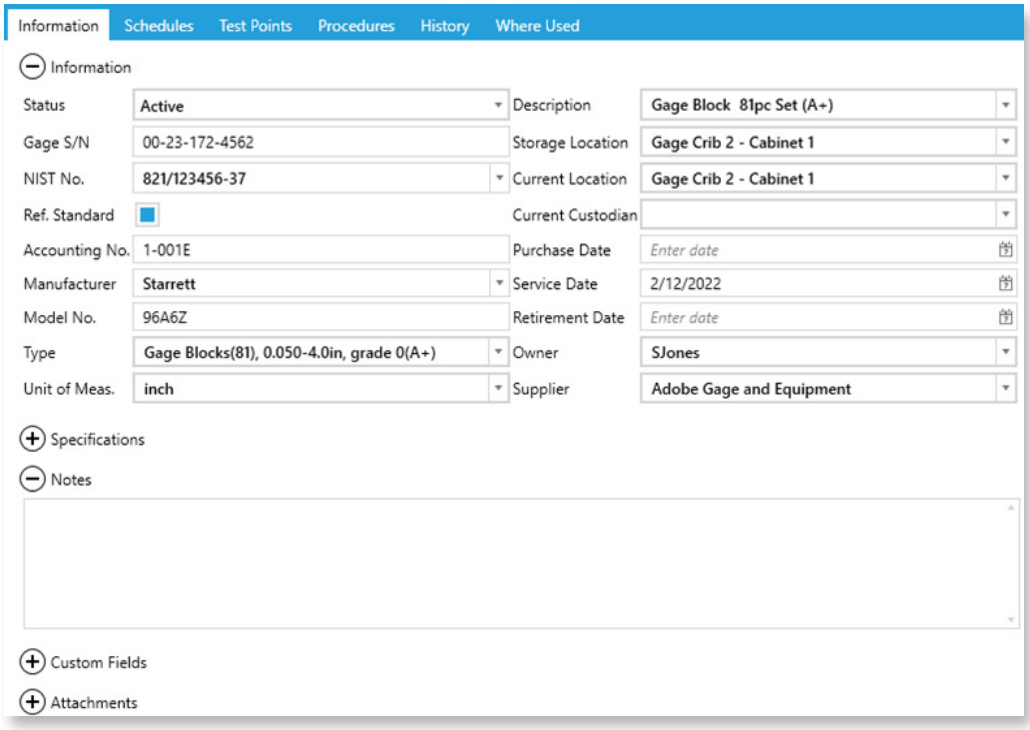
When you make changes to the default view, such as opening group box expanders in the details view or moving columns in the grid view, those changes are retained as your **Current View**. (The **Load View** field will display **Current View**.) The next time you open that screen, your **Current View** will be displayed.

Details View

Record information is displayed as a form when using the details view and unlike grid view, users are viewing only one record at a time. To see this view of any record, click the **Details View** icon: .

Group Box Expanders

Group box expanders save space when in a collapsed state and will decrease the need to scroll on form details that contain more information. If they are left open (expanded), they will be saved as part of any view you are in and will remain open for the next time. In the example below, the **Information** and **Notes** groups have been expanded, while all other groups remain collapsed.



Pop-Up Calendar for Date Fields

You can enter dates by choosing them from a pop-up calendar instead of manually typing them. Whenever you're entering information in a filter or data entry screen that contains a date field, click the **Calendar** icon in that field to open the calendar.

If the date field is blank when the calendar is opened, then the date highlighted on the calendar will be the current date. If there is a date in the field, the calendar will show that date in gray and today's date will be highlighted. Click the left or right arrow in the calendar header to scroll to the desired month and year and then click a day to select it. The selected date will populate the date field.

Drop-down Lists

Drop-down list arrows indicate that a field contains a list of values. When you click the arrow, it presents the list in a scrollable box. Click an item in the list to select it. There are two types of drop-down lists: self-building lists and managed lists.

A self-building drop-down list allows you to manually enter a new value which can be automatically added to the list for future selection, and with no restriction. For instance, the **NIST** field in **Gages** allows a user to enter any applicable value. These fields will typically support auto-fill behavior.

A managed list contains data that is more restricted and may only allow a user to enter new values if the **List Management** configuration permits it. For example, in the **Status** drop-down list in the **Gages -> Information** tab, values for this field can only be created within the **Settings -> List Management** tab. Since this field is restricted, users can only select from existing status values. This data management tool ensures you do not have erroneous data entry to clean up in critical data fields. An administrator, however, can configure some drop-down lists to accept new values from the user, if the user chooses to save the value to the list. In those cases, the user will be presented with a **Save** icon for the new item (like the one below). This can ensure users are prompted to check their work before saving a misspelled value to a list, and therefore, saves on data clean-up efforts later.

Grid View

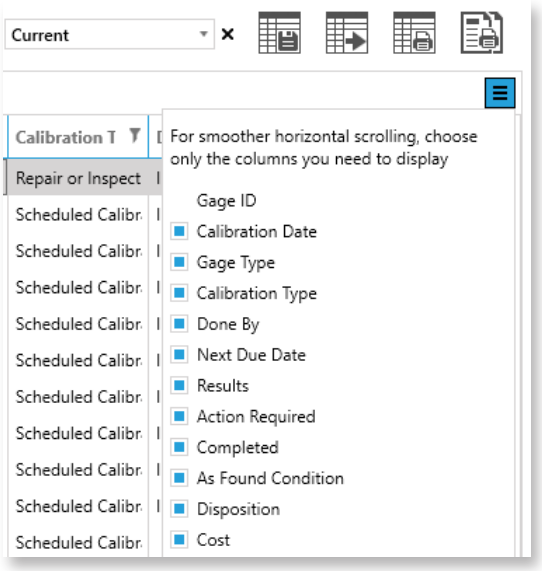
Grid View operates similarly to a spreadsheet program, displaying many records at once, so it can be a more efficient interface for adding or modifying your records. Click the **Grid View** icon . Each row represents a record and each column represents a field. In grid view, you can view, add and edit records.

Click on a row to select that record. If you were to then click the **Details View** icon, you would see the details view of that particular record. When a record is selected, you can delete it by clicking the Delete icon in the record navigation bar; deletion confirmation will ensue.

With the exception of ID fields, most other fields can be altered in Grid View by simply clicking on them to enable the cursor. Always save modifications by clicking the Save icon .

Column Chooser

Located in the upper-right corner of the grid is the **Column Chooser** icon ☰. This is an invaluable tool for setting up your views and ad-hoc report output. You can use drag-and-drop to position columns in your grid view from within the column chooser window or directly from the grid. Use the checkbox to the left of each item on the chooser window to make it visible in your grid views or to remove it.

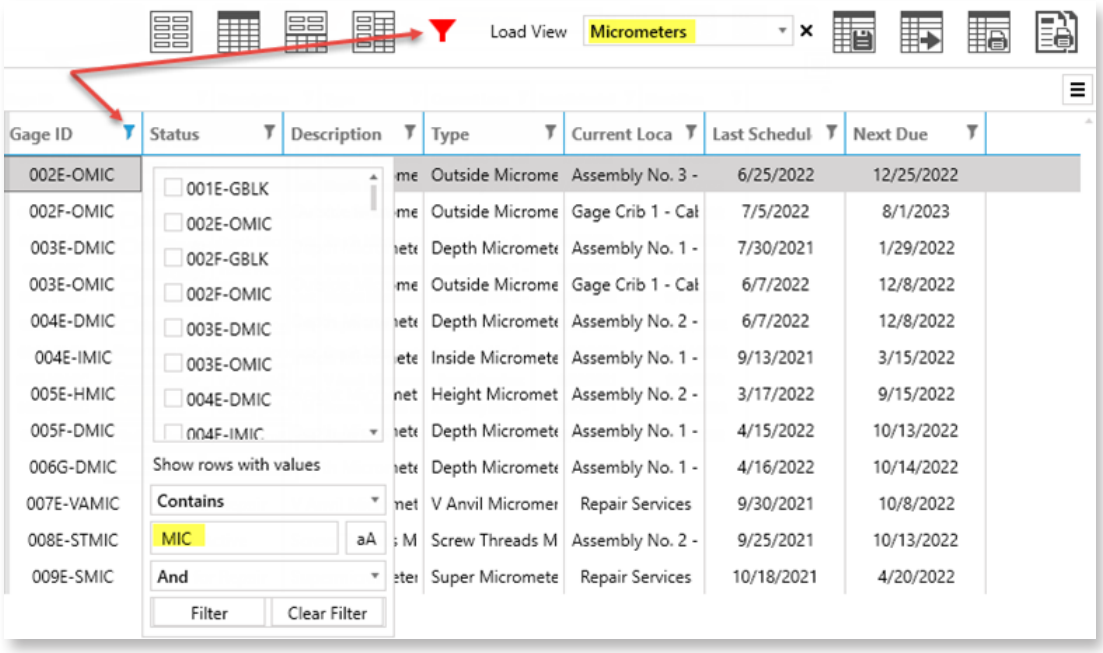


Sorting Records

In grid view, each column header contains the name of the field that it represents. When you click a column header, you sort your records by that field. Click once for ascending, again for descending and a third time will remove the sort on that column. A small black arrow is visible on fields that have been sorted by the user. Note: Most views have a default sort order, typically by the identification fields, such as **Gage ID** or by date, such as **Calibration Date**. If you change the sort, it is saved automatically and the next time you return to that view, your previously selected sort will remain (see the **Saving Views** section).

Filtering Records

In grid view, each column header contains a **Filter** icon . Click that icon to see the filtering options. In the example below, gage records are filtered to show every gage whose **Gage ID** contains MIC (filtering for micrometers). After entering your filter criteria, click the **Filter** button. When no filter is active, the filter icon in that column is gray; when a filter is active, the filter icon is blue and a red filter indicator will be visible in the header (this is to notify the user that a the current records are filtered and may not be displaying all of the records in the database). To remove a filter, click the blue filter icon and then click **Clear Filter.**

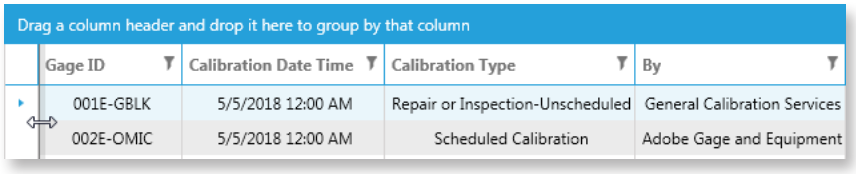


Saving Views

After filtering records, you can save your filter criteria for future access. It is also important to note that saved views are also used to generate reports and email notifications. Click the **Save View** icon , enter a name for your filter and then click **OK**. To use that filter later, select it from the **Load View** drop-down list. To delete a previously saved view, select the view and click the red X; confirm the deletion. Saved views will only be visible to you, unless you check the **View Sharing** option provided. Once shared, any user can see and manage that saved view. Views are a great option for presenting your data in several ways and we think you will find them to be an invaluable tool for viewing and managing your data.

Freezing Columns

When in grid view, there is a vertical gray bar at the left of the grid. Hovering over the bar with your mouse will change the mouse pointer to a double arrow. Click and drag the bar to the right; any columns of data that remain to the left of the bar will be frozen for scrolling.



Exporting Records

To export records from grid view, click the **Export** icon , select an export format, browse to a destination location, enter a name for your file and click **OK**. Any records that are currently visible in that view will be exported. For example, if your grid view is filtered to show only micrometers, then your exported output will only contain those micrometer records. Note: This capability is also available in detail view, but it is easiest to export from grid view, so that you can determine which columns will appear in your export.

CHAPTER 4: SETTINGS

Before you begin entering records, we recommend that you first configure GAGEtrak Pro. From the **Configuration Menu**, select **Settings**.

Settings – Information Tab

Enter a **GAGEtrak Instance Name** if you intend to utilize GAGEtrak for MQTT Publishing. This is the unique name for you GAGEtrak instance, which is used in MQTT and other applications (see the **Settings – MQTT Publishers Tab** section). If you will not be utilizing the MQTT Publisher capability in GAGEtrak, you can leave this field blank.

Enter your company's information in the **Company** group box. Your company name and division name will appear in your report headers. Here you can also enter your text that will appear on certificate reports, as well as your company logo which will be displayed on all reports. Ideally, your logo will be 200 pixels wide x 84 pixels high. If you already have a logo file (.jpg, .png or .gif), click **Insert Object** and then browse to and select the file; the graphic will be displayed in the **Logo** field. If you do not have a logo file, but your logo is displayed in another document, you can use a screen capture program to capture the graphic and then copy it to the Windows clipboard. In GAGEtrak Pro, you would then click the **Paste Logo** button and the graphic will be displayed in the **Logo** field. Click the **Save** icon.

Settings – Calibration Tab

The **Calibration** tab provides configurations for calibration-related items.

Default Reports

Here you can select the reports that appear by default when you click the **Print Report** or **Print Label** buttons found in **Calibrations** (bottom of details view or on the right-click option in grid view). Choosing the defaults here will mean that you do not have to select these each time you create a new record.

CyberSensor Settings

This section is only utilized if you have purchased the CyberSensor add-on product. The CyberSensor can be used to automatically populate the **Temperature** and **Humidity** fields in **Calibrations** with the current room temperature and humidity. Since the CyberSensor unit itself cannot be adjusted during verification, it may be necessary to enter a temperature correction if one is provided. For example, if a CyberSensor is found to be off by -0.25 degrees Fahrenheit when tested against a master, then you would enter the correction value of .25 here to ensure that an accurate temperature in populated when that CyberSensor unit is selected during your calibration. The **Serial Number** differentiates one CyberSensor from another should you have multiple units in use.

Settings – Schedules Tab

Skip Days and Skip Dates

GAGEtrak Pro lets you define dates that you want skipped when it calculates calibration due dates. These skip dates or skip days might include holidays, vacation periods or plant shutdown periods. To skip days of the week (like weekends), check the box next to each day of the week you want to skip. To skip specific dates, enter those dates as either single dates or as a range. Enter as many skip dates as necessary. To delete a skip date, simply highlight and delete the contents of the field.

If a calculated calibration due date falls on a skip day or date, GAGEtrak Pro schedules it on the following or previous working day, depending on the **Skip Date Direction** setting for each gage. Here in the **Schedules** tab, you set the default **Skip Date Direction** which is used for any gage that does not have an individual skip direction applied.

Changes made to skip days and dates will not automatically change any existing due dates. Only due dates calculated after the changes are made will have the skip days and dates taken into account. Recalculate any existing due dates to use the new skip day or skip date settings. If you manually enter a calibration due date, GAGEtrak Pro won't apply your skip dates to it.

Date Formats

GAGEtrak Pro supports all of the available numeric date formats within Windows. For example, you can represent the date of November 1, 2022 as 11/1/22, 11/01/22, 11/1/2022, 22/11/1, 22/1/11, or 2022/11/1.

Because GAGEtrak Pro's reports use only numeric dates, you can select only numeric date formats. Therefore, you can't use dates like *November 1, 2022*.

As a precaution, you may want to verify your date settings in Windows. Click the Windows Start button and navigate to the **Control Panel -> Region -> Formats** tab. The date formats that you enter into GAGEtrak Pro must match the Windows date setting; otherwise, errors will occur while you're running the program.

Due Listings Settings

In the **Due Listings** pane, set how far out GAGEtrak Pro should display schedules as due or past due for calibrations and due and past due flags on the **Gages** detail form. Here, you can also decide to include past due schedules in Due Listings.

Settings – Automatic Numbering Tab

GAGEtrak Pro can automatically generate a number sequence for your calibration certificates and gage IDs. Use this form to set the desired format or leave the format fields blank for standard, incremental numbering. After deciding on a format, be sure to enable automatic numbering by checking the corresponding checkbox.

Use a question mark (?) for incremental letters and the pound sign (#) for incremental digits. For letters or numbers that will not be incremental, enter the text as you want it to appear in the automatically generated

number. These letters must all be capitalized. If you want to include date information in the automatic number, use the following date codes in your format:

dd = numeric day of the month (01 to 31)

ddd = text day of the week (Sun to Sat)

mm = numeric month (01 to 12)

mmm = text month (Jan to Dec)

yy = two-digit year (16)

yyyy = four-digit year (2016)

Settings – List Management Tab

Earlier in this guide, we touched on drop-down lists and it is here, in **List Management**, that you can configure how the lists will behave and manage their content. The options here allow you to configure and control the content of common list boxes found throughout GAGEtrak Pro.

Gage Status, **Gage Type** and **Calibration Type** are just a few examples of data that you will come to rely on when locating records. Therefore, how you control the user's interaction with these data objects is integral to keeping a searchable and comprehensive database. The value of managed lists is that you can limit the collection of bad or erroneous entries that tend to collect in a database over time. In many cases, you will inherit this data, and managed lists will give you the means by which to clean it up and control future entries.

In addition to controlling the data that populates these important lists, you can also control how GAGEtrak Pro will interact with these values. For instance, you can determine if GAGEtrak Pro will ignore due dates for gage records in your system that have a **Status** value of **Scrapped**. You can also control if users are allowed to create records from assignment fields, i.e., allow a user to create a new **Custodian** record when assigning **Responsible Person** on a schedule.

Also managed here is the **Calibration Signature Level**. Should you decide to use the electronic signature functionality available in GAGEtrak Pro, this area allows you to add or remove electronic signature levels for your calibration records; depending on your quality process, you may need more than one individual to sign on a completed calibration.

Settings – Custom Tab

Though GAGEtrak Pro provides an abundant number of fields for storing data in each category, you may find you need still additional fields.

For this reason, each major entry screen accommodates six additional user-definable, custom fields. In this tab, you can create your own custom field labels for each of the six fields provided in each part of the program. There are four text fields, one date field and two list box fields for each major application screen.

Also found in this tab is a data administration tool for removing saved views when they are no longer needed or they have ceased to function. If a saved view becomes corrupted, for instance, the users will often be blocked from accessing that view as a result. By removing a corrupted view here, you can restore the default view for that section. You can also reassign Custom Views if, for instance, a staff member leaves, but you want to retain that person's saved views.

Settings – MQTT Publishers Tab

MQTT (Message Queuing Telemetry Transport) is a lightweight messaging protocol ideal for low-bandwidth, high-latency or constrained environments. It supports real-time, decoupled communication between devices and systems.

MQTT allows devices to publish messages to a central broker, which then sends those messages to all devices or applications that subscribed to that topic. For instance, in a smart factory, a temperature sensor can publish readings every second. The quality control system subscribes to those readings to make real-time decisions, while a historical analytics tool also subscribes to log the data.

GAGEtrak is an MQTT Publisher. This means that any changes to gage or calibration data can be published to a Broker in your MQTT ecosystem.

If your organization is utilizing IIoT (Industrial Internet of Things) in your facility, it is possible to add your GAGEtrak client to that ecosystem by establishing an MQTT Publisher in this tab. Once established, your GAGEtrak client will begin publishing gage or calibration data to either JSON files or to URI, which can then be processed by a Broker in your ecosystem or by the GAGEtrak MQTT Broker application (purchased separately).

A typical use case is sending Gage Status, Next Due Date or Current Location to an SPC or other quality management application that is capable of subscribing to MQTT topics. Once configured, GAGEtrak will publish any changes in **Gages** or **Calibrations** to a JSON file or to a URI (Uniform Resource Identifier).

IMPORTANT: You will likely need assistance from your information systems or integration team to assist in setting up the MQTT Publishers. Do not attempt to set up a Publisher record without knowledge of your MQTT ecosystem.

CHAPTER 5: BASIC RECORD ENTRY

Gages

To begin entering your gage records, select **Gages** from the Main Menu. This is the primary view where all of your gage records are created and tracked in GAGEtrak Pro.

Gages – Information Tab

To create a new gage record, click the **New Record** icon ⊕ in the record navigation bar. You must enter a unique alphanumeric identification code (**Gage ID**) for each gage in the **Create New Gage** window. For consistency and efficiency, you'll need to develop your own ID numbering system. Avoid using special characters in your IDs or other fields, such as quotation marks or ampersands. See the **Settings -> Automatic Numbering** tab section for information about automatic numbering for gages.

To search for a particular gage record for viewing or editing, you can locate and select it in grid view, use the **Gage Quick Search** field, or use the **Gage ID** column filter in the grid.

To the right of the **Gage ID** field is a date field, the name and color of which change depending on the gage's calibration status. Upon creating a gage record, this field will not be visible until the calibration **Schedule** tab is complete with a **Next Due** date.

Additionally, if the gage's **Status** value is configured to ignore due notifications, then the **Next Due** date field and related flags will also not be displayed. See the **Settings -> List Management** tab section for how to set **Status** values to be included in due listings. The **Status** field is an invaluable search tool and is an important indicator as to whether gages are tracked for calibration or available for transfers within GAGEtrak Pro.

Check the **Ref. Standard** checkbox to indicate that the record is a calibration reference standard (such as a gage block or reference weight). Enter NIST numbers for reference standards traceability.

Transfer Gage

The **Transfer Gage** option is a companion to the Crib capability in GAGEtrak Pro. This provides a quick and easy way to transfer a single gage to a new location, work center or job. While the Crib will let you transfer more gages in one batch transaction, and it will offer more control over gage transfers, the **Transfer Gage** option will utilize the same steps and rules established in the **Crib Settings**. You can see more on Crib functionality later in this guide.

Gage Cloning and Gage Templates

If you want to copy a particular gage record, including its set of calibration test points and procedures, click the **Clone Gage** button (located at the bottom of the **Gages** window). The **Clone Gage** window will appear. Enter a new **Gage ID** (or if you are cloning a gage in a series and want to name the new gage similarly, select an existing **Gage ID** from the drop-down list and then modify it to be a unique value). Click **OK**. The new gage record will be displayed, allowing you to enter the gage's unique information.

Alternatively, you can create new gage records from pre-defined **Gage Templates**. When you create a new gage record, you will see the option to create **From Gage Template**. This option not only saves time, but also provides you with a valuable tool for updating information on linked templates in the future. Gages that are created using a given template are linked to that template record. Therefore, any changes you make to the template can be used to update en masse for gage records that share the same template link. Note: For users of previous GAGEtrak products, the Gage Template feature expands on the Test Point Group and Standards Groups capabilities.

Renaming a Gage

To change the Gage ID of a particular gage, click the **Rename Gage** button (or right-click on the gage record) and then follow the on-screen instructions. When finished, click **OK** and then click **Yes** in the ensuing confirmation message.

Gages – Schedules Tab

In this screen, you will set up the schedules for each gage. While the primary focus of GAGEtrak Pro is the calibration schedule for your gages, there are also **Reminders**, **Activities** and **MSA** scheduling options.

When you first enter the gage record, be sure to enter the gage's **Last Schedule Date** for each of the schedule options you want to track. Later, the program will automatically update this field as you create and complete historical records for each of the schedule options, i.e., creating and completing a calibration record for the gage will automatically update the **Last Schedule Date** and the **Next Due** date.

As stated above, the **Next Due** field is automatically updated whenever you create and complete an associated calibration, activity or MSA record for recurring schedules (**Next Due** = **Last Schedule Date** + frequency). Any recurring reminder schedules will reset when the current reminder due has been dismissed.

To manually calculate the next due date immediately after you have entered a frequency and last schedule date, click the **Calculate** button. If required, you can also manually enter any date into the **Next Due** field. It is important to understand that the **Next Due** date provided determines what will appear on your **Due Lists** and which other notification methods will appear. In **Gages**, the **Next Due** field label will be replaced with **Due** or **Past Due**, based on the current operating system date. Please note that gage records with a **Status** value that is configured to be excluded from due lists will not display a **Due** or **Past Due** flag.

Schedule Frequencies

Choose from standard frequency units (Daily, Monthly, Yearly or One Time). The **Recurs every** options allow you to select the specific number of frequency days, months or years required to calculate next due dates. You can also choose from specific recurrence points, such as the first Monday of every 24 months. The recurrence options provided give you flexibility and control over your scheduling.

Pausing Schedules

Pausing a gage's schedule can be used to limit the days the gage progresses toward the original specified due date for that schedule. For instance, gages that will only progress towards a scheduled calibration due date for days the gage is actually in use, could be paused whenever that gage is returned to the crib and is no longer in use in production. A gage's schedule can be paused manually from the **Schedule** tab, or it can be automatically paused when it is transferred using a rule that pauses the schedule, i.e., transferring a gage using a **Return to Crib** rule.

The **Allow Pause** feature in GAGEtrak should be used for crib gages that may spend significant time in storage before or in between uses. It is also highly recommended that only the **Daily** frequency option be used for gages that will have their schedules paused (a Yearly or Weekly schedule may yield confusing results). Therefore, the **Pause** capability is intended to be measured as usage days, days in use, etc. **Allow Pause** should also not be used to count cycles of use or times used in a given day.

You should not use the **Pause** feature for gages that have fixed schedules. If you put a calibration sticker on your gages, you will have to print a new label once the gage schedule is resumed, since it will now have a due date further into the future.

The **Pause schedule when calibrated** option means the gage will not have its next due date calculated when a calibration record is completed. Instead, the next due date will be calculated only when the gage schedule is resumed, i.e., once the gage is transferred out of the crib for use. This option is ideal for outsourced calibrations when gages are returned sealed and will not be placed into service immediately.

Time Left and **Time Used** are read-only fields that provide visibility into the times calculated at the last **Pause/Resume** cycle. They do not necessarily reflect the current time left, however, as this will change as days have elapsed since the last **Pause/Resume** cycle.

If you want to create an ad hoc report on how many days a gage has been used, or how many days remaining until due, the **Time Left** and **Time Used** fields are visible columns in the datasheet view. You can use the available column filters for more precise report results. Pausing can be a great tool for extending calibration due dates to reduce calibration time and expense. Do be cautious, however, as extending due dates in this way can have an adverse effect on your quality management effort if it is not monitored closely. You can achieve a similar result by identifying the ideal calibration frequency based on common frequency adjustment factors or stability study results.

Pause and Resume Simplified:

- **Pause** stops time
- **Resume** starts time
- **Calibration** resets counters, but does not stop time (unless configured)
- Each **Resume -> Pause** cycle = 1 full day of **Time Used** (even on the same day)
- No valid start date = no **Time Used**

Skip Date Direction

If a calculated calibration due date falls on a skip day or date, GAGEtrak Pro schedules it on the following or previous working day, depending on the **Skip Date Direction** setting for each gage. However, you can set the default skip direction in the **Settings -> Schedules** tab.

Gages – Procedures Tab

Procedure records must first be entered within **Procedures** and then will be available to link to a gage in this screen. Click the **New Record** icon (under the **Procedure Name** field) and then select a procedure from the **Procedure Name** drop-down list; the **Procedure Text** will auto-fill. The text is not editable in this screen - only in the **Procedures** data entry area.

Under the **Procedure Name** field is a record navigation bar that pertains to this subset of procedure records; gages can have multiple procedures assigned. To add another procedure to the gage, you would click the **New Record** icon in this bar and then select another procedure to link to this gage.

Gages – History Tab

The group box content in this tab has been designed to provide a quick look at important historical information for each gage record, such as calibration history. This is very useful in an audit situation, as you will have immediate access to a gage's complete history all in one tab. For a detailed look, right-click on a record to open it in its native view.

Gages – Where Used Tab

This tab contains valuable information regarding where a gage is used within your organization. Link your gages to product, authorized persons and even specific measurement ranges the gage can support.

Calibrations

The **Calibrations** window is where you will establish your history of calibration for each of your gages in your GAGEtrak Pro inventory. To enter calibration records, select **Calibrations** from the Main Menu.

Calibrations – Information Tab

When you first open this screen, GAGEtrak Pro displays the most recent View. By default, the records will be sorted to display the most recent calibration records. However, if you have sorted by a different field, such as **Gage ID**, then the default sort will be removed and when you later return to the **Calibrations** screen, records will be sorted by **Gage ID**.

From the **Information** tab, you will be able to document many details about each calibration. Once a calibration record is checked as **Completed**, the **Next Due** date will be calculated and several of the fields in this record will be locked to avoid accidental changes to the historical data. If you want the records completely locked and controlled, see the **Electronic Signature** section of this guide.

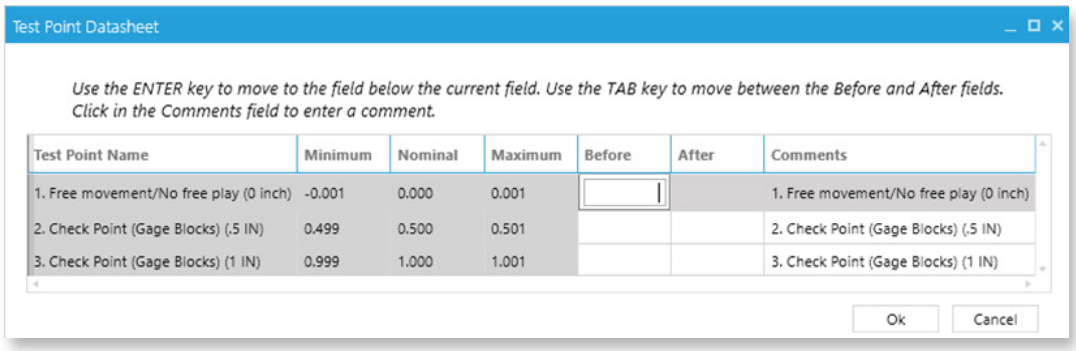
To create a new calibration record, click the **New Record** icon and then select the desired gage from the **Gage** list (or select multiple gages to batch create calibration records). GAGEtrak Pro automatically displays the current operating system date. If you have selected multiple gages, you can assign them all the same calibration date, calibrator (**By**) and **Calibration Type**. You can also alter the gage's **Status** and **Current Location** in this window.

Calibrations – Measurements Tab

This form accommodates measurement documentation for your calibration or verification inspections. If you have defined **Test Points** in the gage record, those will carry over here in the **Measurements** tab.

GAGEtrak Pro supports multiple reference standards on each test point, so that measurements that utilize a combination of master standards will be documented for standards traceability. Measurements can also contain multiple tolerances within a single calibration. This permits accurate tolerance recordings for gages or instruments that support multiple +/- tolerances. You can use this screen to compare the actual before and after measurements of the gage with the standards that you use to calibrate the gage.

The **Test Point Datasheet** button provides a rapid data entry grid, so that measurements can be entered quickly using Tab stops. This grid is also useful for collecting data from external sources, such as the WinWedge Pro solution or from a USB or RS232 serial-enabled gage.



Calibrations – Procedures Tab

In this screen, you can see any calibration procedures linked to the gage record; procedures are read-only in this area. If you click the **View** button, the procedure will open in print preview in a separate tab, which can then be printed or exported to a supported format. To edit procedure records within GAGEtrak Pro, go to **Procedures** from the Configuration Menu.

Calibrations – Signature Tab

Should you decide to use the electronic signature functionality available in GAGEtrak Pro, this **Signature** tab will allow you to digitally sign and lock each calibration record. This will ensure that the historical record for each calibration cannot be modified or tampered with after the fact. The record can be unsigned if needed, providing a digital record with justifications for doing so. Based on your quality policy, you can also specify as many signature levels as are needed, and in what order they must be signed or unsigned. You must have GAGEtrak Pro Security enabled to utilize this feature.

CHAPTER 6: PRODUCTIVITY TOOLS

Due Lists

Select **Due Lists** from the Navigation Menu. The GAGEtrak Pro **Due Lists** feature organizes and presents pre-filtered information in an easy-to-read format and allows for interactive record navigation. **All Schedules Due** is useful for providing line managers with a comprehensive listing of every upcoming gage schedule, while the **Calibrations**, **Activities**, **MSA** and **Transfers Due** lists provide the breakdown for each.

The **Current Range** shown at the top left of a **Due List** is dictated in the **Due Listings** section of the **Settings -> Schedules** tab, such as 30 days, 90 days, etc. Past due items will be anything older than the current date, and for gage status values that meet the criteria. If you do not wish to display **Past Due** information, this can be disabled in the same area of **Settings**. In the grid portion of any due list, click any column header to sort the data by that field.

To create a record directly from this list, such as a new calibration record, first click the checkbox associated with the gage (or select multiple gages this way) and either click the **New Record** icon in the record navigation bar or use the record's right-click menu and select **Create calibrations for selected gages**. You can also view the gage's open records from the right-click menu (this is useful to avoid creating duplicate records for due items).

Calendar

The **Calendar** provided in the **Due Lists** menu is a companion to the standard listings that allows you to see items due in a daily, weekly or monthly perspective. The **Calendar** differs from the **Due Listings** in that it is not only a valuable visualization tool, but also provides an easy drag-and-drop capability to reschedule items when conflicts are found. Simply drag a due item to a new date in that month to easily reschedule. Be mindful, however, that while this will assign a new due date for that gage, you may already have gage labels or other reports issued that will reflect the previous due date.

Activities

From the Main Menu, select **Activities**. This feature allows additional scheduling opportunities for gages (this feature replaces **Additional Schedules** from GAGEtrak version 7). You can assign multiple activity schedules to any gage record using pre-defined activities or activity templates. Activities can be used to schedule non-calibration events, such as pre-calibration surveillance or maintenance activities, i.e., 6-month gage inspection or 90-day maintenance.

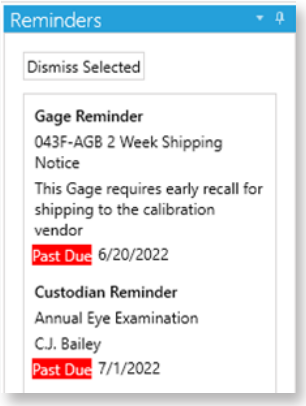
The **Activities** data entry screen is provided so that you can create a historical record of when activities occur with complete procedures, steps and other notes. Completion of an activity record will reset the next activity due for that gage and activity history will be saved in the **History** tab for each gage record. There is no limit to the number of activity schedules you can assign to a gage and any upcoming or past due activity schedules will appear in the **Activities Due List**, reports and other notifications.

Custodians

A custodian is any entity (human or organization) that may have custody of a gage at any given time, past or present. A custodian can be a calibrator, gage end-user, vendor, supplier or customer. Custodians can also be authorized persons, notification email recipients or GAGEtrak security users. If you have migrated to GAGEtrak Pro from a prior version, your **Supplier** and **Staff** records will be found here, with a **Custodian Type** of Supplier or Staff, respectively. The **Custodians** section can be an invaluable tool for tracking the human and organizational influence on a gage's life cycle.

Reminders

Reminders are visible only within the GAGEtrak applications and can be used to provide in-window notifications of things that do not require a historical record to be created. For example, you can set a reminder on a gage record to remind you two weeks before a gage comes due to recall it early for shipping to a vendor or you can set a reminder on custodian records to remind you when eye exams are due for your staff. Reminders can be one-time or recurring and there is no limit to the number that can be set. In the upper right corner of the program window, hover over or click **Reminders** to see a list of all reminders coming due. You can also view due and upcoming reminders in your due lists.



Reports and Labels

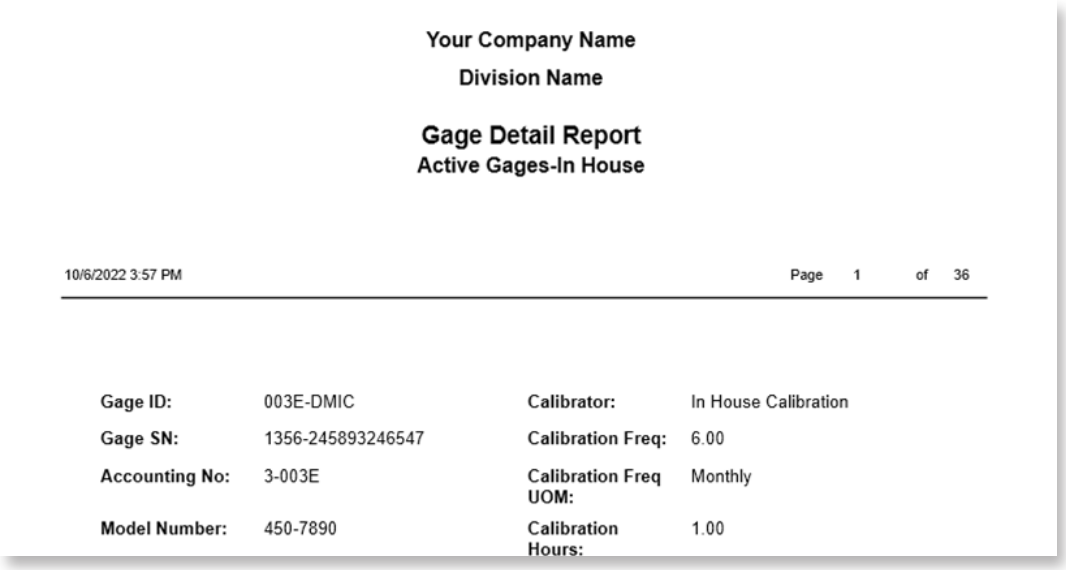
GAGEtrak Pro provides ample reporting in each relevant area of the application. For example, any reports related to your gages and their upcoming schedules can be run directly from the **Gages** screen. For historical and calibration-related reports, locate these in **Calibrations**, etc. Reporting in GAGEtrak Pro was designed to provide report output from the very screens in which you are working day to day, rather than having to access a separate section of the program for reporting. As covered earlier in this guide, any **Saved Views** you created in each entry screen can be used to generate report output from your filter results. Reports in GAGEtrak Pro are available in two formats, ad-hoc listings and canned reports.

Ad-hoc Reports

Ad-hoc reports are customizable and allow more control over the content of your report listing. The **Column Selector** and **Saved Views** mentioned earlier in this guide will allow users to not only select the columns that will appear on the ad-hoc report, but also control the sort order and specific records that will appear on the report output. Creating and saving pre-filtered views will play a pivotal role in ad-hoc reporting; when emailing reports on a schedule, you specify in the **Notification Manager** which view to use for the report output when it is sent to your recipients.

Canned Reports

The canned reports available in each major view are pre-formatted reports designed for each particular need. Reports such as Calibration Certificate, Gage Detail and Calibration Work Order are among a few examples of these purpose-built reports. Like the ad-hoc reports, the canned reports in GAGEtrak Pro will also use your saved views for output. For example, if you are currently on a view that contains only your active, in-house gages, then the Gage Detail Report output will only contain these records. You can also use the **View Name** to your advantage, as it will appear as a subtitle on all of your reports, such as in the example below using our Active Gages-In House view name.



Your Company Name

Division Name

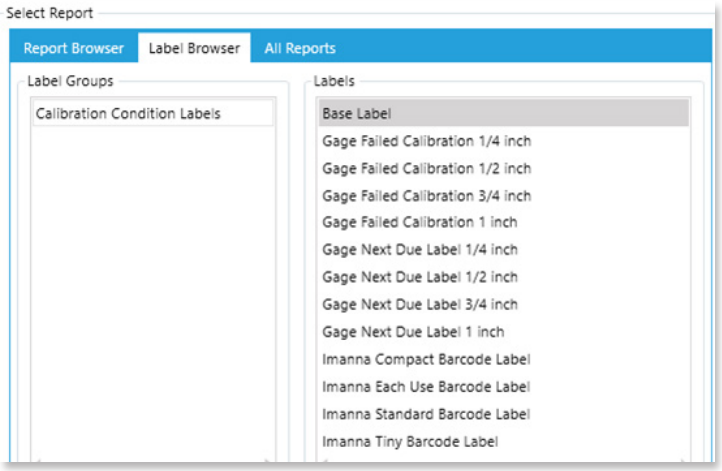
Gage Detail Report
Active Gages-In House

10/6/2022 3:57 PM Page 1 of 36

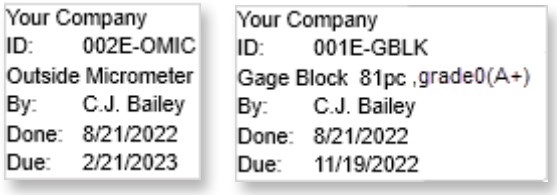
Gage ID:	003E-DMIC	**Calibrator:**	In House Calibration
Gage SN:	1356-245893246547	**Calibration Freq:**	6.00
Accounting No:	3-003E	**Calibration Freq UOM:**	Monthly
Model Number:	450-7890	**Calibration Hours:**	1.00

Labels

Gage and calibration labels are also considered to be report output. Therefore, the labels are accessible via the **Canned Report** sections, where applicable. Various sizes of labels are available for both your calibration and gage records.

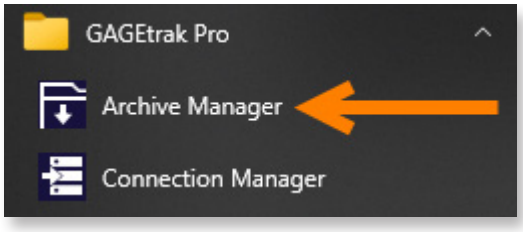


It is important to note that the sizes specified are for the height of the labels only, not the length. In the example below, the 1" label report output is one inch tall, but length will be dictated by the data that is presented, and hence may be a little longer for one gage record than it is for another.



Record Archiving

Over time, you will inevitably build up significant historical data for your gages, and this can create a great deal of clutter when you are navigating your records. Deleting historical data from your primary database is one way to reduce clutter and improve application performance but can result in findings or compliance issues with customers and auditors. For this reason, GAGEtrak Pro has a dedicated **Archive Manager** application, which can be accessed from the GAGEtrak Pro Windows Program Group. The **Archive Manager** application presents read-only data from your current GAGEtrak Pro database connection and allows you to archive and unarchive historical data such as calibrations and transfers. Therefore, the **Archive Manager** is a safe and effective way to remove records from your primary database and safely store them elsewhere.



CHAPTER 7: CRIB

GAGEtrak Crib is a full-featured crib management solution. The Transfers component of the Crib is intended to give you the ability to track your gages though their entire lifecycle by providing detailed information about where and when they have been transferred, as well as what products and product characteristics they were used to measure or compare. This information is critical should you have a product recall or if a recalled gage is found out of tolerance. Further, GAGEtrak Crib will give you better control over gages with its comprehensive transfer rules, allowing you to automatically pause or resume schedules and update gage status, locations and custodians depending on the transfer options you choose.

While GAGEtrak Crib gives you the ability to transfer multiple gages simultaneously, users can also transfer gages individually from the Gages screen in the GAGEtrak core application using the Transfer Gage button. This provides a quick and easy way to transfer a single gage on the fly and it can even use the same transfer rules established in the Crib application.

Whether your gages are routed from location to location, or they are issued and then returned to your crib, GAGEtrak Crib has you covered.

Installing Crib as a Separate Application

Continue with this section only if you are installing Crib as a separate application, i.e., you are connecting Crib to a GAGEtrak Pro database without having full access to GAGEtrak Pro. You will also need to see the License Code and Product Activation section of this guide.

Whether you have downloaded your software or requested it on physical media, launch the GAGEtrak Crib executable (.exe) file. It is recommended to install it under computer or domain administrative permissions. Once launched, the **GAGEtrak Crib Setup** screen will open; simply click **Install** to begin. Follow the on-screen instructions to complete the installation.

During installation, under the **Database Type** option, you can select to connect to your existing database or to connect later from the application. If you select to connect to your existing database, a **GAGEtrak Connect** window will display. In the **Connection Name** field, name your database connection; this will make the database connection easier to identify, especially if you plan to have multiple databases. Select the appropriate **Data Source Type** (use Standard SQLite option unless instructed by your IT team to select one of the other DBMS options provided). The **Database File Name** field is automatically populated; click the **Browse** button and navigate to your GAGEtrak database and select it. Click **Save and Connect**.

If Installation Fails

If you are unable to install or receive any error messages during installation, please try again. If it fails again, please write down any error messages and call tech support at +1 (480) 212-1257 for assistance.

How to Uninstall

To uninstall, go to the **Windows Control Panel -> Programs and Features -> Uninstall or change a program**, select GAGEtrak Crib and click **Uninstall**. Once it has been uninstalled, simply remove the program group from the Start Menu and delete the GAGEtrak Pro/Crib directories. Windows 10 and 11 users: by default, GAGEtrak Crib installs in C:\Program Files (x86)\CyberMetrics...

Launching Crib

Launch Crib from the GAGEtrak Pro Main Menu or locate the GAGEtrak Crib program group in your Windows Start Menu if you have installed it as a separate application; the program group contains shortcuts to the GAGEtrak Crib application along with other utilities and functions. Please do not modify the properties of these shortcuts, as this may affect the program's ability to correctly launch.

To save time and ensure consistency, GAGEtrak Crib uses program conventions, which are standard commands and design elements that make the different windows and forms operate in the same way. You should become familiar with these conventions before you begin using GAGEtrak Crib. Please see the Conventions chapter of this guide.

Login

If security has been activated through the **Security Manager** in GAGEtrak Pro, the **Login** window will appear upon launch of Crib. Enter your User ID and Password in the appropriate fields and then click **OK** to log in.

Gage Lookup

Gage Lookup (accessible from below the Main Menu) allows you to easily lookup a gage to see if it is currently available to include in a new transfer. You can also create a new transfer from this screen by selecting one or more of the Gage IDs and right click. You can then choose between **Create a Transfer** for the selected gages or **Create a Service Request** for the selected gages.

Crib Settings

Before you begin entering records, we recommend that you first configure GAGEtrak Crib. Below the Main Menu, click **Configuration Menu** and then click **Crib Settings**. This is the administrative part of the Crib in which you can set up templates, rules and letters or make changes to crib settings.

Crib Settings – Information Tab

Enter your company's information in this form. Please note that any changes made here will carry over to the **Settings -> Information** tab in GAGEtrak Pro. If these settings were already completed within GAGEtrak Pro, no changes will be needed here in Crib.

To insert your logo, use the **Insert Object** or **Paste Logo** buttons. Ideally, your logo will be 200 pixels wide x 84 pixels high. If you already have a logo file (.jpg, .png or .gif) click **Insert Object** and then browse to and select the file; the graphic will be displayed in the **Logo** field. If you do not have a logo file, but your logo is displayed in another document for instance, you can use a screen capture program to capture the graphic and then copy it to the Windows clipboard. In GAGEtrak Pro, you would then click the **Paste Logo** button and the graphic will be displayed in the **Logo** field. Click **Save** in the Ribbon. Your logo will be shown on reports.

Crib Settings – Automatic Numbering Tab

Crib can automatically generate a number sequence for your Service Requests and Transfers. Use this form to set the desired format or leave the format fields blank for standard, incremental numbering. After deciding on a format, be sure to enable the automatic numbering by checking the corresponding checkbox.

Use a question mark (?) for incremental letters and the pound sign (#) for incremental digits. For letters or numbers that will not be incremental, enter the text as you want it to appear in the automatically generated number. These letters must all be capitalized. If you want to include date information in the automatic number, use the following date codes in your format:

dd = numeric day of the month (01 to 31)

ddd = text day of the week (Sun to Sat)

mm = numeric month (01 to 12)

mmm = text month (Jan to Dec)

yy = two-digit year (16)

yyyy = four-digit year (2016)

Example: G-###### = G-001234

Crib Settings – Default Values

Crib can automatically select the default rules for both a quick transfer and a standard transfer. Your default rules for the quick transfer or the standard transfer are: In House Issue, In House Return, Out for Repair, Out for Calibration, Return from Repair/Calibration or Returned Inoperable. You can also decide between the type of transfer using either a two-step process or single step routing. These default values can be manually changed on each transfer, but this sets the defaults.

Crib Settings – List Management

Crib has drop-down list management on select fields (caution: some changes made in Crib also affect GAGEtrak records. You can also change how the fields function, by deselecting the **Allow users to add new manage list items from forms** option.

Select the field that you want to edit from the drop-down list at the top of the page. The values of that drop-down list will populate the lower pane. You can then hide a value (by deselecting **Allow User to Select**) or delete a value (by selecting the value and then clicking the X icon). If that value is being used in any records, Crib will prompt you to replace the value. Follow the on-screen instructions to remove or replace the value.

Crib Settings – Custom

GAGEtrak Crib allows you to create custom fields for information you need to track for which there are no default fields. For the Crib, this includes fields for Products, Custodians and Custom Form Views (filters). There are three alphanumeric text fields, two managed drop-down list fields and one date field. Select the type of custom field that you would like to use and change the name of the field to the new field name. Save the change. You will need to close the form if it is currently open and reopen the form to see the changes.

Transfer Templates

For any common transfers that you make, you can create a template that automatically prefills most of the fields. When you click the **New Record** icon, enter the **Transfer Template Name** and click **Ok**. In the new template record, select the types of transfers that can use the template (any, transfer, or service request) in the **Transfer Template Usage** field and select either routing or two-step in the **Transfer Type** field. The **Routing** Transfer Type only has one rule applied and will complete the transfer record as soon as it is transferred.

The **Two-Step** Transfer Type is a traditional “issue out and return later” scenario. For example, a transfer record contains gages that have a defined storage location to which they will be returned, such as a crib or a work center. The Two-step transfer will not be closed on the initial transfer and it will have two separate rules that can be applied (one for each step). A Two-Step transfer record will have an expected resolve date until a user completes the transfer.

Transfer Templates – Information Tab

First, select the **Transfer Type** from the drop-down, then select rules for steps one and two. If you need to edit a rule after you select it, click the [...] box.

If you have a standing **Purchase Order** for specific gages or a specific vendor, enter that into the corresponding field; otherwise, leave it empty to fill in once you create the transfer. The **Total Gage Cost** will auto populate from the gages that you add to the transfer (this cost information needs to have been previously entered in GAGEtrak within the gage’s **Information** tab, **Specifications** section, **Cost** field). The **Service Cost** is the amount of a service request or transfer. The expected resolve date is the duration for which the gages will be needed at the new location. The **Gages** section lists the gages that are linked to this template and **Notes** can be added on how to use the transfer template.

Transfer Templates – Edit Gages Tab

Use this tab to add gages to the templates (only choose to do this if you have specific gages that are needed for a product).

Transfer Templates – Reminders Tab

To create a reminder, click the **New Record** icon, enter the **Reminder Name** and click **Ok**. In the **Responsible Person Options** field, select the person who will receive the reminder.

In the **Schedule** section, enter the frequency of this reminder. For example, you may want to do a maintenance inspection of the gages in this transfer every 30 days, or a battery check. When you select an option from the upper drop-down list in this section, the field options below it change.

Transfer Templates – Product Tab

Use this tab to link a product to a template. The lower portion of the form will auto-populate with any associated inspection points and let you know what specific gages and gage types your team would need to have used to inspect the product.

Transfer Templates – Gage Type Tab

If you have multiples of a gage type and it doesn't matter which specific gage is selected, then you can simply add a gage type. When the transfer is created from the template and sent, GAGEtrak will automatically select a gage of that type to include in the transfer.

Transfer Templates – Procedures Tab

Procedure records must first be entered within **GAGEtrak -> Configuration Menu -> Procedures** and then will be available to link to a gage in this screen. Multiple procedures can be linked to a transfer template.

Under the **Procedure Name** field is a record navigation bar that pertains to this subset of procedure records. Click this **New Record** icon and then select a procedure from the **Procedure Name** drop-down list; the **Procedure Text** will auto-fill. The text is not editable in this screen - only in the **Procedures** data entry area in GAGEtrak. To add another procedure to the gage, click the **New Record** icon again and then select another procedure. Procedures on how to use the gages included in the transfer can be linked to the transfer, then select the procedure to link.

Rules

Rules define standard actions for common types of transfers. They determine how gages are handled during a transfer and can serve as either guidelines (adjustable on individual transfers) or enforced rules (locked down by restricting access to the **Edit Rule** functions in **Transfers**). It is also important to note, however, that transfer rules are not intended to be restrictive for your crib users, but rather to assist them with easier

workflows and gage data updates. For example, a user might need to temporarily override a rule's gage status criteria if gages are not currently set to **Out for Calibration**, but still need to be available for transfer to an outsource calibration supplier.

The GAGEtrak application comes preloaded with suggested rules. These can be cloned, modified, or simply used as examples when creating additional rules. While you can create unlimited rules, keep in mind that too many may confuse crib users. At least one rule is required to perform transfers.

Rules consist of two parts: any supported **Changes** you want made to gages that are part of a given transfer record, and gage **Selection Criteria** — the conditions that gages must meet to be eligible for transfer. Your rules can be simple, containing minimal changes and basic selection criteria, or more complex, tailored to your organization's needs.

Rules and Changes on Transfer

Changes on Transfer automatically update gage information when a rule is applied. For example, if you are transferring gages to a work cell, the **In House Issue** rule can automatically update the location for all gages in that transfer. Rules can also pause or resume a gage's schedule, for instance, pausing when gages are returned to the crib, or resuming after calibration.

Rules and Selection Criteria

Selection Criteria determine which gages qualify for transfer under a given rule. For example, if the **In House Issue** rule is applied, only gages that meet its criteria (e.g., not past due for calibration) will be available for transfer. By default, a gage cannot be transferred unless it meets the rule's criteria.

Important Note
Some predefined rules, such as **In House Issue** and **Out for Repair**, include both **Changes on Transfer** and **Selection Criteria** that replicate the default Issue/Return behaviors from earlier GAGEtrak versions. These are included to make the transition easier for upgrade users.

Letters

There are three default letters in the Crib for service requests to outside vendors. You can create additional letters as needed and include them in a transfer or service request with the rules that are applied to those transfers. For example, you can have a letter for a specific vendor that includes the PO number or a specific job number.

Quick Transfers

From the Main Menu, click **Quick Transfers**. To create a new quick transfer record, click the **Transfer Rule** drop-down and select the type of transfer you need to create (remember, you can select the default rule in **Crib Settings -> Default Values** for the type of transfer you most frequently use). If you need to view or modify the default rule settings, click the **Edit Rule** button. The default rule settings may change depending on how you want the transfer to work and whether it is a one-step or two-step issue.

Under **Transfer Type**, select Routing or Two-Step. A routing transfer has only one rule applied and will complete as soon as it is transferred. A two-step transfer will not be closed out on the initial transfer, and it will have two rules that can be applied (one for each step).

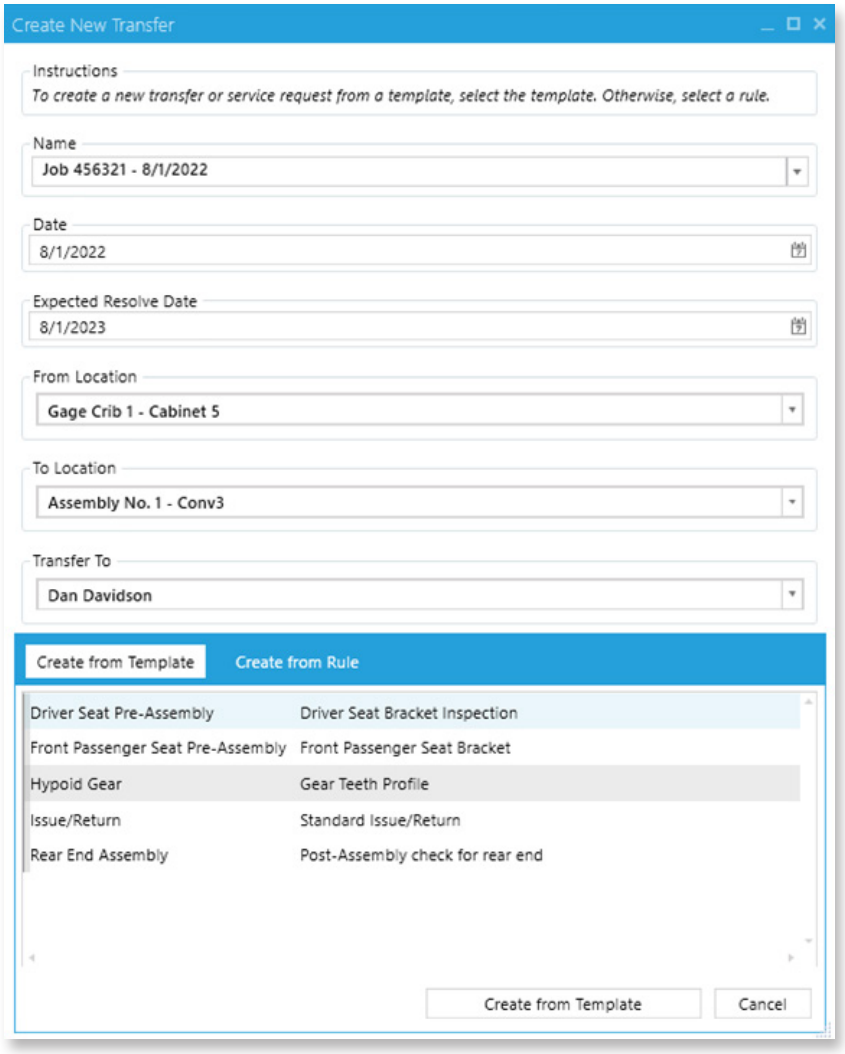
Click the **Find Available Gages** button, the list of available gages will be based on the selection criteria in the transfer rule selected. Click the checkbox of the gage or gages to be transferred and then click the **Transfer** button. If you selected a two-step transfer, you could complete the transfer from the main **Transfers** section.

Transfers

To enter transfer records, select **Transfers** from the Main Menu.

Click the **New Record** icon ⊕, the **Create New Transfer** window will open. You can select whether this will be a routing or two-step transfer (see description above). Then, select whether the transfer will be created from a template (found in the **Configuration** menu) or from a rule. You can have templates already set up for transfers with the gages or gage types already attached. Complete the form to start new transfer.

Transfer Name ideally would be the Job # or PO # and then the date of the transfer. Date will auto populate with the current date. **Expected Resolve Date** is the date you expect the gages to be returned to the crib. **From Location** is where the gages were located before the transfer. **To Location** is where the gages are going.



Once you have completed the information on the **Information, Edit Gages, Reminders, Products, Gage Types** and **Procedures** tabs, click the **Transfer** button near the bottom of the window.

The transfer is then created, and you change the transfer description, the transfer type (routing or two-step), the transfer date or the expected resolve date.

Transfers – Information Tab

Under the **Information** tab, if you used a template, it would tell you which template you used. You can select and edit the rules (**Step One Rule** and **Step Two Rule**) for this transfer by clicking the **[...]** box on the right side of the rule (See **Quick Transfers** for an example of the rules page). The **Issued By** field is the name of the person using GAGEtrak and transferring the gages. **From Location** is where the gages are before the transfer. **To Location** is the location where the gages are going. **Transfer To** is the name of the person responsible for the gages. **Set expected resolve date to** is the estimated number of days the gage will be at the new location (until the vendor return the gage).

Gages lists the gages added to the transfer on the **Edit Gages** tab. **Notes** is for any notes about the transfer or the reason for the transfer. **Custodians** is the responsible person(s) for the gage. **Attachments** is for any documentation that is needed, for example, pictures of the gages, a copy of the print, a picture of the product, etc.

Transfers – Edit Gages Tab

Under the **Edit Gages** tab click the **New Record** icon ⊕ to add gages to the transfer, the **Add Gages** window will open and display the **Valid Gages** based on the rule chosen, the **Gages Not Meeting Rule Criteria** tab will display gages that don't meet the selected transfer rule criteria. You can pick your gage(s) from either tab; if you select a gage not meeting the criteria a warning message will display to confirm that you want to override the criteria. If your transfer includes multiple gages, rules can be set individually for each gage from this tab. The gages selected will appear on the **Information** tab. Any gages that do not meet the transfer criteria will be listed under the **Attached Gages Not Valid** section.

Transfers – Reminders Tab

To create a reminder, click the **New Record** icon ⊕, enter the **Reminder Name** and click **Ok**. In the **Responsible Person Options** field, you can select the person who will receive the reminder. In the **Schedule** section, enter the frequency of this reminder. For example, you may want to do a maintenance inspection of the gages in this transfer every 30 days, or a battery check.

Transfers – Products Tab

Products can be linked to the transfer under this tab. Click the **New Record** icon ⊕, and select a **Product** from the list. If it is a new product, you will need to add the product to the products page available on the Main Menu before it can be linked to the transfer.

Transfers – Gage Types Tab

If the transfer doesn't have to be a specific gage, but only a type of gage, you can have GAGEtrak select the gage number to include in the transfer. For example, it doesn't matter which gage specifically goes to work on this product, only that it requires 2 micrometers that are 0-1 inch. When you add a gage type to the transfer, it will ask you the quantity that you need and if those gages are to be used exclusively in that area for this specific product or can they be transferred elsewhere.

Transfers – Procedures Tab

Procedure records must first be entered and are only editable from within **Procedures** (in the **Configuration** menu of GAGEtrak, not the Crib application) and then will be available to link to a gage in this screen). Click the **New Record** icon ⊕ (under the **Procedure Name** field) and then select a procedure from the **Procedure Name** drop-down list; the **Procedure Text** will auto-fill.

Under the **Procedure Name** field is a record navigation bar that pertains to this subset of records (procedures). To add another procedure to the gage, you would click the **New Record** icon in this bar and then select another procedure. Procedures on how to use the gages included in the transfer can be linked to the transfer, then click **Ok**.

Service Requests

Service Requests are mainly for transferring gages to outside vendors and are typically two-step transfers. The established rules are typically set up for the type of vendor you are sending gages to and include a standard issue and return, calibration request or a repair request. Popular naming conventions for service requests would be the type of request or the PO number; the date auto populates in the **Service Request Name** field. The **Expected Resolve Date** auto populates as one year from the creation date. The **From Location** is the current location of the gage. The **To Location** is where the gage is going, usually something like Outside Calibration or Outside Repair. The **Transfer To** field would be the name of the outside vendor. You can create the service request using a template or from a rule. Then click the **Create** button on the popup.

Service Requests – Information Tab

Transfer Template Name and the **Transfer Template Description** fields will auto populate with the name of the template selected to create the transfer. The **Transfer Rule** and **Return Rule** fields will auto populate based on the type of template you selected, but if you need to change the rules that apply, click the **[...]** box on the right side of the field.

Purchase Order is the PO number. **Total Gage Cost** is the original cost of the gage (purchase price or replacement cost).

Issued By is the name of the person sending the gages to the outside vendor. **From Location** is the location from which the gages are being moved. **To Location** typically auto populates with Outside Calibration Lab (as set by the rules). **Transfer To** is the name of the outside vendor. **Shipping Costs** is the cost of shipping the gages to the vendor. **Service Cost** is the total charge of the service.

Gages lists the gages added to the transfer on the **Edit Gages** tab. **Notes** is for any notes about the transfer or the reason for the transfer. **Custodians** is the responsible person(s) for the gage. **Attachments** is for any documentation that is needed, for example, pictures of the gages, a copy of the print, a picture of the product, etc.

Service Requests – Edit Gages Tab

Click the **New Record** icon ⊕ to add a gage to the request. You can filter the list of gages available for transfer and select multiple gages at once. Then click **Ok** to add them to the request.

You can change the gage-specific information if the gage is going to a different location or returning to a different location. You can enter gage-specific comments in the **Comments** section.

When you create a service request, the **Attached Gages Not Valid** page within the service request will list gages that were attached to the template but do not meet one or more of the selection criteria. These gages will not be part of the service request unless you choose to override.

Service Requests – Reminders Tab

This section allows you to add reminders about this transfer, such as a follow-up on gages not returned from the vendor. To create a reminder, click the **New Record** icon, enter the **Reminder Name** and click **Ok**. In the **Responsible Person Options** field, select the recipient of the reminder. In the **Schedule** section, enter the frequency of this reminder.

Service Requests – Procedures Tab

Procedure records must first be entered within **Procedures** (in the Configuration menu of GAGEtrak, not the Crib) and then will be available to link to a gage in this screen). Click the **New Record** icon under the **Procedure Name** field and then select a procedure from the **Procedure Name** drop-down list; the **Procedure Text** will auto-fill. The text is not editable in this screen - only in the **Procedures** data entry area.

Under the **Procedure Name** field is a record navigation bar that pertains to this subset of procedure records. To add another procedure to the gage, you would click the **New Record** icon in this bar and then select another procedure. Procedures on how to use the gages included in the transfer can be linked to the transfer, then click **Ok**.

Products

Products allows you to link specific gages to the product you are manufacturing and to add inspection points. GAGEtrak also tracks when a product was referenced in an MSA study or a transfer. It is important to note here that **Products** make up a **Where Used** tracking option, so they do not have to be strictly defined as actual products. They can be product assemblies or job numbers or work orders. The use of **Products** is optional, but it is recommended, as this link will help you establish how and where your gages are used throughout their life cycle.

Products – Information Tab

This is where you can define the product information such as the description, type of product, company product number, model number, which area of operation is working on the product, if it is assignable to link to gages, the product supplier, the product custodian, its unit of measure and the purchase date.

In the **Specification** section, enter the drawing number, date and currently applicable change level. You can also specify the plus and minus tolerances and the cost of the product. If a gage is out of tolerance, and if it is linked to a product, having entered the product cost here will help calculate costs of the out of tolerance to include if product needs to be scrapped or reworked.

In the **Notes** section, enter any comments about the product that might affect transfers or gages. **Products** allows you to have six custom fields for anything else you might need. The field names can be identified in Crib's **Settings -> Custom** tab.

Products – Inspection Points Tab

Here you can list the inspection points required for your products and include the gage type used to inspect those characteristics. If your gages have measurement ranges defined in **Gages**, then they can potentially be identified as capable of inspection for that product, or eliminated when they do not meet the required measurement criteria.

Products – History Tab

Review the history of the products that have been used in MSA studies or linked to transfers.

Products – Where Used Tab

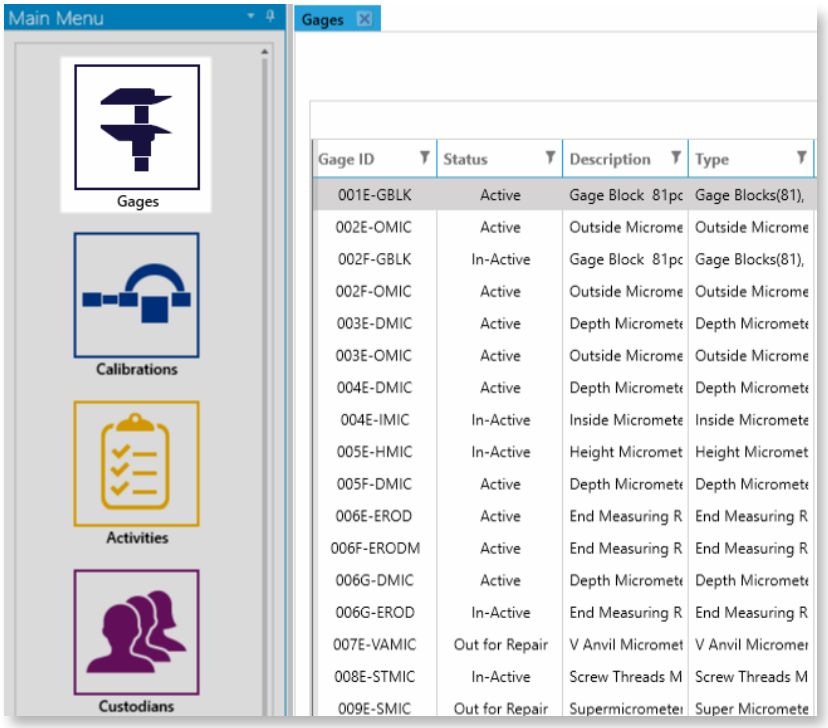
If a gage is linked to a product for specific measurement ranges, then it will be easier to trace that gage back to the products it was used to inspect should it ever be found out-of-tolerance. If the same gage is linked to inspection points for the product, then it can be easier to determine if that gage is a direct contributor, or may be likewise eliminated, depending on the specific characteristic or measurement range noted in the findings. In the end, linking gages to the products they are used to inspect is an important step toward effective corrective actions.

CHAPTER 8: INFO CENTER

GAGEtrak Info Center is a read-only access point from which managers or gage end users can retrieve and report on various aspects of GAGEtrak data when a full license of GAGEtrak is not required. This stand-alone utility connects to your GAGEtrak Pro database(s), allowing you to generate ad-hoc reports, filtered and sorted as needed, as well as formatted canned reports, for gage, calibration, activity, custodian, product and transfer records. If you are a current user of GAGEtrak Info Center, then this chapter will give you a brief overview of this application's capability.

Navigation Menu

The main navigation menu in GAGEtrak Info Center provides access to all of the primary data views available in the GAGEtrak Pro core application. Click on any of the icons provided in the menu to view data for each relevant view. You can also use the **Find/Replace Tool** located in the Navigation Menu to locate records, but please note that because Info Center is read-only, the Replace capability will not be available.



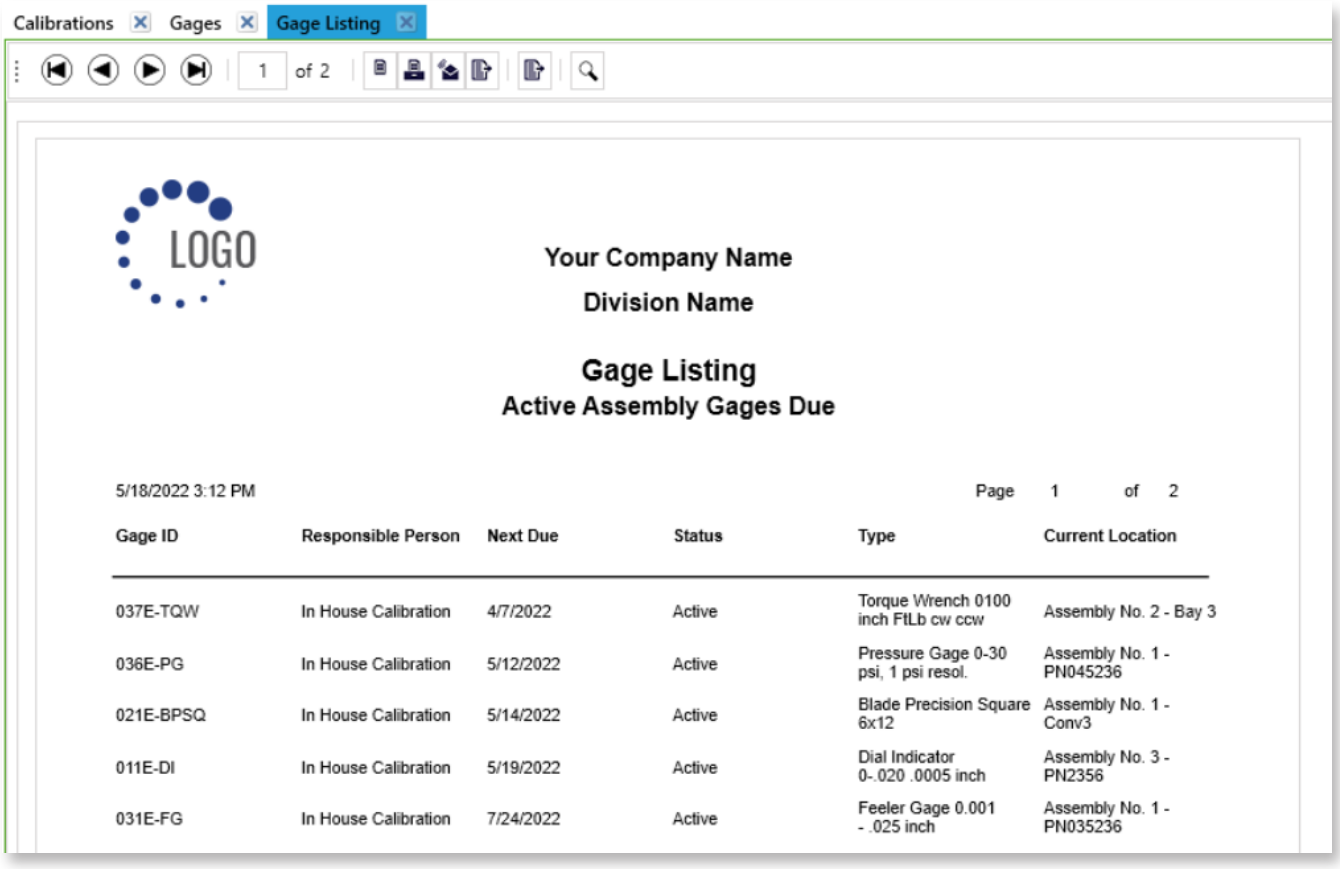
Grid Views

Info Center presents all data in grid views. These grid views can be modified by hiding or repositioning columns and the data can be filtered and sorted in any way you choose.

You can then save each view if you intend to use it again or if it will be emailed or exported on a regular schedule. Additionally, you can share your saved views in Info Center and they will be visible to the GAGEtrak core application users as well. Additionally, any views saved and shared in the GAGEtrak core application will likewise be visible to Info Center users.

Generating Reports

Both the ad-hoc and canned reports (including cal certs and failure notices) are generated directly from relevant areas of the program and with just a few clicks, you can sort, filter, modify, export, print, save and email reports. You can also schedule recurring and triggered report emails via **Notifications**.



Because Info Center connects to your GAGEtrak database, your **User Info Settings** (company name, division name and company logo) and **Report Control ID** text settings (for document control) are all active in Info Center. It also utilizes the same security system as GAGEtrak, so anyone with a GAGEtrak user account can access Info Center.

You can refer to the **Conventions** chapter of this guide for more detailed instruction on creating and saving views and see the **Productivity Tools** chapter for more information about running ad-hoc and canned reports.

The **Notification Manger** is also available within Info Center, which can be used to schedule and send reports via email to designated recipients. See **Notifications** in the **Configuration** chapter of this guide.

CHAPTER 9: MSA

With MSA, you can assess your measurement systems using the statistical test procedures. When launched from GAGEtrak Pro, the MSA application will open in a separate program window and provide access to a powerful suite of Measurement Systems Analysis tools such as repeatability, reproducibility, bias, stability and linearity (collectively referred to as MSA Studies). This feature saves time and prevents the mistakes that can be made with manual assessment of measurement systems. You will soon find that it is an essential tool for analyzing and managing your MSA studies as well as meeting industry compliance standards.

This feature was designed for calibration technicians, metrologists, inspectors and other quality control professionals who need a convenient, easy-to-use method for documenting, tracking and performing measurement systems analysis. The software is based primarily on the techniques described in the AIAG MSA guide and other industry publications.

Before starting SPC, capability studies or any type of repetitive measuring, use MSA to make sure that your measurement system can give you reliable measurements. Instructions for performing studies on your measurement system are given throughout this chapter.

The purpose of this chapter is to help you learn how to operate the software. It's not meant to be an authoritative guide on conducting, analyzing and interpreting your gage MSA studies. Although this section describes MSA study procedures, they are simply the views as documented by various industry publications. The software is simply a tool used to store data, calculate results and generate printed reports and charts. It does not determine whether a measurement system is good or bad. As the user, this determination is your sole responsibility.

Important: The technical support available for this software is limited strictly to the operation of the software. We cannot provide advice or support on interpreting results or charts. If you have interpretation questions, please consult your customer, a statistician or other qualified professional.

Validating the Software

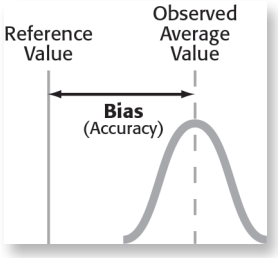
This software has been tested, validated and deemed suitable for release. Calculation validation was conducted using test data with known results. However, you should still conduct your own validation tests using data with known results - those that you calculate by hand or proven published values. When comparing the software results to your manually calculated results, remember that you may find differences due to rounding errors. The software uses up to 17 significant digits of precision in all intermediate calculations, rounding only the final results.

Terms and Definitions

Before using the MSA application, you may want to familiarize yourself with the following terms.

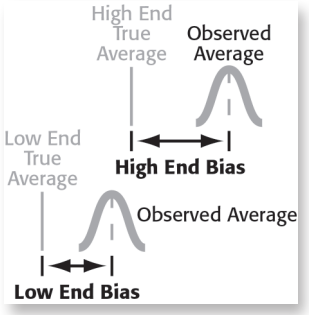
Bias

The difference between the observed average of measurements and the reference value is known as bias (sometimes called accuracy; however, accuracy is a qualitative term that should be avoided when referring to bias). The reference value (accepted reference value or master value) functions as an agreed-upon reference for the measured values. You can determine a reference value by using a higher level of measuring equipment (such as metrology lab or layout equipment) to average several measurements.



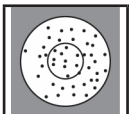
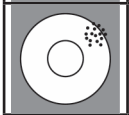
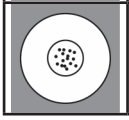
Linearity

Linearity is the difference in the bias (accuracy) values through the gage's estimated operating range.



Precision and Accuracy

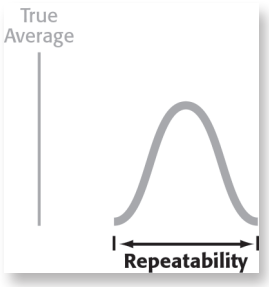
Below is bull's-eye target to illustrate the difference between precision and accuracy.

	Accurate but not precise. Notice the readings are fairly well centered on the target, but there is wide scatter.
	Precise but not accurate. You can see that the readings are all close to each other, but are not centered on the target.
	Precise and accurate. In this, the best condition, the readings are all close to each other and centered on the target.

Precise and **accurate** are general qualitative terms that are not actually used in MSA studies.

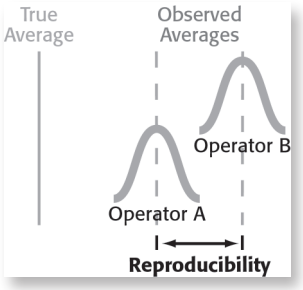
Repeatability (Equipment Variation)

Gage repeatability is the measurement variation that occurs when one appraiser uses the same gage to measure identical characteristics of the same products.



Reproducibility (Appraiser Variation)

When different appraisers use the same gage to measure identical characteristics on the same products, unexpected variation in the average of these measurements is known as gage reproducibility.

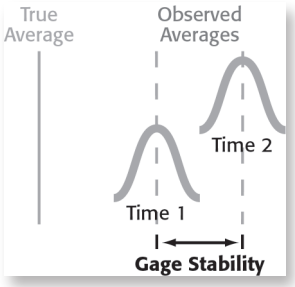


Appraiser × Product Interaction

When reproducibility error varies from product to product, that is called Appraiser × Product Interaction.

Stability

When using a measurement system to evaluate the same characteristic on a master or product over an extended period of time, the maximum change in bias is known as stability uncertainty (or drift).



Consistency

When using a measurement system to evaluate the same characteristic on a master or product over an extended period of time, the maximum change in repeatability is known as consistency uncertainty (or drift).

Variation Components

Equipment Variation (EV): Equipment Variation is an alternate term for repeatability, used primarily when we want to refer to repeatability by initials (EV).

Appraiser Variation (AV): Appraiser Variation is an alternate term for reproducibility, used primarily when we want to refer to reproducibility by initials (AV). Although appraiser usually refers to an operator or technician, it can also mean different instruments, different plant locations, etc., or all of the above.

Interaction (INT): Interaction is short for Appraiser × Product Interaction, used when we want to refer to it by initials (INT).

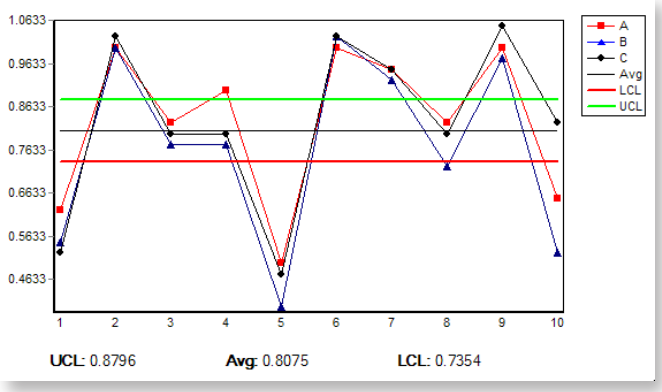
Gage Repeatability and Reproducibility (GRR): Gage Repeatability and Reproducibility is the RSS (root-sum-square) sum of the equipment variation, appraiser variation and interaction; it is usually referred to as GRR, GR&R or Gage R&R.

Product Variation (PV): The product variation is the product of the total GRR study error that is due to the products being measured.

Total Variation (TV): The total variation is the RSS (root-sum-square) sum of the gage repeatability and reproducibility (including interaction, if available) and the product variation. Total variation is an estimate of process variation that can be used when process variation is unknown.

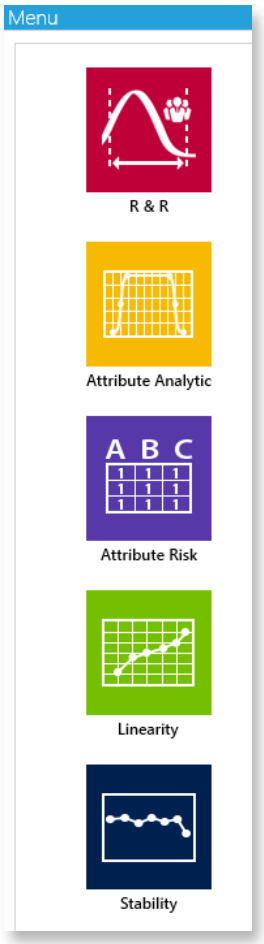
Illustration of Gage Errors

The chart below illustrates several terms we have discussed. The three zigzag patterns show the pattern of Product Variation (PV) as measured by three different appraisers. These patterns vary a lot more than the control limits, which is good (the control limits show the variation to be expected due to Repeatability (EV), if we always measured the same product). The three patterns are not close in height, which is an error called Reproducibility (AV). The three patterns are not close in shape, which is an error called Appraiser × Product Interaction (INT).



MSA Menu

In the GAGEtrak Pro Navigation Menu, click the MSA icon to launch the MSA application. Once the application has launched, you can select any study from the MSA Navigation Menu to view or create studies.



R&R

R&R studies look at the ability of a calibrated gage to measure an actual product characteristic using real operators and production conditions. R&R studies are specific to a product characteristic and can apply to multiple gages.

Study Types

Analysis of Variance (ANOVA)

This method gives the most information. If GRR% of TV or Tol is unsatisfactory, you will be able to view EV, AV, INT and PV for clues as to what should be done. This method is usually done with 2 or 3 trials, 2 or 3 appraisers and 10 products.

Nested ANOVA Option

When this option is selected, the program will assume non-replicable data where repetition takes place within a single group of products rather than the same product, i.e., a row of trials are measurements on the same product group, but not actually the same product. For best results, within-group variation should be small (e.g., consecutive products) and between-group variation should be large (e.g., different batches, lots, or time periods). INT is not calculated. If between-group (product) variation is significant, you may be able to use regular ANOVA (also called crossed ANOVA); try it both ways, if you wish.

R&R Method (Long-AIAG)

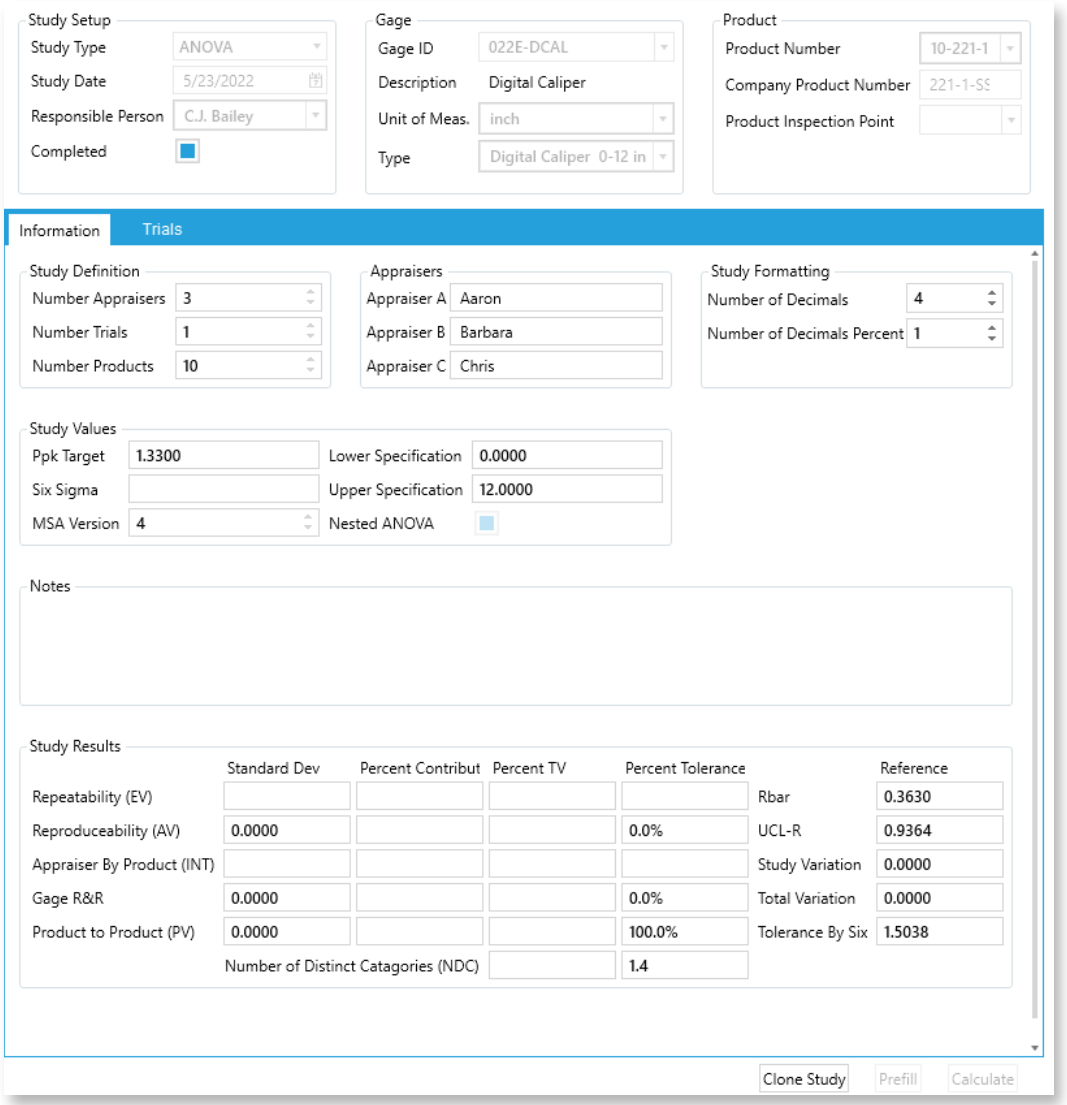
This method is the most familiar (it became popular pre-computer, for its ease of calculation). If GRR% of TV or Tol is unsatisfactory you will be able to view EV, AV and PV, but not INT, for clues as to what should be done. This method also requires 2 or 3 trials and 2 or 3 appraisers, and is usually done with 10 products.

Range Method (Short-AIAG)

This method is quick and easy. If GRR% of TV or Tol is unsatisfactory, it provides no clues as to why. PV and TV will be calculated only if you provide an external estimate of 6-sigma process variation or tolerance. This method is for one trial only and is usually done with 5 products and 2 appraisers.

Information Tab

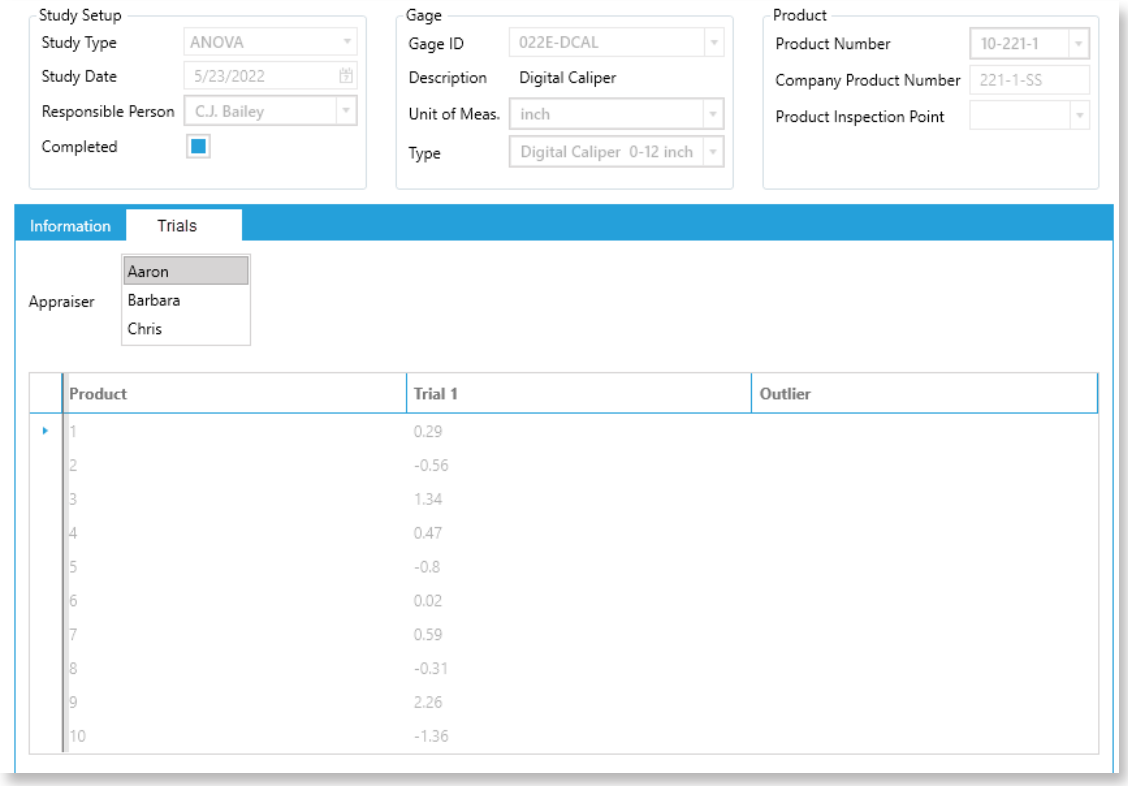
When you are ready to begin an R&R study, complete all of the required information for the study in the form header first, then move on to the **Information** tab to define the parameters that will be applied to this study. The **Study Results** section will be populated once all data has been entered and you click the **Calculate** button. When the study is completed, be sure to check the **Completed** box. This will close out the study and if R&R is conducted on a regular schedule for this gage, this will recalculate the MSA Schedule **Next Due** in the gage **Schedules**.



Trials Tab

When you are ready to start entering your R&R trial measurement results, click the **Trials** tab. After you enter the first measurement result for Product 1, press the Enter key to move your cursor down and use the Tab key to move your cursor to the next field to the right.

If most of your measurements begin with the same numbers (such as 1.1651, 1.1650 and 1.1658), you can save time by prefilling the measurements with those digits. In this case, click the **Prefill** button and then enter a prefill value of 1.165. Now you need to enter only the last digit of each measurement. Before using this feature, enter the number of trials, appraisers and products for the study on the **Information** tab.



R&R Study Values and Calculations

Below are descriptions and explanations for study values and calculations that will affect your R&R study results. Also included below are descriptions or explanations for the calculated study results.

Study Definitions and Values

Study Type: Select ANOVA (preferred), Long AIAG or Short-AIAG.

Number Appraisers: Select the number of appraisers to be used for this study (and the Prefill). The number of appraisers will affect the calculated results in various ways. For example, a Short Study with one or two appraisers and a single trial will not provide complete calculated results for EV, AV or TV, etc.

Number Trials: Select the number of trials to be used for this study (and the Prefill). Like the number of appraisers, too few trials will also affect the calculated results.

Number Products: Select the number of products to be used for this study (and the Prefill). Typically, a sample size is ten of the same product. Like appraisers and trials, the number chosen will affect calculated results.

Number of Decimal/Percent: Select the format you want for calculations. This will assist in unwanted rounding of results in study input and calculated results.

Six Sigma: If you know the Six Sigma Process Variation of the characteristic that you're measuring, enter it here. This causes the program to use this value instead of estimating product variation from your sample of study products. If you know the standard deviation of the characteristic (from SPC or capability studies), multiply it by six and enter the result here. See your Process Engineer or Quality Engineer for help.

Ppk Target: A process capability or performance target may be entered (typically 1.33 or 1.67). GAGEtrak will use it to reduce Tolerance to be an estimate of Process Variation.

Lower/Upper Specification: Be sure to enter the minimum and maximum Specification Limit values for the product Inspection Point; otherwise, the software cannot calculate the Percent Tolerance values for your study.

MSA Version: Refers to the Measurement Systems Analysis Reference Manual published by AIAG. Use Version 4 for new studies. Existing Version 3 studies may be updated for new features by changing to Version 4. Updates are reversible.

Nested ANOVA: Will appear to the right of the MSA Version field when the ANOVA study type is selected. Use the Nested ANOVA option if trials are non-replicable i.e., destructive testing.

Study Results

The program calculates these fields when you click the **Calculate** button. Blank results will occur in some of these if, for instance, you have used a Study Type that cannot calculate a particular value (see Study Values section above).

Repeatability (EV): Equipment Variation (Repeatability)

Reproducibility (AV): Appraiser Variation (Reproducibility)

Appraiser by Product (INT): Appraiser × Product Interaction

Gage R&R: Combined variation for EV, AV and INT.

Product to Product (PV): Product-to-product Variation will be calculated and displayed from Total Variation TV. If Specification Limits have been entered, PV will be separately calculated for the % of Tolerance column. The latter version will display as % of Tol only.

Number of distinct categories (NDC): MSA 4th Edition authorizes using number of distinct categories as a substitute for GRR%. The two statistics are related in the same way that Fahrenheit and Celsius are two ways of measuring the same property. Technically, there is no reason to use both measures at the same time. See **Interpreting number of distinct categories** below for more information and why some people might prefer one or the other.

Rbar: The overall average range (relates to repeatability).

UCL-R: Upper Control Limit for the range control chart. (If the range chart is out of control, there will be "flags" on the appraiser tabs to indicate likely typos or measurement mistakes).

Study Variation: Total Variation as calculated from the products in the study. It will only match the Total Variation shown below if there was no entry in 6-Sigma Proc Var.

Total Variation (TV): If there is an entry in 6-Sigma Proc Var, it will be divided by 6 and entered here. Otherwise, Study Variation will be used here. Total Variation represents 100% in the % of TV column.

Tolerance By Six (Tol): If there is an entry in Pp Target, then Tolerance will be calculated from the specification limits, divided by 6Pp and entered here. Otherwise, Tolerance will be divided by 6. Tolerance/6 represents 100% in the % of Tol column.

Standard Dev: Standard deviation (1s, not 5.15s) This is used for uncertainty calculations.

Percent Contribution: This is the percentage of overall variation from each variance component. It is calculated as the variance component for each source divided by the total variation, then multiplied by 100 to express as a percentage.

Percent TV: Percent of Total Variation - this is the primary comparison tool.

Percent Tolerance: Percent of Product Tolerance (based on 6s, not 5.15s) - an alternate comparison tool.

Interpreting Gage R&R

If you tend to think of gage improvement in terms of reduced measurement variation (reduced uncertainty), then you may prefer Gage R&R as a percentage of Total Variation or as a percentage of Tolerance (referred to in this guide as GRR%) over number of distinct categories, because with GRR%, reduced numbers are better.

Most manufacturing companies follow the Automotive Industry Action Group (AIAG) rules. If Gage R&R as a percentage of Total Variation (or % of Tolerance, whichever is more appropriate) is:

- Under 10% - the system is acceptable.
- Between 10% and 30% - you might need to further analyze the system to find the cause of the error.
- Over 30% - the system is not acceptable. You should perform further analysis on the system to find the cause of the error. If you use Long AIAG, you will be able to view EV, AV and PV for clues as to what should be done. If you use ANOVA, you will be able to view EV, AV, INT and PV for even more clues as to what should be done. It is important to also view the charts.

Interpreting Number of Distinct Categories

If you tend to think of gage improvement in terms of increased precision (increased gage capability) then you may prefer number of distinct categories over GRR%, because with number of distinct categories increased numbers are better. Number of distinct categories, as the name suggests, can be visualized as categories or cells of an imaginary histogram chart.

For every value of GRR%, there is a corresponding value of number of distinct categories, in a format that is roughly proportional to the reciprocal of GRR%. Technically, there is no reason to use both measures at the same time. Whichever format you prefer will provide equally complete information.

The table below shows selected values of number of distinct categories and the corresponding values for GRR%.

Comparing number of distinct categories to GRR%:

number of distinct categories	4.5	5	10	14	20	28	35
GRR%	29.9%	27.1%	14.0%	10.0%	7.0%	5.0%	4.0%

Reject limit for number of distinct categories: The usual reject limit for number of distinct categories is 5, which corresponds to 27%GRR. If you think it is important to have a reject limit that is closer to the AIAG specification limit of 30%GRR, then use number of distinct categories = 4.5 as a minimum.

Conversion formula for number of distinct categories:

The relationship is: number of distinct categories = $1.41((100/GRR\%)^2 - 1)^{0.5}$

For GRR% = 30, then number of distinct categories = $1.41((100/30)^2 - 1)^{0.5} = 4.48$

Note: This conversion formula is not used in GAGEtrak, but is presented here for information. If you want to verify the formula, just compare it to results in GAGEtrak.

Myths about number of distinct categories:

1. Myth: By using the specified number of categories, you can eliminate errors in sorting situations such as making a histogram.

   Fact: There is always significant probability of a one-category sorting error, because measurements and actual values can fall on opposite sides of a boundary. However, being off by two categories is highly unlikely with number of distinct categories. That is as good as it gets, but "error free" is an exaggeration.

2. Myth: Number of distinct categories is at 97% confidence.

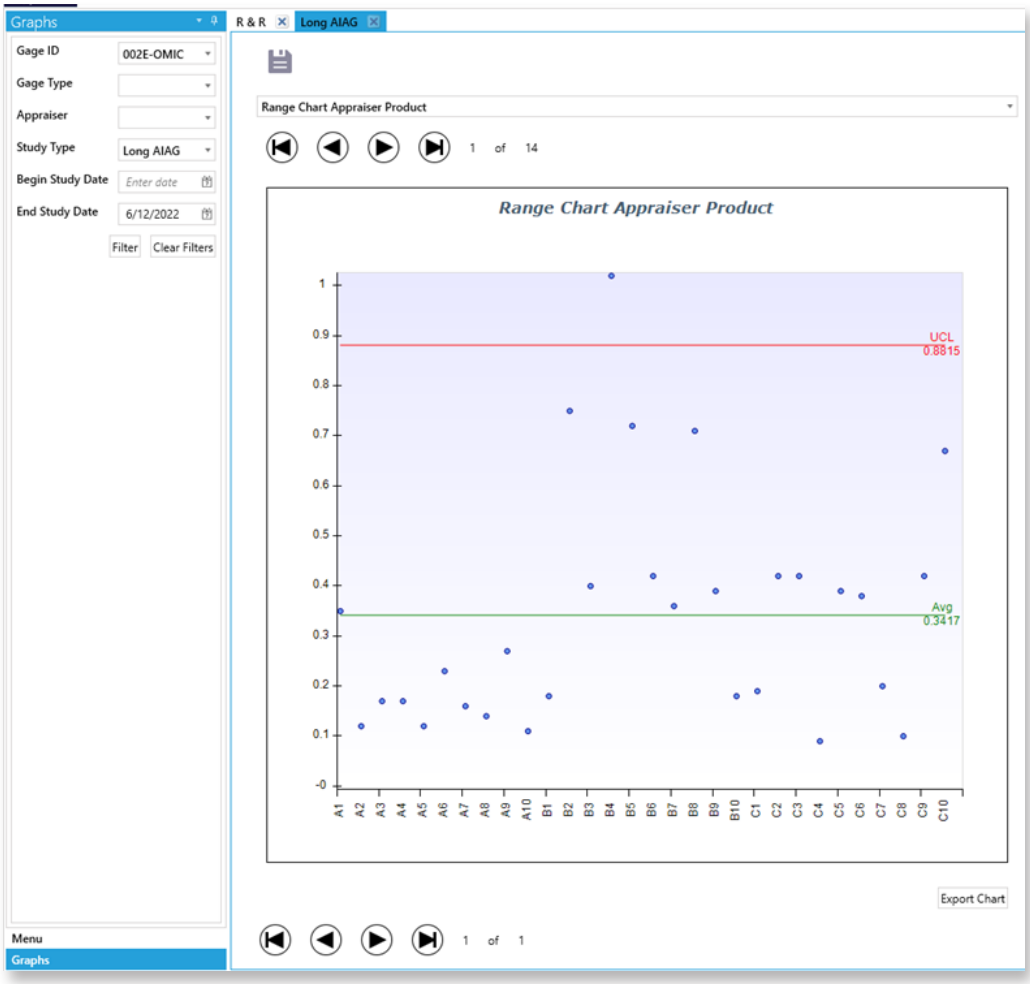
   Fact: Number of distinct categories is not related to any particular confidence level except when it is calculated based on tolerance. When based on tolerance/6 compared to GRR, the confidence level is 99.73%. To see where ideas about 97% confidence (and truncation) started, look at the second part of the next paragraph.

Want to sort with number of distinct categories?

To actually use the specified number of categories for sorting into a histogram, you would need to choose a width for the categories. Since we now can calculate number of distinct categories from tolerance, you would likely prefer to round that value to an integer and divide it into tolerance. The resulting category width would cover the entire tolerance. The authors that introduced number of distinct categories chose a (typically narrower) category width by truncating number of distinct categories to an integer and dividing it into the equivalent of a 97% confidence interval for product variation (4.34 PV). Either category width would be suitable for practical use.

Generating Charts

R&R offers an extensive variety of charts to help you determine the causes of measurement error. To generate a chart from your R&R study, click the **Graphs** option on the bottom of the MSA Navigation Menu. A **Graphs** filter option will appear allowing you to print a chart from any of your Study Types. You do not need to open a study to view its charts, just use any of these filter options after providing the Study Type.



Exporting Charts

Each chart can be exported to various image file formats using the **Export Chart** button below the preview. Once exported, they can be printed or emailed.

Range Chart by Appraiser/Product (and by Product/Appraiser)

Using a standard **Range** chart, this chart plots the ranges of each appraiser's readings, including the average range and control limits. You can choose to plot the data grouped by product or grouped by appraiser.

Range Chart Interpretation

The **Range** chart can help you determine both statistical control in regard to repeatability and homogeneity of the measurement process among appraisers for each product. Neither chart should show patterns in the data relative to the appraisers or products. Out of control points on this particular chart usually indicate typos or measurement mistakes. The suspect data will be flagged on one of the **Appraiser** tabs.

Error Chart

The **Error** chart shows the individual deviations from the accepted reference values. GAGEtrak calculates the individual deviation or error for each product according to the following formula:

Error = Observed Value – Average Measurement of the Product

Before you do any other statistical analysis, you should thoroughly screen the deviations for clear causes of variations that you can ascribe to specific factors.

Look for any uniform patterns in your **Error** chart, including the following: one appraiser's second (or third) set of readings is consistently higher than his first; one appraiser's average is higher than the other appraisers' averages; and/or one product standing out as more difficult to consistently measure.

Run Chart and Average Chart

Run Chart by Product

This chart plots the averages of each appraiser's various readings, using product number as an index. The **Run** chart shows product variation and can detect reproducibility and appraiser × product interaction error.

If the patterns are not at the same height there is a reproducibility error. If the patterns are not the same shape, there is an appraiser × product interaction error.

Average Chart by Product

The **Average** chart is much like the **Run** chart, except that it also calculates the overall average and control limits. From this chart, you can determine the measurement system's acceptability.

Normalized Individuals Chart (by Product/Appraiser and by Appraiser/Product)

In this chart, the plotted data consists of the individual readings minus the overall average of the readings. The normalized data is plotted, grouped by appraiser or product number. This chart can help you determine reproducibility, consistency among appraisers, occurrences of abnormal readings and the interaction between the products and appraisers.

Whiskers Chart

The Whiskers chart plots and connects the high and low data values and the average, by product, by appraiser. This chart helps you see consistency among appraisers, occurrences of abnormal readings and the interaction between the products and the appraisers.

X–Y Plot of Averages by Size

This chart plots the averages of each appraiser's various readings for each product, using the overall product average. If the appraisers disagree on certain products (Appraiser × Product interaction), this can help to determine whether that depends on product size.

Comparison X–Y Plots

In a Comparison X–Y Plot, the averages of each appraiser's readings on each product are plotted against each other, using appraiser as an index. This plot compares one appraiser's readings to those of another appraiser. If the appraisers' readings matched perfectly, the plotted points would form a diagonal straight line.

Scatter Plot

The Scatter Plot charts individual readings, by appraiser, by product to help you determine consistency among appraisers, occurrences of abnormal readings and the interaction between the products and appraisers.

Repeatability Range Control Chart

Using a standard range chart, this chart plots the ranges of the readings by each appraiser, for each product, including the average range and control limits. Appraiser groups the data, and lines connect the points for each appraiser.

Repeatability Range Chart Interpretation

The Range Control chart shouldn't show data patterns relative to the appraisers or have any out-of-control points. An in-control Range Control chart is a sign that the appraisers use the gage in the same way.

With the Range Control chart, you can determine whether repeatability is the same for all appraisers (the numerical methods do not answer this question).

Using a standard average chart, the averages of each appraiser's readings for each product are plotted, including the overall average and control limits. Appraiser groups the data with lines connecting each appraiser's points.

If half or more of the points are outside of the control limits, then the measurement system should be able to detect product-to-product variation. If less than half is outside the control limits, it might be because the measurement system isn't able to thoroughly distinguish differences or because the product sample doesn't represent the expected process variation.

Residual Plot by Size

The averages of each appraiser's readings for each product are subtracted from each trial, and the residuals are plotted versus the overall product average. There should be no discernible patterns on this chart. Any visible pattern would suggest that something is wrong with the data or the measuring system.

R&R Formulas

Range (Short Form) Method

Values of d_2^* for one trial

Products	1	2	3	4	5	6	7	8	9	10
2 Appr's	1.41421	1.27931	1.23105	1.20621	1.19105	1.18083	1.17348	1.16794	1.16361	1.16514
3 Appr's	1.91155	1.80538	1.76858	1.74989	1.73857	1.73099	1.72555	1.72147	1.71828	1.71573

EV = Not calculated

AV = Not calculated

GRR = $1 \div d_2^* \times \overline{R}$

% GRR = 100 × GRR ÷ TV

or

%GRR = 100 × GRR ÷ (TOL ÷ 6)

where TV is (6σ Process Variation) ÷ 6

AIAG R&R Method (Long Form)

Note K_1, K_2, and K_3 are all equal to $1/d_2^*$

Equipment Variation (EV) – Repeatability

Trials	2	3
K_1	0.8862	0.5908

$$EV = \bar{R} \times K_1$$

$$\%EV = 100 \times (EV \div TV)$$

or, if comparing to tolerance:

$$\%EV = 100 \times EV \div (Tol \div 6)$$

Appraiser Variation (AV) – Reproducibility

Appr's	2	3
K_2	0.7071	0.5231

$$AV = \sqrt{\left[(\bar{X}_{diff} \times K_2)^2 - (EV^2 \div n \times r)\right]}$$

where n = # of parts, r = # of trials

Note: If a negative value results under the square root, the AV is reported as "0".

$$\%AV = 100 \times (AV \div TV)$$

or, if comparing to tolerance:

$$\%AV = 100 \times AV \div (Tol \div 6)$$

Repeatability & Reproducibility (R&R)

$$R\&R = \sqrt{(EV^2 + AV^2)}$$

$$\%GRR = 100 \times GRR \div TV$$

or if comparing to tolerance:

$$\%GRR = 100 \times GRR \div (Tol \div 6)$$

Product Variation (PV)

Products	2	3	4	5	6	7	8	9	10
K_3	0.7071	0.5231	0.4467	0.4030	0.3742	0.3534	0.3375	0.3249	0.3146

$$PV = R_p \times K_3$$

$$R_p = \text{Max}\,\bar{X}_p - \text{Min}\,\bar{X}_p$$

$\bar{X}_p$ values are the averages of each measured part

Note: If you know the 6-Sigma Process Variation (from SPC or Capability studies), enter it into the Proc. Var. field.

If entered into the **R&R Study** form, the software will calculate TV as:

$$TV = (6\,\text{Sigma Proc. Var.} \div 6)$$

and calculate PV as:

$$PV = \sqrt{(TV^2 - R\&R^2)}$$

Total Variation (TV)

$$TV = \sqrt{R\&R^2 + PV^2}$$

ANOVA Formulas

Estimate of Variance Components

	Variance Estimate
Gage	$\tau^2 = MS_e$
Interaction	$\gamma^2 = \frac{(MS_{op} - MS_e)}{r}$
Appraiser	$\omega^2 = \frac{(MS_o - MS_{op})}{nr}$
Part	$\sigma^2 = \frac{(MS_p - MS_{op})}{kr}$

ANOVA Calculation

Source	DF	SS	MS	F	EMS
Appraiser	2	0.04800	0.02400		$\tau^2 + 2\gamma^2 + 20\omega^2$
Parts	9	2.05871	0.22875		$\tau^2 + 2\gamma^2 + 6\sigma^2$
Appraiser x Part	18	0.10367	0.00575	4.45*	$\tau^2 + 2\gamma^2$
Gage (Error)	30	0.03875	0.00129		τ^2
Total	*59*	*2.2491*	** Significant at α = 0.25 level*		

Estimate of Variance	Std. Dev. (σ)
τ^2 = 0.00129 (Repeatability)	0.0359
ω^2 = 0.00091 (Operator)	0.0302
γ^2 = 0.00223 (Interaction)	0.0472
R&R = 0.00443 ($\tau^2 + \gamma^2 + \omega^2$)	0.0666
σ^2 = 0.0371641 (Part)	0.1928

Source: AIAG Measurement Systems Analysis Guide

Sample ANOVA Study

This section contains data and calculations for a sample ANOVA study. You can use this sample study as a model for your own ANOVA studies.

Readings

Appraiser A

Product	Trial 1	Square	Trial 2	Square	Sum	Sum Square
1	0.65	0.42	0.60	0.36	1.25	0.78
2	1.00	1.00	1.00	1.00	2.00	2.00
3	0.85	0.72	0.80	0.64	1.65	1.36
4	0.85	0.72	0.95	0.90	1.80	1.62
5	0.55	0.30	0.45	0.20	1.00	0.50
6	1.00	1.000	1.00	1.00	2.00	2.00
7	0.95	0.90	0.95	0.90	1.90	1.80
8	0.85	0.72	0.80	0.64	1.65	1.44
9	1.00	1.00	1.00	1.00	2.00	2.00
10	0.60	0.36	0.70	0.49	1.30	0.85
		7.14		7.13		
Total = 16.55						
SS Total = 14.27						

Appraiser B

Product	Trial 1	Square	Trial 2	Square	Sum	Sum Square
1	0.55	0.30	0.55	0.30	1.10	0.65
2	1.05	1.10	0.95	0.90	2.00	2.00
3	0.80	0.64	0.75	0.56	1.55	1.20
4	0.80	0.64	0.75	0.56	1.55	1.20
5	0.40	0.16	0.40	0.16	0.80	0.32
6	1.00	1.00	1.05	1.10	2.05	2.10
7	0.95	0.90	0.90	0.81	1.85	1.71
8	0.75	0.56	0.70	0.49	1.45	1.05
9	1.00	1.00	0.95	0.90	1.95	1.90
10	0.55	0.30	0.50	0.25	1.05	0.55
		6.65		6.03		
Total = 15.35						
Sum Square Total = 12.63						

Appraiser C

Product	Trial 1	Square	Trial 2	Square	Sum	Sum Square
1	0.50	0.25	0.55	0.30	1.05	0.55
2	1.05	1.10	1.00	1.00	2.05	2.10
3	0.80	0.64	0.80	0.64	1.65	1.28
4	0.80	0.64	0.80	0.64	1.65	1.28
5	0.45	0.20	0.50	0.25	0.95	0.45
6	1.00	1.00	1.05	1.10	2.05	2.10
7	0.95	0.90	0.95	0.90	1.90	1.80
8	0.80	0.64	0.80	0.64	1.65	1.28
9	1.05	1.10	1.05	1.10	2.10	2.20
10	0.85	0.72	0.80	0.64	1.65	1.36
		7.19		7.21		
Total = 16.55						
Sum Square Total = 14.40						

Legend

AV = appraiser variation	k = number of appraisers
AV_{LCL} = appraiser variation lower control limit	LCL = lower control limit
AV_{ss} = appraiser variation sum square	MS_{ap} = appraiser x products mean square
AV_{UCL} = appraiser variation upper control limit	MS_{err} = gage error mean square
CF = correction factor	MS_{p} = products mean square
DF = degrees of freedom	n = number of products
CHI = CHI probability distribution	PC = percent contribution
CHI_{INV} = inverse of CHI probability distribution	PV = product variation
DF = degrees of freedom	PV_{LCL} = product variation lower control limit
DF_{ap} = appraiser x products degrees of freedom	PV_{SS} = product variation sum square
DF_{app} = appraiser degrees of freedom	PV_{UCL} = product variation upper control limit
DF_{err} = gage error degrees of freedom	r = number of trials
DF_{p} = products degrees of freedom	R&R = repeatability & reproducibility
EV = equipment variation	RR_{LCL} = R&R lower control limit
EV_{i} = inverse of equipment variation	RR_{SS} = R&R sum square
EV_{LCL} = equipment variation lower control limit	RR_{UCL} = R&R upper control limit
EV_{SS} = equipment variation sum square	S^2 = sum square
EV_{UCL} = equipment variation upper control limit	SS_{ap} = appraiser x products sum square
F_{INV} = inverse of F probability distribution	SS_{app} = appraiser sum square
F = F probability distribution	SS_{err} = gage error sum square
I = interaction	SS_{p} = products sum square
I_{LCL} = interaction lower control limit	TV = total variation
I_{SS} = interaction sum square	TV_{SS} = total variation sum square
I_{UCL} = interaction upper control limit	UCL = upper control limit

Study Values

k = 3
n = 10
r = 2

Appraiser DF = k – 1
= 3 – 1
= 2

Parts DF = n – 1
= 10 – 1
= 9

App × Parts = App.DF × PartsDF
= 2 × 9
= 18

$$\text{TotalDF} = (n \times k \times r) - 1$$
$$= (3 \times 10 \times 2) - 1$$
$$= 60 - 1$$
$$= 59$$

$$\text{Gage(Error)} = \text{Tot}_{DF} - A_{DF} - P_{DF} - AR_{DF}$$
$$= 59 - 2 - 9 - 18$$
$$= 30$$

Sum All Readings
16.55 + 15.35 + 16.55 = 48.45
Sum Square All Readings
273.90 + 235.62 + 273.90 = 783.42

Products	Sum	Square
1	3.40	11.56
2	6.05	36.65
3	4.80	23.04
4	4.95	24.50
5	2.75	7.56
6	6.10	37.21
7	5.65	31.92
8	4.70	22.09
9	6.05	36.65
10	4.00	16.00
Totals	48.45	247.08

Correction Factor for ANOVA

$$CF = (\text{Sum Readings})^2 \div n \div k \div r$$
$$= 48.45^2 \div 10 \div 3 \div 2$$
$$= 39.123$$

Appraiser Sum Square

$$SS_{app} = (\text{SS Reading} \div n \div r) - CF$$
$$= (783.42 \div 10 \div 2) - 39.123$$
$$= 0.048$$

Appraiser Mean Square

$$= SS_{app} \div DF_{app}$$
$$= 0.048 \div 2$$
$$= 0.024$$

Products Sum Square

$$SS_p = (\text{Parts Sum Square} \div k \div r) - CF$$
$$= (247.08 \div 3 \div 2) - 39.123$$
$$= 2.057$$

Products Mean Square

$$MS_p = SS_p \div DF_p$$
$$= 2.124 \div 9$$
$$= 0.2286$$

App. x Products Sum Square

$$SS_{ap} = (\text{Sum Square Total Readings} \div r) - CF - SS_p - SS_{app}$$
$$= (82.668 \div 2) - 39.123 - 2.057 - 0.048$$
$$= 0.106$$

App. x Products Mean Square

$$MS_{ap} = SS_{ap} \div DF_{ap}$$
$$= 0.106 \div 18$$
$$= 0.0059$$

Gage Error Sum Square

$$SS_{err} = (\text{Sum Square All} - CF) - SS_{ap} - SS_p - SS_{app}$$
$$= (41.373 - 39.123) - 0.106 - 2.057 - 0.048$$
$$= 0.039$$

Gage Error Mean Square

$$MS_{err} = SS_{err} \div DF_{err}$$
$$= 0.039 \div 30$$
$$= 0.0013$$

$$\text{F Value} = MS_{ap} \div MS_{err}$$
$$= 0.0059 \div 0.0013$$
$$= 4.5385$$

$$F_{0.25} = (\text{from F Table})$$
$$= 1.310$$

ANOVA Table

Source	DF	SS	MS	F	$F_{0.25}$
Appraiser	2	0.048	0.024		
Products	9	2.057	0.2286		
App. x Products	18	0.106	0.0059	4.5385	1.310
Gage Error	30	0.039	0.0013		
Total	59	2.249			

Components of Variance

Most of these values are calculated using values from an F-distribution table. You can find F-tables in most statistics manuals.

Sum Squares

$$AV = (MS_{app} - MS_{ap}) \div (nr) \qquad EV = MS_{err}$$

$$PV = (MS_{p} - MS_{ap}) \div (kr) \qquad R\ \&\ R = AV_{ss} + I_{ss} + EV_{i}$$

$$I = (MS_{ap} - MS_{grr}) \div r \qquad TV = RR_{ss} + PV_{ss}$$

Table	S^2
AV	0.00091
PI	0.03716
I	0.00223
EV	0.00129
RR	0.00444
TV	0.04165

Study Variation

$$TV = \sqrt{TV_{ss}}$$
$$= \sqrt{0.0416}$$
$$= 0.204$$

Repeatability

$$EV = \sqrt{EV_{ss}}$$
$$= \sqrt{0.00129}$$
$$= 0.0359$$

$$\%TV = (\text{Rep. Std. Dev.} \div \text{Study Variation}) \times 100$$
$$= (0.0359 \div 0.204) \times 100$$
$$= 17.6\%$$

Reproducibility

$$AV = \sqrt{AV_{ss}}$$
$$= \sqrt{0.00091}$$
$$= 0.0302$$

$$\%TV = \text{Std. Dev.} \div TV$$
$$= 0.0302 \div 0.204$$
$$= 14.8\%$$

Product x Appraiser

$$INT = \sqrt{I_{ss}}$$
$$= \sqrt{0.00223}$$
$$= 0.0473$$

$$\%TV = \text{Std. Dev.} \div TV$$
$$= 0.0473 \div 0.204$$
$$= 23.2\%$$

GRR

$$GRR = \sqrt{RR_{ss}}$$
$$= \sqrt{0.00444}$$
$$= 0.0666$$

$$\%TV = \text{Std. Dev.} \div TV$$
$$= 0.0666 \div 0.204$$
$$= 32.7\%$$

Product to Product

$$PV = \sqrt{PV_{ss}}$$
$$= \sqrt{0.03716}$$
$$= 0.1928$$

$$\%TV = \text{Std. Dev.} \div TV$$
$$= 0.1928 \div 0.204$$
$$= 94.5\%$$

Linearity, Bias and Uncertainty

Linearity & Bias Study

Linearity studies measure multiple reference standards throughout the operating range of the gage. Typically, bias is determined at five different reference values. Ideally, bias will appear to be slightly above or below zero at each of the five reference values.

If bias is found to vary significantly from zero, the study will tell us whether it varies in a linear way (easy to compensate for) or a non-linear way (more difficult to compensate for). Some gages are calibrated with custom-made masters, and there are only one or two reference standards. If you don't have at least three reference standards, you can do the study using "calibrated" products, e.g., have the products measured by a more authoritative instrument such as a coordinate measuring machine. Then each product will have a reference value. If enough reference standards are available, it is better not to use products.

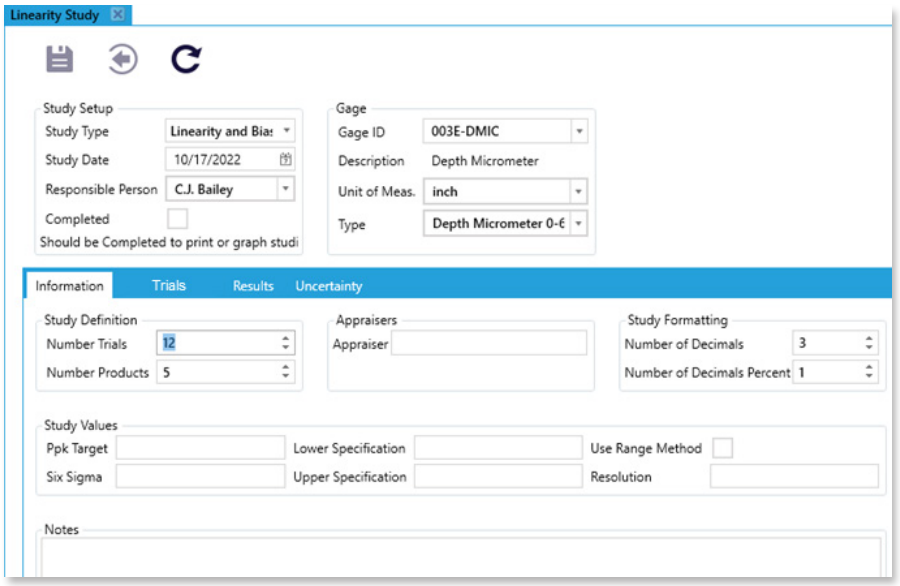
If a linearity study is to represent an entire family of gages, you may want to use a different gage for each reference value. Then the repeatability of calibration will actually be GRR of calibration because it will include appraiser variation. (Appraiser variation can refer to gages, operators or laboratories.) You could even use two technicians, by letting each do half of the trials.

Bias Only Study

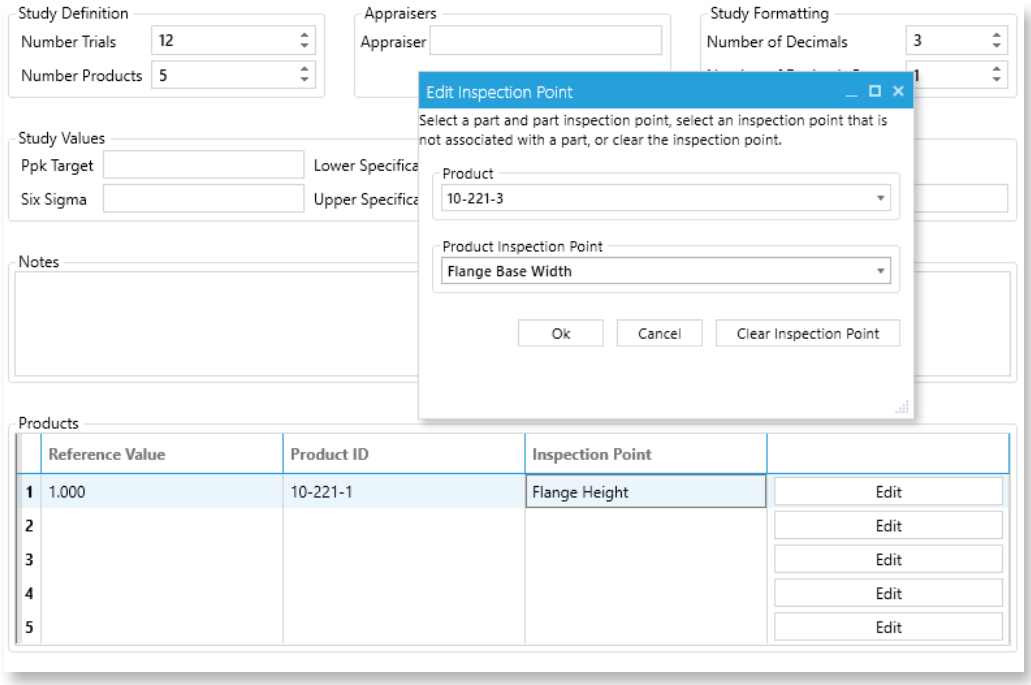
When you only want to check bias at a single reference value, select Bias Only for **Study Type**. (You will still be able to do Uncertainty, except for the Linearity contribution.)

Linearity - Information Tab

When you are ready to begin a new Linearity study, complete all of the required information for the study in the form header first, then move on to the **Information** tab to define the parameters that will be applied to this study. The **Results** tab will be populated once all data has been entered and you click the **Calculate** button. When the study is completed, be sure to check the **Completed** box. This will close out the study and if Linearity is conducted on a regular schedule for this gage, this will recalculate the **MSA Schedule Next Due** in the gage **Schedules**.

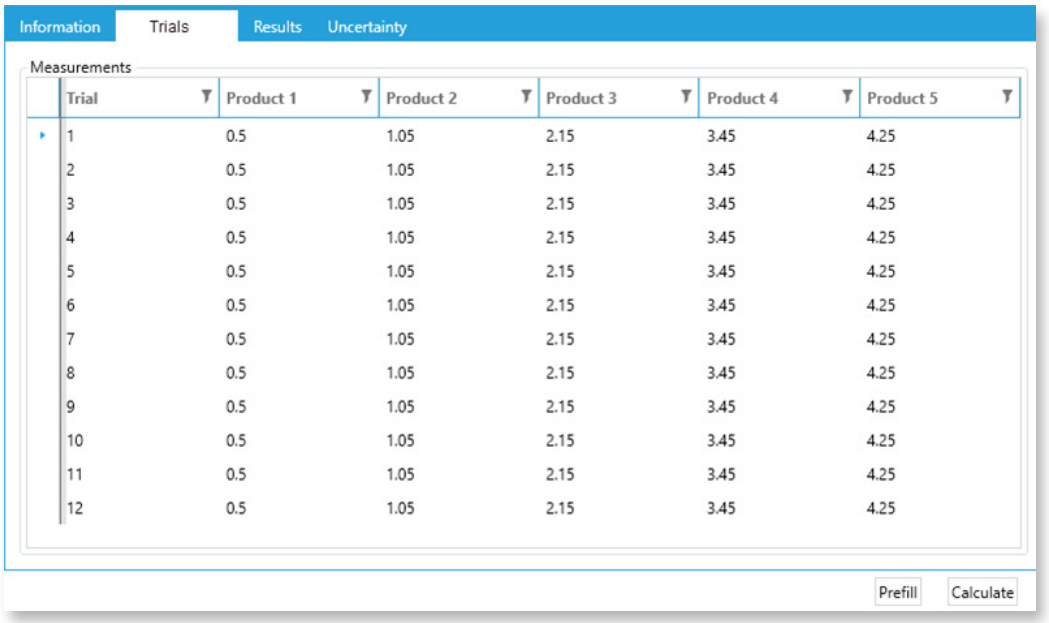


Click **Edit** to enter three to five **Reference Values** that include **Product ID** and **Inspection Point** in the **Products** area. The **Product ID** and **Inspection Point** values are populated from the **Products** area of the **Crib**. The smallest product reference values should be entered as 1 and the largest reference values entered as 5. You can then use **Prefill** to speed data entry on the next tab.



Linearity - Trials Tab

Click the **Trials** tab to begin entering the trial's corresponding measurements for each **Product Inspection Point**. Start with Product 1. Press the **Enter** key to move your cursor down and use the Tab key to move your cursor to the next field to the right.



Trial	Product 1	Product 2	Product 3	Product 4	Product 5
1	0.5	1.05	2.15	3.45	4.25
2	0.5	1.05	2.15	3.45	4.25
3	0.5	1.05	2.15	3.45	4.25
4	0.5	1.05	2.15	3.45	4.25
5	0.5	1.05	2.15	3.45	4.25
6	0.5	1.05	2.15	3.45	4.25
7	0.5	1.05	2.15	3.45	4.25
8	0.5	1.05	2.15	3.45	4.25
9	0.5	1.05	2.15	3.45	4.25
10	0.5	1.05	2.15	3.45	4.25
11	0.5	1.05	2.15	3.45	4.25
12	0.5	1.05	2.15	3.45	4.25

Study Definition and Values

Study Type: Choose Linearity & Bias if you have 3 to 5 reference values. If there is only one reference value, choose Bias Only.

Number of Trials/Products: Enter 5 to 12 for each reference value or 5 to 60 for Bias Only studies (required). Enter 1 to 5 products for this study.

Appraiser: Enter the name of the person conducting the study.

Number of Decimal/Percent: Select the format you want for calculations. This will assist in unwanted rounding of results in study input and calculated results.

Ppk Target: A process capability or performance target may be entered (typically 1.33 or 1.67). GAGEtrak will use it to adjust or reduce Tolerance results where relevant to this study.

Six Sigma: If you know the 6-Sigma Process Variation of the characteristic that you're measuring, enter it here. It will be divided by 6 and used for Total Variation TV calculations.

Lower/Upper Specification: Be sure to enter the minimum and maximum Specification Limit values; otherwise, the software cannot calculate the relevant % tolerance values for your study, i.e., EV% of Tolerance.

Use Range Method: Check this option to use the Range Method for Bias; otherwise, GAGEtrak uses standard deviation.

Products:

- **Reference Value** - Enter three to five product reference values for Linearity and Bias. Enter one for Bias Only studies. The smallest reference values should be entered as 1 and each value increases toward the largest reference values entered as 5.

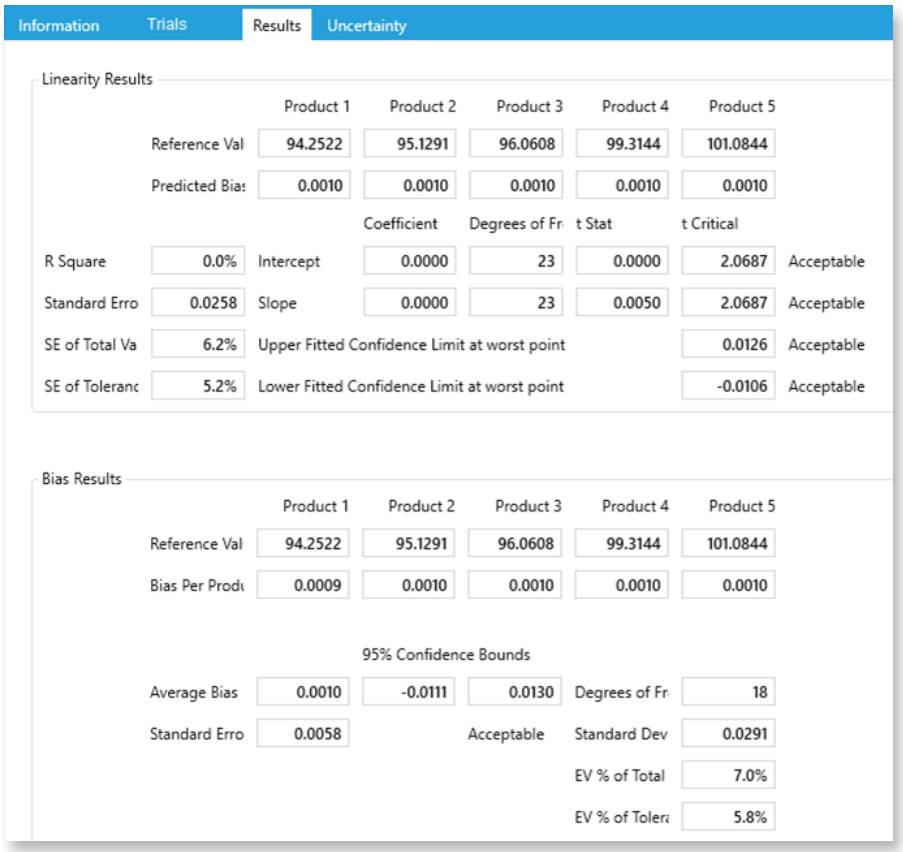
  Example:
  Reference Value 1 = 2.009
  Reference Value 2 = 3.009
  Reference Value 3 = 4.009
  Reference Value 4 = 5.009
  Reference Value 5 = 6.009

- **Product ID** - Select a related reference standard or product number, such as the customer or supplier product number, if relevant.

- **Inspection Point** - In this field, enter the name of the characteristic you measured, i.e., Flange Height. This is for information only; it does not contribute to study results.

Linearity Results Tab

All Linearity and Bias or Bias Only analysis calculated results will appear under this tab.



Linearity and Bias Results

Predicted Bias: The bias predicted by the regression line.

Coefficient: Both Intercept and Slope are called coefficients of the regression equation (Predicted Bias = b + a × Reference Value). Where a = Slope, and b = Intercept.

Degrees of Freedom: Degrees of Freedom (sample size –2) used to determine t critical.

t Stat: Each coefficient is converted to a "t Statistic" so it can be compared to t Critical.

t Critical: A 95% two-sided confidence limit for the t distribution. When the absolute value of either t Statistic is larger than t Critical, the corresponding error is not acceptable.

R Square (Goodness of Fit): A measure of how well the regression line fits the data points, on a scale of 0 to 1. Values near 1 fit well. Values near 0 fit poorly. In case of poor fit, the data must be evaluated graphically rather than numerically.

Standard Error: The standard deviation of the regression (not the raw data).

SE of Total Variation: The Standard Error divided by Total Variation. If this is large, it can cause false acceptance of statistical tests.

SE of Tolerance: The Standard Error divided by Tolerance/6. If this is large, it can cause false acceptance of statistical tests.

Intercept: A coefficient of the regression equation, equal to predicted bias when the reference value is zero (assuming the gage were capable of measuring zero).

Slope: A coefficient of the regression equation, equal to the change in bias per unit of change in reference value.

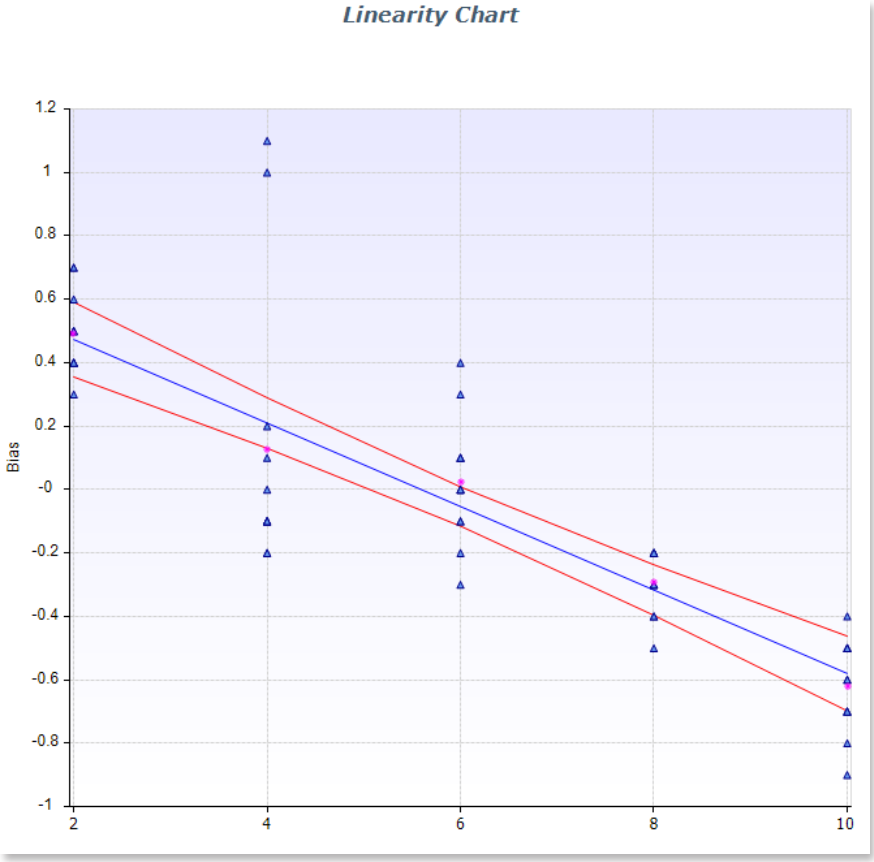
Upper/Lower Fitted Confidence Limit at worst point: Upper Limit may not be less than zero. Lower Limit may not be greater than zero.

Bias Per Product: Individual bias for each product reference value.

Average Bias: Average bias from each product reference value.

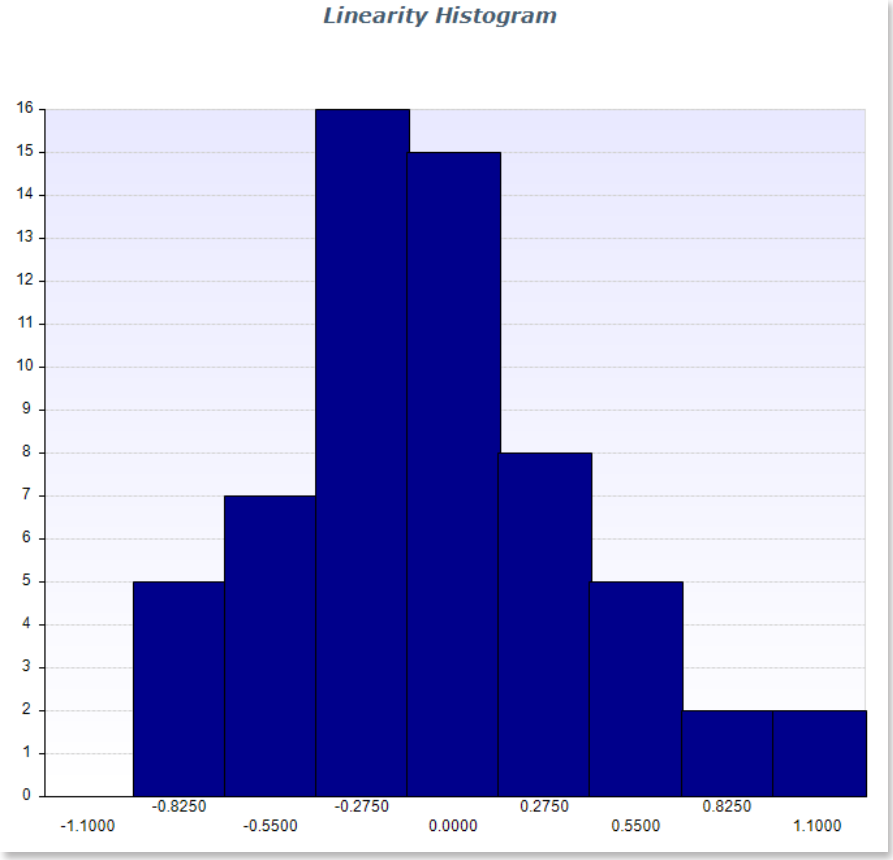
Linearity Chart

To generate a **Linearity** chart, click the **Graph** option on the MSA Navigation Menu and select the Linearity and Bias Study Type from the filter. You'll see a plot of individual and average bias versus the reference values on the x-axis (bottom) of the chart, as well as a best-fit linear regression line and arrow-shaped confidence limits. To be acceptable, the zero bias line must fit within the confidence limits.



Linearity Histogram

This chart is used to show the central tendency, spread and shape of the distribution of Bias values.



Linearity and Bias Study Interpretation

The **Goodness of Fit** value (R Square) of the linear regression line determines whether the biases and reference values have a good linear relationship. This value will be a number between 0 and 1; the closer it is to 1, the better the linear relationship.

You can also evaluate goodness of fit by looking at the chart. If the fit is adequate, then apply three criteria:

1. The horizontal zero bias line on the chart should fit within the confidence limits.
2. The absolute value of the t Statistic for Slope should not be larger than t Critical.
3. The absolute value of the t Statistic for Intercept should not be larger than t Critical.

If the regression line does not fit well, do not apply the above criteria. Study the chart for evidence of non-linearity. Non-linearity can be acceptable if bias per product is always near zero.

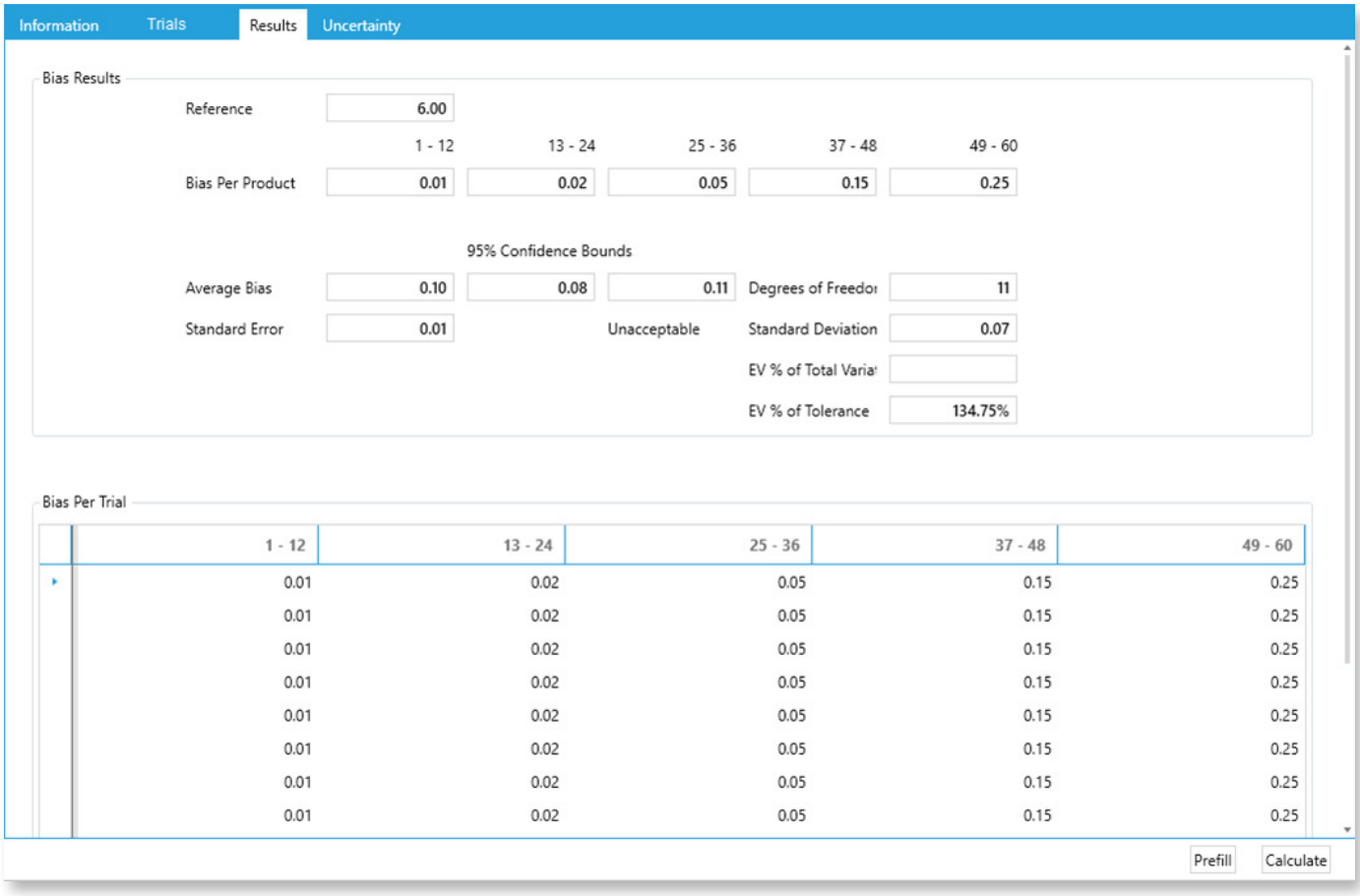
If a measurement system has significant linearity error, look for these possible causes:

1. Gage not calibrated properly at lower and upper ends of the operating range
2. Error in the minimum or maximum master
3. Worn instrument
4. Internal instrument design characteristics
5. Mistakes in measurement or typos

If there is significant linearity error that cannot be eliminated, you may be able to use the gage by using the regression equation to correct future measurements. In the automotive industry, this requires customer permission.

Bias Only - Results Tab

Bias Only study analysis results appear in the **Results** tab. As noted earlier, use the **Bias Only** study if you only wish to check bias at a single reference value. Just like the **Linearity and Bias Study**, you must enter Bias Only **Study Type** and the **Product Reference** value on the **Linearity Study** header and **Information** tab. Then, enter your data in the **Trials** tab before coming to the **Results** tab.



Note: Bias studies using the control chart method are part of the Stability studies and are not included in this screen.

The **Bias Only Results** tab calculates the following fields:

Bias Per Product: Individual Bias estimates for each trial in the study. For a Linearity and Bias study, they are labeled 1-12 in each of 5 columns. For a Bias Only Study, they are labeled 1-60.

Average Bias: The average of all the Bias estimates.

Standard Error: The standard deviation of Average Bias.

95% Confidence Bounds: The Lower 95% Confidence Limit (must not be greater than zero); the Upper 95% Confidence Limit (must not be less than zero).

Degrees of Freedom: The "effective sample size" of the Plus or Minus value. This will typically be less than the actual sample size for the study.

Standard Deviation (EV): The variability of the individual Bias estimates.

EV % of Total Variation: Equipment Variation (Standard Deviation) divided by Total Variation. If this is large, it can cause false acceptance of statistical tests.

EV % of Tolerance: Equipment Variation (Standard Deviation) divided by Tolerance/6. If this is large, it can cause false acceptance of statistical tests.

Interpretation of Bias Results

To be acceptable, the lower 95% confidence limit must not be greater than zero and the upper 95% confidence limit must not be less than zero. If not acceptable, then the Histogram may identify outliers or patterns that provide clues. Possible causes are:

1. Gage not calibrated properly at lower and upper ends of the operating range
2. Error in the minimum or maximum master
3. Worn instrument
4. Internal instrument design characteristics
5. Mistakes in measurement or typos

Uncertainty Tab

Uncertainty refers to the potential variation of gage error that accumulates in the chain of calibrations from NIST through various intermediate calibration labs to the final calibration of a working gage and its use in a production environment. At each intermediate stage of calibration, the uncertainty increases because the input uncertainty will be combined with new uncertainty contributors to create an output uncertainty that is always larger. Each uncertainty along the way is communicated to the next link in the chain by a calibration certificate or test report. Each certificate maintains traceability to the original NIST calibration by citing the NIST number. This system of traceability is important because without it, uncertainty would inevitably grow to the point where customers and suppliers could not trust each other's measurements.

To quote from ISO17025:

Reasonable estimation [of uncertainty] shall be based on knowledge of the performance of the method and on the scope and shall make use of, for example, previous experience and validation data. Sources

contributing to the uncertainty include, but are not necessarily limited to, the reference standards and reference materials used, methods and equipment used, environmental conditions, properties and condition of the item being tested or calibrated, and the operator.

The uncertainty contributors to be included are selected on the basis of judgment and knowledge of the measurement method. Items selected are designated as Type A, which means derived from an MSA study, or Type B, which means some other source such as a certificate or an experience-based, educated guess.

Keep in mind that uncertainty is not an estimate of gage error; it is the potential variability in gage error, i.e., the extent to which gage error is unknown.

Here are some examples of potential uncertainty contributors, and where they come from. This is not an exhaustive list.

Uncertainty of Calibration (Type A)

Uncertainty Contributors	Where Available
Linearity	Linearity studies
Bias	Linearity or Stability studies
Resolution	Linearity or Stability studies
Repeatability or GRR	Linearity or Stability studies
Stability (of the reference standard)	Stability studies (if the reference standard is a variable gage)
Consistency (of the reference standard)	Stability studies (if the reference standard is a variable gage)
Hysteresis	This is a side study, similar to linearity, but easy to do manually.

Uncertainty of Measurement (Type A)

These apply to working use of a gage, after calibration, for variable measurements.

Uncertainty Contributors	Where Available
GRR or its components EV, AV and INT	R&R studies
Stability (of the gage)	Stability studies
Consistency (of the gage)	Stability studies

General Uncertainty Contributors (Type B)

These may apply to both uncertainty of calibration and uncertainty of measurement.

Uncertainty Contributors	Based On
Reference Standard	Certificate
Temperature Difference	Experience
Parallax Error	Experience

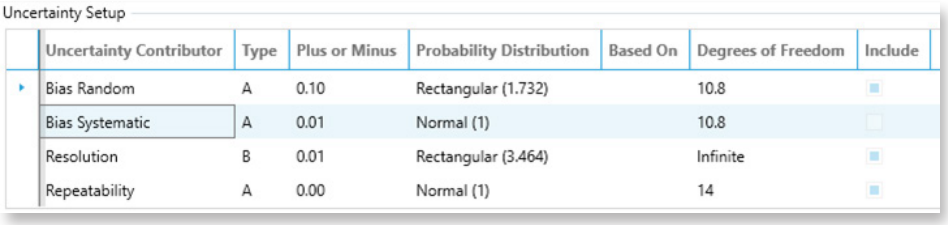
Details about each of these potential uncertainty contributors can be found in the **Background on Uncertainty Contributors** of this chapter.

The Type A or Type B classification depends on whether you do a statistical study (A) or not (B). Thus, if you estimate stability error without doing a study, it becomes Type B instead of Type A. Likewise, if you do a statistical study to determine the uncertainty of temperature difference, it becomes Type A instead of Type B.

The task of determining uncertainty for a calibration or a laboratory measurement involves deciding which uncertainty contributors are to be included and listing them on a form called an uncertainty budget or error budget. This form combines all the contributors for you, using RSS root-sum-square addition, and calculates Expanded Uncertainty for use on certificates or test reports.

Uncertainty Setup

The function of this sub-tab is to help you make decisions about which **Uncertainty Contributors** to include on the **Uncertainty Budget**.


Uncertainty Setup

Uncertainty Contributor	Type	Plus or Minus	Probability Distribution	Based On	Degrees of Freedom	Include
Bias Random	A	0.10	Rectangular (1.732)		10.8	☑
Bias Systematic	A	0.01	Normal (1)		10.8	☐
Resolution	B	0.01	Rectangular (3.464)		Infinite	☑
Repeatability	A	0.00	Normal (1)		14	☑

Column Descriptions

Uncertainty Contributor: The type of measurement error variation to be considered as a contributor.

Type: Everything on this sub-tab is Type A, meaning it was determined from observation and statistics.

Plus or Minus: The amount of plus or minus variation that was observed, expressed as a maximum deviation or a standard deviation.

Probability Distribution: The assumed pattern of variation for each type of error. See the **Background on Probability Distributions** section of this chapter.

Based on: The information or calculation that was used to determine the Plus or Minus value.

Degrees of Freedom: Think of DF as the effective sample size of the Plus or Minus value. This will be less than the actual sample size, depending on the method of calculation. The Uncertainty Budget will use DF to determine a t Statistic.

Include: Check **Include** to determine whether an item is to be included in the Uncertainty Budget. This is the only column that is editable here. The question of when to include an Uncertainty Contributor in the Uncertainty Budget are provided below.

- **Linearity, with Linearity and Bias corrected:** If Linearity was unacceptable, use this estimate. (Even if you will not actually make a correction). This estimate has been corrected for systematic error. You may use this choice at all times, but the next two choices are also available.
- **Linearity, with Only Bias corrected:** If Linearity was acceptable and Bias was unacceptable, you may substitute this estimate for the first choice (even if you will not actually make a correction). This estimate has been partially corrected for systematic error and is more conservative than the first choice.
- **Linearity, Uncorrected:** If Linearity and Bias were both acceptable, you may substitute this estimate for the first choice. This estimate is not corrected for systematic error and is more conservative than the first choice.

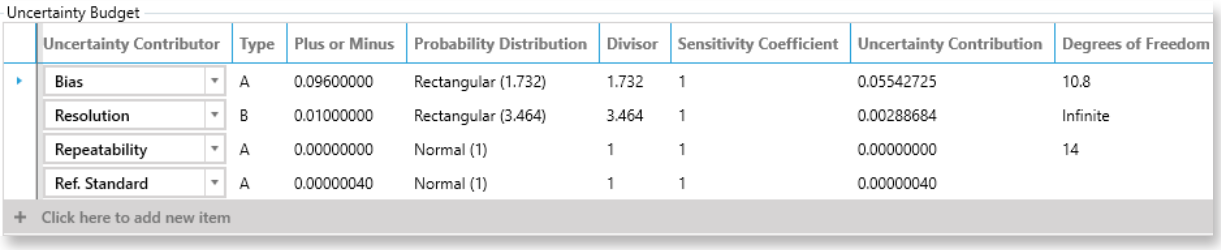
Note: If you believe Linearity error is negligible and not relevant, you may select No for all three Linearity choices.

- **Bias, corrected or not:** Include, unless it is not relevant.
- **Resolution:** Include, unless it is not relevant.
- **Repeatability, or GRR:** Include, unless it is not relevant. This would be GRR if there is more than one appraiser. For example, if this study will apply to a family of gages you could use a different gage for each reference value. Another example would use one technician for half the trials and another technician for the rest.

When your choices have been made, click **Update Budget**. This will partially fill out the **Uncertainty Budget**.

Uncertainty Budget

Up to four rows will already have been filled in according to the choices you made in **Uncertainty Setup**. You may edit these choices here, and doing so will not change **Uncertainty Setup**. To enter additional **Uncertainty Contributors**, select from the drop-down list in an empty row. You may add to most of the drop-down lists. Just type an entry or modify an existing entry. The added item will appear the next time you open this screen.


Uncertainty Budget

Uncertainty Contributor	Type	Plus or Minus	Probability Distribution	Divisor	Sensitivity Coefficient	Uncertainty Contribution	Degrees of Freedom
Bias	A	0.09600000	Rectangular (1.732)	1.732	1	0.05542725	10.8
Resolution	B	0.01000000	Rectangular (3.464)	3.464	1	0.00288684	Infinite
Repeatability	A	0.00000000	Normal (1)	1	1	0.00000000	14
Ref. Standard	A	0.00000040	Normal (1)	1	1	0.00000040	
+ Click here to add new item							

Column Descriptions

Uncertainty Contributor: Select the type of measurement error to be included or type in a new one.

Type: Choose Type A if the Plus or Minus value will be based on statistical observations. Choose Type B if this is based on certificates or experience.

Plus or Minus: Enter the Plus or Minus variation caused by this contributor.

Probability Distribution: Select a Probability Distribution from the drop-down list or key in a new one. See the **Background on Probability Distributions** section.

Divisor: GAGEtrak will fill this in if it recognizes the Probability Distribution. You may change it. See the **Background on Probability Distributions** section.

Sensitivity Coefficient: If the Plus or Minus value is in the proper units and applies directly, then use the default value of one. If the units must be converted or adjusted, insert the proper multiplier here. For example, the Plus or Minus value might be in temperature units, and you wish to use length and the coefficient of thermal expansion for this material to convert to millimeters.

Uncertainty Contribution: This is the standard uncertainty, or standard uncertainty times the Sensitivity Coefficient. It will appear when you click the **Calculate** button. You cannot change it.

Degrees Of Freedom: For Type A items, insert the Degrees of Freedom here. If unknown, you may leave it blank (blanks will be treated as infinite). Degrees of Freedom for Type B items are Infinite by default.

Click the **Update Budget** button and GAGEtrak automatically calculates these fields:

t for 95% Confidence: This is a multiplier that could be used to convert Combined Uncertainty to a 95% confidence limit. It is based on the DF for Combined Uncertainty. It is here for comparison to Coverage Factor k.

Coverage Factor K: This multiplier is used to convert Combined Uncertainty to Expanded Uncertainty. Most, but not all, calibration certificates use a Coverage Factor of k = 2 for approximately 95% confidence. You can change Coverage Factor k if you wish. Values of 1 or 3 are sometimes used, or a value equal to t for 95% Confidence. Coverage Factor k should be stated on calibration certificates.

Combined Uncertainty: This is the total of the Uncertainty Contributors, added by the RSS root-sum-square method, i.e., they are squared and summed and the square root is taken.

Degrees of Freedom (for Combined Uncertainty): This is also called effective degrees of freedom. It is used to calculate t for 95% Confidence. It is a good idea to include this DF on calibration certificates.

Expanded Uncertainty: This is the value to be included on applicable calibration certificates. Coverage Factor k should also be included. DF (of Combined Uncertainty) is good to include also.

Background on Probability Distributions

Normal Distribution

The bell-shaped probability distribution occurs so frequently that it is named *Normal*. When a quantity is influenced by a large number of variables (as is usually true), the pattern of variation will tend to be Normal. The Plus or Minus variability of this distribution is expressed as some multiple of the standard deviation, such as 1s, 2s or 3s. When entering these Plus or Minus values, choose Normal (1), Normal (2) or Normal (3) and GAGEtrak will select the appropriate Divisor to be used to convert to a standard uncertainty (1s). When you run into something different, like 1.96 s, just enter Normal for Probability Distribution and 1.96 for Divisor. When you run into total variation like 6s or 5.15s, you can enter Normal and specify a divisor of, say, 5.15. You could also divide by two before entering the Plus or Minus value and enter a Divisor of 2.576. Note that GAGEtrak currently displays and prints GRR value as 1s, but other software or old printouts of GAGEtrak GRR studies may have been using 5.15s.

Rectangular Distribution

This is the distribution of choice when you do not know what the real distribution is. This distribution occurs when something varies between limits, from one extreme to the other. An example would be air temperature as controlled by a thermostat. Enter the plus or minus value as one-half the difference between the extremes. GAGEtrak will select a Divisor of 3 = 1.732. For temperature of solid objects, see the **U-shaped Distribution** section.

Triangular Distribution

This distribution occurs when two rectangular distributions combine to form a third distribution. An example would be summing a pair of dice. Choose this distribution when you believe a distribution is not quite Normal. Enter the Plus or Minus value as one-half the difference between the extremes. GAGEtrak will choose a Divisor of 6 = 2.449.

U-Shaped Distribution

Choose this when you believe that the extremes are more likely than values at the center. An example would be temperature of solid objects when controlled by a thermostat. The variation will resemble a sine wave when viewed on a time scale and will produce a U-shape when viewed as a distribution. Enter the Plus or Minus value as one-half the difference between the extremes. GAGEtrak will use a Divisor of 2 = 1.414.

Background on Uncertainty Contributors

The following is a background of many well-known contributors, but it is not a complete list.

Uncertainty of Calibration (Type A)

Linearity: Use the maximum residual as a Plus or Minus value. This means the maximum of (observed value minus the reference value minus any systematic error). The Probability Distribution is Rectangular.

Bias: Use the Standard Error of the Average Bias. The Probability Distribution is Normal (1).

Resolution: Use the smallest increment by which a measurement with this gage could increase or decrease. The Probability Distribution is Rectangular. If you prefer to use half of the resolution, enter a multiplier of 0.5 in the Sensitivity column.

Repeatability or GRR: For Linearity & Bias studies, use the pooled standard deviation. For Bias Only Studies, use the Standard Deviation of Bias. The Probability Distribution is Normal (1). GRR Studies are not ordinarily used for this, but they can be. The Probability Distribution is Normal (1) for an updated study, otherwise use Normal with a Divisor of 5.15. Linearity & Bias studies can be designed to use multiple gages from a gage family, in which case the result will be GRR rather than Repeatability. Both Linearity and Bias and Bias Only can be designed to use more than one appraiser. For example, by having two appraisers do six trials each.

Hysteresis: Use the maximum difference between upscale and downscale readings on the same artifacts. This test should cover the full range of the gage. For example, gently add weights to a scale, one at a time, until you get to the full range, then gently remove the weights one at a time. Record readings at each step. The weights don't have to be known values. The Probability Distribution is Rectangular.

Stability (of the reference standard): Include this item if the reference standard is a variable gage and if a Stability study shows instability of the X bar chart. See the **Uncertainty of Measurement (Type A)** section for instructions. The Probability Distribution is Rectangular.

Consistency (of the reference standard): Include this item if the reference standard is a variable gage and if a Stability study shows instability of the s chart. See the **Uncertainty of Measurement (Type A)** section for instructions. The Probability Distribution is Normal (1).

Uncertainty of Measurement (Type A)

These apply to working measurements made after calibration.

GRR or its components EV, AV, and INT: These are available in GRR studies. In this version of GAGEtrak, the Probability Distribution is Normal (1). Other sources or old printouts may require a Divisor of 5.15.

Stability (of the gage): Include this item when a Stability study shows instability. Use the maximum shift or drift that occurs on an X bar chart. This can be done by ignoring where the centerline of the limits is currently drawn on the chart, and imagining the limits were centered around the variation at the beginning of the chart, then imagining that the limits were centered around the variation at the point of maximum shift or drift. Use the difference between the two imaginary centerlines as the Plus or Minus value. The Probability Distribution is Rectangular.

Consistency (of the gage): Follow the instructions for Stability, but do it with the s chart, when the s chart is unstable. The Probability Distribution is Normal (1).

General Uncertainty Contributors (Type B)

These apply both to uncertainty of calibration and uncertainty of measurement.

Reference Standard: Use the Expanded Uncertainty from the reference standards' incoming calibration certificate. Expanded Uncertainties are usually Type B, and the Probability Distribution is usually Normal (2). Look for the Coverage Factor k and DF. Use k as the Divisor. If DF is furnished, enter it and consider choosing Type A.

Temperature Difference: There are multiple kinds of uncertainty that result from materials and gages not being exactly at 20°C (68°F). Estimate the Plus or Minus values based on experience and calculate a Sensitivity Coefficient using the length and coefficient of thermal expansion. The Probability Distribution is usually U-shaped (although it was long thought to be Rectangular).

Parallax: This variable occurs when a pointer or indicator mark is not in the same plane as the dial face or scale, and the dial face or scale is not perpendicular to the appraisers' line of site (recall trying to read a speedometer from the passenger seat). The Probability Distribution is usually Rectangular.

More Information on Uncertainty

For detailed and authoritative information about uncertainty, we recommend consulting NIST Technical Note TN1297. It meets all applicable ISO and ANSI Standards and is more specific. We can also recommend European Accreditation publication EA-4/02. Information on how to calculate Plus or Minus values for specific Uncertainty Contributors comes from the NIST/ SEMATECH e-Handbook of Statistical Methods. See Other Techniques/References at the end of this MSA chapter for details on how to download or view many of these free publications.

Linearity Formulas

x = reference value

y = observation – x

b = intercept

a = slope

m = subgroup size

g = number of subgroups

$\hat{y}$ = predicted bias

R^2 = goodness of fit

SE = standard error of linearity

df = degrees of freedom

$$a = \frac{\Sigma xy - \left(\Sigma x \frac{\Sigma y}{gm}\right)}{\Sigma x^2 - \frac{(\Sigma x)^2}{gm}}$$

$$b = \Sigma\frac{y}{gm} - a \times \left(\Sigma\frac{x}{gm}\right)$$

$$SE = \sqrt{\frac{\Sigma y^2 - b\sum y - a\sum xy}{gm-2}}$$

df = gm-2

$$t\,Stat_a = \frac{|a|}{\frac{SE}{\sqrt{\sum_1^{gm}(x-\bar{x})^2}}}$$

$$t\,Stat_b = \frac{|b|}{SE \times \left(\frac{1}{gm} + \frac{\bar{x}^2}{\sum_1^{gm}(x-\bar{x})^2}\right)}$$

$$\hat{y} = b + a \times x$$

confidence bands for x_0:

$$= b + a \times x_0 \pm \left(t_{gm-2,0.025} \times SE \times \sqrt{\frac{1}{gm} + \frac{(x_0-\bar{x})^2}{\sum_1^{gm}(x-\bar{x})^2}}\right)$$

$$R^2 = \frac{\left[\Sigma xy - \Sigma x \frac{\Sigma y}{gm}\right]^2}{\left[\Sigma x^2 - \left(\frac{(\Sigma x)^2}{gm}\right)\right] \times \left[\Sigma y^2 - \left(\frac{(\Sigma y)^2}{gm}\right)\right]}$$

Bias Formulas

y = observation – x

SE_B = standard error of bias

$\hat{\sigma}$ = repeatability

$$\text{Avg. Bias} = \bar{\bar{y}}$$

$$\hat{\sigma} = \sqrt{\frac{\sum (y - \bar{\bar{y}})^2}{gm - 1}}$$

df = *gm*-1

$$SE_B = \hat{\sigma} / \sqrt{gm}$$

Confidence Bounds

$$= Bias \pm SE_B \times t_{df,0.025}$$

when range method is specified for bias:

$$\hat{\sigma} = \bar{R} / d_2^*$$

df = from d_2^* table

Confidence Bounds

$$= Bias \pm \frac{d_2}{d_2^*} \times SE_B \times t_{df,0.025}$$

m

d_2^* Table (g.1 row is *df*, g.2 row is d_2^*)

g	2	3	4	5	6	7	8	9	10	11	12
1.1	1	2	2.9	3.8	4.7	5.5	6.3	7	7.7	8.3	9
1.2	1.41421	1.91155	2.23887	2.48124	2.67253	2.82981	2.96288	3.07794	3.17991	3.26909	3.35016
2.1	1.9	3.8	5.7	7.5	9.2	10.8	12.3	13.8	15.1	16.5	17.8
2.2	1.27931	1.80538	2.15069	2.40484	2.65438	2.76779	2.90562	3.02446	3.12869	3.22134	3.30463
3.1	2.8	5.7	8.4	11.1	13.6	16.0	18.3	20.5	22.6	24.6	26.5
3.2	1.23105	1.76858	2.12049	2.37883	2.58127	2.74681	2.88628	3.00643	3.11173	3.20526	3.28931
4.1	3.7	7.5	11.2	14.7	18.1	21.3	24.4	27.3	30.1	32.7	35.3
4.2	1.20621	1.74989	2.10522	2.36571	2.56964	2.73626	2.87656	2.99737	3.10321	3.19720	3.28163
5.1	4.6	9.3	13.9	18.4	22.6	26.6	30.4	34.0	37.5	40.8	44.0
5.2	1.19105	1.73857	2.09651	2.35781	2.56263	2.72991	2.87071	2.99192	3.09808	3.19235	3.27701
d_2	1.12838	1.69257	2.05875	2.32593	2.53441	2.70436	2.84720	2.97003	3.07751	3.17287	3.25846

g	13	14	15	16	17	18	19	20
1.1	9.6	10.2	10.8	11.3	11.9	12.4	12.9	13.4
1.2	3.42378	3.49116	3.55333	3.61071	3.66422	3.71424	3.76118	3.80537
d2	3.33598	3.40676	3.47193	3.53198	3.58788	3.64006	3.68896	3.73500

Uncertainty Formulas

p = plus or minus value

d = divisor

c =sensitivity coefficient

u_i = individual uncertainty contribution

df_i = individual degrees of freedom

u_c = combined uncertainty

df_c = combined (effective) degrees of freedom

k = coverage factor

U = expanded uncertainty

$$u_i = p/d \times c$$

$$u_c = \sqrt{\sum u_i^2}$$

$$df_c = u_c^4 \Big/ \sum \frac{u_i^4}{df_i}$$

$$U = u_c \times k$$

df for uncertainty of linearity are not specified in the usual literature. GAGEtrak uses the *df* from d_2^* row 1.1 as a reasonable estimate. The following Weibull approximation of *df* from d_2^* row 1.1 is used for gm > 20:

$$df = (gm - 1) \times e^{-\left(\frac{gm-3}{54.69}\right)^{0.888}}$$

Stability (and Bias)

When we choose a calibration frequency of, say, every 6 months it is the assumption, or hope, that the gage calibration will remain stable for that length of time. A Stability Study verifies this assumption to see if it is true. Plotting a control chart of calibration for a particular reference standard does this. For example, we could check a 1-inch gage block 3 times and do this once a week for 25 weeks, or once every two weeks for 50 weeks. (Automotive requirements call for a minimum of 25 data points to establish stability.)

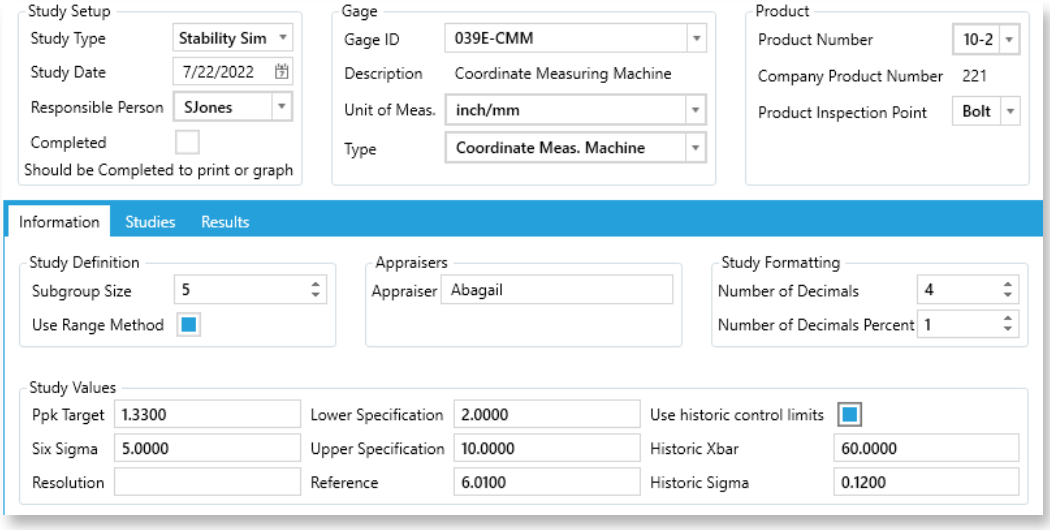
During the study, adjustments are not usually made unless there is an instability signal. Instability signals include 1 point out of limits, 2 points out of 3 beyond 2/3 of a limit, or 7 points in a row on the same side of the central line (some industries use 8 or 9 points in a row). See one of the references on statistical process control (SPC) for more information. The X bar, or X, chart detects changes in bias. If these charts are stable, it means the bias did not change and GAGEtrak can calculate the bias (as long as you are able to enter a reference value for the reference standard or retained sample that was used). If the chart shows a shift or

drift in bias, the amount of change (estimated visually) is the Stability contribution to uncertainty. If bias was not stable, the estimate of bias in this study should not be used.

The R, s and MR charts detect changes in repeatability of calibration. If the chart shows a shift or drift in repeatability, the amount of change (estimated visually) is the Consistency contribution to uncertainty.

Information Tab

As in previous studies, complete the **Stability** header information, then move down to the **Information** tab.



Important study fields in the **Information** tab are explained below.

Study Type: GAGEtrak automatically sets this field to Stability Simple; you can instead choose Stability Complex. Simple stability studies use subgroups containing replications. Complex studies use subgroups containing additional variables such as different standards, specimen portions or test stands. See AIAG Measurement Systems Analysis 4th Edition p.159 (S5, S5a & S5b).

Appraiser: Enter the name of the person conducting the study.

MSA Version: Refers to the Measurement Systems Analysis Reference Manual published by AIAG. Use Version 4 for new studies. Existing Version 3 studies may be updated for new features by changing to Version 4. Updates are reversible.

Specification Limits: Be sure to enter the minimum and maximum Specification Limit values; otherwise, the software can't calculate the % tolerance values for your study.

Ppk Target: A process capability or performance target may be entered (typically 1.33 or 1.67). GAGEtrak will use it to reduce Tolerance to be an estimate of Process Variation.

Six Sigma: If you know the 6-Sigma Process Variation of the characteristic that you're measuring, enter it here. It will be divided by 6 and used for Total Variation TV.

Study Format: Number of Decimals and Decimals Percent - select the format you want for calculations.

Resolution: Enter the resolution of the gage. This controls the minimum resolution of the Histogram chart.

Reference: The value of the reference standard used in the study (used to calculate Bias).

Use Range Method: If selected, bias statistics will be calculated from an R chart, otherwise the RMS standard deviation will be used.

Use historic control limits: If selected, control limits will be calculated from historic values of X bar and sigma. Historic Xbar and Historic Sigma will only be visible if this option is selected.

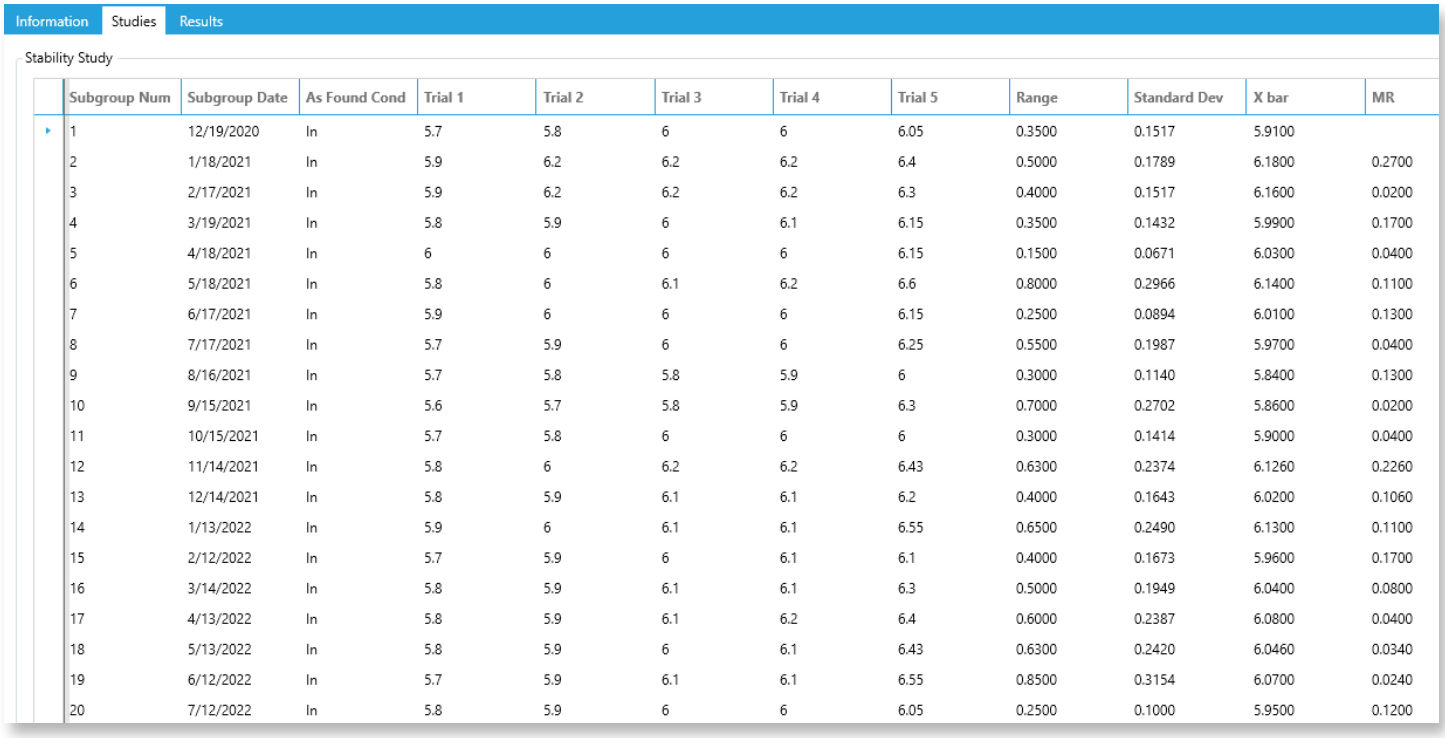
Historic X Bar: If available, enter a known value for the grand average. (This might be known from a Linearity or Bias study or from a previous Stability study.)

Historic Sigma: If available, enter a known value for the standard deviation. (This might be known from a Linearity or Bias study or from a previous Stability study.)

Studies Tab

To add stability subgroup measurements, click on the first row in the subgroup table. Each subgroup row represents the values of the repeated master (or master product) measurements that you make. You must use the same number of readings for each subgroup of measurements; for example, you shouldn't use a sample size of five repeated readings on your first subgroup and then use only three repeated readings on your second subgroup. Add additional subgroups to the rows following the first subgroup row.

Note: Subgroup sizes of 3 to 5 Trials are common for stability studies. GAGEtrak can accommodate subgroup sizes of 1 to 10.


Information | Studies | Results

Stability Study

Subgroup Num	Subgroup Date	As Found Cond	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Range	Standard Dev	X bar	MR
1	12/19/2020	In	5.7	5.8	6	6	6.05	0.3500	0.1517	5.9100	
2	1/18/2021	In	5.9	6.2	6.2	6.2	6.4	0.5000	0.1789	6.1800	0.2700
3	2/17/2021	In	5.9	6.2	6.2	6.2	6.3	0.4000	0.1517	6.1600	0.0200
4	3/19/2021	In	5.8	5.9	6	6.1	6.15	0.3500	0.1432	5.9900	0.1700
5	4/18/2021	In	6	6	6	6	6.15	0.1500	0.0671	6.0300	0.0400
6	5/18/2021	In	5.8	6	6.1	6.2	6.6	0.8000	0.2966	6.1400	0.1100
7	6/17/2021	In	5.9	6	6	6	6.15	0.2500	0.0894	6.0100	0.1300
8	7/17/2021	In	5.7	5.9	6	6	6.25	0.5500	0.1987	5.9700	0.0400
9	8/16/2021	In	5.7	5.8	5.8	5.9	6	0.3000	0.1140	5.8400	0.1300
10	9/15/2021	In	5.6	5.7	5.8	5.9	6.3	0.7000	0.2702	5.8600	0.0200
11	10/15/2021	In	5.7	5.8	6	6	6	0.3000	0.1414	5.9000	0.0400
12	11/14/2021	In	5.8	6	6.2	6.2	6.43	0.6300	0.2374	6.1260	0.2260
13	12/14/2021	In	5.8	5.9	6.1	6.1	6.2	0.4000	0.1643	6.0200	0.1060
14	1/13/2022	In	5.9	6	6.1	6.1	6.55	0.6500	0.2490	6.1300	0.1100
15	2/12/2022	In	5.7	5.9	6	6.1	6.1	0.4000	0.1673	5.9600	0.1700
16	3/14/2022	In	5.8	5.9	6.1	6.1	6.3	0.5000	0.1949	6.0400	0.0800
17	4/13/2022	In	5.8	5.9	6.1	6.2	6.4	0.6000	0.2387	6.0800	0.0400
18	5/13/2022	In	5.8	5.9	6	6.1	6.43	0.6300	0.2420	6.0460	0.0340
19	6/12/2022	In	5.7	5.9	6.1	6.1	6.55	0.8500	0.3154	6.0700	0.0240
20	7/12/2022	In	5.8	5.9	6	6	6.05	0.2500	0.1000	5.9500	0.1200

The **Stability Study** subgroup record fields are explained below (use the table's horizontal scroll bar to view the fields on the right side of the table).

Subgroup Number: Use this number to identify the subgroup; usually you will start with 1, then go to 2, then 3, and keep using consecutive numbering. However, you can also use letters, such as M-01, M-02 and M-03.

Subgroup Date: In this field, enter the date on which you measured the repeated readings.

As Found Condition: Note if the gage is found in or out of tolerance when taking the initial reading for that study subgroup.

Trial 1 through 10: Enter the actual measurements taken on the master (or master product). For example, if you're taking a sample size of three repeated readings, enter the first reading in field 1, the second in field 2, the third in field 3. In this example, the subgroup size is five, so fields 6 through 10 remain blank.

Range: In this field, you'll see the range for the subgroup (the largest reading minus the smallest reading). This value is calculated; you cannot change it.

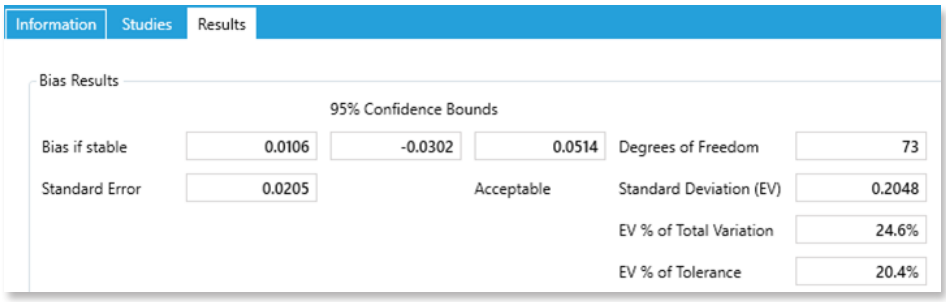
Standard Dev: GAGEtrak calculates the standard deviation for the subgroup (only when the subgroup size is two or more). You can't change this value.

X bar: In this field, you'll see the average (arithmetic mean) for the subgroup. This value is calculated; you can't change it.

MR: In this field you'll see the Moving Range between this subgroup average and the previous subgroup average. This will be blank for the first subgroup.

Results Tab

To see the following fields, enter data on the **Studies** tab and click the **Calculate** button. These estimates should not be used unless the control charts have been confirmed to be stable. If the charts discussed below do not appear stable, the following estimates will be incorrect.



Bias, if stable: The bias of the gage.

Standard Error: The variability of the bias estimate.

95% Confidence Bounds: The Lower 95% confidence limit of Bias will be unacceptable if greater than zero. The Upper 95% confidence Limit for Bias will be unacceptable if less than zero.

Degrees of Freedom: Degrees of freedom for the Standard Deviation and Standard Error.

Standard Deviation (EV): The repeatability of individual measurements.

Creating an Uncertainty Budget for Bias by Control Chart Method

Go to the Linearity, Bias and Uncertainty section and set up the **Linearity** tab. Choose **Study Type** Bias Only and enter 0 as a single reference value (or you can do a linearity study with real data if you prefer). Indicate in **Comments** that Bias values will come from the Stability study and specify study date. Enter a column of 5 zeros in trials. Then setup an **Uncertainty Budget** like this:

Uncertainty Budget

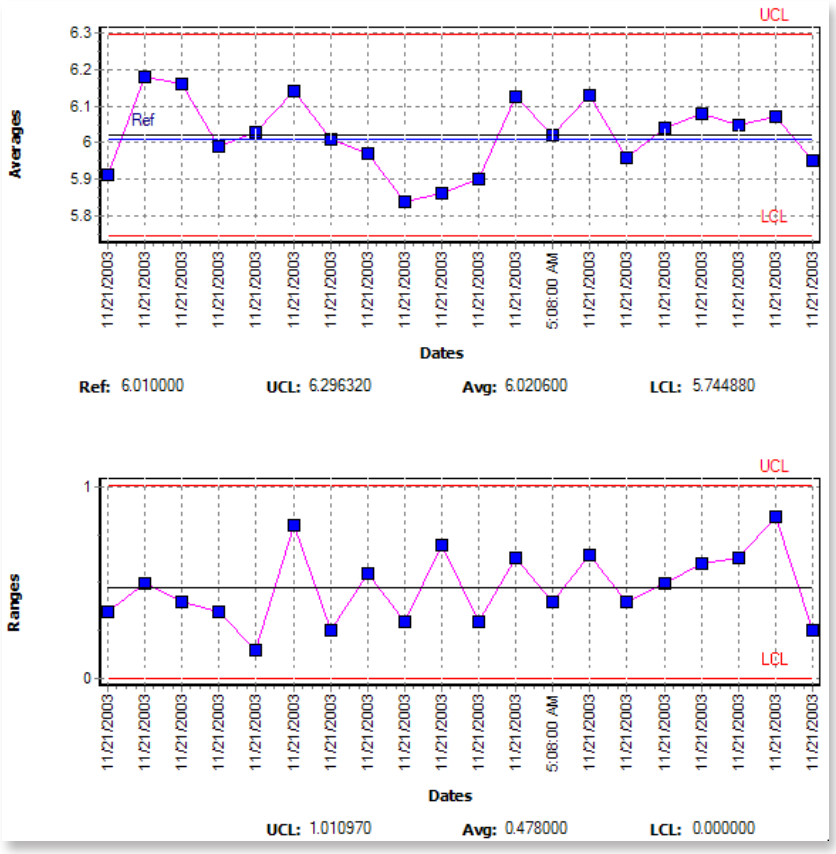
Uncertainty Contributor	Type	Plus or Minus	Probability Distribution	Divisor	Sensitivity Coefficient	Uncertainty Contribution	Degrees of Freedom
Linearity	A	0.0010	Rectangular (1.732)	1.732	1	0.0006	20
Bias	A	0.0010	Rectangular (1.732)	1.732	1	0.0006	18.4
Resolution	B	0.0100	Rectangular (3.464)	3.464	1	0.0029	Infinite
Repeatability	A	0.0277	Normal (1)	1	1	0.0277	20

To complete the Uncertainty Budget, enter the following from the Stability study.

1. For Bias, enter Standard Error as the Plus or Minus value and df.
2. Enter Resolution; if you want to use half, enter 0.5 as a Sensitivity Coefficient.
3. For Repeatability, enter Standard Dev as the Plus or Minus value and df.
4. Enter any additional items you wish and click **Calculate**.

Viewing Stability Control Charts

To view a Stability Control chart, click the **Graph** option on the MSA Navigation Menu and select the Stability Simple or Stability Complex **Study Type** from the filter.



X bar & R Charts (R&R Charts)

These charts will be familiar to many users because they are used extensively in manufacturing. They work best for small subgroup sizes and are not recommended for subgroup sizes of 9 or 10. They do not work for a subgroup size of 1.

X bar & s Charts (Average and Standard Deviation Charts)

These charts work well for subgroup sizes of 2 and up. They do not work for a subgroup size of 1.

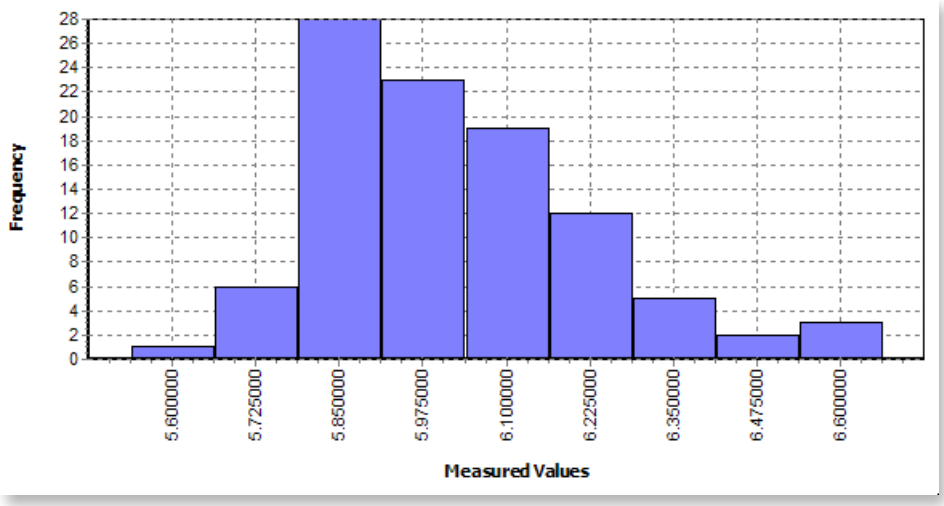
X & MR Charts (Individual and Moving Range Charts)

These charts work for a subgroup size of 1 and up. Control Limits are based on variation between subgroups rather than variation within subgroups. The ability to use a subgroup size of 1 allows use for destructive or non-replicable measurements. See Chapter 4 of Measurement Systems Analysis, Third Edition (MSA3) for more information and other applications. For subgroup sizes larger than 1, the other charts are usually preferred, but if their limits seem too tight or too loose, then use X & MR.

Note: Despite the name Individual Chart, when the subgroup size is greater than 1, averages are plotted.

Histogram

This chart is used to show the central tendency, spread and shape of the distribution.



Calculated control chart fields: These are calculated from the data, unless you specified to use historic values for X bar and Sigma.

UCL: Upper Control Limit for mean or range, etc.

AVG: Average mean or average range, etc.

LCL: Lower Control Limit for mean or range, etc.

Control Chart Formulas

m = subgroup size (number of observations in subgroup)

g = number of subgroups

X = individual sample measurement

X_0 = reference value

R = Range

$\bar{x}$ = subgroup average

s = subgroup standard deviation

$\hat{\sigma}$ = repeatability standard deviation

SE = standard error of bias

A_2, A_3, B_3, B_4, C_4, d_2, D_3, D_4 = control chart constants based on value of *m*, as shown in the table below:

m	A_2	A_3	D_3	D_4	c_4	B_3	B_4
2	1.87997	2.658679	0	3.267	0.797885	0	3.267
3	1.02333	1.954410	0	2.574	0.886227	0	2.568
4	0.72865	1.628102	0	2.282	0.921318	0	2.266
5	0.57682	1.427299	0	2.115	0.939986	0	2.089
6	0.48325	1.287128	0	2.004	0.951533	0.030	1.970
7	0.41928	1.181916	0.076	1.924	0.959369	0.118	1.882
8	0.37253	1.099096	0.136	1.864	0.965030	0.185	1.815
9	0.33670	1.031661	0.184	1.816	0.969311	0.239	1.761
10	0.30826	0.975350	0.223	1.777	0.972659	0.284	1.716

$\bar{X}$ & R Charts	$\bar{X}$ & s Charts	X & MR Charts
$\bar{X} = \Sigma X / m$	$\bar{X} = \Sigma X / m$	$\bar{X} = \Sigma X / m$
R = Max X - Min X	$s = \sqrt{\frac{\sum (X - \bar{X})^2}{m-1}}$	$MR = \lvert \text{This } \bar{X} - \text{Previous } \bar{X} \rvert$
$\bar{R} = \Sigma R / g$	$\bar{s} = \Sigma s / g$	$\overline{MR} = \Sigma MR / (g - 1)$
$UCL_R = \bar{R} \times D_4$	$UCL_s = \bar{s} \times B_4$	$UCL_{MR} = \overline{MR} \times 3.267$
$LCL_R = \bar{R} \times D_3$	$LCL_s = \bar{s} \times B_3$	$LCL_{MR} = \overline{MR} \times 0$
$\bar{\bar{X}} = \Sigma \bar{X} / g$	$\bar{\bar{X}} = \Sigma \bar{X} / g$	$\bar{\bar{X}} = \Sigma \bar{X} / g$
$UCL_{\bar{X}} = \bar{\bar{X}} + (A_2 \times \bar{R})$	$UCL_{\bar{X}} = \bar{\bar{X}} + (A_3 \times \bar{s})$	$UCL_{\bar{X}} = \bar{\bar{X}} + (2.65868 \times \overline{MR})$
$LCL_{\bar{X}} = \bar{\bar{X}} - (A_2 \times \bar{R})$	$LCL_{\bar{X}} = \bar{\bar{X}} - (A_3 \times \bar{s})$	$LCL_{\bar{X}} = \bar{\bar{X}} - (2.65868 \times \overline{MR})$
$Bias = \bar{\bar{X}} - X_0$	$Bias = \bar{\bar{X}} - X_0$	$Bias = \bar{\bar{X}} - X_0$
for $m > 1$:	$\hat{\sigma} = \sqrt{\frac{\sum (X - \bar{\bar{X}})^2}{(g \times m) - 1}}$	for $m = 1$ (note subgroup size for MR is 2, for any m):
$\hat{\sigma} = \bar{R} / d_2^*$	$df = (g \times m) - 1$	$\hat{\sigma} = \overline{MR} / d_2^*$
df = from d_2^* table	$SE = \hat{\sigma} / \sqrt{g \times m}$	df = from d_2^* table
$SE = \hat{\sigma} / \sqrt{g \times m}$	Confidence Bounds	$SE = \hat{\sigma} / \sqrt{g}$
Confidence Bounds	$= Bias \pm SE \times t_{df, 0.025}$	Confidence Bounds
$= Bias \pm \frac{d_2}{d_2^*} \times SE \times t_{df, 0.025}$		$= Bias \pm \frac{d_2}{d_2^*} \times SE \times t_{df, 0.025}$

m d_2^* Table (g.1 row is *df*, g.2 row is d_2^*)

g	2	3	4	5	6	7	8	9	10
1.1	1.0	2.0	2.9	3.8	4.7	5.5	6.3	7.0	7.7
1.2	1.41421	1.91155	2.23887	2.48124	2.67253	2.82981	2.96288	3.07794	3.179905
2.1	1.9	3.8	5.7	7.5	9.2	10.8	12.3	13.8	15.1
2.2	1.27931	1.80538	2.15069	2.40484	2.65438	2.76779	2.90562	3.02446	3.12869
3.1	2.8	5.7	8.4	11.1	13.6	16.0	18.3	20.5	22.6
3.2	1.23105	1.76858	2.12049	2.37883	2.58127	2.74681	2.88628	3.00643	3.11173
4.1	3.7	7.5	11.2	14.7	18.1	21.3	24.4	27.3	30.1
4.2	1.20621	1.74989	2.10522	2.36571	2.56964	2.73626	2.87656	2.99737	3.10321
5.1	4.6	9.3	13.9	18.4	22.6	26.6	30.4	34.0	37.5
5.2	1.19105	1.73857	2.09651	2.35781	2.56263	2.72991	2.87071	2.99192	3.09808
6.1	5.5	11.1	16.7	22.0	27.0	31.8	36.4	40.8	45.0
6.2	1.18083	1.73099	2.08985	2.35253	2.55795	2.72567	2.86680	2.98829	3.09467
7.1	6.4	12.9	19.4	25.6	31.5	37.1	42.5	47.6	52.4
7.2	1.17348	1.72555	2.08543	2.34875	2.55465	2.72263	2.86401	2.98568	3.09222
8.1	7.2	14.8	22.1	29.2	36.0	42.4	48.5	54.3	59.9
8.2	1.16794	1.72147	2.08212	2.34591	2.55208	2.72036	2.86192	2.98373	3.09039
9.1	8.1	16.6	24.9	32.9	40.4	47.7	54.5	61.1	67.3
9.2	1.16361	1.71828	2.07953	2.34370	2.55013	2.71858	2.86528	2.98221	3.08896
10.1	9.0	18.4	27.6	36.5	44.9	52.9	65.6	67.8	74.8
10.2	1.16514	1.71573	2.07746	2.34192	2.54856	2.71717	2.85898	2.98100	3.08781
11.1	9.9	20.2	30.4	40.1	49.4	58.2	66.6	74.6	82.2
11.2	1.15729	1.71363	2.07577	2.34048	2.54728	2.71650	2.85791	2.98000	3.08688
12.1	10.7	22.0	33.1	43.7	53.8	63.5	72.6	81.3	89.7
12.2	1.15490	1.71189	2.07436	2.33927	2.54621	2.71504	2.85702	2.97917	3.08610
13.1	11.6	23.8	35.8	47.3	58.3	68.7	78.6	88.1	97.1
13.2	1.15289	1.71041	2.07316	2.33824	2.54530	2.71422	2.85627	2.97847	3.08544
14.1	12.5	25.7	38.6	51.0	62.8	74.0	84.7	94.9	104.6
14.2	1.15115	1.70914	2.07213	2.33737	2.54452	2.71351	2.85562	2.97787	3.08487
15.1	13.4	27.5	41.3	54.6	67.2	79.3	90.7	101.6	112.1
15.2	1.14965	1.70804	2.07125	2.33661	2.54385	2.71290	2.85506	2.97735	3.08438
16.1	14.3	29.3	44.1	58.2	71.7	84.5	96.7	108.4	119.5
16.2	1.14833	1.70708	2.07047	2.33594	2.54326	2.71237	2.85457	2.97689	3.08395
17.1	15.1	31.1	46.8	61.8	76.2	89.8	102.8	115.1	127.0
17.2	1.14717	1.70623	2.06978	2.33535	2.54274	2.71190	2.85413	2.97649	3.08358
18.1	16.0	32.9	49.5	65.5	80.6	95.1	108.8	121.9	134.4
18.2	1.14613	1.70547	2.06917	2.33483	2.54228	2.71148	2.85375	2.97613	3.08324
19.1	16.9	34.7	52.3	69.1	85.1	100.3	114.8	128.7	141.9
19.2	1.14520	1.70480	2.06862	2.33436	2.54187	2.71111	2.85341	2.97581	3.08294
20.1	17.8	36.5	55.0	72.7	89.6	105.6	120.9	135.4	149.3
20.2	1.14437	1.70419	2.06813	2.33394	2.54149	2.71077	2.85310	2.97552	3.08267
d_2	1.12838	1.69257	2.05875	2.32593	2.53441	2.70436	2.84720	2.97003	3.07751
cd	0.8765	1.8150	2.7378	3.6230	4.4658	5.2673	6.0305	6.7582	7.4539

For g > 20 use d_2, and estimate *df* with the constant difference *cd*.

Attribute Risk Analysis

Attribute gages produce binary outputs like pass or fail and zero or one. To perform this study, you need to select fifty products with a range of measurement values that extends all the way from out of specification at the lower specification limit to out of specification at the upper specification limit. You will need three appraisers who check each product in random order and then check them all again in a different random order, for a total of 3 trials per appraiser.

This procedure is similar to a study in previous versions of GAGEtrak called the Short Attribute study. The Short Attribute study involved only twenty products and published requirements called for perfect agreement. New requirements allow a modest amount of disagreement within or between appraisers.

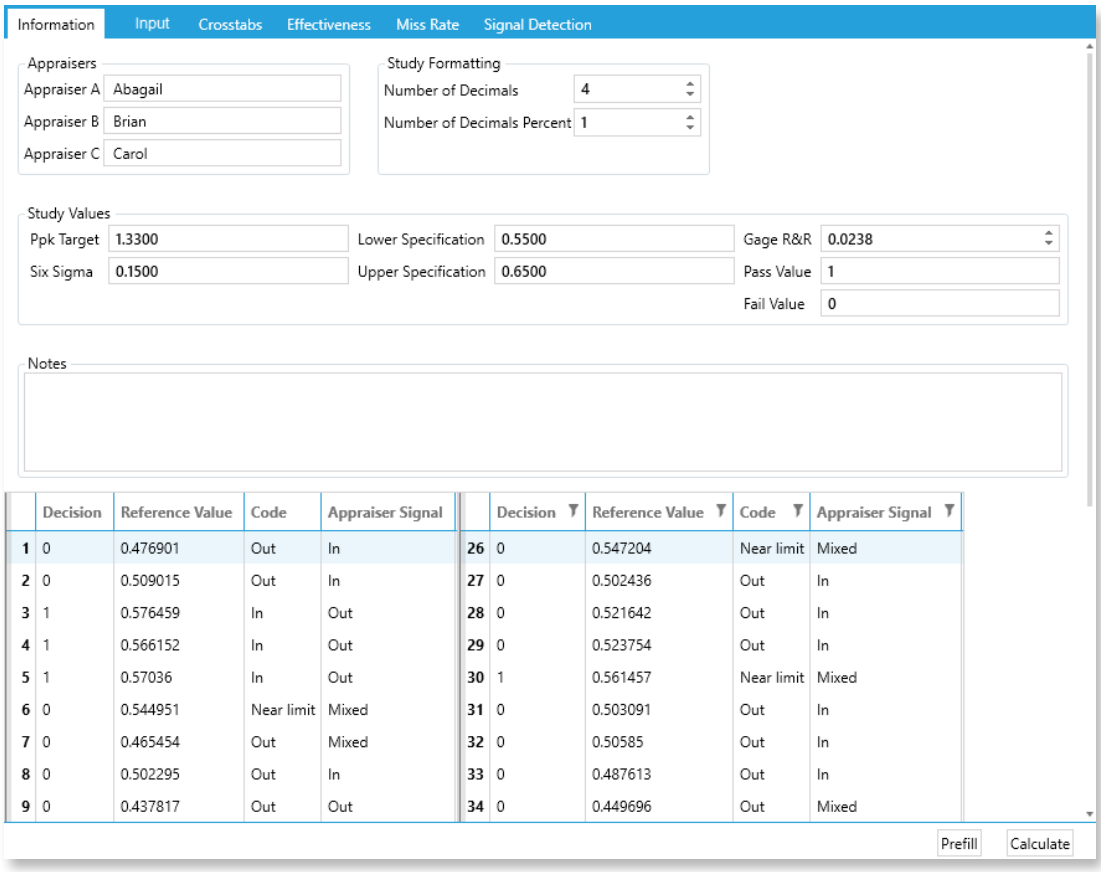
Gage theory tells us that a product made exactly on a specification limit would have a fifty-fifty chance of being accepted by a perfect gage that has no bias. This is true for both attribute and variable gages. (For customer protection, attribute gage manufacturers deviate from theory and shoot for slightly less than 50% acceptance at the specification limit.)

Because all gages, attribute and variable, have repeatability and reproducibility problems, products made too near a specification limit will experience inevitable disagreements between and within appraisers.

Attribute Risk will compare pairs of appraisers and perform hypothesis tests to determine if there is sufficient agreement. If a variable gage is available that can check the same products, GAGEtrak will compare attribute and variable decisions and calculate gage repeatability and reproducibility (GRR) for the attribute gage. If variable measurements are not feasible, you can substitute attribute reference values from an authoritative attribute source (the customer, perhaps).

Information Tab

As in previous studies, complete the **Attribute Risk** header information and then move down to the **Information** tab.



	Decision	Reference Value	Code	Appraiser Signal		Decision	Reference Value	Code	Appraiser Signal
1	0	0.476901	Out	In	26	0	0.547204	Near limit	Mixed
2	0	0.509015	Out	In	27	0	0.502436	Out	In
3	1	0.576459	In	Out	28	0	0.521642	Out	In
4	1	0.566152	In	Out	29	0	0.523754	Out	In
5	1	0.57036	In	Out	30	1	0.561457	Near limit	Mixed
6	0	0.544951	Near limit	Mixed	31	0	0.503091	Out	In
7	0	0.465454	Out	Mixed	32	0	0.50585	Out	In
8	0	0.502295	Out	In	33	0	0.487613	Out	In
9	0	0.437817	Out	Out	34	0	0.449696	Out	Mixed

The **Information** tab contains the following important fields:

Appraisers A, B and C: In these fields, enter the name of each appraiser. Each of these will have product trials entry on the Input tab.

Study Formatting: Select the Number of Decimals and Number of Decimals Percent format you want for calculations.

Ppk Target: If variable data will be used for reference values, a process capability or performance target may be entered (typically 1.33 or 1.67). GAGEtrak will use it to reduce Tolerance to be an estimate of Process Variation.

Six Sigma: If variable data will be used for reference values, and you know the 6-Sigma Process Variation of the characteristic that you're measuring, enter it here. It will be divided by 6 and used for Total Variation TV.

Upper/Lower Specification: These are the upper/lower specification limits for the product. If attribute data will be used for reference values, enter a numerical code for Pass Value (e.g., 1), enter a slightly larger value for Upper Limit (e.g., 1.5) and smaller value for lower (e.g., 0.95).

Gage R&R: If the variable gage has a known GRR for this product characteristic, enter it here. Note: The program needs standard deviation multiplied by 6. Do not use percent.

Pass Value: Enter the code to be used for Pass (like 1 or P) - letters and numbers are accepted.

Fail Value: Enter the code to be used for Fail (like 0 or F) - letters and numbers are accepted.

Notes: Enter any comments, such as the Gage ID of a variable gage to be used for cross checking.

Decision (1-50): The Pass or Fail Decision made by the Reference Value will appear after you click the **Calculate** button. IMPORTANT: An Attribute Risk Study Decision can only be provided with properly defined Upper/Lower Specifications and Reference Values.

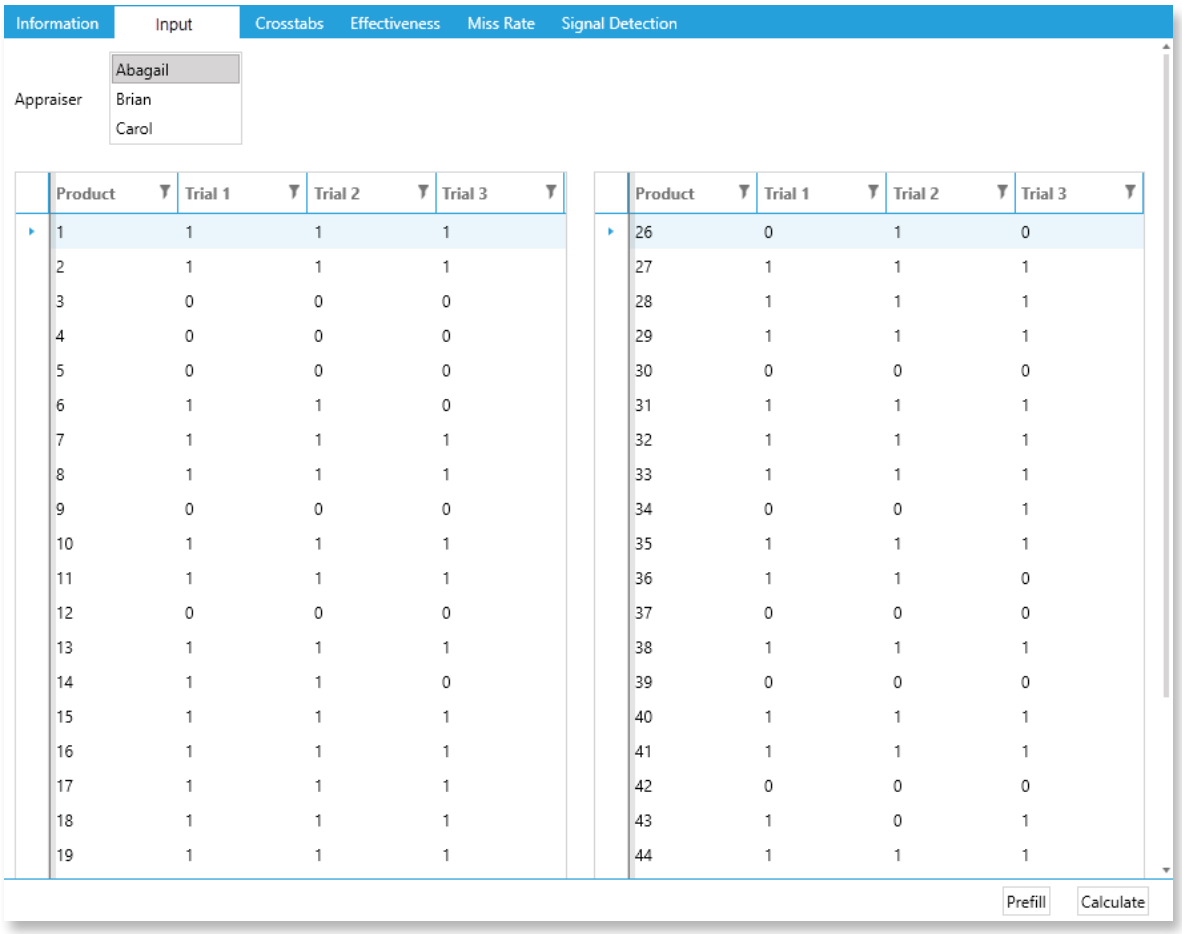
Reference Value (1-50): Enter measurements from a variable gage or rating system. If variable measurements are not feasible, you may substitute numerical codes (like 0 and 1) from attribute decisions by an authority (the customer, for example).

Code: If GRR was entered for the variable gage, products too close to the limit for consistent decisions are coded *Near Limit* after you click the **Calculate** button.

Appraiser Signal: Products that appraisers made mixed decisions about are coded *Mixed* after you click the **Calculate** button.

Input Tab

When you are ready to start entering your Attribute Risk Trial measurement results, click the **Input** tab. After you enter the first measurement result for Product 1, press the Enter key to move your cursor down and use the Tab key to move your cursor to the next field to the right. You can use the **Prefill** feature to fill all measurements with the code for Pass (or Fail) if convenient. Before using the **Prefill** feature, be sure to enter the number of trials, appraisers and products for the study on the **Information** tab.

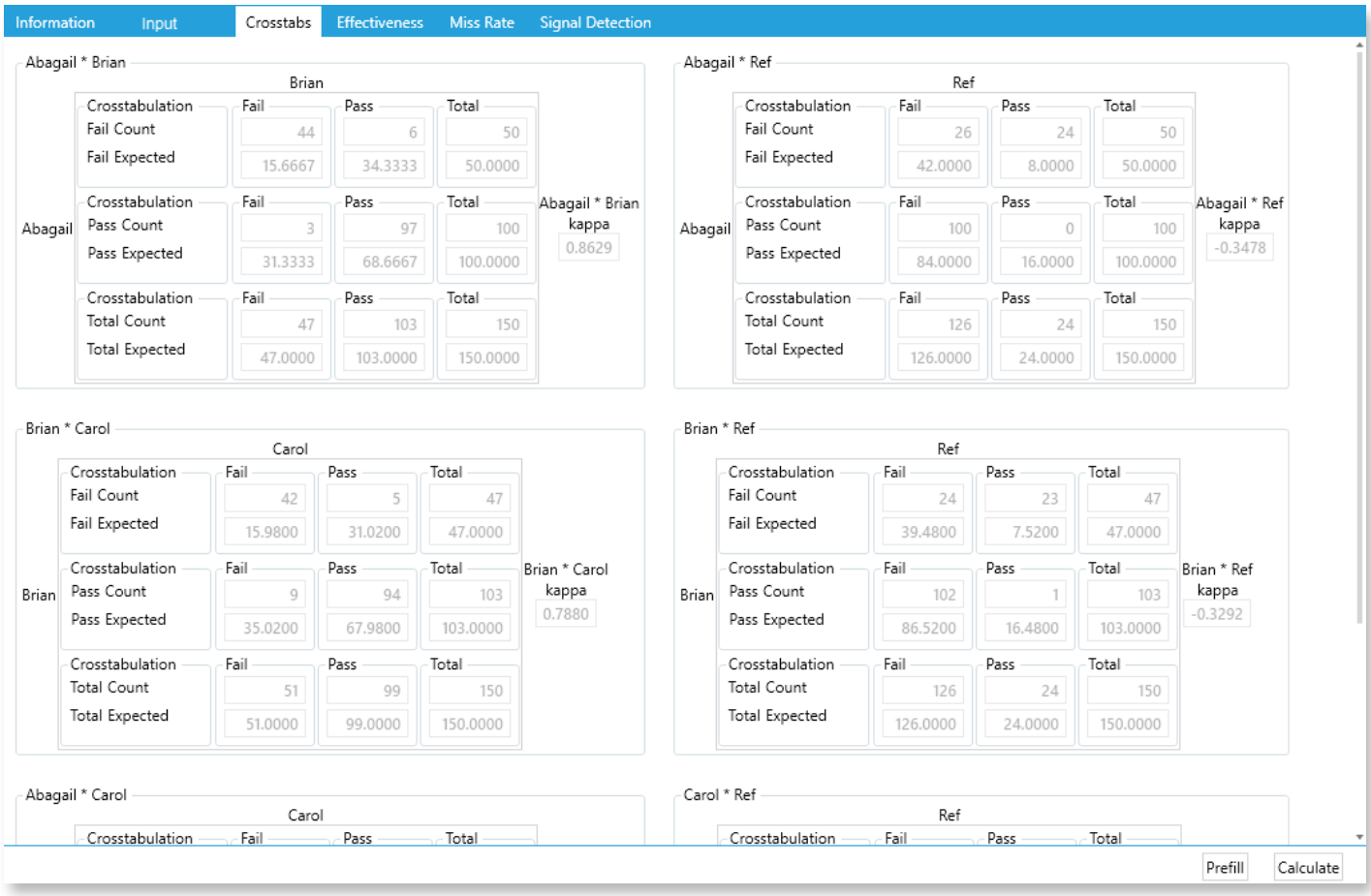


The **Input** tab contains these important fields and buttons:

Appraiser: Click on the Appraiser to begin entering their measurement results in these fields (1-50 products).

Calculate: After you enter all of the measurements for each appraiser, click this button to see the results of your study.

Crosstabs Tab



Appraiser vs. Appraiser

In the left set of group boxes, the tables compare appraisers to each other two at a time, using a method called Crosstabulation.

Appraiser vs. Ref. Value

In the right set of group boxes, the tables compare each appraiser to the variable gage. The **Crosstabs** tab has these fields:

A* (e.g., Appraiser A * Appraiser C) Crosstabulation: Select which pair of Appraisers you want to evaluate.

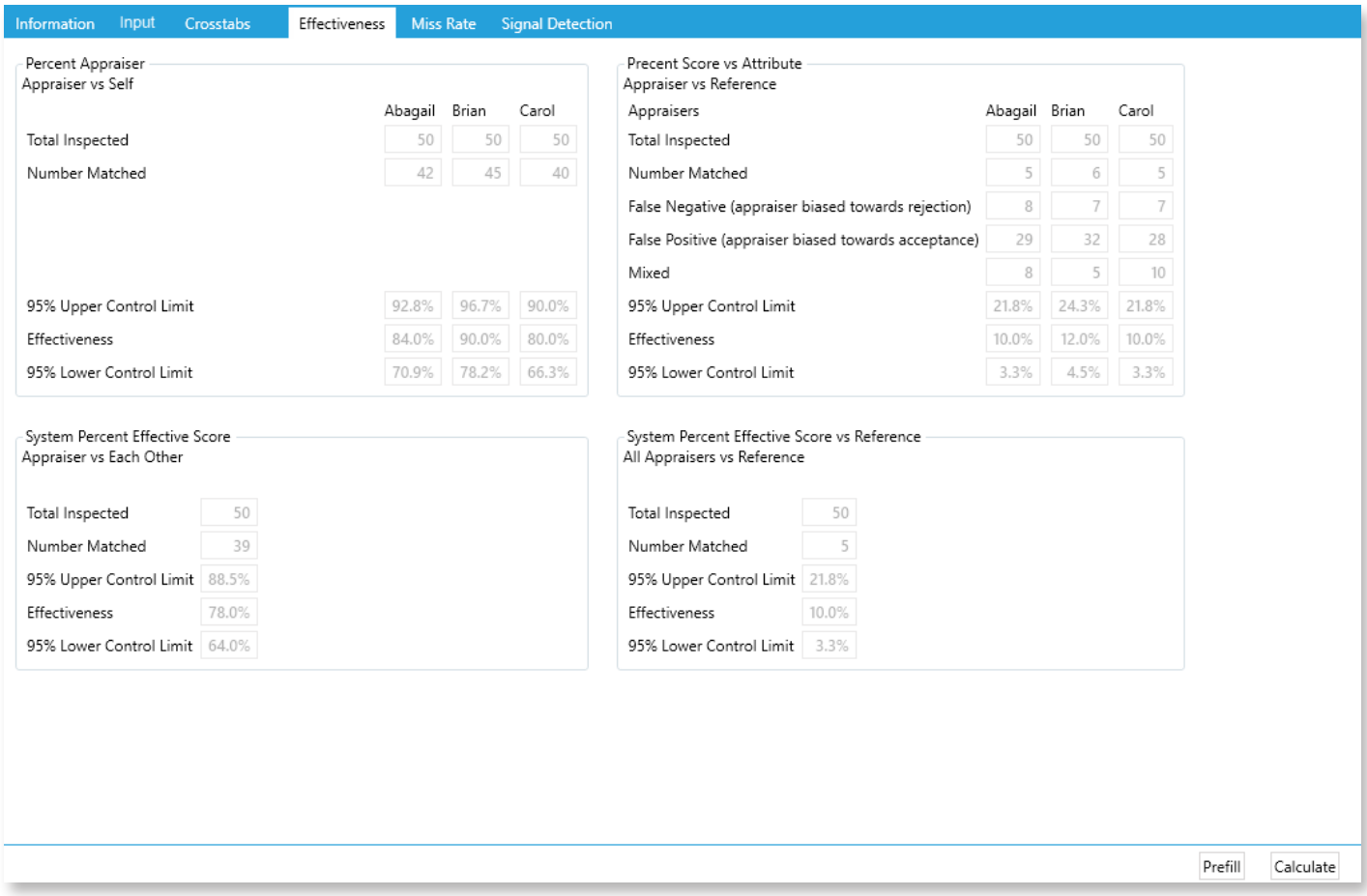
Crosstabulation Fail Count: The number of times the two selected Appraisers voted a particular way. For example, suppose there were 6 times A said Fail and B said Pass.

Crosstabulation Fail Expected: The number of times we would expect a particular vote combination to occur based on the totals.

Crosstabulation Total Count: The totals for each column and row.

Kappa: The Kappa statistic measures agreement, on a scale of zero to one. Over 0.75 is considered good, under 0.40 is considered poor.

Effectiveness Tab



The following fields are available and apply to each group box in which they appear. Each group box provides comparisons of each appraiser to themselves, each other, and the reference values from the variable gage.

Total Inspected: Number of products inspected for each appraiser.

Number Matched: Number of products with consistent ratings for each appraiser.

False Negative (appraiser biased towards rejection): Number of products that were consistently rejected by the appraiser and accepted by the variable gage.

False Positive (appraiser biased towards acceptance): Number of products that were consistently accepted by the appraiser and rejected by the variable gage.

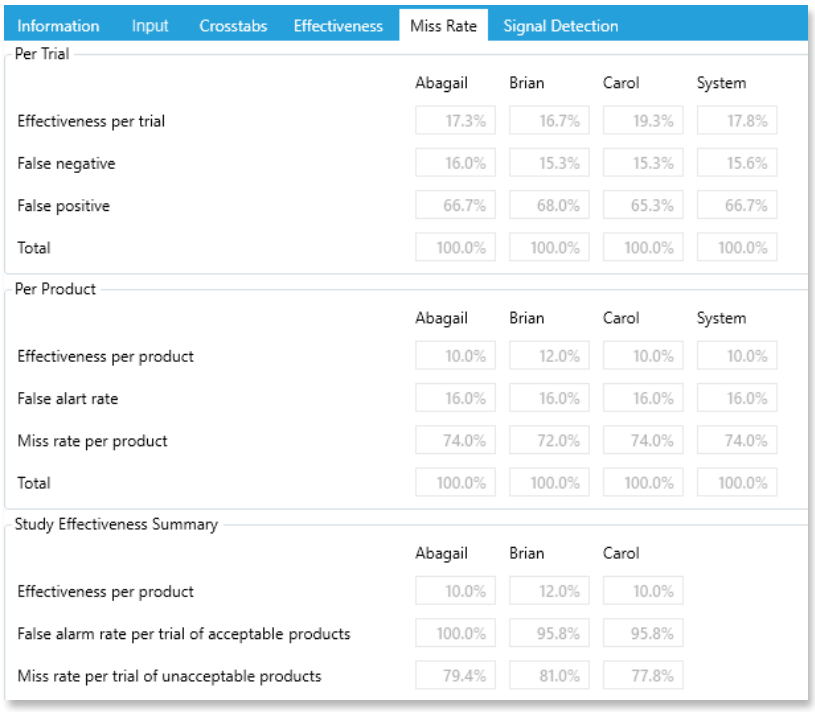
Mixed: Number of products where an appraiser had inconsistent results.

95% Upper Control Limit: A 95% Upper Confidence Limit for the Effectiveness score.

Effectiveness: Percent of products that consistently matched. This number should be within the confidence bounds for the other appraisers.

95% Lower Control Limit: A 95% Lower Confidence Limit for the Effectiveness score.

Miss Rate Tab



The following fields compare each appraiser to the reference value from a variable gage. Each group box compares the appraisers, as a group, to the reference values from the variable gage.

Per Trial

Effectiveness per trial: The percent of trials that agreed with the variable gage.

False negative: The percent of trials that rejected when the variable gage accepted.

False positive: The percent of trials that accepted when the variable gage rejected.

Total: All the percentages add up to 100%.

Per Product

Effectiveness per product: The percent of products that consistently matched the variable gage.

False alarm rate: The percent of products that were accepted by the variable gage and had at least one rejection by the appraisers.

Miss rate per product: The percent of products that were rejected by the variable gage and had at least one acceptance by the appraiser(s).

Total: The percentages add up to 100%.

Study Effectiveness Summary

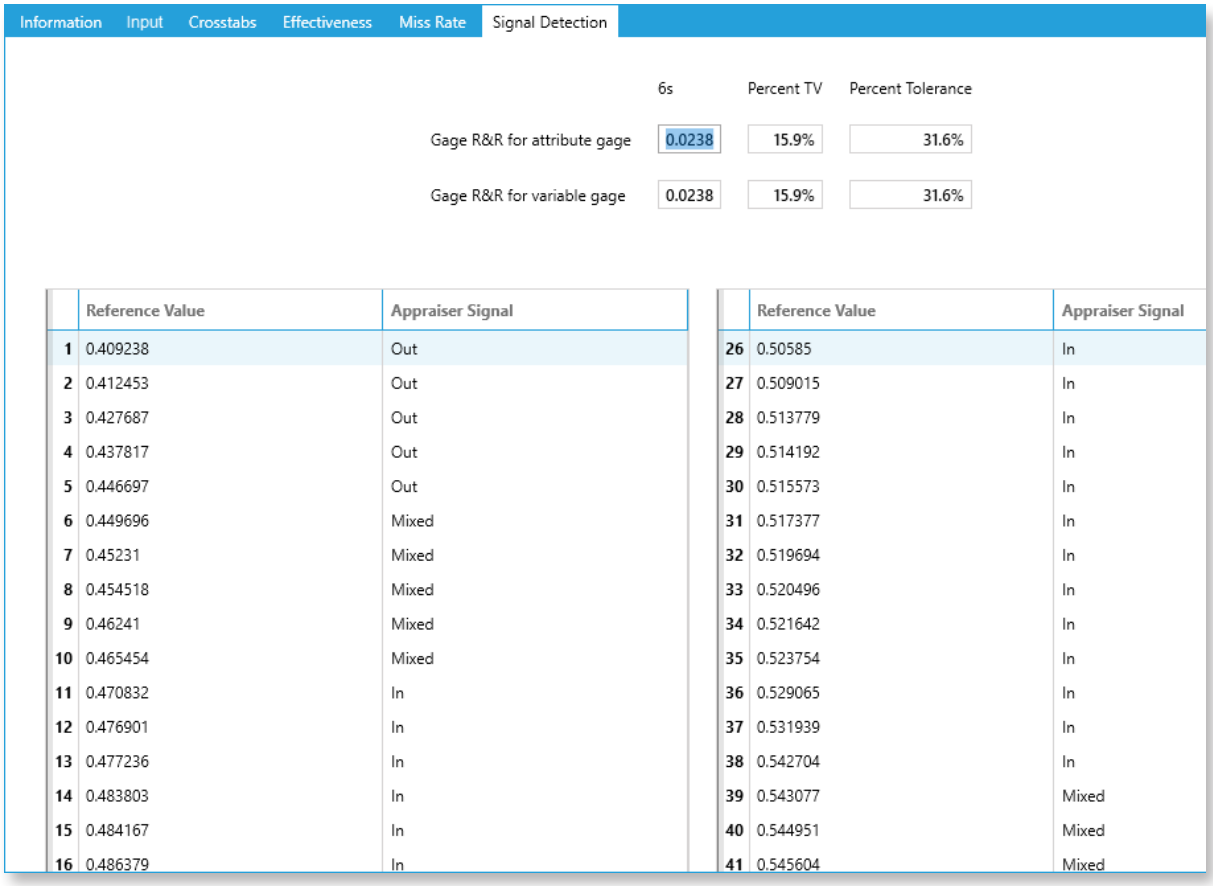
Effectiveness per product: The percent of products that consistently matched the variable gage.

False alarm rate per trial of acceptable products: The percent of products that were accepted by the variable gage and were rejected by the appraisers.

Miss rate per trial of unacceptable products: The percent of products that were rejected by the variable gage and were accepted by the appraisers.

Signal Detection Tab

If reference values are available from a variable gage, this tab estimates Gage Repeatability (GRR) for the attribute gage.



	Reference Value	Appraiser Signal
1	0.409238	Out
2	0.412453	Out
3	0.427687	Out
4	0.437817	Out
5	0.446697	Out
6	0.449696	Mixed
7	0.45231	Mixed
8	0.454518	Mixed
9	0.46241	Mixed
10	0.465454	Mixed
11	0.470832	In
12	0.476901	In
13	0.477236	In
14	0.483803	In
15	0.484167	In
16	0.486379	In

	Reference Value	Appraiser Signal
26	0.50585	In
27	0.509015	In
28	0.513779	In
29	0.514192	In
30	0.515573	In
31	0.517377	In
32	0.519694	In
33	0.520496	In
34	0.521642	In
35	0.523754	In
36	0.529065	In
37	0.531939	In
38	0.542704	In
39	0.543077	Mixed
40	0.544951	Mixed
41	0.545604	Mixed

Gage R&R for attribute gage: GRR is estimated as the range from consistently *out* to consistently *in*. If the study includes Upper and Lower Specification Limits, GRR will be an average range and GRR% of Tol will also be calculated. Assuming the attribute gage is for sorting or validation, and is not used for process control, the criterion is GRR% of Tol of 10% or less is acceptable. GRR% of Tol over 30% is unacceptable.

Gage R&R for variable gage: This is the GRR that was entered on the Information tab.

Percent TV: Gage R&R divided by Total Variation. Under 10% is acceptable, 10 to 30% may need improvement, over 30% is not acceptable.

Percent Tolerance: Gage R&R divided by Tolerance. Under 10% is acceptable, 10 to 30% may need improvement, over 30% is not acceptable.

Reference Values (1-50): The Reference Values from the variable gage sorted in ascending order, and the corresponding Appraisal Signal.

Crosstabulation Formulas

OC = observed count

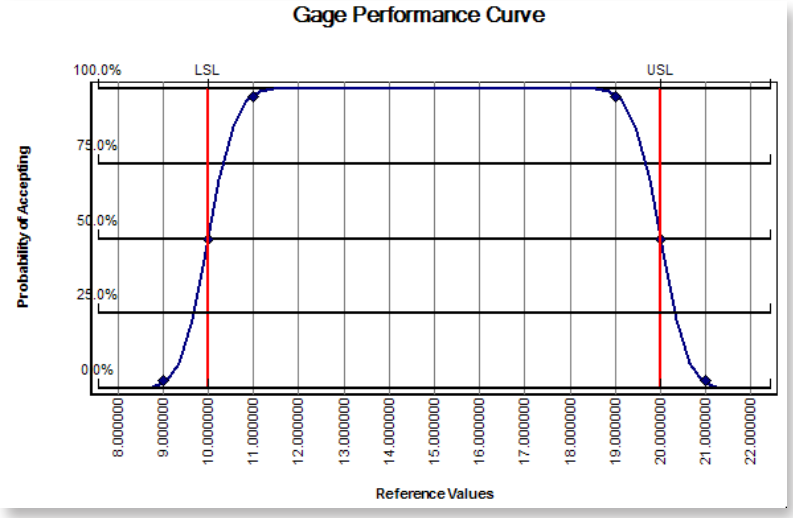
EC = expected count

$$\mathrm{EC} = \frac{\sum OC(row) \times \sum OC(column)}{\sum OC(all)}$$

$$\mathrm{kappa} = \frac{OC(agree) - EC(agree)}{\mathrm{EC(disagree)}}$$

Attribute Analytic

Gage theory tells us that a gage with no bias should have a fifty-fifty probability of accepting a product that was made exactly on a specification limit. That is true of both attribute and variable gages. It is also true for both types of gages, that because of repeatability problems, products just inside the limit will have a probability of acceptance that gradually increases to 100%, and products just outside the limits will have a probability of acceptance that gradually decreases to 0%. A chart called a **Gage Performance Curve** shows how this works for both attribute and variable gages.

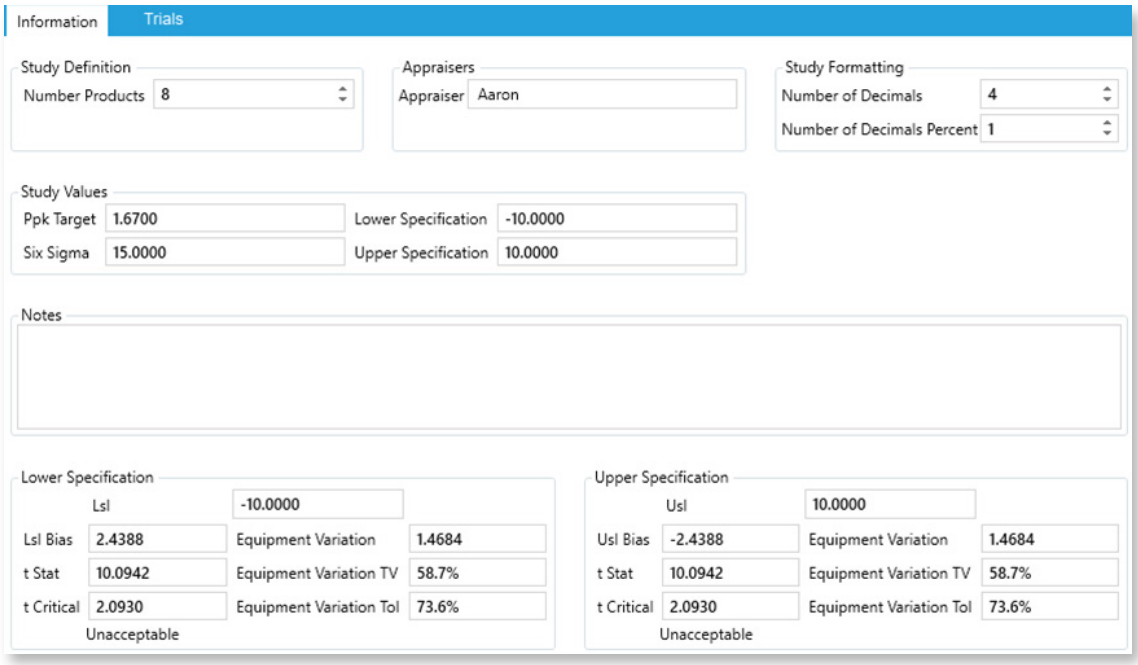


The chart shows how the probability of acceptance gradually changes in an ∫ curve near the Specification Limits. The horizontal width of the ∫ curve is about six times the Repeatability, and the horizontal distance between a specification limit and the 50% point on the curve is Bias. With the data for making this chart, GAGEtrak is able to calculate Repeatability and Bias for an attribute gage.

To plot this chart for attribute gages, we need products that are made near, and on both sides of, a specification limit. The study can be done at either specification limit or at both limits. We need variable measurements in addition to attribute data for each product used in the study. Only eight products are needed for the study, but since we need to find products that meet certain criteria, we often must check more than eight products. The attribute data consists of checking each product twenty times and recording how many times the product is accepted. We do this until we have found at least one product that is accepted zero times, at least one product that is accepted twenty times, and at least six products with acceptance counts that can be anywhere from one to nineteen. In case there are extra products, GAGEtrak will allow up to three entries for each acceptance count. (In case there are more than three products for a certain acceptance count, there are instructions on how to choose which three to include.)

When you click the **Calculate** button, GAGEtrak adjusts the percent accepted for each product and converts it to a *normal score* which makes the ∫ curves plot as diagonal straight lines. GAGEtrak then uses linear regression to calculate repeatability and bias.

Information Tab



The **Information** tab contains the following important fields:

Number Products: Enter the number of products involved in this study.

Study Format: Select the Number of Decimals/Decimals Percent format you want for calculations.

Lower/Upper Specification Limits: Be sure to enter the minimum and maximum Specification Limit values; otherwise, the software can't calculate the % tolerance values for your study.

Ppk Target: A process capability or performance target may be entered (typically 1.33 or 1.67). GAGEtrak will use it to reduce Tolerance to be an estimate of Process Variation.

Six Sigma: If you know the 6-Sigma Process Variation of the characteristic that you're measuring, enter it here. It will be divided by 6 and used for Total Variation TV.

Trials Tab (Lower/Upper Specification Data)

0 (zero): Enter a variable measurement for at least one product that was accepted zero times out of twenty. If you have more than three such products, enter the three largest.

Trials 1-19: Enter variable measurements for six or more products with acceptance counts between one and 19, out of twenty. If you have more than three products with the same acceptance count, then enter them randomly.

Trial 20: Enter a variable measurement for at least one product that was accepted twenty times out of twenty. If you have more than three such products, enter the three smallest.

Lower Specification Trial Results

Enter appraiser result in the **Trials** tab, under the **Lower Specification** group box on the left. Once all entries have been completed, click the **Calculate** button to see lower specification results on the **Information** tab.

The **Information** tab contains the following **Lower Specification** results fields:

LSL: Displays the Lower Specification Limit.

LSL Bias: Bias for the Lower Specification Limit. LSL Bias will appear after you enter LSL data and click **Calculate**.

t Stat: The Bias number is converted to a t-Statistic. The absolute value should be smaller than t-Critical.

t Critical: A 95% confidence limit for t-Stat.

Equipment Variation: This measures the variation one appraiser has when measuring the same part (and the same characteristic) using the same gage more than one time. This variation is usually referred to as (EV) in the Gage R&R study. Equipment Variation will appear after you enter LSL data and click **Calculate**.

Equipment Variation TV: Percent of Total Variation.

Equipment Variation Tol: Percent of Tolerance.

Upper Specification Trial Results

Enter appraiser result in the **Trials** tab, under the **Upper Specification** group box on the right. Once all entries have been completed, click **Calculate** to see **Upper Specification** results on the **Information** tab.

USL: Displays the Upper Specification Limit.

USL Bias: Bias for the Upper Specification Limit. This will appear after you enter data and click **Calculate**.

t Stat: The Bias number is converted to a t-Statistic. The absolute value should be smaller than t-Critical.

t Critical: A 95% confidence limit for t-Stat.

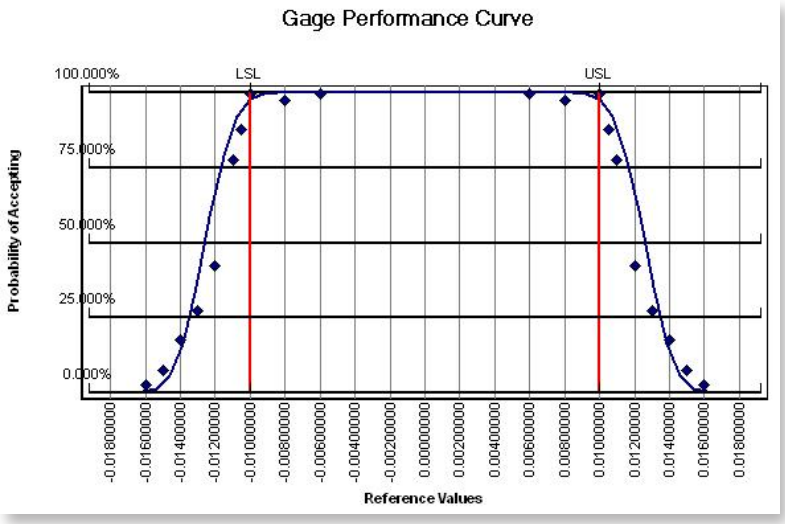
Equipment Variation: Gage Repeatability and Reproducibility (GRR) for the Lower Specification Limit. EV will appear after you enter LSL data and click **Calculate**.

Equipment Variation TV: Percent of Total Variation.

Equipment Variation Tol: Percent of Tolerance.

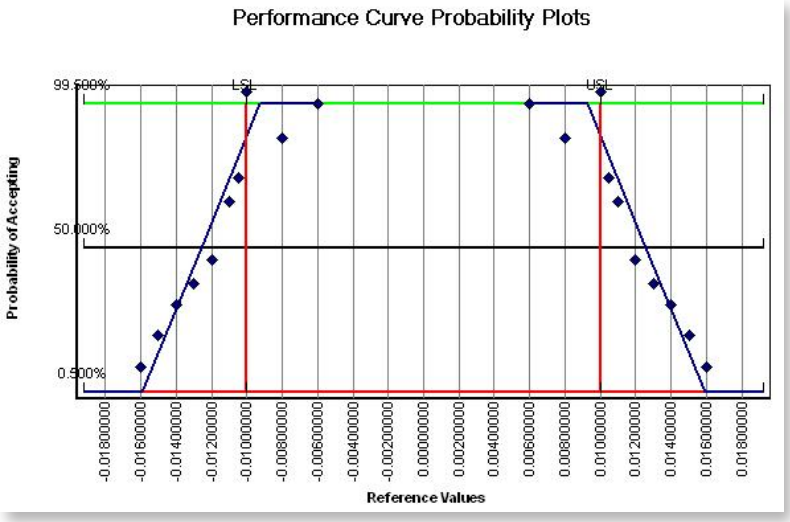
Gage Performance Curve

This chart shows how the probability of acceptance gradually changes in an ∫ curve near the Specification Limits. The horizontal width of the ∫ curve is about six times the repeatability, and the horizontal distance between a specification limit and the 50% point on the curve is Bias. The repeatability and bias are not necessarily the same at both specification limits.



Performance Curve Probability Plots

This chart uses a special scale that makes the Gage Performance Curve look like a series of straight lines. The horizontal width of the diagonal line is 5.15 times the Repeatability, and the horizontal distance between a specification limit and the 50% point on the corresponding diagonal line is Bias. The repeatability and bias are not necessarily the same at both specification limits.



This chart shows how the probability of acceptance gradually changes in an ∫ curve near the Specification Limits. The horizontal width of the ∫ curve is about six times the Repeatability, and the horizontal distance between a specification limit and the 50% point on the curve is Bias.

Attribute Analytic Formulas

C = acceptance count

P = probability of a particular acceptance count

x = normal score (plots on vertical scale, in this case)

y = variable measurement (plots on horizontal scale, in this case)

$\hat{y}$ = predicted variable measurement

b = intercept

a = slope (horizontal/vertical, in this case)

n = sample size

Adjustment for Discrete Data

Adding or subtracting 0.5, to make the number closer to 10, adjusts each acceptance count to calculate P values that convert well to normal scores. For example, P(0) = (0 + 0.5)/20 = 0.025. A table of the normal distribution will show that the corresponding normal score is –1.96.

Table of Counts, Probabilities and Normal scores

C	0	1	2	3	4	5	6	7	8	9
P	0.025	0.075	0.125	0.175	0.225	0.275	0.325	0.375	0.425	0.475
x	-1.96	-1.44	-1.15	-0.93	-0.76	-0.65	-0.45	-0.32	-0.19	-0.06

C	10	11	12	13	14	15	16	17	18	19	20
P	0.5	0.525	0.575	0.625	0.675	0.725	0.775	0.825	0.875	0.925	0.975
x	0.00	0.06	0.19	0.32	0.45	0.65	0.76	0.93	1.15	1.44	1.96

Note: When there are multiple products with a count of zero (or twenty), only the one closest to the average will be used in the linear regression. The extra products will be plotted on the charts, but will not affect calculations.

Separate linear regressions are done for upper and lower specification limits. The custom for these charts is opposite of the usual practice: x, or P, will plot on the vertical scale, and y will plot on the horizontal scale.

$$\hat{y} = b + a \times x$$

$$a = \frac{\Sigma xy - \left(\Sigma x \frac{\Sigma y}{n}\right)}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}$$

$$b = \Sigma \frac{y}{n} - a \times \left(\Sigma \frac{x}{n}\right)$$

Bias = Specification Limit – b

$$GRR = \frac{\hat{y}(\text{at } x = 2.576/1.08) - \hat{y}(\text{at } x = -2.576/1.08)}{5.152}$$

The 1.08 empirical correction factor compensates for the adjustment that was made above to the P values. On the probability plot, the regression line ends at ± 2.576/1.08.

MSA v2 Studies

If you've upgraded to GAGEtrak Pro from an earlier GAGEtrak version, MSA v2 is provided for backward compatibility so that users can view older records created in those versions, hence, they cannot be used for new records. There are five options for MSA v2 studies; namely, MSA2 R&R, MSA2 Linearity, MSA2 Stability, MSA2 Attribute and MSA2 ANOVA. Please refer to the older manuals for a description of these options.

Other Techniques/References

GAGEtrak includes the basic measurement system analysis (MSA) techniques. These rely on proven statistical tools such as Confidence Interval Determination, Control Charting, Performance Curve Plotting and ANOVA. For more information on how the tools work, see, especially NIST/SEMATECH, Duncan or Box in the list below. To view the studies in GAGEtrak, see AIAG chapter 3. To see alternative or special purpose applications for MSA, see AIAG or NIST/SEMATECH. For examples using uncertainty to summarize MSA studies, see EA-4/02 and NIST/SEMATECH. Where websites are referenced, the publications can be freely viewed online, downloaded or both.

We used the following publications as references in developing MSA studies; we recommend them to expand your understanding of measurement system analysis: AIAG, MSA Measurement Systems Analysis Reference Manual, Forth Ed., Chrysler Group, Ford, General Motors, 2010 (highly recommended - to order a copy, call AIAG at (248) 358-3570 and ask for document number "MSA").

AIAG, MSA Measurement Systems Analysis Reference Manual, Third Ed., Daimler Chrysler, Ford, General Motors, 2002 (highly recommended - to order a copy, call AIAG at (248) 358-3570 and ask for document number "MSA").

ASTM, Special Technical Publication 15D, Manual on Presentation of Data and Control Chart Analysis, 1976.
BOX, G. E. P., Hunter, W. G., Hunter J. S., Statistics for Experimenters, John Wiley & Sons, New York, 1978.

DUNCAN, A.J., Quality Control and Industrial Statistics, Fourth Ed., Richard D. Irwin, Inc., Homewood, IL, 1974.

EA-4/02, Expression of the Uncertainty of Measurement in Calibration, 1999, www.european-accreditation.org.

GRUBBS, F. E., "Errors of Measurement, Precision, Accuracy and the Statistical Comparison of Measuring Instruments, Technometrics", Vol. 15, February 1973.

HICKS, C. R., Fundamental Concepts in the Design of Experiments, Holt, Rinehart and Winston, New York, 1973.

ILAC, G17:2002, Introducing the Concept of Uncertainty of Measurement in Testing in Association with the Application of the Standard ISO/IEC 17025, 2002, www.ilac.org.

ISO, Guide to the Expression of Uncertainty in Measurement, 1993, (Revised 1995).

NIST, TN 1297, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, 1994, www.nist.gov

NIST/SEMATECH, e-Handbook of Statistical Methods, www.itl.nist.gov

WESTERN ELECTRIC, AT&T Statistical Quality Control Handbook, Charlotte, NC, Delmar Printing Company, 1984.

CHAPTER 10: CONFIGURATION

The Configuration Menu contains features such as procedure entry, frequency adjustment and templates, which only require initial setup and occasional updates. For this reason, they have been placed apart from the Main Menu data entry points. These data entry points can also be easily secured from users who will not have access to modify them.

Procedures

Use **Procedures** to specify work instructions for gage calibrations, activities and transfers, where applicable. From here, you import or create procedures and edit them any time, if the procedure has not been previously used in historical records. If a procedure you want to edit has been used in a calibration, GAGEtrak Pro will prompt you to create a new revision of the procedure. Once the new revision is created, you will have the opportunity to link it to all of the gages that will use it in the future. This is a document control measure, to ensure that the historical procedure record is not altered. It is important to note that this data entry point is the only area of GAGEtrak Pro in which your procedure records can be edited or removed.

Frequency Adjusting

The **Frequency Adjusting** capability applies only to gages for which A1, A3 or Reliability Study has been specified in the **Frequency Adjustment** field in the **Gages -> Schedule** tab. The A1/A3 terms refer to methods that are outlined in Recommended Practice RP-1 “Establishment and Adjustment of Calibration Intervals” (3/96). RP-1 is a publication of NCSL International, a professional organization for standards labs. See www.ncsli.org.

Method A3 lets you specify a reliability target and requires a low risk of making unnecessary changes, before recommending that a change in calibration frequency is necessary. Reliability is defined as the probability that a gage will still be in tolerance at the end of the calibration interval. GAGEtrak estimates the current reliability by combining the calibration histories of all gages with the same gage type and same calibration frequency. Then, based on the reliability target, GAGEtrak calculates the probability that a change is not needed (called significance). If significance is below the significance threshold, then GAGEtrak suggests a recommended change. When a change is found to be necessary, method A3 uses formulas that optimize the calibration frequency in fewer steps than method A1.

When method A1 is chosen as opposed to A3, the calibration frequency usually changes every time you calibrate, even after the calibration frequency has achieved high end-of-period reliability. Most users will prefer less frequent changes and may not want the short calibration intervals that go with high reliability. Method A1 is included for users who are familiar with it and wish to continue using it. This method increases the existing calibration frequency by 10% if the as-found condition of the gage is in tolerance (multiplied by 1.1). If the as-found condition of the gage is out of tolerance, then it reduces the interval by 55% of the existing frequency (multiplied by .45). If the gage is new and you’ve never calibrated it, then the interval remains the same (multiplied by 1). Simulation studies show that you achieve measurement reliability target of 95% EOP using this approach. EOP stands for End Of Period – it refers to the reliability of a gage at the end of its calibration interval. You can change the table to use different factors if you need to use another frequency adjustment method. Example: If the frequency is 30 days and the as-found condition before calibration is in tolerance, then the frequency would be set to 33 days (1.1 x 30 = 33 days). If the as-found condition was out of tolerance, the frequency would be automatically reduced to 13.5 days (.45 x 30 = 13.5).

Method A3 Formulas

a = significance at I0

g = number in tolerance at I0

n = number calibrated at I0

I0 = existing interval

I1 = new interval

R0 = reliability at existing interval R = reliability target

R0 = g/n

If R0 < R , $$\alpha = 2\sum_{k=0} \frac{n!_g}{k!(n-k)!} R^k (1-R)^{n-k}$$

If R0 ³ R, $$\alpha = 2\sum_{k=g} \frac{n!_n}{k!(n-k)!} R^k (1-R)^{n-k}$$

a will not be allowed to exceed 1.

Use the following formulas if a £ Significance Threshold.

Extrapolation Formulas

I1 = ln R/ln R0 for 0 > R0 < 1 I1 = (1 + 1/R)I0 for R0 = 1

I1 = (1 + R/2)I0 for R0 = 0

Interpolation formulas (Used when a change(s) has already been made, that has proved to be excessively large):

I2 = (I0 + I1)/2

Each subsequent increment of change is reduced by half.

Reliability Study

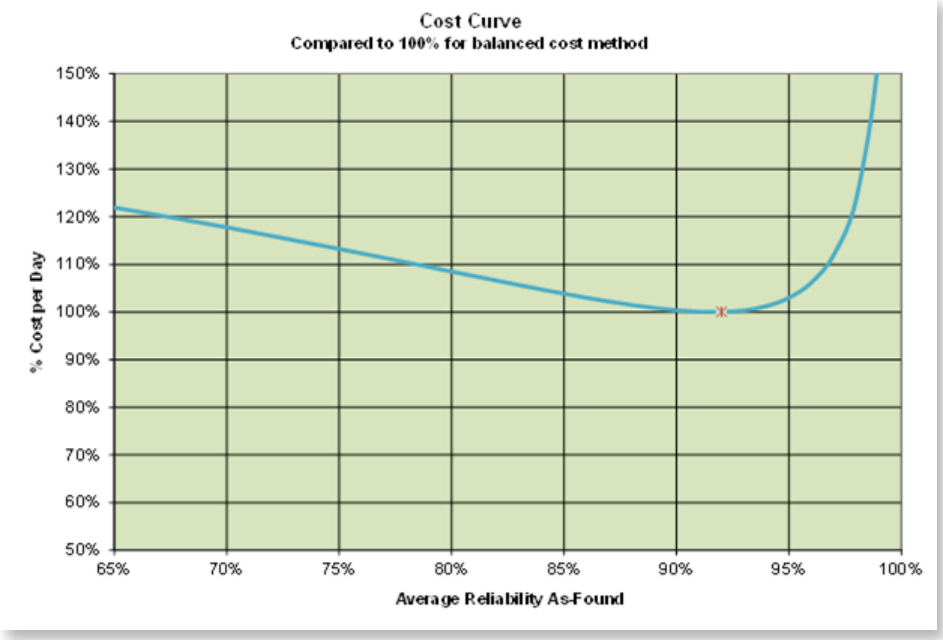
In addition to A1 and A3 frequency adjustment methods, a **Reliability Study** option is provided, which can be useful in determining the best frequency optimization targets for your gages based on reliability and out-of-tolerance cost. Gage reliability is used to measure whether a gage is calibrated too often or not often enough. Obviously, calibrating too often is a waste of money. Not calibrating often enough would mean that the gages will have more frequent failures. Gage reliability is the percentage of times that a gage is found to be in usable condition on the calibration due date. Because this is a more comprehensive study, you will be able to make more informed decisions regarding optimum frequency while balancing calibration costs. Note: If the **Frequency Adjustment** method is Reliability Study in the gage's schedule, then you must also provide the out-of-tolerance cost for the gage (cost of calibration or rework).

Adjustment History

To monitor your adjustments over time, use the **Adjustment History** tab. This grid view will allow you to see frequency changes and decisions. This will be a very useful view for audits and other frequency reviews.

Cost Curve

The **Cost Curve** tab will provide charting for the Reliability Study option. The cost curve example below shows that minimal cost occurs when a company's gage reliability is at 92%. On the left side of the chart, the cost increases up to 20% or more because of too many failures. Note that on the right, the curve increases very quickly to over 50% because of calibrating too often.



Gage Templates

If you have several gage families that share the same basic information, such as procedures, schedules, custodians, test points and other characteristic information, you can define a gage template, and then simply select that template for any new gage records you create within that family. In the **Gage Templates** section, you can also update existing gage records that share a template, as well as create a new template from an existing gage record. You can still clone gages in GAGEtrak Pro, but information changes over time and these templates provide you with greater flexibility to update hundreds of records simultaneously and help ensure more consistent data.

Activity Templates

From the Configuration Menu, select **Activity Templates**. A companion to **Activities** and **Activity Schedules**, **Activity Templates** allow you to predefine your activities so that they can be scheduled and assigned to the gages that will use them. In a template, enter the custodians responsible for completing the activity, any steps, procedures or notes they will need, as well as a general, recurring frequency. If something changes for the activity, such as a new custodian, you can update the activity for all or just some of the gages that use it.

Notifications

From the Configuration Menu, select **Notifications**. The Notification Manager opens in a separate program window allowing for access to the features detailed below.

Email Events

This area the Notification Manager allows you to specify when email notifications will be sent based on predefined event triggers in GAGEtrak Pro. For example, you can configure an email to be sent when specific gages have their status changed, or they fail calibration. Please note: These email events are based on activities that occur in the program, so they cannot be scheduled like other notifications in GAGEtrak Pro. The types of events available are predefined, and you cannot add custom events. You can, however, create and schedule as many email event notifications as you will need for any given event type.

Email Reports

This area allows you to assign any ad-hoc or canned report to be emailed to specific recipients. You can either set up a regularly scheduled interval for reports to go out (such as weekly due listings) or a one-time schedule. You can even save view filters for specific reports to ensure that only data for a specific individual will appear on the report. For example, your shift supervisor has requested a gage due listing be sent for all gages currently in his area at the beginning of each week. So, you set up a view filter in **Gages** that queries all gages due weekly for either that location or that specific custodian and then create an **Email Report** schedule event to be sent on Monday for each week. You can schedule as many of these schedules as you need and for as many reports as you like; there is no limit.

Auto Cal Due

This area will let you view any of the scheduled notification events currently configured specifically for calibration due listings. These can also be configured via the **Email Reports** configuration, or via the backstage area of the GAGEtrak Pro core application. You can select any current schedule and pause it if needed. Example: A production line is temporarily halted for retooling, or a plant shutdown is coming up, so you do not want email notifications going out during that time, but you would like them to resume when everyone returns. Therefore, you can pause those schedules and then start them back up later.

Formulas

GAGEtrak has included a formula calculator with five predefined formulas. Additional formulas can be added (or cloned) and tested using the calculator provided. Once created, your formulas can be assigned to test points for calibrations. Predefined formulas only work with calibration measurements and once assigned, will automatically convert measurement results; a notification will be displayed near the results indicating a formula was applied.

TRAINING

To save time, avoid common mistakes and get the most out of your software, it is imperative to receive proper training and we offer a wide variety of training options to meet every need and budget.

Completion of comprehensive training entitles each participant to a completion certificate in order to provide proof to an auditor that you've received proper training from the software manufacturer.

Go to https://gagetrak.com/training-schedule/ for details about types of training, schedules and pricing.

CONTACT US

Feel free to contact us at any time, for any reason. We're here to help and value your feedback.
1-800-777-7020 https://gagetrak.com/contact-us/