

Easy GR&R™

for Windows

Gage Repeatability
& Reproducibility
Analysis Software

User's Manual
Version 3.0

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Easy GR&R *for Windows*

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GR&R Studies In General

Easy GR&R provides six methods to calculate GR&R studies. The methods are:

- Analysis of Variance (ANOVA)
- Automotive Industry Action Group (AIAG)
- General Motors (GM) / Chrysler
- Ford
- Within Part Variation (WPV)
- Short GM

Study Type Requirements

GR&R studies require a combination of operators, parts, and trials. The study method you select will depend on your gaging system and the level of analysis you desire.

ANOVA, AIAG, GM / Chrysler, and Ford Methods

The ANOVA, AIAG, GM / Chrysler, and Ford methods allow up to three trials and three operators. All four methods require a minimum of two operators, two trials and ten parts. The GM and Ford methods require a tolerance to calculate and express the results. The ANOVA and AIAG methods do not.

The GM and Chrysler methods are the same. For the remainder of the manual and in the software, both the GM and Chrysler method are referred to as the GM method.

Within Part Variation Method (WPV)

The Within Part Variation methods always requires two operators, two trials each containing the maximum and minimum measurements, and ten parts. This method is based on the AIAG method with a few changes to the calculations. A tolerance is optional.

Short Method

The Short method requires a minimum of five parts and two operators. Each part is measured only once. A tolerance is optional.

Selecting The Correct Study Type

If you do not require the individual components of Equipment Variation (E.V.) and Appraiser Variation (A.V.), the Short method provides a quick and meaningful way of determining the acceptability of the gage measurement variations.

The “Long” methods, GM, Ford, and AIAG methods provide E.V. and A.V. component measuring errors. For many years the standard method was to use the GM method which provides the GR&R as a percent of the tolerance. The AIAG method provides an improvement to the AIAG method by expressing the GR&R as a percent of the Total Variance (T.V.). Easy GR&R will perform both the GM and the AIAG method on the same study if you enter a tolerance on the AIAG method study form. By studying the calculations in the references or in Gage R&R Formulas starting on page 36, the differences between the methods will become apparent.

If there seems to be considerable within part variation, using the WPV method may provide insight on how the part variations affect the GR&R results. Unless there seems to be a repeatable difference in the measurements of a part, a maximum and minimum, there is little need to use this method. The AIAG reference contains the formulas for the WPV method and are not included with this manual.

For those who enjoy and have a higher level of understanding of statistics, the ANOVA method also calculates a GR&R ratio. However, the interpretation of the results is difficult for the untrained. The AIAG reference contains the formulas for the ANOVA method and are not included with this manual. Simply put, the ANOVA method is a good example of something simple made complicated.

In most instances, the AIAG method using tolerances to calculate both the AIAG and GM results for comparison will provide satisfactory results for evaluating your gaging process.

Understanding The Measurement Process

Measurement may be thought of a process in which a gage or other measurement device is used to obtain data about something. The input to the process is the item which is being measured. The process which acts to measure the item has four components:

- The measurement reference or standard
- The measurement equipment
- The operator(s) measuring the parts

- The procedure, technique, or method used to measure the part

These four process components combine to create the measurement process which result in the measurement of the item of interest.

The purpose of this software is to expose these components of measurements through quantitative (numerical GR&R results) or qualitative (graphical) analysis. Once the components are analyzed, steps may be taken to reduce or eliminate the variability.

The Interpretation & Analysis section starting on page 29 will help you accomplish this once you have the completed the studies.

GR&R Studies Requiring Special Considerations

In many instances measurements for GR&R studies do not fit the “textbook” examples where the same part may be measured for each trial by the operators. Using some creative ideas and understanding the limitations they put on the measurement results is the only solution.

Destructive Tests

Sometimes parts or items may only be measured once because the measurement process is destructive and the part is damaged or consumed. Typically tensile strength and chemical analysis measurements fall in this category. A typical solution to this problem is to select samples from a homogenous lot and assume that the within part variation is minimal.

Getting Started

This section contains information on how to:

- Install Easy GR&R
- Select the database paths
- Use the Control Block
- Exit Easy GR&R
- Obtain technical support

This manual contains notes which provide reminders or insights on how to get the most out of Easy GR&R. A total listing of notes may be found on page 40.

NOTE: Easy GR&R is designed to run using a screen resolution of 640 x 480 pixels.

Installing Easy GR&R On Windows 3.1, 95, 98, 2000, and NT

Installation takes about 10 minutes. To install Easy GR&R for Windows 3.1:

1. Start Microsoft Windows 3.1.
2. Place diskette # 1 labeled "Easy GR&R for Windows" in drive [A] or [B].

NOTE: Some Windows Systems programs may already be installed and you will have the option to install them over the current file. If you select “No” and Easy GR&R will not run, reinstall Easy GR&R and select “Yes” when prompted.

3. In the Windows Program Manager, select “File”, then “Run”, Type A:SETUP.EXE (or B:SETUP.EXE) in the Run dialog box Command Line field as shown below.

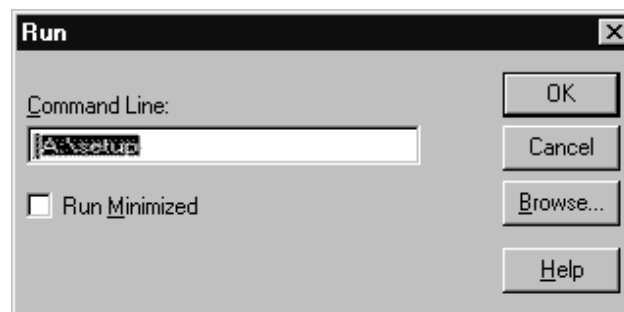


Figure 1: Windows 3.1 Run Dialog Box

Then, select the “OK” button and follow the directions on the setup program. Easy GR&R will start after the install program is completed.

Installing Easy GR&R On Windows 95

Installation takes about 10 minutes. To install Easy GR&R:

1. Start Microsoft Windows 95.
2. Place diskette # 1 labeled "Easy GR&R for Windows" in drive [A] or [B].

NOTE: Some Windows Systems programs may already be installed and you will have the option to install them over the current file. If you select "No" and Easy GR&R will not run, reinstall Easy GR&R and select "Yes" when prompted.

3. In the Windows Task Bar, select "Start", then "Run", Type A:SETUP.EXE (or B:SETUP.EXE) in the Run dialog box Command Line field as shown below.

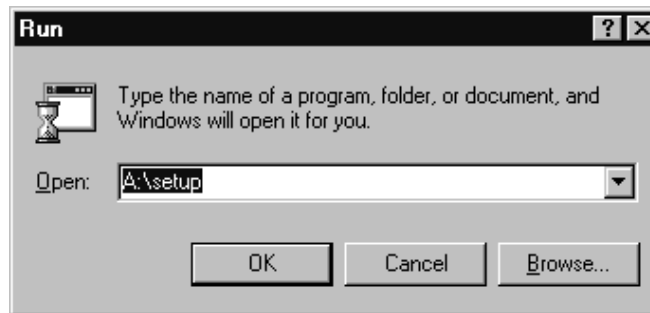


Figure 2: Windows 95 Run Dialog Box

Then, select the "Okay" button and follow the directions on the setup program. Easy GR&R will start after the install program is completed.

If you don't like having the Easy GR&R icon above the "Start" button on your screen, click on the icon with your right mouse button and select "Delete." Then place it in the Waste Basket. If you want to eliminate the Easy GR&R Program Group, Select "File", then "Close" on the Easy GR&R Program Group.

Starting Easy GR&R

To start Easy GR&R, select the Easy GR&R for Windows icon. For Windows 3.1, this is located in the Easy GR&R Program Group. For Windows 95, select "Start" then "Programs" then "Easy GR&R" using the Program shortcuts..



Figure 3: Easy GR&R 3.0 Icon

Selecting Database Paths

When Easy GR&R starts for the first time you may need to enter the path for the Easy GR&R database files. To select the paths, see Changing The Easy GR&R Database Path on page 25. You can have multiple databases if you copy the easygrr.mdb file and rename it. Then, to access the database, select the database path as explained above.

Easy GR&R Basics

Easy GR&R uses the standard Windows interface consisting of selection buttons, pull down menus, and text boxes. When using a mouse, commands and selections are only a click away. If your computer does not have a mouse, the tab, arrow, and enter keys provide a convenient method to make selections on the forms and menus.

Making Selections & Entering Values

To make selections on the Main Menu using a mouse, click on the menu heading to show the option for the selected heading. Once the menu appears, select the option by clicking on the option text.

If the computer does not have a mouse, make selections on the Main Menu by holding down the “Alt” key and pressing the underlined letter. Once the sub menu appears, again make selections by holding down the “Alt” key and pressing the underlined letter.

Using The Control Block

The Control Block contains the option buttons for various GR&R study functions on the forms. Button options include: deleting, recalling, saving, creating, cloning, prefilling and calculating studies. The study selector on top of the Control Block provides a means to step through the previous studies in the database by clicking on the arrows with the mouse. The Control Block also has a button to exit the study form to the Main Menu.



Figure 4: Control Block

The buttons on the Control Block function as follows:

New: Prepares the form and database for a new study.

NOTE: *Always select “New” when you start a study. Do NOT select the “New” button when selecting the “Prefill” and “Clone” buttons.*

Delete: Deletes the current study on the form from the database.

NOTE: *Once deleted a study can not be recalled.*

Recall: Recalls studies based on entered criteria.

Prefill: Places a value you specify into each measurement field to save typing.

NOTE: *Do NOT select the “New” button before selecting the “Prefill” button. The “Prefill” button also includes the “New” button function when selected.*

Clone: Uses the current header value which includes the gage identification, description, part number, etc..

NOTE: *Do NOT select the “New” button before selecting the “Prefill” button. The “Prefill” button also includes the “New” button function when selected.*

Calculate: Calculates the GR&R values based on the measurement values.

Graph: Displays graphs which help interpret the measurements. See Graphical Analysis on page 29 for more information.

Save: Saves the current study in the database.

Print: Prints the current study on the default windows printer.









Exit: Returns to the main Easy GR&R Main Menu.

Help: Displays the Easy GR&R help window. The database Study Record Selector shown below provides methods for stepping through the study database.

The Study Selector shown below provides the capability to step through the study database and indicates the number of records in the database or as a result of a database search. The 16 indicates there are 16 records in the database, or 16 records were found matching the search criteria if a search was performed. The function of each button on the Study Selector is described below.



Figure 5: Study Selector

<u>Button</u>	<u>Function</u>
	Displays first record in the database or sort
	Advances ten records towards the beginning of the database or sort
	Advances one record towards the beginning of the database or sort
	Bookmarks the record
	Returns the record which had the bookmark
	Advances one record towards the end of the database or sort
	Advances ten records towards the end of the database or sort
	Displays first record in the database or sort

Using Help

Easy GR&R has extensive on line Help which provides instructions for using Easy GR&R and performing GR&R studies. To select Help, use the mouse to select Help from the Main Menu, or when available, use the mouse to click on a “Help” button.

Exiting Easy GR&R

To exit Easy GR&R, select the “File” option from the Main Menu. Then, select the “Exit” option.

Obtaining Technical Support

For technical support, please use the technical support number listed on the bottom of the first page in this manual.

Quick Start Overview

To begin using Easy GR&R without reading any more of this manual than you have to, do the following:

1. Set the database configuration by selecting “Settings”, then “Database Users” from the Main Menu and choose the stand alone or network setting. See Stand Alone & Network Easy GR&R Database Users on page 24.
2. Set the database paths by selecting “Settings”, then “Database Paths” from the Main Menu and set the paths. Use the “Search” button to find the database if you don’t know the path of the Easy GR&R database. See Changing The Easy GR&R Database Path on page 25.
3. Enter the gages identification numbers and descriptions into the database by selecting “Settings” the “Gage ID and Description”. Select “Form” or “Table” to enter the gage information using a form or a table. This information will make the gage information accessible on the study forms.

Alternatively, you may enter the Gage IDs and Descriptions for each different gage when entering data for the study on the GR&R study form. By adding gages using this method, select “Yes” to the Message Dialog Box after selecting the “Save” button for each completed study.

Under “Settings”, select “Company Name & Division.” The names you enter on the form will appear on the printed GR&R reports. See page 24 for more information.

Read the section on the Control Block on page 6 and the Notes on page 40.

4. Select the type of study you want to perform by selecting “Methods” from the Main Menu.
5. Select the “New” button on the study form.
6. Enter the information on the form, then select the “Calculate” button.
7. Select the “Save” button to Save the study to the database. If you entered a new Gage ID, you will be asked if you want to save it to the Gage ID and Description database.
8. Select the “Print” button to print the GR&R study.

Performing A GR&R Study

This section contains information on how to:

- Select a study method form
- Gather the data
- Make operator and trial selections
- Calculate the study
- Save a study
- Update a study
- Delete a study
- Clone a study
- Recall a study

Selecting The Study Form From The Main Menu

From the Easy GR&R Main Menu select “Method”, then the study method you want to use. Easy GR&R performs ANOVA, AIAG, Ford, GM and Short method GR&R studies. Summary studies allow placing precalculated study values into the Easy GR&R study database. After selecting the study type, a form appears similar to the one shown below.

ANOVA Measurement Entry & Calculation Form

Gage ID: 100 Part No.: Z-92-0358
 Gage Desc.: caliper Part Name: Bearing assembly
 USL: 1 LSL: .6 Characteristic: OD
 Date: 10/19/96 Company Part No.: MFG-2010-05 REV C
 Memo: GR&R study requested by mfg mgr

Trials: 2 3
 Operators: 2 3
 % Confidence: 90

Buttons: Delete, Calculate, Print, Recall, Save, New, Exit, Prefill, Graph, Clone, Help

#	Master Measurement	Operator A Name: Bob			Operator B Name: Betty			Operator C Name: Pete		
		Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	.5666667	.65	.6	.65	.55	.55	.55	.5	.55	.5
2	1.016667	1	1	1	1.05	.95	1.05	1.05	1	1.05
3	.8055556	.85	.8	.85	.8	.75	.8	.8	.8	.8
4	.8222222	.85	.95	.85	.8	.75	.8	.8	.8	.8
5	.4611111	.55	.45	.55	.4	.4	.4	.45	.5	.45
6	1.011111	1	1	1	1	1.05	1	1	1.05	1
7	.9444444	.95	.95	.95	.95	.9	.95	.95	.95	.95
8	.7888889	.85	.8	.85	.75	.7	.75	.8	.8	.8
9	1.011111	1	1	1	1	.95	1	1.05	1.05	1.05
10	.6666667	.6	.7	.6	.55	.5	.55	.85	.8	.85

Interaction Present	LCL	5.15 STD. DEV.	UCL	% STUDY VARIATION	% CONTRIBUTION	% TOLERANCE
Repeatability (EV)	.122	.151	.196	14.40	2.07	37.78
Reproducibility (AV)	0	.133	2.274	12.60	1.60	33.17
Part x Operator (INT)	.163	.276	.501	26.30	6.90	47.48
Gage R&R (R&R)	.309	.341	2.296	32.50	10.57	85.29
Part-to-Part (PART)	.466	.993	2.439	94.60	89.43	NA

Figure 6: GR&R Study Form

If the Easy GR&R database contains any prior studies, the form will show the studies for the gages first sorted by the gage number ascending and second by date descending. If the first record in the database does not contain information, the form appears without any study information in the fields. Delete this record by selecting the “Delete” button.

Data Gathering and Entry Overview

The following steps provide an overview of performing the GR&R study and using Easy GR&R.

1. Decide on the number of operators and trials. For a ANOVA and Long method studies you must have at least two operators, ten parts, and perform two trials.
2. Make sure the gage has a current calibration sticker. Preferably have the gage calibrated immediately before and after the study.
3. Number the parts for the study so their identity is not apparent to the operators. If the parts are small, using a numbered container or tag so the operators can't see the part numbers works well.
4. Select the “New” button on the study form.
5. Have operator “A” measure the parts and enter the results on the study form. Be sure to put the result in the value entry box that matches the part number. If the first

randomly selected part is number four, put the value in the fourth entry box, not the first even though it was the first part selected.

Repeat step 5 with each operator (B and C) until you have completed the number of trials you decided upon at the beginning (2 or 3) trials.

Use Easy GR&R to calculate the results by selecting the “Calculate” button. If you want to save the study to the database, select the “Save” button.

Entering a New Study

Before you start typing in the observed values from your GR&R study, select the “New” button from the Control Block.

The form entry boxes are cleared allowing you to enter the new study information. Notice that the form indicates that a new study is ready to be entered under the LSL and to the right of the Date value entry boxes.

Selecting Operator & Trial Options

The study form contains option buttons to select the number of operators and trials near the top center of the form as shown.

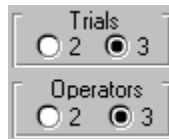


Figure 7: Trial & Operator Option Buttons

Select the number of trials and operators you want to have in the study. After selecting the number of trials and operators you want for the study, the form adjusts itself for the study by disabling the entry boxes which will not be used.

Generally, more confidence on the gaging process is gathered when more trials are used in the GR&R study. However, using three trials instead of two takes more time.

Entering Information and Measurements

Use the mouse cursor to move to the value entry box you want to type the values into by placing the cursor over the value entry box and clicking the left mouse button. Then, use the “Enter” key to move through the form in sequence. If you notice a mistake, use the mouse to once again select the value entry box and retype the correct information.

When entering measurement values, Easy GR&R checks what you type and does not allow you to enter letters in the numerical value entry boxes.

Gage ID: Select the gage you will use in the study. Use the scroll bar to view more gages and click the mouse on the gage you want to use in the study. The gage description automatically appears in the Description value entry box. Rather than scrolling through the gages, you may enter the Gage ID and click on the attached down arrow, the gage and description will be already highlighted. Click on the highlighted gage and description to enter them on the GR&R form.

If you want to use a gage which is not in the database, type the Gage ID in the value entry box and the description in the description box. This new Gage ID and description will be saved in the gage database for future use. When adding gages using this method, select “Yes” to the Message Dialog Box when saving the study to the database.

Gage Desc.: If you selected a gage from the Easy GR&R database, this field is already filled in for you. Enter a description if you entered a Gage ID without a description.

USL: Enter the upper specification limit for the part feature. The USL value is required for the ANOVA and Long methods.

LSL: Enter the lower specification limit for the part feature. The LSL value is required for the ANOVA and Long methods.

Date: Easy GR&R automatically places the current date in the value entry box for you. If you want to change the date, use the same format (MM/DD/YY).

Part No.: Enter the part number your customer uses for the part.

Part Name: Enter the part name your company uses for the part.

Characteristic: Enter the characteristic that the study will focus on. Typically a description of the dimension being measured.

Company Part No.: Enter the part number your company uses for this part.

Memo: Enter any notes or other information you would like to store about the study.

Operator Names: Enter the names of the operators in the study. If you have decided to use more or less operators, use the mouse and select the number of operators (2 or 3) under “Operators” next to the Control Block.

Trial Values: Enter the values obtained from the trials for each operator. The cursor will move to the next value entry box after pressing the Enter key. If you decided to change

the number of trials, use the mouse and select the number of trials (2 or 3) under “Trials” next to the Control Block. For WPV studies enter the maximum and minimum results for the trial.

Calculating GR&R Values

To calculate the GR&R study values, select the “Calculate” button from the Control Block.

The calculated values appear in the bottom of the study form. If you did not enter a USL or LSL, an error message appears on the bottom of the screen requesting the information. Select the “Okay” button and enter the USL or LSL before selecting “Calculate” again. The Short method study form does not require the USL and LSL.

For more information on what the calculated values indicate, see on page 29.

Saving The Study

To save the study in the Easy GR&R database, select the “Save” button from the Control Block.

The study will be saved to the GR&R database and may be recalled at a later date using the “Recall” button, or printed in a report.

If you decide not to save the study after entering the information and calculating the values, select the “New” button from the Control Block to prepare the form for a new study if needed.

Recalculating A Study

If at any time you have found an error in the information in the measurement values entered on the form, the study can be recalculated after entering the correct values and selecting the “Calculate” button.

Saving A Recalculated Study

After recalculating a study with the corrected values, store the corrected results in place of the old study in the database by selecting the “Save” button in the Control Block.

Deleting A Study

NOTE: Once deleted a study can not be recalled.

If you decide that a particular study is no longer needed, select the “Delete” button from the Control Block. This deletes the study from the GR&R database...for good.

Recalling A Study

Studies may be recalled by:

- Gage ID
- Gage Description
- Part Number
- Company Part Number
- Date performed, as well as between two inclusive dates

Easy GR&R allows “compound” recalls such as by both Gage ID and a Study Date.

Follow these steps to recall the studies:

1. Select the “Recall” button from the Control Block.
2. Enter the information requested on the form as shown. For dates, enter the dates that you want to see all studies between in the mm/dd//yy format. For text, use the asterisk (*) character as a wildcard. For example, digital* would include digital caliper, digital micrometer etc.

The screenshot shows a dialog box titled "Study Database Sort Form". It contains instructions: "Select the primary and secondary sort from the options below. Enter the match for the selected sort in the value entry boxes. Use the * (asterisk) key as a wildcard. If searching on one specific date, enter only one date in the beginning date and leave the ending date blank." The form is divided into two main sections: "Primary Sort" and "Secondary Sort".

Primary Sort: Radio buttons for Gage ID (selected), Part No., Gage Description, Date, and Company Part No. Below are two text input boxes labeled "Gage ID".

Secondary Sort: Radio buttons for Gage ID, Part No., Gage Description, Date (selected), and Company Part No. Below are two text input boxes labeled "Beginning Date" and "Ending Date".

Sort Directions: "Primary Sort Direction" has radio buttons for Ascending (selected) and Descending. "Secondary Sort Direction" has radio buttons for Ascending (selected) and Descending.

Study Type: Radio buttons for ANOVA (selected), AIAG, Ford, GM, Short, and Summary.

Buttons for "Okay" and "Cancel" are at the bottom.

Figure 8: Study Database Sort Form

3. Choose the “Okay” button and the first GR&R study matching the criteria will appear on the GR&R study form.”

4. To view the rest of the studies use the “Study Selector” above the Control Block to scroll through the studies.

Keep in mind that by recalling studies based on specific criteria, only a few of the studies in the database may match the criteria. To have access to all of the studies again, perform another recall using wild cards, or exit to the Main Menu and reselect the study type.

Prefilling A Study

Prefill provides a convenient method to place the same values into all value entry boxes on the study forms. For example, suppose that the first three digits of your measurements are all the same and only the fourth digit varies. With Prefill, you can save some time and have Easy GR&R enter the first three values for you.

NOTE: Do NOT select the “New” button before selecting the “Prefill” button. The “Prefill” button also includes the “New” button function when selected.

To enter a prefill value:

1. Select the “Prefill” button from the Control Block.

Enter the prefill value, and select the number of trials and operators on the form.

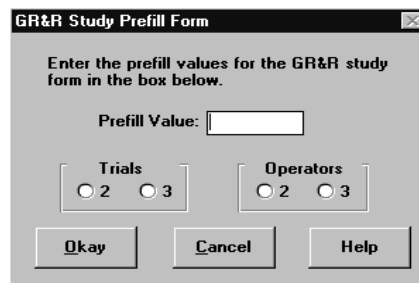
The image shows a dialog box titled "GR&R Study Prefill Form". Inside the dialog, there is a text prompt: "Enter the prefill values for the GR&R study form in the box below." Below this prompt is a text input field labeled "Prefill Value:". Underneath the input field are two groups of radio buttons. The first group is labeled "Trials" and contains two radio buttons labeled "2" and "3". The second group is labeled "Operators" and also contains two radio buttons labeled "2" and "3". At the bottom of the dialog box are three buttons: "Okay", "Cancel", and "Help".

Figure 9: Prefill Form

2. Select “Okay” and continue entering the trailing digits.

Cloning A Study

Select the “Clone” button to use the current header value such as the gage identification, description, part number, etc..

NOTE: Do NOT select the “New” button before selecting the “Clone” button. The “Clone” button also includes the “New” button function when selected.

Printing A Study

To print the current study on the form:

1. Select the “Print” button from the Control Block. On the next dialog, select the Current Study option, then select the “Print button.” After a few seconds, the print preview screen appears as shown below.

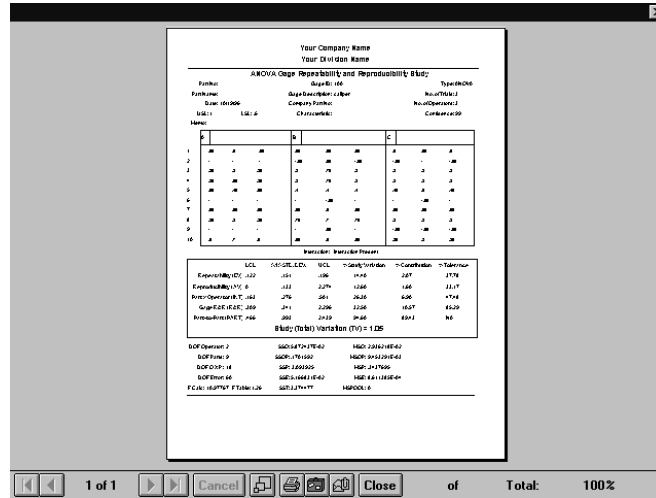


Figure 10: Print Preview Screen

2. Review the margins on the page to be sure they are set correctly. To change the margin settings, see Changing Margins on page 20.

NOTE: It is possible to change the margins so all of the report does not print on the page, or on multiple pages. It is important to look at the margins on the Print Preview Screen to make sure the entire report is on the page as you desire it.

On the bottom of the print preview screen several icon options are available. The icons are shown below with an explanation on their uses. Selecting the interlocked squares icon zooms the print preview in and out to view the page and information.



Figure 11: Print Preview Zoom Icon

Selecting the printer icon provides options on the number of copies to print. If you need to change the printer, return to the Program Manager screen (press Alt-Tab) and change the printer from the Control Panel within the Main program group. Then select the printer icon. Select the printer you want to use and return to Easy GR&R to print the study (press Alt-Tab again).



Figure 12: Print Preview Print Icon

These button options are not required for Easy GR&R.



Clicking the "Close" button option returns back to the GR&R form.



To enter your company and division name on the report, see page 24.

Exiting The GR&R Study Form

Exit the form by selecting the "Exit" button on the Control Block. The Main Menu will then appear.

Creating A Completed Studies Report

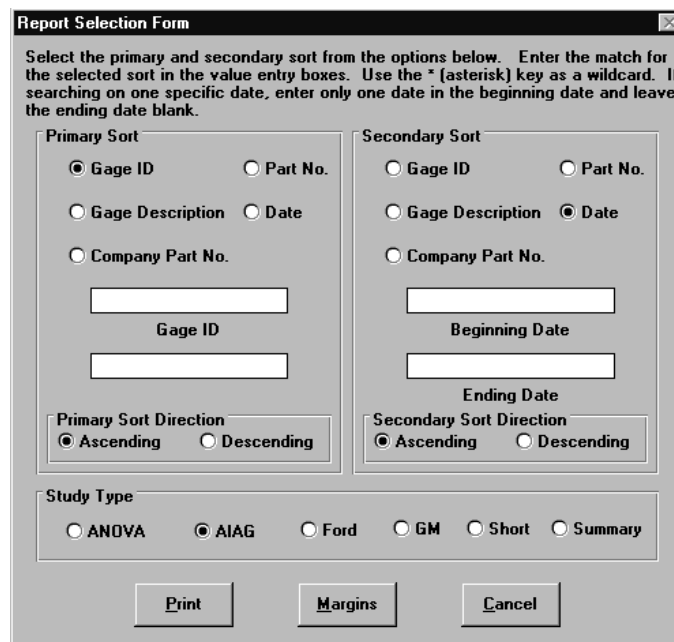
This section contains information on how to:

- Create a report using a sort
- Set the report margins
- Place your company & division name on the report

Easy GR&R provides a detailed report generator which allows sorts based on the header fields in the study forms and the type of study. To obtain a report with calculated intermediate values, the report must be printed from the GR&R form.

To print a report:

1. From the Main Menu, select “Reports.”
2. Select “Completed Studies.” The Report Selection Form appears as shown.



The screenshot shows a dialog box titled "Report Selection Form". It contains instructions: "Select the primary and secondary sort from the options below. Enter the match for the selected sort in the value entry boxes. Use the * (asterisk) key as a wildcard. If searching on one specific date, enter only one date in the beginning date and leave the ending date blank." The form is divided into three main sections: "Primary Sort", "Secondary Sort", and "Study Type".

Primary Sort: Radio buttons for Gage ID (selected), Part No., Gage Description, Date, and Company Part No. Below are two text input boxes labeled "Gage ID".

Secondary Sort: Radio buttons for Gage ID, Part No., Gage Description, Date (selected), and Company Part No. Below are two text input boxes labeled "Beginning Date" and "Ending Date".

Sort Directions: "Primary Sort Direction" has radio buttons for Ascending (selected) and Descending. "Secondary Sort Direction" has radio buttons for Ascending (selected) and Descending.

Study Type: Radio buttons for ANOVA, AIAG (selected), Ford, GM, Short, and Summary.

At the bottom are three buttons: "Print", "Margins", and "Cancel".

Figure 13: Report Selection Form

The report selection requires you to have a primary and secondary sort. Select the primary and secondary sort from the options shown on the form.

The sort types are:

- Gage ID
- Gage Description
- Part Number
- Company Part Number
- Date performed, as well as between two inclusive dates

Easy GR&R allows “compound” recalls such as by both Gage ID and a Study Date.

When searching for text such as gage descriptions or gage identification numbers, use the asterisk key (*) for a wildcard.

When searching for a specific date, only enter the beginning date and leave the ending date blank. Dates you enter are inclusive. For dates, use the mm/dd/yy format. Do not use the asterisk key (*) for a wildcard on dates. If you don’t know the date of a study you are trying to find, select two dates you would expect it to fall between.

Both the primary and secondary sort criteria can not be the same for a report.

4. To print the report, select the “Print” button. After a few second the print preview screen appears to preview the first page of the report. Review the margins on the page to be sure they are set correctly. To change the margin settings, see Changing Margins on page 20.

On the bottom of the print preview screen several icon options are available. See Printing A Study on page 17 for information on the icons.

Changing Margins

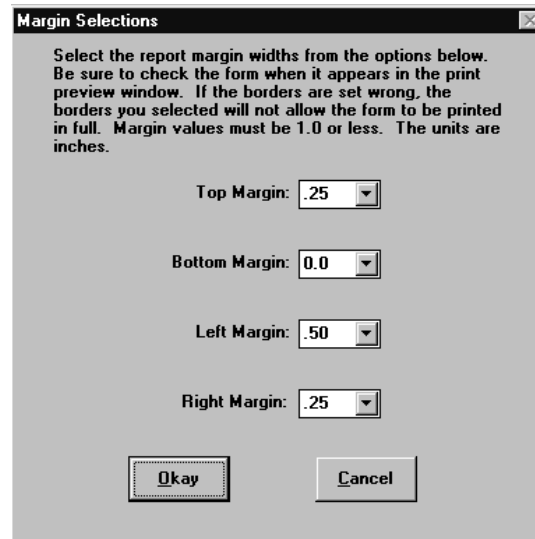
In some instances, you may want to adjust the page margins on the reports to accommodate a three ring binder punch hole. To accomplish this, the margins may be moved on the report.

NOTE: It is possible to change the margins so all of the report does not print on the page, or on multiple pages. It is important to look at the margins on the Print Preview Screen to make sure the entire report is on the page as you desire it.

To change the report margins:

1. From the Main Menu select “Settings.”

2. Select “Report Margins.”
3. Enter the margins on the Margin Selection form as shown below



The image shows a dialog box titled "Margin Selections" with a close button in the top right corner. Inside the dialog, there is a block of text: "Select the report margin widths from the options below. Be sure to check the form when it appears in the print preview window. If the borders are set wrong, the borders you selected will not allow the form to be printed in full. Margin values must be 1.0 or less. The units are inches." Below this text are four rows, each with a label and a dropdown menu: "Top Margin: .25", "Bottom Margin: 0.0", "Left Margin: .50", and "Right Margin: .25". At the bottom of the dialog are two buttons: "Okay" and "Cancel".

Figure 14: Margins Selection Form

The limits for the margins are from zero to one inch. Remember, if you make the wrong margin selections, some of the report may not be printed, or what should be on one page may end up on two. Decrease the top margin if the report uses more than one page per study. Be sure to examine the print preview screen carefully to be sure you have the entire report on the page.

Scheduled Studies

Scheduled studies provide for planning future GR&R studies on a specific date, much like a gage recall system works for recalling a gage for calibration.

Scheduling A Study

To schedule a study for a future date, on the study method form, select the “New” button. Select the Gage ID for the study, enter a future date, and type any information you may want in the other fields. The report for Scheduled Studies prints only the following fields: Date, Gage ID, Gage Description, Study Type, and Memo. Be sure to type any special information in the memo field about the study you would like to see on the report.

Blank measurement text boxes define a scheduled study. Therefore, scheduled studies dated in the past, the current date, and in the future will print on the report when measurements have not been entered on the study form.

Printing A Scheduled Study Report

From the Main Menu, select “Reports”, then “Scheduled Studies.” Select to have the report sorted by Gage ID or Date. Then select the “Print” button to preview and print the report. On the bottom of the print preview screen several icon options are available. See Printing A Study on page 17 for information on the icons.

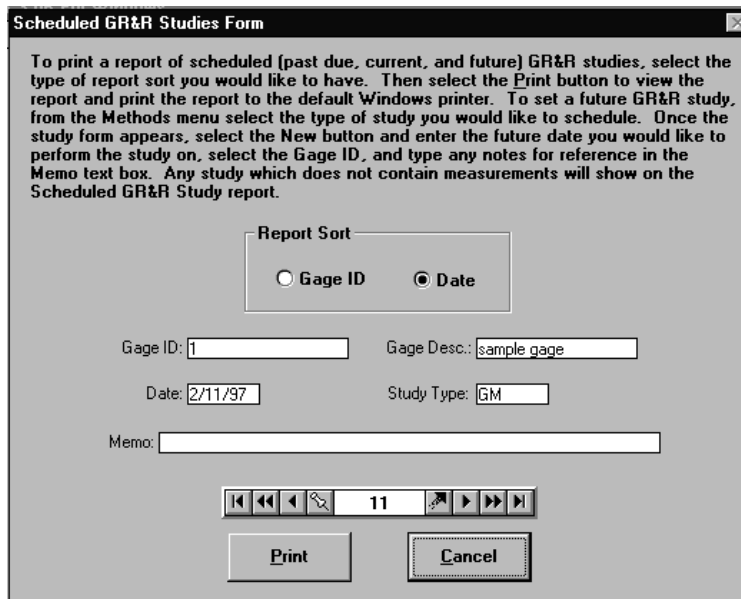


Figure 15: Scheduled GR&R Studies Form

To view the Scheduled Studies one at a time, use the study selector. Information on the study selector is on page 8. The report for Scheduled Studies prints only the following fields: Date, Gage ID, Gage Description, Study Type, and Memo.

Deleting A Scheduled Study

To delete a Scheduled Study, from the Main Menu select “Method” then the type of study you want to delete.

Use the “Search” button to find the specific Date and Gage ID. Or, you may use the Study Selector.

Then select the “Delete” button and confirm the deletion.

Entering Measurements For A Scheduled Study

To enter a Scheduled Study, from the Main Menu select “Method” then the type of study you had scheduled. Use the “Search” button to find the specific Date and Gage ID. Or,

you may use the Study Selector. Enter the study measurements, select the “Calculate” button. To save the study to the database, select the “Save” button. Once measurements are entered on the study form, the study is no longer scheduled even if the study date may be in the future. The only difference between a Scheduled Study and a “regular study” is that the Scheduled Study does not have any measurements.

GR&R Study Result Colors

To help flag and bring your attention to GR&R studies which may require further analysis, color warnings may be set for the GR&R results. Typically, for GR&R results less than or equal to 10%, the color green is displayed as a background color. For results greater than 10%, but less than 30%, a yellow background is displayed. For results greater than or equal to 30%, a red background is displayed. To understand the significance of the colors, see Numerical Analysis on page 29.

Setting The Colors

From the Main Menu, select ”Settings”, then “R & R Color Limits.” On the form shown below, enter the minimum and maximum limits you would like to use.

R & R Color Limits

This form allows setting colors for repeatability and reproducibility limits for the GM and AIAG percentage R & R calculations. The colors will display in the R & R calculation results as the background color. Default values are Green <= 10%, Yellow > 10% and < 30%, Red >= 30%. If you don't want to use any colors, click on the check box. Checking the check box will ignore any values you have entered for color limits.

AIAG Calculations (%T.V.)	GM Type Calculations (% Tolerance)
Green <= 10 %	Green <= 10 %
Yellow > 10 % And < 30 %	Yellow > 10 % And < 30 %
Red >= 30 %	Red >= 30 %

Don't show any colors on GR&R study forms.

Default Values **Done**

Figure 16: R & R Color Limits Form

To reset the maximum and minimum limits, select the “Default” button. If you do not wish to display any color limits on the study forms, click on the check box. When you are done, select the “Done” button to return to the Main Menu.

Placing Your Company Name & Division On The Studies & Reports

To place your company name and division on the studies and reports:

1. Select “Settings” from the Main Menu.
2. Select “Company Name & Division” from the menu. In place of the default values, type in your company and division name.

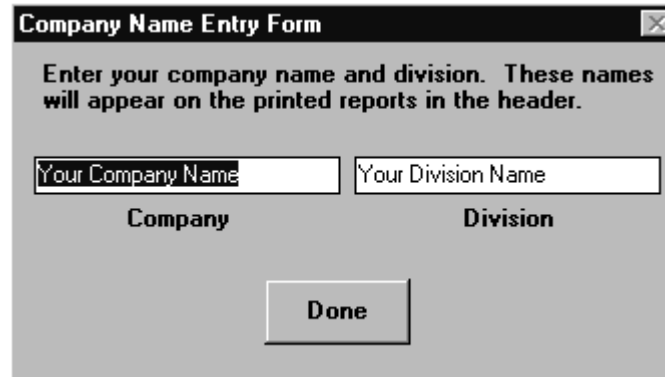


Figure 17: Report Company Name & Division Entry Form

3. Select the “Done” button.

All printed reports and studies will contain your company and division name in the printed header in place of the default values.

Changing Settings

This section contains information on how to:

- Set the database users as stand alone or network
- Set the path to the Easy GR&R database
- Repair and compact the Easy GR&R database

Stand Alone & Network Easy GR&R Database Users

You can configure Easy GR&R to run in a multi-user network or stand alone single user computer. The advantage to using the single user stand alone mode is that if the Easy GR&R database is not on a network, Easy GR&R will perform database functions somewhat faster. When set in the multi-user network mode, Easy GR&R will also work on a stand alone system as well. If Easy GR&R is used on a network *and* you will be sharing the program with other users, then the setting must be set to the multi-user mode.

To configure The Easy GR&R database:

1. From the Main Menu, select “Settings.”
2. From the Setting sub menu, select “Database Users”. The Database Configuration Form appears.

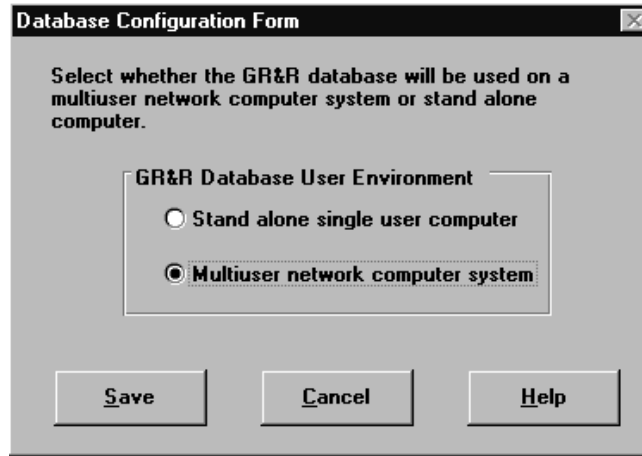


Figure 18: Database Configuration Form

3. Click on the user environment you have, either stand alone, or multi-user network.
4. Select “Okay.”

NOTE: If configured for a network, your autoexec.bat must have the following line: `c:\dos\share.exe /L:500 /F:5100`. If you have a network problem, this may be the problem.

Changing The Easy GR&R Database Path

Use the following procedure to change the path of the Easy GR&R database.

1. From the Main Menu select “Settings.”
2. From the Settings Menu, select “Database Paths” and the following form appears:

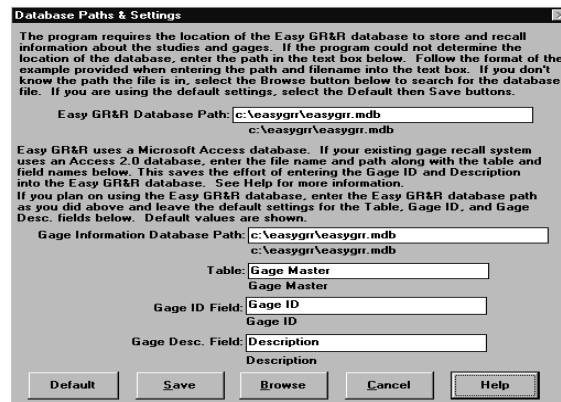


Figure 19: Database Paths & Settings Form

3. If you know the path names, type them in the value entry boxes and select “Save.” The default values shown on the form may be selected by clicking on the “Default” button.

If you aren't sure of the location of the databases, select “Browse” and use the Database Finder.

1. Select the drive by clicking on the down pointing arrow and select the drive which has the databases. Double click on the root directory to show all directories on the disk as shown.

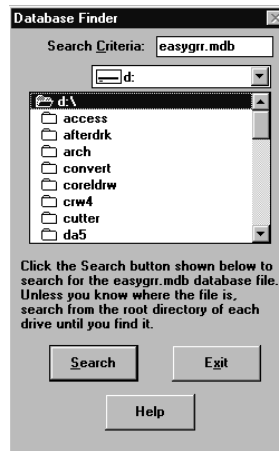


Figure 20: Database Finder Form

2. Select the “Search” button. Easy GR&R will search for all databases with the ".mdb" extension. Click on the easygrr.mdb file when it appears. If the Easy GR&R database wasn't located, try a different drive as described above.
3. Click on the Easy GR&R button to indicate that the next database you will choose is the Easy GR&R database. Then click on the easygrr.mdb file.
4. Select “Exit” to save the database locations to file.

Repairing & Compacting The Easy GR&R Database

The database utilities provide capabilities to compact and repair the Easy GR&R database. Compacting the database on a regular basis minimizes the disk space required for the database. Repairing the database should only be required if power is lost or some similar problem occurs. If the database seems to recall records erratically, repair the database.

To perform the database utilities:

1. From the Main Menu, select “Settings.”
2. From the Setting sub menu, select “Database Utilities.”
3. Select either “Compact Database” or “Repair Database.” After completion, the form closes and the action is complete.

Backing Up / Restoring The GR&R Studies

NOTE: Make sure you backup your GR&R database on a routine basis and keep hard copies of the study results as well as the study measurements.

There are several methods to backup your GR&R studies.

You may elect to:

- Either copy the file to a different directory, or copy and rename the file to the same directory
- Use the Windows backup program by selecting from the Main Menu “Settings” then “Database Utilities.” Then click on the “Backup / Restore” button. This starts the Windows utility if it is available on your computer.

Measurement Manipulation

Coding and nominal data provide methods of simplifying data entry without loss of data integrity for calculations. Each method is explained below.

Coding Data

Since Easy GR&R requires that all measurements must be 8 digits or less, there may be instances when the data will require coding to fit into the measurement entry boxes on the study method forms.

For example, suppose the actual measurement consisted of 2223.11221, 2223.12373, and 2223.10312 and have a drawing specification of 2223.10 +/- .05. The measurements exceed the 8 digit limit and will have to be coded. To code the data, only use the last 8 digits of the measurements.

In the case of 2223.11221, the coded measurement would be 23.11221.

Coding the specifications would result in 23.10 +/- .05 (i.e. USL = 23.15 and LSL = 23.05).

The resulting GR&R percent tolerance values obtained from the study (%R&R, %EV, and %AV) will still be correct.

Notice in this example the gage is probably much too accurate for the tolerances specified. A less precise and probably less expensive gage could be used that only reads to the nearest thousandth (.001). Even a gage which reads to the nearest hundredth (.01) would yield a 10:1 ratio of tolerance to the gage resolution (.10 / .01).

Nominal Measurements

Rather than taking direct measurements for calculations, some people find it easier to work with nominal measurements. A nominal measurement is a measurement that is subtracted from a fixed value such as the center of a specification. This results in using deviations for calculating the GR&R values. There is no difference in the results whether you use nominal or direct measurements for performing GR&R studies. Just remember to adjust the tolerances to reflect a positive and negative number correlating to the tolerance range.

Interpretation & Analysis

Easy GR&R provides for both numerical and graphical interpretation. Numerical results provide quantitative results for evaluating the gaging process. Graphical results provide a qualitative look at the measurement results.

Numerical Analysis

There are no exact rules for what percentage of the part tolerance lost to gaging error is considered “acceptable” or “unacceptable.” Marginal manufacturing processes generally require better gaging because much of the tolerance is taken up by the manufacturing process. Generally, the following guidelines are accepted by industry:

- If the GR&R as a percent of the tolerance is 10% or less, the gaging system is acceptable.
- If the GR&R as a percent of the tolerance is between 11% and 29%, the gaging system may require further analysis to find the source of the error.
- If the GR&R as a percent of the tolerance is 30% or greater, the gaging system requires further analysis to find the source of the error.

If the error component of the reproducibility is large, perhaps twice as much as the repeatability, gaging error may be reduced by:

Providing the operators with training on use and reading of the gage.

Ensuring the gage face or readout is clearly legible to the operators.

If the error component of repeatability is large, perhaps twice as much as the reproducibility, the gaging error may be reduced by:

Cleaning and repairing the gage - paying particular attention to sticking parts.

Redesigning the gage and fixturing to be more rigid.

Graphical Analysis

Easy GR&R provides the following three types of graphical analysis for ANOVA and Long study methods: Gage Performance Curves, Interaction Plots, and Error Charts. For more detailed information than what is covered in this User’s Guide, refer to the AIAG reference.

Gage Performance Curves

The Gage Performance Curve (GPC) determines the probability of either accepting or rejecting a part by plotting the probability of acceptance versus the reference part measurements. Displayed with the USL and LSL, the curve provides insight to the probability of accepting or rejecting parts within the limits. The following figure illustrates a gage performance curve.

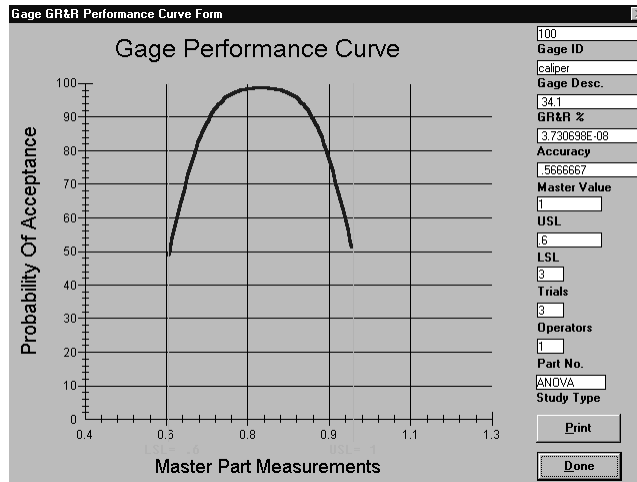


Figure 21: Gage Performance Curve

Interaction Plots

Gage Interaction Plots provide a visual comparison between the average measurements for each operator. The plot displays consistency between appraisers and interaction significance between parts and operators in the ANOVA method.

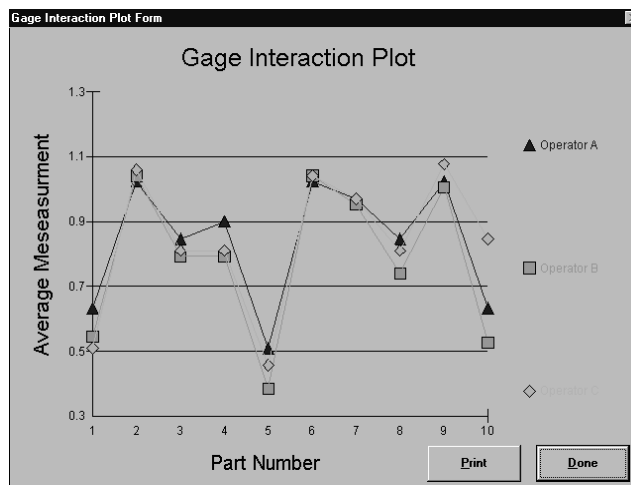


Figure 22: Interaction Plot

Error Charts

Error Charts plot differences of individual values for a specific part compared to a reference value. When compared against other parts in the study, difficult to measure parts may be identified, as well as consistently high or low measurements by a particular operator.

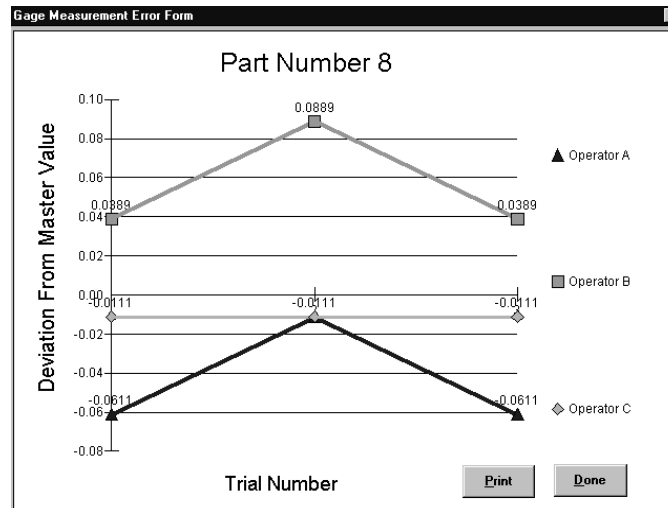


Figure 23: Error Chart

Terms & Definitions

Accuracy

Gage accuracy is the difference between the observed average of measurements and the true average. To establish the true average, use the most accurate measuring equipment available, or send the standards to a calibration laboratory to be measured. By having a gage calibrated, errors in accuracy can usually be eliminated.

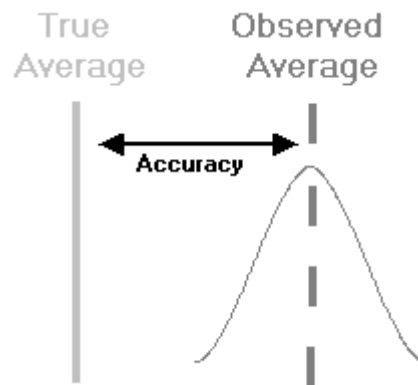


Figure 24: Accuracy Illustration

Linearity

Gage linearity is the difference in the accuracy values through the gage's operating range.

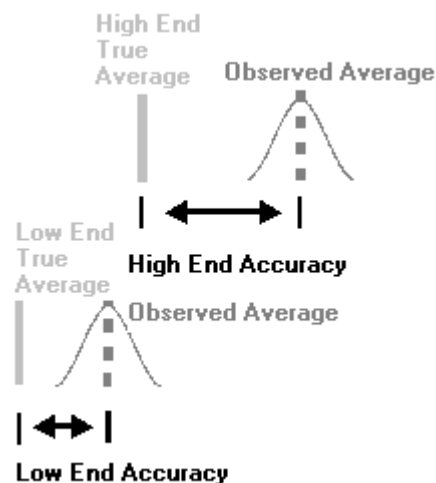
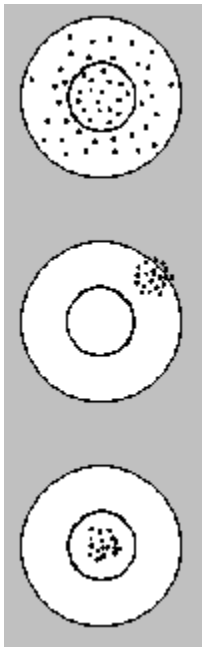


Figure 25: Linearity Illustration

Precision

Three precision examples are described below.



Accurate but not precise. Notice that the average of all the readings would be in the center of the target. A measuring instrument like this would have a significant amount of error.

Precise but not accurate. Notice that the readings are all "close" to each other. Statistically, this amounts to a histogram with a small spread with the average of the measurements differing from the true value.

Precise and accurate. Notice that the readings are all "close" to each other and centered. *This is the best condition.*

Figure 26: Precision Illustration

Repeatability (Equipment Variation)

Gage repeatability is the variation in measurements obtained when one operator uses the same gage for measuring identical characteristics of the same parts.

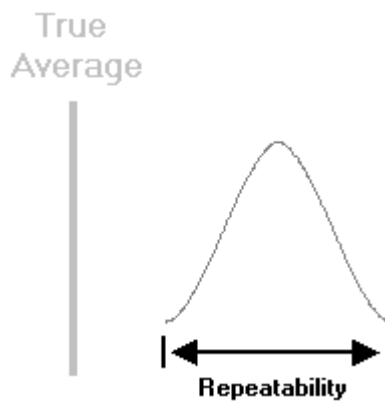


Figure 27: Repeatability Illustration

Reproducibility (Appraiser Variation)

Gage reproducibility is the variation in an average of measurements made by different operators using the same gage when measuring the same characteristics on the same parts.

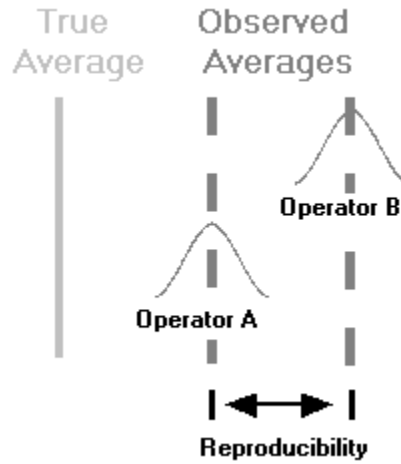


Figure 28: Reproducibility Illustration

Stability

Gage stability refers to the difference in the averages of at least two sets of measurements obtained with the same gage on the same characteristics taken at *different times*.

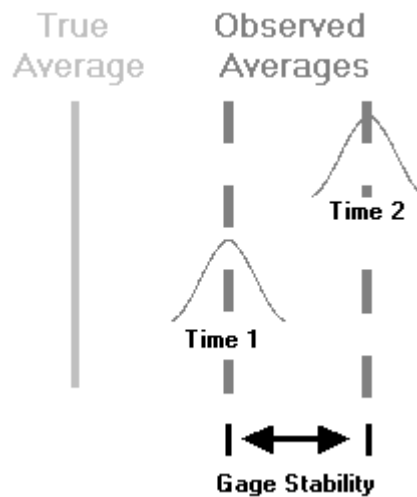


Figure 29: Stability Illustration

Variation Components

Equipment Variation (EV): The equipment variation is the component of the total GR&R study error that is caused by the measurement device. A large EV may be attributable to a worn out gage or a non rigid fixture on the gage.

Appraiser Variation (AV): The appraiser variation is the component of the total GR&R study error that is caused by the operator's measurement technique. A large AV may be attributable to poor measurement technique or not knowing how to read the measurement instrument.

Part Variation (PV): The part variation is the component of the total GR&R study error that is caused by the parts being measured.

Total Variation (TV): The total variation is the sum of the equipment variation, appraiser variation, and the part variation. Typically the TV should be less than 10% of the total tolerance. TV between 20% to 30% should be reduced if cost effective measures such as training can be found to reduce the error. Beyond 30% TV, actions need to be taken to correct the measurement error. A TV larger than 30% causes problems in that unless a process has a high capability index, good parts may be deemed unacceptable and bad parts may be accepted in error.

Gage R&R Formulas

This section presents the formulas used by the Easy GR&R program when calculating Gage R&R study results.

Short Form Method

$$R \& R = 5.15 \times \bar{R} / d_2$$

$$\text{Operators} = 2, \text{Parts} = 5, d_2 = 1.19$$

$$\text{Operators} = 2, \text{Parts} = 10, d_2 = 1.16$$

$$\text{Operators} = 3, \text{Parts} = 5, d_2 = 1.74$$

$$\text{Operators} = 2, \text{Parts} = 10, d_2 = 1.72$$

AIAG Long Method

Equipment Variation (E.V.) - Repeatability

$$E.V. = \bar{R} \times K1$$

$$\text{Trials} = 2, K1 = 4.56$$

$$\text{Trials} = 3, K1 = 3.05$$

$$\% E.V. = 100 \times (E.V. \div T.V.)$$

Appraiser Variation (A.V.) - Reproducibility

$$A.V. = \sqrt{(\bar{X} \text{ diff} \times K2)^2 - ((E.V.)^2 \div (n \times r))}$$

n = number of parts, r = number of trials

$$\text{Operators} = 2, K2 = 3.65$$

$$\text{Operators} = 3, K2 = 2.70$$

NOTE: If the calculated A.V. is less than zero, the A.V. is reported as zero.

$$\% A.V. = 100 \times (A.V. \div T.V.)$$

Repeatability & Reproducibility (R & R)

$$R \& R = \sqrt{(E.V.)^2 + (A.V.)^2}$$

$$\% R \& R = 100 \times (T.V. \div \text{Tolerance})$$

Part Variation (P.V.)

$$P.V. = R_p \times K_3$$

$$\text{Parts} = 5, K_3 = 2.08$$

$$\text{Parts} = 10, K_3 = 1.62$$

$$R_p = \bar{X}_p \text{ max} - \bar{X}_p \text{ min}$$

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

Total Variation (T.V.)

$$T.V. = \sqrt{(R \& R)^2 + (A.V.)^2}$$

GM / Chrysler Long Method

Equipment Variation (E.V.) - Repeatability

$$E.V. = \bar{R} \times K_1$$

$$\text{Trials} = 2, K_1 = 4.56$$

$$\text{Trials} = 3, K_1 = 3.05$$

$$\% E.V. = 100 \times (E.V. \div T.V.)$$

Appraiser Variation (A.V.) - Reproducibility

$$A.V. = \sqrt{(\bar{X} \text{ diff} \times K_2)^2 - \left((E.V.)^2 \div (n \times r) \right)}$$

n = number of parts, r = number of trials

$$\text{Operators} = 2, K_2 = 3.65$$

$$\text{Operators} = 3, K_2 = 2.70$$

NOTE: If the calculated A.V. is less than zero, the A.V. is reported as zero.

$$\% A.V. = 100 \times (A.V. \div T.V.)$$

Repeatability & Reproducibility (R & R)

$$R \& R = \sqrt{(E.V.)^2 + (A.V.)^2}$$

$$\% R \& R = 100 \times (R\& R \div \text{Tolerance})$$

Ford Long Method

Equipment Variation (E.V.) - Repeatability

$$E.V. = \bar{R} \times K1$$

$$\text{Trials} = 2, K1 = 4.56 \quad \text{Trials} = 3, K1 = 3.05$$

$$\% E.V. = 100 \times \left((E.V.)^2 \div (R\& R \times \text{Tol}) \right)$$

Appraiser Variation (A.V.) - Reproducibility

$$A.V. = \bar{x} \text{ diff} \times K2$$

n = number of parts, r = number of trials

$$\text{Operators} = 2, K2 = 3.65 \quad \text{Operators} = 3, K2 = 2.70$$

NOTE: *If the calculated A.V. is less than zero, the A.V. is reported as zero.*

$$\% A.V. = 100 \times \left((A.V.)^2 \div (R\& R \times \text{Tol}) \right)$$

Repeatability & Reproducibility (R & R)

$$R \& R = \sqrt{(E.V.)^2 + (A.V.)^2}$$

$$\% R \& R = \% E.V. + \% A.V.$$

ANOVA Method

For the ANOVA method, refer to *Measurement System Analysis* which may be obtained from the Automotive Industry Action Group at 810-358-3570.

Notes

This is a summary of the more important notes found in this manual. They contain information on using Easy GR&R and provide a basis of trouble shooting problems you may encounter.

NOTE: If configured for a network, your autoexec.bat must have the following line: c:\dos\share.exe /L:500 /F:5100. If you have a network problem, this may be the problem.

NOTE: Do NOT select the “New” button before selecting the “Prefill” or “Clone” button. The “Prefill” and “Clone” buttons include the “New” button function when selected.

NOTE: Always select “New” when you start a study. Do NOT select the “New” button when selecting the “Prefill” and “Clone” buttons.

NOTE: Once deleted a study can not be recalled.

NOTE: If the calculated A.V. is less than zero, the A.V. is reported as zero.

NOTE: It is possible to change the margins so all of the report does not print on the page, or on multiple pages. It is important to look at the margins on the Print Preview Screen to make sure the entire report is on the page as you desire it.

NOTE: Some Windows Systems programs may already be installed and you will have the option to install them over the current file. If you select “No” and Easy GR&R will not run, reinstall Easy GR&R and select “Yes” when prompted.

NOTE: Make sure you backup your GR&R database on a routine basis and keep hard copies of the study results as well as the study measurements.

NOTE: Easy GR&R is designed to run using a screen resolution of 640 x 480 pixels.

References & Information Sources

Measurement System Analysis which may be obtained from the Automotive Industry Action Group at 810-358-3570.

Evaluating The Measurement Process, Wheeler, available from ASQC.

General Motors Statistical Process Control Manual (# 1693), available from GM Supplier Development Administration, 4-163 General Motors Building, 3044 W. Grand Blvd., Detroit, MI 48202-3091

Concepts For R&R Studies, Barrentine, available from ASQC.

National Conference of Standards Laboratories, 303-440-3339. Call and ask for information about joining.

Course material from *Quality Management In The Lab, How To Evaluate, Control, and Improve Your Laboratory Results*, Quality Associates of Clemson, PO Box 1864, Clemson, SC 29633-1864

Government Industry Data Exchange Program (GIDEP), GIDEP Operations Center, Corona, CA 91720

Technical Information Series Report # 73CRD291, Somethings Engineers Should Know About Statistics (1973), General Electric Corporate Research & Development, PO Box 43, Bldg. 5, Schenectady, NY 12301.