THORUD INC.

PURPOSE: This form is to be used to collect, analyze and report MSA studies for **variable** gages. A typical Gage R&R study should be based on 10 parts, 3 operators, and 3 trials. If business needs make a typical study impractical or uneconomical, alternative designs may be used as long as the study design meets the Woodward WPQR-9102 requirements. *This form is designed to accommodate R&R study designs using up to 10 parts, 3 operators, and 3 trials.* Data to be entered utilizing the Data Entry tab.

Supplier Name:	THORUD INC.	**MSA Completed by:**	K. Fuchs
Gage/Gage Family Name:		**Date of Study:**	30-Apr-12
Item / Part #:	4647C80G01	**Item Rev:**	T
Item / Part Description:	BOTTOM CAP		
Device Identification:	22141	**Item / Part Feature:**	Char 41 Ø1.499-1.50
Units of Measurement:	0.0001	**Feature Tolerance:**	0.002
		Operator #1 Name:	Kevin
		Operator #2 Name:	Kathy
		Operator #3 Name:	Timmy

Has consideration has been given to **Stability** of the Measurement System? _____ *Notes or reference -* _____

Has consideration has been given to **Bias** of the Measurement System? _____ *Notes or reference -* _____

Has consideration has been given to **Linearity** of the Measurement System? _____ *Notes or reference -* _____

Repeatability and Reproducibility Report

Operator:	Kevin				Kathy				Timmy			
Sample #	1st Trial	2nd Trial	3rd Trial	Range A	1st Test	2nd Test	3rd Test	Range B	1st Test	2nd Test	3rd Test	Range C
1	1.49970	1.49970	1.49980	0.00010	1.49970	1.49980	1.49980	0.00010	1.49970	1.49980	1.49980	0.00010
2	1.49980	1.49980	1.49970	0.00010	1.49980	1.49980	1.49980	0.00000	1.49980	1.49970	1.49980	0.00010
3	1.49950	1.49950	1.49950	0.00000	1.49950	1.49950	1.49950	0.00000	1.49950	1.49950	1.49960	0.00010
4	1.49980	1.49970	1.49970	0.00010	1.49970	1.49970	1.49960	0.00010	1.49970	1.49970	1.49980	0.00010
5	1.49970	1.49970	1.49980	0.00010	1.49980	1.49980	1.49980	0.00000	1.49970	1.49980	1.49980	0.00010
6	1.49950	1.49960	1.49960	0.00010	1.49950	1.49960	1.49950	0.00010	1.49960	1.49960	1.49960	0.00000
7	1.49980	1.49970	1.49980	0.00010	1.49980	1.49980	1.49970	0.00010	1.49970	1.49980	1.49980	0.00010
8	1.49970	1.49970	1.49970	0.00000	1.49970	1.49970	1.49970	0.00000	1.49970	1.49970	1.49980	0.00010
9	1.49970	1.49970	1.49980	0.00010	1.49980	1.49970	1.49970	0.00010	1.49970	1.49980	1.49980	0.00010
10	1.49990	1.49990	1.49990	0.00000	1.49990	1.49990	1.49990	0.00000	1.49990	1.49990	1.49990	0.00000
TOTALS	14.99710	14.99700	14.99730	0.00070	14.99720	14.99730	14.99700	0.00050	14.99700	14.99730	14.99770	0.00080
	$Xbar_A$ =	1.499713	$Rbar_A$ =	0.000070	$Xbar_B$ =	1.499717	$Rbar_B$ =	0.000050	$Xbar_C$ =	1.499733	$Rbar_C$ =	0.000080

$Rbar_A$ =	##########
$Rbar_B$ =	##########
$Rbar_C$ =	##########
Rbarbar =	##########

# Trials	D_4
2	3.27
3	2.58
4	2.28

Rbarbar x D_4 = UCL_R

(0.000067) x (2.58) = 0.000172

Total Tolerance = 0.0020

Max. Xbar =	1.499733
Min. X bar =	1.499713
Xdiff =	0.000020

Range values above the UCL_R will be automatically highlighted as out of control (cell color with bold text).
Identify cause of out of control readings and correct. Either repeat these readings using the same operator and unit as originally used or discard the values and recompute Rbar and the limiting UCLR from the remaining observations.

Repeatability or Equipment Variation (EV)

K_1 = 3.05

EV = Rbarbar * K1

Trials	2	3	4
K_1	4.56	3.05	2.50

sigma EV = EV/5.15

%EV = 100(EV/tolerance)

EV = 0.000203 | sigma EV = 0.000039 | %EV = **10.2%**

Reproducibility or Appraiser Variation (AV)

r = number of operators / appraisers

n = number of parts

Appraisers	2	3	4
K_2	3.65	2.70	2.30

$AV = \sqrt{(ABS ((X(diff) * K_2)^2 - ((EV)^2/(n*r))))}$

K_2 = 2.70

sigma AV = AV/5.15

%AV = 100(AV/tolerance)

AV = 0.000039 | sigma AV = 0.000008 | %AV = **2.0%**

Repeatability and Reproducibility (R&R)

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

sigma R&R = R&R/5.15

%R&R = 100(R&R/tolerance)

R&R = 0.000207

0.0%

sigma R&R = 0.000040

%R&R = 10.4%

MSA is Acceptable

Note: E.V. and A.V. are based on predicting 5.15s (99% of the area under the normal distribution) The K_1 factors are only appropriate if (# of operators) x (# of samples) is greater than 15. For A.V.; if a negative value is calculated under the square root sign or if there is only one operator, then A.V. = 0. Tolerance is generally the total tolerance.