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Gauge Repeatability and Reproducibility Studies and Measurement System Analysis: A Multimethod Exploration of the State of Practice

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Introduction

The manufacturing environment, by its very nature, relies on two types of measurements to verify quality and to quantify performance: (1) measurement of its products, and (2) measurement of its processes. Therefore, product evaluation and process improvement require accurate and precise measurement techniques. Due to the fact that all measurements contain error, and in keeping with the basic mathematical expression: Observed value = True value + Measurement Error, understanding and managing "measurement error," generally called Measurement Systems Analysis (MSA), is an extremely important function in process improvement (Montgomery, 2005). In the early 1990's, the Automotive Industry Action Group formalized MSA in the automotive industry with its publication of *Measurement Systems Analysis, Reference Manual*, now in its Third Edition, eventually becoming a *de facto* standard of the entire manufacturing industry (AIAG, 1992, 2002).

MSA is a comprehensive set of tools for the measurement, acceptance, and analysis of data and errors, and includes such topics as statistical process control, capability analysis, and gauge repeatability and reproducibility, among others (Besterfield, 2004). MSA recognizes that measurements are made on both simple and complex products, using both physical devices and visual inspection devices that rely heavily on human judgment of product attributes.

Despite the comprehensive approach of MSA, and the documented importance

of gauge control (Besterfield, 2004), experts throughout the manufacturing industry express concerns about the reliability of measurements used in decision making (Daricilar & Peters, 2005). When data quality is low, the benefit of the measurement system is also low, likewise when the data quality is high, the benefit is high (AIAG, 2002).

Purpose of Research

As noted above, a gap appears to exist between the actual use of measurements by manufacturing professionals and the theories of gauge control in measurements. This study, therefore, seeks to explore that theory-practice gap, specifically focusing on the use of gauge repeatability and reproducibility studies (GRRS), in both physical measurements and visual inspection processes for the manufacturing environment.

Using a mixed method, an online quantitative survey and a qualitative follow-up questionnaire (both targeting manufacturing professionals), this research seeks to fulfill the following objectives:

- A. Determine the perceived need and commitment to overall improvement of measurement systems analysis, specifically to the use of GRRS, for the improvement of physical measurement and visual inspection accuracy.
- B. Determine the use of other recognized quality approaches, such as continuous improvement, design of experiments, and Six Sigma.
- C. Determine basic demographic information about the organization

where respondents are employed, including size of organization, type of manufacturing, and commitment to formalized quality systems. In addition, information relative to the participant's position and role within the organization is sought.

Based upon the foregoing, the following hypotheses are formulated:

1. GRRS are well established in manufacturing, but are not used as often as other MSA improvement methods.
2. Visual inspection methods in manufacturing rarely use GRRS to improve measurement accuracy.

Review of the Literature

The effectiveness of a measurement system depends upon accurate gauges and proper gauge use. Common measuring devices such as calipers and micrometers are of particular concern when used incorrectly (Hewson, O'Sullivan, & Stenning, 1996). Measuring equipment and processes must be well controlled and suitable to their application in order to assure accurate data collection (Little, 2001).

According to the *MSA Reference Manual*, MSA defines data quality and error in terms of "bias," "reproducibility," "reliability," and "stability" (AIAG, 2002). Further, MSA provides procedures to measure each term, however the phrase Gauge Repeatability and Reproducibility Studies (GRRS) has come to incorporate the procedures recommended for measurement of "bias," "reproducibility," and "reliability" (Foster, 2006).

Following the definitions of MSA, *bias* is the "systematic error" in a measurement, sometimes called the "accuracy" of a measurement. *Repeatability* is "within operator" (one appraiser, one instrument) error, usually traced to the gauge itself, and is best considered to be "random error." *Reproducibility* is "between operator" (many appraisers, one instrument) error, and is usually traced to differences among the operators who obtain different measurements while using the same gauge (Kappele & Raffaldi, 2005; Montgomery, 2005).

Several authors address the use of GRRS to specifically address the management of these errors, especially the human aspects of these errors (Besterfield, 2004). Dasgupta and Murthy (2001), for example, addressed the use of GRRS as both an audit tool and as a source of feedback to improve the measurement procedure. Wang (2004) recommended the use of GRRS as feedback for measurement system improvement. Lupan and Bacivarof (2005) recommended the analysis of measurements to detect "the most important causes for process variation" (p. 723). And Smith, Callahan, and Strong (2005) demonstrated the practical use of GRRS for improving measurements.

In addition to reliance on physical measurements there is an additional and unavoidable reliance on human visual inspection processes, which rely very heavily on subjective judgment of specific product or process attributes. Juran and Zeccardi (1988) captured the limitations of this methodology, "Visual inspection remains the largest single form of inspection activity. For these characteristics, the written specifications seldom describe completely what is wanted, and often inspectors are left to make their own interpretation" (p. 18.49). Visual inspections are greatly influenced by environmental factors, such as the type, color, and intensity of lighting in the inspection area, and the inherent characteristics of the product itself.

Although the problems associated with visual inspection loom large, the industry recognizes that MSA systems exist that improve overall measurement accuracy. According to Raffaldi and Kappele (2004), "If measurement variation can be reduced and gauge repeatability and reproducibility ratios improved, it is easier to differentiate between parts that are in or out of specification, allowing parts to be accepted or rejected with greater confidence" (p. 48). In a recent study where GRRS was applied to multiple visual inspection data significant improvement in accuracy was realized through an application of

review and discussion of GRRS results (Smith et al., 2005).

As noted, the researchers determined the need for using GRRS as feedback to improve measurement systems. These findings piqued the researcher's interest in a possible theory-practice gap, leading to the following study on the state-of-practice of GRRS, using an exploratory, regional survey.

Research Methodology

Research Design

To test the research hypotheses, this research used a mixed quantitative survey and qualitative follow-up questionnaire, as follows:

First, an exploratory, on-line survey determined industry use of and emphasis on GRRS. The survey was developed using a 5-point *Likert-scale*, allowing the assignment of numeric values of one to five, with five representing the "always" response. A complete copy of the survey is included in Appendix A. Mean values of the raw data are reported, herein, as an overview for various questions. To gain clarity on the statistical significance of these differences, the *t*-statistic is also reported.

Second, a targeted quantitative questionnaire focused on determining what other techniques (non-GRRS) are used to monitor, control and improve measurement and visual inspection accuracy. The qualitative research results provide explanations for the quantitative results.

Population Sample

For the survey, approximately 60 participants were invited to take part in a Web-based survey through an e-mail distribution. The e-mail list was a combination of known quality professionals developed from a variety of resources including professional organizations, university data bases, and research contacts. Because the survey was otherwise unprotected a password was used to assure that uninvited participants were blocked. An original request and a reminder were sent, resulting in 30 individual participants.

For the targeted questionnaire phase, 15 respondents of the on-line survey were asked to respond to a qualitative, follow-up questionnaire.

Instrumentation

For the exploratory study phase, a confidential, on-line survey was developed and administered through a common Web-based environment. The survey featured 20 information seeking questions of the true/false, Likert-scale multiple choice, and multiple answer variety. The survey's questions asked respondents to provide information about the importance and the use of GRRS in both physical measurements and visual inspections.

For the follow-up, qualitative instrument, each individual was asked the basic question "what techniques (other than GRRS) are appropriate to monitor, control and improve measurement and visual inspection accuracy?" Basic findings from the literature review, on-line survey, and targeted questionnaire are presented in this article.

Data Analysis and Research Findings

Of the 60 surveys, a total of 30 survey responses provided the data useful for both descriptive and inferential analysis. This represents a 50% response rate. Analyzed data is presented in the following sections.

General Demographics

Table 1 shows the results of general demographic information about size and type of manufacturing organization that each participant represented. The respondents generally represent small- to medium-size manufacturing organizations that are both "make" and "assemble" focused.

The Quality Demographic

Three questions were designed to determine the types of quality initiatives these organizations embraced.

- With regard to ISO 9001 certification, participants reported only a 53% certification level for their organizations.

Table 1. General Summary of Survey Respondent Demographics.

Question	Response/ Number of responses (percentage)			
	A	B	C	D
The approximated total number of employees at your facility.	1-49 1 (3.3%)	50-199 10 (33.3%)	200-499 10 (33.3%)	500+ 9 (30%)
Select the general type of manufacturing for your facility.	Design, Make, Assemble 12 (40%)	Make and Assemble 14 (46.7%)	Assemble Only 1 (3.3%)	Make Only 3 (10%)

- With regard to "Six-Sigma" qualifications, 57% of the participants reported their organization has such (an) individual(s). More specifically, among actual survey participants 20% reported being "Six-Sigma" Black Belt qualified, 3% Green Belt qualified, and 7% as a "Six-Sigma" Champion.
- Finally, 23% classified themselves as American Society for Quality Control qualified at the Quality Engineer level, and 43% reported being qualified through a formal internal program. However, 27% reported having no formal quality qualification at all.

These survey results suggest that the participants in this survey are generally qualified and experienced in current quality practices.

Formalized Continuous Improvement

Four questions elicited information about formalized use of a continuous improvement process (CIP):

- 90% of organizations reported using CIP from "occasionally" to "always."
- 100% of participants reported that their organization "occasionally" to "always" maintains a formalized quality system
- 84% of the respondents reported "occasional" to "always" use of SPC (statistical process control); and
- 60% reported "occasional" or more use of design of experiments (DOE).

These survey results suggest that the participants in the survey represented companies that embrace current trends

in quality system practices.

Results Relative to Physical Measurement

Respondents were questioned about the importance of using a system for measurement capability improvement: 47% reported it as something that should be done always and the remaining 53% reported it as something that should be done occasionally or often (see Row A of Table 2).

The survey then asked about information relative to what was actually being done to assure measurement accuracy, the descriptive results being shown in Rows B through F of Table 2. Row B, for example, shows that organizations have a strong reliance on gauge calibration (63% always use). Rows C through F, however, indicates that using GRRS for evaluation, training, and qualification of operators and devices is not performed as often.

To take the analysis further, the researchers used the two-tailed statistical *t*-test for dependent (also called matched, paired, or correlated) samples, comparing the mean scores on a 5-point Likert scale between (a) recognized need to use a process for improvement versus (b) actual use of that process. The SPSS procedure "Paired Samples T Test" performed the two-tailed *t*-test. These results are reported in Table 3.

As shown in Table 3, with the exception of the "Use Gauge Calibration for Measurement Devices," all questions resulted in statistically significant differences.

Table 2. Physical Measurement Control and Improvement.

Row	Question	Never	Seldom	Occasional	Often	Always
A	Need a Process to Improve Measuring Capability	0%	0%	16.6%	36.7%	46.7%
B	Use Gauge Calibration for Measurement Devices	0%	6.6%	10.0%	20.0%	63.3%
C	Use GRRS to Evaluate Operators and Inspectors Capability	10.0%	30.0%	23.3%	33.3%	3.3%
D	Use GRRS in Training Operators and Inspectors	20.0%	26.7%	20.0%	30.0%	33.3%
E	Use GRRS for Qualifying Measuring Devices	20.0%	23.3%	16.7%	30.3%	10.0%
F	Use GRRS for Qualifying Operators and Inspectors	23.3%	40.0%	13.3%	20.0%	3.3%

Table 3. t-test Results for Physical Measurements: Comparing Mean of Need to Mean of Actual Use

Row	Question	Need		Actual Use		t-statistic
		Mean	SD	Mean	SD	
A	Need a Process to Improve Measuring Capability	4.3	0.75	—	—	—
B	Use Gauge Calibration for Measurement Devices	—	—	4.4	0.93	-0.43
C	Use GRRS to Evaluate Operators and Inspectors Capability	—	—	2.9	1.09	5.77 *
D	Use GRRS in Training Operators and Inspectors	—	—	2.7	1.21	6.35 *
E	Use GRRS for Qualifying Measuring Devices	—	—	2.9	1.33	5.15 *
F	Use GRRS for Qualifying Operators and Inspectors	—	—	2.4	1.16	7.32 *

Notes: two-tailed, dependent t-test of mean difference = 0; (vs. ≠ 0)

— signifies no data in that cell; the t-statistic is calculated by comparing A to B, A to C, A to D, A to E, and A to F.

* meets significance level of $\alpha \leq 0.05$

It is important to recognize that 100% of participants reported that the organization should take steps to improve measuring capability at the "occasional" to "always" level and, more specifically, nearly 47% responded "always." While this response would seem to indicate an understanding of a need for measurement improvement, the inferential statistics indicates that the actual usage is significantly different from the perceived need. There is considerable reliance on calibration as a means to control measurement capability, and little use of GRRS in the training and qualifying of operators and inspectors.

Results Relative to Visual Inspection

Regarding the set of questions asked about the need for and use of systems to control and improve visual inspection capability, Table 4 provides a descriptive summary of survey results. 47% of participants reported that a system should "always" be used for visual inspection control and improvement, the remaining 53% reported that something should be done on "occasional" to "often."

Participants' responses to a question regarding the organization's actual use of visual inspections show a heavy

reliance on visual inspections (77%), reflecting a finding consistent with that found in the literature.

While there is a heavy dependence on visual inspection in the organizations represented by this survey, Rows B through E of Table 4 provides evidence of the actual use of GRRS to evaluate operator and inspector visual inspection capability (typical responses showing that 60% - 70% never or seldom ever actually evaluate).

Similar to the t-test presented for physical measurement (shown in Table 5),

Table 4. Results Relative to Visual Inspection Control and Improvement.

Row	Question	Never	Seldom	Occasional	Often	Always
A	Organization needs to control and improve visual inspections.	0%	6.7%	16.6.0%	30.0%	46.7%
B	Reliance on Visual Inspection	3.3%	10.1%	20.0%	36.6%	30.0%
C	Use GRRS to Evaluate Visual Inspection Capability	33.3%	33.3%	16.7%	13.3%	3.3%
D	Use GRRS in Training Operators and Inspectors	30.0%	40.0%	13.3%	13.3%	3.3%
E	Use GRRS for Qualifying Operators and Inspectors	36.6%	23.3%	16.7%	20.0%	3.3%

the analysis for visual inspection demonstrates that the differences between perceived need and actual use are statistically significant.

GRRS for Physical Measurement Devices versus Visual Inspection

The literature review, discussed previously, provides evidence that GRRS are both adequate and appropriate for use in controlling and improving measurement and visual inspection accuracy. However, the literature provides more information on the use of GRRS for physical measuring devices than for visual inspection. To provide information in this area, the researchers statistically compared (again using the *t*-statistic, shown in Table 6) the response data to determine if there was a difference between responses for measurement devices and visual inspection; only one of the four questions were found to have

statistically significant differences.

The results show a significant difference between the uses of GRRS to evaluate physical measurements versus visual inspections. On the other hand, there was no significant difference in training and qualifying operators/inspectors doing physical measurements versus those doing visual inspections.

Demographics versus Use of GRRS

In addition to the survey results presented above, consideration was given to the impact of two quality demographics on participant responses: "Six-Sigma" qualification and ISO certification. Recall, from earlier in the paper, the high qualifications of the survey respondents. Despite this fact, when comparing without exception there was no significant difference in the use of GRRS between respondents either from

organizations that were or were not ISO certified or from organizations with or without "Six-Sigma" practitioners on-site. Thus, it appears that organizations involvement with quality related programs, such as ISO and "Six-Sigma," has little to do with the actual use of GRRS for measurement improvement.

Targeted Qualitative Results

A follow-up qualitative questionnaire, shown in Appendix B, was distributed to some of the survey participants to gain further input about the discrepancy found, in the quantitative survey, between perceived need and actual use. Regarding Physical Measurement The difference between the need (regarded as "high") versus the actual use (found to be "low") for physical measurements, the respondents stated that the training for operators and inspectors is an important component,

Table 5. *t*-test Results for Visual Inspection Devices: Comparing Mean of Need to Mean of Actual Use

Row	Question	Need		Actual Use		<i>t</i> -statistic
		Mean	SD	Mean	SD	
A	Organization needs to control and improve visual inspections.	4.2	0.95	—	—	—
B	Use GRRS to Evaluate Visual Inspection Capability	—	—	2.2	1.16	7.43 *
C	Use GRRS in Training Operators and Inspectors	—	—	2.2	1.13	7.82 *
D	Use GRRS for Qualifying Operators and Inspectors	—	—	2.3	1.26	6.61 *

Notes: two-tailed, dependent *t*-test of mean difference = 0; (vs. ≠ 0)

— signifies no data in that cell; the *t*-statistic is calculated by comparing A to B, A to C, and A to D.

* meets significance level of $\alpha \leq 0.05$

Table 6. *t*-test Results for GRRS for Physical Measurement Devices Compared to Visual Inspection

Row	Question	Physical Measurement		Visual Inspection		<i>t</i> -statistic
		Mean	SD	Mean	SD	
A	Should have a Process for Measurement Improvement	4.2	0.75	4.2	0.95	0.60
B	Use GRRS to Evaluate Operators and Inspectors Capability	2.9	1.09	2.2	1.16	2.41 *
C	Use GRRS in Training Operators and Inspectors	2.7	1.21	2.2	1.13	1.66
D	Use GRRS for Qualifying Operators and Inspectors	2.4	1.16	2.3	1.26	0.32

Notes:

t-test of mean difference = 0; (vs. $\neq 0$)

* meets significance level of $\alpha \leq 0.05$

but is limited to the reinforcement of a characteristic's definition and/or to the proper procedure for measurement. One respondent stated that using "GRRS to train and qualify operators is a good idea" since operators typically do not use instruments correctly. Another respondent stated that GRRS are only used on critical components or when components fail.

Regarding Visual Inspections

Regarding the difference between the need (again regarded as "high") versus the actual use (again "low") for visual inspections, the qualitative survey found:

- Visual inspection are limited to larger tolerances and less critical features;
- GRRS for visual inspection is a lower priority;
- GRRS for visual inspection is done on a less frequent basis than for hard gauges; and
- GRRS calibration of visual inspection is scheduled every three years.

Respondents stated that operator training relies heavily on the use of visual "references," such as finish samples, master paint chips, and die penetrates, to improve visual inspection for cracks.

Conclusion and Recommendations

Published literature on quality improvement, including industry handbooks and guides, research studies, and textbooks, demonstrates that physical measurement and visual inspection data for decision making can be enhanced through the use of GRRS (AIAG, 2002; Besterfield, 2004; Dasgupta & Murthy, 2001). This confidence is shared by the respondents of this study's survey.

Based on both the quantitative and the qualitative results, Hypothesis 1-that GRRS is not used as often as other MSA improvement methods-is accepted. For physical measurement, survey responses indicate that appraiser training stops with process training, failing to actually verify the measuring ability of inspectors. Manufacturing quality professionals obtain accuracy improvement by placing primary importance on test equipment calibration, but place a much lower level of importance on using GRRS to validate inspectors' ability to obtain accurate measurements. And GRRS is used mostly as an audit-tool, along with other improvement techniques, to reinforce training ideas, but not in "root-cause" (of measurements) analysis, nor in taking action to correct measurement systems.

In addition, Hypothesis 2-that GRRS is rarely used in visual inspection-is also accepted. Accuracy of visual inspection is even more problematic because quality management methods, such as GRRS, are less developed and not widely used, as compared to physical measurement devices (which are low as well). Plus, as indicated by the qualitative "expert input," visual inspections are given less priority by quality professionals.

Implications for educators in the field of industrial technology are clear. Greater emphasis should be placed on the use of GRRS beyond mere auditing ability, in the classroom, through industry sponsored workshops, and in direct technology transfer programs. The effects of human error on physical measurement devices should have a prominent place in quality training and education. Perhaps GRRS should be incorporated into hands-on training environments where visual quality inspection is utilized to evaluate processes such as welding and surface finishes.

Developing and establishing standards for visual inspection processes and developing accepted methods for improvement of inspection accuracy should be made a top priority.

A major limitation is that available literature concerning the use of GRRS for visual inspection is very limited. This is especially true regarding proven GRRS specific to visual inspections, leaving little background information in this area (Smith et al., 2005).

Another major limitation relates to the definition of the quality function within manufacturing environments. This limitation made it difficult to target the individual(s) in the organization actually performing the quality function. To overcome this problem, survey respondents were grouped as "manufacturing professionals" to provide a data source of acceptable size.

Further research is needed to demonstrate that these research results are can be generalized beyond the sample group used herein. However, these results demonstrate the existence of a large theory-practice gap among those surveyed.

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Appendix A & B on following pages

Appendix A - Quantitative Survey Questionnaire

Participant Consent to Participate

1. The following survey will be used to determine different factors regarding the use of Gauge Repeatability and Reproducibility in the manufacturing sector of business. You and your company's name will remain completely anonymous. The demographic questions asked in the survey do not need your name or your company's name to conduct the survey. Your participation is completely voluntary. There are no substantial risks involved. All data collected will remain in the hands of the researchers with the exception of summary data. No individual results will be disclosed. Do you wish to participate?

- A. Yes
- B. No

General Information

2. The approximate total number of employees at your facility.

- A. 1-49
- B. 50-199
- C. 200-499
- D. 500+

3. Select the general type of manufacturing for your facility.

- A. Manufacturing (Design, Make, Assemble)
- B. Manufacturing (Make and Assembly Only)
- C. Manufacturing (Assembly Only)
- D. Manufacturing (Make Only)

4. The organization is ISO 9001 (or related standard) Registered

- A. True
- B. False

5. There are individuals in the organization, qualified in six-sigma techniques.

- A. True
- B. False

6. Your quality related qualifications are: (check all that apply)

- A. Six-sigma champion
- B. Six-sigma green belt
- C. Six-sigma black belt
- D. ASQC quality engineer
- E. Internal company qualification program
- F. No formal qualification certification

7. The organization utilizes and documents a formal continuous improvement process.

- A. Never
- B. Seldom
- C. Occasionally
- D. Often
- E. Always

8. The organization has implemented and maintained a formalized quality system.

- A. Never
- B. Seldom
- C. Occasionally
- D. Often
- E. Always

9. The organization utilizes traditional statistical process control techniques to monitor and control manufacturing processes.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
10. The organization studies and improves processes using design of experiment techniques.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always

Items Specifically Related to the use of Measurement Devices to Monitor and Control Process and/or Product

11. The organization should take steps to control and improve measuring capability.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
12. The organization utilizes a measuring and monitoring device calibration program.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
13. Gauge R&R techniques are used by the organization to determine individual operator/inspector measurement capability.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
14. The organization utilizes Gauge R&R in training to improve operator/inspector measurement capability.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
15. Gauge R&R is used by the organization to select appropriate measuring and monitoring devices.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always

16. Operators/inspectors are formally qualified to measure and record variable data with Gauge R&R being a part of the process.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always

Items Specifically Related to the Use of Visual Subjective Inspections to Monitor and Control Process and/or Product

17. The organization monitors and controls product quality using visual (subjective) inspections.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
18. The organization should take steps to control and improve operator/inspector capability for visual inspections.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
19. Gauge R&R type techniques are used to determine individual operator/inspector capability to adequately complete visual inspections.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
20. Gauge R&R type techniques are used by the organization in training to improve operator/inspector visual inspection capability.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always
21. Operators/inspectors are formally qualified to do visual inspections with Gauge R&R being a part of the process.
- A. Never
 - B. Seldom
 - C. Occasionally
 - D. Often
 - E. Always

Appendix B - Targeted Qualitative Questionnaire

A survey, conducted by this researcher, relative to the use of Gauge R&R Techniques for determining operator/inspector capability with both measuring devices and in visual inspections revealed some interesting results. We seek your input to further this research effort.

Measurement Results: In response to the question “The organization should take steps to control and improve measuring capability” the overwhelming response was that it should be done always. While, always was the response to using calibration as a means for assuring measurement device accuracy, responses ranged in the never to seldom range for using Gauge R&R techniques to train and/or qualify operator/inspectors. We seek your input into what other steps might or are being taken to assure R&R of measurements.

Measurement Capability Techniques (Your Input)

Visual Inspection Results: The survey also sought information relative to visual inspection. Results were somewhat similar to those found for measurement. In response to the question “the organization should take steps to control and improve operator/inspector capability for visual inspection” the overwhelming response was always. However, responses ranged in the never to seldom range for using Gauge R&R techniques to train and/or qualify operator/inspectors. We seek your input into what other steps might or are being taken to assure R&R in visual inspections.

Visual Inspection Capability Techniques (Your Input)

Your Name (optional):