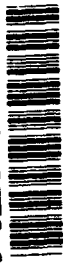


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INFORMATION ON INDUSTRY USE OF ACCEPTABLE QUALITY LEVELS (AQLs)
AND NONGOVERNMENT STANDARDS (NGS)

Karen J. Richter

April 1993

Prepared for
Office of the Assistant Secretary of Defense
(Production and Logistics)

Approved for public release; distribution unlimited.



INSTITUTE FOR DEFENSE ANALYSES
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PREFACE

This document reports some of the findings from work performed by the Institute for Defense Analyses (IDA) under the Task entitled *Government-Industry Standardization of Product Acceptance Based on Process Data*. This work was performed for the Office of the Assistant Secretary of Defense (Production and Logistics), Production Resources/ Industrial Engineering and Quality [OASD(P&L)PR/IEQ] under the technical cognizance of the Army Armament, Munitions, and Chemical Command (AMCCOM), Quality Assurance Directorate. This document records responses from industry standardization groups to questions on their use of Acceptable Quality Levels (AQLs) for product acceptance sampling and their views on the adoption of nongovernment standards (NGS) by the Department of Defense (DoD). This information is related to the AQL elimination initiatives within DoD and its move toward greater use of industry standards.

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INTRODUCTION

For many years DoD has relied on a philosophy of defect detection using sampling inspection as the basis for acceptance of manufactured product. The principal military sampling standards that have been cited in military specifications are indexed using Acceptable Quality Levels (AQLs) for selecting appropriate sampling plans. Implied in this approach is the notion that the DoD is willing to accept some level of defective product and, as a result, suppliers are not driven to provide quality levels beyond that which the sampling plan permits. Recent demonstrated successes in obtaining quality products has shifted industry focus to defect prevention through the control of manufacturing processes. This change in philosophy drove DoD to issue repeated policy statements that nonconforming products will not be accepted, and AQLs will no longer be cited in military specifications. As a result, valid modes of acceptance sampling are limited to 100% inspection and accept-on-zero (A-o-Z) defects sampling plans. These plans can be costly and still do not motivate or reward the defect-prevention thrust.

AQL ELIMINATION EFFORTS

In conjunction with the sponsors, IDA has been working on a new standard for product acceptance based on statistical process control and the supplier's demonstrated quality program that encourages continuous improvement of the supplier's manufacturing processes and protects DoD from accepting defective product. The information contained in this document was collected to provide background for this standard. IDA has been working with the sponsors to ensure that this standard becomes accepted as an industry standard to be cited in specifications in lieu of the military standards still referencing AQLs. This intent complements the efforts under way in DoD to reduce the acquisition process paperwork and enable the use of commercially available products by using industry standards in place of those once unique to the military.

This slide shows the amount of time and effort that has gone into eliminating the use of AQLs and Lot Tolerant Percent Defectives (LTPDs) from the military specifications.



AQL Elimination Efforts

October 1986: OASD(P&L) Memorandum on "Achieving Continuous Quality Improvement" directed all DoD spec preparation activities to remove AQLs/LTPDs.

Mar 87: OASD(P&L) memo, as above, to Quality Assurance community.

July 1988: Final Report of the Joint Services Working Group on the Elimination of Fixed Defect Levels.

February 1989: OASD(P&L) TQM/SDM orders compliance to 16 Oct memo by 30 June 1989, Deadline later postponed and formation of DoD-wide Process Action Team (PAT) on AQL/LTPD removal directed.

June 1989: Memorandum, "AMC First-Stage Policy for the Elimination of Acceptable Quality Levels/Lot Tolerance Percent Defectives (AQLs, LTPDs) from Military Specifications" eliminates AQLs/LTPDs, specifies interim measures, supports OASD position on eliminating AQLs/LTPDs.

September 1990: Final report of DoD-wide PAT on AQL/LTPDs removal recommends revising MIL-STDs 961, 962, and 490 to prohibit AQL and LTPD expressions of nonconformance in new and revised specs and eliminate AQLs and LTPDs from specs during the normal document review cycle (5 years).

May 1991: Memorandum, AMC acting DCS for Concurrent Engineering for Commander, U.S. Army LABCOM, Materials Technology Laboratory confirmed previous AQL/LTPD policy and effort to introduce SPC-based schemes into industry standardization picture.

INDUSTRY STANDARDS ASSOCIATIONS QUERIED

The list of industry standards associations from which to solicit information was derived from the listing of industry groups in the Standardization Directory (SD-1) of the Defense Standardization and Specification Program. Industry groups were chosen if their name implied that they might be more product than process oriented and more likely to have standards or specifications for product inspection. The list is as follows:

Abrasive Grain Association	Institute of Electrical and Electronics Engineers
Acoustical Society of America	International Association of Plumbing & Mechanical Officials
Aerospace Industries Association	Magnetic Materials Producers Association
Aluminum Association, Inc.	Material Handling Institute, Inc.
American Association of Government Industrial Hygienists	McGill Manufacturing Co., Inc.
American Dental Association	National Association of Corrosion Engineers
American Gear Manufacturers' Association	National Electrical Manufacturers Association
American Hot Dip Galvanizers Association	National Fire Protection Association
American Institute of Aeronautics and Astronautics (AIAA)	National Hardwood Lumber Association
American Institute of Timber Construction	National Institute of Oilseed Products
American Petroleum Institute	National Wood Window and Door Association
American Plywood Association	Rack Manufacturers Association
American Society of Agricultural Engineers	Rubber Manufacturers Association
American Society of Civil Engineers	SKF USA, Inc.
American Society of Mechanical Engineers	Society of Automotive Engineers, Inc. Air & Space
American Society of Quality Control	Society of Automotive Engineers Land & Sea
American Society for Testing and Materials	Solar Energy Industrial Association
American Welding Society	Southern Pine Inspection Bureau
Anti-Friction Bearing Manufacturers Association	Steel Door Institute
Association for Information and Imaging Management	Steel Window Institute
Association for Manufacturing Technology	Tire and Rim Association, Inc.
Cast Iron Pipe Institute	Tile Council of America, Inc.
Construction Specifications Institute	Torrington Co.
Dairy Food Industries Supply Association	Truck Manufacturers Association (TMA)
Diamond Wheel Manufacturers Institute	Underwriters Laboratories, Inc.
Electronic Industries Association	Variable Resistive Components Institute
Facing Tile Institute	



Industry Standards Associations Queried

- **Letter sent to all organizations listed in SD-1 whose name implied they may have product standards (as opposed to process)**
- **53 Organizations**
- **22 Responses**

QUESTION #1 RESPONSES

Question #1: *Do your standards and specifications make reference to acceptance sampling? If so, please state any acceptance sampling documents referenced (e.g. MIL-STD 105). There were 12 "yes" responses and 10 "no." Specific responses (not single word answers) are listed below.*

Yes, MIL-STD-105. Sampling procedures are in accordance with MIL-STD-105 and to the AQLs as stated in the specification. Many of our part standards reference a military procurement specification.

Yes, MIL-STD-105D or Chrysler Motor's Sampling Plan, Table II

Yes, for lot verification of E-rated lumber, the principles in MIL-STD-105 were adopted.

Yes, ANSI/ASQC Z1.4-1981 (MIL-STD-105), ANSI/ASQC S1.1987

Yes, over 25 listed under Sampling—hundreds more under Acceptance Testing, Quality Control, etc.

Yes, MIL-STD-105D. All of our Government and aircraft use MIL-STD-105 plans. Our internal documents use $c = 0$ inspection plans.

Yes, MIL-STD-105, Zero Acceptance Sampling Plans, $c = 0$ developed from N.L. Squeglia.

Yes. We use $c = 0$ for all plans and refer to MIL-STD-105E for sample size.

Yes, MIL-STD-105.

Yes, we utilize MIL-STD-105 when dictated by Defense Contractors as part of the Purchasing Contract. Otherwise, we use the standard tables of $c = 0$ sampling plans as formulated by Nicholas L. Squeglia.

Yes. Our own, MIL-STD-105. For Sampling Guide only—not specified AQL.

No. Our industry's products are high value, low volume. Generally, they do not lend themselves to acceptance sampling, which was developed primarily for the high volume, low-to-medium value items.

No, we recommend 100 percent inspection at this time.

In general, no. Possibly one document (which I can't identify at the moment) out of 200 references a sampling document.



Question #1

- Do your standards and specifications make reference to acceptance sampling?
- If so, please state any acceptance sampling documents referenced (e.g. MIL-STD 105).

Responses:

- 12 yes
- 10 no

QUESTION #2 RESPONSES

Question #2: *Are your acceptance sampling plans indexed by Acceptable Quality Levels (AQLs)? If possible, please list your standards and specifications that use AQLs. The specific answers follow.*

Yes. Specifications: NAS 1289, 1290, 4002, 4003, 4004, NA 007, 008, 0028, 0057, 0071, 0072, 0154, 0161

Specifically referenced in Form and Style for ASTM Standards, Section B15, Sampling. Would have to look at each standard—probably Vol. 14.02 E11 committee—also ASTM Standards on Precision and Bias for Various Applications.

Yes, AITC Test T124.

Yes, Aircraft Product: Receiving Inspection $c = 0$, 0.65%, 1.0%, 4.0%, 10%; In Process Inspection MIL-STD-105, 0.65%, 1.0%; Final.

Commercial Product: Receiving Inspection $c = 0$, 0.65%, 1.0%, 4.0%, 10%; In Process Inspection, MIL-STD-105, 1.0%; Final Inspection, MIL-STD-105, 1.0%.

Incoming inspection standards. Some in-process toll gate inspection.

MIL-STD-105D (required to use by the government).

Yes, our standards and specs don't specifically list AQL levels, but our basic level is 0.65% with more stringent AQL levels for critical characteristics and less stringent levels for insignificant characteristics.

ANSI 137.1—1986 Para 4.2 Sampling Plan

Yes, we use 0.65, 1.0, and 2.5 AQL. By Government requirement our QC-IN-76 is based on various AQLs. Normally parts that do not receive 100% inspection are 0.04% AQL. All commercial plans AR $c = 0$ at various AQLs.

No. We use $c = 0$ for all plans.



Question #2

- Are your acceptance sampling plans indexed by Acceptable Quality Levels (AQLs)?
- If possible, please list your standards and specifications that use AQLs.

Responses:

- 9 yes—approximately 20 listed
- 9 no
- 2 not applicable

QUESTION #3 RESPONSES

Question #3: Have you published any continuous improvement or statistical process control documents? If so, please list them. Specific answers follow.

Internal documents only. We utilize SPC through control charts, histograms, lot plots, capability analysis, pareto analysis, and DoE.

AITC Inspection Bureau Memo #8—SPC for End Joint Production

ISO-9000 internally and at key suppliers. SPC on all critical/major parameters. Design review encompassing: Cp Studies; FMEA (Design and Process); Team Problem Solving.

ANSI/ASQC Q90-Q94 distributed by ASTM.

No. We do use SPC and now ISO-9000. We use a training manual developed in house for SPC and continuous improvement.

We have published a comprehensive continuous improvement document patterned to the spirit of the ISO 9000 series standards. This document titled "Management Handbook for Quality Systems Development in Machine Tool and Related Industries" contains specific information, suggestions and recommendations for the implementation of continuous quality improvement in a typical machine tool company.

We are currently revamping our SPC system to fall within the guidelines of Boeing D1-9000, Advanced Quality System Program.

Yes, samples attached

We have only published internally. We have documents on SPC, Capabilities Studies and our Quality Assurance manual.

We have published for our own use, and as examples for our customers and suppliers, the following:
TPS-7000 The Torrington Co.—Quality Systems
TPS-70001 The Torrington Co.—SPC Reference Document



Question #3

- Have you published any continuous improvement or statistical process control documents?
- If so, please list them.

Responses:

- 10 yes—ISO 9000 and Boeing D1-9000 listed frequently, many internal documents also cited
- 10 no

REQUEST FOR ADDITIONAL COMMENTS—AQL ELIMINATION

Further information was requested as follows: *Please add any comments you may have regarding either objective—AQL elimination or government use of nongovernment standards (NGS).* The responses on AQL elimination are as follows.

Both objectives are good and should be pursued.

It's about time AQLs are eliminated. We actually operate on $c = 0$. Any defects require a lot to be 100 percent sorted.

We would like to use smaller sample lots with 0 reject (not MIL-STD-105—bigger lots and acceptance on 1, reject on 2).

Excellent idea. The thought of accepting lots that contain known defectives is quickly becoming out of step with worldwide industry.

The DoD's AQL should be gradually phased out and replaced with existing civilian standards like ANSI/ASQC A2, ANSI/ASQC B1, B2 and B3, ANSI/ASQC Q3, ANSI/ASQC S1 and similar. Most of these documents were developed only recently by some of the same authors that were involved in the writing of the Government Quality Specifications.

We seldom see AQL levels specified by contract, but we frequently see MIL-STD-105 as a requirement. Since industry as a whole has switched to the $c = 0$ sampling plans (as an adjunct to SPC), we would like to see the Government do likewise. We are not ready to give up sampling even though we are using SPC extensively, and would not expect anyone else to do so until they have achieved a consistent level of quality (approximately 60 ppm defect level).

The need for AQLs will never be eliminated.

Seems like the AQL should be set for each part of a whole for a product that is manufactured from parts.

AQL acceptance methods are still valid—until all key processes have $C_p \geq 1.33$ —for visual defects.

I am uncertain from the initiative how risk (producer/consumer) would be quantified vis-a-vis attributes sampling.



Request for Additional Comments—AQL Elimination

- **Please add any comments you may have regarding either objective—AQL elimination or government use of nongovernment standards (NGS).**

Responses on AQL elimination:

- **5 thought it an idea whose time had come**
- **5 objected to or were uncertain about the feasibility or implementation of the idea**

REQUEST FOR ADDITIONAL COMMENTS—NGS USE

The responses on the use of NGS by the government are shown below.

Military sampling standards tend to be outdated as compared to progressive industry approach to continuous quality improvement stressing process control. Control of processes through statistical methods targeting to achieve 1.0 C_{pk} seems to present higher reliability of product quality (100% inspection is only 80-85% reliable). Automotive programs and concepts such as Boeing D1-9000 are more intuned to today's manufacturing objectives of improved quality, efficiency and service.

AIAA is beginning an appraisal of the value of ISO 9000 to aerospace, both civil and military. Because of its forward-looking approach, it seems likely that any conformity assessment included in AIAA standards would be oriented in this direction.

The use of non-government standards and participation by the government in ASTM follows the criteria established in OMB Circular 119. The continued involvement and active participation by DoD in ASTM will provide DoD with the opportunity of adopting standards acceptable to DoD needs.

The Department of Defense and Standardization Office has listed all 3-A Sanitary Standards (for equipment) and 3-A Accepted Practices (for systems) in their Standardization Directory, SD-1.

I feel the government should move towards the use of more modern standards. MIL-Q-9858 should be replaced by ISO-9001/9002. MIL-I-45208A should be replaced by ISO-9003.

I agree with government use of nongovernment standards. However, most quality control, sampling/analysis systems are found within third party certification and testing programs. The government could be well serviced by products "certified" to meet industry standards.

The above questions are appropriate for product standards but not installation, use, and maintenance standards in general. Use of non-government standards for procurement of products and services is a major step forward.

Voluntary, consensus standards available in the private sector should be used whenever possible.

Government quality systems standards should be eliminated in lieu of ISO-9000 series standard.

We support the use, by the government, of nongovernment standards wherever feasible.

We support to the fullest extent possible the use of best commercial industry standards for non-uniquely military items.

In the aerospace industry, the government standards and the nongovernment standards (NGS) together make a complete set of documents, i.e., they are not duplicative. Therefore, for the government to use NGS, the NGS would have to be developed. This only adds unnecessary expense to the standardization process.



Request for Additional Comments—NGS Use (Cont'd)

Responses on NGS use:

- **12 favorable responses**
- **Only 1 negative reply**
- **ISO-9000 series mentioned often**

INTERESTING RESULTS

When the comments are seen attributed to the specific standards organization, it appears as though those with the greatest defense application are those most in favor of keeping AQLs. Almost all organizations favored the greater use of NGSs by DoD.

Name of Organization	Additional Comments
Aerospace Industries Association	The need for AQLs will never be eliminated. In the aerospace industry, the government standards and the nongovernment standards (NGS) together make a complete set of documents, i.e., they are not duplicative, therefore, for a government to use NGSs—the NGSs would have to be developed. This only adds unnecessary expense to the standardization process.
Aluminum Association, Inc. American Gear Manufacturers' Association	Both objectives are good and should be pursued. It's about time AQLs are eliminated. We actually operate on $c = 0$. Any defects require a lot to be 100 percent sorted. I feel the government should move towards the use of more modern standards. MIL-Q-9858 should be replaced by ISO-9001/9002. MIL-I-45208A should be replaced by ISO-9003.
American Institute of Aeronautics and Astronautics (AIAA)	AIAA is beginning an appraisal of the value of ISO 9000 to aerospace, both civil and military. Because of its forward-looking approach, it seems likely that any conformity assessment included in AIAA standards would be oriented in this direction.
American Institute of Timber Construction	Seems like the AQL should be set for each part of a whole for a product that is manufactured from parts.
American Society of Agricultural Engineers American Society of Quality Control	Voluntary, consensus standards available in the private sector should be used whenever possible. Government quality systems standards should be eliminated in lieu of ISO-9000 series standard. AQL acceptance methods are still valid, until all key processes have $C_p \geq 1.33$ for visual defects.
American Society for Testing and Materials	The use of non-government standards and participation by the government in ASTM follows the criteria established in OMB Circular 119. The continued involvement and active participation by DoD in ASTM will provide DoD with the opportunity of adopting standards acceptable to DoD needs.
Anti-Friction Bearing Manufacturers Association	We would like to use smaller sample lots with 0 reject (not MIL-STD-105—bigger lots and accept on 1, reject on 2). Excellent idea. The thought of accepting lots that contain known defectives is quickly becoming out of step with worldwide industry.
Association for Manufacturing Technology	The DoD's AQL should be gradually phased out and replaced with existing civilian standards like ANSI/ASQC A2, ANSI/ASQC B1, B2 and B3, ANSI/ASQC Q3, ANSI/ASQC S1 and similar. Most of these documents were developed only recently by some of the same authors that were involved in the writing of the Government Quality Specifications.



Interesting Results

When the comments are seen attributed to the specific standards organization, it appears as though:

- **Those with the greatest defense application are those most in favor of keeping AQLs.**
- **Those with the greatest defense application are those least in favor of using NGS.**

INTERESTING RESULTS (Cont'd)

Name of Organization	Additional Comments
McGill Manufacturing Co., Inc.	Military sampling standards tend to be outdated as compared to progressive industry approach to continuous quality improvement stressing process control. Control of processes through statistical methods targeting to achieve 1.0 C _{pk} seems to present higher reliability of product quality (100% inspection is only 80-85% reliable). Automotive programs and concepts such as Boeing D1-9000 are more intuned to today's manufacturing objectives of improved quality, efficiency and service.
National Fire Protection Association	Use of non-government standards for procurement of products and services is <u>a major step forward</u> .
National Wood Window and Door Association	I agree with government use of nongovernment standards. However, most quality control, sampling/analysis systems are found within third party certification and testing programs. The government could be well serviced by products "certified" to meet industry standards.
Rack Manufacturers Association	I am uncertain from the initiative how risk (producer/consumer) would be quantified vis-a-vis attributes sampling.
We support to the fullest extent possible the use of best commercial industry standards for non-uniquely military items.	
Rubber Manufacturers Association	We support the use, by the government, of nongovernment standards wherever feasible.
SKF USA, Inc.	We recommend the elimination of AQLs with replacement by "0" defects. This means, in all cases, if one reject is found, then the lot should be 100 percent sorted.
Torrington Co.	We seldom see AQL levels specified by contract, but we frequently see MIL-STD-105 as a requirement. Since industry as a whole has switched to the c = 0 sampling plans (as an adjunct to SPC), we would like to see the Government do likewise. We are not ready to give up sampling even though we are using SPC extensively, and would not expect anyone else to do so until they have achieved a consistent level of quality (approximately 60 ppm defect level).



Interesting Results (repeated)

When the comments are seen attributed to the specific standards organization, it appears as though:

- Those with the greatest defense application are those most in favor of keeping AQLs.**
- Those with the greatest defense application are those least in favor of using NGS.**

CONCLUSION

To follow on the general comments made by the standards organizations, IDA conducted phone conversations with quality assurance personnel from various commercial and defense companies and organizations, including Texas Instruments (TI) Defense Electronics Group (Malcomb Baldrige winner), Ford Motor Company, Motorola, SEMATECH, National Center for Manufacturing Sciences (NCMS), and TRW. The questions asked were:

- Do you use AQLs in inspection sampling for your suppliers?
- How does the use of AQLs relate to your process improvement and quality?

The answers can be summarized as follows:

- If AQLs are used, it is only where they are still required in a government contract.
- AQLs are seen as out-dated and contradictory to quality programs for achieving continuous process improvement.

Typical responses were:

- We still have to deal with the Mil-Spec AQLs and AOQLs at the commodity level with our suppliers. These ought to be out, but we still have them in our contracts...But in relationship with its suppliers, TI "anticipates and expects no nonconformance."
- AQLs imply a willingness to expect achieving a given level of quality, not continuous improvement. "AQLs represent a missed opportunity for improvement." (TRW)



Conclusion

Modern quality practices stressing the need for continuous improvement are driving the move away from specifying an acceptable level of quality.