VALIDATION PACKAGE

SAMPLING PROGRAMS DISK

Accompanying Book

GUIDE TO ACCEPTANCE SAMPLING

By Dr. Wayne A. Taylor

VALIDATION PROTOCOL

GUIDE TO ACCEPTANCE SAMPLING

Protocol Number: TE-94-1

1.0 PURPOSE

This protocol is designed to validate the programs on the diskette accompanying the book *Guide to Acceptance Sampling*. These programs are used to select and evaluate sampling plans. These sampling plans are in turn used to release product and in validation studies. The validation of these programs is intended to demonstrate that these programs correctly calculate the protection provided by the sampling plan's inputted to them.

Three versions of these programs are included in this validation: Version 1.0 and 1.1 for IBM PCs and compatibles, and Version 1.1 for the Macintosh. The only difference between these versions is code dealing with the input and output of text on the screen due to differences between FORTRAN compilers. However, all tests are performed on each version. In addition the tests are repeated on multiple PCs representing different processors and versions of the operating system.

2.0 BACKGROUND

2.1 DESCRIPTION OF THE SOFTWARE

The sampling programs disk that comes with the book *Guide to Acceptance Sampling* contains the following six programs:

PROB	-	Calculates probabilities based on the binomial, hypergeometric, Poisson, normal and beta distributions.
SINGLE	-	Evaluates and selects single sampling plans
VALUE	-	Selects single sampling plans based on a economic evaluation
DOUBLE	-	Evaluates and selects double sampling plans
QSS	-	Evaluates and selects quick switching systems
VARIABLE	-	Evaluates variable sampling plans

The use of these programs is documented in the book *Guide to Acceptance Sampling*. The algorithms and formulas used are documented in the appendices of this book.

The PC versions where compiled using version 3.20 of Microsoft's FORTRAN 77 compiler. They run under DOS 3.0 and above. The Macintosh version was compiled using version 3.0.1 of Language Systems' FORTRAN compiler. They run under System 7. The differences between these three versions are limited to the code for reading from and writing to the screen. These versions exist because of compiler differences in handling line feeds when reading and writing. Version 1.0 was the initial version and accompanies the book. In version 1.1, all reads and writes were rewritten to call five compiler dependent functions to handle line feeds. This allowed Version 1.1 to be recompiled on the Macintosh with only minor changes to these five functions. Table 1 gives information on identifying the different versions.

Table 1: Identification of Three Versions

Version	Machine	Main Menu	Date Stamp
1.0	PC or compatible	No version number	11/7/92
1.1	PC or compatible	"IBM DOS Ver 1.1"	3/7/93
1.1	Macintosh	"Macintosh Ver 1.1"	3/6/93

2.2 OPTIONS TO BE VALIDATED

This study validates those options required to evaluate the protection provided by sampling plans. Specifically options 1, 2, and 3 of the programs SINGLE, DOUBLE, QSS, and VARIABLES are validated for Type-B OC curves. These options are used to obtain the OC curve and associated summary statistics such as the AQL, LTPD and AOQL of a sampling plan. The other options are not validated nor are options 2 and 3 validated for Type-A OC curves. These other options have however undergone extensive testing and as the date of this protocol, there are no known bugs. For sampling plans selected by the above programs, options 2 and 3 should be used to verify they provide the desired protection.

2.3 COMPUTER EQUIPMENT AND OPERATING SYSTEMS USED

Because of the variety of hardware and operating systems found on PCs, version 1.0 and 1.1 for PCs are to be tested on two different PCs, one with and one without a math coprocessor. The machines to be used for this validation are as follows:

Table 2: Test Equipment

Make	Processor	Coprocessor	Operating System	Versions Tested
Gateway	80486	yes	DOS 5.0 under Win 3.1	PC 1.0 & 1.1
Compaq	80286	no	MS DOS 5.0	PC 1.0 & 1.1
Macintosh	IIci	n/a	System 7.1	Mac 1.1

3.0 TEST PROCEDURE

3.1 PROGRAM SINGLE TEST CASES

Table 3 shows the different test cases for program SINGLE along with their expected results. These cases were obtained from Table X of Mil-Std-105E (1992), and Appendix 4 of Dodge and Romig (1959). These test case were constructed to test the program SINGLE over a range of sample sizes and accept numbers when both defectives and defects are tallied.

Table 3: Test Cases for Program SINGLE and Expected Results

Tally	Sampling Plan	Item	Value	Source
Defectives	n=2, a=0	AQL	2.53	105E, p34
		$p_{0.90}$	5.13	105E, p34
		$p_{0.50}$	29.3	105E, p34
		LTPD	68.4	105E, p34
		$p_{0.05}$	77.6	105E, p34
		OC(2.53)	0.95	105E, p34
		OC(29.3)	0.50	105E, p34
		OC(68.4)	0.10	105E, p34
	n=80, a=1	AQL	0.446	105E, p50
		$p_{0.90}$	0.667	105E, p50
		$p_{0.50}$	2.09	105E, p50
		LTPD	4.78	105E, p50
		$p_{0.05}$	5.79	105E, p50
		OC(0.446)	0.95	105E, p50
		OC(2.09)	0.50	105E, p50
		OC(4.78)	0.10	105E, p50

Table 3: (Continued)

Tally	Sampling Plan	Item	Value	Source
Defectives	n=80, a=14	AQL	11.9	105E, p50
		$p_{0.90}$	13.2	105E, p50
		$p_{0.50}$	18.3	105E, p50
		LTPD	24.2	105E, p50
		$p_{0.05}$	26.0	105E, p50
		OC(11.9)	0.95	105E, p50
		OC(18.3)	0.50	105E, p50
		OC(24.2)	0.10	105E, p50
	n=1060, a=2	AOQL	0.13	Dodge, p182
	n=5140, a=19	AOQL	0.25	Dodge, p182
	n=39, a=1	AOQL	2.2	Dodge, p185
	n=380, a=30	AOQL	5.7	Dodge, p185
Defects	n=2, a=0	AQL	0.0256	105E, p34
		$p_{0.90}$	0.0527	105E, p34
		$p_{0.50}$	0.347	105E, p34
		LTPD	1.15	105E, p34
		$p_{0.05}$	1.50	105E, p34
		AOQL	0.18	105E, p26
		OC(0.0256)	0.95	105E, p34
		OC(0.347)	0.50	105E, p34
		OC(1.15)	0.10	105E, p34
	n=2, a=30	AQL	11.22	105E, p34
		$p_{0.90}$	12.06	105E, p34
		$p_{0.50}$	15.33	105E, p34
		LTPD	19.16	105E, p34
		$p_{0.05}$	20.35	105E, p34
		AOQL	11	105E, p26
		OC(11.22)	0.95	105E, p34
		OC(15.33)	0.50	105E, p34
		OC(19.16)	0.10	105E, p34

Table 3: (Continued)

Tally	Sampling Plan	Item	Value	Source
Defects	n=80, a=1	AQL	0.00444	105E, p50
		$p_{0.90}$	0.00665	105E, p50
		$p_{0.50}$	0.0210	105E, p50
		LTPD	0.0486	105E, p50
		$p_{0.05}$	0.0593	105E, p50
		AOQL	0.011	105E, p26
		OC(0.00444)	0.95	105E, p50
		OC(0.0210)	0.50	105E, p50
		OC(0.0486)	0.10	105E, p50
	n=80, a=14	AQL	0.116	105E, p50
		$p_{0.90}$	0.129	105E, p50
		$p_{0.50}$	0.183	105E, p50
		LTPD	0.252	105E, p50
		$p_{0.05}$	0.274	105E, p50
		AOQL	0.12	105E, p26
		OC(0.116)	0.95	105E, p50
		OC(0.183)	0.50	105E, p50
		OC(0.252)	0.10	105E, p50
	n=2000, a=1	AQL	0.000178	105E, p64
		$p_{0.90}$	0.000266	105E, p64
		$p_{0.50}$	0.000839	105E, p64
		LTPD	0.00194	105E, p64
		$p_{0.05}$	0.00237	105E, p64
		AOQL	0.00042	105E, p26
		OC(0.000178)	0.95	105E, p64
		OC(0.000839)	0.50	105E, p64
		OC(0.00194)	0.10	105E, p64
	n=2000, a=21	AQL	0.00745	105E, p64
		$p_{0.90}$	0.00812	105E, p64
		$p_{0.50}$	0.0108	105E, p64
		LTPD	0.0141	105E, p64
		$p_{0.05}$	0.0151	105E, p64
		AOQL	0.0073	105E, p26
		OC(0.00745)	0.95	105E, p64
		OC(0.0108)	0.50	105E, p64
		OC(0.0141)	0.10	105E, p64

3.2 PROGRAM DOUBLE TEST CASES

Table 4 shows the test cases for the program DOUBLE. OC curve values were obtained through hand calculations. The binomial and Poisson probabilities required were obtained from Tables T3-4 and T3-5 from Schilling (1982). The OC curve values validate Option 3.

Table 4: Test Cases for Program DOUBLE and Expected Results

Tally	Sampling Plan	Item	Value	Source
Defectives	n1=2, a1=0, r1=2 n2=1, a2=1	OC(0.0)	1.0000	Hand Calc.
		OC(8.0)	0.9818	Hand Calc.
		OC(100.0)	0.0000	Hand Calc.
		AQL	13.54	Verify - Opt 3
		$p_{0.90}$	19.58	Verify - Opt 3
		$p_{0.50}$	50.00	Verify - Opt 3
		LTPD	80.42	Verify - Opt 3
		$p_{0.05}$	86.46	Verify - Opt 3
		AOQL	26.00	Verify - Opt 3
	n1=30, a1=0, r1=2 n2=30, a2=1	OC(0.0)	1.0000	Hand Calc.
		OC(1.0)	0.9055	Hand Calc.
		OC(5.0)	0.2874	Hand Calc.
		OC(8.0)	0.09950	Hand Calc.
		OC(100.0)	0.0000	Hand Calc.
		AQL	0.6901	Verify - Opt 3
		$p_{0.90}$	1.035	Verify - Opt 3
		$p_{0.50}$	3.314	Verify - Opt 3
		LTPD	7.986	Verify - Opt 3
		$p_{0.05}$	9.909	Verify - Opt 3
		AOQL	1.657	Verify - Opt 3
	n1=30, a1=5, r1=8 n2=30, a2=12	OC(0.0)	1.0000	Hand Calc.
		OC(8.0)	0.9977	Hand Calc.
		OC(100.0)	0.0000	Hand Calc.
		AQL	12.90	Verify - Opt 3
		$p_{0.90}$	14.61	Verify - Opt 3
		$p_{0.50}$	21.51	Verify - Opt 3
		LTPD	29.96	Verify - Opt 3
		$p_{0.05}$	32.71	Verify - Opt 3
		AOQL	13.48	Verify - Opt 3

Percentiles and AOQLs must be determined interatively so are not amenable to hand calculations. Therefore values were obtained using Option 2 of Version 1.0 of DOUBLE on the Gateway computer. The accuracy of these results were then verified using Option 3. All hand calculations and verifications are detailed in the lab notebook and computer printouts.

Table 4: (Continued)

Defects	n1=2, a1=0, r1=2	OC(0.0)	1.0000	Hand Calc.
	n2=1, a2=1	OC(0.2)	0.8898	Hand Calc.
		OC(0.5)	0.5910	Hand Calc.
		OC(1.0)	0.2349	Hand Calc.
		OC(2.0)	0.02823	Hand Calc.
		AQL	0.1259	Verify - Opt 3
		$p_{0.90}$	0.1886	Verify - Opt 3
		$p_{0.50}$	0.5995	Verify - Opt 3
		LTPD	1.413	Verify - Opt 3
		$p_{0.05}$	1.737	Verify - Opt 3
		AOQL	0.2999	Verify - Opt 3
	n1=30, a1=0, r1=2	OC(0.0)	1.0000	Hand Calc.
	n2=30, a2=1	OC(0.01)	0.9055	Hand Calc.
		OC(0.05)	0.2978	Hand Calc.
		OC(0.1)	0.05722	Hand Calc.
		OC(0.3)	0.0001	Hand Calc.
		AQL	0.006888	Verify - Opt 3
		$p_{0.90}$	0.01035	Verify - Opt 3
		$p_{0.50}$	0.03355	Verify - Opt 3
		LTPD	0.08301	Verify - Opt 3
		$p_{0.05}$	0.1041	Verify - Opt 3
		AOQL	0.01677	Verify - Opt 3
	n1=30, a1=5, r1=8	OC(0.0)	1.0000	Hand Calc.
	n2=30, a2=12	OC(0.1)	0.9846	Hand Calc.
		OC(0.2)	0.6044	Hand Calc.
		OC(0.3)	0.1481	Hand Calc.
		AQL	0.1232	Verify - Opt 3
		$p_{0.90}$	0.1412	Verify - Opt 3
		$p_{0.50}$	0.2177	Verify - Opt 3
		LTPD	0.3221	Verify - Opt 3
		$p_{0.05}$	0.3590	Verify - Opt 3
		AOQL	0.1320	Verify - Opt 3

3.3 PROGRAM QSS TEST CASES

Table 5 shows the test cases for the program QSS. OC curve values were obtained through hand calculations. The binomial and Poisson probabilities required were obtained from Tables T3-4 and T3-5 from Schilling (1982). The OC curve values validate Option 3.

Table 5: Test Cases for Program QSS and Expected Results

Tally	Sampling Plan	Item	Value	Source
Defectives	$n1_r$=2, $a1_r$=0, $r1_r$=2	OC(0.0)	1.0000	Hand Calc.
	$n2_r$=1, $a2_r$=1	OC(8.0)	0.9790	Hand Calc.
	n_t=2, a_t=0, s_t=0	OC(100.0)	1.0000	Hand Calc.
		AQL	12.14	Verify - Opt 3
		$p_{0.90}$	16.97	Verify - Opt 3
		$p_{0.50}$	40.30	Verify - Opt 3
		LTPD	70.39	Verify - Opt 3
		$p_{0.05}$	78.47	Verify - Opt 3
		AOQL	21.05	Verify - Opt 3
	n_r=30, a_r=1	OC(0.0)	1.0000	Hand Calc.
	n_t=30, a_t=0, s_t=0	OC(1.0)	0.9534	Hand Calc.
		OC(5.0)	0.3247	Hand Calc.
		OC(8.0)	0.1043	Hand Calc.
		OC(100.0)	1.0000	Hand Calc.
		AQL	1.036	Verify - Opt 3
		$p_{0.90}$	1.466	Verify - Opt 3
		$p_{0.50}$	3.782	Verify - Opt 3
		LTPD	8.110	Verify - Opt 3
		$p_{0.05}$	9.966	Verify - Opt 3
		AOQL	1.927	Verify - Opt 3
	$n1_r$=30, $a1_r$=5, $r1_r$=8	OC(0.0)	1.0000	Hand Calc.
	$n2_r$=30, $a2_r$=12	OC(8.0)	0.9960	Hand Calc.
	n_t=30, a_t=3, s_t=1	OC(100.0)	1.0000	Hand Calc.
		AQL	10.65	Verify - Opt 3
		$p_{0.90}$	11.54	Verify - Opt 3
		$p_{0.50}$	14.90	Verify - Opt 3
		LTPD	21.21	Verify - Opt 3
		$p_{0.05}$	23.96	Verify - Opt 3
		AOQL	10.39	Verify - Opt 3

Percentiles and AOQLs must be determined interatively so are not amenable to hand calculations. Therefore values were obtained using Option 2 of Version 1.0 of QSS on the Gateway computer. The accuracy of these results were then verified using Option 3. All hand calculations and verifications are detailed in the lab notebook and computer printouts.

Table 5: (Continued)

Defects	$n1_r$=2, $a1_r$=0, $r1_r$=2 $n2_r$=1, $a2_r$=1 n_t=2, a_t=0, s_t=0	OC(0.0)	1.0000	Hand Calc.
		OC(0.2)	0.8589	Hand Calc.
		OC(0.5)	0.4735	Hand Calc.
		OC(1.0)	0.1503	Hand Calc.
		OC(2.0)	0.0185	Hand Calc.
		AQL	0.1140	Verify - Opt 3
		$p_{0.90}$	0.1650	Verify - Opt 3
		$p_{0.50}$	0.4761	Verify - Opt 3
		LTPD	1.186	Verify - Opt 3
		$p_{0.05}$	1.514	Verify - Opt 3
		AOQL	0.2386	Verify - Opt 3
	n_r=30, a_r=1 n_t=30, a_t=0, s_t=0	OC(0.0)	1.0000	Hand Calc.
		OC(0.01)	0.9525	Hand Calc.
		OC(0.05)	0.3354	Hand Calc.
		OC(0.1)	0.0585	Hand Calc.
		OC(0.3)	0.0001	Hand Calc.
		AQL	0.01026	Verify - Opt 3
		$p_{0.90}$	0.01457	Verify - Opt 3
		$p_{0.50}$	0.03821	Verify - Opt 3
		LTPD	0.08427	Verify - Opt 3
		$p_{0.05}$	0.1047	Verify - Opt 3
		AOQL	0.01940	Verify - Opt 3
	$n1_r$=30, $a1_r$=5, $r1_r$=8 $n2_r$=30, $a2_r$=12 n_t=30, a_t=3, s_t=1	OC(0.0)	1.0000	Hand Calc.
		OC(0.1)	0.9604	Hand Calc.
		OC(0.2)	0.1702	Hand Calc.
		OC(0.3)	0.0214	Hand Calc.
		AQL	0.1030	Verify - Opt 3
		$p_{0.90}$	0.1127	Verify - Opt 3
		$p_{0.50}$	0.1507	Verify - Opt 3
		LTPD	0.2258	Verify - Opt 3
		$p_{0.05}$	0.2597	Verify - Opt 3
		AOQL	0.1016	Verify - Opt 3

3.4 PROGRAM VARIABLE TEST CASES

Table 6 shows the test cases for the program VARIABLE. OC curve values were obtained from Guenther (1977). The OC curve values validate Option 3. Percentiles and AOQLs must be determined interatively so are not amenable to hand calculations. Therefore values were obtained using Option 2 of Version 1.0 of QSS on the Gateway computer. The accuracy of these results were then verified using Option 3. All hand calculations and verifications are detailed in the lab notebook and computer printouts.

Table 6: Test Cases for Program VARIABLE and Expected Results

Tally	Sampling Plan	Item	Value	Source
σ known	n=14, k=1.205	OC(10.0)	0.613	Guen., p70
1 spec limit		OC(15.0)	0.264	Guen., p72
		AQL	5.002	Verify - Opt 3
		$p_{0.90}$	6.086	Verify - Opt 3
		$p_{0.50}$	11.41	Verify - Opt 3
		LTPD	19.42	Verify - Opt 3
		$p_{0.05}$	22.20	Verify - Opt 3
		AOQL	6.254	Verify - Opt 3
σ unknown	n=21, k=1.761	OC(4.15)	0.50	Guen., p77
1 spec limit		AQL	1.000	Verify - Opt 3
		$p_{0.90}$	1.414	Verify - Opt 3
		$p_{0.50}$	4.145	Verify - Opt 3
		LTPD	9.848	Verify - Opt 3
		$p_{0.05}$	12.15	Verify - Opt 3
		AOQL	2.075	Verify - Opt 3
σ known	n=10, k=1.271	OC(10.0)	0.539	Guen., p90
2 spec limit	Cp=2/3	AQL	5.001	Verify - Opt 3
		$p_{0.90}$	5.686	Verify - Opt 3
		$p_{0.50}$	10.50	Verify - Opt 3
		LTPD	19.42	Verify - Opt 3
		$p_{0.05}$	22.70	Verify - Opt 3
		AOQL	5.640	Verify - Opt 3

3.5 EVALUATION OF TEST CASES AND DOCUMENTATION

For the PC versions 1.0 and 1.1, each test case must be executed on each of the two systems. Further, test cases where defects are tallied must be executed for each both continuous lots and lots consisting of defects. Files of the test cases are to be constructed and the programs executed using these files as input. The program output is to be saved to a file and then inspected for correct answers. Each input file must be executed four times, once for each combination of the software version and hardware configuration. All files are to be saved on disk.

For Macintosh version 1.1, the test cases must be executed by hand. Each test case must be checked for correctness. A log of the values obtained must be maintained.

4.0 ACCEPTANCE CRITERIA AND FINAL APPROVAL

The validation outlined in this document passes if execution of each of the test cases results in the correct value for all three versions and on each on the hardware configurations outlined. A value is considered correct if, when rounded to the same number of digits as the value given in this document, it differs by no more than one in the last digit.

Following the execution of the test cases, all supporting materials are to be submitted to the President of Taylor Enterprises, Inc. for final inspection and review. The president will check that all the required files, and printouts have been correctly saved and that the log is complete, before providing the final approval.

5.0 REFERENCES

Dodge, Harold F. and Romig, Harry G. (1959). *Sampling Inspection Tables Single and Double Sampling Plans*. John Wiley & Sons, Inc., New York.

Guenther, William C. (1977). *Sampling Inspection in Statistical Quality Control*. Charles Griffin & Company, London.

Mil-Std-105E (1989). *Sampling Procedures and Tables for Inspection by Attributes*. Department of Defense, Washington D.C.

Schilling, Edward G. (1982). *Acceptance Sampling in Quality Contro*l. Marcel Dekker, Inc., New York.

PROTOCOL APPROVAL:

Wayne A. Taylor — 3/7/94

Wayne A. Taylor
Chairman, Taylor Enterprises, Inc.

Ann B. Taylor — 3-7-94

Ann B. Taylor
President, Taylor Enterprise, Inc.

VALIDATION FINAL REPORT

GUIDE TO ACCEPTANCE SAMPLING

Protocol Number: TE-94-1

1.0 TEST RESULTS

The test results on the PCs were saved to file, printed and verified for correctness. The tests on the Macintosh were recorded in the lab notebook and verified for correctness. In no case did the expected result differ by more than 1 in the last significant digit. The printouts, files, and lab notebook have all been saved.

2.0 CONCLUSION

The acceptance criteria provided in the protocol was meet. The validation has been successfully concluded.

FINAL APPROVAL:

Wayne A. Taylor — 3/8/94
Wayne A. Taylor
Chairman, Taylor Enterprises, Inc.

Ann B. Taylor — 3-8-94
Ann B. Taylor
President, Taylor Enterprise, Inc.