



OMCL Network of the Council of Europe QUALITY ASSURANCE DOCUMENT

PA/PH/OMCL (07) 28 DEF CORR

EVALUATION AND REPORTING OF RESULTS

Full document title and reference	Evaluation and reporting of results PA/PH/OMCL (07) 28 DEF CORR
Document type	Guideline
Legislative basis	-
Date of first adoption	October 1999
Date of original entry into force	February 2000
Date of entry into force of revised document	December 2007
Previous titles/other references	This document replaces document PA/PH/OMCL (07) 28 DEF
Custodian Organisation	The present document was elaborated by the OMCL Network/EDQM of the Council of Europe
Concerned Network	GEON

EVALUATION AND REPORTING OF RESULTS

GUIDELINE FOR OMCLs

1. SCOPE

This guideline defines basic principles for evaluation and reporting of results of OMCL testing of industrially manufactured medicinal products¹. The purpose of this OMCL testing is to determine compliance of the product with the specifications laid down in the Marketing Authorisation and other relevant regulations. The OMCL testing can be considered as a verification of the testing by the manufacturer who has declared the same product in compliance with the specifications.

2. INTRODUCTION

An Official Medicines Control Laboratory (OMCL) performs testing of medicines for human and veterinary use on behalf of the Competent Authority.

The testing by an OMCL is performed within the context of activities such as market surveillance studies (MSS), testing of centrally authorised products (CAP), testing of products with mutual recognised authorisation (MRP), official control authority batch release (OCABR) and pre-licensing evaluation. The OMCL should operate the testing in a quality system based on ISO 17025 to guarantee a sufficient level of confidence in the results. The results of the OMCL testing may have significant consequences for the products involved, especially if a sample is found to be out of specification. Measures taken by the Competent Authority may include recalls, batch rejection, thorough production investigations, refusing of marketing authorisation (in pre-licensing evaluation) and it should be noted that results obtained from the testing by OMCLs are communicated within the network and to all competent authorities.

Therefore the OMCLs have to give careful consideration to the establishment of a test result and conclusions of conformity or non-conformity of a product.

This document is not necessarily applicable to testing of certain products at national level (such as herbals, extemporaneous preparations, illegal products, old registrations, etc), for which validation data are not available.

3. TEST RESULTS

Test results are to be obtained using validated methods. Guidance on validation of methods by OMCLs is provided in a separate document [1]. All tests are to be performed by competent staff and all results are to be verified and authorised.

Uncertainty of measurement. Information on the precision and accuracy of the results are to be included in the validation report. Where relevant, appropriate controls for precision and accuracy are to be taken into consideration in the design of the assay.

¹ The term "medicinal product" follows the definition of directive 2004/27/EC as amended.

For all quantitative measurements the uncertainty of the measurement should be considered in the result. This uncertainty can be expressed as one of the following:

- a. confidence limits with a defined probability (e.g. $P=0.95$), for a predefined number of tests.
- b. standard deviation, which should not significantly exceed the standard deviation established in the method validation.

Concerning Ph Eur monographs, it should be noted that the Ph Eur states that no further tolerances are to be applied to the limits prescribed since they are based on data obtained in normal analytical practice and they take account of normal analytical error, of acceptable variations in manufacture and compounding and deterioration during storage to an extent considered acceptable. This also applies to preparations described in the Ph. Eur.

4. EVALUATION OF RESULTS

In MSS, CAP, MRP testing and OCABR, the OMCL test results should be assessed against specifications approved in the marketing authorisation and/or the Ph Eur monograph of the product concerned.

The OMCL should clearly define how, if applicable, averaging of results is performed and how these results are evaluated.² The analytical acceptance criteria, should comply with predefined criteria as described in the documents “OMCL Policy on the Estimation and Application of Uncertainty in Analytical Measurements”. For quantitative (physico-) chemical methods, the exact design with repeats of the testing and the evaluation of the results is often not described in the Marketing Authorisation.

In Appendix IA, two examples of approaches are given which are elaborated for pharmacopoeial testing of active substances. An approach when testing the content of active substance in finished products is given in Appendix IB. Other approaches are possible if their scientific rationale is given.

Out of specification result (OOS result). When a result does not comply with the specifications, the OMCL has to operate a standard procedure to establish whether this result is due to analytical error, the influence of variables unrelated to the product, or whether this result reflects the actual condition of the product tested. This procedure should be based on the following principle:

- a. An appropriately competent supervisor has to conduct a documented investigation of any OOS result based on information provided by the staff who performed the test³. If

² An average can provide more information about the true value of a product than an individual test result but it can also hide variability among individual test results.

³ Information concerning the steps taken as part of the supervisor’s assessment can for example be found in the FDA “Guidance for Industry - Investigating Out-of-Specification (OOS) Test Results for Pharmaceutical Production” chapter III.B “Responsibilities of the Laboratory Supervisor” (Appendix IIA) for consultation. In Appendix II B, an example of template for use in the investigation of OOS results is presented.

this investigation reveals a technical reason for the suspect result, such as an analyst's mistake, malfunctioning laboratory equipment, or inappropriate sample storage, the suspect assay is not valid and the result is rejected. The OMCL repeats the assay and only the result of the repeated assay is considered for evaluation.

- b. The exact cause of an OOS result by the OMCL is often difficult to identify. After the initial investigation, the OMCL may decide to involve information from the manufacturer on the production and control of the suspect batch in the investigation.

If the OOS result cannot be explained, the OMCL has to perform a retest programme to confirm the OOS result. In such cases the numbers of replicates, operators, sampling procedure and method for evaluating results have to be predefined and documented.

Depending on the type of activity, specific documents may be available defining the different steps of the investigation and actions to be undertaken in case that OOS results are obtained (e.g. in the CAP programme, see document "Testing of Centrally Authorised Products (CAPs). Handling of out of specifications (OOS) results").

The retest programme and evaluation should be based on sound scientific judgement and may depend on the characteristics of the assay⁴. Unless invalidated, the initial OOS result is not rejected and it is included in the evaluation of the product. As a general principle re-testing should be limited and not used to "test a product into compliance".

5. REPORTING OF RESULTS

The OMCL should transfer the result and its assessment in a written report to the competent authority and, if applicable, to other OMCLs and the EDQM. The information given in the test report is to be based on the requirements given in ISO 17025 (Chapter 5.10) and shall include all the information requested by the competent authority and necessary for the interpretation of the test result. The report shall make reference to the method used (in-house / compendial / reference material where relevant). The results and the relevant specification shall be reported as the mean of a predetermined number of replicates, given with appropriate number of figures and, if applicable, the standard deviation.

If a product does not comply with the specification, a critical evaluation based on the OMCL failure investigation procedure has to be given and, if applicable, information from the manufacturer. A recommendation to the competent authority for follow up activities may be included in the report.

However, in the case where specific procedures already exist for reporting of results (e.g. OCABR – EC Administrative procedure for OCABR) these should be followed and any circulation of information to other agencies should respect the limits of confidentiality

⁴ The approach defined here may differ considerably between, on the one hand, precise and robust physico-chemical assays (see Appendix I) and, on the other hand, inherently variable and time-consuming biological assays. If a Ph Eur procedure exists for repetition of a particular test (e.g. the rabbit pyrogen test) this procedure is to be followed.

characteristic of that activity (e.g. EU specific networks versus general OMCL activities). The involved OMCLs and Competent Authorities should define in addition their internal procedures for storage and internal exchange of data and any follow up measures taking into account the recommendations noted above.

6. REFERENCES

(For all references, the latest version applies)

- 1 OMCL Guideline “Validation of Analytical Procedures”.
- 2 General OMCL Policy for implementation of Measurement Uncertainty in Compliance Testing.
- 3 OMCL Policy on the Estimation and Application of Uncertainty in Analytical Measurements. To be used by OMCLs for activities other than compliance testing.

APPENDIX IA

EVALUATION OF RESULTS – ACTIVE SUBSTANCE – TWO POSSIBLE APPROACHES

This document is based on publications in *Pharmeuropa* Vol. 9, No. 1, 148-156 (1997) and *Pharmeuropa* Vol 11, No. 4, 571-577(1999)

Two approaches based on two and three determinations are presented which may be applied by OMCLs when testing active substances. However, these examples are not intended to be all-inclusive and other valid approaches may be adopted for evaluation of the acceptability of test results. These proposals were tested against data sets obtained from proficiency tests and were shown to be satisfactory to take a decision.

Approach 1

Perform 2 determinations. If the RSD_2 ⁵ is smaller than the RSD_{max} permitted for 2 determinations (see Table 1), and the mean falls within the content limits, the sample passes. If either of the two conditions is not met, one further determination is performed. If the RSD_3 of the 3 values meets the criterion and the mean of the 3 results falls within the content limits, the sample passes. This can be repeated up to a maximum of 6 determinations. The sample can only be rejected if the mean is outside the content limits and the criterion for the RSD_n is met. If at any stage the RSD_n is greater than the value listed in Table 2, further determinations are useless because it can be predicted that the RSD will not meet the criterion. Instead, the reason for the poor repeatability should be investigated. As a consequence the sample can neither be accepted nor rejected. Only if an error in the assay procedure has been shown to have occurred, the results are rejected and the assay is repeated. This approach is illustrated in Figure 1.

Approach 2

Perform 3 determinations. If the RSD_3 is smaller than the RSD_{max} permitted for 3 determinations (see Table 1), and the mean falls within the content limits, the sample is accepted. If either of the two conditions is not met, 3 further determinations are performed unless the RSD exceeds the value in Table 2 in which case further assays are useless. If the RSD_6 of the 6 values is smaller than the RSD_{max} permitted for 6 determinations, and the mean of the 6 values falls within the content limits, the sample is accepted. The sample can only be rejected if the mean is outside the content limits and the criterion for the RSD is met. If the RSD is too large, the reason for the poor repeatability should be investigated and, in such circumstances, the sample can neither be accepted nor can it be rejected. Only if an error in the assay procedure has been shown to occur, the results are rejected and the assay is repeated. This approach is illustrated in Figure 2.

⁵ Note that using RSD_2 is equivalent to using the relative range if the requirement for $n = 2$ is multiplied by $\sqrt{2}$.

APPENDIX IB

EVALUATION OF RESULTS – FINISHED PRODUCTS – A POSSIBLE APPROACH

An approach based on three determinations is presented which may be applied by OMCLs in testing the content of active substances in finished products. However, this example is not intended to be all-inclusive and other valid approaches may be used for evaluation of the acceptability of the test results

For recently registered products with fully validated analytical methods information regarding repeatability and intermediate precision of the test method is supplied in the application file. The repeatability might be reported with different degrees of freedom depending on the experimental design. The minimum degrees of freedom is 5, as given in the ICH guideline.

During the assessment process the performance characteristics of the quality control processes are evaluated versus the specification limits proposed by the manufacturer. When approved the results of the tests performed shall fall within the specification limits.

When a product is to be tested at an OMCL the MAH file is consulted in order to find the suitable conditions for the test method and also to get information on its performance characteristics. The repeatability of the results obtained during testing can therefore be used as a quality indicator and checked versus the value in the dossier.

The observed standard deviation varies from occasion to occasion following a skewed distribution. To test whether standard deviations, or rather variances, are not significantly different, the quotient of two variances is calculated and compared with the critical F-value at a specified probability for the relevant degrees of freedom. In Table 3 to Table 6 the critical F-values at the 5% level have been used to calculate the maximum allowable standard deviations under the assumption that the observed repeatability is not significantly worse than that reported in the dossier.

Approach 3

1. Find the RSD and the degrees of freedom for the repeatability in the dossier.
2. Perform 3 determinations and obtain the results in % of label claim. Calculate the mean and the relative standard deviation.
3. Check in the relevant Table 3 to Table 6 in the present Appendix I if the obtained RSD for the repeatability is larger than the critical value given in the table corresponding to the reported value in the dossier or not.
4. If the RSD is not larger than the table-value and the mean is within the acceptance range; sample passes.
5. If the RSD is not larger than the table-value, but the mean is outside the acceptance range, perform 3 more determinations and calculate the mean and the standard deviation of the 6 determinations.

- 6 If the RSD is still not larger than the table-value and the new mean is within the acceptance range; sample passes.
- 7 If the RSD is not larger than the table-value, but the mean is outside the acceptance range, calculate the confidence interval using the standard deviation from the independent determinations performed by the laboratory and/or from the MA dossier, the corresponding t-value and square root of 6 according to the following formula

$$\bar{x} \pm \frac{t_{(90\%,v)} \times \hat{\sigma}_{(v)}}{\sqrt{6}}$$

- 8.1 If no part of the confidence interval is inside the acceptance range; sample fails.
- 8.2 If part of the confidence interval is inside the acceptance range; further investigation is needed.

This approach is illustrated in Figure 3.

Figure 1 - Decision tree for approach 1

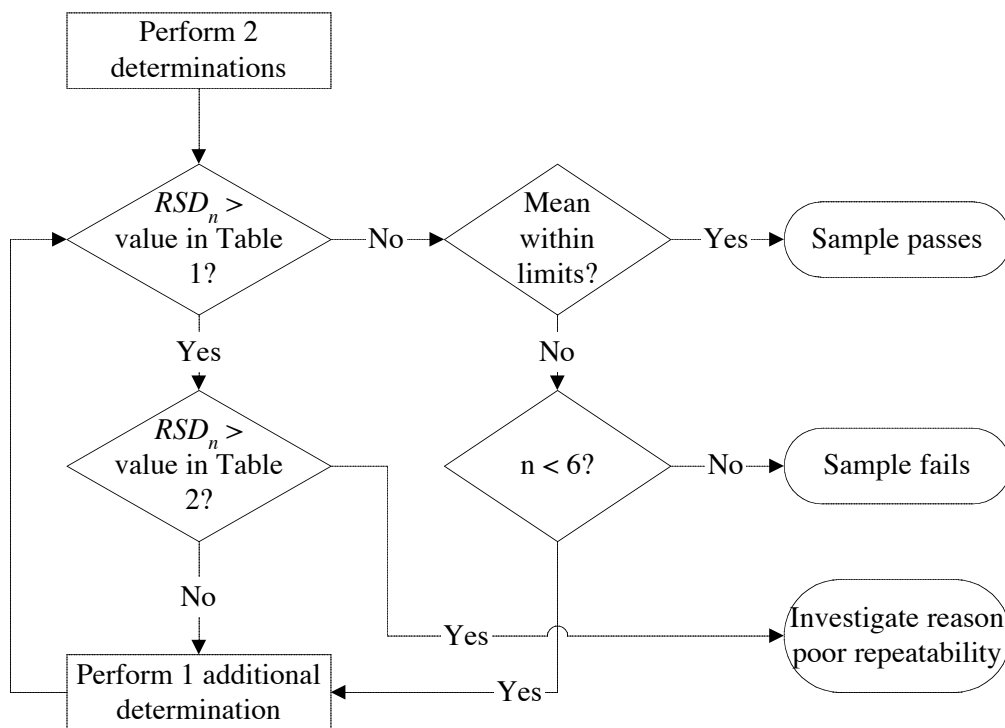


Figure 2 - Decision tree for approach 2

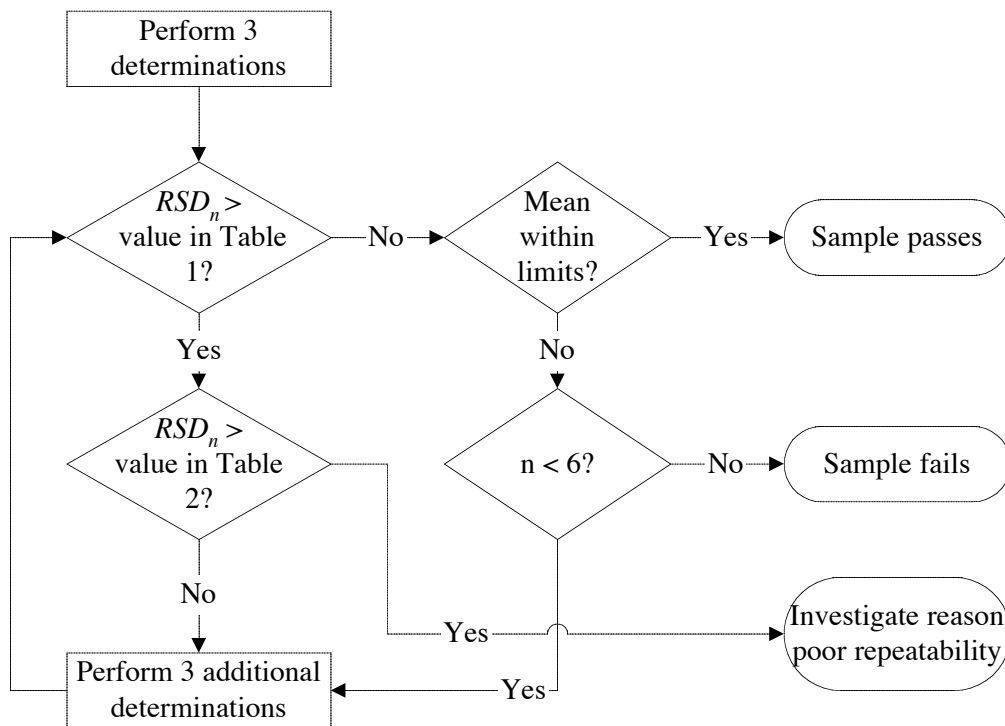


Figure 3 - Decision tree for approach 3

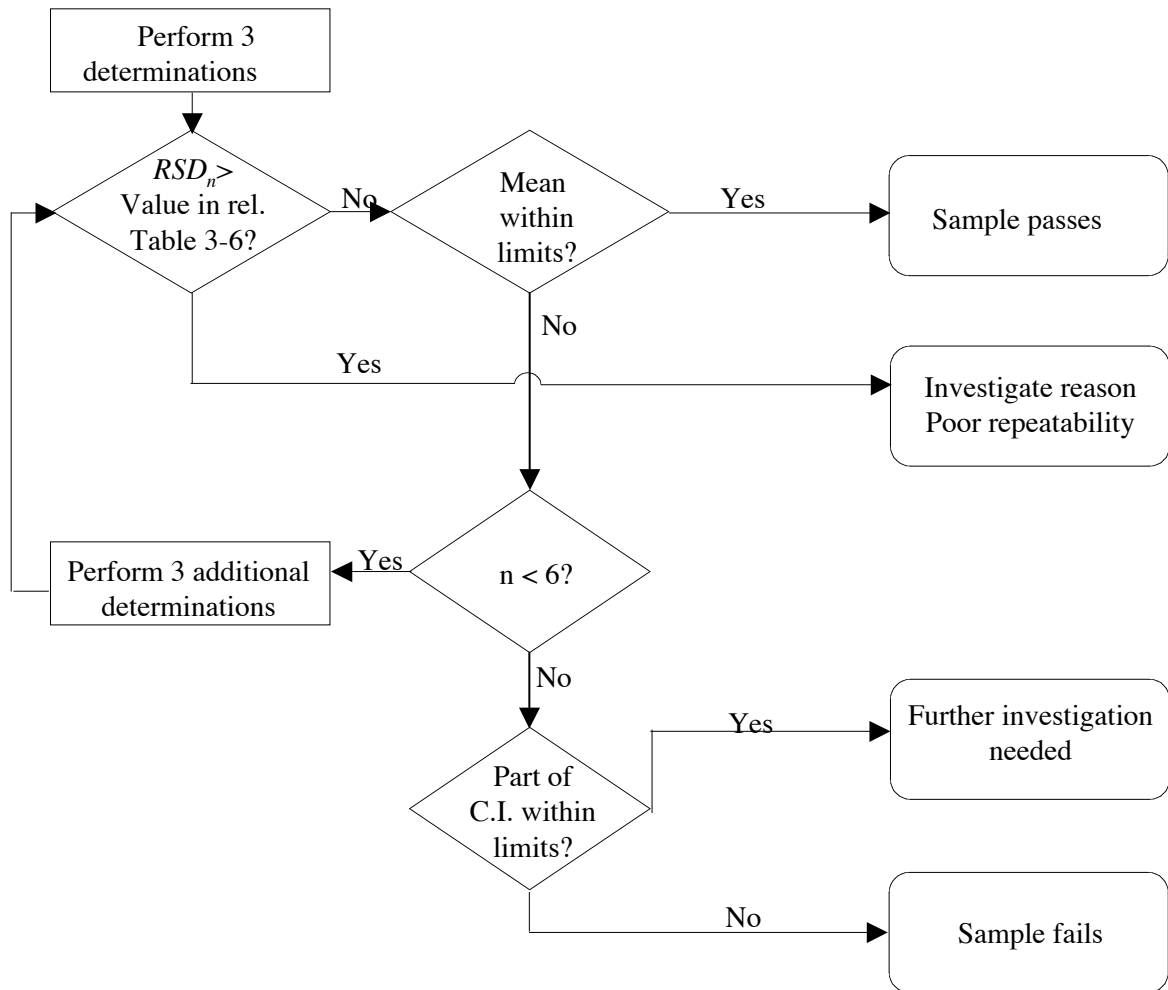


Table 1 — If the RSD_n is greater than the values listed, additional assays are required up to a maximum of 6.

<i>B</i>	Number of determinations (<i>n</i>)				
	2	3	4	5	6
1.0	0.11	0.29	0.42	0.52	0.60
1.5	0.17	0.44	0.63	0.78	0.90
2.0	0.22	0.59	0.84	1.04	1.20
2.5	0.28	0.73	1.05	1.30	1.50
≥ 3.0	0.33	0.88	1.26	1.55	1.80

B = Upper specification limit - 100

Table 2 — If the RSD_n is greater than the values listed, additional determinations are useless.

<i>B</i>	Number of determinations (<i>n</i>)				
	2	3	4	5	6
1.0	1.34	0.95	0.77	0.67	0.60
1.5	2.01	1.42	1.16	1.01	0.90
2.0	2.68	1.90	1.55	1.34	1.20
2.5	3.35	2.37	1.94	1.68	1.50
≥ 3.0	4.02	2.85	2.32	2.01	1.80

Table 3: - Maximum acceptable observed RSD for validation based on 5 degrees of freedom

90 % t-value for $\nu=5$ 2,015	5%				
	Repeatability from validation % $\nu=5$ (ICH)	df=2	df=3	df=4	df=5
		F= 5.79	F= 5.41	F= 5.19	F= 5.05
0.40	0.96	0.93	0.91	0.90	
0.50	1.20	1.16	1.14	1.12	
0.60	1.44	1.40	1.37	1.35	
0.70	1.68	1.63	1.59	1.57	
0.80	1.92	1.86	1.82	1.80	
0.90	2.17	2.09	2.05	2.02	
1.00	2.41	2.33	2.28	2.25	
1.10	2.65	2.56	2.51	2.47	
1.20	2.89	2.79	2.73	2.70	
1.30	3.13	3.02	2.96	2.92	
1.40	3.37	3.26	3.19	3.15	
1.50	3.61	3.49	3.42	3.37	
1.60	3.85	3.72	3.65	3.60	
1.70	4.09	3.95	3.87	3.82	
1.80	4.33	4.19	4.10	4.04	
1.90	4.57	4.42	4.33	4.27	
2.00	4.81	4.65	4.56	4.49	

Table 4: - Maximum acceptable observed RSD for validation based on 6 degrees of freedom

	5%				
	Repeatability	df=2	df=3	df=4	df=5
	from validation	F=	F=	F=	F=
	%	5.14	4.76	4.53	4.39
	v=6 (ICH)				
90 % t-value for v=6 1,943	0.40	0.91	0.87	0.85	0.84
	0.50	1.13	1.09	1.06	1.05
	0.60	1.36	1.31	1.28	1.26
	0.70	1.59	1.53	1.49	1.47
	0.80	1.81	1.75	1.70	1.68
	0.90	2.04	1.96	1.92	1.89
	1.00	2.27	2.18	2.13	2.10
	1.10	2.49	2.40	2.34	2.30
	1.20	2.72	2.62	2.55	2.51
	1.30	2.95	2.84	2.77	2.72
	1.40	3.17	3.05	2.98	2.93
	1.50	3.40	3.27	3.19	3.14
	1.60	3.63	3.49	3.41	3.35
	1.70	3.85	3.71	3.62	3.56
	1.80	4.08	3.93	3.83	3.77
	1.90	4.31	4.15	4.04	3.98
	2.00	4.53	4.36	4.26	4.19

Table 5: - Maximum acceptable observed RSD for validation based on 10 degrees of freedom

	5%				
	Repeatability	df=2	df=3	df=4	df=5
	from validation	F=	F=	F=	F=
	%	4.10	3.71	3.48	3.33
	v=10				
90 % t-value for v=10 1,812	0.40	0.81	0.77	0.75	0.73
	0.50	1.01	0.96	0.93	0.91
	0.60	1.21	1.16	1.12	1.09
	0.70	1.42	1.35	1.31	1.28
	0.80	1.62	1.54	1.49	1.46
	0.90	1.82	1.73	1.68	1.64
	1.00	2.02	1.93	1.87	1.82
	1.10	2.23	2.12	2.05	2.01
	1.20	2.43	2.31	2.24	2.19
	1.30	2.63	2.50	2.43	2.37
	1.40	2.83	2.70	2.61	2.55
	1.50	3.04	2.89	2.80	2.74
	1.60	3.24	3.08	2.98	2.92
	1.70	3.44	3.27	3.17	3.10
	1.80	3.64	3.47	3.36	3.28
	1.90	3.85	3.66	3.54	3.47
	2.00	4.05	3.85	3.73	3.65

Table 6: - Maximum acceptable observed RSD for validation based on 20 degrees of freedom

	5%				
	Repeatability	df=2	df=3	df=4	df=5
	from validation	F=	F=	F=	F=
	%	3.49	3.10	2.87	2.71
	v=20				
90 % t-value for v=20 1.725	0.40	0.75	0.70	0.68	0.66
	0.50	0.93	0.88	0.85	0.82
	0.60	1.12	1.06	1.02	0.99
	0.70	1.31	1.23	1.19	1.15
	0.80	1.49	1.41	1.36	1.32
	0.90	1.68	1.58	1.52	1.48
	1.00	1.87	1.76	1.69	1.65
	1.10	2.05	1.94	1.86	1.81
	1.20	2.24	2.11	2.03	1.98
	1.30	2.43	2.29	2.20	2.14
	1.40	2.62	2.46	2.37	2.30
	1.50	2.80	2.64	2.54	2.47
	1.60	2.99	2.82	2.71	2.63
	1.70	3.18	2.99	2.88	2.80
	1.80	3.36	3.17	3.05	2.96
	1.90	3.55	3.35	3.22	3.13
	2.00	3.74	3.52	3.39	3.29

APPENDIX IIA

Extract from the FDA Guidance for Industry “Investigating Out-of-Specification (OOS) Test Results for Pharmaceutical Production”, chapter III B

RESPONSIBILITIES OF THE LABORATORY SUPERVISOR

Once an OOS result has been identified, the supervisor's assessment should be objective and timely. There should be no preconceived assumptions as to the cause of the OOS results. Data should be assessed promptly to ascertain if the results may be attributed to laboratory error, or whether the results could indicate problems in the manufacturing process. An immediate assessment could include re-examination of the actual solutions, test units, and glassware used in the original measurements and preparations, which might provide more credibility for laboratory error hypotheses.

The following steps should be taken as part of the supervisor's assessment:

1. Discuss the test method with the analyst; confirm analyst knowledge of and performance of the correct procedure.
2. Examine the raw data obtained in the analysis, including chromatograms and spectra, and identify anomalous or suspect information.
3. Verify that the calculations used to convert raw data values into a final result are scientifically sound, appropriate, and correct; also determine if unauthorized or unvalidated changes have been made to automated calculation methods.
4. Confirm the performance of the instruments.
5. Determine that appropriate reference standards, solvents, reagents, and other solutions were used and that they meet quality control specifications.
6. Evaluate the performance of the testing method to ensure that it is performing according to the standard expected based on method validation data and historical data.
7. Fully document and preserve records of this laboratory assessment.

The assignment of a cause for OOS results will be greatly facilitated if the retained sample preparations are examined promptly. Hypotheses regarding what might have happened (e.g. dilution error, instrument malfunction) should be tested. Examination of the retained solutions should be performed as part of the laboratory investigation.

Examples:

- Solutions can be re-injected as part of an investigation where a transient equipment malfunction is suspected. Such hypotheses are difficult to prove. However,

reinjections can provide strong evidence that the problem should be attributed to the instrument, rather than the sample or its preparation.

- For release rate testing of certain specialized dosage form drugs that are not destroyed during testing, where possible, examination of the original dosage unit tested might determine whether it was damaged during laboratory handling in a way that affected its performance. Such damage would provide evidence to invalidate the OOS test result, and a retest would be indicated.
- Further extraction of a dosage unit, where possible, can be performed to determine whether it was fully extracted during the original analysis. Incomplete extraction could invalidate the test results and should lead to questions regarding validation of the test method.

It is important that each step in the investigation be fully documented. Laboratory management should ascertain not only the reliability of the individual value obtained, but also the significance these OOS results represent to the laboratory quality assurance program. Laboratory management should be especially alert to developing trends. As part of an effective quality system, a firm's upper management should appropriately monitor these trends and ensure that any problematic areas are addressed.

Laboratory error should be relatively rare. Frequent errors suggest a problem that might be due to inadequate training of analysts, poorly maintained or improperly calibrated equipment, or careless work. Whenever laboratory error is identified, the firm should determine the source of that error and take corrective action to prevent recurrence. To ensure full compliance with the CGMP regulations, the manufacturer also should maintain adequate documentation of the corrective action.

In summary, when clear evidence of laboratory error exists, laboratory testing results should be invalidated. When evidence of laboratory error remains unclear, a full-scale OOS investigation should be conducted by the manufacturing firm to determine what caused the unexpected results. It should not be assumed that OOS test results are attributable to analytical error without performing and documenting an investigation. Both the initial laboratory assessment and the following OOS investigation should be documented fully.

APPENDIX IIB

MODEL TEMPLATE FOR USE IN LABORATORY INVESTIGATIONS OF OOS RESULTS⁶

Sample information (name and testing laboratory code): _____

Analytical procedure: _____

- | | |
|---|--|
| <input type="checkbox"/> RSD OF SAMPLES HIGHER THAN ACCEPTABLE | <input type="checkbox"/> ENVIRONMENTAL CONDITIONS |
| <input type="checkbox"/> RSD OF REFERENCE STANDARD HIGHER THAN ACCEPTABLE | <input type="checkbox"/> (INADEQUATE TEMPERATURE, MOISTURE etc) |
| <input type="checkbox"/> MEASUREMENT OUTSIDE LINEAR RANGE | <input type="checkbox"/> SYSTEM SUITABILITY TEST MISSING OR FAILED |
| <input type="checkbox"/> VALUES BELOW LIMIT OF DETECTION OR QUANTITATION | <input type="checkbox"/> INSTRUMENT CALIBRATION MISSING |
| <input type="checkbox"/> BLANK-VALUE IGNORED | <input type="checkbox"/> WRONG INSTRUMENT PARAMETERS |
| | <input type="checkbox"/> WRONG INSTRUMENT USED |
- DEVIATION FROM THE SPECIFIED METHOD

- WRONG METHOD USED
- MISTAKES OF GENERAL CHARACTER
- | | |
|--|--|
| <input type="checkbox"/> weighting error | <input type="checkbox"/> solutions or reagents expired |
| <input type="checkbox"/> use of wrong reagents | <input type="checkbox"/> reagents not dissolved completely |
| <input type="checkbox"/> impurity of solvents | <input type="checkbox"/> error during filtration |
| <input type="checkbox"/> improper storage of reagents | <input type="checkbox"/> carry - over of reagents |
| <input type="checkbox"/> improper storage of solutions | |
- MISTAKES WITH STANDARDS
- | | |
|---|--|
| <input type="checkbox"/> wrong reference standard used | <input type="checkbox"/> inappropriate storage of reference standard |
| <input type="checkbox"/> reference standard without required quality used | <input type="checkbox"/> reference standard expired |
| <input type="checkbox"/> dilution error with standard solutions | <input type="checkbox"/> carry - over of reagents |
- MISTAKES IN RESULT CALCULATION
- | | |
|--|--|
| <input type="checkbox"/> calculation error | <input type="checkbox"/> wrong factor used |
| <input type="checkbox"/> formula wrong | <input type="checkbox"/> data transfer error |
- MISTAKES IN PIPETTING OR DILUTION
- | | |
|--|---|
| <input type="checkbox"/> glassware or pipetting device with wrong volume | <input type="checkbox"/> dilution error |
| <input type="checkbox"/> pipettes with broken top | <input type="checkbox"/> carry – over |
| <input type="checkbox"/> uncalibrated or substandard glassware | |

OTHER POSSIBLE REASONS FOR OOS-RESULTS

DURING THE PRESENT FAILURE INVESTIGATION, NO REASONS FOR AN OOS-RESULT WERE FOUND

Date: _____

Signature: _____

⁶ This list is not exhaustive and might need to be updated.