



Validation and Use of Excel® Spreadsheets in Regulated Environments

For Compliance with FDA Part 11 EU Annex 11.

27 Novembre, Moscou

Today's Agenda

- Regulatory requirements/business requirements
- Recommendations from the FDA
- Design Spreadsheet for Part 11/GxP compliance
- Validation during development and installation

Part 1

Q&A'S

- How to ensure integrity&security of spreadsheets
- How the FDA is using spreadsheets
- Documentation requirements
- Validation example from beginning to the end
- Case studies for Part 11 compliance

Part 2

Q&A'S

Regulations/Guidelines

- **GxPs**
Systems should be suitable for intended use
- **21 CFR Part 11 – E-Signatures/Records**
Defines requirements for electronic records, electronic signatures in FDA regulated industries
- **EU Annex 11 to GMPs**
Defines requirements for software and computer systems in EU GMP regulated environments
- **PIC/S Good Practice Guide**
Has lots of good recommendations on using computers in regulated environments

Common Requirements

- Strict access control to the systems and data
- Record handling and maintenance
 - Authenticity
 - Integrity
 - Confidentiality
 - Accuracy
- Tools:
 - Electronic audit trail
 - Electronic signatures
 - Digital signatures for system not under direct control
 - Validation

FDA Part 11 Validation Guidance

FDA Requirements

- Spreadsheet Calculations and Macro Programs used in GxP environments should be validated
- Testing should cover full range
- **End users should validate any program Macros and other customizations that they prepare**

Spreadsheet Calculations and Macro Programs should comply with 21 CFR Part 11 (E-records/signatures)

FDA Warning Letters

- **No procedures are established to validate for its intended purpose the Microsoft Excel software** used in creating and maintaining nonconformance records, product return records, internal audit corrective records, or corrective action records. (189)
- In addition, you continued to release products based on assay results generated by the **spreadsheet that have not been verified for accuracy** (W-237)
- **Spreadsheets** intended to check for outliers and calculate mean, SC, % CV, **not validated** (W-201)

Validate Spreadsheets

Ref: www.fdawarningletter.com

FDA Warning Letters

- Failure to validate computer software for its intended use according to an established protocol. For example; the Microsoft Excel **spreadsheet software program was not validated for formulation of reagents and was seen to give incorrect data** (W-125)
- Microsoft Excel **spreadsheet software** used manufacturing **has not been validated** for the purpose of generating a worksheet for formulation of reagents.
- **No documentation** was found to establish or verify **corrections** made to the program. (W-125)

Validate Spreadsheets

Ref: www.fdawarningletter.com

FDA Warning Letters

- "Your laboratory records did not include a record of all calculations performed in connection with laboratory tests as required by 21 CFR §211.194(a).
- For example, the notebook does not document reference to the spreadsheet calculation used to generate the results.
- Your SOP omits instructions to include in the notebook the reference to the spreadsheet calculation used to generate the results, as well as the raw data and calculations."

Record Spreadsheet Calculations

Ref: www.fdawarningletter.com (W-237)

Warning Letter

- Failure to use **fully validated computer spreadsheets** to calculate analytical results for in-process and finished product testing [21 CFR 211.165(e)]. For example, the computer **spreadsheets used to calculate analytical results for... have not been validated.**
- QA/QC Spreadsheet Validation, is deficient in that **only a small range** of values are being used to challenge computerized spreadsheet mathematical calculations.

Validate Spreadsheets over wide range

Ref: www.fdawarningletter.com (W 063)

Verification of Corrective Actions

EIR

- These tests include the entry of the following types of data: **aberrant high findings, aberrant low findings, in-specification findings, zeros, negative numbers,** and alphanumeric combinations
- Each spreadsheet is product specific and has a separate validation package
- Each package contains the initial testing of the information as entered into the **Spreadsheet, a blank spreadsheet, and a spreadsheet showing the calculation formulas** used in the appropriate cells.

Validation

EIR = Establishment Inspection Report

Ref: www.fdawarningletter.com (W 106)

Verification of Corrective Actions

EIR

- The package contains a list of the tests conducted and the dates they were performed as well as hand calculations of some trial data for comparison
- Revised SOP "QA/QC Computer Spreadsheet Validation," contains **directions for testing new and existing spreadsheets prior to use in analytical testing.**
- The spreadsheets are **checked monthly by a familiar analyst with previously entered data.**
- The **check results are compared to the originals** to make sure that corruption of the file has not occurred

Validation

EIR = Establishment Inspection Report

Ref: www.fdawarningletter.com (W 106)

Verification of Corrective Actions

EIR

- The firm now **saves the spreadsheets in read-only form** to compact discs, specific to product.
- **Changes to spreadsheets cannot be saved in this format.**
- Two sets of CDs were made, one Set for the daily laboratory use and one master copy containing all spreadsheets kept by
- **If one spreadsheet on a CD is changed, then a new CD is burned and the old one is archived.**
- The spreadsheet when **printed out bears a file path** at the bottom to assure it came from the CD

Integrity

Ref: www.fdawarningletter.com (W 106)

EIR = Establishment Inspection Report

European Medicines Agency GMP-Q&A

- Q: Which type of accuracy checks (Annex 11 p 6) are expected for use of spreadsheets?
- A: Data integrity should be ensured by suitably implemented and **risk assessed controls**.
The calculations and the files should be secured in such a way that **formulations are not accidentally overwritten**.
Accidental input of an inappropriate data type **should be prevented or result in an error message** (e.g. text in a numeric field and or a decimal format into integer field) - so called boundary checks are encouraged.

Ref: EMA Website

European Medicines Agency GMP-Q&A

- Q: Are there any specific considerations for the validation of spreadsheets?
- A: Validation according to paragraph 4 of Annex 11 is required at least for **Spread-sheets that contain custom code (e.g. Visual basic for applications)**. Formulas or other types of algorithms should be verified for correctness..

Ref: EMA Website

Compliance Problems with Spreadsheets

- Easy access to programs
- Everybody (not trained on GxP validation and computer science) can write programs
- Everybody can change ==>Frequent change without control
- No validation, no documentation
- Many different environments (operating systems, PC hardware)
- Many versions in use (local PC, server, inbox, delete folders)
- No or insufficient documentation
- **Typically do not comply with regulations (e.g., Part 11), and QA Unit is not aware of this**

What to do for GxP/Part 11 Compliance ?

1. Use other programs
e.g., perform calculations in **secure and validated** environments with functions for Part 11, e.g., chromatographic data systems, LIMS etc
2. Use document management software with built-in Excel support and Part11/GxP functionality, (E.g., Agilent OpenLab)
3. Develop, implement, and enforce procedures for development and use of Spreadsheets with **quality, security and validation** in mind.
4. Evaluate and use add-on software with more security and compliance functionality, e.g., e-audit trail, e-signatures
Examples: e-Infotree from Cimcon, www.part11solutions.com,
ExcelSafe from Ofnisystems, www.ofnisystems.com/ExcelSafe

Today's focus

Design Spreadsheets for Part 11/GxP

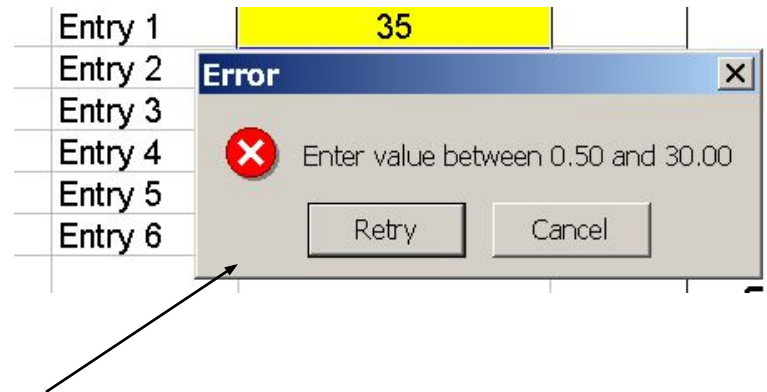
1. Follow documented procedures
2. Design for error detection
3. Design with integrity in mind
 - Don't enable users to change spreadsheets
4. Design for security
5. Validate during development, before and during use
6. Develop and apply rigorous change control procedures

Design for Error Detection

- Spreadsheet should detect errors during data entry
 - wrong type, e.g., string characters instead of numbers
 - wrong sequence of entries
 - wrong data range
 - wrong format (e.g., date)
- Spreadsheet should prompt the user in case of wrong entries, and not crash

With VBA

- Check and alert the user if a single data entry is 50% above average.




Design for Integrity and Authenticity

- Protect all cells not used for data entry
- Protect use of Excel sheet by passwords
- Store and load from write protected directory (e.g., secure server or CD)
- Display directory, subdirectories, file name and sheet name at the bottom of the spreadsheet
- Display date and time of last data entry
- Display&print operator name
- Verify file integrity with hash function

With VBA (example 3)

- Disable menu and tool bars to limit function to the intended use
- Disable 'save' and 'save as' Disable cut/copy and paste control keys

**Directory,
path, file name**

	Path, file, worksheet	Cell("filename")		
	C:\Ae_Winword\Book2002-Macro\Macro\RetentionTime-Macro[Excel-Level1-0-01.xls]Template			

Md5 Hash Calculations for File Integrity Check

- Based on security software from RSA
 - Used to check accuracy or e-mail transfer
 - Used for digital signatures
 - Used to verify proper software installation
 - Used to verify file transfer accuracy in networks
1. Calculate hash value (124 bit string)
 2. Store the value
 3. For verification: recalculate and compare with original value

Design for Security

1. Develop, implement and test procedures for limited system access to authorized users
(e.g., through user ID/password)
2. Configure and use secure operating systems (Windows 7, XP, VISTA)
3. If available, use secure server for storage of spreadsheets and access to spreadsheets
4. Maintain user lists with authorized access

What to Validate / What not to Validate

Not to Validate

- Excel software
- Standard calculations under normal conditions (GAMP Category 3)

Validate

- Everything we customize, e.g.,
 - user interface (input/outputs)
 - validation functions for data entry
 - macros (VBA Scripts)
- Extreme conditions (at and above/beyond limits)
- Security functions (e.g., passwords, cell protection)
- Spreadsheet integrity (e.g., hash function)

What does Validation of Spreadsheets Include?

- **Planning**
- **Writing specifications**
 - functional specifications
 - computer requirements
 - user profile (skills)
 - design specifications
- **Design and code review**
- **Installation qualification/documentation**
- **Testing during development and after installation**
- **Change control/requalification**
- **Validation report**

Should we Test Standard Excel Functions?

1. Standard functions used in normal operation range don't need to be verified (GAMP category 3)
2. Verify standard functions if used in extreme ranges (e.g., very small numbers) and if there are indications for problems with Excel
3. Use commercial calculator for verification for 2.
4. Regularly check the vendor's website for errors (need written procedure)

Recommendations from GAMP

- Document the purpose of the spreadsheet
- Verify that the correct calculations have been used, e.g., $(a+b)*c$ can be easily mixed up with $a + (b*c)$
- Document formula
- Verify any cell links
- Protect the spreadsheet
- Strict access controls
- Validate data input of critical data
- Ensure integrity of electronic data

No need to verify accuracy of native functions

Ref: (GAMP 5, Page 294)

Excel Spreadsheet Validation from Beginning to End (1)

1. New spreadsheet proposed
2. Proposal approved
3. Establish validation team
4. Develop preliminary project plan
5. Interview anticipated user departments about use of the SS
6. Update project plan and distribute to QA and operation manager
7. Interview anticipated users for intended use and requirements
8. Interview anticipated users about required functions
9. Draft of requirement specifications
10. Conduct risk assessment
11. Qualify developer/supplier
12. Develop template for design specification and review
13. Develop and review design specification

Excel Spreadsheet Validation from Beginning to End (2)

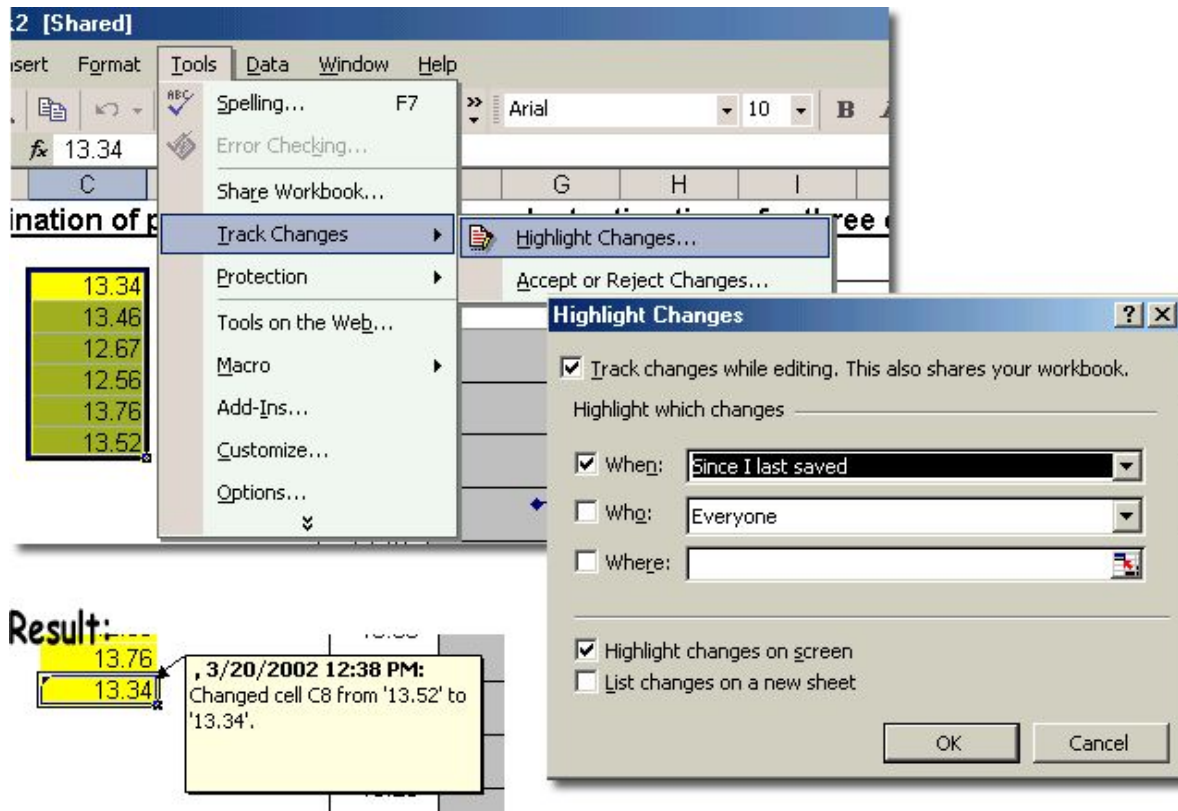
14. Develop functional specification test plan
15. Distribute test plan to test persons (user representatives)
16. Test functional specifications
17. Evaluate test results (and correct deficiencies, if there are any)
18. Develop a list with anticipated users
19. Distribute spreadsheet to anticipated users
20. Install and document spreadsheet
21. Test spreadsheet in the user's environment
22. Add the spreadsheet to the company's spreadsheet data base
23. Write the validation report
24. Repeat tests from (21) every quarter
25. Follow documented procedures for any changes and record changes in the change history

How to Comply with the Audit Trail Requirement

- **Procedures**
For low risk systems
- **Print and sign**
For low risk systems
- **Use 'Track Changes' function**
For medium risk systems
- **Use 3rd party software**
e.g., ExcelSafe, e-Infotree
For high risk systems

Design for Tracking Changes (Audit Trail)

1. Click on *Tools* -select *Track Changes* -select *Highlight Changes*
2. Select **which changes you want to track and time range**
3. Result: Changes can be reviewed and printed

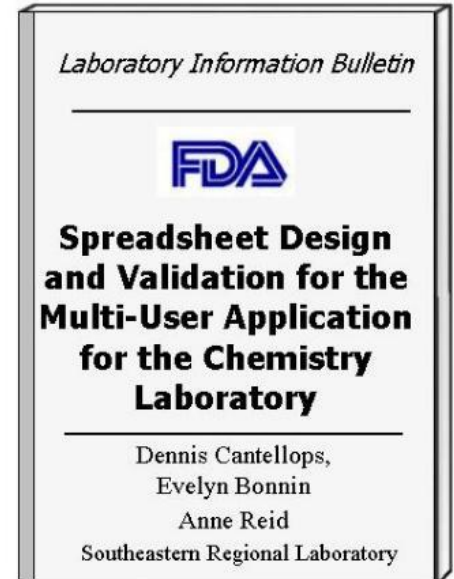


Multi-User Excel Spreadsheets in FDA Laboratories

1. User ID/Password for secure log-on
2. MS NTFS to limit access to files
3. Store spreadsheets on write protected server directories
4. Validate spreadsheet applications
5. Control and archive spreadsheets for internal audits
6. Standardize design of templates (use of colors, cell protection)

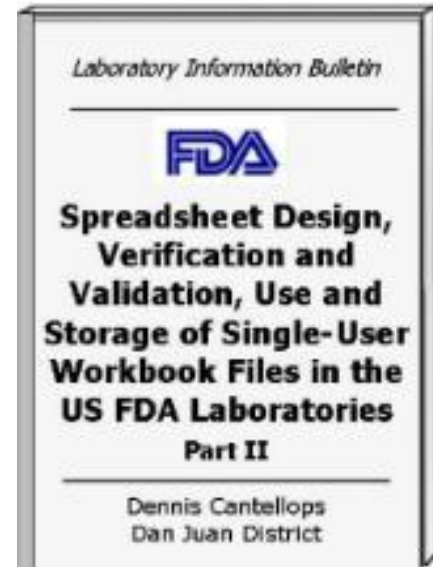
Source: FDA LIB:

Spreadsheet Design and Validation for the Multi-User Application for the Chemistry Laboratory



Single-User Excel Spreadsheets in FDA Laboratories

- Test and document correct functioning (input/output, customized formula)
- Document used formula
- For direct input of raw data: verify data entry through second person (only for high risk records)



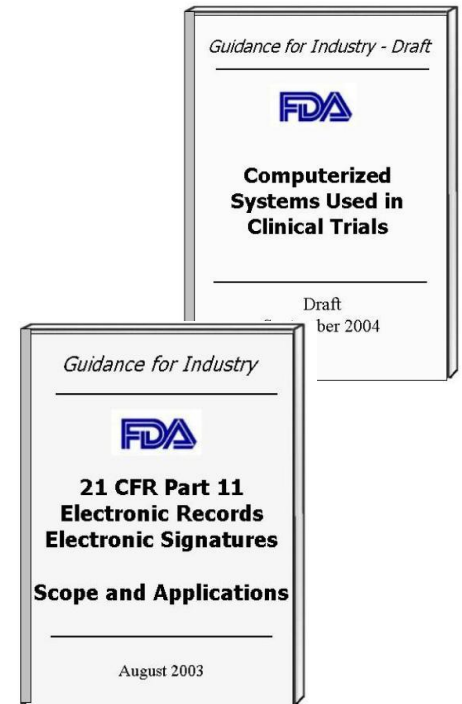
Source: FDA LIB:

Spreadsheet Design, Verification and Validation, Use and Storage of Single-User Workbook Files in the US FDA Laboratories

Documentation for Part 11

FDA Recommendation: We recommend that each study protocol identifies at which steps a computerized system will be used to create, modify, maintain, archive, retrieve, or transmit data.

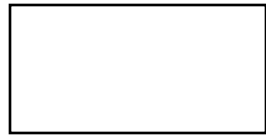
1. Document your business practices especially important: where can users change records (e.g., spreadsheet templates)
2. Define and document your rationale behind part 11 controls (e.g., audit trail, archiving on paper vs. electronic, validation)



Example – Using Excel Template as Calculator

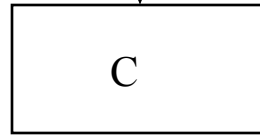
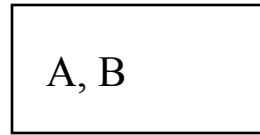
Paper

Raw data
Results



PC

Excel software
Calculates results



Printer



Business Practice - Steps

1. Spreadsheet loaded from **write-protected server**
2. Data from paper is typed into an Excel spreadsheet
Example: weights of balance
3. Spreadsheet performs calculations and results are printed and signed
4. **All printed results are archived together with original data**
5. No electronic records stored

Recommendations

- No e-audit trail
- Load spreadsheet from write protected server
- Print file source with each result
- Maintain records in paper form

Records required by predicate rule

No ___ Explicit_x Implicit ___

Regulated activity relies on e-records

Yes_x No___

Impact on product quality

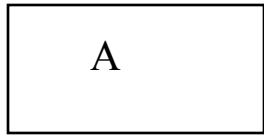
High_x Medium ___ Low ___ No ___

Events

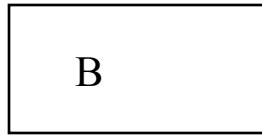
- A. Original e-record stored
- B. User has authorized access to data
- C. Approval

Automatic Transfer of Intermediate Data to Excel

Equipment
e.g., autoclave
or UV for
Dissolution



Computer 1
Data acquisition
Primary data
evaluation



Computer 2
Excel software
Primary data
evaluation



- A. Data generation (temperature, pressure, results)
- B. Data is stored temporarily and processed
- C. Authorized access to data
- D. Operators can manipulate data

Remark: Computer I and II can be combined

Recommendations

- No e-audit trail on Comp1
- E-audit trail on Comp2
- E-signature on Comp2
- Need Excel remediation software
- Comp1 and Comp 2 must be validated

Business Practice - Steps

1. Data generated by equipment (e.g., process parameters, signals)
2. Data transferred to computer 1 for primary data evaluation (no operator interaction)
3. Intermediate results transferred to computer 2 for secondary evaluation with operator interaction
4. Results from secondary evaluation are signed on computer 2 and archived

Records required by predicate rule

No ___ Explicit_x Implicit ___

Regulated activity relies on e-records

Yes_x No___

Impact on product quality

High_x Medium ___ Low ___ No ___

R11

Operator Name

Date & Time

Precision of Retention Times in Chromatograph

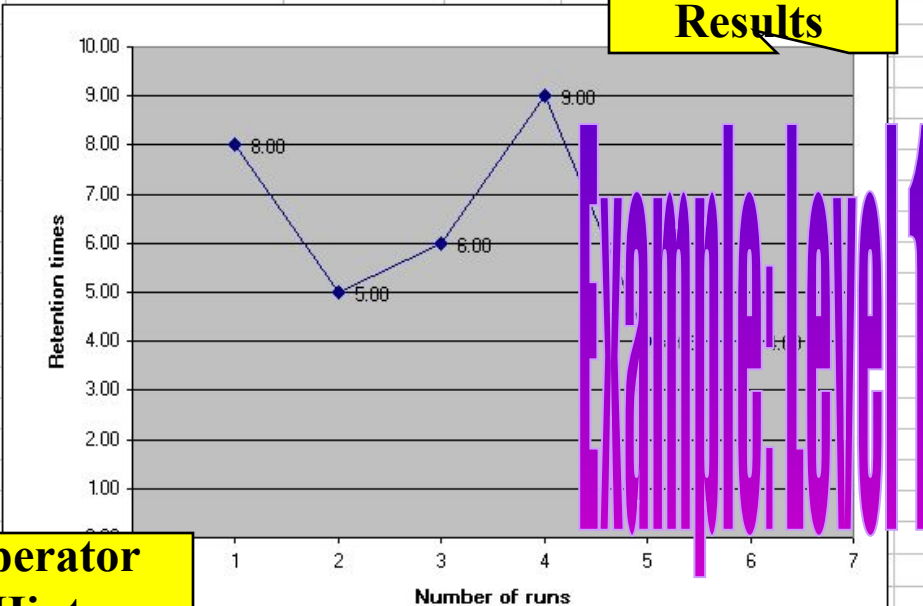
Operator Name: Mike Miller
Compound name: Caffeine

Dats&time (mm/dd/yyyy hh:mm) 7/28/2002 6:12

Data entry Yellow cells

Graphical Results

Ret		
Entry 2	8.00	
Entry 3	5.00	
Entry 4	6.00	
Entry 5	9.00	
Entry 6	4.00	



Results Green cells

Result	
Average Entry	6.00
Standard Deviation:	2.10
Relative Standard Deviation:	34.96%
Highest	9.00
Lowest	4.00

Flags Red cells

Operator Hints

Flags	
Rel STD greater than 2% (*)	Yes

Directory Path & file

Print on Single page

(*) if rel std. > 2%, redo chromatographic runs. If problem still exists, check instrument according to SOP 45-77

LabCompliance Path, file, worksheet Cell("filename")
 C:\Ae_Winword\Book2002-Macro\Macro\RetentionTime-Macro\Excel-Level1-0-01.xls\Template

Disable Menu and Tool Bars and CTRL Keys

Start **Print** **Exit**

Operator name **Date & Time**

Data entry Yellow cells

Operator name:	Ludwig Huber	Date/time (m/d/ly hh:mm):	Sunday, October 19, 2003 --- 7:11:43 AM
Sample name:	Caffeine		

Results Green cells

Average	3.50
Standard Deviation:	0.07
Relative Standard Deviation:	2.05%
Higher	3.60
Lower	3.40

Flags Red cells

Rel STD greater than 2% (*)	Yes
Up or Down (**)	No

Graphical Results

Operator Hints

Directory Path & file/vers.

Print on Single page

(*) if rel std. > 2%, redo chromatographic runs. If problem still exists, check instrument according to manual.
 (**) if yes, four out of five consecutive entries go either up or down. Check instrument according to manual.

LabCompliance Path, file, worksheet Cell("filename")
 C:\Af_ppt\Videos\Macro-CD-Rev-2-00\Excel Spreadsheets - Macros\Excel-Level3-Ver-1-00.xls\Temp

Minimal Documentation

(equally important for new and existing spreadsheets)

1. A description of what the program does
2. Description of formulas used
3. User manual incl. description of color coded cells
4. Explanation of the relationship of formulas used in procedures to Excel equations
5. Listing of VBA Macros
6. Test sheets with anticipated results, acceptance criteria and actual results
7. Security and password maintenance, user lists
8. Documentation of operating systems, spreadsheet version, workbook version, date of installation

Thank You

