Information Management Systems in an Industrial Hygiene Laboratory:

Unique Challenges, Positive Results

By Mathew Abraham, Christine Paszko and Eileen Jutras

The implementation of a laboratory information management system, or LIMS, in an industrial hygiene laboratory has its own set of specific challenges. An IH laboratory processes a very broad range of sample types, including clinical specimens as well as environmental samples. There are also broad ranges of test methods that need to be used in the analysis of these sample types. A LIMS for an IH laboratory must be capable of handling literally thousands of bacterial and fungal genus and species names as well as calculations and descriptors for background material. The environmental background of the sample is important to industrial hygienists performing indoor air quality surveys for interpreting data.

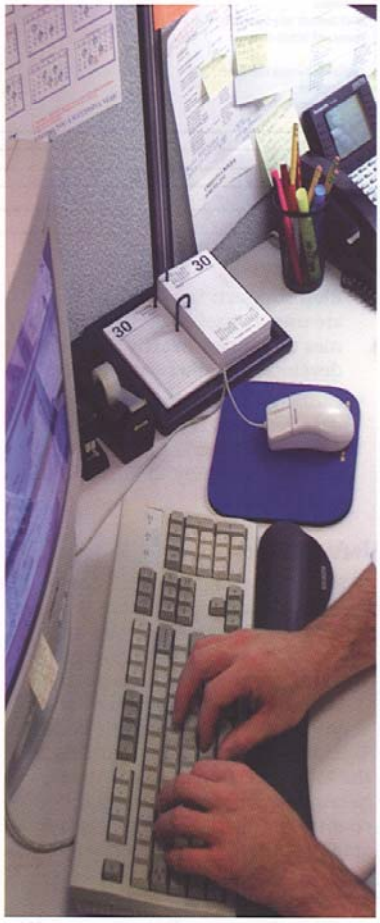
The results entry for an IH laboratory also needs to be flexible enough to accommodate text entry for the genus and species names as well as symbols and text interpretations. The setup of each test to allow for the type of results entry that best fits the test method is crucial.

This article will focus on the process of streamlining the results entry process through the use of drop down list boxes, hot look-ups and calculated fields and integrating these advantages with the existing automation of the LIMS. Successful implementation of LIMS should result in improved data quality, faster turnaround times and greater customer satisfaction.

Industrial Hygiene Demands

The greatest challenge in automating the data management of an IH laboratory is the variety of data inputs, calculations and reporting requirements. Along with the ability to create parameters on the fly, users require the ability to do the following in an efficient and user-friendly manner:

- **Freeform text entry:** In an IH laboratory results are at times represented descriptively, so freeform text entry is a must.
- **Ability to enter symbols:** Certain numerical values need to be represented using symbols to be able to fulfill IH laboratory nomenclature requirements.
- **Drop down lists for selecting results:** There are tests that have result values that are descriptive. Instead of typing these results out each time, which would be time consuming and can also yield inconsistent reporting and spelling errors, it is advantageous to use drop down lists that contain these descriptive results for users to select from.
- **Calculated fields:** Instead of doing calculations of results by hand, which may be prone to errors, a more automated approach would include using calculated fields so that once scientists enter the raw data counts, the final corrected values are automatically calculated.
- **Reporting:** A LIMS allows clients to produce timely, consistent reports that display results for individual samples that can be printed, converted to PDF, faxed or e-mailed to clients to decrease turnaround time.



System Prerequisites

Before we discuss the specialized IH result entry we need to examine the data management solution as a whole. Several basic prerequisites must be met before attempting to streamline result entry.

You should eliminate login bottlenecks by having an efficient and easy way of adding, deleting and copying additional samples to be logged into the LIMS, organizing and maintaining contact and billing information and tracking analyses required with client-specific limits that can be displayed on client-specific reports. Implementing bar coding also enhances accuracy and throughput of sample login by eliminating transcription errors and providing fast and efficient sample flow through the analysis process. The ability to create work lists, bench sheets and quality control batches is also important.

Additional prerequisites include:

- **Manual entry:** This is the ability to enter the results manually from a data entry screen configured to allow fast and efficient result entry. A well-organized system groups together sample results and all of the QC information with color-coded result entry flags.
- **Electronic chain of custody:** This refers to the ability to be able to find a sample at any given point from any workstation that is running the LIMS software.
- **Results import/automated result entry:** This is the ability to import result values that may come directly from an instrument output file or any other electronic import source. This can be automated by having the LIMS scan a specific directory and automatically import results as they become available.
- **Limit checking based on user definable criteria:** This should include both upper and lower "soft" or warning limits and upper and lower "hard" limits, limits that should not be exceeded.
- **Peer review:** This is a QC function of the LIMS. When activated, the LIMS will require validation and approval in the result entry section to occur by someone other than the person that entered the data. This is also a requirement for AIHA accreditation.
- **Full audit trail:** This is the ability to have an electronic document of all changes made to the final result following the approval stage. The audit trail records the original result, with who entered it and the date and time that it was entered, and includes any changes that were made and who made them. System auditing can also be turned on, which records all system modifications.

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Industrial Hygiene Result Entry

As noted previously, results entry for an IH laboratory needs to be flexible enough to allow text entry for genus and species names as well as entry of symbols and text interpretations. To enhance data quality and minimize transcription errors, the LIMS can use drop down lists, with hot look-up. This allows the analyst to select the correct numerical or text result form in an alphabetical drop down list or to type until the desired result appears.

The ability to perform specific IH calculations such as spore/M^3 = (total air volume/sampled air volume) or count * correction factor, as well as the ability to enter free text and append preselected result values, provides the analyst with the flexibility required for results entry.

Reporting

The final product of the laboratory is information. Therefore, a LIMS that can facilitate rapid and accurate reporting is key to a successful laboratory. Figure 1 is a sample analysis report.

Only standardized tools such as Microsoft Access, Adobe Acrobat, Crystal Reports, Microsoft SQL Server and others should be employed, for a number of reasons:

- **Sharing information:** If you want to share information with clients or peers, it becomes easier when using a standardized tool.
- **Short learning curve:** Development and maintenance become much easier; there is more information and support since a large number of people are using the same tool.
- **Fewer software anomalies:** Again, more people are using the tool and reporting a majority of possible anomalies, which are fixed with patches released by the software company.
- **Less complexity:** The look, feel and organization of functionality follow a consistent pattern, making it easier to learn, such as with the Microsoft Office Product Suite.

Figure 1. Sample Analysis Report

Hygiene Laboratories, Inc.

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Van Waleri, C.A. 90781
(610) 688-0400 (780) 618-8900 fax

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FINAL REPORT: Total Non Viable Fungal Spore Trap Count

PROJECT NUMBER: train
Hygiene Technologies International, Inc.
Attention:
5548 Daffodil Way Suite 180
Sparks, NV 90503-1643

LABORATORY ID NUMBER: 0307008
December 19, 2003

Customer Sample Number:
Background

Date of Analysis: 08/07/03

Sample Volume: 75

Genus (species)	Raw Count	Comment	Total Spores / M^3
Ascospores	3		39
Cladosporium	4		52
Smuts	3		39
Torula	1		13
TOTAL	11		140

- **Rich support:** Standardized tools are usually backed by stable companies that invest heavily in research, development and maintenance.
- **Cutting-edge technology:** Standardized tools usually exist in a competitive market, forcing the software company to improve its technologies.

Invoicing

After reporting, the next step is invoicing, and its importance is obvious. The LIMS should provide an automated function that quickly, accurately and efficiently facilitates the creation of an invoice with the ability to allow client-specific prices. The invoice should list, at a minimum, the bill-to address, payment terms, an itemized detail of the pricing, any discounts, any special charges and a total amount due.

Conclusions

Streamlining results entry in an IH laboratory begins with a complete understanding of the laboratory's data management and reporting needs. This includes sample login, work lists, QC batch creation, results entry, reporting and invoicing. Sample login should be streamlined using a well-organized format for the ordering of samples, tests and customer information; tools such as bar coding, hot look-up functionality and multiple ordering from one screen will also expedite the process. The reporting section should allow for quick and efficient data entry and mining as defined by user-selectable criteria and the ability to feed the mined data to a predefined report template.

Streamlining the results entry process provides the ability to invoice upon result reporting. As soon as the last sample is approved and validated, it can be automatically invoiced with the invoice report e-mailed, faxed or sent by regular mail to the customer. Invoicing can occur at this accelerated pace due to the fact that the LIMS offers integrated reporting functionality. This system integration offers the customer a quicker turnaround time, increased efficiency and a superior return on investment.

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