

LABORATORY INFORMATION MANAGEMENT SYSTEMS IN THE SOUTHERN AFRICAN SUGAR INDUSTRY

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Abstract

The sugar factory laboratory has over the years evolved into the centre of all factory throughput, quality, and efficiency measurement and reporting procedures. The basis for the gathering and processing of results and information, and subsequent formatting into efficient reporting processes is the Laboratory Information Management System (LIMS). Initially designed to cater for laboratory testing and calculations only, the LIMS has developed into a more encompassing system that can potentially cover all operations in the wider factory environment without being limited by location.

This paper considers recent trends in sugar factory information management with specific reference to key functionalities and capabilities essential to a LIMS that is fit for function and to the benefit of both growers and millers. As the performance of a computerised system depends on key inputs, typical configurations of the data capture environment in a modern factory are considered. Current capabilities with regards to network configuration that best suit the sugar manufacturing environment are also covered.

Keywords: computer, software, data, laboratory, factory, reporting

Introduction

Over the years technological improvements have been adopted in the sugar industry to improve performance. Motorised vehicles for transportation, par low control (PLC) for process control and cellular phones for communication have all swiftly established themselves as necessary and logical ways to conduct business in the modern factory environment. However, the arrival of computer technology has been embraced more cautiously, largely due to perceptions regarding costs and concerns about reliability. Over the past decade significant strides have been made in the information technology (IT) field making implementations readily available, affordable and generally more acceptable. Consequently, the adoption of IT systems in the sugar industry indicate wider acknowledgement of benefits accumulated such as automation in weighbridge operations, laboratory testing and information gathering and collation. This coincided with a growing demand for reliable information that is readily available for factory management to make informed decisions to minimise losses and enhance profitability.

Networking and connectivity

Developments and improvements in networking infrastructures have made high speed data access with vastly improved reliability, a reality. The migration from microcomputers to Local Area Networks (LANs) was a significant stride (King *et al.*, 1993) that revolutionised IT in the South African sugar industry. Today fibre optic and wireless technologies, among others, allow long distances between the server and various workstations, enabling a high

performance and reliable data capture operation. Typically sites can be located hundreds of kilometres apart and operate on a real-time basis, provided the link between the sites is configured to have sufficient capability. The link can be established through a Virtual Private Network (VPN) making the relative location of sites and servers of little consequence. This opens new opportunities with regards to information availability for operations that transcend borders and different sites within a group. Technical support is carried out remotely, thus reducing response time and travel costs between provider and client.

Data capture and integrity

For improvements in the integrity of data for the operational environment and payment systems, it is essential that the human element be minimised. Laboratory computerisation has played an integral part in this process as instrument and equipment readings can be automatically captured onto the database (King *et al.*, 1979). Weighbridge digitisers are automated, hence increasing the integrity of all weights captured. The automation process extends to factory scales and PLCs capturing production statistics directly into the database.

Where manual data capture is the only option, security systems can be used to ensure that all parameters are validated against predetermined values and parameters. The validation process assists the operator or analyst in eliminating typing errors and omissions. At the same time, any suspect data will be tagged, giving management an easy tool to monitor potentially incorrect results. Log reports are generated against all data and operational changes that are carried out, enabling investigation and correction where necessary.

All analytical methods and calculations are pre-recorded and only the analytical steps need to be carried out by analysts or testers. No manual calculations are necessary. Most analytical instrument readings can be relayed directly into a database to produce a result and report with minimal to no human intervention. The results are therefore immediately available for factory personnel to utilise. In addition, each analyst or tester has a unique identity which is stored and transferred with the results, to authenticate the source of the data. This also helps to improve the quality of work, as system users are easily traceable and accountable for their work actions at all times.

Redefining the factory environment

The factory environment can be redefined beyond the perimeter fencing of the sugar factory to include all operations that make it successful. These operations take place independently, yet within a LIMS-based environment they are interfaced, and each function is catered for based on its key deliverables.

The agricultural environment

Information pertaining to operations, efficiency and sustainability is captured and reported. This includes:

- delivery information presented at the weighbridge; additional data can be captured, depending on the complexity of reporting requirements
- mill and loading zone arrival and departure times enable trending of turnaround times
- vehicle, contractor and driver details aid in management of their performance
- odometer readings and route codes enabling efficient fuel management
- Burn and cut times improve management of sucrose degradation caused by infield delays.

The loss control environment

For a sugar mill the two largest contributors to the bottom line are transacted and managed at the weighbridge. Cane delivery (purchasing) and sugar dispatches (sales) are significant cost and revenue drivers, and managing them well reduces losses. The deliverables of loss control are significantly improved by the implementation of a LIMS security enhanced weighbridge. Some features of such a weighbridge are listed below.

- Short message service (SMS) and email functionalities on LIMS relay anomalies and/or suspicious activity at the weighbridge to relevant personnel for immediate intervention.
- Installation of security hardware incorporated into the software via PLC controllers to give controlled access to the weighbridge. This ensures physical restrictions to free movement on the weighbridge. Non-conforming transactions will lock booms, fail the weighbridge reading and immobilise the vehicle until the appropriate authority override is made.
- Installation of digital cameras and positioning beams enhances these measures.

The laboratory environment

Traditionally the laboratory has been the benefactor of LIMS installations, and their benefits are well documented (Taylor, 1984). The laboratory seldom uses analytical information, its main function being the provision of quality analytical results carried out on time. Samples analysed in the laboratory determine the quality of the various operational processes, and provide information to mill staff for efficient operation.

The mill environment

This is the traditional factory environment and is usually defined by confines of a perimeter fence and all the manufacturing processes are contained therein. It is the main beneficiary of LIMS data, as most information generated has a direct impact on operations. Information is required to ensure that set targets are met; these targets can be short term in nature and, with regards to throughput hourly, daily or weekly. To achieve targets, LIMS provides analytical results enabling decision making that enhances efficiency. These results include values for boiler water quality, process pH control and operational purity profiles up to and including the quality of sugar produced.

Management needs to monitor performance based on trends, and thus reports with averaged results for day, week, month and season to date figures are produced. Stoppage data and reports are used to make decisions pertaining to maintenance, service and replacement of equipment.

The financial environment

Few businesses have the luxury of large reserves of readily available resources. Shareholders and owners demand value for invested capital. This makes financial planning and foresight a necessity. The LIMS may facilitate this process by providing information on performance of operations that demand financial resources.

- Performance of growers on delivery volumes
- Cane quality and projected dues
- Transporter performance
- Revenue projections from weighbridge dispatches
- Packing efficiencies by capturing and monitoring materials used.

These improve decision making on resource allocation for operations, and payment of growers and transporters. The financial and milling budget processes are enhanced by utilising information available in LIMS, as an analysis of trends and historical data enables more accurate budget projections.

Benefits to the factory environment

The different operational personnel and management shown in Table 1 have specific benefits accumulated to their workplace. These benefits (King *et al.*, 1981) enable efficient execution of activities.

Table 1. Benefits to key personnel.

Job title	Factory environment	Activity	Key benefits accumulated
Grower	Agriculture	Cane growing and harvesting	Performance data per defined field or farm. Burn to grind delays and cane quality data.
Agricultural Manager	Agriculture	Cane growing, harvesting and transport	Field performance data with trends. Variety performance and comparisons. Transporter performance and vehicle delays/turnaround times. Grower allocation management.
Loss Control Manager	Loss control	Loss prevention	Manage activities related to weighbridge transactions both cane and sugar.
Weighbridge Operator	Laboratory	Data capture	Increased number of deliveries captured per unit time. Reduced errors and fraud.
Analyst/Tester	Laboratory	Analysis	Increased sample throughput. No manual calculations, increased accuracy of results.
Lab Manager	Laboratory	Analysis and reporting	Increased result accuracy. Reduced manual calculations and automatically generated reports (Taylor, 1984).
Shift Staff	Mill	Process control	Results available soon as tests are completed.
Process Manager	Mill	Process management	Improved process control. Reduced losses and enhanced quality of product.
Factory Manager	Mill	Factory management	Improved Factory performance. Improved plant utilisation statistics.
Financial Manager	Financial	Financial management	Projection of grower deliveries for payment. Accurate and real time revenue/sales data.
CEO, MD, GM	Corporate	Overall management	Information availability for reporting and decision making. Information reliability.

Integration with other systems

With LIMS being an integral part of a wide range of operations and disciplines, it integrates with other management systems (Figure 1). This brings new possibilities with regards to information generation and usage.

Grower systems

Growers that operate computerised systems (e.g. Cane-pro) can interface their systems such that all analytical results are automatically uploaded, providing a more comprehensive analysis of field performance.

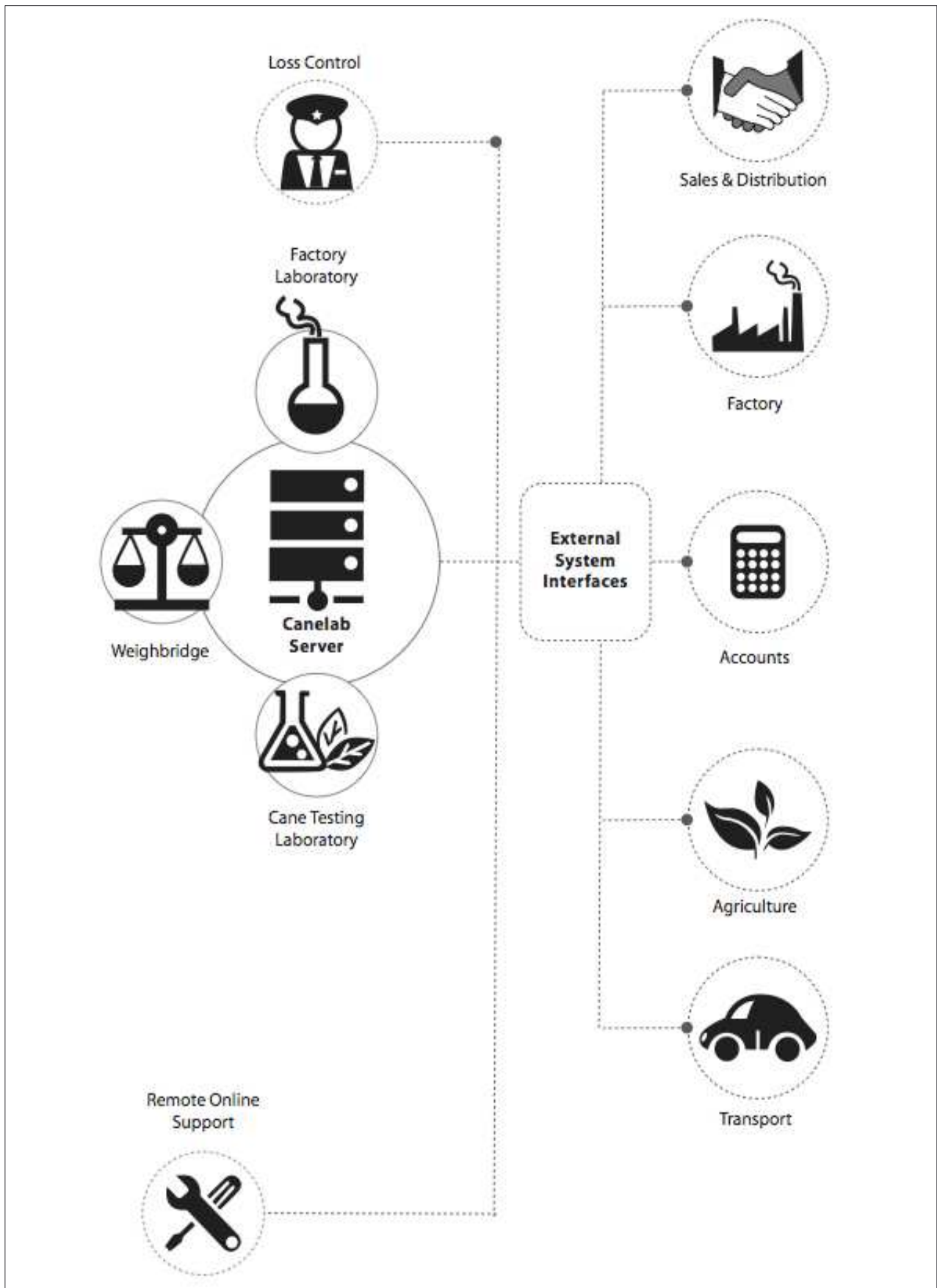


Figure 1. Functional diagram for LIMS interfaces.

Transporter systems

The interface assists in management of cane supply. Details captured at the weighbridge are uploaded into fleet management systems, providing an efficient means of data sharing.

Financial payment systems

The LIMS will upload cane quantity and quality data, having taken into account the appropriate payment rules. This allows for automatically generated cheques or electronic transfers to growers after subtraction of milling fees and other deductibles.

Sales and distribution systems

Interface with the weighbridge system ensures adequate management of sugar movement. Related securities are built in such that loading authority numbers and purchased masses generated in the sales system are validated against actual at the weighbridge.

Report generating and publishing

The most immediate and measurable benefit of a LIMS is the availability of information required to run the various aspects of the business.

- Primarily the system provides credible analytical services, commencing with the correct execution of analytical procedures and rigorous factory performance calculations. Results are available immediately after testing to those with access to the system.
- Report generation has been revolutionised by the development of reportable items and up to 100 000 different items can be reported on a daily basis. These can be reported on in many formats including Microsoft Excel, allowing user definable reporting and data manipulation to cater for the sugar production value chain.
- Multiple site data collation and reporting allow individual performance information from different sites to be collated and uploaded into a central database. This enables centralised assessment of performance by head office and technical personnel.

Implementation of new IT developments over the past 12 months

Production scales

Currently laboratory and process control systems data can be stored for further evaluation (Vogl *et al.*, 2000) by data management systems. Mass balance automation is still hampered by the unavailability of reliable on-line measuring and analytical equipment. Interfacing of production scales into LIMS is a step towards an automated on-line factory mass balance.

Transaction Imaging

Storing of database images against specific transactions is being employed with weighbridge data and massecuite crystal images.

Web Reporting

This enables real time database extraction and publishing of information. This will enable remote access of transaction and performance data.

Conclusions

Developments in IT have revolutionised computerised capabilities within the sugar industry with regards to networking, instrument or equipment connectivity, and system interfaces. These developments have been embraced, developed and incorporated into LIMS, making them an integral part of the sugar manufacturing business. The improvements in analytical accuracy, process optimisation and troubleshooting capabilities consequently attained give a competitive edge to LIMS users.

The ability to avail operational information on a real-time basis enables quicker decision making and increases organisational efficiency. LIMS aim to have automated on-line mass balance capabilities and current developments draw closer to that goal. New features highlighted indicate continued advances in data collation and information publishing.

Developments in LIMS have transformed such systems from purely laboratory management systems to a comprehensive information source for the whole organisation. The ability to adopt technological advances in instrumentation, and computer hardware and software has improved the functionality and efficiency of LIMS.

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