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SELECTING LABORATORY INSTRUMENTS

As a young salesman, I usually got involved in buying fairly late in the selection process. Most often I began with a sales call when a potential customer responded to an interest card in a technical magazine, asked our company for a pricing quotation, or received a referral by a colleague.

I have talked to new customers after their system was purchased and installed, asking them how they determined exactly what type of equipment they needed for their laboratory to allow me to get involved earlier in the selection process. The success of my business depends on getting involved in the selection process as *early* as possible.

I found that the need for a particular laboratory instrument usually grows out of the design of an analytical protocol. An apparatus is needed to assay the completeness of a reaction's conversion and separate the components produced, achieve a desired compound purification, or analyze and identify a compound. A particular instrument is selected by (1) reproducing equipment used in similar separations in the customer's laboratory, (2) selecting a system recommended in a technical article or in a piece of literature, or (3) buying one recommended by a colleague doing a similar investigation. Some institutions had an individual well versed in a variety of laboratory instruments who acted as an in-house expert consultant to facilitate equipment-buying decisions.

Buying and Selling Laboratory Instruments: A Practical Consulting Guide.
By Marvin C. McMaster

Customers generally know what the equipment needs to accomplish. What they often do not know is exactly what a particular system can do, how to use it, and how well it matches their requirements. Customers want the system to solve their research problems at a reasonable cost; they do not want the equipment to turn into a research project that will consume the laboratory's time and resources.

Sales literature and sale representatives can and should offer an education on the instrument's features and how they may benefit the customer's research. Someone will need to sort through all the features/benefits to see if any of them will be useful to the laboratory now or in the future. A research project's need for a laboratory instrument usually begins with someone reading an article in a technical journal, either during normal reading or in a library search. It may also be triggered by an equipment display, a presentation, or a poster session at a technical meeting. Technical articles usually list the equipment and conditions used for a separation or an analysis. Some laboratories will simply buy a duplicate of that equipment, but usually these articles are simply guides suggesting the type of equipment needed for the work. The laboratory specialist in charge of selecting or recommending equipment will contact major manufacturers for literature on the specific instrument of interest. This will provide prices, features, and specifications to guide the specialist in making buying decisions and bidding specifications. This type of contact will also probably trigger a number of sales calls from other company representatives offering to help link features to benefits for the research and to sell the customer their instruments.

I am often asked why a researcher will usually buy from a major manufacturer rather than from one of many other companies that sell similar but less expensive hardware. My answer in the past, when I worked for major manufacturers, was that these companies became major manufacturers because they made the investment in time and money to do research, provide quality control, and offer a more complete package of hardware, service, and support. Responsive, knowledgeable, preferably local warranty service representatives from vendors are very important in keeping instruments up and running and fixing them when things go wrong, as they often can. Vendor-provided technical support laboratories and training schools offered by the major manufacturers can educate the instrument users about your laboratory and help keep your instrument from becoming a research project. This is especially true when the laboratory is unfamiliar with the type of instrument and its capabilities.

Smaller vendors lack the investment money to make this kind of commitment to help the customer succeed. They offer the hardware and expect the customer to handle the rest After an instrument becomes more generic or a commodity type and third parties or an in-house service department can repair it, it becomes safer to consider smaller companies as suppliers. These companies make sales by offering lower prices, lowering manufacturing specifications and quality control standards, and making their profit on volume sales.

For the customer, getting expert advice as early in the sale as possible is important in ensuring a successful instrument purchase. An alternative to the literature search is to go to a colleague's laboratory, explain your research project, and ask what equipment this person would recommend and from what source. This approach has been so successful that some large companies support a technical guru. This individual is usually an early adopter of this type of equipment who has made a strong effort to develop considerable expertise in selecting and using the instruments for his or her investigations. The guru is usually a tinkerer who has done research, has optimized his or her equipment, and knows how to apply it in a number of applications. Gurus know the players in the field, both in manufacturing and in research environments, and can help you determine the best instrument for your research problem.

Identifying this guru is very important for purchasing success, both for the prospective customer and for the sales representative. Nothing makes a customer more comfortable with a buying decision than the approval of a local technical guru. Listen to his or her advice; it is usually the fastest way to figure out exactly what you really need.

If you don't have access to such an individual, you may be able to get good advice from an outside consultant, a local university guru, or a technical sales representative. Consultants will obviously cost more but will be more objective if their information is current. Local university gurus may only be able to offer you theoretical information on the instrument, and if they have laboratory experience, it may only involve older equipment. Sales representatives obviously have a commitment to their employer, but they usually have access to current equipment and training. If they have actual laboratory experience of their own, they may be able to understand the research you are doing and be willing to act as an unpaid consultant for applying the instrument to the research. Take time to find out the representative's background.

Things change fairly rapidly in the technical instrument field. A manufacturer who led the field in innovation five years ago may have run into hard times, especially in this age of corporate takeovers and buyouts. Talk to the people in your company or in nearby universities who have recently purchased this type of equipment about the type of service and support they have received recently from the manufacturer you are considering. Get referrals to other users from your guru, consultant, or sales representative and call them to ascertain their level of satisfaction.

Very few laboratories, except those in cost-per-test facilities, such as environmental laboratories, can dedicate a piece of equipment solely to the application for which it was purchased. Things change as your research advances. If you are working in a cost-per-test laboratory, you will want to buy the most rugged, least expensive, simplest-to-operate instrument, work it to death, and then replace it with a similar instrument. Most laboratories need more flexible and therefore more complex and expensive systems. These can be reconfigured and used for a variety of applications. They often can be used for methods development application scouting to develop new uses for your instrument. These do-it-all systems are the lead instrument in the manufacturer's catalog, but often they cost as much as two simpler instruments that could each be applied to different applications.

Only the person who understands the research laboratory's goals and budget can make an intelligent decision on which instrument type provides the laboratory with the most bang for its buck. Ten years from now, you probably will not remember the cost of the flexible instrument that could handle many jobs, but you will always remember the cost of the simpler one that could not do enough.

There is always a decision to make when buying analytical equipment: (1) buy everything in one box or (2) buy a modular system. The system-in-a-box is usually cheaper, has a smaller footprint on the laboratory bench, and often comes as a complete solution for your current laboratory problem. Modular systems sprawl all over the laboratory bench, but they offer flexibility for expansion, component upgrades, and reconfiguration. They can be organized in a component rack, but they will always appear more incomplete and usually be more expensive than a system-in-a-box.

1.1 MODULAR SYSTEMS

Research systems are almost always modular in nature. When you buy a research system, you know your immediate needs, but you must plan for changes of direction that may occur and for new projects. You buy the state-of-the-art system because of its cost and appearance, but you are aware that instruments evolve and improve almost daily, especially in detector and computer technology.

Using high-performance liquid chromatography (HPLC) as an example, a typical research system might use two pumps, a computer-based gradient controller, a manual injector, and a variable-wavelength ultraviolet (UV) detector with data acquisition and processing done by a board inside the system-controller computer. Another configuration may involve a single-pump system using a controller-operated solvent-switching valve to provide programmable on-line access to three or four solvents for solvent gradients and column washout. Most system-in-a-box HPLCs will use the latter type of pumping system.

As your research progresses, you may need to add a secondary detector such as a coronal-charged aerosol detector (CAD) to analyze for phospholipids at a sensitivity significantly below what can be determined at 209 nm on the UV detector. If you bought the all-in-one system, you may find that the only place you can put the new detector is on top of or beside the box, like a lean-to addition.

Evolution does not always eliminate the need for older systems. Two-pump systems generally provide more reproducible gradients than a switching-valve system. Once you have worked out the solvent composition for a couple of separations, you may separate the two-pump gradient into two parallel isocratic systems by adding another detector and a second injector or an autosampler to automate one of the separations. The variable UV system may not be sufficiently sensitive or provide a definitive identification, so you may choose to add an in-line mass spectrometric detector with its own computer-based controller and data processor. This will provide the needed definitive identification and extend the laboratory's capability.

All of this will involve an increase in price, laboratory bench confusion, and the need for expertise and training. It is usually easier to justify the purchase of additional equipment for an existing system based on changing research needs than a brand new system. System-organizing racks can be purchased as the system is extended to control the bench-littering problem. When stacking mixed liquid-handling and electronic components, it is important to remember to keep the liquid-handling components such as pumps, injectors, and detectors below the electronic components. Liquids tend to leak, and electronic components such as computers are not always sealed against such leaks.

1.2 SYSTEMS-IN-A-BOX

Buying a system-in-a-box works very well in a cost-per-test laboratory with well-developed methodology. These systems are often sold as a turnkey system, including proven methodology protocols and all the supplies needed to turn the system on and run the first analysis. They may be sold as a system for a specific analysis, such as a carbohydrate analyzer, complete with step-by-step analysis protocols and everything needed for the initial analysis. They include consumable components, such as HPLC columns, filters, and solvents, that have to be replaced periodically, but they are generally very cost effecive. Cost-per-test laboratories require systems with automated components such as autosamples and a robotic sample preparation system to increase sampling accuracy, allowing around-the-clock operation, and decrease the need for operator intervention.

The problem with this type of system occurs when service is required or changes need to be made. The component requiring service is usually not accessible without tearing everything out of the box. Reassembly after repair must be carefully checked to ensure a return to smooth operation. Systems-in-a-box usually share common power supplies and a computer as the controller; when something happens, everything in the box is affected and out of operation. The system-in-a-box is difficult or expensive to retrofit with the latest technology if a technology leap occurs, and it is often left behind unless it simply needs a software upgrade. New components such as new detectors may not fit in the box.

It is usually more profitable for a manufacturer to sell you a new box rather than upgrade the old one. You are left with an old box filled with old technology, and you will need an operator to run outdated technology. This happened often with gas chromatography/mass spectrometry (GC/MS) systems equipped with mini-computer controllers. Operators were expensive to train and maintain, and the laboratory filled up with archived data stored on a variety of old computers. Many environmental laboratories have a graveyard of archived obsolete data systems that might be called on sometime in the future to produce information for a legal defense.

Cost-per-test laboratories operating on a three-shift, 24-hour day will often dedicate a system-in-a-box for a particular analysis to prevent sample cross-contamination. They can quickly justify the system's cost based on the analysis fees produced and will buy a new system-in-a-box if they add a new analysis to their portfolio or if a system needs to be replaced. If they do their own methods development, they probably have a modular component system somewhere in the laboratory for the development work and for problem troubleshooting.

1.3 AUTOMATION

Automated components are expensive, and there is always the question of whether automating the system is worth the cost or whether the money could be better spent elsewhere. University laboratories usually prefer to use graduate students to automate their equipment. Cost-per-test laboratories prefer adding computerized hardware automation allowing them to run minimally attended equipment around the clock and recover the expense of automation out of the increased profitability. Most environmental laboratories estimate that they can recover the cost of any level of automation within three to six months.

Automation can be added at the front end of a system in sample preparation and sample handling, such as in-line sample extraction, filtration, chromatography stations, and autosamplers. Total system controllers can integrate run start signals and valve openings. Back-end automation usually involves decision-aiding software to provide detector signal peak identification, data processing, compound identification, and report generation. Next-higher-system integration occurs when you move beyond automation of a single system to controlling data production from multiple systems of the same type from a single computer. The final automation integration is the laboratory instrument management system (LIMS) computer that pulls together instrument data, wet chemistry results, and typed-in sample data to produce a completed sample report for customers and for archival storage.

Computerized robotic sample treatment systems are programmable stations that can dilute, filter, extract, run simple chromatography with cartridge columns, and inject sample solutions into chromatography systems for analysis. Autosamplers are programmable injectors that hold sample solutions in vials until they are needed for injection. These autosamplers can also be programmed to periodically inject a series of standards used for sample concentration quantitization and automatically start the chromatography system components. They benefit a laboratory by replacing much labor-intensive sample handling and avoid errors occurring during repetitive manual workups.

Simple data processing automation systems perform peak detection on the detector's signal, identify peaks based on retention times, and generate a peak identification table based on signal strength versus retention times. The next level of data automation involves doing quantization calculations by comparison to signals from concentration standards and generating calibration and sample concentration reports. At the final level of data processing, the system will perform definitive compound identification from mass spectral data and produce a compound quantization and identification report.

The rule of thumb for automation is that the more complex it is, the more it will cost and the more things that can go wrong. It will always require human inspection and possible intervention. Although it generally can run unattended, if an error occurs it can rapidly generate large quantities of useless data. With sufficient use of internal standards, blanks, and surrogate compounds, it is sometimes possible to adjust and rescue a portion of the erroneous data.

1.4 DATA ARCHIVAL AND RECOVERY

Data sets are of little use unless they can be retrieved when needed. Data reports can be stored in easily recovered word processing formats, but there are times when the raw data are required as proof of analysis or for repeating a calculation or recalculation based on new standards or assumptions.

Data are usually stored in proprietary meta-files that vary widely from manufacturer to manufacturer and sometimes among various generations of machines from the same manufacturer. Public analysis laboratories are called on occasionally to defend their data in court. University research data can sometimes be challenged in the literature and require a defense.

Over the years, translation software has been written to allow popular proprietary formats to be translated into modern data formats that allow recalculation. The majority of raw data produced will never be needed for defense, so it makes no sense to translate all the archived data of a firm. Many laboratories employ storage rooms for old data systems that allow retrieval of data from long-dead and discarded systems. This is usually successful until the storage hard drive dies or the previous operator departs.

There have been attempts over the years to build a common data format (CDF) in which all chromatography data could be generated or into which the data could be translated. This CDF format was created, but it never became popular because manufacturers wanted to maintain proprietary formats to block future system sales to their competitors. For marketing purposes, it is easier to control a laboratory's purchases if the new, competitive system does not speak the same language as the laboratory's older systems. It was hoped that the introduction of the data integration LIMS systems would end this practice, but LIMS primarily accumulates and processes word processing types of reports and information.