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Successfully Implement a Reliability Program

Avoid eight common pitfalls that can lead to failure

By Adam Grahn, Deloitte Canada

The purpose of a reliability program is to ensure that a plant's physical assets can meet production goals at the lowest possible unit cost while mitigating safety and environmental risks. Such a program requires ongoing assessment, testing and performance reporting. It should become embedded into the culture of the plant as just "part of the way work is done."

Any information and measures must be used to assess the financial, environmental and operational impact of the plant's assets, and consequently to bolster the bottom line of the organization in a cycle of continuous improvement.

A reliability program will ensure the "hidden capacity" of a plant is uncovered and exploited for maximum operating effectiveness at the lowest marginal cost. This is especially true as the age of a facility begins to take a toll and equipment approaches (or exceeds) its expected useful life, as is so often the case in the chemical industry.

Unfortunately, implementation of a reliability program isn't without pitfalls. Missteps can seriously derail successfully implementing the program and sour plant leadership and frontline staff on any future attempts. So, it's critical that a reliability program is implemented correctly the first time.

WHY DOES RELIABILITY MATTER?

Put simply, from a cost/benefit perspective a business-focused and technically based reliability program arguably is the most economically feasible and successful method for delivering a strong return on assets. Reliability is the grease that lubricates a plant's ability to "do more with less," which is the economic reality that many chemical processing facilities face.

A well-functioning reliability program ensures a plant is positioned to take advantage of market changes that can make a particular chemical more (or less) profitable almost overnight. Moreover, as a plant's asset base begins to degrade and long-range capital budgets are slashed, applying reliability principles aimed at getting the most out of the existing assets and extending their life while simultaneously managing new capital assets properly is imperative.

At its root, a well-designed maintenance and reliability program will:

- identify and quantify high-risk assets to allow for prioritization of maintenance, operations and new capital efforts;
- pinpoint and mitigate known causes of failure so equipment functions to its intended design requirements;
- reduce susceptibility to catastrophic events;
- optimize maintenance and operating costs;
- ensure spare parts are on hand when needed… and aren't when they're not;
- defer capital and extend asset life;
- make certain new assets are adequately cared for and available to operate for their entire expected life; and
- promote building a culture of asset care and continuous improvement into the workforce.

CAUSES OF FAILURE

Unfortunately, despite the strong business case and clear benefits of implementing business-focused technically based maintenance and reliability programs, such programs often fail to deliver on their promise at a chemical plant. Let's look at eight typical reasons for this:

1. Lack of leadership support. An informal survey pointed to this as the most common cause of failure. In essence, it usually stems from:

- absence of a well-defined business case to identify the benefits of implementing the program;
- poor communication of the scale and impact of implementing a reliability program on the rest of the organization; and
- senior management viewing maintenance and reliability as a cost center.

What to do: Engage leadership early and build a business case that clearly outlines the benefits to your organization based on your specific chemical and plant configuration. Ensure the business case is presented in the language of your senior management and is aligned with its vision. Don't shy away from critical issues of cost and risk — and build out a clear roadmap that indicates when financial benefits should be expected and how they will be measured.

2. Poor application of risk-based thinking. One of the first steps to building a reliability program is to identify a plant's assets and evaluate their criticality and risk in a structured way. Too often, chemical manufacturers neglect to undertake this important activity or misapply the logic, leading to devoting significant effort to assets that present low risk to the organization's goals or, conversely, contribute little to its profitability.

What to do: Make certain a clear and consistent risk matrix is used across the production asset base. Ensure the organization correctly applies the outcomes of the risk evaluation to scheduling maintenance work, evaluating capital projects, performing reliability-centered-maintenance-type analyses, and everything in between.

3. Failing to treat the effort as a program. Too many chemical manufacturers regard a reliability improvement initiative as a one-time project rather than as an ongoing program. This inevitably undermines sustainment of the effort and leads to poor implementation of the outcomes of the development work.

What to do: Build a sustainment plan from the outset. Ensure the key performance indicators selected to monitor the program are both project-based (schedule, budget, etc.) as well as performance-based (availability, cost per unit produced, etc.). Also, make sure there's a clear mandate for change management and sustainment support and appropriate budget allocated to that effort.

4. Wrong choice of people. Many organizations tend to view reliability as "extra work." So, they assign people to the program based on convenience as opposed to skills — often picking people on "light duty" to support a program at its launch.

What to do: Get the key technical and leadership people "into the tent" from the beginning of the project. Don't settle for "Special Project Bob."

5. Infatuation with software. In many cases, people become transfixed by the software tools and the tools quickly turn into the focal point for the initiative. While software tools are important, my experience clearly shows that process, practice and people are the most crucial elements for success.

What to do: Build and implement business processes and drive tool selection based on the process that will work for your organization. Effectively put the horse before the cart.

6. No short-term wins. People often begin a reliability program implementation with the best of intent. However, they quickly become overwhelmed by the size and scale of the activity.

This often can be seen when there's a short-term high level of investment but support for the project quickly evaporates when meaningful improvements to equipment performance and cost measures don't appear in the first few months of the program.

What to do: It is critical that early efforts show tangible and meaningful wins that can be (and are) communicated throughout the organization.

7. Inattention to change and integration. Many chemical makers will devote significant technical resources to a reliability initiative — but with little regard to the impact of the program on the "day to day" lives of their people. This causes fear and distrust of the program and often a passive-aggressive attitude that inevitably will cause the program to fail.

What to do: Put dedicated resources and budget to tackle the change and cultural development aspects of the program. Ensure these resources aren't just about holding hands and singing "Kumbaya" but have a well-defined and structured approach to leading the change elements.

8. Death by training. Armed with the best of intentions, many organizations will look at the reliability program particularly as a means for addressing a lack of knowledge within their technical group. In such cases, the companies will engage industry experts to train a specific subset of their people. They do this with little regard for the organization at large and a lack of appreciation of the substantial effort required for developing and implementing a reliability program. This leaves the organization susceptible to employee attrition. It also leads to significant effort and budget spent on formal training — with little attention to coaching, auditing, implementation, etc., that will ensure the training is put to good use.

What to do: Look at training (especially formal classroom training) as a supplemental method for ensuring knowledge transfer. However, make sure the expectations are reasonable, and the trainees are capable of delivering the outcomes expected of them.

ACHIEVE SUCCESS

While the business case that supports implementing a reliability program is strong from a profit, safety and environmental stewardship perspective, many factors can cause failure of the program. Despite these challenges, if an organization develops a practical and robust strategy, trains its employees to embrace a proactive culture toward reliability, and gets real commitment from its leadership team, then it's likely to achieve impressive business results from its reliability program.

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Motor Maintenance Trifecta Pays Off

Quality control, trending and troubleshooting increase reliability and reduce maintenance headaches

By Noah Bethel, PdMA Corp.

The odds are against picking the first-place winner of a horse race. The odds of picking the first-, second-, and third-place winners are even less favorable, but when it happens the trifecta payday is big! In the world of horseracing, guessing the winners is pretty much a gamble. But imagine if gamblers knew in advance the trifecta of the race. It would be a no-brainer, and they would put everything they had on the race knowing they would see huge returns on the investment.

Using the same concept of a trifecta (three factors for success), the winning strategies of motor maintenance focus on the three reliability tasks for electric motor testing and the order in which they should be applied. Following these steps will improve a company's odds in motor reliability and result in a big production goal payday.

ELECTRIC MOTORS

A basic understanding of electric motor construction is essential before discussing the trifecta of motor maintenance. Commonly, an AC electric motor is a component of a fan, pump or larger piece of equipment such as a mixer, conveyor or winder. Electric motors have three main parts: the rotor, the stator and the enclosure. The rotor and stator are the motor's working parts. The enclosure serves to protect these working parts.

The stator is the part that doesn't move. Its core is made of thin laminations of metal. These laminations are arranged in a hollow cylinder into which coils of insulated wire are placed. The rotor, as the name

> Just because the motor worked when delivered doesn't guarantee that problems won't develop as the motor sits idle over time.

suggests, is the rotating piece in the motor. It also is made of thin metal laminations to form a cylinder, and a shaft is inserted into its center. The rotor is inserted inside the stator, but a small air gap ensures they do not touch. The enclosure holds the stator and rotor assembly. A yoke supports the stator and rotor assembly, while bearings mounted on the rotor shaft allow the rotor to spin. A cooling fan also may be attached.

Electric motors work on the basic principle of electromagnetism. When an electric current is passed through the insulated wire windings in the stator, it creates a rotating magnetic field. The magnetic rotor, working on the principal that opposite electric charges attract, spins as the electric field moves and pulls the rotor's south pole toward the field's north pole (and the rotor's north pole toward the field's south pole). This in turn spins the shaft, which allows work to be done, whether the shaft is connected to a pump, conveyor or other piece of equipment.

TRIFECTA PART ONE: QUALITY CONTROL

The first piece of the motor maintenance trifecta is quality control (QC). QC is a general term that impacts a variety of people, assets, times and locations. It's both the asset being maintained and the environment in which it's stored. Companies should ask several questions regarding their motors from delivery to installation.

First, is the motor tested when it's delivered, or do the employees in charge of receiving the equipment assume that all is well? Assuming the motor works as specified, a second consideration is how the motor is stored. Is the environment suitable in terms of temperature, humidity, protection from the elements and easy accessibility? Third, the motor should be tested intermittently during storage. Just because the motor worked when delivered does not guarantee that problems won't develop as the motor sits idle over time.

Additionally, motors should be installed in an overall system that is quality controlled. The electrical distribution system is a vital component. For example, a voltage imbalance of 5–10% can cut motor life in half. In this situation, replacing a motor isn't solving a problem. Rather, it's starting the failure cycle again. This leads to the old adage cited by veteran employees in work environments without adequate QC: "Let the new guy start it."

TRIFECTA PART TWO: TRENDING

Once a motor is in place and operating, it's not a good practice to leave well enough alone and assume there are no problems if everything seems to be running smoothly. While many motor failures are mechanical, nearly half are electrical. Up to 41% of motor failures are caused by bearings and 12% by "other" problems, while a whopping 47% of failures are caused by rotors (10%) and stators (37%).

Data collection is the key to preventing these failures. Machine operators often call a repair company with just one data point. Trending is a term that refers to taking data points on a regular basis, so that potential problems can be identified well in advance, and a detailed history of the problems can be assembled.

What types of trending data should be gathered, and how often? When it comes to data collecting, "trend is your friend." Using software and testing equipment that can analyze both dynamic and static data, a detailed history can be obtained for a motor that shows potential problems before a catastrophic failure occurs. Six fault zones should be analyzed regularly to obtain trending data:

1. *Power Quality*. Power quality relates to the quality of the voltage (which is determined by the power system) and the quality of the current (which is determined by the load). Factors that can be analyzed include low or high voltage, harmonic voltage factor, crest factor and total harmonic distortion for both the voltage and current.
2. *Power Circuit*. The power circuit fault zone contains everything from the test point down to the motor, including things such as circuit breakers, fuses and disconnects. Measurements of voltage imbalance and resistive imbalance can be taken to analyze the power circuit fault zone.
3. *Insulation.* This can be affected by old age, moisture, temperature, vibration and other factors. In the insulation fault zone, appropriate hardware and software can measure resistance-to-ground, capacitance-to-ground, polarization index and step voltage.
4. *Stator*. In the stator fault zone, inductive and impedance imbalances are measured to indicate the health of the insulation between the turns of wire in the stator coils.
5. *Rotor*. Current signature analysis (CSA), in-rush current, inductive imbalance and a rotor influence check (RIC) test are performed in the rotor fault zone.
6. *Air Gap*. In the air gap fault zone, CSA and RIC tests determines levels of static eccentricity and dynamic eccentricity in the shaft.

Quarterly or semi-annual trends are much more valuable than tests performed at random intervals.

How often these tests are performed will depend on the type of motor being used; the frequency, intensity and duration of use; and the company's seasonal production patterns. Another factor may be the environment in which the motor is run. Whatever the interval, consistency is the key. Quarterly or semi-annual trends may be much more valuable than tests performed at random intervals or whenever the staff remembers to have the data collected.

TRIFECTA PART THREE: TROUBLESHOOTING

All motors have a limited lifespan. Eventually, a motor will fail. What happens at this point depends on whether the company has been diligent with Parts One and Two of the trifecta: quality control and trending. If so, the third part of the trifecta, troubleshooting, will be much easier. Troubleshooting refers to what happens when a motor fails or performs poorly enough that it causes a problem.

A good example is the case of the local coal mine that experienced trouble with a wound rotor motor on a Saturday. The local electrical company was dispatched to the mine, where production had ground to a halt and dollars had begun to bleed from the operation. This motor type generally couldn't be fixed in the field, but the mining company had the foresight to have a spare motor on hand. By Monday afternoon, a crane was in place to swap the motors; by midnight, the new motor was installed and ready to start.

The miners waited with bated breath as the start button was pressed, and...a growl and a blown $1,000 fuse resulted. Adjustments were made, and another $1,000 fuse blew. By 4:30 in the morning on Tuesday, the third $1,000 fuse blew. At 7 pm Tuesday — more than four days after the initial failure — the electrical company prepared to remove the spare motor and take it to the shop for inspection. However, someone had the idea to use electric motor testing equipment and software to identify the problem. On Wednesday morning, testing revealed that two leads were reversed. The problem was fixed quickly and the spare motor started.

Needless to say, this scenario could have been avoided had the three parts of the trifecta been in place. QC would have detected faulty wiring in the spare motor at delivery or while in storage, trending would have identified problems in the original motor before it failed, and troubleshooting — what to do when a problem arises — would have saved the miners five days of downtime.

When it comes to troubleshooting, the first key is having written instructions, in a manual, that spell out the company's policies on motor failures. This includes employee training. Second, the policy should require that the job site have the technology available to assist in diagnosing the problem. If the miners and the electric company had used the electric motor testing equipment on Monday morning, down time on Tuesday and Wednesday would have been avoided. The plan also should stipulate calling in outside experts when the scope of a problem exceeds the training or knowledge of the employees.

MANAGEMENT AND PREDICTIVE MAINTENANCE

For example, studies show that industrial rotating machinery failures cost $17 per hp of the motor per year for companies practicing only reactive maintenance — in other words, if it breaks, fix it. Compare that with $12 per hp for companies practicing preventive maintenance (regular maintenance without the benefit of data) and $8 per hp for companies using predictive maintenance.

The maintenance trifecta is the very essence of predictive maintenance: using QC and regularly collected data to fend off and forecast problems before catastrophic failures occur. And the impact on the bottom line? Repair costs reduced by more than 50% over companies with a "close our eyes and hope it turns out okay" approach.

Predictive maintenance saves money in other ways, too. With predictive maintenance, there are fewer unexpected motor failures and less need to keep extra motors and parts on hand, resulting in less costly inventory and need for storage space. And repairs and maintenance can be scheduled during the company's slow periods — not at peak production on a Saturday.

WINNING THE TRIFECTA

All business involves risk. Some risk, such as entrepreneurial risk, is beyond anyone's control. But other types of risk can be alleviated and mitigated with best practices. By putting their money on the trifecta of motor maintenance — quality control, trending and troubleshooting — companies can hedge their bets and increase their chances of a big payday.

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Seven Trends Help Deliver Improved Reliability

Ranging from physical to virtual, these practices help boost plant efficiency

By Justin Kadis, Federal Equipment Co.

While greater efficiency and productivity always will be goals in manufacturing, demand is increasing to optimize processes in chemical manufacturing, including better equipment reliability. A general lack of growth in the industry — with the rare exception of certain specialty areas and new materials — is forcing manufacturers to look beyond volume to drive growth. Manufacturers looking to increase efficiency and reduce costs must be open to new approaches to process development and associated equipment, engineering and business models.

NEW TECHNOLOGIES

Chemical manufacturers, particularly those working in the specialty chemicals segment, traditionally have sought to develop most processing and production technologies in-house. However, a recent shift has been seen among major manufacturers to instead seek technologies created by smaller, innovative developers. Technology developers can assist manufacturers from feasibility studies and pilot testing through extensive process development, reducing the risks and complications that have made companies resistant to adopting new, external technologies.

CONTINUOUS PROCESSING

Chemical manufacturing companies increasingly are using modularized continuous-flow process approaches to overcome the disadvantages of batch processing and reduce the development time from initial idea to commercialization. Continuous processing approaches offer a suite of advantages

A more reliable approach involves constructing plants from preconfigured standard modules.

over traditional batch processes: reduced process cycle times, lower operating costs, smaller equipment and facilities, reduced ecological footprints and greater and simplified quality control.

In continuous chemical processing, the products of one reaction flow directly into the next in small-volume pipes, allowing for reactions not feasible in batch processing, such as reactions that are highly exothermic, have high kinetics, are driven by UV impulses or require tight control of temperature or pH. Adopting continuous processing approaches not only promises to increase efficiency and reduce cost but also can potentially open up new fields in industrial chemistry.

MODULAR PLANT SYSTEMS

Fully realizing the potential of continuous manufacturing requires restructuring entire production facilities. However, the higher outputs typically needed in the specialty chemicals industry may not be best served by the microstructured reaction systems being adopted in other industries, such as pharma and biopharma.

A better, more reliable, approach seems to involve constructing plants from preconfigured standard modules, which themselves are constructed from individual components that are integrated and multiscalable. Taking a modular approach to manufacturing laboratory equipment can simplify scale-up by guiding the design of the final production facility along the same modular principles, allowing for concurrent planning and engineering of production at different scales. The modular approach to process engineering can result in increased efficiency and reduced time to market.

QUALITY BY DESIGN

Another reliability trend already in wide use in many manufacturing industries, including the chemicals industry, is the concept of quality by design (QbD). QbD is a systematic approach to development that emphasizes predefined objectives, understanding and control of processes and quality risk management within a framework of defined science to optimize process quality and, ultimately, the supply of product to the customer.

Adopting a QbD approach to process development can provide a better understanding of the process with more effective control of further changes and development, less batch failure and higher return on investment (ROI) or cost savings and may further create opportunities for more flexible regulatory approaches.

DIGITIZATION

Digitization has the potential to transform the chemical industry in areas as diverse as reliability efforts, development, manufacturing, corporate decision-making and customer service. In terms of process and development and reliability improvements, companies are increasingly collecting and integrating data from cyber-physical sensor systems throughout manufacturing processes.

Improving the integrity of all data collected throughout the manufacturing process will have a significant impact on the utility and effectiveness of analytics and all possible applications of that data. Machine learning and artificial intelligence technologies are taking advantage of this wealth of data to make and execute decentralized decisions with minimal input from human operators.

AUTOMATION

The increasing embrace of digitization additionally is creating new possibilities for automation in manufacturing processes. The synthesis of the two approaches to process development enables the construction of a physical–digital–physical cycle in which automated sensors capture real-time data during production processes, data analysis and digital decision-making occur rapidly, and those decisions are carried out directly through automated process equipment. The resulting "smart factories" can offer benefits in terms of improved reliability, transparency, efficiency and cost savings.

GROWING USED EQUIPMENT MARKET

As manufacturers look for new ways to increase productivity while optimizing efficiency and reducing costs, equipment needs are changing across the supply chain. The markets for purchasing reliable used equipment and for selling surplus equipment are expanding.

One driver for this trend, across many manufacturing industries, is increased industry consolidation, which has added to the importance of resource recovery for redundant equipment. High-quality used equipment often can be obtained at 40–50% of the original cost, sometimes as low as 20%. Another significant advantage of used processing equipment is that it typically is available immediately, reducing lead times and promoting efficiency.

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Safely Use Mobile Devices

Understanding ignition sources and levels of device protection are crucial to eliminating risk

By Justin Olivier, Pepperl+Fuchs, Inc.

Mobile devices can solve many challenges in hazardous industrial environments — from monitoring lone workers to enabling predictive maintenance to streamlining field support (Figure 1). But a device that lacks the proper protection could seriously compromise the safety of your plant and personnel. Even something as simple as a hot surface on an unprotected device can have disastrous consequences.

HAZARDOUS ENVIRONMENTS
Figure 1. Mobile devices solve a variety of challenges in hazardous areas.

IGNITION SOURCES

Ignition sources are possible even when unprotected mobile devices are turned off, including:

- A battery short circuit in an unprotected device
- A loose battery in an unprotected device

SAFE MOBILE DEVICES
Figure 2. Intrinsically safe mobile devices ensure potential ignition sources are removed or prevented.

- Electrostatic discharge — for instance, from pulling an unprotected device out of a holster

Other typical ignition sources include:

- Hot surfaces and open flames
- Electrical arcs and sparks
- Lightning
- Mechanical friction or impact sparks
- Electromagnetic and optical radiation — i.e., from radios or barcode scanners in an unprotected device

Intrinsically safe mobile devices ensure that these potential ignition sources are removed or prevented (Figure 2). But to eliminate the risk of explosion, it is not enough to select just any protected device.

ZONE/DIV. 1 AND ZONE/DIV. 2 TESTING

Zone/Div. 2 devices are tested only for the above-listed ignition sources under normal conditions — not if the device develops a fault. Zone/Div. 1 devices, on the other hand, are tested in both normal and fault conditions.

Further, the batteries in Zone/Div. 2 devices are not tested for temperature increase under short-circuit conditions. Only Zone/Div. 1 devices ensure that temperatures remain low enough to prevent an ignition. In short, Zone/Div. 1 devices are subjected to more stringent tests under both normal and fault conditions.

Answer the questions in Table 1 to help determine whether the smartphones,

ELIMINATE RISK

Table 1. Asking the following questions can help determine whether the mobile devices in your plant are putting personnel, assets and the environment at risk. Note: This information is intended for educational purposes only.

QUESTION	RESPONSE	RISK LEVEL
Are you using Zone/Div. 2 devices in Zone/Div. 1 areas?	**Yes**	**High**
Are you carrying switched-off Zone/Div. 2 devices through Zone/Div. 1 areas?	**Yes**	**High**
Does your Zone/Div. 2 device protect against, and has it been tested for, all typical ignition sources?	**No**	**High**
Will your Zone/Div. 2 device be used for multiple applications in the future, in both Zone/Div. 1 and Zone/Div. 2 areas?	**No**	**High**
If your Zone/Div. 2 device develops a fault, is it protected from causing a fire or explosion? (Look for markings such as Ex ic, UL 913, FM2610, or CSA 157.)	**No**	**High**
Are Zone/Div. 2 and Zone/Div. 1 areas clearly marked in your plant? Do mobile workers know when they are in a Zone/Div. 1 area?	**No**	**High**
Does your insurance liability cover incidents caused by Zone/Div. 2 devices found in Zone/Div. 1 areas?	**No**	**High**

tablets, scanners and other mobile devices in your plant are putting personnel, assets and the environment at risk.

ELIMINATE RISK

Using the wrong mobile device creates an enormous amount of risk. To eliminate risk, follow these basic steps:

- Use the correctly certified and marked devices in hazardous areas.
- Select manufacturers with a proven track record of delivering mobile devices for use in hazardous areas.
- Do not compromise on safety. Always consult safety and certification specialists. ●

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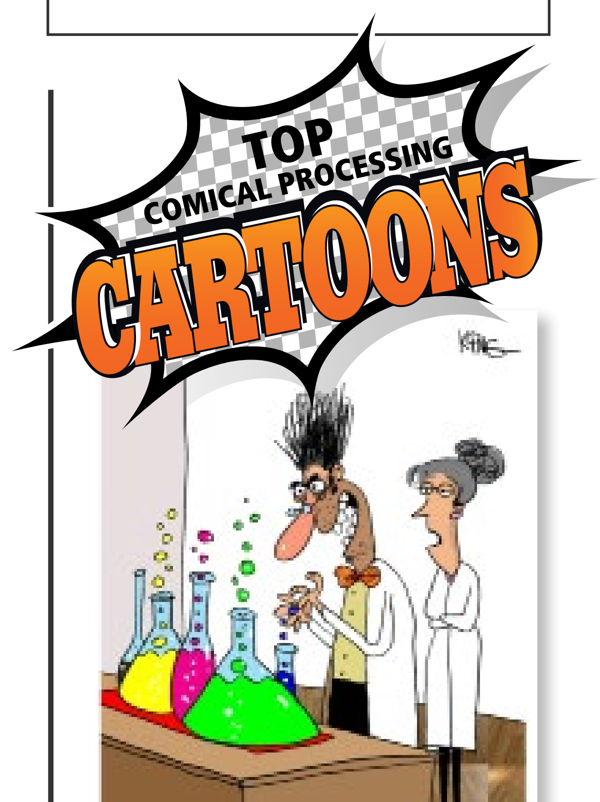

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