Implementing Instrument and Process Control Mechanical Integrity and Reliability Improvements

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Abstract

Successful and sustainable implementation of mechanical integrity for instrumentation and controls require well-defined interactions involving *people, equipment* and *work practices* across the entire lifecycle. Companies, which document and master these interactions, have the opportunity to add millions of dollars to their annual operating income, while at the same time improving operational safety. The results of a recent industry survey; however, indicate few companies are focusing resources on instrumentation and controls reliability and in general industry appears to be heading in the wrong direction.

1. Introduction

There is significant business value to be gained by consistent practices in mechanical integrity (MI), information management, and analysis. Quality assurance in MI is also an expectation of OSHA PSM.

One of the OSHA NEP findings is that many companies have plans, programs, procedures and documents, but they do not seem to be coordinating and implementing many of them in a quality manner. Without strong leadership at the executive level and personnel invested in and taking ownership of data/information quality at the plant levels, companies will not be successful in closing gaps indicated in these findings.

During the 4th quarter of 2010 SIS-TECH Solutions, LP initiated a survey to gauge actual instrumentation and controls MI performance against world class performance metrics published in the Materials Technology Institute (MTI) Instrument Reliability Manual. The results of the survey indicate some significant gaps and cause for concern vs. what is considered world-class performance.

This paper will detail some of the gaps identified and efforts currently underway to close those gaps including focusing on improving work process interaction, methods to identify and address gaps, and leading indicators of concern in operating companies.

2. Why Instrumentation and Controls MI Process?

Instrumentation (process connections, instruments, wire, conduit, logic solver, control programming) makes up the brain and central nervous system of a process operation. These pieces of equipment when healthy and working in harmony ensure safe and reliable operation, product quality and customer satisfaction, and optimal production capability. These components must reliably function 24/7/365 with their only scheduled time off being a plant turn around.

The MI plan provides the foundation that enables long-term reliable operations. It ensures equipment is properly designed, documented and maintained across the lifecycle in a manner that sustains specified performance for the expected life. Sound MI planning includes aspects of project front end loading, construction/commissioning, maintenance/operations and data/documentation collection and management.

Rigorous and competent MI is an enabler of reliability whereby the equipment performs its required function under the specified conditions for the specified mission time. If the equipment does not attain its intended performance, then we need good data to analyze and determine why.

3. Who Cares?

We should all care. It is just good business sense to deliver a usable product to the consumer in the safest and most efficient way possible.

Specifically, OHSA cares. It is written into Process Safety Management 1910.119 (j)(6) Quality Assurance and stated as follows: "in the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used" and " appropriate checks and inspections shall be performed to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions."

Furthermore for safety instrumented systems, IEC 61511 is a recognized and generally accepted good engineering practice (RAGAGEP). In Clause 5.2.5.3, it states "procedures shall be implemented to evaluate the performance of the safety instrumented system against its safety requirements." In Clause 11.5.3.1, "appropriate evidence shall be available that the components and subsystems are suitable for use in the safety instrumented system." Finally, in Clause 16.3.1.5, "at some periodic interval (determined by the user), the frequency of testing shall be re-evaluated based on various factors including historical test data, plant experience, hardware degradation and software reliability."

4. Key Elements of Instrument MI Process

To meet the intent of what is described in PSM and the supporting RAGAGEP there are three key lifecycle process elements that must be addressed: people; equipment and tools; and work processes and procedures.

1. *People* must understand the responsibilities of their particular discipline, whether it is engineering, maintenance or operations. One thing to make clear is this directive is not just a maintenance issue. All functions across the lifecycle have responsibilities to fulfill.
2. *Equipment* and tools must support the MI work processes. Proper tool selection includes selecting engineering/design databases, computerized maintenance management systems, I/A smart asset management systems and approved equipment list.

3. *Work processes* and procedures must promote interaction between engineering, maintenance and operations in achieving the targeted performance.

Managing these three elements can be a complex task, especially when many large capital projects involve multiple EPC firms. A management and planning strategy should be implemented that covers the information hand-offs needed for design, process automation and maintenance/operations. These interactions/hand-offs should be specifically covered in the job instructions or job specifications provided to the EPC service provider.

5. The Evolution of Instrument MI

This is a “simplistic” view description but it is to the point. In the early days the MI philosophy for operating facilities could be simply stated as “when it breaks fix it”. Very little, if any, failure or repair data was captured. Without this knowledge, improvements could not be implemented to prevent failure reoccurrence. Perhaps a few years back, a company with large inventories could fill orders even with numerous shutdowns, but with global competition and concerns for safety and security, plants have had to greatly change that mode of thinking.

In the present day what we want is “if it ain’t broke don’t fix it.” In fact, performing PPM at frequent intervals increases the likelihood of systematic failures due to maintenance error.

So, the question arises, how do you know if you are doing too much PPM and testing, or not enough, and if you are doing it, are you doing it at the right time? Where is the data, what shape is it in, and can we capture data in such a way that we are comparing “apples to apples”?

Some of the barriers which keep us from consistently capturing data and turning it into information which enables us to know instrument performance as an industry are listed in the CCPS IPS Book published in 2007.

- Poor data integrity and quality. This could be caused by not having any “go-by” for accountability to collect, categorize and maintain data
- Poor information availability and consistency. This could be caused by not having any clear guidance on how to turn data into actionable information, e.g., lots of data, what do I do with it?
- Lack of broad understanding and consistency. Even if a company process is in place to capture data and turn it into useful information, it is not well communicated or implemented.
- Poor or missing internal practices or procedures. Maintenance technicians will note good observations on a PPM form but there is no documented way to get that feedback into the appropriate work process to drive improvement.
- Poorly understood compliance expectations. Compliance needs proof, proof needs data, data analysis requires action; however, there is a lack of granularity in mid range to lower level work company processes defining what individuals need to do, and document, from a compliance standpoint.
- Inadequate revision control or notification of changes. Management Of Change (MOC) applies across all phases of the lifecycle, but there are still times when changes are not well communicated and documented, e.g. red mark as-built changes not updated to master documentation repository.
- Lack of comprehensive training on data, information, procedures, documentation practices and ownership. Individual or team goals are set with no direction or “game plan” to complete, no mile stones or directions given for mid course corrections when needed.

6. Where Should We Begin?

Good engineering practices means “staying with the herd,” Ken Bond, Shell Chemical Co. (now retired), at a late 90s Texas A&M University Instrumentation Symposium. This good common-sense observation applies to many key performance indicators, including instrument reliability. Sometimes it is good to be at the front of the herd, sometimes perhaps not. Usually it is not good to be lagging behind the herd. The safest place is usually with the main body of the herd. Once you get your bearings, e.g. good data, you can probably venture a little further into the lead and help set the standard.

But how do we all know where we are right now? Do we have anything we can gauge our current performance against? We actually do. The Materials Technology Institute (MTI) was forward thinking in the development of an Instrument Reliability Manual in 2007. At that time, the manual developers identified a number of world-class instrument reliability metrics.

In the 4th quarter of 2010, SIS-TECH Solutions, LP developed an industry owner/operator survey to determine current performance in a number of MTI metrics. The performance metrics chosen are as follows:

- Annual Maintenance $ Spent vs. Replacement Asset Base (RAB)
  - Target: < 3% overall instrument equipment asset value
- Instrument Work Orders closed as “no problem found”
  - Target: < 5%
- Percent of instrument overdue work orders
  - Target: 0% (perhaps a bit ideal but should drive to be a close as possible)
- Percent overtime spent by instrument mechanic/technician
  - Target: 5% to 10%
- Percent time spent by instrument mechanic in training
  - Target: 7% to 10%

Refineries, petrochemical and off shore oil/gas production companies responded to the survey. The survey was completed by process control engineers, instrument reliability engineers, and maintenance supervisors.

Figure 1: Survey Responses – Distribution

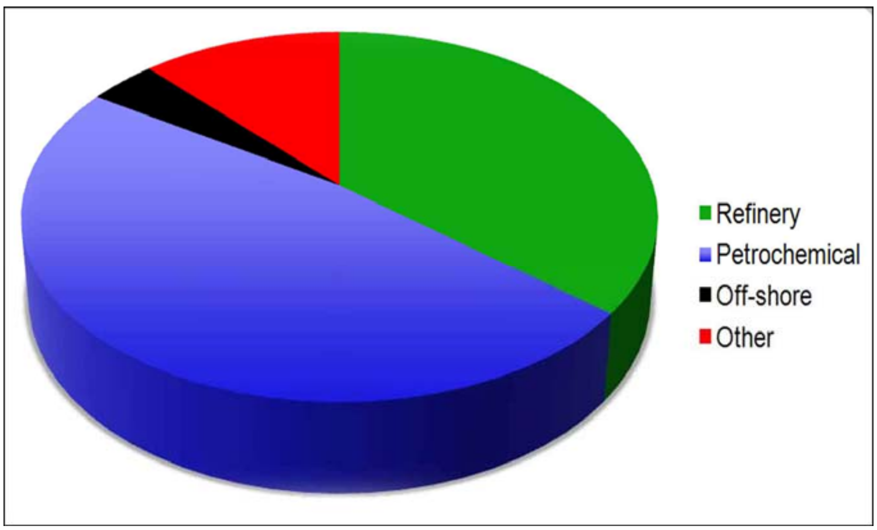
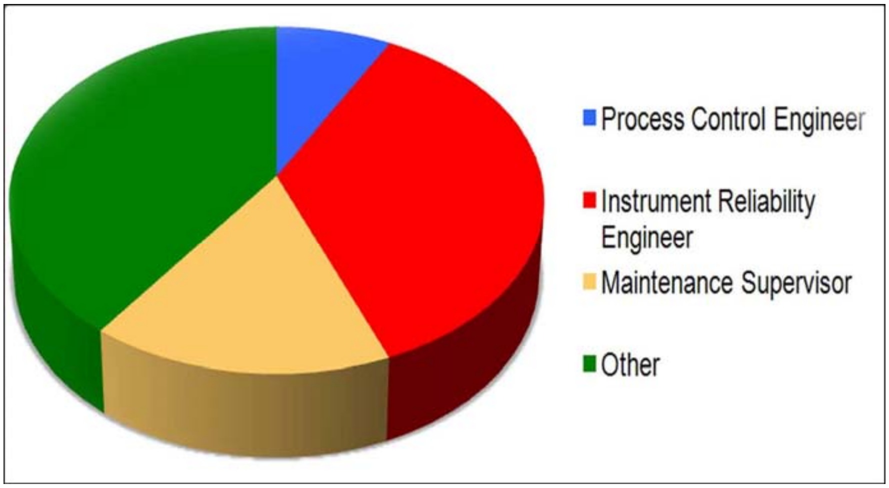


Figure 2: Survey Responses – Disciplines



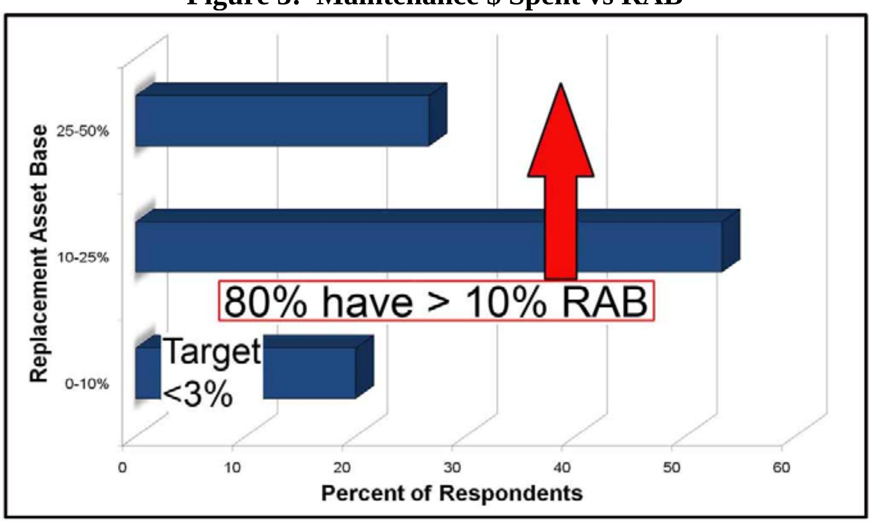
7. Survey Results

The results of the survey indicate that we, as an industry, are heading in the wrong direction and need a "wake-up" call. The data clearly shows a need for change in the current situation before it contributes to, or becomes an enabler of, a serious incident.

Maintenance $ Spent Vs. %RAB: Eighty percent of respondents spent in excess of 10% maintenance spending vs. RAB. It appeared that some respondents, over a two-year period, were spending enough maintenance dollars to replace their entire installed base of instruments. But, this metric can be a tricky one. The spending could by impacted by control complexity, batch recipe changes, the type of instruments in use, e.g. large numbers of pH probes, etc.

These results will require additional "drill down" to determine the cause and possible corrective actions for this high degree of maintenance spending. For example, the drill down could reveal spending not appropriately classified, or that a CHAZOP is needed for a batch facility where cost has been attributed to a high number of manual actions required by maintenance personnel or operators that would be less costly if replaced with automation.

Figure 3: Maintenance $ Spent vs RAB



Percentage of Overdue Work Orders: Seventy percent of the respondents indicated over 10% of their instrument work orders are classified as overdue. Any defects or inefficiencies in plant processes are cumulative. Poorly written or missunderstood procedures (for both operations and maintenance), technician expertise or lack thereof, starts the snowball rolling down the hill. Some overdue Work Orders evolve into Emergency Work Orders further compounding the issue.

Figure 4: Percentage Over Due Work Orders

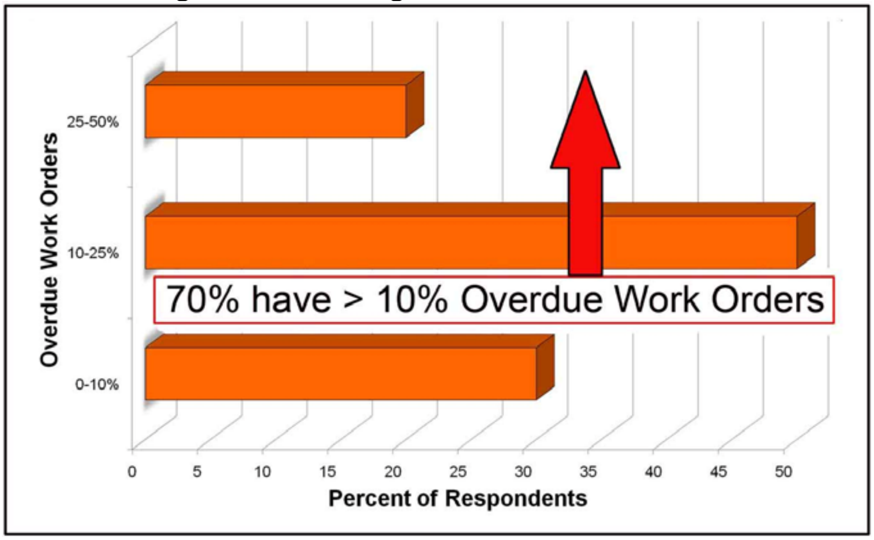
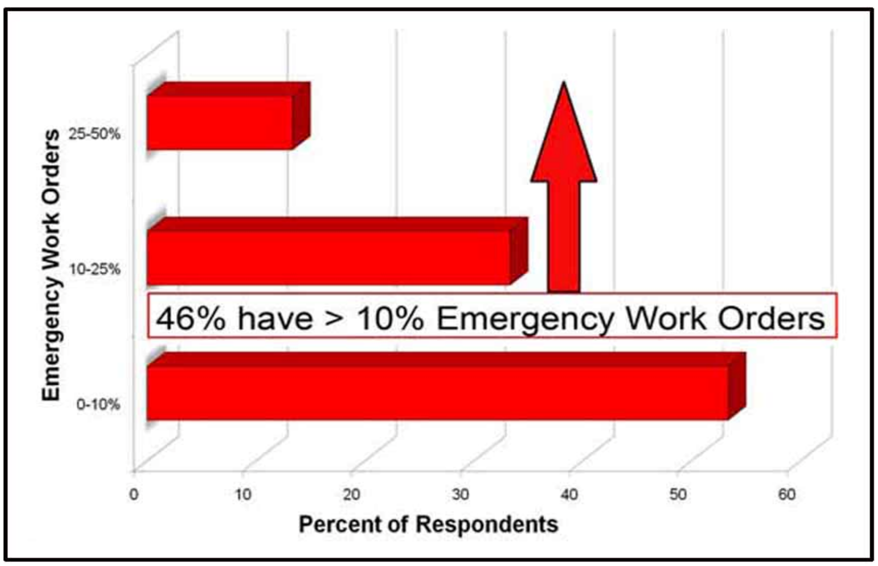
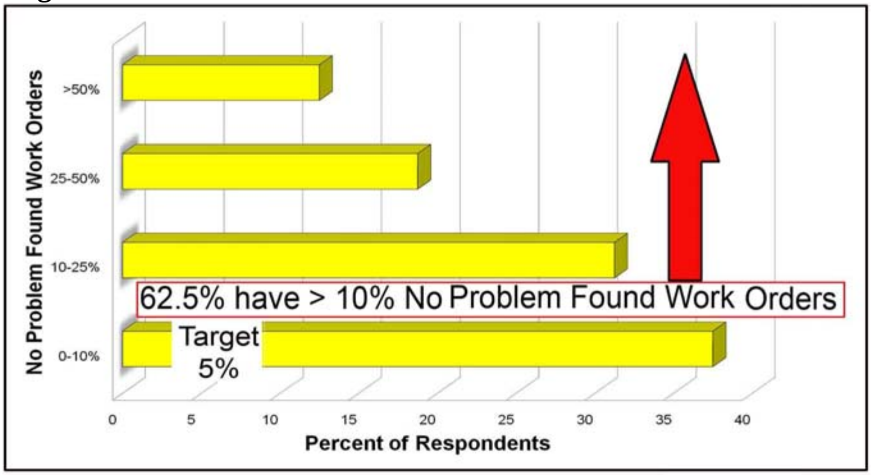


Figure 5: Percentage Emergency Work Orders



Instrument Work Orders closed as "No Problem Found": Sixty-two percent of respondents indicated over 10% of their instrument work orders are closed and classified as "no problem found". Some respondents indicated numbers approaching 50%. Is there really such a thing as a "no problem found" Work Order? There is clearly a problem somewhere. The problem may not be exhibited at the time the mechanic is troubleshooting due to a variety of contributing factors; yet, there is a cost to a "no problem found" work order. The time to plan, get paper work together etc. can approach $300 per Work Order. There is no return on investment if there is no plan of action to investigate where the real problem lies. These should be treated seriously, continuing to ignore or not follow-up can lead to a serious events.

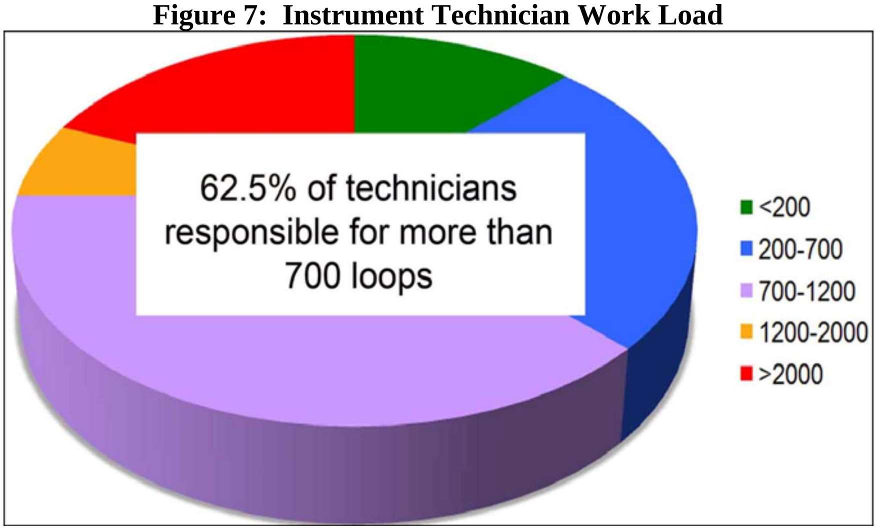
Figure 6: Instrument Work Orders Closed as "No Problem Found"



Instrument Mechanic Workload: Fifty-six percent of respondents indicated their instrument mechanics work over 10% overtime. Sixty-three percent of respondents indicated that mechanics are each responsible for 700 or more loops. Overtime is not necessarily a bad thing. A small amount of overtime is generally expected and accepted in most working environments. Reliance on higher levels of overtime indicate possible systematic weaknesses in the overall maintenance and reliability work process.

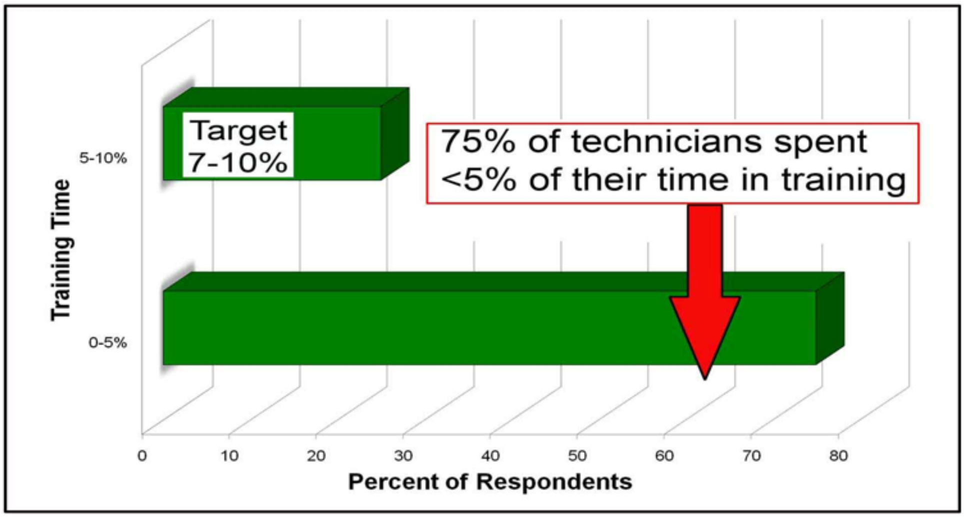
Human reliability itself degrades with long cumulative exposures to heat, cold, noise, etc. A high ratio of instrument loops to technician can be good or bad depending on whether the company has a well-defined instrumentation and controls MI process, where failures with equipment (or work processes) are properly analyzed and permanently fixed. If a company does not have a well-defined process coupled with a large numbers of repeat "maintenance offenders" and "no problem found" work orders, then this is not good—for the mechanic or the company.

Figure 7: Instrument Technician Work Load



% Instrument Mechanic Time Spent In Training: Over seventy-five percent of the respondents indicated that their instrument mechanics spend less than 5% of their charged time in "training". Instrument technology and capability changes rapidly, as can the process used to control or provide for safe operation. Training for instrument mechanics should be targeted for the specific technology and its purpose in order for the mechanic to be as effective as possible from a technical, work process and reliability improvement standpoint.

Figure 8: Percentage of Time Spent in Training



8.   Possible Causes of Benchmarking Gaps

MI involves three major components: Equipment, People and Work Processes. Some of the possible contributors to gaps discussed in the previous section have been grouped (Table 1) to provide more clarity and to aid in developing a strategy for defining sustainable corrective actions.

Table 1.

	Challenge	Potential MI Impact
Equipment	New Instrument Technology	• Data collection and analysis • Mechanics ability to effectively troubleshoot • Availability of spare parts • Diagnostic equipment capability
	Control Complexity	• Limited technology suitable for the application • Revised process parameters affect existing instrumentation adequacy • Increased procedure requirements • Testing expectations
	Instrument Type and specification	• Revised process parameters affect existing installation • Useful life • Reliability
	Operating Environment	• Ambient conditions affect useful life or reliability
	Installation	• Roles and responsibilities • Design specification • Construction techniques • Inspection practices • Required follow-up on findings
Work Practices	Roles and Responsibility	• Overall MI Plan • Data and documentation management • Design and operational expectations for control program • Procedural detail and training requirements
	Overall MI Plan	• Design requirements from capital projects • Schedule and required MI activities
	Data and Documentation Management	• Data collection and analysis • Disaster recovery plan • Documentation retention
People	Roles and Responsibility	• Resource and tool requirements • Training and testing requirements
	Management and Leadership Engagement	• Instrumentation and controls MI on continuing operations • Key performance indicators

9. Moving Toward Sustainability

The results of the 2010 survey have provided the data needed to benchmark “the herd” and establish a common direction. Without a sound governing safety and reliability lifecycle work process that details the interactions between the various disciplines, members of the herd are being set up for failure to be picked off one by one by wild cats, wolves and other predators. Quality assurance begins and ends with people, so as an industry, a company, an operating site, or a plant we must:

- Develop a strategy and plans to:
  - Improve multi-discipline work process interaction and accountabilities
  - Enforce life cycle documentation integrity
  - Capture, categorize and analyze performance data
- Improve equipment performance to sustain its specified mission time:
  - 63% of respondents do not track infant mortality after construction/installation. This is an opportunity lost. Sometimes existing construction and loop check practices used by installers can introduce systematic failures, which impact maintenance and production costs down the line. Opportunities for warranty replacement can also be lost.
  - 50% of respondents do not track Mean Time Between Work Orders or Mean Time Between Failures. Tracking work orders written against the same instrument installation will identify when the wrong instrument technology was specified for the process application, justifying device replacement with a technology that delivers the specified performance.
  - 27% of responders did not have a process for tracking bad actors. Bad actors otherwise known as “repeat maintenance offenders” are defined as those pieces of equipment which have two or more work orders in less that a ninety day period. A recent study by a large owner/operator company found that less than 2% of these bad actors contributed to almost 65% of instrument maintenance spending.
  - 42% of respondents do not track production impact due to instrumentation and controls failures. Annual maintenance and repair costs can amount to a very sizable figure. Overall maintenance is believed to be the second largest expenditure for operating facilities right after the cost of feedstock. As large as it may seem, it is still only the tip of the iceberg when compared to lost production due to instrument unreliability.
- Improve Work Processes
  - 53% of respondents had no process for transferring data/documentation from the design database the Maintenance Management System
  - 42% of respondents indicated the design database is the master data repository, while 58% of responders indicated it is the maintenance database. Clearly there are unanswered questions as to which database is a more effective collection tool. Whichever database is defined as the master, impacted disciplines must know so that work processes are in place to synchronize the databases at specified time intervals.
  - 21% of responders used the same MI process for all equipment regardless of critically. There are cases where some instruments are appropriately classified as “run-to-failure” while instruments related to safety and environment need a rigorous MI program.
- Improve People Management
  - 75% of responders invested less than 5% in training, yet expected to get the right information from people in the trenches. These individuals want to do the right thing, but they need to receive training on what is expected, how to document failures, etc.
  - 48% of responders do not use, or have in place, standard failure codes for instrumentation. This may not be surprising since there has not been much published direction for instrumentation. ISO14224 gives some direction for classifying instrument failures, but additional granularity is needed to enable the industry to compare “apples” to “apples” and benchmark against the herd.

10. Remember: This IS a Journey—Patience Is a Virtue
The safety and reliability lifecycle is not one stop and you are done. There will always be many opportunities for improvement that need prioritization. Begin with fixing the obvious - stop designing in and building in systematic failures.

- On capital projects and plant improvements:
  - Control the process parameter inflation provided to size and specify instruments which occurs across the various lifecycle information hand-offs.
  - Identify and design for the ambient environmental conditions which impacts useful life.
  - Control packaged equipment design and fabrication. Make sure the fabricator understands your engineering requirements and maintenance strategy.
  - Storage of equipment prior to installation. Mud, moisture, insects, salt, etc. can shorten the life of an instrument before it is installed and commissioned and possibly void warranty.
  - Work with your instrumentation installation contractor to ensure the installers are trained. Do not have an installer remove a protective sheath on a thermowell thinking that it is a “shipping protector”. These incidents can, and do, occur.
  - Have a detailed commissioning plan in place that includes data/documentation management and a way to feed back observations that can eliminate systematic failures in design or construction.

- During Maintenance and Operations identify opportunities for improvement:
  - Work/repair notifications and Work Orders
  - Instrument mechanic notes/interviews (notes in the file drawer)
  - Asset management system records
  - The process historian and alarm log
  - Emergency and overdue Work Orders

11. The Journey--Looking Down the Road
Obviously, we have some work to do to get everyone on the same page to ensure long-term success and sustainability.

The industry trends in MI are alarming. The need for a master documentation repository, and for all in the industry to report “apples” to “apples” into this repository becomes imperative. Individual companies that have resisted moving from the comfortable status quo — often not recognizing the gaps in their processes where substantial savings can be found when identified and addressed,. The process industry needs to build towards improvement and reliability growth through improvements in MI for instrumentation and controls.

Table 2.

Goals	Areas
Guidance on consistent Data Capture for ‘apples to apples’	Failure type (systematic vs. random) Failure mode Failure cause Failure mechanism
Guidance in documentation repository	Data transfer from design engineering to the maintenance management system Enforce MOC and as-built updates Records management The appropriate retirement of equipment records
Grow instrument reliability network	Owner/operators Instrument manufacturers
Data capture for individual devices	Owner/operators
Sharing of cleansed data	Owner/operators