White Paper: Radio Frequency Identification In Maintenance, Repair and Operation of Flange Based Pressurized Systems

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Introduction

Pipeline Lifecycle Management encompasses a multitude of focus areas including thru-put control and measurement gauges that aid in understanding product flow and pressure, to assure they do not exceed thresholds that jeopardize pipe integrity. In addition, lifecycle management includes ultrasonic devices designed to pass-thru pipeline and inspect and identify areas of potential corrosion, replacement procedures, including activities such as hot-tapping, to assure uninterrupted flow during pipeline repair. It also includes part replacement and operational procedures when handling flanges, gaskets, nuts, and bolts that join independent pieces of pipeline together.

Maintenance, Repair, and Operations (MRO) models can define procedures for supporting the lifecycle of a pipeline. These models underline how and when pipelines need to be maintained in order to preserve their integrity. Furthermore, these models also assure that these activities are performed efficiently and accurately.

As such, an MRO model for pipe lifecycle management needs to assure that theequipment necessary to perform these operations is **readily available and working,** that field operatives **understand how to use this equipment** and **where to perform their designated MRO tasks,** and that there is an **efficient and safe way of performing these tasks.**

Scope

This document will overview **how Radio Frequency Identification (RFID) Technology streamlines MRO activities** by eliminating human-error and increasing the speed and efficiency at which typical tasks are performed. In particular, the focus area for this document will be the maintenance, repair and operations of flanges, gaskets, nuts, and bolts and how RFID can provide a control and data retrieval system for field operatives, as well as a granular data-mine for corporate-level personnel interested in a comprehensive real-time view of their MRO activities across their facility. As such, enabling a safer and more efficient means of performing parts maintenance.

Identifying the Problem

MRO activities are performed on pipelines as a means of assuring continuous and sustained flow of product through the transportation mechanism (the pipe). They are also performed to ensure other auxiliary activities are not jeopardized because of issues with the pipe. In parallel to operational activities, safety is also a major driving factor in the way MRO activities are modeled.

Irrespective of the driving force, with respect to flanges and gaskets many different factors contribute to leaks and all must be controlled to some extent in order to achieve reliable closure of a pressurized system. Joints in pressurized equipment are constantly moving and changing in response to the conditions around them. These changes come both from within the processes they contain and from the environment around the joints. Humidity, temperature, pressure and viscosity of the fluid in the pipeline, and a variety of other factors all can affect the pressurized seal.

There is no such thing as a 100% leak free joint, even “zero leak” criteria stipulates acceptable molecular level loss over a designated period of time.

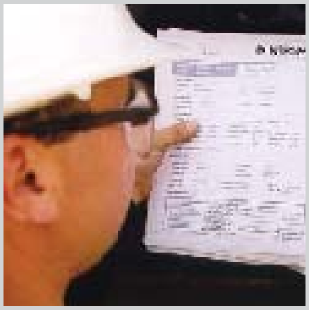
A key to achieving successful or acceptable levels of leakage are typically not bottle-necked by the flanges and gaskets themselves but rather by the MRO model that defines how these activities are to be performed. For instance, maintenance may not be performed with adequate timeframes/frequency, installation of the equipment may be improper, or the optimal part replacement may not be available.

Defining the Solution

Successful leak control comes from successful process control. In defining a maintenance, repair, and operations model, a "zero-leak" environment can be achieved.

Preventive Maintenance is a critical component of successful leak control. Field operatives may use visual or sensory data to inspect bolts for corroded threads, proper tension and torque values, using technologies such as ultrasonic load measurement, and gasket damage. The pipeline pressures, external humidity and temperature, the gaskets and bolts machining specifications, and a variety of other variables all affect the probability at which a potential critical failure can occur and so the frequency at which preventive maintenance activities must be performed. *Effective preventive maintenance can dynamically adjust frequencies of inspections with changing environmental variables.*

Repair of a component that is a part of this pressurized system involves understanding what thresholds and stress levels the part is designed for and the other external system variables that the part will be exposed to. Subsequently, determining a replacement part is needed or a repair or machining process can occur on the existing part. In some cases direct and identifiable part replacements may not be available and so parts with equivalent tolerances may, cautiously, be used. *Effective repair models empower the field operatives with product specification information as well as system-wide variables that help them determine the best selection of product or repair steps to undertake. In addition an effective repair model enables quick and easy part retrieval/procurement.*



Operations of the pressurized system implies knowledge of how the system can be used. System data on particular pieces of pipeline can be retrieved for field operatives via the identifiers on the pressurized system parts. In addition maintenance and repair activities that were recorded digitally or otherwise can be retrieved to understand system limitations with respect to pressure levels, temperatures, liquid viscosities or otherwise. *An operations model that has visibility into the maintenance and repair activities performed by a field operative will provide a real-time view of how the pressurized system (pipeline) can be used. How the pipeline can "operate" will be a dynamic function of how it was maintained and repaired in addition to its original threshold specification.*

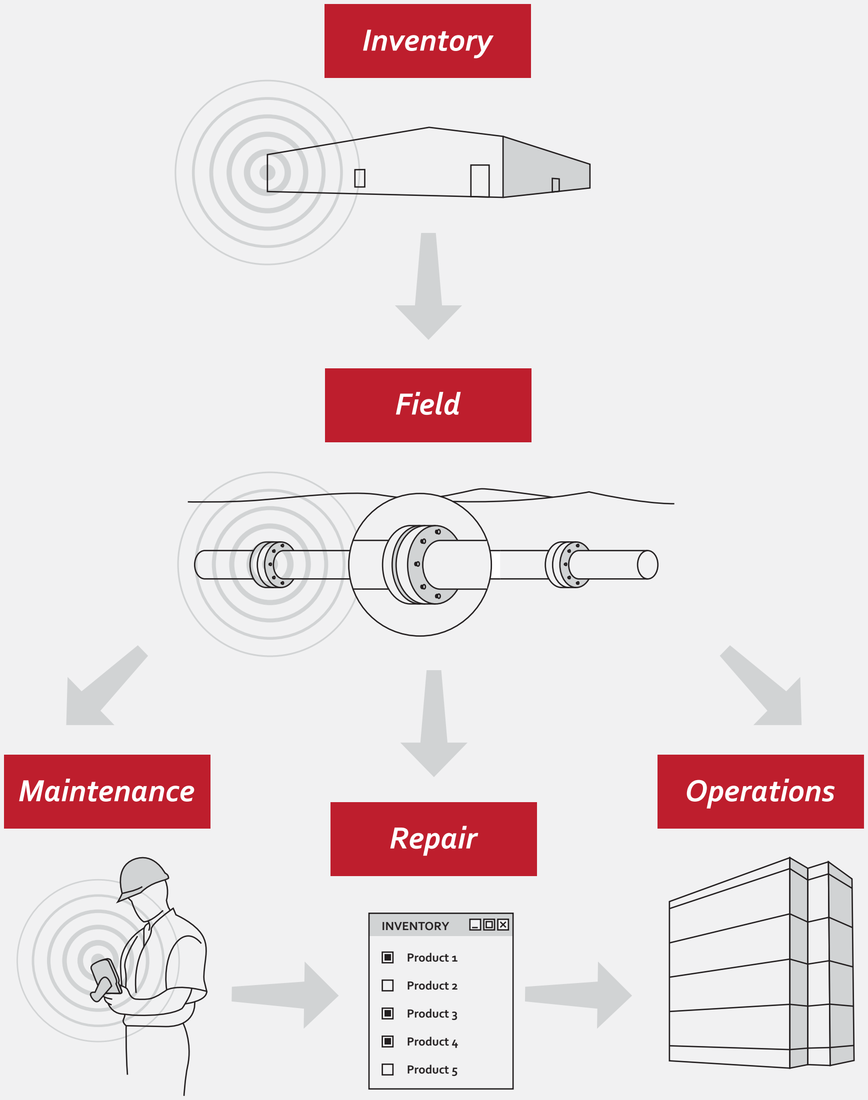
Defining the System

RFID enabling flanges, gaskets, and bolts provides a serializable product trial for all the system components that are a part of the pipeline pressurized system. Field operatives can perform scans on these parts and enable a data fusion between the activities they are performing and the part(s) to which they are performing it to. These activities could include a) exit inventory, b) observed defects, c) maintenance performance, d) product specification retrieval, and a variety of other steps.

Enabling this serialization and data fusion provides the capacity to dynamically adjust inspection frequency, retrieve maintenance records and product specifications on a particular part, validate part replacements to assure they are meeting pressurized system requirements under the dynamic system conditions, and provide operations visibility as to how the pipeline can be used under the real-time changing variables of maintenance and repair.

Defining the System Process

Field operatives use portable RFID reader devices to scan RFID enabled parts throughout their operations. These scans record product identification numbers and associate them to processes performed by the operatives. In addition, fixed reader devices can perform inventory management controls at facility warehouses where parts are stored. Also, auxiliary location based management systems, piggybacked on a wireless network or passive based "scan-to-locate" systems, can be used to associate location to maintenance and repair work being performed.



Defining the System Data and its Value 1/2

Maintenance

Each process performed on the pressurized system will be recorded in data-store. Subsequently analytical models and reports can be retrieved to optimize maintenance procedures depending on the dynamics of these recorded processes. Enabling more efficient use of field operatives used to maintain the pipeline and eliminating the possibility of locations in the pipeline from not being maintained appropriately.

Repair

RFID enabled parts can have the following specification information:

- *Engineering Analysis*
- *Stress Report*
- *Leak Tightness Calculation*
- *Dimensional Characteristics*
- *Machining Requirements*
- *Allowable Defects*
- *Torque and Tension*
- *Flange and Gasket Assembly*
- *Flange surfaces / metallurgy*
- *Bolt tightening and Bolt loads*

Field Operatives will cross-reference theoretical specification requirements with observational and gauge and sensor measurements in the field. Some of these sensors will allow for an automated verification or self-actuation depending on the RFID tag data read. For instance hydraulic bolt tensioning systems can auto-program for appropriate torque depending on the read RFID tag or tags associated to the pressurized system, Ultrasonic Load Measurement data can be validated immediately against theoretical values retrieved from the product identifier identification on the RFID tag, or the maximum operating pressure of hydraulic bolting or hydraulic nut splitting equipment can verified to not exceed pressurized system thresholds.

Defining the System Data and its Value 2/2

Operations

Interaction with the pressurized system in terms of maintenance, repair, or otherwise coupled with static information of product thresholds can provide a dynamic view of the entire pipeline, its real-time maintenance requirements (which areas of the pipeline are in need of critical maintenance/review or otherwise), its threshold characteristics (what pressure levels or otherwise can be flowed through the pipeline taking into account flange, gasket, bolt specifications used during repair/replacement).

Identification & Serialization at a Glance 1/2

Data-fusion, as described in this document, is an association between identification and process and subsequently between different processes or activities. The resulting "fusion" is an intelligent/informative view that improves the capacity of an organization to understand their operations and improve them. The precursor to the data-fusion is the identifier, the critical link that bridges one activity to another activity, that allows for a consolidated view of each part, and consequently of every part in the system.

Serialization of flanges, gaskets, and bolts can be made using standard labeling, chemical or laser etching, color coding, bar-coding, or more advanced methods such as radio frequency identification.

Standard Labeling implies using a "pen & paper" based technique to denote product identification and attaching these "labels" to a product or product bin location. It also can be used to denote maintenance activities related to particular parts of the pipeline/pressurized system. Typically sufficient space is left to denote all important information on the label, however the technique is prone to human-error, illegibility, and lack of system-wide visibility. This means that parts may be mistook for other parts, maintenance activities not performed or wastefully performed, and other inefficiencies inherent to this outdated identification process.

Whereas ***Etching Techniques*** are laser ingrained or chemically engraved identification that can allow for a unique item level serialization, reading a multi-digit serial number off a part is cumbersome and prone to error. In the case of bolts and other auxiliary pressurized system components, the dimensional characteristics can also force the etching to be extremely small, further complicating one's ability to read the identifier.

Color Coding provides clear identification of the part visually, but cannot uniquely identify parts, rather it can segregate them into multiple different groups. In simple pressurized systems with limited replacement options this could provide a viable means of locating parts, but MRO models that monitor this part could not uniquely identify it versus an identical part of the same color coding, thereby limiting color codings capacity to aid in maintenance and repair activities.

Identification & Serialization at a Glance 2/2

Bar-coding enables product identification and relatively quick data retrieval but requires line-of-sight. In space constraining operational environments positioning a visual imager / barcode scanner to retrieve product identification may be very cumbersome. This is also coupled with the fact that bolts or other items with small dimensional characteristics cannot fit a barcode identification label on them as it would be too small to be scanned by an imager. In addition to dust/debris accumulation that can block line-of-sight.

Radio Frequency Identification allows for identification retrieval of parts virtually irrespective of dimension, as some RFID tags can be smaller than 1/8" x 1/8" and contain more than sufficient data capacity to serialize billions of unique components. The wireless based communication between reader device and tag allows for the ability to retrieve identifiers in space constrained environments. Identifier retrieval is virtually instantaneous, not prone to human error, and not effected by dust accumulation. RFID tags are also re-writeable, enabling a self-contained maintenance and product record that in wirelessly disconnected environments is extremely valuable to field operatives performing work. This self-contained record can store product specification information, maintenance and repair procedures, and updatable maintenance logs on the physical RFID tag itself. Each time an interaction with the part is made an update is written to the tag. Not forgoing the fact that in "wirelessly capable" environments the RFID identifier can serve as a key to expedite immediate data/specification retrieval or as a partial onboard or redundant database to the server-side data-store.

Conclusion

Optimizing the maintenance, repair, and operation of flange based pressurized systems significantly reduces leaks and blow-outs that are a consequence of incorrect replacement, repair, and handling of parts. It enables proactive and efficient inspection procedures that address potential system defects before they lead to catastrophic failures. Connecting event/action with part identification requires a reliable data identifier mechanism that can be read quickly and reliably during MRO procedures. Radio Frequency Identification provides the data capacity to serialize individual parts while allowing for automated scanning in space constrained environments. It also enables rewriting capability to the tag and provides the ability to scan multiple parts of the pressurized system rapidly.

Using RFID technology as the data collection mechanism for MRO procedures of a flange based pressurized system provides:

- *Rapid Product Specification Information Retrieval (Reduction in Maintenance/Inspection Time)*
- *Location & Part Specific Maintenance Histories (Reduction in Redundant Maintenance, System-Wide Pipeline Visibility)*
- *Accurate Product Identification & Inspection Records (Reduction in Leaks & Blowouts)*
- *Onboard redundant/self-contained database Records (Inspection Capable in Remote Environments)*
- *Large Data Capacity of Tag (Serializing every single component, not just a model)*
- *Automated Scanning Capability (Quicker processing, immediate self-actuation of repair and inspection tools)*