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RFID for Industrial Gas Cylinder Management

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The benefits and usage of radio frequency identification (RFID) tags can meet all the requirements for a cylinder management system

Abstract

The industrial gas companies use cylinders to deliver gases to their customers. They make huge investment in cylinders. The current process and systems are not able to meet all the requirements of cylinder management systems. The RFID enabled cylinder management systems would help improve productivity, as well as improve the quality, reliability and efficiency of the cylinder management process, thus making an investment in cylinder management worthwhile. This paper described how RFID tags can be used for various applications in cylinder management.

Introduction

Industrial gases play a vital role in the operations of manufacturing, electronics and healthcare industries. These gases are delivered to the customers through pipelines, tankers and cylinders. Gases supplied through cylinders include oxygen, nitrogen, argon, Ar-CO₂ mix, hydrogen, CO₂, etc. Gas companies may own up to millions of cylinders that move across the supply chain through different channel partners—warehouses, dealers, customers and back to factories for refilling. As each regular cylinder costs between \$150 and \$200, the overall asset value is very high.

Considering the fact that the packaged gas business consists of many different kinds of gases being supplied to a large base of fragmented customers, the product life-cycle of cylinders becomes extremely complex; there are just too many products, partners, assets and variables which are part of running this kind of business. For example, the company has to ensure that the cylinders are correctly tagged and supplied to the right customer; empty cylinders must be returned to the correct company for refilling.

All through this process, the ownership of the cylinders still lies with the companies themselves and they have to make sure that the cylinder that leaves the plant

comes back to the factory safely and in proper condition after passing through different channel partners. Since the cylinder supply chain is so complex there are losses; an average company loses 1% of cylinders.

All through the supply chain process, cylinders need to undergo periodic hydrostatic tests, and the maintenance schedule and record of each cylinder delivered needs to be maintained for safety and regulatory reasons. In the subsequent sections, we will try to examine the compressed gases business and the importance of cylinder management in greater detail.

A typical cylinder lifecycle is shown in Figure 1. The cylinder life cycle includes: new cylinder procurement; cylinder (empty, filled and used) storage; filled cylinder transportation and delivery; used cylinder pick-up; cylinder maintenance; and cylinder disposal.

Figure 2 shows the cylinder supply chain. The following is the cylinder movement flow across its supply chain:

1. The empty cylinders from the warehouse are inspected for valve replacement, painting or other routine maintenance-related work before being sent for filling.
2. Based on the daily order report generated every evening by the Customer Service Center (CSC), production is planned and the cylinders are filled.
3. After filling, the cylinders are sorted manually and sent to the filled-cylinder yard.
4. The dispatch officer receives the daily order schedule from CSC in the morning and prepares the dispatch plan for the day.
5. As per stock of the filled cylinder, the dispatch officer arranges for deliveries to the customer.
6. The allocated filled cylinders are loaded onto trucks for dispatch.
7. The driver delivers the filled cylinders, picks up the empty ones, prints the delivery note and proceeds to the next customer.
8. After finishing the deliveries, the truck returns to the fac-

Existing systems cannot accurately track the individual cylinder's movement from the time it is commissioned, through its lifecycle.

tory, the cylinders are manually counted, sorted and stored in an empty cylinder warehouse for the next filling.

9. The driver gives the cylinder pick up/unload data for each customer to the warehouse officer. The officer uploads the data to the system for the individual customer.
10. Bills are prepared based on the data uploaded by the warehouse officer.

Issues and Challenges

The basic problem with the existing system lies in the fact that it cannot accurately track the individual cylinder's movement from the time it is commissioned, through its lifecycle. There is no system that tracks the individual cylinder movement as it flows through the supply chain partners. This inability of current systems can lead to the following issues:

1. It is not possible to track an individual cylinder's utilization record. A cylinder may keep lying in the filled cylinder warehouse without being used.
2. Many times, it is difficult to differentiate between customer-owned, dealer-owned and company-owned cylinders.
3. The damage/pilferage of a cylinder cannot be identified and attributed to a specific customer or delivery.
4. It is not possible to locate individual cylinders lying with customers. The company may realize that some cylinders are missing but they cannot track the cylinder location.
5. The maintenance/testing record-keeping of cylinders becomes extremely tedious as it requires manual inspection and updating. The existing system requires every cylinder to be checked manually for its hydrostatic/corrosion test-

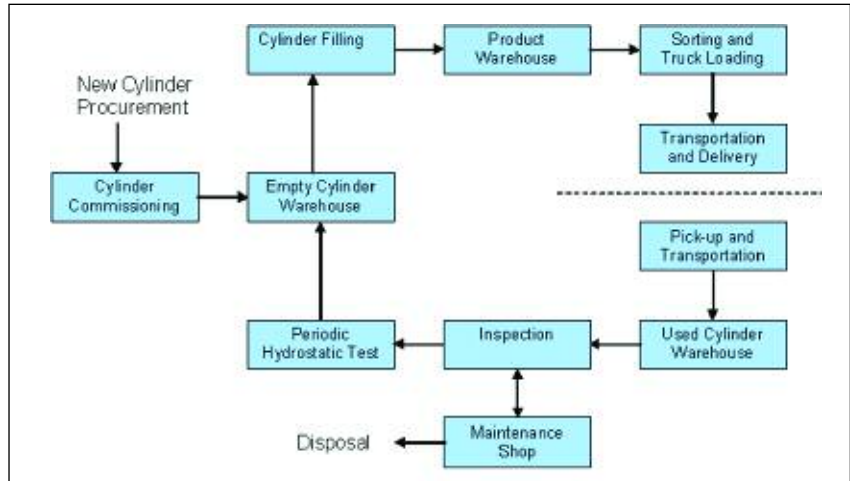


Figure 1. Cylinder Life Cycle

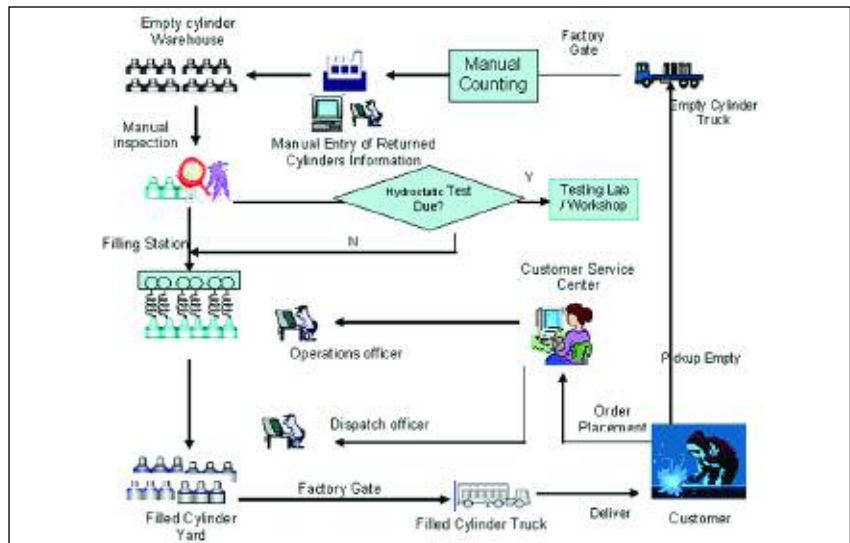


Figure 2. Gas Cylinder Business—Process Flow

- ing due date, which is a time consuming task.
6. The current system results in discrepancies in customer's and company's cylinder holding records because of manual counting and human errors in communication.
7. Cylinder audit or census is extremely difficult as companies have to dig up records to locate the company-owned cylinders.
8. Many times the cylinders which are condemned, or identified as lost or stolen are not reported in the system, which leads to inaccur-

cy in records.

9. Many times the dealers/distributors indulge in malpractices which are difficult to track in the present system, as cylinders are not uniquely tagged and their information can be manipulated.
10. The accounting procedure in the present system is time consuming since the dispatch and warehouse officers have to upload the record of each customer manually after deliveries. This may also result in errors that are difficult to track.
11. The present system does not offer a fool-proof check for pre-

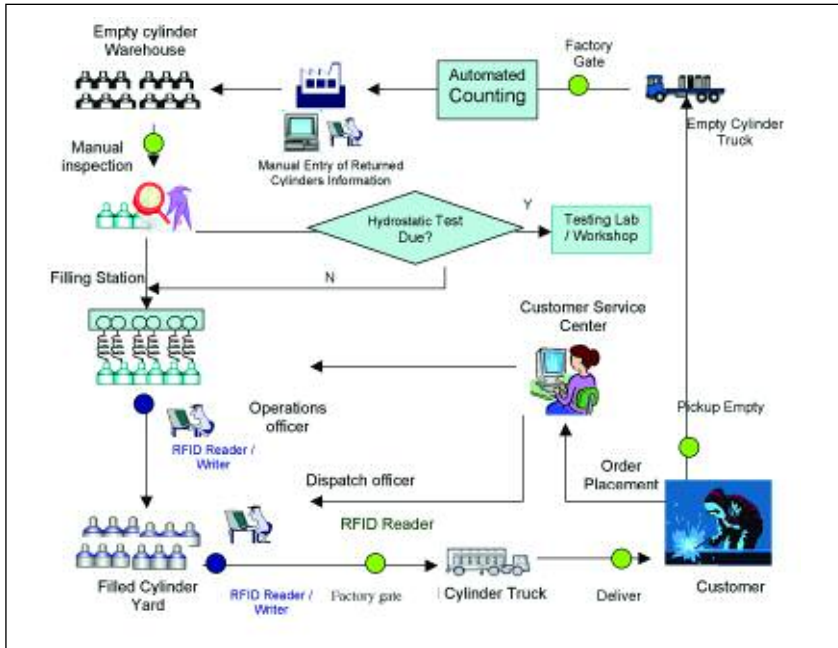


Figure 3. Gas Cylinder Business—Process Flow

venting the wrong gas to be filled in the cylinder. This is a major safety issue.

Moreover, the information about the cylinders is dispersed in multiple systems depending on the supply chain step in cylinder movement. The asset management system might contain the information about the cylinders owned by a company (as the assets) as well as the maintenance records of the cylinders. The information concerning the filled cylinders in warehouses might be maintained in the production and inventory control systems. The information related to cylinder delivery, pick-up or transit may be maintained in the logistics systems.

Thus the current manual or semi-automated systems may result in errors and have an economic impact on the company operations. A company may not have accurate visibility of productivity per cylinder. The accounting discrepancies may result in dissatisfaction among customers. Overall a company has a huge investment in cylinders but may not have requisite information to optimize and

utilize that asset.

We believe that industrial gas companies would benefit by a cylinder

The characteristics of RFID allow it to be easily adopted and integrated with any object that can be tagged—even living beings.

management system in which RFID enabled cylinders can be identified and tracked during their entire life cycle.

RFID

RFID is a data collection technology that uses electronic tags to store identification data along with a wireless transmitter and/or reader to capture it. An RFID tag is the size of

a postage stamp and has contained within it, a minute microprocessor with storage capability, as well as an antenna that communicates with the network and ultimately a database. The characteristics of RFID allow it to be easily adopted and integrated with any object that can be tagged—even living beings.

Production and Warehouse Management

An RFID read/write tag can be conveniently attached to the cylinder collar or neck. It can hold information about the cylinder as a unique item: the product code; testing status; testing schedule; the date of last filling; the customer code; and other relevant information like what the cylinder contains once it is filled.

A cylinder filling station handles a wide range of cylinders having different product assignments. An RFID reader attached to a filler point can read the RFID tag on the cylinder and can ensure that a wrong cylinder is not used. The filled cylinders can also be tracked in the warehouse. At the time of dispatch, the filled cylinders can be accurately identified and dispatched using RFID tags. The dispatch information can be updated on the RFID tags as well as in the cylinder management system. RFID can help in controlling the cylinder inventory, eliminate cylinder losses, reduce rental costs, allocate costs to cost centers and forecast future needs—all with minimum effort.

Customer Consumption and Holding Monitoring

The individual customer's consumption pattern can be conveniently monitored by using RFID. Since RFID can record and store the exact time of cylinder delivery and pick up, an analysis over a period of time for an individual customer can help in generating important reports for that customer, such as their average

daily consumption, variations on specific days, the average cylinder holding of the customer per month, the cylinder turnaround ratio for that customer, etc. Such information can help in managing just-in-time deliveries and the better utilization of cylinders. Also, companies would know the exact number of cylinders the customer would be holding at any instant.

Cylinder Records

For safety reasons and regulatory purposes, all gas companies need to keep a maintenance record of cylinders, since these are high pressure cylinders handling different gases. An RFID tag attached to a cylinder can hold information about its unique item number, which can be correlated with cylinder procurement, movement, maintenance and testing records. Thus, before any process with the cylinder, data accurately identifying the cylinder and associate past and present activity records can be checked, and each cylinder life cycle can be accurately tracked. This would enable one to deduce information like cylinder life, based on maintenance history, idle time, testing history, and corrosion records for each individual cylinder.

Cylinder Stock Taking

One of the most frequent problems gas distributors, manufacturers and consumers come across are the discrepancies between them in the cylinder records, leading to commercial issues regarding cylinder holding and cylinder rental charges. Often, such problems arise from manual errors in counting or record keeping while loading/unloading of cylinders. At times, there may also be a mismatch between the number of filled cylinders delivered and empty cylinders picked up from the customer. RFID can improve data reconciliation and result in im-

proved credibility and customer satisfaction.

RFID Based Cylinder Tracking

A cylinder tracking system using RFID will have different elements:

1. RFID read/write tags attached to cylinder collar/neck; these tags can be attached to every new cylinder being procured. The tags may need to be maintained and replaced a few times during the cylinder life cycle.
2. Tag reader devices that may be mobile or fixed at various locations;
3. The software applications that interface with the reader are for item identification, location identification, movement tracking, information updates, etc. Such software applications would need to talk to or be part of business process applications like ERP, Asset Management, Supply Chain and Logistics, etc.

There would also be additional requirements for networks, mobile devices, application integration, etc.

Figure 3 illustrates the positions where RFID readers can be used to capture and input the data pertaining to a cylinder. In the beginning, all the cylinders are equipped with RFID tags. These tags may be read-only or read/write tags. The read-only tags have a unique tag code that can be linked to a cylinder item number at the beginning of the process. The read/write tag will have the cylinder item number too, and can include the product code along with more dynamic information such as filling pressure, date of filling, etc. Additional data could be product properties as well as MSDS information.

An RFID tagged cylinder management application would work as following:

- 1) An empty cylinder from a warehouse is read by a reader before it enters the filling station. The reader reads the cylinder ID and the RFID supplies the maintenance status (for example the due date of hydrostatic test for that cylinder). The operator would get an alarm if the cylinder is due for testing and such a cylinder would be sent to the workshop.
- 2) As the empty cylinder arrives at a filling point, the reader at the filling point reads the tag ID or cylinder item number to ensure that the correct cylinder is being filled.
- 3) Once the cylinder is filled, it moves to an RFID writer point where the additional information like date and time of filling, cylinder pressure, etc. can be written on the RFID tag. The cylinder can then move to the warehouse.
- 4) The inventory control system would have accurate information about the cylinders in the warehouse based on the filling station as well as the dispatch data. Additionally, a moving reader can facilitate periodic stock-taking in the warehouse.
- 5) Based on the delivery orders and priority reports generated by the CSC, the dispatch officer prepares a dispatch plan for the supplies and uses an RFID writer to enter information such as customer code, date and time of dispatch, truck number, and cylinder count in the RFID tag, and informs the shipping department to load the cylinders on the truck. The dispatched cylinder information can also be loaded onto the mobile device carried by the truck driver. The loaded truck can proceed for delivery to the customers.
- 6) At a customer location, the driver unloads the cylinders corresponding to the delivery order by reading the cylinder tag. While

collecting empty cylinders, the driver reads the cylinder tags with his mobile device and credits the customer with the cylinder. The driver makes a delivery note for the customer and prints it through a portable thermal printer that can be integrated into the handheld mobile device.

7) The empty cylinder laden truck comes back to the factory. During the cylinder unloading, the cylinder data can be read by the readers and the warehouse system can update the cylinder information by downloading the entire cylinder data captured in the driver's mobile device into the in-house database.

Conclusion

Implementing RFID will require an investment in the tags themselves, in the readers/writers and the software; additional investment is needed for carrying out the project and integrating the new system with existing IT systems.

However, in addition to all the benefits of using RFID outlined above, there are safety and compliance issues that can be considered in calculating a company's ROI. Unlike bar coded cylinders, the rugged RFID gives an alarm when maintenance and testing is due, eliminating the need to physically examine the cylinders. RFID also insures that the

wrong gas is not filled into the wrong cylinder and delivered to the wrong customer. This tracking system enables better compliance with government regulations regarding products, product packaging and traceability and promises greater efficiency in complying with future government regulations.

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