RADIO FREQUENCY IDENTIFICATION APPLICATION FOR CONSTRUCTORS

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Abstract: This paper describes the use of radio frequency identification (RFID) for use by constructors as a way to improve the efficiency of construction site operations. An overview of the technology is initially provided. Next, a pilot test related to jobsite material receiving was conducted as part of a Construction Industry Institute research project to investigate the usefulness of this technology in the construction sector. This test demonstrated the usefulness of this technology, in particular, its more robust nature compared to bar code labels. Moreover, RFID's added feature of data storage was also found to be beneficial during the material receiving process as it reduces the likelihood of scanning a tag more than once. Limitations related to this technology are also presented.

Keywords: Radio Frequency Identification, Tags, Transponders, Material Receiving

1. INTRODUCTION

Radio frequency identification (RFID) refers to a branch of automatic identification technologies in which radio frequencies are used to capture and transmit data from a tag or transponder. These tags are typically affixed to assets to assist in the identification and tracking process. Specific applications have already been developed in many areas such as vehicle access, personnel identification, asset tracking, livestock identification, and tolls and fees [1]. Development is currently underway in areas related to baggage handling in airports and grocery labeling. RFID technology, unlike bar code labels, is more robust in the sense that tags do not get damaged as easily and can be read in direct sunlight and other harsh conditions. RFID tags also have the ability to store data and retrieve it at a later time. This technology has significant potential in enhancing several processes in the construction industry. The next section provides an overview of the technology.

2. TECHNOLOGY OVERVIEW

RFID technology involves the use of tags or transponders that can collect data and manage it in a portable, changeable database within the tag; communicate routing instructions and other control requirements to equipment; and withstand harsh environments. These tags are classified as active or passive tags and may have read-write or read-only capability. Passive tags are powered solely by the magnetic field emanated by the reader. Active tags, on the other hand, contain a battery that powers the tag. Active tags can be read or written to from greater distances because of the battery; however, active tags are generally more expensive than their passive counterparts and have a limited 3-10 year life. Passive tags, on the other hand, have an unlimited lifetime. Some active tags are being produced that use the incoming radio signal to recharge their internal battery, extending their life beyond 10 years [2]. Read and write ranges for passive tags are generally less than six feet; in most configurations, the read range is only 2 to 12 inches.

Read-only tags are programmed either during manufacture or by the user once during their lifetime. The information programmed onto read-only tags cannot be altered at a later time. Read-only tags are generally used for simple identification purposes and hold approximately 8 to 128 bits of memory. With read-write tags, as the name implies, the user can alter the information stored within the tag. There are also write-once, read many (WORM) formatted tags that are essentially read-only. The user can program them one time after manufacture. The memory capacity of read-write tags varies anywhere from 64 to 32,768 bytes where one byte equals 8 bits of binary code (i.e., "0" or "1"); this represents several pages of text [3]. Figure 1 shows a photograph of a variety of TIRIS RFID tags manufactured by Texas Instruments.

Figure 1: RFID Tags

RFID uses low-power radio frequencies instead of laser light used for reading bar code labels. These broadcasted radiowaves do not require a direct line of sight; they travel easily and do not have to be in contact with the device that reads the radio signal. The information read by this handheld reader would then be downloaded to the facility information system. Figure 2 shows a photograph of a typical reader.

Figure 2: Trovan Reader

RFID manufacturers use selected frequencies according to application type. Low frequency systems are generally of low cost, work at close range, and are tolerant of metal and electrical noise. High frequency systems generally cover greater distances, are more directional, and are more sensitive to metallic obstructions.

RFID can be used to speed up the data collection process and reduce the chances of human error. Moreover, while other identification technologies rely on optics and require a relatively clean and moisture-free environment, RFID technology is ideal for dirty, harsh, hazardous environments. RIFD can even survive temperatures ranging from minus 40 centigrade to 200 degrees centigrade [2]. The technology is also very reliable and can operate flawlessly for an extended period of time. Passive tags have an extremely long life and usually last longer than the object itself, making it suitable for use in hazardous waste material container tracking and identification.

3.RFID TAGS USED FOR MATERIAL RECEIVING ON A JOBSITE

The following section provides a description of how RFID technology can be used by the construction industry. A pilot test was conducted to better understand this technology's capabilities from a contractor's points-of-view as related to material receiving on a jobsite.

The Red Hills Generating Facility, a $338 million power plant project located in Ackerman, Mississippi (USA), was selected for this pilot test to assess the potential for using RFID tags. The material receiving process plays a significant role in the construction process and provides a reasonable application to test this technology. Pipe hangers were chosen as the material items to track using RFID technology since these materials are difficult to track due to their varied types and sizes. Key participants in the test included Bechtel Power Company, Safetrac-SAT (RFID supplier), and Piping Technologies (pipe hanger and support supplier).

3.1 Manual Pipe Support Receiving Process

The manual approach begins when the hangers first arrive to the site; forklifts are typically used to off load the trucks with their palletized pipe hangers and place them in a designated laydown area. Next, one or two workers unpack the pallets separating the hangers and spreading them out on additional pallets in a process called "shucking". Once the pipe hangers have been shucked, workers physically "kick and count" the hangers and check them against the

packing list. Each hanger has its own unique identification number that can easily be found by the field material inspection team. Once this kick and count procedure is completed, a manual entry of the received items is made into the Bechtel Procurement Tracking System (PTS). One person is responsible for entering all pertinent information from the packing list into PTS. A material receiving report is then prepared and distributed to the on-site field engineers who can then plan for the hanger's use in the facility.

3.2 RFID Approach to Receiving Pipe Supports

With the RFID approach, an RFID tag is placed on the pipe support at the supplier's fabrication plant. Pallets are still unloaded and shucked as with the manual approach. Workers use a Telxon reader to read and write information to the tag. The Telexon reader is a very flexible computer in terms of its windows interface. It also has an RFID tag reader on the right hand side of the unit. Workers were trained in the use of the equipment prior to the test. Using the RFID approach, only one worker is required to kick and count the pipe supports instead of two using the manual approach. The worker scans the tag and populates the screen with information related to the pipe hanger's purchase order number, release number, and requisition number. Three questions were answered related to the quantity, the condition, and the storage location of each hanger. This information was then written back to the tag for later use. Once all tags had been scanned, the last step in this process involved saving the file that has all tag information and downloading it to the procurement tracking system (PTS).

4. RESULTS

During the actual pilot test, it took two workers approximately 35 minutes to open up all the plastic wrap for 69 pipe hangers stored on pallets. Of the 69 hangers received to the site, only 28 of them had RFID tags. It took the two workers 17 minutes to verify the receiving of those 28 items using the manual approach. The receiving process was repeated for the same 28 items using Telexon unit to read and write to the tags attached to the pipe hangers. It took approximately fifteen minutes to train the workers to use the Telxon unit and begin the scanning process. Figure 3 shows a photograph of a worker using the RFID approach to receive pipe hangers.

Figure 3: RFID Approach used to Receive Pipe Hangers

Overall, it took the same receiving team 52 minutes to check the same number of hangers or about 1.85 minutes per pipe hanger. It should be noted that this time is not fairly indicative of the actual time necessary for reading RFID tags because it included providing instruction, answering questions, and practice. As the workers improved their abilities to use the RFID reader, the time recorded per tag dropped to approximately 40 seconds. Although, this particular test did not involve an actual download to PTS, it is estimated that there would be considerable time savings related to this step. In another pilot test, this will actually be performed and will be reported on during the final presentation.

5. LESSONS LEARNED

Overall, the material receiving workers were impressed with RFID technology and could see this technology more broadly adopted by the construction industry. RFID tags were easy to read as they were not hampered by direct sunlight (a complaint commonly heard with bar code labels). Also, it was not possible for the workers to scan a tag twice without knowledge of their mistake since all fields are already populated in a tag that has already been scanned. Another pilot test will take place at a later date and these results will be presented later. Some improvements are necessary for future pilot tests and are discussed as follows:

- Spend time training workers on how to use the RFID system before the test begins not during. This will facilitate the test evaluation process.
- Streamline the software by considering pull down menus for values and allowance to write back to the tag once.
- Evaluate more than 28 hangers during the next test.

- Actually perform the download to the PTS system.
- Use plastic ties to attach RFID tags to pipe supports. Wire ties interfere with the antenna signal if they are wrapped across the top of the tag.

6. BENEFITS

The primary benefits of using RFID are its ability to operate in a non line-of-sight capacity and to store data in a changeable database. In a sense, bar codes are a passive technology, while RFID is active. Another benefit to RFID technology is its ability to be used in harsh conditions. Sunlight can interfere with the bar code scanner whereas this is not the case for RFID technology. If active tags are used, then the scan range increases making it an even more versatile technology.

7. LIMITATIONS

The primary limitations that the research team experienced with this technology related to its read distance and interference with metal objects. The actual read distance was approximately 1-3 inches. This required the worker to bend down and get within close proximity to each tag in order to both read and write to the tag. The workers complained of sore knees after the pilot test was completed. Also, metal objects such as the wire ties used to attach the tag to each pipe hanger created interference that made it difficult to read and write to tags. This was particularly the case when the wire tie was wrapped across the top of the tag. In these cases, the reader antenna had to be positioned underneath the tag in order to properly scan the tag.

8. CONCLUSIONS

Radio frequency identification is becoming more popular as a tagging and identification technology. Aside from its relatively large storage capacity (compared to bar codes) it is very reliable and more robust in harsh environments. Tags can be attached to many types of objects including hazardous waste storage containers. This technology also has a high level of security as it is nearly impossible to replicate tag information. Several applications have already been successfully developed using this technology. It appears that RFID can be a promising technology for enhancing construction operations related to material receiving and also possibly other operations related to maintenance and operations.

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