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Bar coding and radio frequency data communications in industrial gas manufacturing

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**BAR CODING AND RADIO FREQUENCY DATA
COMMUNICATIONS IN INDUSTRIAL GAS MANUFACTURING**

by

Patricia Ann Wolfe

**A Thesis
Presented to the Graduate Committee**

of Lehigh University

in Candidacy for the Degree of a

Master of Science

in

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1990

CERTIFICATE OF APPROVAL

This thesis is accepted and approved in partial fulfillment of
the requirements for the degree of Master of Science.

September 11, 1990
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Table of Contents

	<u>Page</u>
Abstract	1
I. Introduction	2
II. Industrial Gas Application	4
A. Business Function Overview	4
1. Product Line Overview	4
2. Cylinder Life-Cycle	5
3. Existing Computer Environment	10
B. Productivity Improvements, Cost/Benefit Analysis	12
III. Solution Design and Selection Process	18
A. Auto ID Selection	18
B. Equipment Technology Selection	20
C. Vendor Selection	22
IV. Technology Overview	30
A. Bar Code Definition	30
B. Scanning Devices	31
C. Hand Held Terminals	34
D. RF/DC Basics	35
1. Protocols	35
2. Response Time Factors	37
3. Site Survey	39
V. Hand-Held Application Overview	41

Table of Contents

	<u>Page</u>
VI. Summary	47
VII. Direction for Future Research and Development	52
VIII. Conclusion and Recommendations	55
IX. Bibliography	58
Appendices	
A. Bar Code Symbologies	61
B. Sample Application Screens	69
Vita	100

List of Figures

<u>Figure Number</u>	<u>Title</u>	<u>Page</u>
1	Specialty Gas Cylinder Life-Cycle Diagram	9
2	IGD Network Map	11
3	Cylinder Characteristics and Label Placement	19
4	RF Processing Overview	42
5	Radio Frequency Terminal Environment	43
6	Specialty Gas Cylinder Life-Cycle Diagram Illustrating Bar Code Application	44

ABSTRACT

In industrial gas manufacturing, individual specialty gas cylinders are tracked by serial numbers to provide an accurate picture of production and maintenance history for each cylinder. This information is very valuable and necessary in determining possible causes of contamination of the contents of the cylinder, and accurate identification of the cylinder contents in cases where the labels on the cylinder are unreadable. If a problem would be discovered with a particular cylinder, any others that were filled from the same source can be identified. To date, the task of tracking cylinders by serial number has largely been a manual effort. This effort has proved to be labor intensive, error-prone, costly and untimely.

In September, 1989, a system was implemented that identified each cylinder number by bar code. Utilizing radio frequency data communications to transfer data to the host computer, information about the cylinder throughout the manufacturing process is collected in real-time transactions. This thesis project documents the step-by-step process used to select the technology, equipment and vendor to successfully track cylinders through the in-plant manufacturing life-cycle. The resulting application not only provides an automated, low-cost, relatively error-free method of identifying a cylinder, but also a tool that aids in production scheduling, promotes timely accurate inventory control, and establishes a basis for empty cylinder inventories for both the corporation and for individual customers.

I. INTRODUCTION

Bar Code. The name most frequently brings to mind the universal product codes (UPC) found in grocery stores, department stores and almost all types of retail merchandising.

In reality, automatic identification using bar codes has touched nearly every facet of business possible. Bar code is an extremely effective communications tool that provides a highly accurate means of collecting data for just about anything. Bar codes are used extensively in item tracking, inventory control, time and attendance recording, monitoring work-in-process, quality control, order entry, document tracking, security access, shipping and receiving, warehousing, route management, and as patient care aids from tracking medicinal usage to patient billing.¹ Bar code usage generally increases productivity, creates cost savings and improves business operations.²

After bar codes are scanned, the data is transmitted either to a CRT terminal, PC/workstation or a hand-held terminal. Batch type hand-held terminals collect data within the terminal itself and transmit data via RS232 cable to a host at the discretion of the operator. Real time hand-held terminals use radio frequency to transmit data in an on-line mode. This type of technology is rapidly gaining in popularity. It provides great flexibility in using computer terminals in areas where cabling is too costly or prohibitive because of environmental factors.

¹ AID News Directory, p. 6

² AID News Directory, p. 6

This thesis will first describe an industrial gas application which manually tracks cylinders through the manufacturing process. The document will then concentrate on describing the procedures used to implement bar coding with radio frequency data communications to transmit data about activity performed on a cylinder at various stages of its manufacturing life-cycle. In the remaining sections of this thesis, this technology will be explained in detail beginning with the basis behind a bar code. Different types of portable hand-held data collection devices and scanners, used to read bar codes, will be defined. Also, radio frequency data communications (RF/DC) will be explained and evaluated. Finally, a summarization of the implementation process and current project status will be given.

II. INDUSTRIAL GAS APPLICATION

A. Business Function Overview

1. Product Line Overview

The manufacturing application that will be presented centers on tracking industrial gas cylinders through the manufacturing life-cycle while at the producing facility. The industrial gases that are manufactured are high purity specialty gases (straight gases) and gas mixtures of 2 to 20 components.

There are approximately 80 different straight gases that can be produced. These gases are classified in different grades or purities. Each grade is available in many different sizes of cylinders. Most straight gases are stocked and orders are filled from stocking levels. Order quantities range from 3 or 4 cylinders to several hundred cylinders. Many times customers own their own cylinders and send these to be filled. Some customers require a non-standard preparation of the cylinder before it is filled, or request a special valve be used. Other times customers require the gas in the cylinder meet their analytical specifications instead of the established corporate standard specifications. All these special requirements constitute a made-to-order (MTO) situation and proper communication between all areas of the manufacturing plant is critical if these MTO items are to be properly produced and packaged.

Mixes are also manufactured in different types or classifications. Each type may be produced in different sizes. The special considerations that exist for straight gases also apply to mixes. There are only about 12 to 24 standard mixes that are produced on a regular basis and stocked. These common mixes are used in businesses for functions such as emission control testing. These made-to-

stock (MTS) mixes are usually sold in quantities from 10 to 50 at a time. Most mixes, however, are made-to-order and only 1 or 2 are ordered at a time. There have been over 18,000 different specific mix concentrations of various gases manufactured at least once and many have only been produced once.

2. Cylinder Life-Cycle

A typical manufacturing life-cycle for a cylinder begins when it is received at the producing facility. Cylinders are unloaded and sorted into bins. Straight gases are sorted according to what product was last in the cylinder. Mixes are sorted by what type of mix it was, i.e. flammable, inert, etc. Identification of what was last contained in the cylinder is done by interpreting the color of the neckring (the metal ring which constitutes the top of the cylinder), and interrogating the shoulder decal on the cylinder itself. See Figure 3 (page 19) for a pictorial representation of the cylinder components. Customer-owned cylinders are all moved to a separate area. Identification of these cylinders is more difficult especially if the customer has sent cylinders for the first time. Many times there are no distinguishable markings on these cylinders which identify a specific customer. If the customer placed an order before the cylinders were received, a copy of the order is taped to one of the cylinders in the group and they are moved to another holding bin. If the order has not been placed, the cylinders remain in this bin until the order is received. Cylinder serial numbers are manually recorded for these cases: (1) If a common carrier delivered the empty cylinders, the serial numbers are written on the back of the bill-of-lading, or on a separate piece of paper; (2) Export cylinder serial numbers are recorded on a "District Cylinder Return Log Document"; (3) Customer-owned serial numbers are recorded on a "Customer Owned Cylinder Log Document; (4) If the

cylinders are returned goods, the serial numbers are written on a production fill sheet and placed in the lab for retesting or on the full dock for resale.

After a production schedule has been formulated, empty cylinders are selected and inspected. Cylinders are first checked to see if they need to be 'hydrostatically tested'. Cylinders are tested every 5 or 10 years, depending on the type of cylinder. The date the cylinder was tested is stamped into the shoulder of the cylinder. Cylinders may also need some kind of maintenance performed, i.e. painted, shotblasted etc. Most cylinders go through reconditioning (recon) which consists of filling the cylinder with an inert gas and evacuating it again to purge outside contaminants from the cylinder. Residual product that needs to be removed may be transferred back to a bulk supply source in the fill plants, dumped by the residual gas disposal unit, or purged in the recon process.

Cylinders that can be top-filled and do not need any maintenance or testing, are moved directly to a fill area. Cylinders requiring hydrostatic testing are purged of all residual product, devalved, tested, shot-blasted and painted if necessary, valved and then sent to the recon area. Cylinders not requiring testing are purged of residual product, sent to recon, and then shot-blasted and/or painted if necessary. There are no serial numbers manually recorded in this area.

Once the cylinder has gone through maintenance and recon, it may undergo further preparation if the cylinder is to be used for the electronics industry. This process involves a thorough cleansing of the inside of the cylinder to remove any material that may contaminate the final product. When all preparation is

complete, a cylinder goes to a fill area to be filled. Before filling, a fill operator manually records each serial number onto a production fill sheet. All special notes, fill volumes, residual volumes, product, grade, other information about the cylinders such as size, and any problems encountered during the fill process are also recorded on the fill sheet. After a cylinder is filled, it is moved to the laboratory for testing or to the full dock if no testing is required. The fill sheets are given to a data entry clerk to be entered into the computer system. This computer application processes orders, maintains production and inventory control, and maintains history and analytical data about each cylinder. All data is entered via CRT terminals from the various documents and paperwork. The serial numbers are manually typed as they are visually interpreted from each document. More detail about the existing computer environment is given in a later section.

If the cylinder needs testing, it is moved to the laboratory. Testing determines if the contents of the cylinder meet the purity level for a straight gas, or meet the required blend concentration level for mixes. The results of this analysis are first recorded onto the fill sheet and then given to a data entry clerk for subsequent entry into the computer. If the cylinder passes the test, it is moved to the full dock and stored in bins according to product. Rejected cylinders are downgraded to a lower grade if possible, or the contents are dumped and the cylinder starts the life-cycle over again. Sometimes a cylinder is used as the raw material supply source for a mix or smaller cylinders, or it is used within the plant in some other capacity. When this is done, the person using the cylinder fills out a 'withdrawal' card and gives it to a data entry clerk who in turn enters this information into the computer.

In the shipping area, regular delivery trips and common carrier routes are planned based on required shipping dates and product availability. A copy of an order line item that is ready to be shipped, is given to a shipping cylinder handler. The handler records the serial numbers on the order document and moves the cylinders to the loading area. The order document is handed to a shipping clerk who enters the serial numbers into the computer indicating which cylinders were being sent to a specific customer for that order line item. This process is referred to as 'allocating' a cylinder to an order. If any cylinders that were selected for an order do not pass the validation in the computer application, (i.e. wrong grade of product, not analyzed, etc.), the clerk must instruct the cylinder handler to find the incorrect cylinder and substitute another one. Some product requires that a certificate of analysis (C of A), be sent to the customer. This document states what analysis was performed on the cylinder which proves the gas in the cylinder meets the proper specifications. By tying the cylinders to the line item, the customer's name, address and other order information can be printed on the C of A along with the analysis of the cylinders that actually were sent to the customer. The cylinder is then loaded onto the truck and delivered. When the customer returns the empty cylinder, the process begins again. A diagram of the complete cycle is shown in Figure 1.

The manual tracking of cylinders through the plant is very time-consuming, error-prone and paper-driven. Approximately 10% of the cylinder information is estimated to be in error due to the fact that from the time a cylinder is received until it is shipped, the serial number is recorded several times by different people. Each person's interpretation of the serial number can be different,

Specialty Gas Cylinder Life-Cycle Diagram

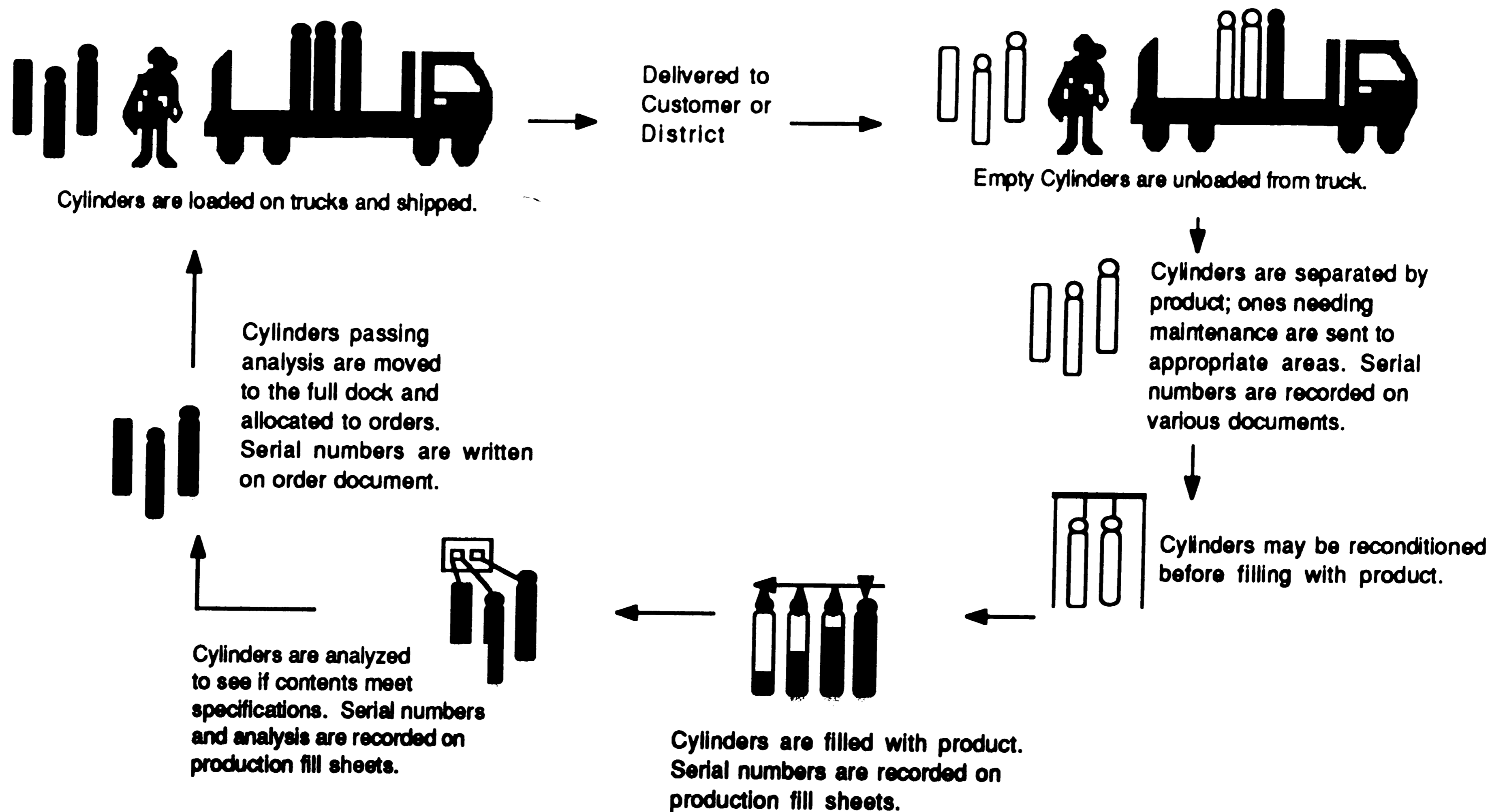


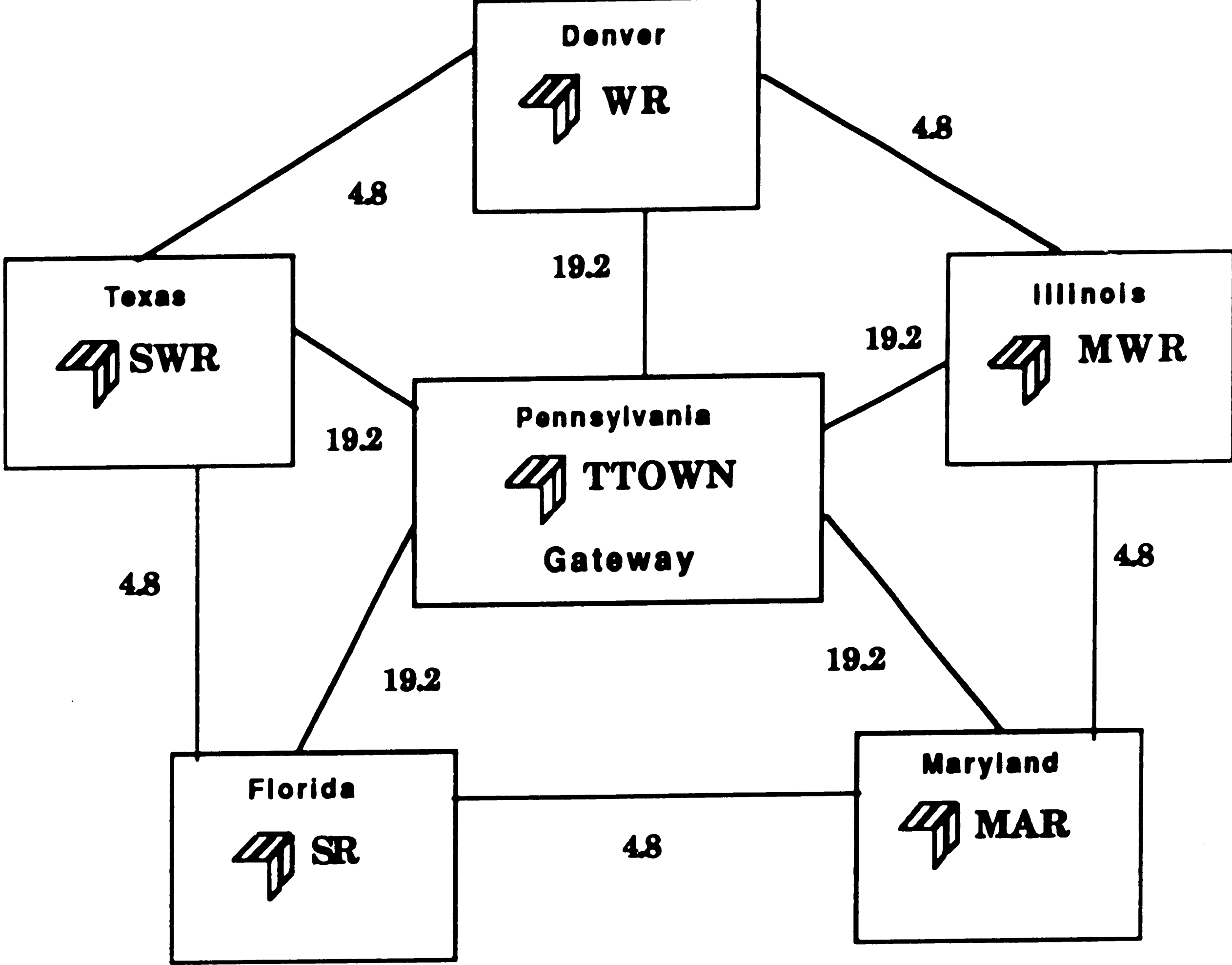
Figure 1

especially if the serial number is difficult to read. Each person may also transpose numbers within the serial number itself when it is written. It takes extra time deciphering serial numbers, writing them on documents and tracking customer-owned cylinders and "specials". About 20 hours a week are needed solely to insure customer-owned cylinders are properly handled. Another 60 hours a week are needed to enter the serial numbers into the computer to collect histories and print certificates of analysis. Another problem that was encountered is tracking duplicate serial numbers. Some cylinder assets acquired through purchase of another industrial gas manufacturer had identical serial numbers as ones already in use. A better way to track cylinders had to be found.

3. Existing Computer Environment

This manufacturing facility is a member of a distributed computer network consisting of one Tandem NonStop VLX and five NonStop EXT25 mainframes linked by Tandem's EXPAND networking software. Each of these computers is thought of as a "node" in the Industrial Gas Division (IGD) Network. Locations are attached to one of the nodes using multidrop data circuits. A location is physically attached to the data circuit by a modem (typically running at 9600 baud) and a Tandem 6600 cluster control unit. Terminals, PC's emulating terminals, and printers are cabled to the 6600 control unit. The protocol used to handle data communications is SNA. This protocol is implemented using Tandem's SNAX SNA software. Figure 2 shows the actual network configuration.

IGD NETWORK MAP



Location
NODE

XX = Line Speed
K Baud Rate

Figure 2

There are approximately 80 locations using this network, 6 of which are specialty gas producing facilities which will eventually be using the automatic I.D. technology chosen for tracking cylinders. Each of the six specialty gas facilities is located on a different node.

B. Productivity Improvements, Cost/Benefit Analysis

A project team was formed to look at improving the current cylinder tracking process. An accurate and automated method of identifying each cylinder has many benefits:

(1) Improve the quality of cylinder data - By eliminating the need to manually record serial numbers and subsequently type each one into a CRT terminal, errors associated with mistyping, misreading and misrecording of serial numbers would be virtually eliminated. Duplicate serial numbers can be traced in a unique fashion. It is estimated that approximately 10% of cylinder data is recorded incorrectly per location. 10% of the total specialty gas cylinder population equates to roughly 12,000 cylinders. It is also estimated that it takes on the average about 10 minutes to investigate and correct each cylinder data error. Therefore,

$$12,000 \text{ cylinders} * (10 \text{ minutes}) / 60 \text{ minutes} = 2000 \text{ hours}$$

The 2000 hours saved per year assumes that the entire population of cylinders has gone through one complete cycle. Since many cylinders do not go through at least one cycle, the hours estimate will be cut in half to account for the inactivity. By multiplying 1000 hours/year times a dollar amount which represents an aggregate cost of labor, \$30/hour, \$30,000 can be saved. The

other 5 specialty gas producing facilities (satellites) put together, have about 1.3 times the volume as this main facility. Therefore the total savings is :

$$1.3 * 30,000 + 30,000 = 69,000$$

(2) Reduce cost of tracking cylinders - On the average, it takes about 10 to 15 seconds to locate the serial number on the cylinder and write it on a document. Many serial numbers are not completely identifiable because of undergoing repeated shot blasting and painting. In these cases, visually determining what the actual number is, takes longer. Identification of a serial number is instantaneous using an automated method. A complete transaction would take approximately 3 seconds with an on-line hand-held terminal. In the worst case, 7 seconds/cylinder would be saved, and on the average 9 to 10 seconds/cylinder would be saved. About 275,000 cylinders are filled per year at the main specialty gas facility. If 10 seconds are saved per cylinder, then

$$275,000 * 10 \text{ seconds} / 3600 \text{ seconds} = 764 \text{ hours}$$

By taking our arbitrary dollar amount , \$30, times 764 hours, a total of approximately \$23,000/year can be saved. However, a cylinder relabelling factor must be considered. If 10% of cylinders must be relabelled, and assuming it takes 15 seconds to relabel a cylinder, then approximately 115 hours would be needed for this task per year. The calculation is as follows:

$$27,500 * 15 \text{ seconds} / 3600 \text{ seconds} = 115 \text{ hours}$$

By using the \$30 hourly rate, about \$3450 would be needed to maintain the labels, therefore the \$23,000 would be reduced to \$19,550.

Also 1 1/2 people can be eliminated because they do not have to enter the serial numbers into the computer after they are filled. Therefore,

1.5 persons at \$30/hour * 40 hrs/wk * 52 wks/yr = approximately \$90,000

The total annual savings at one facility for this benefit is roughly \$109,550. By including the satellite savings (1.3 * 109,550), a grand total of \$251,965 can be saved in this area.

(3) Facilitate Accurate and Timely Inventory Control - Since serial numbers are recorded on a fill sheet and later entered into the computer, inventory levels only reflect what data has been entered. If the data could be captured at the time the cylinder was filled or analyzed, inventory would be up-to-date. Since automatic identification of cylinder movement would be virtually error-free, inventory accuracy would be improved. A definite dollar amount savings estimate is difficult to determine for this benefit because of the highly subjective nature of accurate inventory.

(4) Establish empty cylinder inventory control which would improve production scheduling - No empty cylinder inventories were maintained because it was considered too time-consuming and costly. A visual check of the number of cylinders on the empty dock was done before production schedules were formulated. Even this was not as accurate as it would seem because some empty cylinders might have to be hydrostatically tested before they can be prepped for filling. This fact can't be determined by a visual scan of the empty cylinder dock. No dollar amount is associated with this benefit because the full benefits of having this information is not known.

(5) Assist district operations with the Specialty Gas product line - Specialty Gases are primarily produced at several main facilities within the corporation.

Other locations (districts) that primarily produce lower grade industrial gases, also produce some lower grade specialty gases. Automatic identification of cylinders would provide a feasible way to implement inventory control and container tracking for specialty gases at these facilities. Equating a dollar amount to this benefit is extremely difficult because of varied stocking levels maintained and cylinder handling procedures done in the various districts.

(6) Improved Tracking of Customer Owned Cylinders - Customer-Owned cylinders are very difficult to track because there are not very many features on these cylinders that readily distinguish themselves as belonging to one customer or another. Accurate cylinder histories and reliable identification would facilitate routing these cylinders through the plant and better insure proper handling of these cylinders. Currently, about half of one person's time is spent tracking customer owned cylinders. Therefore, at our arbitrary labor rate of \$30/hour, about \$30,000 can be saved:

$$\text{\$30/hour} * 20 \text{ Hrs/Wk} * 52 \text{ Wks/Yr} = \text{\$30,000}$$

With the satellites' additional volume included, another \$40,000 can be saved, bringing the total savings for this benefit to \$70,000/Year.

The total annual tangible cost savings is:

1. Reduce Cost of Tracking Cylinders	\$251,550
2. Improve Quality of Cylinder Data	\$ 69,000
3. Improve Tracking of Customer Owned Cylinders	\$ 70,000
Total Savings	\$390,550

The equipment initially needed for the project was as follows:

Main Facility

18 terminals @ \$3000	\$ 54,000
1 base station @ 5500	\$ 5,500
4 laser scanners @ 1000	\$ 4,000
14 pencil wands @ 100.....	\$ 14,000
misc costs (battery chargers, cables, antennae, etc.)	<u>\$ 10,100</u>
Total	\$ 75,000

5 Satellites

30 terminals @ \$3000.....	\$ 90,000
5 base stations @ 5500	\$ 27,500
15 laser scanners @ 1000	\$ 15,000
10 pencil wands @ 100	\$.....1,000
misc costs (same as above)	<u>\$ 41,500</u>
Total	\$175,000

The development of the application would cost approximately \$85,000 and the labels would cost \$55,000. Yearly operational costs was estimated to be \$35,000 for hardware and \$10,000 for software maintenance. The program costs can be summarized as follows:

One-Time Costs	Main facility	Satellites
Program Development		
MIS	\$ 85,000	
Cyl Labels	\$ 55,000	
Hardware	\$ 75,000	\$175,000

Total One-Time Costs	\$215,000	\$175,000	<u>\$390,000</u>
Operational Costs			
Hardware Maintenance	\$ 10,000	\$ 25,000	
Software Maintenance	\$ 10,000		
Total Operational Costs	\$ 20,000	\$ 25,000	<u>\$ 45,000</u>

The final Cost/Benefit Summary is as follows:

Total Annual Program Benefits	\$390,550
Total Annual Costs	\$ 45,000
Annual Net Benefits	\$345,550
One-Time Investment	\$390,000

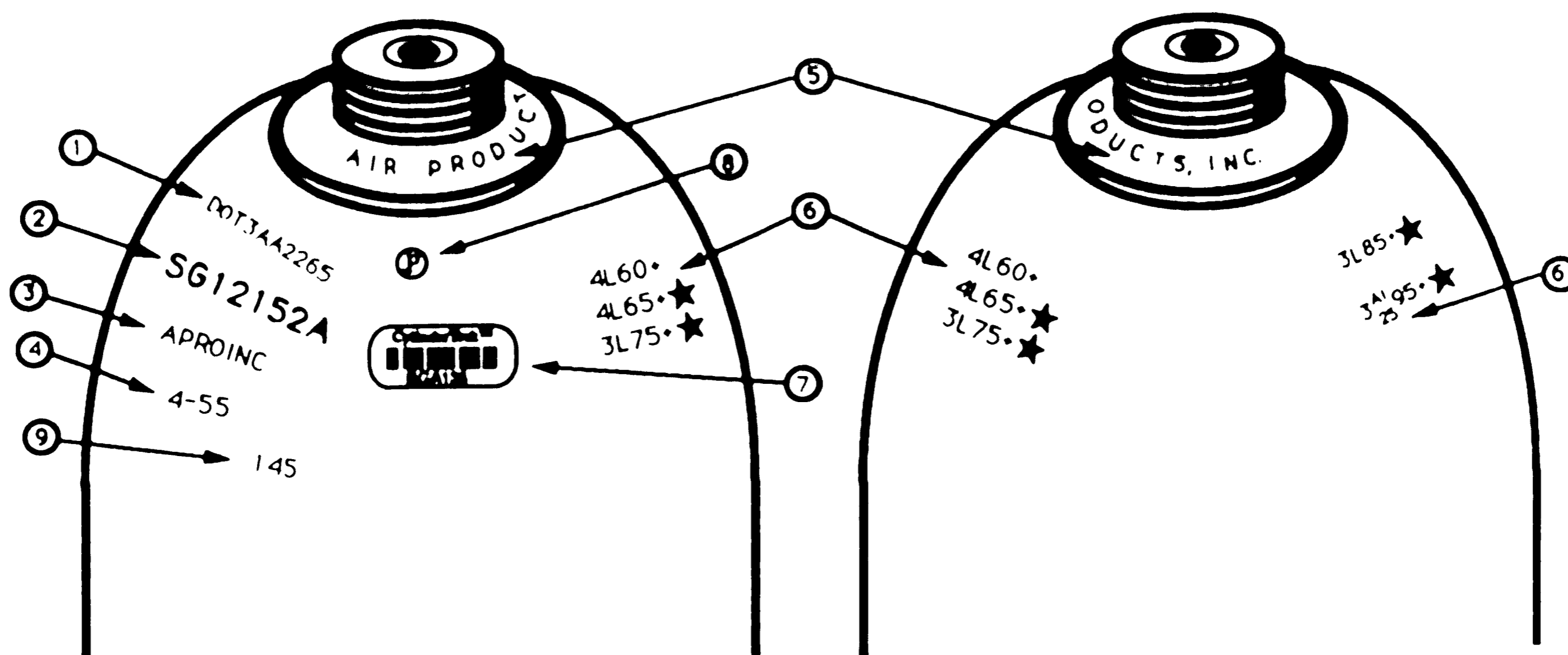
III. Solution Design and Selection Process

Before commencing on designing screens and computer transactions, several key decisions had to be made: (1) What kind of automatic identification of the cylinder should be used? ; (2) What type of data collection device should be used in conjunction with the auto I.D. technology?; (3) What vendor should supply us with the auto I.D. equipment?

A. Automatic Identification Selection

The automatic identification method for tracking cylinders that was selected was a bar code label attached to the shoulder of the cylinder. See Figure 3 for placement of the label. Bar Code definition and a brief history are explained in a later section. Bar Code was chosen first because of an Engineering study conducted within the corporation in the Fall of 1985 that described productivity improvements and cost savings that could be realized through the use of bar code technology applications. Also the Automotive Industry Action Group (AIAG) and the National Welding Supply Association (NWSA) had already published brochures on gas cylinder identification label standards as the recommended way to track industrial cylinders. These standards describe the recommended characteristics of a bar code and depict label placement for various sizes of cylinders. Conformance to these standards is not mandatory, but should be used as a basis in implementing an automatic identification system for gas cylinders. The corporation also has a PC based cylinder tracking system that is used to track cylinders to the customer and back. Within the scope of that application, bar code labels with code 39 symbology were used. A sequence scheme of 3 letters and 3 numbers was designed, i.e. first

Cylinder Markings



- ① **Cylinder Specification:**
 - DOT - Department of Transportation (or ICC - Interstate Commerce Commission) which is the regulatory body that governs the use of cylinders.
 - Specification of the cylinder type and material of construction (ie. 3AA).
 - Service or working pressure in pounds per square inch, PSI (ie. 2265).
- ② **Cylinder Serial Number:**
 - The letters SG precede the serial numbers for Specialty Gas cylinders.
- ③ **Registered Owner Symbol:**
 - Symbol used to indicate the original owner of the cylinder.
- ④ **Date of Manufacture:**
 - This date (month-year) also indicates the original hydrostatic test.
- ⑤ **Neckring Identification:**
 - The cylinder neckring displays the name of the current owner of the cylinder.
- ⑥ **Retest Markings:**
 - The format for a retest marking is: Month - Facility - Year - Plus Rating - Star Stamp
 - The + symbol (Plus Rating) indicates that the cylinder qualifies for 10% overfill.
 - The ★ symbol (Star Stamp) indicates that the cylinder meets the requirements for 10 year retest.
- ⑦ **Bar Code Label:**
 - The bar code label provides a unique cylinder identifier and is used by computer systems to track cylinders throughout the fill process as well as to/from customers.
- ⑧ **Cylinder Manufacturer's Inspection Marking**
- ⑨ **Cylinder Tare (Empty) Weight**
 - This value is sometimes preceded by the letters TW.

Figure 3

label would be AAA000 and the last would be ZZZ999. This label identification sequence would give 17,576,000 unique labels and insure non-duplication of bar code labels in a cylinder population of approximately 1,200,000 specialty gas cylinders. The AIAG standard proposed using the last eight characters of the serial number as the bar code label identification. The NWSA standard proposed using the entire serial number regardless of its length. There are several problems associated with this aspect. Using the serial number as the bar code implies printing labels at the manufacturing facility. It would be a costly, impossible task to pre-print every possible serial number at a printing shop and then find that number amid rolls or sheets of labels when placing a label on a cylinder. And if that one became damaged, how many backup copies do you keep? But printing labels at the producing facility has many drawbacks: (1) There must be an investment in bar code printing equipment. Some smaller locations that only produce lower grades of specialty gases could not afford to invest in this equipment; (2) By using the last eight characters of the serial number, or just the serial number itself, the problem of duplicate serial numbers could not be eliminated; (3) The printing equipment and label material available to print bar codes locally was not of the proper quality to print a very durable, easily readable (by scanner) bar code that adhered well to the cylinder; (4) Printing a bar code right before applying it to a cylinder is more time-consuming and subject to errors than simply peeling off a label from a pre-printed sheet and placing it on a cylinder. Therefore, the decision was made to continue using the labels and number scheme designed in the PC cylinder tracking application.

B. Equipment Technology Selection

Since bar code labels would be used to identify each cylinder, the next decision to be made involved the proper bar code scanning equipment to be used with the bar codes. Several aspects of equipment were considered, batch vs radio frequency terminals, and stationary vs portable terminals. In the first consideration, one must consider cost, ease-of-use, criticality of data and timeliness. Batch terminals cost less, but require an extra step of transferring the data collected into the unit to the host computer and correcting any errors that are encountered that couldn't be detected before the transfer. If the data is such that it can be collected at shift changes or at other infrequent intervals and not hold up normal business operations, then batch terminals may be the proper choice. However, in this cylinder application, timely inventory levels are needed to properly schedule production, process orders and aid customer service. Also, cylinder handlers allocating cylinders would immediately know whether or not a cylinder was appropriate to send to a customer. Cylinders being unloaded could be identified immediately as to the type of gas that it last contained and what district or customer sent it. The extra cost involved with using online radio frequency based portable terminals was considered to be a much needed investment rather than devoting the extra labor into transferring the data into the host computer and correcting errors.

In considering stationary vs portable RF terminals, the decision was made to use portable hand-held terminals. To use stationary terminals, the cylinders must pass in close proximity to each terminal or scanner. The movement of a cylinder as was described, is not the same in all cases and many stationary terminals would be needed to capture all cylinder movement in every area. Portable terminals would provide the most flexibility and also minimize the

number of terminals needed. Different types of scanners (pencil, laser, CCD) could be used once the application was in place to determine which of these worked the best. A complete description of the different types of scanners and terminals is given in a later section.

C. Vendor Selection

Once the auto I.D. and data collection technologies were selected, the attention and focus turned to choosing a vendor to supply the RF equipment.

Six major vendors were selected to evaluate: LXE, MSI-Vectran, INTERMEK Corporation, Norand Corporation, TEKLOGIX, Inc., and Telxon Corporation. These vendors were chosen based upon advertisements in trade journals, reputation and references from other corporations. The evaluation process was done in 2 phases. In phase 1, a high-level overview of each vendor was done. In phase 2, acceptable candidates were further evaluated in detail.

Phase 1:

Each vendor was evaluated based on these key features: (1) Whether the vendor provided RF capability; (2) What the terminal ergonomics were, i.e. size, layout, weight; (3) Safety considerations - was the terminal intrinsically safe for use in hazardous environments; (4) Price of equipment ; and (5) The ability to connect to the Tandem/SNA network.

INTERMEC was eliminated immediately because they did not have RF capability when the initial contact was made. This product line was scheduled

to be marketed at about the same time the project team wanted to begin implementation of the actual application.

The following charts summarize the equipment selections from each vendor:*

Terminal Comparison Characteristics

	LXE	MSI-Vectran	Norand	TEKLOGIX	Telxon
Model#	2021S	MSI-PRT	RT2210	7015	PTC-750
Weight	20 ozs	28 ozs	32 ozs	40 ozs	47 ozs
Screen Size	2 lines X 40 Chars	16 lines X 20 Chars	4 lines X 16 Char	4 lines X 20 Chars	16 lines X 21 Chars
Terminal Size	4" X 8.75 X 1.1"	8.75" X 3.75" X 1.75"	9.4" X 3.4" X 1.8"	9" X 4.2" X 2.5"	9.65" X 4" X 2.8"
Operating Temperature Range	32° - 120° F	32° - 120° F	14° - 120° F	23° - 122° F	32° - 120° F
Battery	Ni-Cad	Lithium	Nickel Cadmium	Ni-Cad	Ni-Cad
Keyboard	Full Features	Full Features	Full Features	Full Features	Full Features
Durability	Unknown	Unknown	Unknown	Survives 4-foot drop test	Survives 3-foot drop test
Programmable Unit	Forms Only	Yes	No	No	Yes
Environmentally Sealed	No	No	No	Yes	Yes
Connect to Printer	Unknown	Yes	No	Yes	Yes

* The information in this chart depicts the hardware selections available in the spring of 1989.

Base Station Comparison Characteristics

	LXE	MSI-Vectran	Norand	TEKLOGIX	Telxon
Model #	LXE130	2800	RC2250	9574/9010	RFX-30 and NIC
Comm Protocol	ASYNCSNA/SDLC	ASYNCSNA/SDLC	ASYNCSNA/SDLC	SDLC/BSC	ASYNCSNA/SDLC
Number of terminals supported	30 - 80	8	32	10	30
Polling Protocol	Proprietary	Proprietary	Proprietary	Adaptive	Proprietary

During this phase, 2 more vendors were eliminated, LXE and TEKLOGIX. LXE had a very awkward device, an odd-shaped terminal with a tethered radio which made holding a terminal, radio and scanner with 2 hands very difficult for long periods of time. If an operator needed to free 1 hand to assist him in any way, this equipment seemed unmanageable. Also, the base station was much higher priced than most of the other vendors, and they were unwilling to demonstrate their ability to connect to the Tandem computer.

TEKLOGIX is a Canadian based company, and did not have many local contacts. Getting service and systems support quickly could prove to be difficult. The terminal was much heavier than most of the other ones, and the base station was also very expensive.

Phase 2

The 3 remaining vendors, MSI-Vectran, Norand and Telxon, were evaluated for the following items: (1) Response Time - Must be 3 or less seconds; (2) Safety -

Must meet safety requirements for use within a hazardous environment, and ideally have an intrinsically safe device; (3) Successful connection to the Tandem host mainframe; (4) Instrument Interface - In the analytical lab where the cylinder contents are analyzed, the radio waves cannot interfere with the analytical equipment; (5) Vendor technical support; (6) Sales Support; (7) Hand-Held ergonomics and Durability; (8) Customer references; and (9) Application Development Flexibility.

MSI-Vectran failed to successfully connect to the Tandem computer, therefore the project team had no choice but to eliminate this company. Another factor which led to this decision was the fact that MSI-Vectran had just merged together as one company and SYMBOL Corporation had bought this merged company. The complete organization was in a somewhat disorganized state which made communication with sales and technical representatives frustrating. Also, their hardware costs were higher than the others.

To formally compare Telxon and Norand, a numeric ranking was done for each company against the evaluation items. These items were weighted to give a truer picture of the results. The weights designated which factors were considered of higher importance. Therefore, if a vendor scored high on the more important factors, and low on the less important attributes, they could still look the same or worse than a vendor that scored low on the more critical factors and was outstanding in the remaining items. The following table summarizes the findings for each company:

Criteria	Weight	Norand	Telxon
Response Time	10	8	4
Safety	10	8	5
Tandem Interface	10	9	6
Instrument Interference	10	9	8
Cost	8	8	7
Vendor Technical Support	7	7	9
Sales Support	3	9	5
Hand Held Ergonomics	8	9	7
Hand Held Durability	5	8	5
Customer References	7	9	5
Applic. Devel. Flexibility	4	<u>5</u>	<u>10</u>
Totals (Sum (Weight * Score))		675	504

Response Time - Norand was faster by a factor of 2 in all tests.

Safety - Both units were approved by the safety committee for use within the plant environment. However, Norand was coming out with an intrinsically-safe device within 6 months, therefore, they were rated higher. Telxon is not developing an intrinsically-safe device.

Tandem Interface - Both companies successfully connected to the Tandem computer, however Norand has an SNA connection where Telxon must use a

PC to convert BISYNC to SNA. This fact also partly attributed to the difference in response time.

Instrument Interface - Both companies could successfully operate outside the analytical lab without interfering with the instrumentation. Once inside the lab Norand interfered less at a closer distance to the equipment.

Cost - List price for Telxon was considerably higher than list prices for Norand. However quoted prices were quite comparable.

Vendor Technical Support - Telxon demonstrated more technical expertise and responded to questions in a more efficient, satisfactory manner. Norand did have satisfactory technical support.

Hand-Held Ergonomics - Telxon had a heavier unit with smaller keys, making keying with gloves difficult. However, the screen size of the Telxon unit was larger which allowed for a better formatted screen with less screens being needed. Norand's new terminal introduction within 6 months contained many of the features of the Telxon unit.

Hand-Held Durability - Both terminals were about the same in surviving a drop test, however again, Norand's new terminal would survive a 6 foot drop test.

Application Development Flexibility - The Telxon unit had to have programming resident within the unit. The programs were written in Telxon's proprietary

language TCAL. Since an application program was resident in the unit, it could be programmed to accept data when the host was down, and transmit the data later when the communication link was restored. This also allowed for some validation to be done in the terminal itself. Screens could also be stored in the terminal and not sent over the communications link which should decrease response time. The Norand unit could not be programmed, therefore if the host failed, or communications were lost, the terminals could not be used. All screens had to be transmitted across the communications link and all validation had to be done in the host.

After this final analysis was done, the choice of hardware vendor went to Norand. The key points that finalized the decision were (1) Faster response time; (2) Developing an intrinsically safe unit; (3) Clean SNA interface (no PC needed to transform communication protocols); (4) lower cost; and (5) Although there was no programming resident in the unit, the project team felt that the cost associated with sending someone to school to learn a new terminal programming language to develop a backup system in the terminal itself was unnecessary. Since the application would eventually be used at 6 locations across the United States, it seemed more advantageous to be able to implement enhancements and corrections very quickly (through the host), rather than sending computer chips by mail to all locations needing updates.

Although the screen size was small, it would be satisfactory for the initial areas that would be using a bar coding application in the pilot project. Norand was introducing a new terminal in about 6 months, the RT3210, which would have the larger screen and environmentally sealed case, survive a 6 foot drop test

and be better designed to fit in one's hand. These features would be needed in later phases of the application as more complex transactions were done. Although it was a risk to rely on a future development, the better response time, safety factor, and SNA interface made Norand the better choice.

IV. Technology Overview

A. Bar Code Definition

Bar codes are composed of a series of vertical bars and spaces of varying widths that record digits, letters or other punctuation symbols to identify an item or regulate its movement.³ Each bar code conforms to a standard or symbology which dictates the arrangement pattern of the bars and spaces.

Bar codes were first used in the 1970's in supermarket checkouts. The National Association of Food Chains (NAFC) commissioned Logicon, Inc., to develop a proposal for a universal coding system. A committee was formed to evaluate proposals to standardize this technology in the food industry, based upon Logicon's recommendations. Seven proposals were submitted by computer manufacturers. The UPC or universal product code was chosen which closely follows the IBM proposal.⁴ For the manufacturing sector, the Code 39 symbology was created by INTERMEC, Inc., and recommended by the Department of Defense. These two symbologies are the most widely used and accepted symbologies in today's business applications. Currently over 20 symbologies exist. Appendix A lists some of the most frequently used symbologies, their characteristics and common application usages.

³ AID News Directory, p. 6

⁴ Craig Harmon and Russ Adams. Reading Between The Lines. Peterborough: Helmers Publishing, Inc., 1989, pp. 6-8

B. Scanning Devices

Scanners are the equipment used to read bar codes. They use a beam of light to "read" each code. The light is absorbed by the dark bars and reflected by the spaces. The scanner then transforms the light fluctuations into electrical impulses which mimic the pattern of the bar code. A microprocessor in the scanner decodes the electrical signal using mathematical algorithms, and the corresponding data are recorded or sent to the host computer, PC or controller.

The success rate of a scanner is measured in two ways, first read rate (FRR) and substitution error rate (SER). First read rate is the percentage of "good scans" achieved within a certain number of scan attempts. For example, if 100 scans were attempted and 97 were successful on the first try, the first read rate would be 97%. Substitution error rate is the ratio of characters or symbols read to those mismatched (where the data encoded in the printed symbol does not match the data decoded by the reader). Examples of substitution errors include: where 7B36G14 is read as 7B36G41, where 123456 is read as 123457, and where 9876543 is read as 98765. Generally, achieving a high FRR and low SER is a factor of matching the correct light source within a scanner to the proper type of label (symbology, print quality and density).

There are basically two types of scanners, contact and non-contact. Contact scanners, as the name implies, must actually touch the bar code to "read" it. The most common contact scanners are light pens or pencil wands. These devices can use visible red, visible white, infrared and laser diode light to read

a bar code. Contact wands are overwhelmingly hand-held in nature. These types of devices are the most popular because of their low cost and portability.

A relatively new scanner called a charged coupled device or CCD reader uses a photosensitive semiconductor device called a linear photodiode array, a device also used in camcorders. The CCD focuses the reflected symbol image onto the photodiode array. A microprocessor samples the photodiodes producing an analog of the symbol, which is then conditioned and decoded. Although a CCD is considered to be a contact scanner, it can "photograph" a bar code from a distance of approximately 1/2 inch.

Non-contact scanners can read a bar code from a distance of several inches to approximately two feet depending on the power of the light source within the scanner. Non-contact scanners mostly use a laser light source, either helium-neon (He-Ne) or solid state diode (visible and infrared). This light source can either be a moving beam or a fixed beam of light and the device itself can be hand-held or stationary. Hand-held laser scanners typically use moving beams and are operated by holding them directly over the bar code. The laser beam moves in a bidirectional optical sweep across the surface of the bar code until a good read is obtained. To use a stationary non-contact scanner, an item must be passed in front of it. Stationary non-contact scanners using a fixed laser beam, only get 1 chance to read a bar code as the bar code is moved past the scanner. For this reason, they are used in applications where the orientation and location of the bar code symbol can be closely controlled which guarantees a successful FRR. Moving beam stationary readers operate in a similar manner

to the hand-held laser scanners, however the stationary readers are very high speed.

Laser scanners offer many benefits: redundant scanning; adaptability to different bar code symbologies and densities; and more tolerance of ambient lighting. One would think that laser scanners would be the number one choice for use in all applications. However the disadvantages of laser scanners include:

- (1) cost, laser scanners cost approximately ten times as much as a pencil wand;
- (2) complex devices with moving parts are considerably more fragile than pencil wands;
- (3) Moving beams have a width limit and may not be wide enough for some applications, where pencil wands are restricted only by the ability of the operator;
- (4) Larger awkward size;
- (5) Although the laser beam used has less than 1 milliwatt of power, this fact could render it unsafe in some environments;
- (6) The laser beam is diffused and invisible to the naked eye when it is used in direct sunlight, which causes an operator to guess where the beam is directed.

"The hand-held laser is to the light pen what a Mercedes-Benz is to a Volkswagen."⁵

⁵ Harmon and Adams, op. cit., p. 115

C. Hand-Held Terminals

As previously stated, scanners transmit data to either a CRT terminal or a hand-held terminal. The scanning device must be directly connected to a port on each type of terminal, or can be an integrated part of the terminal. The CRT sends data directly to the host as if someone typed it on the keyboard. A batch hand-held terminal acts as a data collection device itself. Various levels of intelligence can be built into the device. This intelligence can be simple editing of "YES" and "NO" responses, to editing incoming data against actual database information that was downloaded from a host computer through RS232 cable. These devices usually contain a custom-written program written in a vendor's development language or a form of a commonly used computer language such as BASIC or COBOL. The programs are usually burned into a microchip and not downloaded via cable into memory. There has also been a recent trend to implement MS-DOS within the hand-held terminal itself.

An "on-line" hand-held terminal uses radio waves to transmit data to the host in a real time mode. It can also have various levels of intelligence resident in the device. At a minimum, it can only contain enough firmware to send and receive data and control terminal functions and options. It could ultimately contain programming similar to a batch hand held terminal. The advantages of having a custom-written program in the hand-held are (1) screens can be stored in the terminal instead of transmitting them with every send and receive; (2) redundancy can be built into the terminal which collects data in a batch type mode if the host computer goes down or communication is lost between the hand-held and the host for some other reason. However, having programs resident within the hand-held terminal adds an extra layer of complexity to the

application. If many terminals are involved and many are at remote locations, they must all be upgraded with application enhancements. This effort could prove very time-consuming, untimely and costly.

D. RF/DC Basics

1. Protocols

Radio Frequency Data Communications (RF/DC) is a relatively recent technological breakthrough. Although radio and digital electronics technology itself is quite commonplace, using it to process data is new, and practical applications using this technology have only been developed in the past several years.

As mentioned before, in an RF/DC application, terminals transmit data over a wireless RF/DC link through an RF base station to a host computer. This technology offers the capability of an on-line, real time communications link without the need for traditional wired transmission lines.⁶

Generally, there are two types of RF transmission or multiplexing: polling, and contention (random access). In a polling system, each terminal in sequence is asked whether it has data to send. The controller is completely in charge of directing traffic on the network at all times. The advantage to this method is that there are no "collisions" from two terminals trying to send data at the same instant. The disadvantage is that every terminal in the network will be polled whether or not it has data to send. A terminal has to wait until it is polled to

⁶ AID News Directory, p. 6

transmit data. For this reason, this type of protocol is only successfully used in smaller applications (where there are fewer than 16 terminals in use) and also have high transaction activity. A controlled protocol is needed to eliminate collisions. Since there are a small number of terminals, a complete polling sequence of each terminal is short, minimizing the delay incurred waiting until the terminal is polled and can transmit data.⁷

In applications, using a polling protocol, where one or more terminals may become inactive for short periods of time (such as when workers take staggered breaks), an adaptive polling protocol was developed. In adaptive polling, the controller "remembers" which terminals did not have data to send for a set length of time. It automatically drops these terminals from the normal polling sequence and are polled infrequently. Once a terminal begins to again send data, it is reinstated into the polling sequence.

In a contention protocol, the terminal initiates the transmission. It first checks to see whether the channel is free. If it is, the terminal requests to transmit data. The advantage to this protocol is that each terminal does not have to wait for its turn to be asked to send data, and can initiate a request as soon as the channel is free. Since there is no need for continuous polling of each terminal, the channel is freer to handle the actual data transmission requests. The disadvantage to this protocol is that two terminals might detect that the channel is free at the same time. Thus both terminals may request to send data at exactly the same time which creates a collision. When this happens, both

⁷ Rod Saunders. "How Will You Handle Real-Time Data Collection and Processing?," Automatic I.D. News (July, 1989), 47

terminals cease transmission. Then they both wait a brief period of time and test to see whether the channel is free. Since each wait period for each terminal is calculated to be a random time, the probability of the same two terminals creating a collision twice in a row is rare. Contention protocol works best in applications where there are 10 or more terminals and each sends data intermittently, because there is no time wasted polling each terminal to see if it has data to send.⁸ Applications that have less than 10 terminals could also use contention protocol, however, as the number of terminals decreases, the amount of time required to poll each terminal decreases and is less of a factor in affecting overall response time.

2. Response Time Factors

Response time or throughput is critical to the success of a computer application using RF/DC. Throughput is the amount of time it takes for the data to be passed to the host, processed, and a confirmation message sent back to the terminal. Studies have shown that the maximum amount of time for a terminal operator to wait for a response before becoming impatient is one to two seconds.⁹ Four primary factors influence response time:¹⁰

1. **Hardware overhead:** the amount of time it takes for a radio to get ready to receive or send data. Faster response time can be achieved by using a higher performance radio. Lower performance radios are based on voice radio transmission and modified for data by adding a modem. These radios are tolerant of signal distortion because a human ear can usually understand

⁸ Ibid., p. 47

⁹ Frank Jeffries, "An RF Communications Primer," *ID Systems*, IX, (May, 1989), 62

¹⁰ Ibid., pp. 62-63

slightly garbled speech. However, with data, the error rate is very high which necessitates retransmissions increasing response time. Higher performance radios are designed for data only, and have a superior signal-to-noise ratio.

2. Protocol Overhead: the amount of time lost to hand shaking error detection and the other necessary functions to ensure data integrity. This aspect was discussed in the preceding section.

3. Host Response Time Delay: the amount of time it takes for the host to process a request from a remote terminal. When considering the host part of response time, it is necessary to consider the configuration of the hardware. The host computer can either be front-ended with another processing unit, a personal computer (PC) or interfaced with a communications network such as SNA/SDLC, Async or Bisync. Front-ending with another computer creates an independent work center with more local control. If data from the host can be downloaded to the local computer and daily operations controlled as a separate, autonomous entity, response time is improved and there is less downtime. Data usually has to be uploaded and downloaded to the host in offpeak hours, however the data is "filtered" or "pre-edited" to allow for more efficient updating. If using another computer (usually a PC) is only a means of transferring data to and from the host in an on-line scenario, it can be a factor that increases response time.

The network interface allows multiple users at many local and remote sites to use the host computer simultaneously. The hand-held terminals function as on-line CRTs. This option has higher programmer acceptance because they are working with more familiar tools. Because this familiarity exists, programmer retraining time is reduced. Programmers can use existing development languages and methods, unless the hand-held terminals themselves require

programming. With a network, the reliability of the application depends in a large part on the integrity of the host mainframe. When it is down, data collection is also down.

4. **Data Transmission Rate:** the speed of the link between the remote terminals and the base station. Terminals today operate at speeds of 2400, 4800 and 9600 bits per second (bps). At first thought, one would reason that the faster the transmission speed, the faster the response time, however, this is not necessarily true. The faster the speed, the more error checking is needed which in itself takes time. The effective range of a 9600 bps system is less than that of a 4800 or 2400 bps system. The strength of the signal with respect to the data at 2400 bps is four times better than the same radio running at 9600 bps. The reason being, at 9600 bps, the radio has about 1/4 the time to generate the energy needed to represent a bit of information than the 2400 bps system.

The optimal RF/DC system design is probably a compromise between these four factors.

3. Site Survey

Rather than working out a prototype system design on paper and then selecting a vendor based on these assumptions, actual site testing is performed. The RF/DC equipment is installed at the particular location and fine-tuned to meet the customer needs. The four response time factors can be massaged until an optimum throughput time is reached. Coverage across the entire application area is tested to make sure "dead spots" do not exist.

The site survey is also done to detect what radio frequencies are operating in the specific area. Today, each U.S. location using RF/DC must have a site license from the FCC. The license applicant must specify the exact latitude and longitude where the terminals will be used. There are several industry trade associations such as "NABOR" that help coordinate the choice of frequencies, thus minimizing interference between adjacent businesses. In the future, a new radio band close to the cellular telephone wave length is being investigated for use with RF/DC. When this technology comes to fruition, licensing will not be required. Advances being made in this area will be addressed later.

V. Hand-Held Application Overview

Figure 4 shows how the Norand equipment is configured into the existing network setup, and Figure 5 illustrates how the equipment is integrated into each facility. The Norand RC2250 controller emulates an IBM 3274 controller and the RT3210 hand-held terminals appear as IBM 3278 terminals. The protocol used is a proprietary adaptive polling sequence and data is transmitted at 4800 BPS. A radio frequency has been licensed that is valid at approximately 30 locations across the United States. This enables terminals to be freely exchanged between locations without worrying about what frequency the location is using.

To try the Norand equipment in an actual application, a pilot project was implemented at the main specialty gas producing facility. In the pilot project, 4 transaction types were developed:

1. Label Application
2. Cylinder Status
3. Fill Process
4. Shipping - Cylinder Allocations

Figure 6 shows the cylinder life-cycle and what areas were included in the pilot application.

Label Application:

In this transaction, the bar code label is physically attached to the cylinder and the bar code identifier is equated to the cylinder serial number in

RF Processing Overview

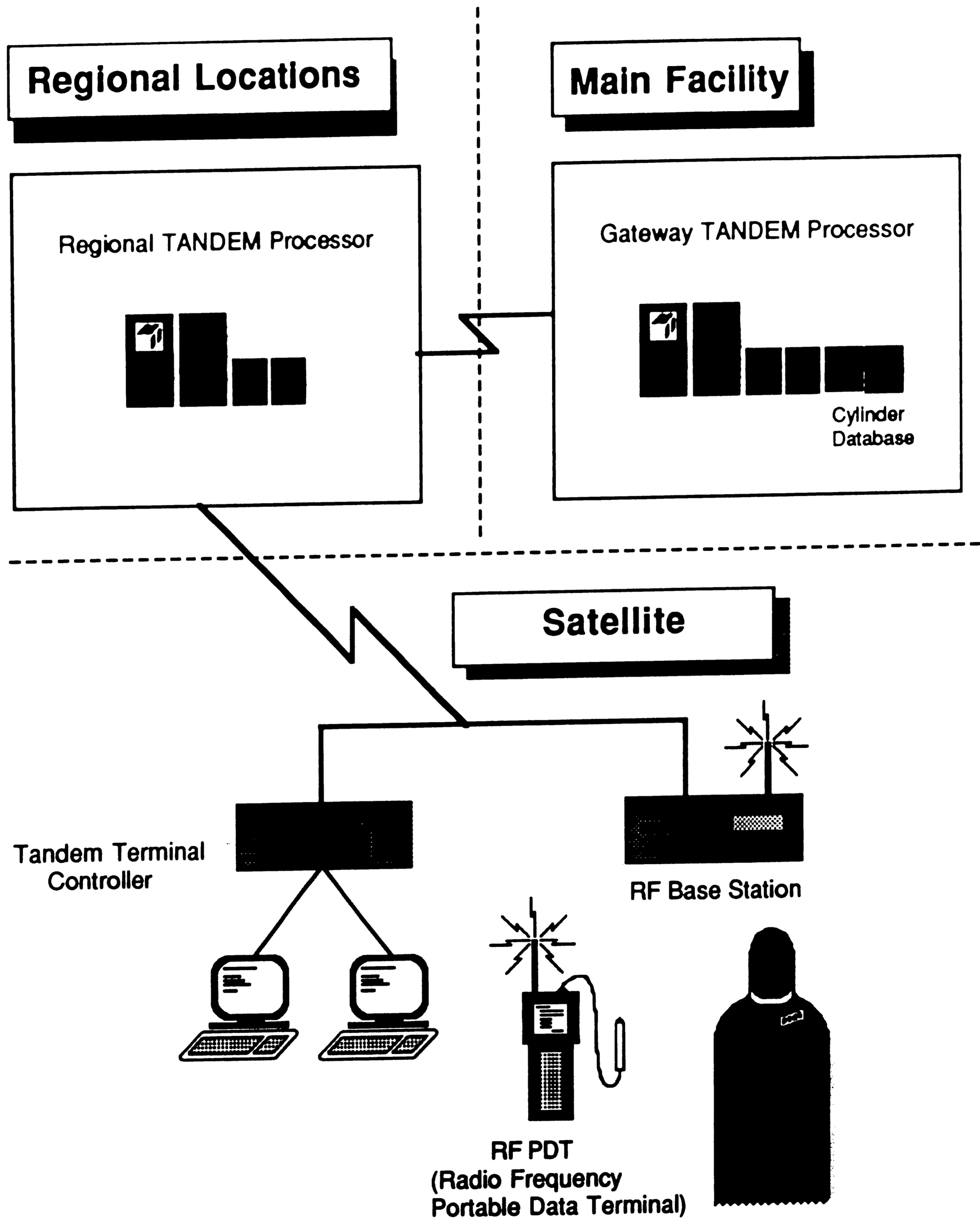


Figure 4
42

Radio Frequency Terminal Environment

Equipment Overview

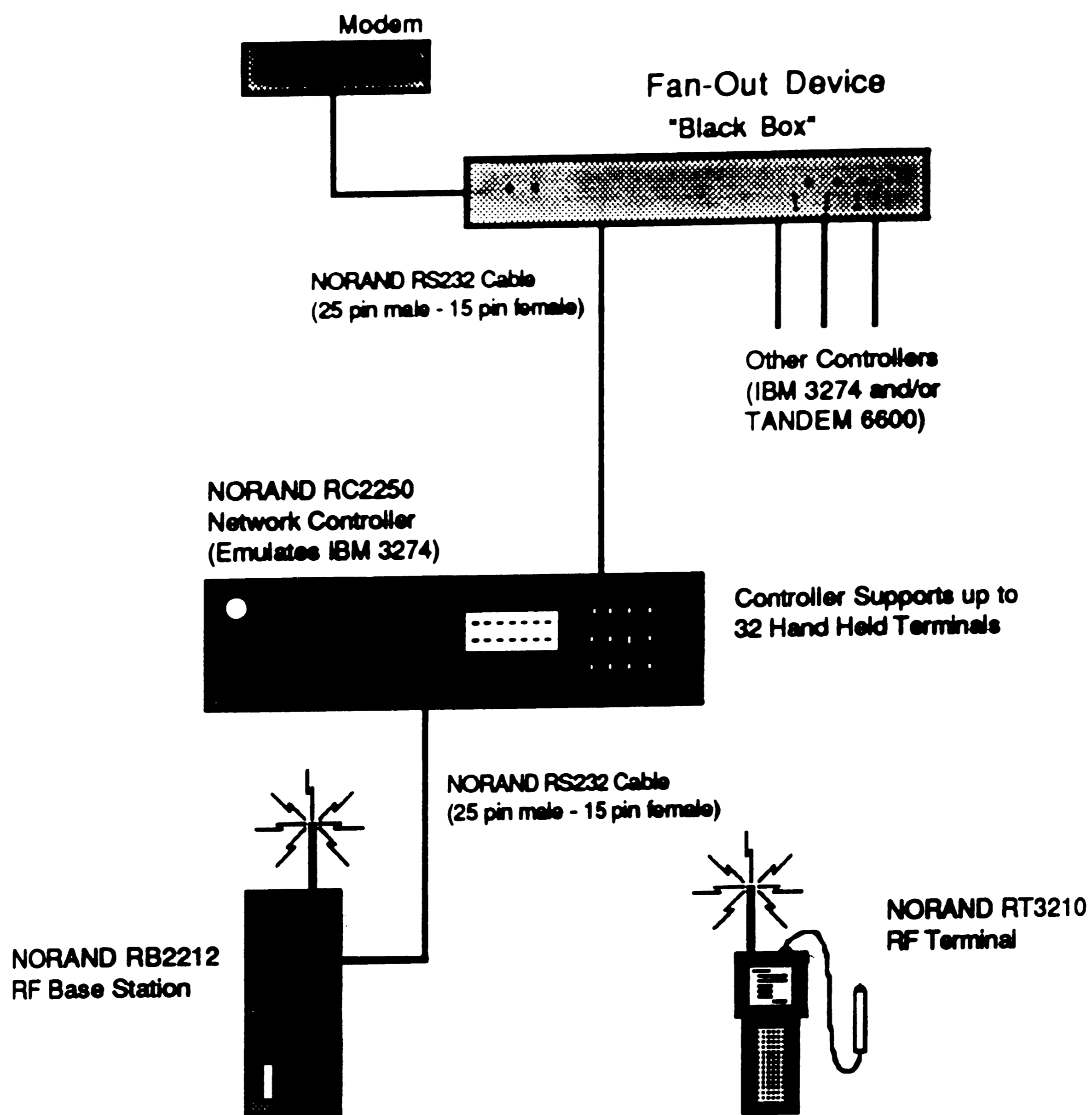


Figure 5

Specialty Gas Cylinder Life-Cycle Diagram

Areas Using Bar Coding are Denoted in Italics

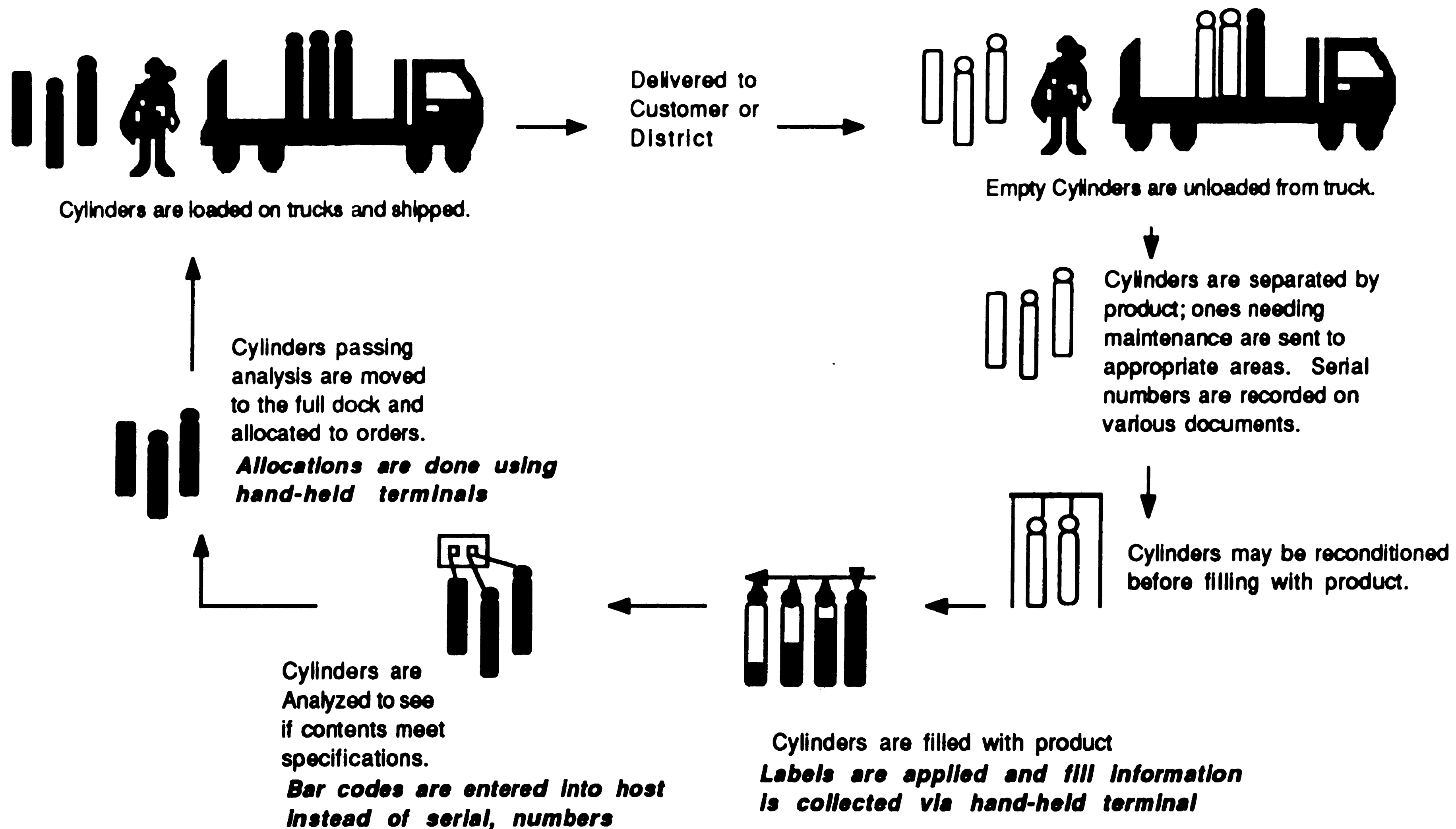


Figure 6

the computer via the hand-held terminal. Initially this function will be done in the production area, before the fill operator fills the cylinders. Eventually it will be moved to the empty dock and performed when the empty cylinder is received.

Cylinder Status:

In this transaction, an operator wands the bar code on the cylinder and the computer returns the current status and other information such as cylinder contents, size, tare weight, etc.

Fill Process:

This transaction prompts a fill operator for such items as raw material supply source, number of cylinders filled, and product being filled. The operator then wands each cylinder he is filling and enters the information into the computer. At that point inventory totals are updated.

Shipping - Cylinder Allocations:

In this transaction, a shipping cylinder handler wands a bar code of the order line item from a shipping scheduling sheet, and then wands each cylinder being sent on that order line. This cylinder handler may then request that a certificate of analysis (C of A) be printed, if one is required.

Appendix B describes these four transactions in detail. There are actually 5 types of fill process functions that have been developed. Only the straight gas fill process has been included to illustrate the fill process transaction.

The next areas that will be using bar coding are the cylinder receiving and maintenance area. In cylinder receiving, empty cylinder inventories and customer-owned inventories will be maintained. Validation and maintenance of hydrostatic test dates will be implemented. In the cylinder maintenance area, the cylinder status will change as it passes through each area. More validation can be done to insure cylinders are properly prepared for the appropriate fill area and customer.

VI. Summary

The specialty gas in-plant bar coding project has been successful thus far. The main producing facility has over half of the entire product line bar coded. So far 4 of the satellite locations are using the technology. Response time, equipment reliability, FRR, and training are the critical factors that will ultimately 'make' or 'break' this project.

Response time has been 2 to 5 seconds for most transactions. The longer response times are mostly a factor of the network design itself, and not a factor of the RF communications. In using a distributed database, certain types of data can be arranged so that they are found on the computer located closest to the actual facility owning the data, such as order data. With serial numbers, no logical way exists to arrange this data because the actual serial number is simply a sequential number. One transaction that updated 3 cylinders could theoretically go to three different computers if the cylinder data was distributed around the network. Therefore cylinder related data is kept in one physical computer and location related data is distributed around the network. The longer response times are incurred when both types of data must be updated in the same transaction.

The equipment works well and has for the most part performed as expected. As with all new technology, there are still some inherent problems. When an operator presses the return key on the terminal, a message appears which reads "waiting for host to respond". This message stays on the screen until the

response is received. Sometimes the host does send a response, however the terminal doesn't recognize the response and the message does not disappear. The terminal remains in this state until someone restarts it which re-initializes it. This situation might happen once or twice a day to one or more terminals at all locations. Another equipment problem is in the controller itself. The largest facility operates three shifts, 7 days a week. During the midnight shift, the controller frequently malfunctions, rendering all the hand-held terminals useless. This problem has been attributed in part to communication line problems, and possible interference from an unknown source that only occurs at night. This situation has only occurred twice at satellite locations, since the application was implemented, but occurs frequently at the main facility. These two equipment problems continue to be monitored and Norand is endeavoring to find the root causes and eliminate these occurrences.

Getting a high first read rate is an extremely important aspect of this project. The laser scanners have achieved higher than a 95% FRR while the pencil wands have demonstrated about a 75% - 80% FRR. Substitution error rate is very low, < 1%, for both types of scanners. Because of the high enthusiasm for the laser scanners, the pencil wands only get used in areas where no laser scanners were distributed (low volume areas were given pencil wands), and when an operator can't find an idle terminal with a laser scanner attached. Since laser scanners cost considerably more than pencil wands, more research will be done to determine whether the correct pencil wand is being utilized for the type of label being used. If a better FRR is unattainable with pencil wands, laser scanners may be the better alternative to promote and maintain a high degree of user acceptance. CCD scanners were not tried in the manufacturing

facilities because the project team could only achieve about a 50% FRR within an office setting. The cost of these devices is comparable to a laser scanner. Since a high FRR was achieved with the laser scanners, we did not pursue further evaluation of a CCD reader.

The initial reaction from the employees using the application has been positive. The general consensus is that using the hand-held terminals is better than writing the numbers on paper. Some have found the experience to be fun, most enjoy not having to write the numbers on paper, and like in typical computer applications, a small percentage of people simply tolerate the situation. Nearly everyone is amazed at the fact that they are communicating with a computer using radio waves. Personnel in all areas of each facility have been given tours and have used the hand-held terminals to lookup cylinder status or apply labels. Educating everyone on the technology has helped insure no one feels "left out", and promotes better understanding of the capabilities of the application. Since an overwhelming number of the plant personnel have never used a computer terminal before, and after they overcome their fear and initial reluctance to using the new technology, we have found many people have acquired a sense of importance associated with incorporating this data collection method into their jobs. Promoting a thorough understanding of the reasons why bar coding is being implemented and that they are key to the success of the project have resulted in the excellent cooperation that we've experienced. Frustration still results from the two equipment problems previously described, and also correcting errors encountered while entering the data. To help with error correction, thorough training of key personnel on all

shifts at each location will be necessary so that errors can be resolved quickly and efficiently. In time, the equipment problems hopefully will be eliminated.

Most of the benefits are beginning to be realized. The people who entered the serial numbers into the computer have more time to do other types of duties instead of entering the numbers. All overtime for these people has been eliminated. In the shipping area, no serial numbers must be written. The complete allocation process can be accomplished with the hand-held terminal. Shipping clerks do not need to wait for the office personnel to validate each serial number to determine whether it is the correct gas to send to the customer. All errors and mistakes are discovered when the cylinders are selected for each shipment. In the fill area, the production fill sheet has been eliminated. All production data is entered through the hand-held terminals which updates inventory data immediately. Previously, a clerk collected all fill sheets that were produced during the evening and midnight shifts and consolidated the totals on a one-page report. Now the information can be determined from a standard computer terminal for management inquiry. The up-to-date inventory totals are aiding management in production scheduling, and customer service processing. The cylinder data accuracy is improving and duplicate numbers are being discovered and resolved. Customer-owned cylinders are able to be associated with an order when they are filled, which greatly aids in tracking them through the plant. As the remaining areas of the application are developed and implemented, continued productivity and cost savings will be achieved.

All this has not been accomplished without some growing pains. The Norand hand-held terminals were new to the corporation as was radio-frequency data communications. The learning curve for this technology was experienced not only by the analysts and computer users, but by the technical support staff and the network help line. Educating all areas in the technology and troubleshooting techniques was a major effort. Another large effort went into training. In the largest producing facility, as was mentioned, some fill areas work 24 hours a day, 7 days a week. A few novice computer users had to be trained in such aspects as "resetting" the controllers and other such problem determination, in addition to learning the application. The computer analysts also had to work around the clock to train all employees on all the shifts. Cooperation and team work from all these areas was key to providing as smooth an implementation as possible.

But the bottom line is, the expected benefits are being achieved. And with continued efforts and teamwork, all the benefits will certainly be realized.

VII. Direction For Future Research and Development

Up to now, if RF/DC is used at a corporation, a license for a specific frequency must be obtained from the FCC. IBM and Motorola have entered into a joint venture called ARDIS to market radio-powered portables that can exchange information instantaneously with a main computer.¹¹ IBM currently has a radio-tower network across 90% of the United States. Utilizing hand-held terminals, IBM's repair personnel use the network to communicate between work sites and dispatch centers. Now IBM is going to begin to sell time on the network. A prospective RF/DC user could pay a fee to use the network which would eliminate the need to obtain an FCC license for a private radio frequency. The data transmission rate will be 4800 baud. Initial price estimates for the service were \$100 - \$150 a month per terminal, with actual costs being based on use, i.e. size and frequency of transmissions.¹²

Motorola Corporation will be manufacturing the hand-held terminals and modems for use with IBM's network. IBM is also testing a prototype laptop computer with a built-in wireless modem.

In the area of equipment, two vendors have developed an RF terminal with a built-in laser bar code scanner. Hand Held Products has just introduced the Laser-Wand RF,¹³ and Symbol Technologies has added the LRT Model 3800

¹¹ Wall Street Journal (New York), April, 1990

¹² IBID

¹³ Kevin R. Sharp, "Mainstream RF/DC," ID Systems, X, (June, 1990), 13

to its product line. The Laser-Wand RF has the same radio characteristics as a regular RF terminal without a built-in scanner. However the LRT Model 3800 has a communication technique called spread spectrum communication technology which was actually developed by the military years ago. In spread spectrum radio communication, the transmitter deliberately spreads the radio signal over a wide frequency range which provides redundancy much like that contained in a bar code. If the bottom of a bar code gets scratched, an operator can still extract all the information from the code by scanning the top part of the label. In much the same way, spread spectrum radio communication can be understood even in the "radio-noisy" environments. If interference occurs in the lower part of the spread spectrum, the receiver can still extract all the information from the transmission by looking at the top of the spectrum.¹⁴

Within the corporation, several other areas have expressed an interest in using RF/DC with bar codes for item tracking purposes. One application centers around tracking spare parts used in construction of air separation plants and processing plants. As selected spare parts are received, they would be scanned and entered into stock. Then, if a spare part was needed, a hand-held terminal could be utilized to determine if a spare part was available. Once it was used, it could be tracked and its current location and status would be readily known. Another potential application would track large containers filled with various chemicals throughout the manufacturing process. The bar code would serve to warehouse and locate these containers for later use. In both these scenarios, RF/DC is being considered because of the real time

¹⁴ Kevin R. Sharp, "The Laser Radio Terminal," ID Systems, X, (March 1990), 51

transaction processing required for up to the minute item status and inventory control.

Within this current project, we would like to find a better label, possibly seeking a way to permanently etch a bar code or some type of identification method directly into the cylinder. Bar code labels have proved effective, however they do become damaged and have to be replaced. Replacement of labels is costly. Therefore, if a more durable label can be found or some type of permanent automatic identification method is developed to identify a cylinder, this technology would be of great interest for use in this project.

As far as RF/DC is concerned, we will probably be looking at the IBM radio network to evaluate whether any response time improvements or cost savings can be realized. We are also in constant communication with the Norand corporation, participating in a round table type of users' group which exchanges future technology advances and allows for feedback on current equipment performance and user expectations and anticipations.

VIII. Conclusion and Recommendations

Bar coding with radio frequency data communications (RF/DC) has proven to be a very effective way of tracking industrial gas cylinders through the manufacturing process. Bar codes themselves have a proven track record of accurately and efficiently collecting data about a specific item in many diverse business scenarios. The decision to use RF/DC depends on the nature of the business. Alan Victor, VP of Monicor Electronics, states, "I think the key words for RF are 'portability' and 'real time'. If you want real time, but don't need the portability, there are many other ways to collect data. If you want to have mobility and portability and at the same time, have real time, then RF makes sense."¹⁵ Tracking cylinders through their in-plant life-cycle required mobility, portability and real time transaction processing, thus RF/DC was the chosen technology for this project.

Once the decision was made to utilize RF/DC, the project direction centered on choosing the equipment necessary to accomplish this goal. The first evaluation involved selecting the proper scanning devices and labels. Label print quality, density and symbology must be matched to the correct scanning devices to produce a low substitution error rate (SER). This factor, together with a high first read rate (FRR), are the critical success factors for selecting this type of equipment. Scanners can be contact or non-contact in nature. Pencil wands, a contact scanner, are very popular because of their low-cost, however an operator must control the device and develop the proper scan technique. Laser

¹⁵ "Radio Frequency Data Communication Round Table," Automatic I.D. News (July, 1989), 48

scanners, high in cost and a much more internally complex device, provide a very fast and flexible scanning device which is very easy to use. Cost and user acceptance among many other factors, must be evaluated to insure project success

Next, a vendor must be selected to supply the hand-held terminals and related hardware. First, during a site survey, the actual equipment is installed and tested for performance criteria, mainly response time and capability of covering the entire facility with one base station. There are primarily four factors that affect response time, hardware overhead, protocol overhead, host response time delay and data transmission rate. These factors are varied until a combination is found that gives the lowest response time in all areas of the facility that will be using the technology. It is important that a vendor be selected, who will provide thorough, competent, reliable analyst and sales support. The rapport that is established with this vendor is a key success factor. Excellent communication and cooperation is essential between the vendor and the user group to quickly solve problems and aid in startup activities. The vendor should have a good understanding of the application and demonstrate an avid interest in the project, so that they can recommend improvements and enhancements in the technology.

The actual industrial gas application centers on applying bar codes on gas cylinders and tracking their movement through the manufacturing facility. The object of using RF/DC technology was to replace the manual recording of serial numbers on various documents by using an automated data collection tool, thus providing a fast, accurate, real-time means of maintaining data on cylinder

movement, production fill data and inventory control. Initially, the application provided the means to apply a label to a cylinder, collect production fill data, and order allocation data. Future enhancements will include establishing empty cylinder inventory control, implement receiving functions and provide the capability to do cycle counting..

The equipment selected for this project includes pencil wands and laser scanning devices, with the laser scanners overwhelmingly preferred by the people using the application. Norand Corporation was chosen as the hand-held terminal vendor after evaluating six major corporations. The key points that led to this decision were clean interface with the host computer, faster response time, and safety. Other criteria considered in the vendor selection process were price, terminal characteristics, technical support, and software development flexibility.

User acceptance of the application has been very high. The efficient capable data collection technology has proved to be an interesting, easy way to collect data that was previously written on paper. Users have taken a lot of pride in the fact that they are effectively using a relatively recent technological advancement in their jobs. The benefits of implementing this automated data collection project include increasing cylinder data accuracy, reduce cost of tracking cylinders, facilitate accurate and timely inventory control, and improve tracking of customer owned cylinders.

IX. BIBLIOGRAPHY

- (1) Allais, David C. Bar Code Symbology - Some Observations on Theory and Practice. Lynnwood: Intermec Corporation, 1989.
- (2) Automatic I.D. News Directory, August 1989.
- (3) "Bar Coding and Productivity," Computype, Inc.
- (4) Bernassi, Frank. "New Technologies in Data Collection," Managing Automation (February, 1990) pp 26-29.
- (5) Bernstein, Amy. "Bar Codes Earn Their Stripes," Business Computer Systems (February, 1985), pp 68-74.
- (6) "Hand-Held Computers Help Field Staff Cut Paper Work and Harvest More Data," Wall Street Journal (April, 1990)
- (7) Harmon, Craig K. and Adams, Russ. Reading Between the Lines - An Introduction to Bar Code Technology. Peterborough: Helmers Publishing, Inc., 1989.
- (8) "IBM, Motorola Plan Radio Link For Computers," Wall Street Journal (April, 1990)
- (9) "IBM, Motorola Unveil Venture to Sell Service," Wall Street Journal (April, 1990)

- (10) Jeffries, Frank. "An RF Communications Primer," ID Systems, Vol 9 No. 4, (May, 1989), pp 61-67.
- (11) Jeffries, Frank. "RF Communications System Performance," ID Systems, Vol 10 No. 2, (February, 1990), pp 22-27.
- (12) Jeffries, Frank. "The Throughput Equation for RF Systems," ID Systems, Vol 9 No. 9, (November, 1989), pp 18-22.
- (13) Palmer, Roger C. "The Basics of Automatic Identification," Canadian Datasystems (September, 1989), pp 30-33.
- (14) Parker, Kevin. "The Basics of Bar Coding," Chemical Processing, (May, 1989), pp 55-60.
- (15) Sharp, Kevin R. "Mainstream RF/DC," ID Systems, Vol 10 No. 6, (June, 1990), pp 12-17
- (16) Sharp, Kevin R. "The Laser Radio Terminal," ID Systems, Vol 10 No. 3, (March, 1990), pp 51-52
- (17) Various Authors, "Insight Special Report, Radio Frequency Data Communications," Automatic I.D. News, (July, 1989), pp 31-62.

- (18) Young, Paul. "Put a PC in Your Hand," Canadian Datasystems,
(October, 1989), pp 74-76.

Appendix A - Common Bar Code Symbologies*

Common Terminology:

Bar Code Symbol: A graphic (printed or photographically reproduced) bar code composed of parallel bars and spaces of various widths. A bar code symbol contains a leading quiet zone, a Start character, one or more data characters including in some cases a check character, a Stop character, and a trailing quiet zone.

Continuous Code: In a continuous bar code the intercharacter space is part of the code structure. Opposite of Discrete.

Discrete Code: A bar code symbol in which the intercharacter space (or gap) is not part of the code and is allowed to vary dimensionally within wide tolerance limits. Opposite of continuous.

Quiet Zone: The area immediately preceding the Start character and following the Stop character which contains no markings.

Self-Checking Bar Code: A bar code which uses a checking algorithm which can be applied against each character such that substitution errors can only occur if two or more independent "printing" defects appear within a single character.

Unit: (same as Module): The narrowest nominal bar or space in the code. Wider bars or spaces are often specified as multiples of one Unit. The width of a Unit or Module is usually referred to as the X dimension.

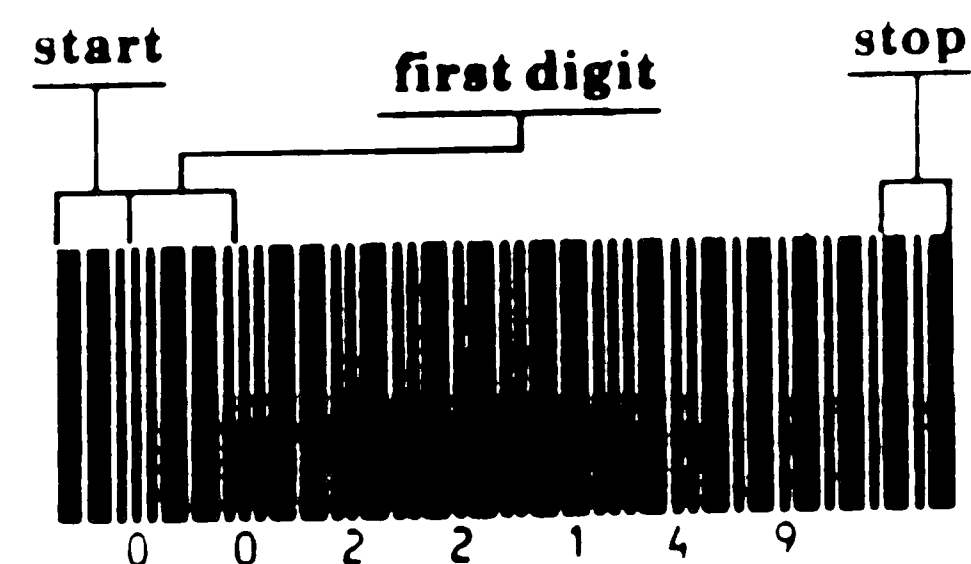
*All figures and information are from:
David Allias, Bar Code Symbology - Some Observations on Theory and Practice, Lynnwood: INTERMEC Corporation, 1989.

Two of Five Code

This code is one of the earliest ones developed, with its origins in the late 1960's. It is mainly used for warehouse sortation systems, photofinishing envelope identification and more recently for sequentially numbered airline tickets. This symbology only uses numbers, is discrete, and has a very low density (a symbol occupies a large printed area). All information is denoted by the bars only, narrow bars are identified as "0" and wider bars as "1". The encoding convention and sample symbol are show below.

Character	Code
0	00110
1	10001
2	01001
3	11000
4	00101
5	10100
6	01100
7	00011
8	10010
9	01010
START	110
STOP	101

Encoding Convention

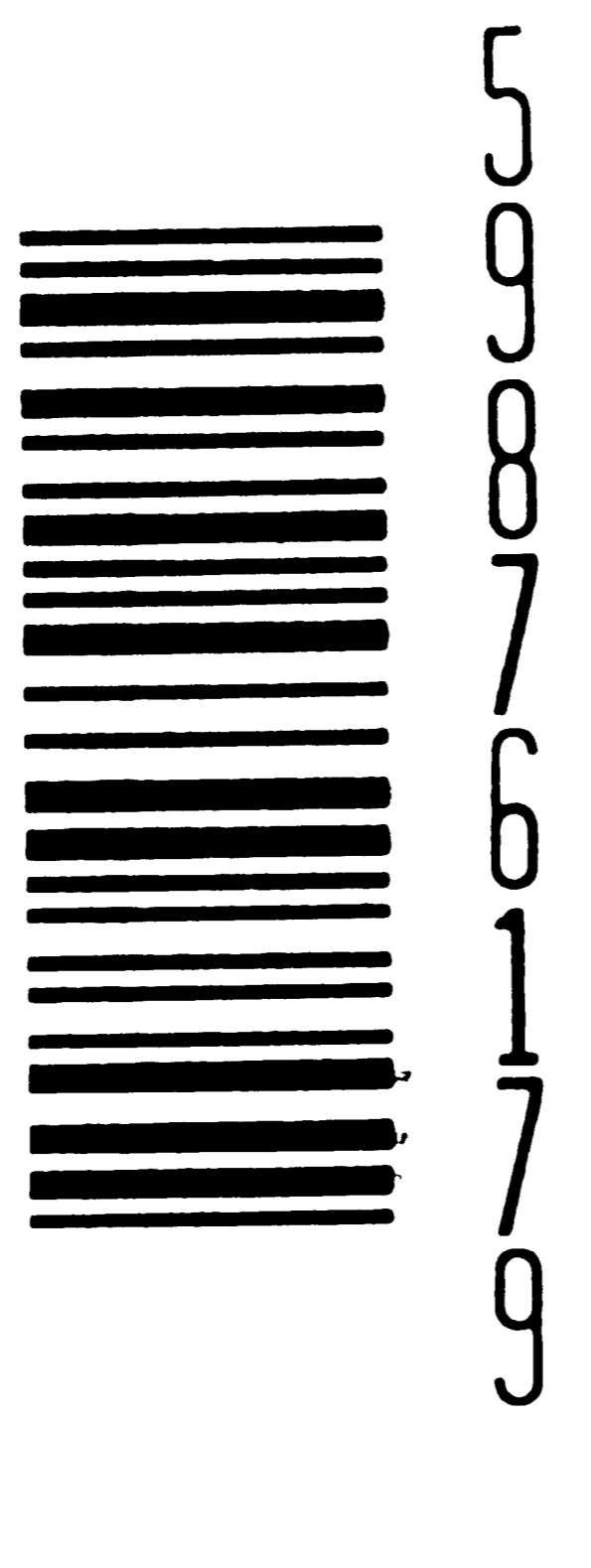


Sample Symbol

Interleaved Two of Five

This numeric symbology is based on the Two of Five symbology, and was developed in the early 1970's. To improve on the density of the symbol, the spaces were included as part of the code making it a continuous code. Thus Interleaved Two of Five only occupies approximately 60% of the space that Two of Five requires. This symbology has its popularity in warehousing

and heavy industrial applications, particularly prominent in the automobile industry. It has been recommended as the standard for labeling corrugated shipping containers and adopted as the standard for outer shipping containers in the grocery industry.



Sample Interleaved Two of Five Symbol

Code 39 (Code 3 of 9)

INTERMEC, Inc. developed this symbology to incorporate letters into the coding sequence as well as numbers. The original proposal incorporated 39 characters into the design and was based on a 3 of 9 structure, wherein 3 of the elements are wide and the remaining 6 are narrow. The final character set consists of the ten digits, 26 letters of the alphabet, and the six symbols ...-,.,\$,/,+ and %. Code 39 is the most versatile because it is fully alphanumeric and variable length. The discrete coding structure contains self-checking properties, therefore it can be successfully printed by the broadest variety of equipment and

processes. With properly designed scanning equipment and excellent quality symbol printing, one may expect only 1 misread in 70 million characters scanned. Code 39 is the most widely used and widely accepted industrial bar code.



APT-038414

Sample Code 39 Symbol

Codabar

Codabar was developed in the early 1970's for use in retail price labeling systems by Monarch Marking Systems Division of Pitney Bowes. This symbology was one of the ones considered for the grocery industry, but lost out to the UPC code. It was then redirected toward diversified nonretail applications and has been mostly widely accepted in libraries, medical applications, photo finishing envelopes and preprinted airbills. In 1977, Codabar was adopted as a standard for blood bags by the American Blood Commission.

Codabar incorporates the 10 numeric digits, the minus sign, dollar sign, colon, slash, dot and plus sign. It is a discrete self-checking code. The difficulty in using Codabar lies in the standardization of the size of the bars and spaces. Usually, the width of the bars and spaces is a multiple of the smallest unit (bar or space). But Codabar uses 18 different widths, some are not multiples of the smallest unit. This results in a superficially complex structure.



Sample Codabar Symbol

Code 11

Code 11 was developed by INTERMEC, Inc., in 1977 to provide a high density numeric bar code. It uses the 10 numeric digits and the dash symbol. Code 11 is a discrete code, but is not self-checking. It is used extensively in labeling telecommunications components and equipment.



Sample Code 11 Symbol

Code 93

Code 93 is a very high density alphanumeric symbology that was introduced by INTERMEC in April, 1982. It is a companion code to Code 39 and uses the same character set. The main difference lies in the density factor. Code 39 uses 13 to 16 units per character, where Code 93 uses 9 units per character. Therefore, Code 93 is used in applications where Code 39 symbols would be too lengthy. Code 93 is a continuous code and is not self-checking.



□1G1AZ37A4CR423456□

Sample Code 93 Symbol

Code 128

This code is very high density and incorporates 107 different data characters. When printed with a .0075 inch nominal width, the resulting alphanumeric density is 12.1 characters per inch. Each character consists of 3 bars and 3 spaces. One character is 11 units wide. Code 128 is used as a secondary symbology for the Uniform Code Council's Shipping Container Specification.



Sample Code 128 Symbol

Code 49

Code 49 is a multi-row symbology that offers extremely high data density. It was developed by INTERMEC, Inc., in the fall of 1987. This symbology employs from 2 to 8 adjacent rows, each contains 18 bars and is 70 units long. Each row contains 4 words of 2 characters. Row information is contained within the coding sequence. Numbers are encoded using a compression scheme that can encode 5 digits in the form of 3 characters. The rows can be scanned in any order, however it is preferable to use a moving beam or CCD scanner. This code was developed specifically for labeling small objects, and efficiently coding several dozen characters.



Sample Code 49 Symbol

Appendix B - Sample Application Screens

Hand Held Terminal Operations:

- This Guide refers to the NORAND P3210 Type Terminal pictured on the last page of this section.
- Terminal Function Keys are special options obtained by pressing:

FUNC + A	Returns to the first screen of a particular function.
FUNC + B	Returns to the most recent menu that was used.
FUNC + C	Is used to completely Sign-Off the System.
FUNC + D	Returns to the previous screen of a particular function
FUNC + E	Is used to restore link to the system after communication loss or to restore screen display when terminal screen is blank.
FUNC + F	Complete key - Used to indicate production batch is complete, or to check the batch summary screen.
FUNC + S	Cylinder status key - Used to transfer to the single cylinder status screen from any fill or allocation screen, (FUNC + A will return you to your initial screen).

System Sign-On:

Sample Screen:

ACCESS CylinderTrak User: _____ Pswd: _____ Terminal ID: T1H20 \$PW01

Screen Operation:

- Type your Logon ID next to the **User:** prompt followed by the letter "B" (for example A1234B).
- Type your user password next to the **Pswd:** prompt (password will not display on the hand held screen).
- Press the ENTER key

System Main Menu:

Sample Screen:

1 SHIPPING
2 SYSTEM MAINT.
3 FILL OPS.
APPLICATIONS
MENU Choice: _

Screen Operation:

- Type the number of the desired menu selection next to the **Choice:** prompt.
- Press the ENTER key

Shipping Menu:

Sample Screen:

```
1 ALLOCATIONS
2 CYL. STATUS

      '
SHIPPING
MENU Choice: _
```

Screen Operation:

- Type the number of the desired menu selection next to the **Choice:** prompt.
- Press the ENTER key

Cylinder Allocations (Screen 1):

Sample Screen:

ALLOCATIONS

Order Number:

Screen Operation:

- Wand the order number from the production document.
- You will automatically be taken to the next screen.

Cylinder Allocations (Screen 2):

Sample Screen:

Order Number:	_____
Ordered :	_____
Allocated:	_____
C:	—
BC:	_____

Screen Operation:

To allocate a cylinder:

- Verify that there is an "A" in the C: prompt. Change if necessary by tabbing to the C: prompt and typing an "A". Tab to the BC: prompt.
- Wand the bar code that was placed onto the cylinder.
- If no errors were encountered the cylinder will be allocated. A running total of cylinders allocated will be shown beside the **Allocated:** prompt.
- Press ENTER when all cylinders are allocated.

To deallocate a cylinder:

- Tab to the C: prompt and change the "A" to a "D".

- Wand the bar code that was placed onto the cylinder.
- If no errors were encountered the cylinder will be deallocated.
- Press ENTER when all cylinders are allocated/deallocated.

Cylinder Allocations (Screen 3):

Sample Screen:

Order Number:	_____
Ordered :	_____
Allocated:	_____
Process Complet	
Print CA (Y/N)?	
—	

Screen Operation:

- The Print CA (Y/N)? prompt will be prevalued with "Y" if a CA is required for that grade of product. If a CA is usually not required for that grade, an "N" will appear. Make sure this value is correct (change if necessary by typing the correct value) and press ENTER. You will return to the beginning of the allocation process to begin another order line item.

System Maintenance Menu:

Sample Screen:

1 LABEL APPL.
2 CYL. STATUS
3 PASSWORD MNT.
SYSTEM MAINT.
MENU Choice: _

Screen Operation:

- Type the number of the desired menu selection next to the **Choice:** prompt.
- Press the ENTER key

Label Application (Screen 1):

Sample Screen:

LABEL APPL. Serial #: <hr/>
Reg. Owner: <hr/>
Bar Code: <hr/>
 <hr/>

Screen Operation:

- Type the cylinder serial number under the **Serial No:** prompt. If APROINC is imbedded in the serial number, do NOT consider this as part of the serial number. This is really the registered owner code. Omit all dashes, dots or other characters other than letters and numbers.
- Tab to the **Reg. Owner** prompt. Type in the registered owner code. If nothing is entered into this field, APROINC will be used.
- Tab to the **Bar Code:** prompt.
- Wand the bar code that was placed onto the cylinder.
- The system will validate the serial number and automatically transfer you to the next screen if no errors were encountered.

Label Application - Apply Initial Label (Screen 2):

Sample Screen:

BC: _____
Cyl Type: _
Verify Serial#:

Cust Own: _
Tare Wgt: _____

Screen Operation:

- Type the cylinder type beside the **Cyl Type:** prompt. Some common types are:

01 - Steel A	04 - Steel D1
02 - Steel B	05 - Steel D
03 - Steel C	28 - Aluminum B
- Type the serial number, under the **Verify Serial#:** prompt, exactly as it was typed on the first screen.
- Type the owner code beside the **CO:** prompt. The correct codes are:

N - APCI Owned
Y - Customer Owned
- Type the tare weight as it is found on the cylinder.
- Press the ENTER key.

- If the two entries do not match, this same screen will continue to be displayed until they match. If you would like to start again, press the FUNC key and A (F1) to return to the first screen to start over.

Label Application - Relabel Cylinder (Screen 1):

Sample Screen:

BC: _____ Verify Serial # to Record Label Change. Serial #: _____ _____

Screen Operation:

- Type the cylinder serial number under the **Serial No:** prompt.
exactly as it was typed on the first screen.
- Press the ENTER key.
- If the two entries do not match, this same screen will continue to be displayed until they match. If you would like to start again, press the FUNC key and A (F1) to return to the first screen to start over.

Cylinder Status (Screen 1):

Sample Screen:

CYL. STATUS
BC or Serial #:

Screen Operation:

- Type the cylinder serial number under the **Bar Code or Serial Number:** prompt, or wand the bar code on the cylinder.
- If the serial number was used, press the ENTER key. If the bar code was wanded, you will automatically be taken to the next screen.

Cylinder Status (Screen 2):

Sample Screen:

BC: _____
Serial #: _____

Reg. Owner: _____

CO: __ Type: __
Location: _____
Status : _____

Screen Operation:

- The screen will display the above information about the cylinder.
- Press the ENTER key to continue displaying cylinder information.

Cylinder Status (Screen 3):

Sample Screen:

Prod :	_____
Grade:	_____
Size :	_____
Components:	_____
Tare Wgt:	_____

Screen Operation:

- The screen will display the above information about the cylinder.
- Press the ENTER key to continue displaying cylinder information. If the status of the cylinder is not "AV" or "AL", pressing the ENTER key will take you back to the first screen.

Cylinder Status (Screen 4):

Sample Screen:

Allocated To Order Number: <hr/>
--

Screen Operation:

- The screen will display the above information about the cylinder if the status of the cylinder was "AL".
- Press the ENTER key to display information about another cylinder.

Cylinder Status (Screen 5):

Sample Screen:

Batch No: <hr/>
Status: _

Screen Operation:

- The screen will display the above information about the cylinder if the status of the cylinder was "AV".
- Press the ENTER key to display information about another cylinder.

Cylinder Status - Function "S" (Screen 1):

Sample Screen:

BC:	_____

Loc:	_____
Status:	___ ∞ ___
Batch :	_____

Order :	_____

Screen Operation:

- The above screen will display after you have transferred from any of the fill or allocation screens when the Function "S" key is pressed.
- Type the cylinder serial number beside the BC: prompt, or wand the bar code on the cylinder.
- If the serial number was used, press the ENTER key. If the bar code was wanded, you will automatically be taken to the next screen.
- The screen will display the above information about the cylinder.
- You can continue checking the status of cylinders or return to fill or allocation screen you transferred from by typing Function "A" - the RETURN key.

Fill Operations Menu:

Sample Screen:

```
1 HCL FILL
2 SF6 FILL
3 LIQUID FILL
4 GAS FILL
5 BLENDING
6 CYL. REJECT
```

FILL OPS.

MENU Choice: _

Screen Operation:

- Type the number of the desired menu selection next to the **Choice:** prompt.
- Press the ENTER key

GAS Fill (Screen 1):

Sample Screen:

GAS FILL	
Batch:	_____
Make/Purch:	_____
Source Type:	_____
BC or Serial #:	_____

Screen Operation:

New Batch:

- If the batch is a purchased batch, tab to the **Make/Purch:** prompt and type a P for purchase. If the batch is being manufactured at the facility the field contains the correct value, M for Make.
- Type the abbreviation for raw material supply source next to **Source Type:**. Valid source types are:
 - CY - Cylinder
 - HT - Hydril Tube
 - LT - Liquid Tank
 - PS - Purchased Source
 - RC - Rail Car
 - TT - Tube Trailer
- If the material source has a bar code attached to it, wand the bar code.
Otherwise, type the serial number or identifier of the supply source next to **Serial #** or **BC:** and press the ENTER key.

Existing Batch:

- Tab back to the **Batch:** prompt and type the batch number next to it.
- Press the **ENTER** key.

GAS Fill (Screen 2):

Sample Screen:

Btch: _____
Srcœ: _____ #: _____
Cyls: _____
CO: _____
Comdty Code: _____
OR Order #: _____

Screen Operation:

New Batch:

- The batch number and the source type will be displayed at the top of the screen.
- APCI cylinders:
 - Type the number of cylinders to be made for the first commodity code next to the Cyls: prompt.
 - Type N for APCI owned cylinders or Y for customer-owned cylinders next to the CO: prompt.
 - Type the commodity code next to the Comdty Code: prompt.
 - Press the ENTER key.

- **Made -to-Order Cylinders:**
 - Wand the order number from the production document.
- The customer owned designation and the scheduled units will come from the order itself.
- Press the ENTER key.

Existing Batch:

- The batch number and the last source entered will be displayed at the top of the screen.
- If any commodity codes have been entered, the first one found for this batch will be displayed. If this is correct, press the ENTER key. If you need to change the information, follow the section for a new batch.

GAS Fill (Screen 3):

Sample Screen:

Btch:	_____
Srce:	___ #: ___
ChSc:	___ C: ___
SC:	_____ FL: _____
Vol :	_____.
BC :	_____

Screen Operation:

- The batch number and the last source entered will be displayed at the top of the screen.
- Wand the bar code on the cylinder.
- The screen will be displayed with CNTNTR ADDED if the data is correct. The fill volume will also be displayed.
- To change the supply source:
 - Tab to the **Chg Srce:** prompt. Type a "Y". Press the ENTER Key. Follow the directions for GAS FILL screen 4.
- To delete a cylinder from a batch:
 - Tab to the **C:** prompt and type a "D". Tab down to the **BC:** prompt and wand the bar code on the cylinder. If the process is successful, the message CNTNR DELETED will show at the bottom of the screen.
- To change the commodity code, or indicate the next cylinders are for a specific order, press the FUNC key and then the D. The previous screen will appear which prompts for a commodity code or another order number. Follow the directions for HCL screen 2.

- When the batch is completely finished, press FUNC and the "F" key to complete the batch. Follow the instructions under screen 5 for completing the batch.

GAS Fill (Screen 4):

Sample Screen:

Source Change
Batch: _____
Source Type: _____
BC or Serial #: _____

Screen Operation:

- The batch number will be displayed at the top of the screen.
- Enter the next source the same way as the first source was entered on screen 1.
- Press the ENTER key.
- The source will be added (if no errors) and screen 3 will be displayed to enter more cylinders.

GAS Fill (Screen 5):

Sample Screen:

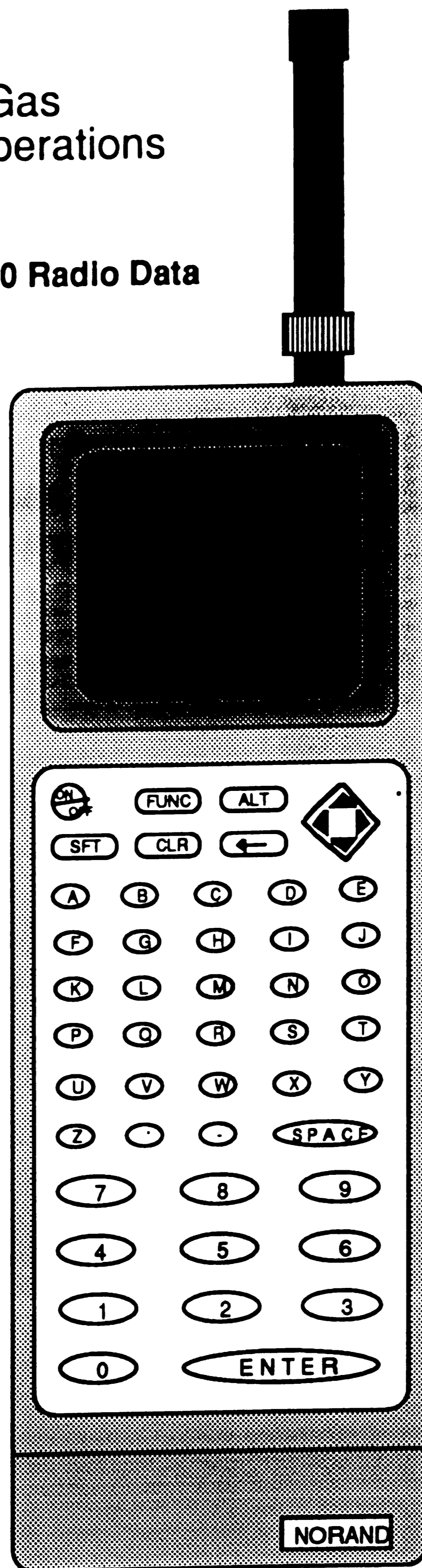
Batch No:	_____		
Prod:	_____		
Grd	Size	Qty	∞
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Screen Operation:

- The batch number will be displayed at the top of the screen. The product that was filled in the batch will appear next. The total qty filled for each grade, size and customer owned designation will be shown. To indicate the batch is complete, press FUNC and "F". If everything completed successfully, the first screen will be displayed and the message "Batch Complete" will be displayed.

Specialty Gas
In-Plant Operations

Norand P3210 Radio Data
Terminal



Vita

The author was born in Halifax, Pennsylvania on December 8, 1951, the daughter of Mr. Richard C. Tobias and Mrs. Evelyn L. (Stence) Tobias. Upon graduating from Halifax Area High School in June of 1969, she attended Shippensburg University (Shippensburg State College), Shippensburg, Pennsylvania, for one year. Her major was secondary education with a minor in French. After a ten year hiatus, she attended Kutztown University, (Kutztown State College), Kutztown, Pennsylvania. She graduated in December, 1981, with a B.S. in Computer and Information Science and a minor in Business Administration. Since graduation, she has been employed in the Management Information Services department of Air Products and Chemicals, Inc., Allentown, Pennsylvania, where she has developed and maintained order processing and production and inventory control systems for the Industrial Gas Division. She currently holds the title of technical analyst.