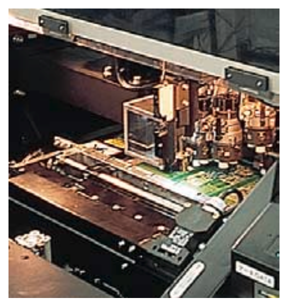
World Class Manufacturing Environment



Andover Controls

WE'RE BUILDING SMART

Contents

Preface

An Introduction to Andover Controls

Andover Controls Corporation designs, manufactures, and markets advanced microcomputer-based "intelligent building" control systems. These systems are critical in helping facility owners and operators manage their buildings more efficiently by providing powerful but flexible solutions for Heating, Ventilation, and Air Conditioning (HVAC), lighting control, security management, process control, and more.

Since 1975, we have maintained our leading position in today's fast-moving controls industry by providing customers with innovative and technologically advanced products. From our very first controllers to the current product line, Andover Controls Corporation has created state-of-the-art technology solutions that allow our customers to control their buildings *their* way.

Today Andover Controls Corporation has over 45,000 systems installed on every continent in the world and in a wide range of applications, including offices, industrial/manufacturing sites, retail locations, supermarkets, hospitals, sports arenas, correctional facilities, schools, and other buildings of various sizes.

Our corporate headquarters, located in Andover, Massachusetts, supports a worldwide network of more than 450 Andover Controls Automation Representatives. Our company's seven regional offices—in Andover, Massachusetts; Ashby-de-la-Zouch, England; Konstanz, Germany; Bois Cedex, France, Mexico City, Mexico; Krakow, Poland; and Kowloon, Hong Kong—provide our customers with the project engineering, technical, and training support they need to effectively manage their own building systems.

Our mission is to *exceed* our customers' expectations by providing high quality, technically innovative products and world class service to the HVAC, Security, and Integrated Building Markets.

A "World Class" Manufacturer

Andover Controls is a "World Class" manufacturer. Towards the realization of our mission, we have been and will remain focused on our customers' requirements, the quality and reliability of our products and services, and the development of a strong, agile, and flexible work force.

This report identifies and explains the "World Class" principles and practices we have in place. These principles and practices are continuously being developed and enhanced in our decentralized manufacturing environment. Our quest for improved customer relations, quality, and performance is truly never ending.

Overview of Andover Controls' World Class Practices

A Structured Approach to Product Development, Manufacturing Assembly, and Testing

Andover Controls Engineering uses a set of standard operating procedures appropriate for each engineering discipline (i.e., software, hardware, mechanical, documentation, etc.). These procedures ensure early participation from all our appropriate internal departments, as well as our end users and suppliers. Cross-functional teams are formed in the conceptual stages of product development. These teams carefully consider and adhere to the Design for Manufacturing Assembly (DFMA) and Design for Manufacturing Testability and Repairability (DFMTR) requirements during this development process. In addition, they consider new technologies, and often research, design, and pilot leading-edge processes prior to manufacturing.

Using our internal Local Area Networks (LANs), our engineering team can download Computer Aided Design (CAD) files directly from our hardware design database into our manufacturing Printed Circuit Board (PCB) assembly and test database. From this point, the off-line development process of automatic assembly and test programs begins.

We use an Engineering Change Order (ECO) system to document and control all design creations, transactions, modifications, and revisions.

Material Planning and Procurement

The demand for product triggers the procurement of raw materials through partnerships, which have been established and nurtured in the early phases of product design and development. During this process, cross-functional teams consisting of suppliers and internal members from the appropriate disciplines have negotiated lead times, quantities, and costs using the customers' requirements, reliability, Just-In-Time (JIT) methods, consignment, and standardization as the baseline elements.

Problem Solving

Over the years we have explored many problem solving methodologies. We found the Eight-Discipline (8D) system to be the most comprehensive and applicable for our environment. This system provides a methodical approach to problem solving and prevention, rather than detection. The scope of the system is extremely broad from the discovery of the problem all the way through to exploring other areas of opportunity for improvement prior to detection. Included in this system are team building, containment actions, root cause analysis detail, process mapping, and the use of specific quality improvement tools.

All employees receive training with this system and are expected to practice these skills on a daily basis.

Real Time Statistical Process Control (SPC)

From the receipt of the raw materials to the completion of each of our systems, real time SPC is utilized. The teams update and track process capabilities and variation using the appropriate data to create variable or attribute charts throughout the entire process. Our operators are trained in basic SPC, so they can calculate the control limits and the averages. They monitor critical characteristics, and, if an out-of-control condition develops, they have both the responsibility and the authority to shut down the process until they understand the cause of variation and correct it. The data from this program provides the foundation for our Continuous Improvement Program (CIP).

Employee Empowerment/Team Building

We believe our employees are our most valuable internal resource. We provide training for all, and active team participation is a requirement for every member of the organization. Teams develop at each critical process point with individual roles changing as activities and expertise expands. The roles of the supervisors and manufacturing and test engineers have evolved into team facilitators and subject matter experts. Each member is empowered to make any change necessary to improve or maintain the integrity of the process. Our decisions are based on data and facts rather than emotion.

ISO 9001 Modeling

We have modeled our documentation and control systems to conform to the ISO 9001 requirements. We have identified the critical elements and have put the appropriate procedures in place. We conduct internal audits periodically, and monitor and review the results with the entire management team. Several of the world's leading manufacturers and service providers have reviewed, scrutinized, and *accepted* our system.

Operator Self Inspection

Operator ownership, proactive thinking, and the use of data allow the individual operators to minimize process variation and non-value-added inspection stations.

Internal teams have created the tools necessary to make this program a success. One hundred percent of the PCBs and systems manufactured are included in this program. The teams consist of either internal or external customers, suppliers, and value-adding individuals from each of the critical manufacturing process points.

The critical characteristics of each assembly at each process point are defined, a checklist created, and training provided.

Preventative Maintenance

The accuracy of the equipment is one of the more important variables required to produce repeatable results. For this reason, we maintain all of the equipment used for the assembly and test of the products per the original manufacturer's specifications. The equipment users perform the daily or more minor maintenance, with the major maintenance completed primarily by external sources.

Electrostatic Discharge Prevention (ESD)

Our understanding of the insidious problems that can result from an ESD event, along with our knowledge of the possible sources of ESD, have stimulated strong interest and comprehensive coverage in this area. All employees and visitors who wish to interact with the manufacturing process must go through a series of ESD preventative steps. They must attach ground straps to their shoes and wear an appropriate lab coat. Our facility is protected from this phenomenon by properly grounded and coated floors, tables, and chairs. ESD preventive tape, bags, bins, and document sleeves are also in place. The environment is carefully controlled and internal inspections are conducted on a regular basis.

Corporate Citizenship

Andover Controls Corporation has developed a relationship with several adult education providers in the Greater Lawrence area. We deliver to them, for their training use, computers and electronic testing equipment at no charge. We also employ graduates of their training programs.

We encourage our employees to become involved in a variety of community organizations and charitable foundations. We believe it is imperative to give back to the community in ways that are available and possible for us.

Environmental Responsibility

During the last decade we have strengthened our position in support of a non-hazardous and clean environment. At one time, the manufacturing process generated thousands of gallons of hazardous waste. This waste had to be handled, processed, and removed using certified suppliers and presented a low-level threat during its use. Within the last few years, we have redesigned the process and completely eliminated the use of hazardous chemicals. The primary source had been the 111-Trichloroethane, which was used to remove the heavy residue left on the PCBs by the flux chemistry in use at the time. We currently use a "non-residue"-based flux chemistry that completely dissolves during the wave solder process. This completely eliminated the need for a post-solder cleaning process.

Overview of the Critical Processes in the PCB Assembly Plant

Introduction

Upon receipt of the individual components, Andover Controls populates its own PCBs. The PCB Assembly Plant currently produces 300 models of PCBs at the rate of approximately 18,000 per month. We run one shift, Monday through Friday. The modules are scheduled and produced based on customer orders received by the company. Sixty-five percent of the components used in the modules are part of our custom replenishment program. This program includes both JIT and consignment deliveries. All modules receive a bar code label at the beginning of the process, which is used to track it through its entire life cycle.

The following key process points utilize the "World Class" practices described earlier in this document with special attention paid to continuous improvement and statistical process control.

Receiving/Incoming Inspection

Of the more than 2,500 individual components received, approximately 80 percent are on our dock-to-stock program. We have classified 20 percent as critical components. These 20 percent, which consist mainly of build-to-order materials such as PCBs and mechanical components, are sample inspected, with the results monitored via our SPC program.

Automatic Insertion

Andover Controls Corporation manufactures products that require the use of both through-hole and surface mount technologies.

We maintain and utilize a complete line of through-hole equipment. The line includes a 100-station sequencer that operates at a rate of 25,000 parts per hour. This sequencer feeds a Variable Center Distance (VCD) machine that operates at a rate of 15,000 parts per hour. The final steps for the through-hole modules are over the Dual Inline Package (DIP) inserter and the contact inserters.

Our surface mount lines include a de-stacker, an automatic screen printer, a glue machine, and a chip-shooter capable of installing 36,000 parts per hour, a flexible placement machine, a re-flow oven, and an X-Ray machine. This line can install discrete components as small as .0402 inches, 15 mil fine pitch multi-lead devices, and micro ball grid arrays. Currently, we are installing discrete components sized at .0603 inches, 15-mil fine pitched devices, and ball grid arrays. The design of the surface mount line is continuously being reviewed and upgraded to take advantage of the emerging technologies.

Semi-Automatic Insertion

This process point couples the precision of the equipment with the dexterity of an operator to accomplish the through-hole assembly of components that are not designed for installation by automatic equipment. These components consist primarily of radial lead devices, light emitting diodes, and transistors.

The equipment indicates the positioning of the component, delivers the component, and performs the cut and clinch function. The operator installs the component as specified and activates the cut and clinch mechanism via a foot pedal.

Through-Hole Wave Soldering

The variables of this process are handled similar to all others. The speed, convection preheat temperatures, angle of approach, wave height, and temperature are all considered when developing the recipe for each module. The process is designed to utilize a low residue flux that requires no secondary cleaning operation. The wave solder machine holds 1,400 pounds of molten solder at a temperature of 500 degrees Fahrenheit.

Post Wave Assembly

At this point, any components that cannot be installed prior to the wave soldering process are hand assembled and soldered. These components consist of items such as lithium batteries, insulated jumpers, and replaceable fuses that may be damaged by the heat from the wave-soldering machine. The operators also visually examine the modules for solder bridging and voids.

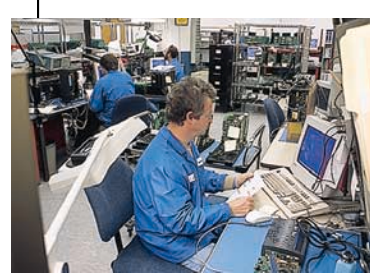
In-Circuit Test

This process point provides an electrical inspection on approximately 90 percent of the modules manufactured in the plant. The operator selects and installs the appropriate fixture onto the test bed. Once the fixture is in place, the module under test is placed into the fixture and the automated test is activated. The tests are designed to check for solder shorts and opens and to perform an active test on the analog and digital devices. The equipment is also used to program some of the on-board programmable devices such as the Erasable Programmable Read Only Memory (EPROM). From this point, the modules are delivered to the System Assembly and Test Plant.

The 10 percent that bypass this point move directly to Functional Bench Test, which is described in the next paragraph.

Functional Bench Test

In this test, we use previously certified product and our operational software to perform the initial power-up and calibration of approximately 10 percent of the modules manufactured. The decision to route a module through this process point is made after careful consideration of the circuit complexity, as well as the volume of modules being manufactured. From this point, the modules are delivered to the System Assembly and Test Plant.



Overview of the Critical Processes in the System Assembly and Test Plant

Introduction

The System Assembly and Test Plant creates our customers' systems by integrating the populated PCBs with mechanical sub-assemblies and the appropriate software. The individual mechanical components, with the exception of the populated PCBs, are purchased and delivered to the manufacturing process. The System Assembly and Test Plant currently produces more than 5,000 models at the rate of approximately 15,000 per month. We run one shift, Monday through Friday. These systems are scheduled and produced based on actual customer orders. Ninety percent of the components used in the systems are part of our build-to-order program. All systems are tracked using the customer's order along with the bar code label applied to the PCB.

The following key process points utilize the "World Class" practices described earlier in this document with special attention to continuous improvement and statistical process control.

Electro-Mechanical Assembly

The task here is to integrate the mechanical components with the PCBs. Pneumatic tools are used to assemble the systems as the work orders are received. From here, the system is passed along to the final test area.

Functional Test

At this point, the system is subjected to a functional test, which confirms the operation of the hardware. We use custom designed test fixtures and stations to perform these tests. Our automated tests are designed based on the National Instruments standard PXI platform, utilizing a combination of Andover Controls *Plain English*® and Lab View® programming. All I/O, communication, and network circuits are 100 percent functionally tested.

Final Assembly

In the Final Assembly area, the final labeling and the paper work is done. The customer's order is now completely assembled and has passed the functional final test.

Final Inspection

This is a final process checkpoint. Personnel in this area visually inspect the physical characteristics of each system, using a checklist to guide the inspection and to provide a record of the results. Once completed, the bar code label is scanned and the packing slip and a shipping label are automatically generated and placed with the system.

Packing and Shipping

At this point, the systems are packaged and shipped to our customer's site.
Our packaging is designed to meet the requirements established by the International Safe Transit Association (ISTA).

Conclusion

You have completed a chronological tour of the key process points in our manufacturing operation. The materials we have procured from around the world have traveled an additional 2,000 feet. During this journey, we have converted these materials into the finished products needed and used by our customers worldwide. The average cycle time for this process is six days.

The manufacturing areas described occupy 20,000 square feet. These areas share our continuous improvement philosophy and are under constant review for improvement based on our customer requirements.

Measurements

Delivery Performance

The key indicators we currently monitor are on-time delivery and actual scheduled date versus the customer's request date. We realize we have a great opportunity in this area and intend to maintain and implement any new programs that are necessary to satisfy our customers' requirements.

Quality

Each process point uses SPC to measure and monitor their progress. These real-time measurements are summarized monthly and reviewed by the individual CITs. The teams use these reports to confirm their continuous improvement activities. We have realized steady yield improvements over the past years and firmly embrace the concept of never-ending improvements.

We measure the field performance of the product in several ways. Some key indicators include the use of the percentage of returns experienced within the warranty period and the associated failure analysis data.

Appendix

Table of Acronyms

Acronym	Definition
8D	Eight Discipline
CAD	Computer Aided Design
CIP	Continuous Improvement Program
CIT	Continuous Improvement Team
DFMA	Design for Manufacturing Assembly
DFMTR	Design for Manufacturing Testability and Repairability
DIP	Dual Inline Package
ECO	Engineering Change Order
EPROM	Erasable Programmable Read Only Memory
ESD	Electrostatic Discharge Prevention
HVAC	Heating Ventilation and Air Conditioning
ISTA	International Safe Transit Association
JIT	Just-In-Time
LAN	Local Area Networks
PC	Personal Computer
PCB	Printed Circuit Board
PXI	PCI eXtension for Instrumentation
SPC	Statistical Process Control
VCD	Variable Center Distance

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