Basics of Manufactured Construction

Second Student Edition
August, 2017

Authors:

Charles J. Kibert
Abdol R. Chini
Shabnam Rumpf-Monadizadeh
Mohamad A. Razkenari

UF
UNIVERSITY of FLORIDA

TRAMCON
Training for Manufactured Construction

THIS COURSE WAS DEVELOPED THROUGH A COLLABORATION OF THE FOLLOWING HIGHER EDUCATION INSTITUTIONS:

Miami Dade College

UF UNIVERSITY of FLORIDA

POLK STATE COLLEGE

Colorado State University

SF SANTA FE COLLEGE

SEMINOLE STATE COLLEGE OF FLORIDA

UNIVERSITY OF WISCONSIN STOUT
WISCONSIN'S POLYTECHNIC UNIVERSITY

This material was funded in whole by a $9.9M TAACCCT grant awarded by the U.S. Department of Labor's Employment and Training Administration. The product was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The U.S. Department of Labor makes no guarantees, warranties, or assurances of any kind, express or implied, with respect to such information, including any information on linked sites and including, but not limited to, accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability, or ownership.

Table of Contents

Module 1 – Detailed Process for Factory Manufactured Homes

Module 2 – The Quality Program and Process for Manufactured Construction

References

My Notes

MODULE 1

DETAILED PROCESS FOR FACTORY MANUFACTURED HOMES

1.1 INTRODUCTION

The **Training for Manufactured Construction** (TRAMCON) curriculum provides opportunities for students who are interested in joining the manufactured construction industry and advancing their knowledge and skills. There are four different levels of certificates that can be achieved by successfully completing the training programs designed for this purpose. The four levels of certification are: Foundation Level, Basic Level, Advanced Level, and Supervisory Level. This course, **Basics of Manufactured Construction**, is a part of the curriculum for the Basic Level certificate and covers (1) the production process of the home (commonly referred to as units) in a factory setting, and (2) the quality program and process for manufactured construction.

As a review from the first TRAMCON manufactured course in the Foundation Level, **Introduction to Manufactured Construction**, TRAMCON focuses on two types of homes manufactured in factories. The first of these is referred to as **manufactured homes** or **HUD code homes**. This type of home is subject to Federal inspection and requirements. The second type is known as **modular homes** and can be thought of as a typical new home manufactured in the factory and assembled on site. Virtually any type of home can be manufactured in a factory and the flexibility of the design and manufacturing process provides an enormous number of options for home buyers. Modular homes are not subject to the HUD code but to the building codes in their local jurisdiction.

1.1.1 – DESIGN THROUGH ASSEMBLY

Most home manufacturers sell their products through a network of independent retail sales centers. The independent sales centers are the first line of contact with the customer. Once the order is taken it is sent to the manufacturer as a production order. Drawings tailored for each home unit are created, submitted for approval, and then used to guide the production of the home unit. The following sections explain the production sequence of a house from design to its complete assembly. **(SEE FIGURE 1.1)**

LAND DEVELOPMENT

Companies that manufacture homes are not typically involved in land development or retailing. Every home needs to be placed in some suitable location and the industry has dealt with this requirement in several ways. Full-service or turnkey retailers of manufactured homes buy, develop and sell land, and can package the ownership or rent of lots as part of the home sale. Some retail dealers can accomplish this since they arrange for most of the consumer financing of manufactured homes through individual banks and financing companies. Other retail dealers either sell manufactured homes to customers who already own land, or they direct customers to owners of lots developed and zoned for manufactured homes and which are either scattered or located in community parks[1].

PREDESIGN AND PREPARATION

In the initial planning phase, **predesign and preparation**, the financial institution providing the construction loan is informed of the details of the transaction. The lot for the house is inspected for proper drainage. Site logistics, crane location, and storage areas are planned to ensure a smooth installation process.

DESIGN

In modular construction the size and design of the house are more flexible than for a HUD code home. The size of the units and sections are subject to the transportation limitations, which are based on state regulations and the unit's path of travel. The manufacturers typically offer a wide variety of homes for sale with predetermined floor plans and sizes to meet the needs of their different users. The customer can either pick a predesigned plan or choose a customized design based on the available plans and their lifestyle. The customer may hire a general contractor to assemble the house or they can act as a general contractor and hire the required subcontractors. The general contractor obtains the required permits and coordinates the required inspections and approvals.

FABRICATION

In the fabrication phase, the home is manufactured in the controlled, enclosed environment of a factory. The components of the home are assembled to create sections or units which fit on a chassis, and are transported by truck to their destination. This module will provide detailed information about the production and off-line stations in the factory, and all the components[2] and operations that are completed at each station. When delivered to the site the fabricated modules will be placed side-by-side, end-to-end, or stacked, allowing a wide variety of configurations and styles for the building layout.

DELIVERY

Transportation is a key to the design of the units because the sections have limitations in size dictated by road width, bridge heights, and other route factors. The sections are delivered or shipped on trucks, trailers,

modular transporters, rail transports, cargo planes, boat containers and, if necessary, can be lifted by cranes or helicopters. The mode of transportation depends on the size and weight of the sections, the transportation distance, and cost implications.

SETTING & ASSEMBLY

Setting and assembly are the final steps in installing the modules at their final location. This phase includes hoisting, positioning, adjusting, connecting and **stitching** or fastening the units together to assemble the home. Lift points for the modules are designed by an engineer to stabilize the weight of the module during **hoisting** while the module floats in the air. For wooden modules, belt straps are used, and as a result, the structure of the module should be stronger than on-site built houses. **Rigs, riggings or spreader bars** may be needed to facilitate the lifting of the modules. In most assemblies, modules must be lifted by a crane and moved into their final location by **on-hook** elements such as guide ropes.

REVIEW QUESTIONS 1.1

1. Explain how turn-key or full-service retailers of manufactured homes operate.
2. What parameters and limitations influence the size of the units?
3. Imagine you are about to order a manufactured home: what preparations do you need to make?
4. Using the internet, determine the minimum and maximum sizes of units that can be transported on roads in your area.
5. Manufactured houses usually have a more rigid structure compared to normal site-built houses. Why?

FIGURE 1.1: DIAGRAM SHOWING THE DIFFERENT STAGES OF THE PRODUCTION OF A HOME IN A MANUFACTURED CONSTRUCTION PROCESS

1.1.2 – IDENTIFICATION OF THE HOME IN THE PRODUCTION PROCESS

Every factory built home is assigned a serial number and has a data plate. The serial number assigned to a factory built home is much like the vehicle identification number assigned to a vehicle. It will be used as a point of identification for the home throughout its life. The serial number is designed to provide specific information about the home, such as the manufacturer and the state of origin. This number is also placed on the home's **data plate**, which contains critical information relative to the design and construction of the home. Some of the information contained on the data plate include the designed wind speed, roof load limitations, and thermal design data. The data plate must be mounted on an inside component of the house in a permanent manner.

MORE ABOUT THE SERIAL NUMBER

The manufacturer assigns a **serial number** to each transportable section of a factory built home. This is true for both HUD and modular homes. The home's serial number is followed by an A, B, C, and so on depending on the number of sections it takes to make up the home. For a two section home, the serial numbers of the A and B sections will be 123456A and 123456B. The serial number can be found inside the house on the home's Data Plate. For HUD homes only, the serial number is required to be stamped into the steel cross member to which the towing hitch is attached.

MORE ABOUT THE DATA PLATE

All factory built homes, both HUD and Modular homes, have a permanently attached Data Plate. The Data Plate contains all applicable information about the specific unit. This information includes the model, manufacturer, and all applicable codes and loads. The Data Plate is permanently affixed so that it cannot be removed without its destruction. Two copies of the Data Plate are created, one retained by manufacturer, to be placed in the job file, and the other copy is forwarded to the third party inspection agency for their files. The Data Plate is

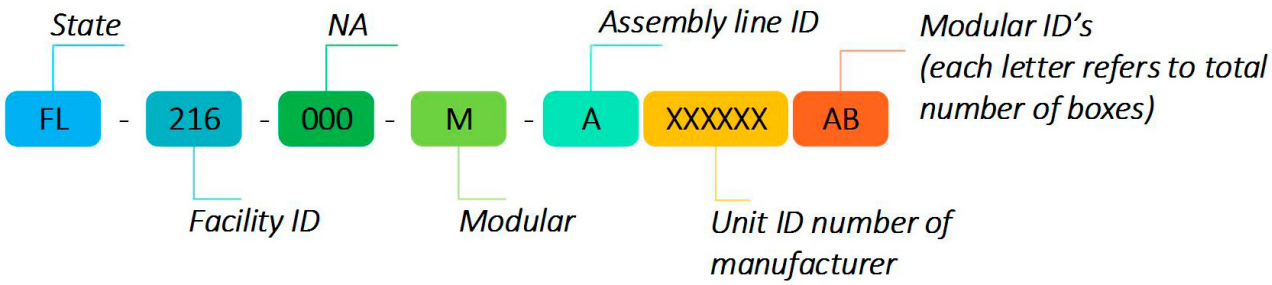

FIGURE 1.2: DIAGRAM SHOWING THE SERIAL NUMBER AND THE MEANING OF THE ABBREVIATED LETTERS

permanently affixed at a specified location in the home prior to the shipment of the home from the production facility. The standard locations for permanently adhering/affixing the Data Plate are on the inside of the electrical panel door, inside of a closet wall, or to other components of the home. In general, the Quality Manager is responsible for attaching the Data Plate to each home. The Data Plate is a source of critical information about the home. Because the local agencies may not have seen the construction documents for the home, or may have not inspected the home during construction, the Data Plate can provide valuable information about the home's construction and design elements.

REVIEW QUESTIONS 1.2

1. Why are the serial number and the data plate in manufactured homes important?
2. A house has 3 units which will be attached together on site. How is this designated in the serial number?
3. What locations in the HUD home can be used for affixing the serial number and the Data Plate?

1.2 OVERVIEW OF THE FACTORY BUILT HOME PROCESS

Manufacturing companies are continuously looking for effective quality improvement programs. The production process of factory built homes is much the same as for automobiles moving through a manufacturing process. Quality programs have proven to be extremely effective, and all manufactures have adopted very effective quality assurance and control programs.

PRODUCTION LINE

On the **main production line**, units start at one end of the assembly line and move to the other end to eventually become a complete unit. The main production line consists of various stations. Off to the side of the main production line are **off-line stations** where major components are pre-assembled. Off-line stations do not travel and are fixed in place. At these stations, components such as walls, roofing and millwork are built. The products of these stations feed the main production line. These peripheral activities and spaces include cabinet shops, the millwork shop, a welding station for building the chassis, wall and truss stations, and storage for adhesives or other materials.

The production of the units in a factory is divided into 5 groupings of stations and substations that are referred to as **major construction departments**: (SEE FIGURE 1.3)

(1) Frame and floor building and assembly
(2) Wall building and assembly
(3) Roof building and assembly
(4) Exterior finish
(5) Interior finish

FRAME AND FLOOR DEPARTMENT

A typical Frame and Floor Department contains multiple substations, for example, four main line production stations where the wood floor system is framed in an inverted position, insulated, and equipped with floor plumbing, water distribution piping, and electrical wiring. A steel chassis custom designed for the unit is attached to the floor and the floor system is then flipped into a horizontal position and the floor decking is installed. The floor decking is then sanded and made ready for the floor finish material.

WALL BUILD AND WALL SET DEPARTMENT

The Wall-Build and Wall-Set Department typically consists of one main line production station and five off-line support stations. In this department, the interior partition walls, **marriage-wall,** and side and end walls are built. This area consists of several tables specially designed for the construction of the various types and sizes of walls needed for the homes being manufactured. When the walls are built, they are placed into **production transition racks**, awaiting the wall set installation personnel. The wall set personnel are required to determine the locations where the various walls are to be installed on the floor or unit traveling along the production line. Once the wall location is identified, a logical order for setting the walls will begin. The order in which the walls are set is dependent on the floor plan and production restrictions. The bathtubs and shower units are often positioned on the floor prior to the installation of the

bathroom walls. This provides adequate space for the placement of the large construction components around these fixtures.

ROOF BUILD AND ROOF SET DEPARTMENT

The Roof Build and the Roof Set Department typically consists of two offline stations and one main line production station. The first offline station has a roof build table where the ceiling gypsum sheets are placed on the table followed by the placement of the roof trusses. The ceiling material is attached to the roof assembly using a two-part adhesive that is sprayed along the gypsum and the bottom chord of the truss. All components related to the roof construction, such as ridge-beams, are completed at this point.

Electrical wiring is placed in the roof system as required by the plans. In addition, at this time any ceiling ductwork and insulation is installed. Once all the components of the roof system are completed, the roof assembly is transferred to a second off-line station. In this station, work on the ceiling system begins. All ceiling prep work is performed within this area. Once the ceiling prep work is completed, the ceiling finish material is applied. Upon the completion of the ceiling finish, the roof assembly moves onto the production line and is placed on the previous floor where the walls were recently installed. In the roof setting process, the connection between the roof and wall elements are checked to make sure they are square and in alignment. Finally, the required connections between the assemblies are made and any components that extend through the roof system are prepared.

ROOF FINISH EXTERIOR FINISH / INTERIOR WORK DEPARTMENTS

The Roof Finish Department is usually a main production line station and it may have multiple substations. In this area of the plant, the roof decking is installed along with any penetrating devices, the soffit and fascia, windows, doors, exterior trim and exterior siding. The interior finish, cabinets and interior electrical work are completed along with the plumbing

FINISH DEPARTMENT

The Finish Department may have several substations and extend outside of the building into the yard area. Many different activities are conducted in the finish department at the same time as the exterior of the home is being completed in the previous station. Many of the tasks that were started a station or two back in the Main Production Line are now being completed. New activities such as finish plumbing, finish electrical work, and interior trim are underway. The start of cleanup begins and window treatments are installed. Any rework that has been identified should be nearing completion. The home testing is also completed at this station. It consists of tests of the electrical, plumbing, water, drain, and gas systems. Final quality control inspections are conducted, along with final clean-up. Any products that are needed for installation are placed into the home and the appropriate Insignia is affixed. The home is now ready for shipment.

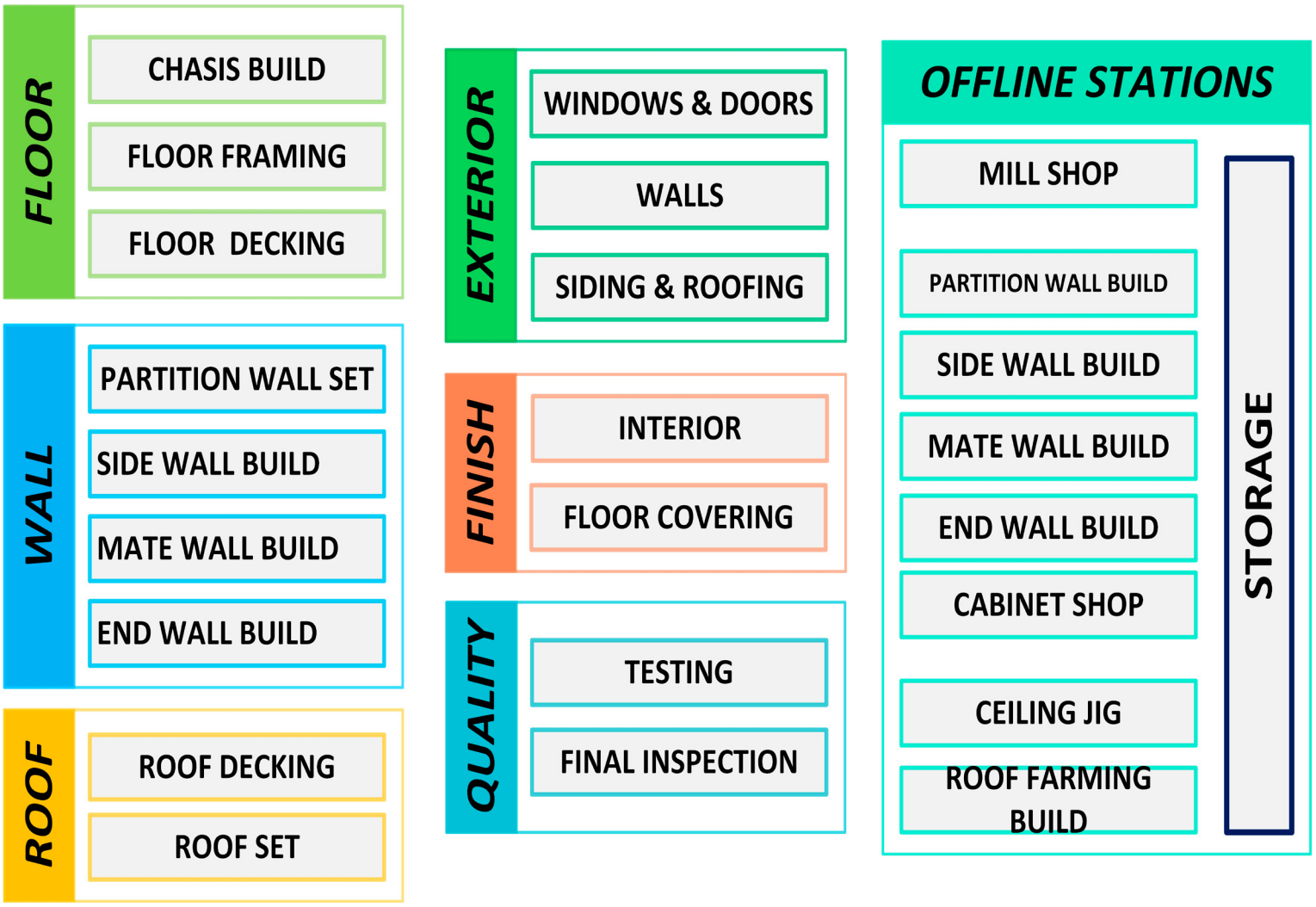

FIGURE 1.3: DIAGRAM SHOWING THE DIFFERENT STATIONS IN A MANUFACTURED CONSTRUCTION PLANT

REVIEW QUESTIONS 1.3

1. Describe the main production line. What is the difference between the main production line stations and offline stations? What stations are not part of the main production line?
2. In the factory, the walls are first built and then connected together on the flooring system. True or false? Explain.
3. When and at what stations are the bathtubs and shower units installed on the production line?
4. Name a few offline stations in the Wall Build and Wall Set departments.
5. What are the operations typically performed in the Roof Build and Roof Set departments?
6. You are working in the Roof department. What component would you start building first? What next?
7. The building process for manufactured housing starts from the exterior and proceeds to the interior finishing. True or false? Explain.

1.3 DETAILED DESCRIPTION OF THE FACTORY BUILT HOME PROCESS

PRODUCTION PROCESS:

In a manufacturing plant, the work begins with building the chassis in the first station and continues through to the last station, which includes testing and inspection. The manufacturer has the option of scheduling inspection and quality control work earlier or later in production for the purpose of balancing the production line. Individual components such as walls, the floor, and the roof are checked for being square before being assembled onto a movable support system. As modular component units are assembled during the manufacturing process, they continue to be checked for squareness and proper fit before they are delivered to the site. Overhead cranes, carts, and rails are used throughout the offline and online production lines to move modules and components within the facility.

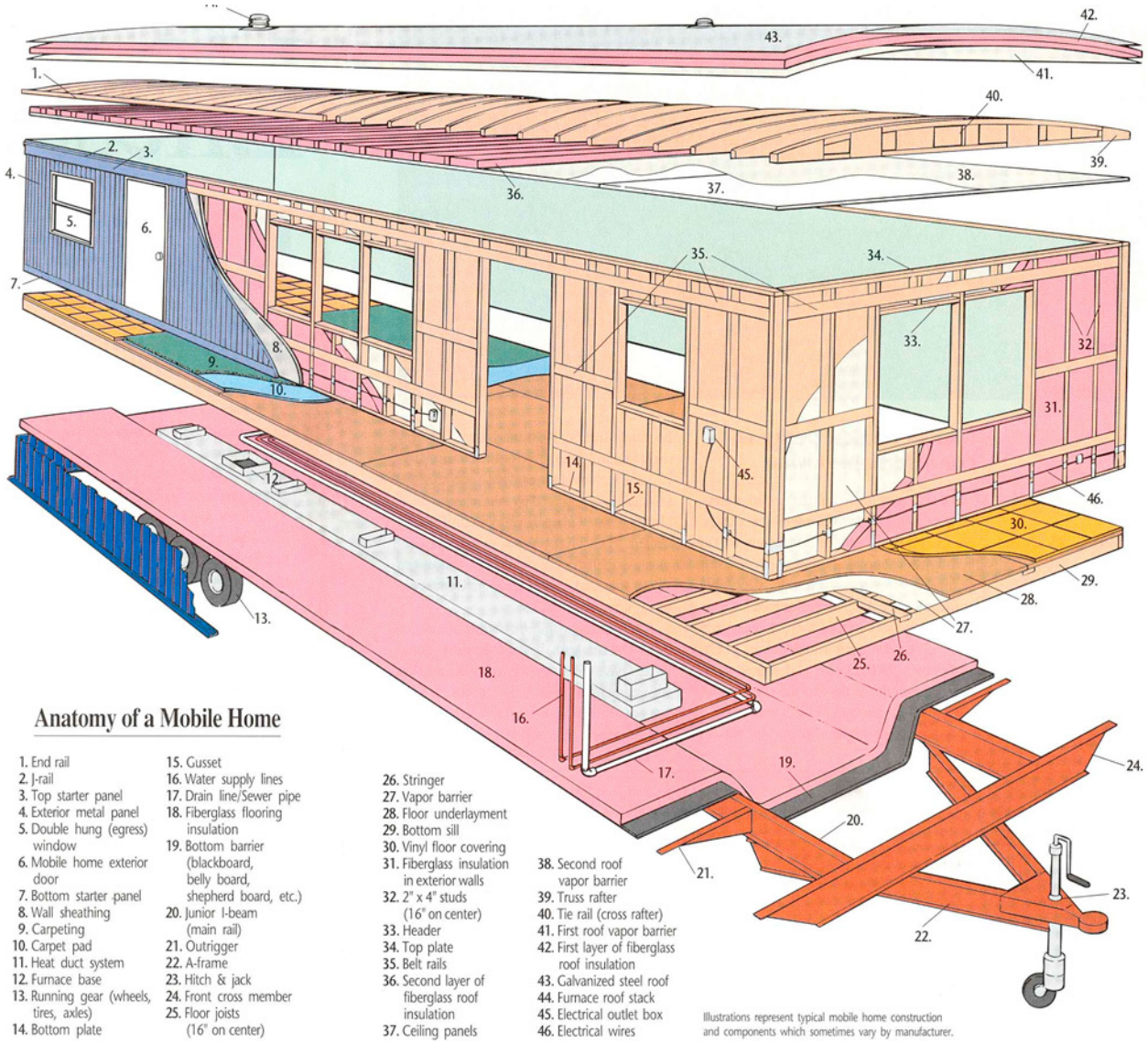

FIGURE 1.4: DIAGRAM SHOWING THE PARTS OF A MANUFACTURED HOME.

1.3.1 - FLOOR DEPARTMENT/STATION INCLUDING SUBSTATIONS

General activities at the Flooring Station are: **(SEE FIGURE 1.5)**

- Building the chassis
- Framing the floor
- Installing floor deck, water lines, floor wiring, in-floor drain, waste, and vent (DWV) piping, and floor heating ducts
- Insulating floor and applying bottom boards
- Installing floor coverings as necessary
- Installing fire stops using applicable materials
- Assembling plumbing / gas lines in an offline substation

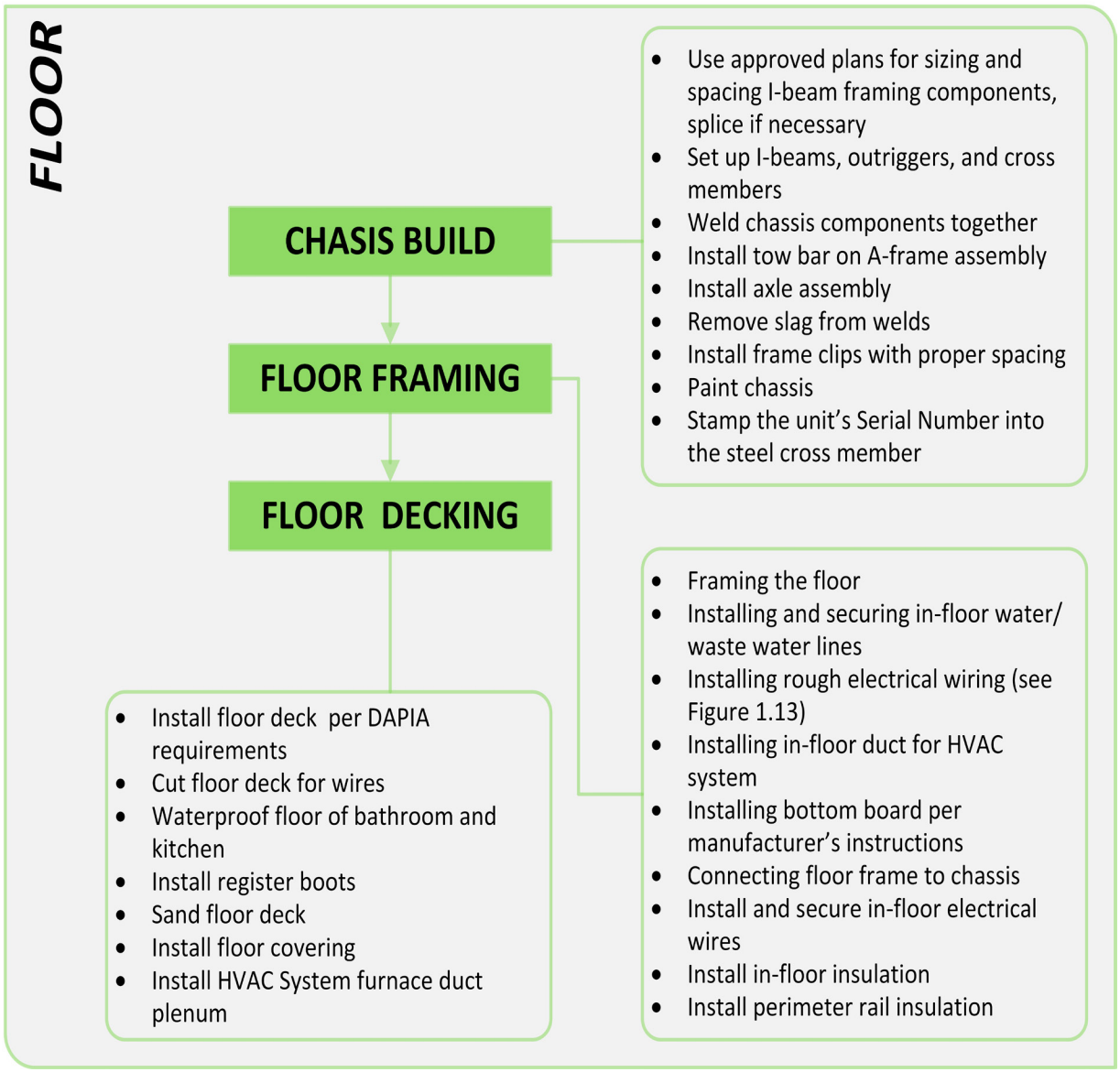

FIGURE 1.5: DIAGRAM SHOWING FLOORING STATION ACTIVITIES IN A MANUFACTURED CONSTRUCTION PLANT

1.3.1.1 CHASSIS BUILD SECTION

In this section of the floor department the chassis, a steel frame structure that supports and carries the house to its destination, is built **(SEE FIGURE 1.6)**. For HUD houses, the chassis stays with the house and, by law, it cannot be removed from a HUD house. For modular houses, the chassis is usually returned to the factory. For this reason, it is built with heavier I-beams and is therefore more durable to allow repeated usage. If the chassis is part of the design of the house, it will stay on-site with the house.

FIGURE 1.6: THE CHASSIS IS USED TO SUPPORT AND TRANSPORT THE HOME TO ITS FINAL DESTINATION.

FIGURE 1.7: CHASSIS IS BUILT AND MOVED ON RAIL TO FACILITATE FLOW ON THE ONLINE PRODUCTION LINE. ALTHOUGH THE CHASSIS IN THIS PHOTO DOES NOT USE OUTRIGGERS, SOME CHASSIS WILL REQUIRE THEM FOR THE TYPE OF HOME THEY ARE SUPPORTING AND TRANSPORTING.

Chassis components include:

- I-beams
- Spring hangers (part of the axle assembly absorbing the load)
- Outriggers **(SEE FIGURE 1.8)**
- Cross members
- Hitch

ACTIVITIES:

In this station, the frame structure used to transfer the home is built. The parts are assembled and the tow assembly and axle assembly are mounted. Finally, the steel structure of the chassis is welded and painted.

1. Use approved plans for sizing and spacing I-beam framing components, splice if necessary
2. Set up I-beams, outriggers, and cross members
3. Weld chassis components together
4. Install tow bar on A-frame assembly
5. Install axle assembly
6. Remove slag from welds
7. Install frame clips with proper spacing
8. Paint chassis
9. Stamp the unit's Serial Number into the steel cross member

The sizes of the chassis components vary and depend on the weight of the home. I-beam sizes and length of cross members and their specifications are specified on the plan. Outriggers, when required, are welded to the I-beam and extend out perpendicular to the I-beam. The I-beams must be properly attached to the cross members to prevent any movement during transportation.

FIGURE 1.8: THE OUTRIGGER IS AN EXTENDED PIECE COMING OUT AND ATTACHED TO THE I-BEAM. IT EXTENDS TO CARRY ALL THE LOAD TO THE EDGE OF THE UNIT.

FIGURES 1.9, 1.10, AND 1.11: STAGES IN THE CHASSIS BUILDING PROCESS

TOOLS:

- Welding equipment
- Rods
- Slag chipping device

The slag is the residual build up caused by a welding rod which burns and creates a coating over the weld. The coating has to be removed for proper inspection of the welds.

PROCESS:

I-beams are typically pre-cut into 40 ft. long pieces. If the home is longer than 40 ft., the I-beams need to be extended. When welding I-beams together, the splice must be made in accordance with the approved drawings and specifications.

PROBLEMS AND AREAS OF CONCERN:

- Slag is a by-product of the welding process and forms a coating over the weld. To properly inspect the weld, the slag should be removed, exposing the weld. Some building codes require that only specific critical welds be cleaned prior to inspection.
- The placement of the chassis members is important. An improperly placed outrigger can create a misalignment of the chassis connection to the floor joists, causing interference with the axle system or misalignment with the fastening points on the floor framing system.
- A cross member that is not properly positioned behind the outrigger may not stabilize the I-beam adequately and cause in-transit problems.
- Welding of the spring hangers to the chassis is critical.

1.3.1.2 FLOOR FRAMING SECTION

The following activities take place in the floor framing section:

1. Framing the floor
2. Installing and securing in-floor water/waste water lines
3. Installing rough electrical wiring
4. Installing in-floor duct for HVAC system
5. Installing bottom board per manufacturer's instructions
6. Connecting floor frame to chassis
7. Install and secure in-floor electrical wires
8. Install in-floor insulation
9. Install perimeter rail insulation

MATERIALS USED:

Dimensional precut lumber, open-truss members, such as joists, wiring, piping and fittings, insulation material, and vapor barrier

TOOLS:

Pneumatic nail guns, impact drivers, clips or heavy gate washers to secure the chassis to the framing, jig or marked floor table, saws, wire staples, strapping, nail-gun or hammer, chop saws for cutting materials to length, rimming tools, various adhesives, cementing tools for the piping, levels and squares to set the piping, and fittings for the plumbing system

PROCESS:

1. The size and spacing of dimensional lumber for the floor joists depends on the joist span and the design loads. The floor joists are typically 16″ on center. Along the perimeter of the floor there are two rim joists that run parallel to the joists plus header joists that run perpendicular to the joists. The header joists have to be placed according to the drawings and then secured to the joists by fasteners or nails.
2. Different sizes of electrical wiring are installed. The wires are pulled from point to point as specified on the plans. The gauge of the wire must be selected in accordance with the drawings. The wires are secured to the floor joist members in accordance with the National Electrical Code (NEC).

FIGURE 1.12: ELECTRICAL INSTALLATION IN THE FLOOR

FIGURE 1.13: PLUMBING INSTALLATION WITHIN THE FLOOR-FRAMING STATION

FIGURE 1.14: PLUMBING INSTALLATION WITHIN THE FLOOR-FRAMING STATION

3. Pipes for hot and cold water distribution system are installed based on the drawings and specifications. The water lines are usually made of CPVC or other approved materials, and are installed with fittings such as T's and 90's to change the direction of the piping. Connection of CPVC pipes is accomplished using cement. The pipes must also be secured to the framing system. **(SEE FIGURE 1.14)**

4. PVC piping is the most common material used in the Drain Waste and Vent (DWV) system. Directional changes are achieved through the use of angular fittings. Compliance with the approved plans and codes is critical to assure proper flow and ventilation of the wastewater system.

5. Roll-type insulation is laid between the joists and runs the entire width of the flooring.

FIGURE 1.15 AND 1.16: INSULATION IS APPLIED ON THE WOODEN FLOORING

FIGURE 1.16: INSULATION IS APPLIED ON THE WOODEN FLOORING

FIGURE 1.17: PARALLEL TO THE CHASSIS STATION AND THE FLOORING STATION, THE OFF-LINE PLUMBING STATION IS PREPARING THE PIPES THAT WILL BE INSTALLED IN THE FLOORING DEPARTMENT

6. A plastic protective layer is applied along the full length of the home over the insulation. The outer skin creates a barrier between the outside environments and protects the home structure.

7. The chassis is moved and turned over and secured to the floor system.

FIGURE 1.18, 1.19: THE CHASSIS IS MOVED AND TURNED OVER TO ALLOW FOR FRAMING.

FIGURE 1.20: THE CHASSIS IS MOVED AND TURNED OVER TO ALLOW FOR FRAMING.

PROBLEMS AND AREAS OF CONCERN:

- In the floor framing station, the position of the floor members, such as multiple joists at specified locations, is important.
- For electrical wiring, it is important that the correct wiring is pulled between points and that the wiring is secured to the frame. If the wiring is not correctly installed or the wrong wire is used, corrective action may need to be taken later in production, causing major problems and delaying the production process.
- For the DWV system, pipe sizes are important. Incorrect pipe size or routing can cause major problems in the installation of fixtures later in production. .

REVIEW QUESTIONS 1.4

1. Name and explain the function of the different parts that make the chassis.
2. Why is slag caused by welding removed during the chassis assembly?
3. What influences the size of a chassis?
4. Why is it so important to attach the I-beams of the chassis to the cross-members of the unit?
5. Why is the correct placement of the outrigger so important?
6. Are heavier joists parallel or perpendicular to the length of the unit? What about rim joists?
7. How is the electrical wiring and the plumbing run through a joist?
8. How do the pipes change direction? Explain.

1.3.1.3 FLOOR DECKING / FINISH SECTION

ACTIVITIES:

1. Install floor deck per DAPIA requirements.
2. Cut floor deck for wires
3. Waterproof floor of bathroom and kitchen
4. Install air register boots
5. Sand floor deck
6. Install floor covering
7. Install HVAC System furnace duct plenum

MATERIALS USED:

Floor sheathing material, floor framing material, appropriate adhesives, fasteners floor covering, and sealants.

TOOLS:

Pneumatic nail-gun, hammer, various types of saws for wood and drain piping, butterfly bits to drill holes through the floor decking, paint brush

PROCESS:

In this station, the floor sheathing material is attached to the floor joist assembly. The sheathing material must be checked for the proper grade, species, and size. The orientation and decking seam offset must comply with plans and specifications. Incorrect sheathing placement may result in inadequate support for the floor. The nailing pattern, which can be found in the specifications, is normally accomplished using pneumatic nail-guns. The deck installer may need to cut and drill the floor sheathing for any plumbing and electrical penetrations shown on the drawings.

The next step is sanding the floor deck. The installer has to pay close attention not to damage any water pipes, drain pipes, and electrical lines that extend through the floor.

FIGURE 1.21: THE FLOOR DECK INSTALLATION

FIGURE 1.22, 1.23 AND 1.24: THE FRAMING IS COVERED AND PENETRATED TO BRING ALL THE NECESSARY PLUMBING AND ELECTRICAL WIRING ABOVE THE FLOOR.

After sanding preparation, the finish floor covering is installed, **(SEE FIGURE 1.24)**. If ceramic tile is specified for a unit, the finish floor process is delayed until later in the production process. Products such as linoleum are often used in kitchens and baths where moisture proofing of the floor is needed. The electrical and plumbing penetrations are sealed to prevent water migration into the cut edges of the decking material.

Once the walls are installed in the home, it may become impossible to install large components such as tubs and showers. For this reason the tubs and showers are installed prior to the wall installation

PROBLEMS AND AREAS OF CONCERN:

- Supporting the floor deck and getting the proper edge support is critical.
- Orientation of sheathing materials
- Sealing penetrations in wet areas
- Fasteners are the proper size and are properly placed
- Proper offset between sheathing materials

1.3.2 WALL BUILD AND SET STATION INCLUDING SUBSTATIONS

In these stations, walls and cabinets are built and set, rough plumbing is installed and finished.

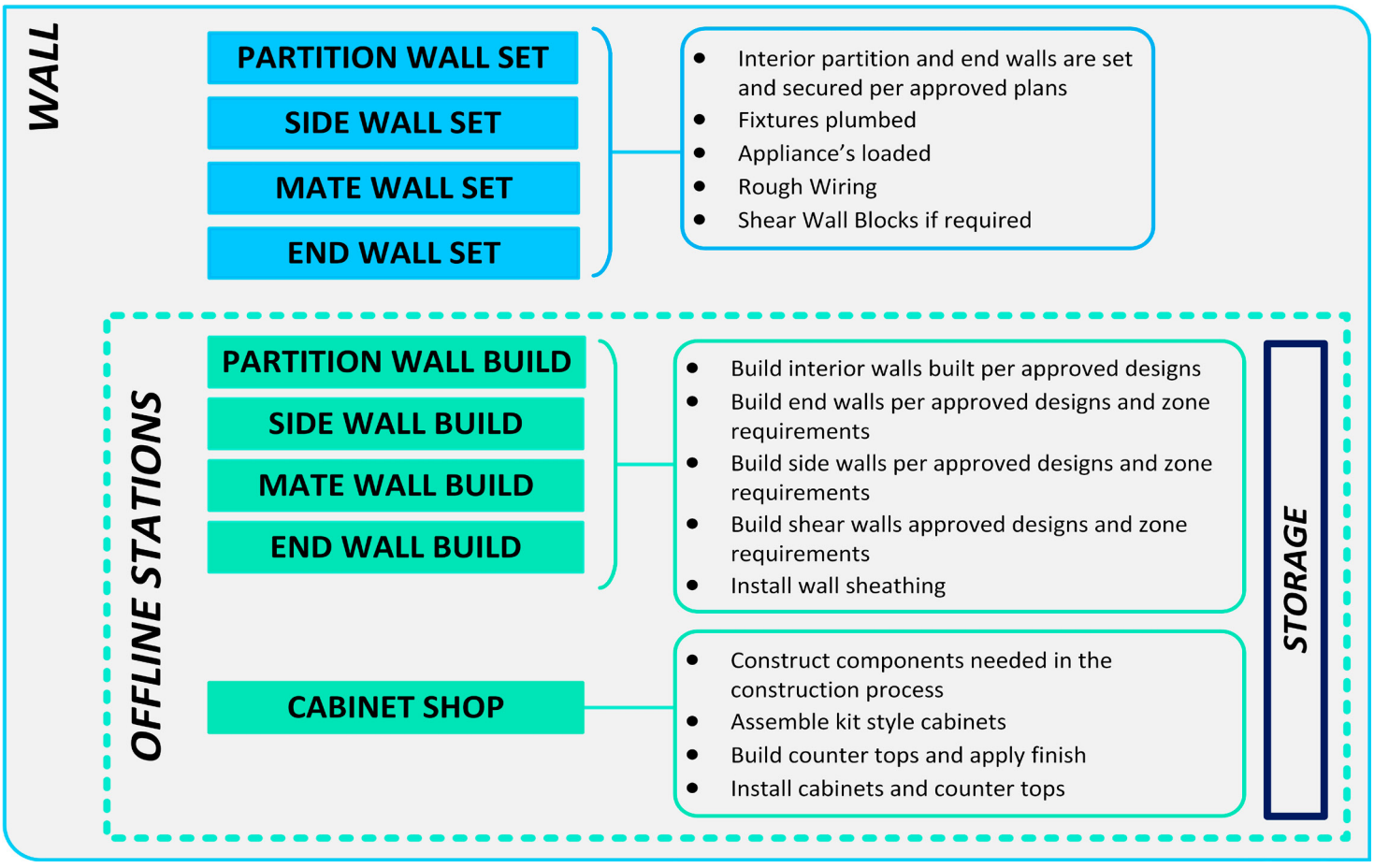

FIGURE 1.25: DIAGRAM SHOWING THE WALL STATIONS IN A MANUFACTURED CONSTRUCTION PLANT

REVIEW QUESTIONS 1.5

1. How many types of floor covering elements are used in the flooring department? Name and explain their function.
2. After the floor deck is complete, why does sanding take place?
3. Why is proper sealing needed in the wet areas? What penetrations need to be properly sealed?

1.3.2.1 OFFLINE STATION: BUILD INTERIOR, SIDE, MATE AND END WALLS

ACTIVITIES:

1. Build interior walls per approved designs
2. Build end walls per approved design and zone requirements
3. Build side walls per approved design and zone requirements
4. Build shear walls per approved design and zone requirements
5. Install wall sheathing

MATERIALS USE:

Wall studs and top and bottom plate materials, wall finish materials, adhesives, and fasteners.

TOOLS:

Jig table, staple gun or nail gun for framing, screw gun, adhesive gun to glue the wall finish to the stud

PROCESS:

In this station, the partition or interior walls are built. The wall builder uses the specially designed tables to construct the walls. These tables are usually equipped with stud placement identification markings along with other critical and commonly used information to help simplify the construction process. First, the top and bottom plates are positioned on the table, and then the appropriate studs will be spaced and secured in-between. The types and sizes of the dimensional lumber can vary, for example, either 1" or 2' dimensional lumber is used for the top and bottom plates Once the wall framing is complete the interior wall finish is attached to the framed wall system. This process requires the application of an adhesive to the wood member, followed by the attachment of the finish material. **(SEE FIGURES 1.26, 1.27, AND 1.28)**

Side walls are constructed as a single member that extends the entire length of the home. The studs must be spaced according to the plans and specifications. Alternate spacing may be required in various locations in the wall. One example is an area of the wall known as the "End Zone". This area of the wall is designed to transmit higher loading conditions, and, as a result, special framing may be needed. Correct securement and attachment is required between the studs and the top and bottom plates. The fasteners have to be compliant with the plans and specifications. Openings that occur in the exterior walls will require special framing considerations. The header and jamb studs are designed based on the loading conditions and the size of the opening. It is extremely important to comply with the approved plans and specifications. Shear walls are specially designed walls that are used to transmit loads through the structure. In the design process, special consideration is given to both areas of wall

FIGURE 1.26, 1.27 AND 1.28: THE INDIVIDUAL WALLS ARE BUILT AND STORED, READY TO BE LIFTED AND USED IN THE NEXT STATION, THE SET WALL STATION.

construction and fastening of the sheathing and between construction elements. Similar to many other structural elements, compliance with the approved plans and specifications are critical. After completion of the walls construction, they are placed in a storage rack. Walls will be removed from the rack to the production process in a sequence needed for the production line.

PROBLEMS AND AREAS OF CONCERN:

- Proper length and height of wall
- Proper material and lumber grade
- Walls in sloping areas constructed with proper roof slope
- Tight-fitted studs
- Proper spacing of the framing members
- Check for warping of lumber
- Proper application of adhesives
- Placement of wall sheathing

REVIEW QUESTIONS 1.6

1. Explain the components of a wall in the order it is built in the manufactured construction process.
2. On the end zone of the walls, a different stud spacing may be required. Explain why.
3. There may be a door or window in the wall. Explain what components are used to create the hole in the wall for the door or window.
4. What are shear walls?

1.3.2.2 OFFLINE STATION: CABINET SHOP

ACTIVITIES:

- Construct components needed in the construction process
- Assemble kit style cabinets
- Build counter tops and apply finish
- Install cabinets and counter tops

MATERIALS USE:

Pre-fabricated cabinet parts
Dimension lumber and finished sheathing
Hardware parts such as hinges, knobs, and drawer guides
Cabinet top substrate and finish material
Several different adhesive types

TOOLS:

Saw, screw gun, nail gun, brushes, sander, router, table saw, clamps and several other hand tools.

PROCESS:

The cabinet shop is an offline operation. Although many manufacturers build their own cabinets, they use pre-manufactured components such as rail stock cut into length. Some manufacturers buy prefabricated cabinet kits. The cabinet shop is responsible to make the cabinets ready for installation, which is performed by the cabinet install crew. The cabinets may be custom built, meaning they are built according to the plans and cabinet drawings for the specific home.

PROBLEMS AND AREAS OF CONCERN:

The cabinets must be built according to the plans for proper fit. Color, type, and style are all based on the options offered by the manufacturer. Proper workmanship in this area is important for long term durability.

1.3.2.3 STATION SET INTERIOR, SIDE, MATE AND END WALLS

ACTIVITIES:

1. Interior partition and end walls are set and secured per approved plans
2. Fixtures are plumbed
3. Appliances are loaded
4. Rough wiring is completed
5. Shear wall blocks are installed if required

MATERIALS USED:

Ready-made partition walls built in the offline station and stored on the racks

TOOLS:

Screw, staple and nail gun, tape measure, chalk line

PROCESS:

In this station, the interior walls are carefully set. The walls that are built on the offline stations have only one side paneled. The locations of the walls are determined using the floor plan, and the walls are positioned on the floor per the plans. Walls are usually named and numbered for easing communications about their placement.

During the wall setting process, joining walls are positioned and attached to each other. Errors made during the wall set procedures can quickly compound, very quickly making a small error into a large problem. Depending on the plan, the structural walls can be erected first followed by the secondary walls. To fasten and secure the walls, screws, nails, and staples are used. The enclosing walls around the tubs and showers are placed.

At the final stage, all of the room configurations are created. The installer has to be aware of all of the electrical wiring and plumbing lines that extend through the walls. Holes must be drilled in the bottom plate to accommodate the designated services.

FIGURE 1.29, 1.30: THE SIDE WALL IS BUILT IN THE OFFLINE STATION AND THEN SET ON THE ONLINE PRODUCTION LINE.

FIGURE 1.31, 1.32: THE SIDE WALL IS BUILT IN THE OFFLINE STATION AND THEN SET ON THE ONLINE PRODUCTION LINE.

FIGURE 1.33 AND 1.34: IN THE ON-LINE PRODUCTION LINE, THE UNITS ARE CONTINUOUSLY COMPLETED AND MOVED TO THE NEXT STATION.

Side walls are lifted off the table with a hoist system.

First, the wall is hoisted and moved into position to be set and attached to the floor/unit. The wall has to be aligned with the corner of the home and set flush to create a smooth surface for securing the exterior siding. At this stage, the wall is temporarily secured by a set of screws to position it in place.

The securement is complete as soon as the end wall is butted and attached to the sidewall to support it. Gasketing material is placed between the bottom plate of the wall and the floor to prevent any outside air from penetrating into the interior spaces of the home. **(SEE FIGURE 1.35)**

Marriage walls or **mate walls** are the walls where two units are jointed together during on-site installation. Like the side walls, they are also built on a full-length table on the offline station. However, unlike side walls, marriage walls may have a series of openings, for example, the opening between a single large room that is located in the two units being joined. The other difference is that marriage walls are not exposed to the weather and outside conditions as is the case with the side walls. As a result, marriage walls are not as robust as the side walls along the exterior side of the home.

Load concentrations occur close to the wall's centerline. Therefore, columns are positioned at the clear span openings in the marriage walls to carry the load. Loads transmitted through the columns will vary depending on the size of the home and the clear span of the wall opening. It is not uncommon to have clear spans of 20 feet or more. These large spans can have extremely high gravity and uplift forces acting on them. Special requirements may be outlined in the specifications and drawings to address these issues.

The function of the marriage wall is to carry the load of the roof system to the floor and foundation system. Marriage walls may be much taller than the sidewalls because of vaulting conditions. Normally there is no insulation in the marriage walls because there is no exposure to unconditioned space.

End wall construction is similar to the side walls. End walls are built the width of the unit or a portion of a multi-unit. The end wall could be either flat or contoured into a cathedral condition depending on the floor plan and the roof system. In some factories, the lifting is done by two people who set the end wall in place.

At this point, the sidewall is finally squared, pulled tight and plumbed. The walls are set perpendicular to the floor. This action is critical because unlike the level situation of a conventional slab on grade site-built home, the manufactured floor may not be truly leveled. Leveling in the factory is not always possible. Therefore, confirming the square and plumbness of the wall to the floor by checking that the wall and floor are perpendicular is good practice.

Gasketing material is installed between the sidewall and the end wall and between the end wall and the floor. Its main purpose is to control air infiltration through construction elements exposed to the outside.

(SEE FIGURE 1.35)

FIGURE 1.35: GASKETING MATERIAL IS USED TO AVOID AIR EXCHANGE IN BETWEEN DIFFERING WALL TYPES.

PROBLEMS AND AREAS OF CONCERN:

The pieces of the home are like a jig-saw puzzle and must fit correctly and within tolerances. Any misalignment or dimensional error can result in major problems later in the production line.

- Each wall must be square where it meets the floor system and the wall perpendicular to it.
- Dimensions and lumber grade and species must be based on the drawings.
- Check the openings and columns for double or triple studs where shown on the drawings.
- Check that the fasteners meet the requirements in the specifications.
- Ensure the correct fasteners properly connect the walls.
- The walls must be square in all directions.
- Ensure all dimensions for length, width, and openings are correct.

REVIEW QUESTIONS 1.7

1. When do the built cabinets enter the production line?
2. Are the set stations on-line or off-line production lines?
3. How are the walls labeled and installed in the correct place?
4. How are the wiring and the piping run through the wall?
5. Explain what a hoisting device is.
6. Why are the temporary securements in the wall set?
7. What does a gasketing material do?
8. What are the properties of the marriage or mate walls?
9. How wide is an end wall? What shape can it have?
10. Describe the act of “plumbing” and why is so important?

1.3.3 ROOF BUILD AND ROOF SET STATIONS

The activities at the Roof Build and Roof Set station on the production line are as follows:

1. The roof is built and set on the walls.
2. Roof wiring is installed.
3. Exterior sheathing is applied
4. Wall wiring is completed.
5. Roof is insulated.
6. Dormers are built and installed.
7. Roof sheathing is completed.

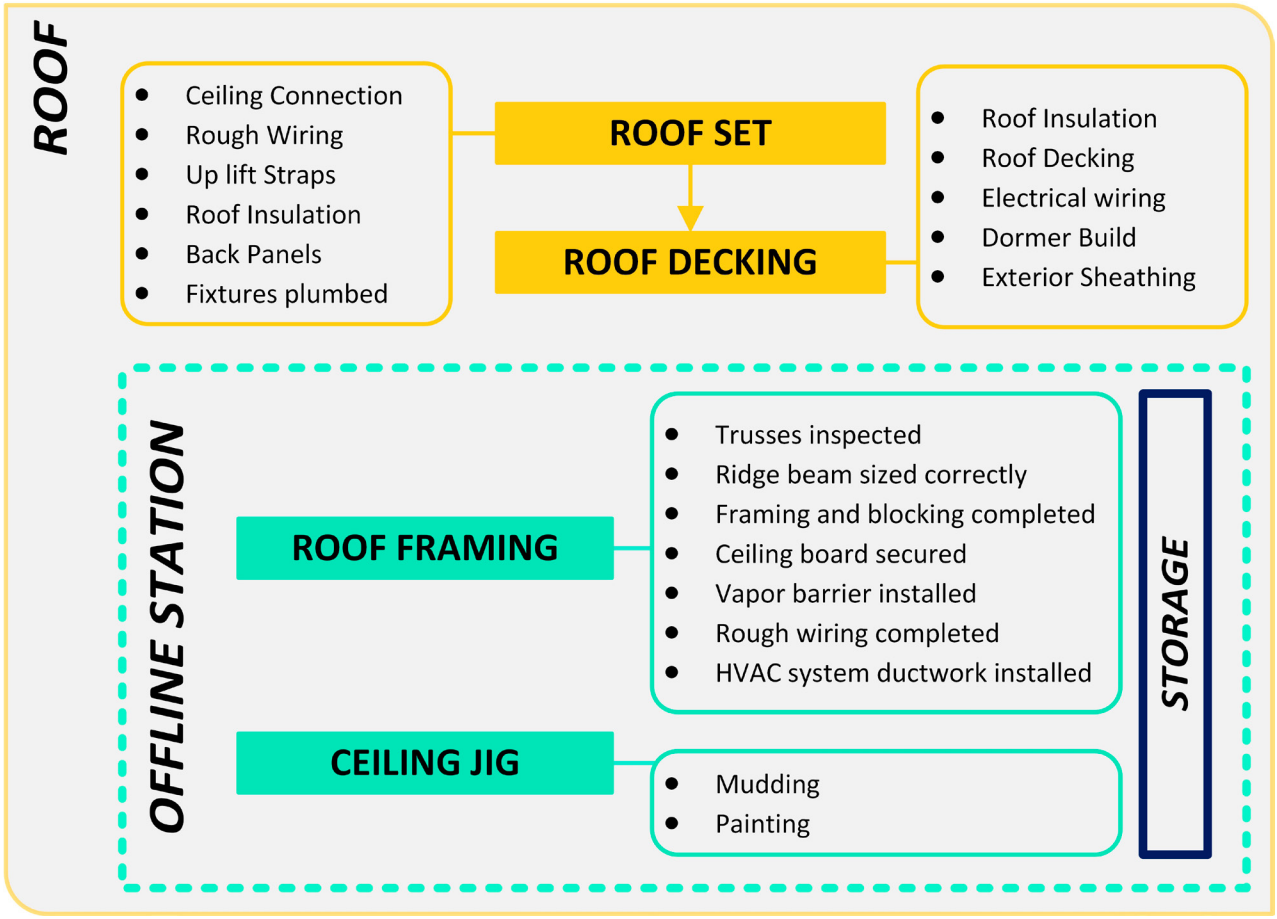

FIGURE 1.36: DIAGRAM SHOWING THE ROOFING STATIONS IN A MANUFACTURED CONSTRUCTION PLANT

1.3.3.1 OFFLINE STATION: ROOF FRAMING BUILD

ACTIVITIES:

1. Trusses inspected
2. Ridge beam sized correctly
3. Framing and blocking completed
4. Ceiling board secured
5. Vapor barrier installed
6. Rough wiring completed
7. HVAC system ductwork installed

MATERIALS USED:

Gypsum boards used for the ceiling are typically 4′ x 8′ in size. Using full width material reduces the number of seams that require finishing and as a result the gypsum boards are placed along the edge parallel to the floor. Rafters or trusses are typically purchased from a manufacturer specializing

in truss fabrication. Other materials required at this station include nails, two-component glue, wiring and electrical panels, blown-in insulation, and ductwork.

TOOLS:

Tape measure, saws, drills, hammers, screw guns, adhesive applicator, and drywall finishing tools

PROCESS:

There are two major types of roofing systems used in manufactured/modular home construction: flat or pitched. Roof systems can have attachments such as dormers and ceiling trays that are attached to the main roof. Roof trusses or rafters are the main components of the roof.

Roof trusses are engineered and pre-fabricated, triangulated wood structures which are built in a factory. They are designed to carry the load of a home's roof to the outside walls. The triangles formed by the beams, bars ,and ties allow the truss to distribute the weight it carries over a broader area.

Rafters are sloped framing members running downward from the peak of the roof all the way to the plates of the outside walls. Similar to trusses, rafters support the roof loads. Ceiling joists tie the outside walls together, support the ceiling materials for the room below, and secure the bottom ends of the rafters.

For both roof trusses and rafters, boards known as rafter boards are installed perpendicular to these members at ceiling level to provide additional support for the truss or rafter roof system

FIGURE 1.37: THE STRUCTURE SUPPORTING THE ROOF IN THIS PICTURE IS COMPOSED OF RAFTERS WHICH ARE PRODUCED AND ASSEMBLED ON-SITE.

FIGURE 1.38: THE ROOF SUPPORT SYSTEM IN THIS HOME IS MADE UP OF TRUSSES THAT ARE ENGINEERED AND MANUFACTURED BY SPECIALIZED TRUSS MANUFACTURERS.

The process of building a typical roof system starts with placing the gypsum boards for the ceiling on the roofing table. The trusses are placed on top of the ceiling gypsum boards in preparation for their attachment to the boards. In addition to the trusses, rafter boards are set perpendicular to the trusses to provide structural support.

The rafters or trusses are set vertically on the ceiling material. After the truss or rafter is set in position, it is glued in place with a two-part adhesive. **(SEE FIGURE 1.39)** The next step is to install the registers, duct boxes, transition boxes, and risers in the ceiling. The duct runs are then connected to the room registers and provide conditioned air flow to the completed home.

Once the rafters are secured to the gypsum ceiling material, construction continues within the ceiling area. The electrical wiring is installed and secured to the framing. The electrical wires will eventually be pulled through holes in the framing and ceiling to connect lights, power switches, and the main electrical service.

The next step is to install insulation into the roof. Most manufacturers utilize a blown fiberglass or cellulose insulation material. The depth of the insulation will vary based on the desired thermal resistance or **R-value**. On the lower side of the rafter, baffles are used to allow proper air flow from the roof system through the ventilated soffit area.

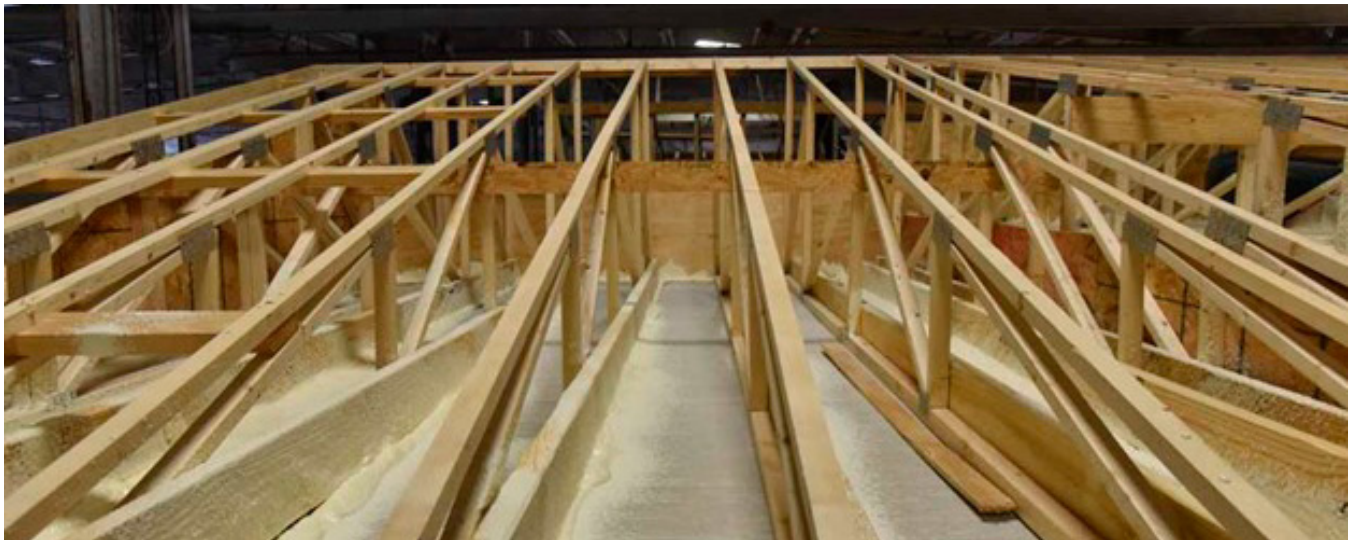

FIGURE 1.39, 1.40, AND 1.41: TRUSSES AND RAFTERS ARE SET VERTICALLY ON THE GYPSUM BOARD AND ATTACHED WITH ADHESIVE MATERIAL AND APPROPRIATE FASTENERS.

PROBLEMS AND AREAS OF CONCERN:

- Check the plans for accurate truss positioning
- Make sure there is no insulation material in roof outside the walls
- Check that the trusses have been placed squarely in the roof system

REVIEW QUESTIONS 1.8

1. Are rafters and trusses built in the manufactured housing plant or are they purchased from a different manufacturer? Explain.
2. What is the difference between rafters and roof trusses?
3. How are rafters and trusses supported and fixed for structural purposes?
4. Which is true? A) In manufactured construction, the roof is built from inside towards outside. B) In manufactured construction, the roof is built from outside towards inside.
5. What is R-value and how does it influence the insulation thickness?
6. What are baffles and what is their function?

1.3.3.2 OFF-LINE STATION: CEILING JIG

ACTIVITIES:

1. Mudding
2. Painting

MATERIALS USED:

Mud paste spray
Paint

TOOLS:

Spray guns

PROCESS:

After the roof has been built in the off-line station, it is moved to the next station where work on the ceiling is completed. The seams on the ceiling must be treated and finished because they will be visible from the interior of the home. To move the roof, a hoist mechanism locks onto the rafters, lifts and moves it onto the ceiling finish station, and then lowers it down to a temporary position.

FIGURE 1.42: THE CEILING IS FINISHED AND THE ROOF IS READY TO BE INSTALLED AT THIS STATION.

At this station, the ceiling has to be finished completely before its final installation onto the home. The distance between the ceiling and the ground is positioned so that scaffolding or an elevated mechanism is not needed to reach the work area. Drywall mud is applied to the gypsum board seams and a ceiling finish material is used to complete the process. After the ceiling mud is applied and dried, the ceiling is painted. If the factory does not have a **stand-by station**, the roof is carried to the next station.

PROBLEMS AND AREAS OF CONCERN:

- Drywall seams must be thoroughly finished and properly coated
- Adequate drying time must be provided after the ceiling mud application

REVIEW QUESTIONS 1.9

1. How are the seams in the ceiling treated? Explain.
2. After the ceiling mud application, what is the required drying time.

1.3.3.3 PRODUCTION STATION: ROOF SET/ INSTALLATION

ACTIVITIES:

1. Ceiling Connection
2. Rough Wiring
3. Up lift Straps
4. Roof Insulation
5. Back Panels
6. Fixtures plumbed

MATERIALS USED:

Nails

TOOLS:

Nail guns

PROCESS:

After the roof has been built on the off-line station, it is moved to the Roof Set/Installation Station on the production line. The roof has to be carefully positioned on the leveled home. The corners of the home must all be at the same level for the roof to properly fit. To set the roof system on the wall system, a crane lifts the roof, moves it over the wall system, and lowers it onto the roof system. The roof system is temporary secured on top of the walls. A system of catwalks or gantries along the side walls and the marriage wall is used to facilitate the roof placing process. The catwalks allow the workers to easily install the fasteners and connect the roof to the wall system. **Truss clips or hurricane clips** are installed to connect the ceiling trusses to the walls. Edge fasteners are also used to connect the rafters to the gypsum drywall. Wood blocking is used along clear span areas of the ceiling to accommodate the edge fastening.

PROBLEMS AND AREAS OF CONCERN:

- Properly positioned
- Square
- Level
- Timing
- Connecting the edge fasteners between the rafters and the wall

REVIEW QUESTIONS 1.10

1. Name the types of fasteners are used to connect the roof system to the wall system.
2. What is the function of wood blocking?

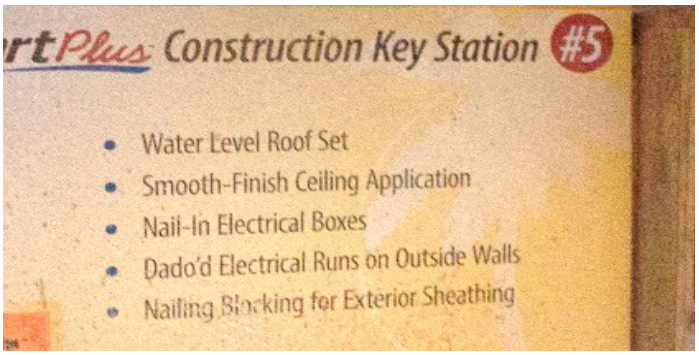

FIGURE 1.43, 1.44, 1.45, AND 1.46: THE ROOF IS SET ONTO THE WALLS AND SQUARED AND FASTENED PROPERLY.

1.3.3.4 PRODUCTION STATION: ROOF DECKING/ INSULATION

ACTIVITIES:

1. Roof Insulation
2. Roof Decking
3. Electrical wiring
4. Dormer Build
5. Exterior Sheathing

MATERIALS USE:

Staples or nails, 4′ x 8′ deck sheathing

TOOLS:

Staples and nail guns, cement for connecting vent pipes

PROCESS:

At this station roof sheathing or decking is installed on top of the rafters or trusses. Dormers or any specialty roof treatments are also installed at this station, the sheathing is typically 4′ x 8′ sheets of plywood that are set perpendicular to the trusses. The end pieces or "started pieces" are precut to facilitate the layout of the sheathing. Fiberglass or cellulose insulation is blown into the roof cavity to prevent thermal energy from moving between the attic and home interior.

PROBLEMS AND AREAS OF CONCERN:

- The grade and the thickness of the sheathing material is correct.
- Truss clips are used between the sheathing to avoid any sagging.
- Fastening pattern is checked with the approval specifications.
- Accurate location of penetrations for ducts, pipes, and attic ventilation.

REVIEW QUESTIONS 1.11

1. In roof decking, what are the end pieces or started pieces?
2. When is the cellulose insulation blown into the attic area?

FIGURE 1.47: THE INSULATION IS BLOWN INTO THE VOID BETWEEN THE TRUSSES.

FIGURE 1.48, AND 1.49: THE INSULATION IS BLOWN INTO THE VOID BETWEEN THE TRUSSES.

FIGURE 1.50: SHEATHING BEING APPLIED TO THE ROOF.

1.3.4 EXTERIOR FINISHES AND ROOFING STATIONS

At the exterior stations, exterior and interior finishes are completed, and roof underlayment, shingles, flashing, and vents are installed.

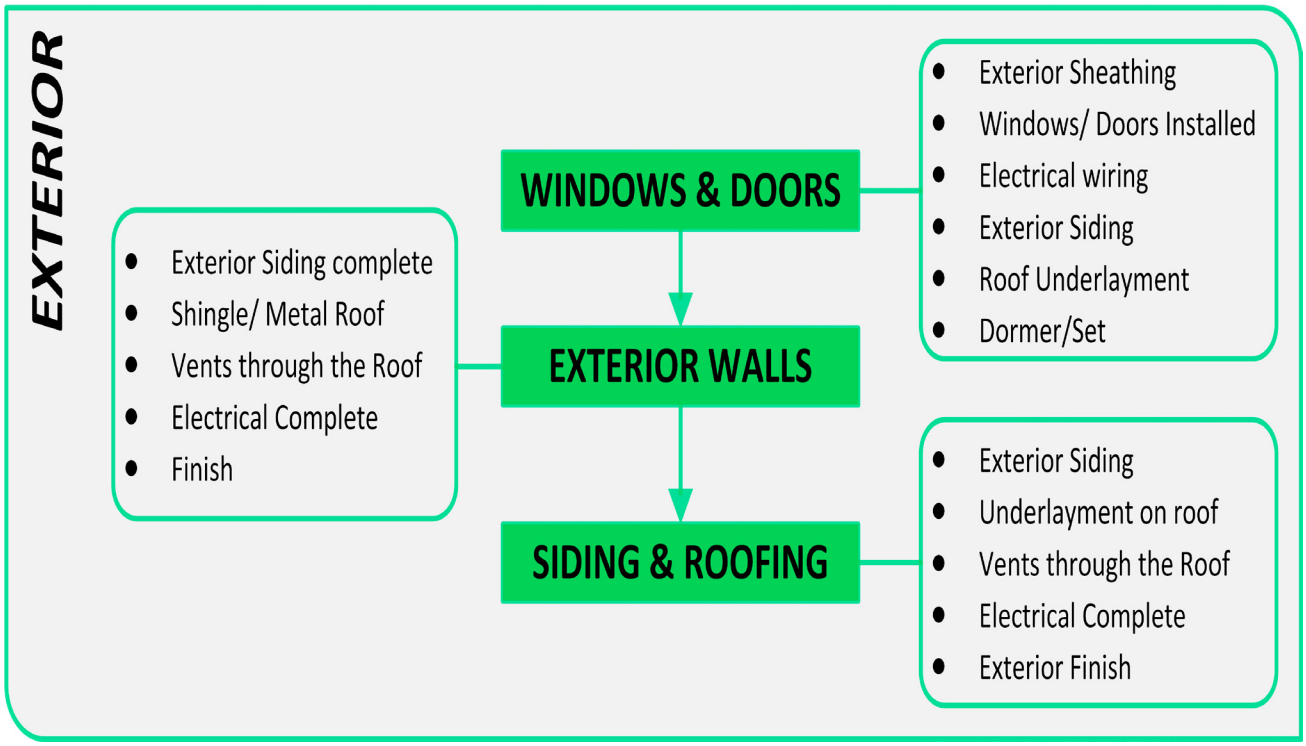

FIGURE 1.51: DIAGRAM OF THE EXTERIOR STATION ACTIVITIES IN A MANUFACTURED CONSTRUCTION PLANT

1.3.4.1 PRODUCTION STATION: EXTERIOR/ WINDOWS AND DOORS

ACTIVITIES:

1. Exterior Sheathing
2. Windows/ Doors Installed
3. Electrical wiring
4. Exterior Siding
5. Roof Underlayment
6. Dormer/Set

MATERIALS USE:

Pre-made, pre-hung doors and windows

TOOLS:

Screw and staple guns

PROCESS:

During roof installation, several activities occur simultaneously, including interior work such as wiring, and installation of windows, door treatments, cabinetry, bathroom vanities, and countertops.

Exterior wall sheathing is applied either horizontally or vertically depending on the design package requirements. Appropriate fasteners must be applied in the proper pattern to fasten the sheathing to the walls. An **air barrier wrap** such as Tyvek is installed on the wall sheathing to limit the movement of air and water. In locations where doors and windows are installed, barrier wrapping around corners must be based on the manufacturer's specification. The air barrier material is temporarily fastened to the sheathing using staples and then sandwiched between the sheathing and the exterior siding as the siding is installed. (SEE FIGURE 1.59)

The doors and windows should be squared and checked for operability. Doors must be correctly hung so that the door properly strikes the jam and header stops.

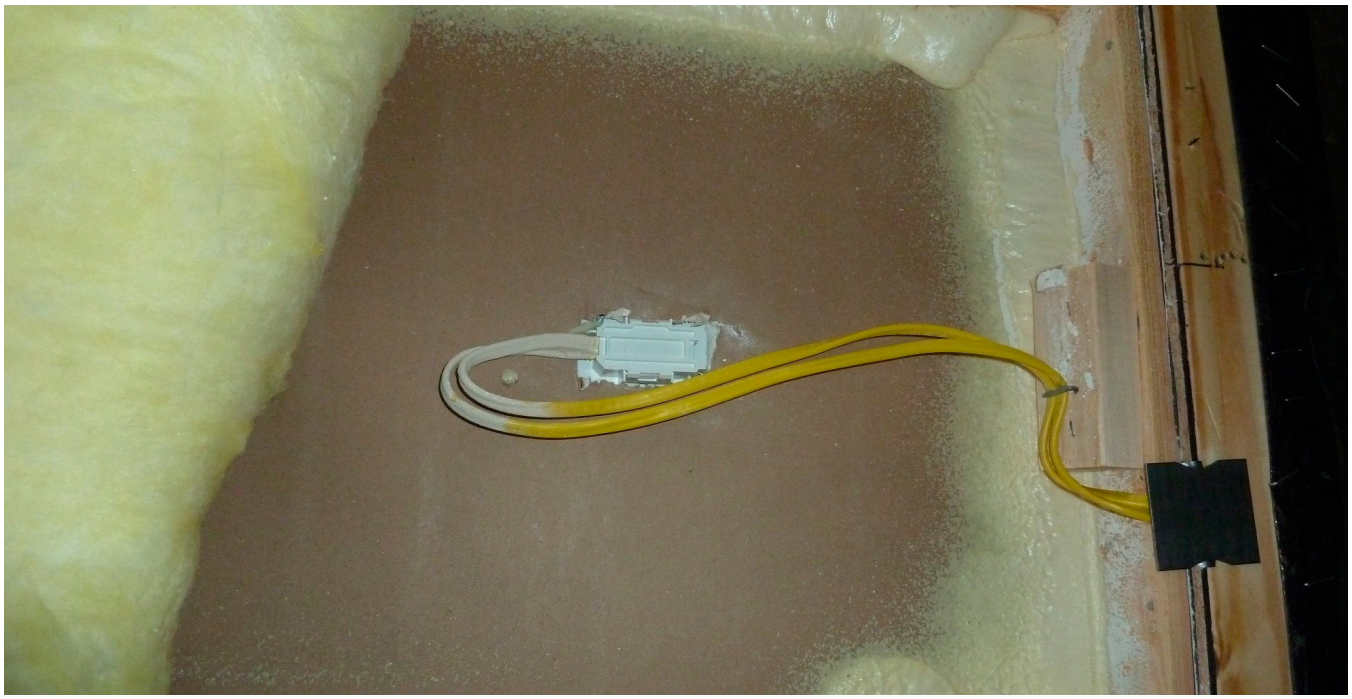

FIGURE 1.52: THE ELECTRICAL WORK IS COMPLETED INSIDE THE WALLS AND SEALED TO PREVENT MOISTURE PENETRATION.

FIGURE 1.53: PRE-MADE DOORS ARE STORED AND READY TO BE INSTALLED DURING THE ON-LINE PRODUCTION PROCESS.

FIGURE 1.54: WINDOWS ARE SET AND FASTENED.

PROBLEMS AND AREAS OF CONCERN:

- Proper location and installation of doors and windows
- Correct fasteners for exterior sheathing
- Correct grade of exterior sheathing

REVIEW QUESTIONS 1.12

1. There are many activities taking place simultaneously during the roof installation. Name them. Estimate how many people would work at the same time in this station.
2. What is the function of Tyvec wrapping? Where is it placed?

1.3.4.2 PRODUCTION STATION: EXTERIOR WALLS / UNDERLAYMENT ROOF

ACTIVITIES:

1. Exterior Siding
2. Underlayment on roof
3. Vents through the Roof
4. Electrical Complete
5. Exterior Finish

MATERIALS USED:

Vinyl siding, cement based product, different variety of pre-finished boarding based on the specification, cabinets, countertops

TOOLS:

Nails, screws, staples, wide-crown fasteners, router screw guns

PROCESS:

The horizontal vinyl or cement based siding material have corner posts. The transitional pieces around windows and doors should be installed first followed by the horizontal covering pieces or components. At the same time the siding is being installed and the work continues on the roof. The underlayment and the felt paper are installed, and flashing preparation is completed. On the inside of the home, workers complete rough electrical work, finishing, cabinetry, and counter tops.

FIGURE 1.56: EXTERIOR SHEATHING BEING INSTALLED ON THE EXTERIOR OF THE HOME

1.56: EXTERIOR SHEATHING BEING INSTALLED ON THE EXTERIOR OF THE HOME

PROBLEMS AND AREAS OF CONCERN:

- Fasteners for the cement based siding should be the right type and size
- Vinyl must to be cut to size and consider the expansion joints
- Avoid short cutting to prevent leakage
- Building wrap has to be complete
- Moisture migration must be detected and the cause corrected
- Torn felt paper must not be used anywhere on the roof

1.3.4.3 STATION EXTERIOR SIDING AND ROOFING

ACTIVITIES:

1. Exterior siding complete
2. Shingle/ metal roof
3. Vents through the roof
4. Electrical complete
5. Finish

MATERIALS USED:

Shingles, flashing, hard-ware around valleys, mastic, vents, sealants

TOOLS:

Staple guns

PROCESS:

The preliminary **flashing**, **eave drip**, and the felt paper are installed. The shingles are applied starting from the **starter-row** on the eave are of the roof. The size and number of fasteners depend on the wind zone applications. A **mastic** is used during shingle

installation to prevent water migration. In addition to the shingling, vent pipes and fire-place chimney stacks are installed with special attention to the details indicating proper installation. Attic ventilation shall be installed and shingles must be installed around this vent as indicated in the details. Appropriate sealants should be installed around the openings.

Other activities that are taking place at this station include trim-work and electrical installations.

FIGURE 1.57: SHINGLES ARE BEING LAID AND NAILED TO THE ROOF.

PROBLEMS AND AREAS OF CONCERN:

Proper shingle installation procedures must be followed to assure a water-tight seal and to enable them to be wind resistant. **Valleys** created by dormers and other roof transitions are shingled in accordance with the details. Appropriate flashing on the vents and stacks is installed per the details. The height of the fire chimney and slope of the roof must be based on the drawings for the home being manufactured.

REVIEW QUESTIONS 1.13

1. What are corner posts?
2. Explain what a "mastic" is.
3. What are valleys and where are they found?
4. Name the different types of flashing needed for the roof.

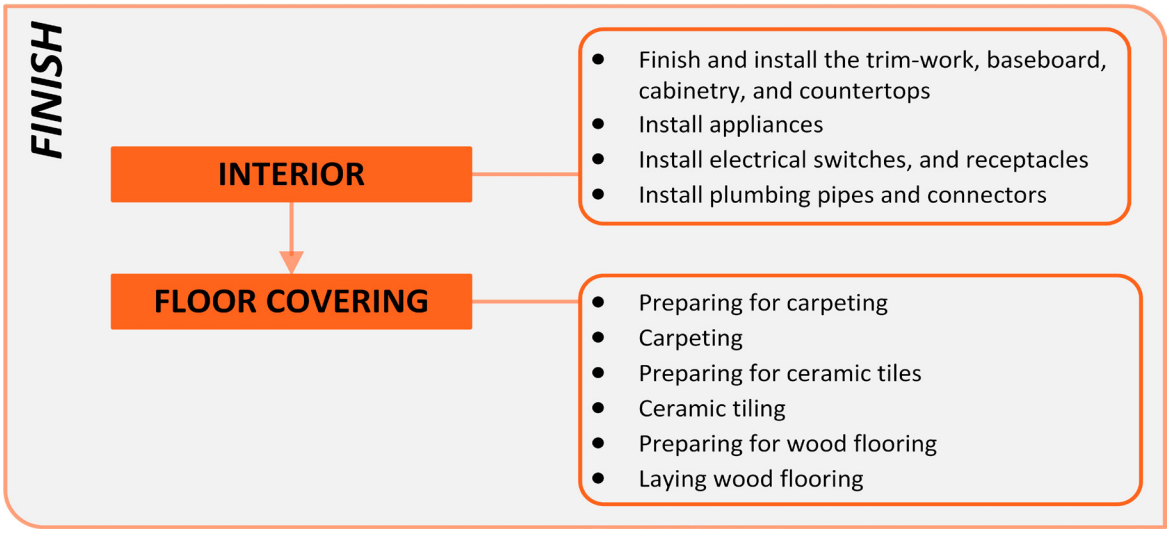

FIGURE 1.58: DIAGRAM SHOWING THE FINISHING STATION IN A MANUFACTURED CONSTRUCTION PLANT

1.3.5 FINAL FINISH STATIONS

Final work is completed and systems are function tested. Labels/Insignias are to be installed after all work has been completed, including function testing. Final repair and rework is done and system tests are performed. Installation of the water system, DWV system, and shower compartment is completed. Electrical and gas system testing is completed. Energy compliance inspections are completed as required.

1.3.5.1 PRODUCTION STATION FINAL FINISH/ INTERIOR

FIGURE 1.59, 1.60, & 1.61: TRIM WORK, REMAINING ELECTRICAL INSTALLMENT, AND OTHER FINISHES ARE DONE IN THIS STATION

FIGURE 1.60 AND 1.61: TRIM WORK, REMAINING ELECTRICAL INSTALLMENT, AND OTHER FINISHES ARE DONE IN THIS STATION

ACTIVITIES:

1. Finish and install the trim-work, baseboard, cabinetry, and countertops
2. Install appliances
3. Install electrical switches, and receptacles
4. Install plumbing pipes and connectors

MATERIALS USED:

The finishing products such as trim-work components, electrical switches and wiring, plumbing devices

TOOLS:

A wide variety of tools are used in the final finishing process.

PROCESS:

Final electrical installations, final plumbing, and trim work are completed at this station. The trim work includes finishing all wall panels, baseboards, cabinetry, counter tops, and window sills. Touchup work such as installing the bathroom mirror and interior light are completed at this station. Final plumbing including the sinks in the kitchen, bathtubs, and lavatories is completed and the vanities are installed. All the interior work is completed at this station. The final stage is the cleanup of the home prior to shipping.

PROBLEMS AND AREAS OF CONCERN:

Proper installation of finishes

REVIEW QUESTIONS 1.14

1. Name the trimwork items that need to be installed in the finishing station.
2. Name the activities of the final stage of the main production line.

1.3.5.2 PRODUCTION STATION: FINAL FINISH/ TESTING

ACTIVITIES:

1. Electrical testing
2. Document and label installation
3. Install HUD labels prior to shipping
4. Check the installation of the amperage plate
5. Fireplace installation
6. Dielectric strength test
7. Electrical continuity test
8. Electrical operational tests
9. Electrical polarity test
10. Electrical panel bonded to chassis
11. Water distribution test
12. DWV-flood test/fixture test
13. Gas line test and attaching the gas line label
14. Grounding the gas line to chassis
15. Complete installation of furnace, water heater, vent fans, smoke alarms, lights, and electrical entrance panels

TOOLS:

A wide variety of tools are used at this station.

PROCESS:

The **dielectric strength test** involves introducing high voltage into each circuit for a specified period of time. The purpose is to check for wiring break down, arcing, or failure between the electrical conductors.

The **polarity test** ensures that the electrical devices are not wired backwards and that there is no open grounding.

Flood level testing checks to ensure that there is no leakage in the drain system.

The **water distribution pressure test** involves in pressurizing hot and cold water lines and ensuring there is no drop in pressure during the test. The water heater connections are completed, and the electrical and plumbing and compartment is sealed. The water heater must not be pressurized during the testing procedures. Range venting is provided via fans in the microwave or range-hood.

Two types of gas system testing are required. The first test is a high-pressure test which tests the gas lines. The second one is a low pressure test which checks the connections within the home.

PROBLEMS AND AREAS OF CONCERN:

All tests must be carried out based on the specified test procedures for the various systems.

REVIEW QUESTIONS 1.15

1. Name the tests required after the unit completion.
2. Describe these terms: Dialectic strength test, polarity test, flood level test, water distribution pressure test.
3. In the gas testing process there are two types of testing: Low-pressure and high-pressure test. Describe the difference.

1.3.5.3 PRODUCTION STATION: FINAL FINISH / FLOOR COVERING

ACTIVITIES:

- Preparing for carpeting
- Carpeting
- Preparing for ceramic tiles
- Ceramic tiling
- Preparing for wood flooring
- Laying wood flooring

MATERIALS USED:

Carpet, wooden flooring, ceramic tiles

TOOLS:

Glue, nail, material cutting tools

PROCESS:

Various types of floor coverings including carpeting, vinyl flooring, ceramic tiles, and wood flooring are installed based on the design of the home and the manufacturer's instructions. Ceramic tiling can be applied directly on the plywood decking or to a substrate. Tack strips are used to secure the carpet. Some types of the flooring materials are glued down, while others are nailed only.

PROBLEMS AND AREAS OF CONCERN:

Installation of the specified floor finishes in the specified locations.

FIGURE 1.62: TILING AND FLOOR COVERING

1.3.5.4 PRODUCTION STATION: FINAL INSPECTION/ QUALITY CONTROL SIGN OFF

ACTIVITIES:

1. Inspecting floor bottom board for holes, rips, and repairs
2. Final cleaning of the unit
3. Check all lag bolts (tight) and repaint frame
4. Uplift straps complete
5. HUD labels installed
6. Sealants applied as required
7. Fire stopping inspected
8. Check Quality Assurance traveler for rework
9. Serial number correct with ticket/Data Plate
10. Data Plate filled out correctly and agrees with order
11. IPIA inspected the unit during production
12. Air quality warning label installed on the kitchen counter top

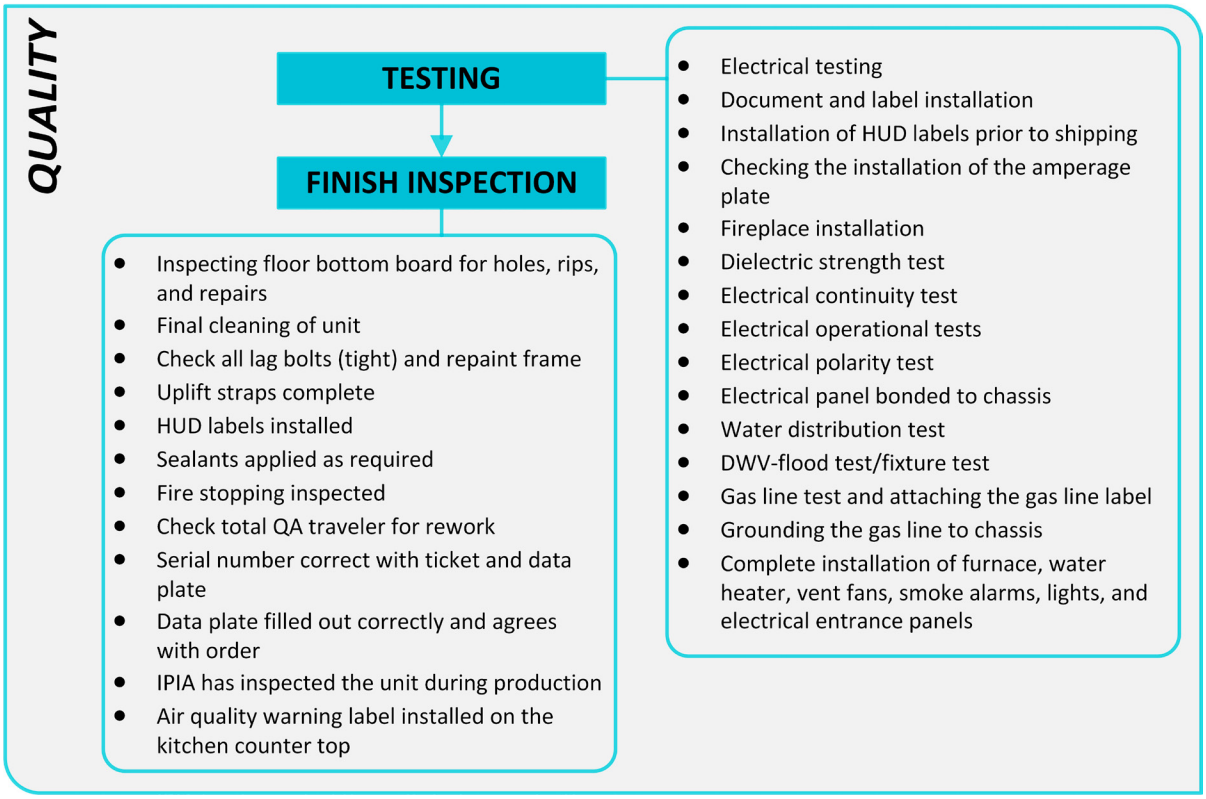

FIGURE 1.63: TRIM WORK, REMAINING ELECTRICAL INSTALLMENT AND OTHER FINISHES ARE DONE IN THIS STATION

Final inspection of the interior, exterior, and roofing is carried out using a checklist. The home is cleaned and prepared for shipment. Any defects should be identified and marked on a non-conformance sheet and turned into the appropriate supervisors for corrective action.

Installation kits such as additional shingles, plumbing materials, fasteners, and carpeting are placed in the unit prior to shipping.

FIGURE 1.64: FINAL CLEANING OF THE UNIT

1.3.6 STATION: SURGE / EXTRA TIME STATIONS

Larger plants may have standby or surge stations available for storage of completed components or for other purposes. Additional stations are sometimes necessary to complete work or perform tests. Test stations may be located anywhere in the shipping yard or the testing be conducted at any station where the work is completed.

REVIEW QUESTIONS 1.16

1. Name a few different types of floor coverings used in manufactured construction plants.
2. Name all the required items on the quality control checklist.
3. What is the content of the installation kit?
4. What is a surge station?

1.4 OTHER ACTIVITIES

1.4.1 MATERIALS STORAGE

When material and sub-components, which are subject to deterioration or weather damage, are stored outside in bulk at the manufacturing facility, they are protected by protective sheeting. Material will be supported on skids or blocks to provide air space between it and the ground, and will be properly covered until required on the assembly line. Limited shelf-life products such as glue will be closely monitored and cycled in accordance with manufacturer instructions. Other materials are rotated into production on a first-in, first-out basis. Glued fabricated components such as beams, headers, and wall sections are stacked awaiting use, or lifted into place for immediate use. Overhead cranes and similar devices are used in handling materials and components where weight requirements dictate their use.

Completed units and units stored outside the production building are protected from the elements by waterproof materials. When completed units require storage in excess of one week prior to their

FIGURE 1.65: A TYPICAL STORAGE STATION IN A MANUFACTURED CONSTRUCTION PLANT

final installation, **temporary blocking** is required under the transportation system if the units are longer than 48 ft. At a minimum, blocking is required at approximately ½ the distance from the front (hitch) end of the unit to the axle assembly, and at the rear end. The blocking is provided under each main I-beam of the transportation system.

1.4.2 DELIVERY

Units are transported on a factory assembled transportation system consisting of steel I-beams with cross members, outriggers, and axle assemblies. A hitch is installed on one end to facilitate hook up to a transporter truck. Each new model design will be monitored for damage caused by the transportation system. If no transportation damage is evident the transportation system is assumed to be adequate.

1.4.3 ASSEMBLY

Once the home arrives on site, the installation process begins. Most single-wide homes are shipped complete and require only setup. Multi-wide homes will require on-site work including connection to other units along the marriage wall, utility connections and completion of interior finish work. Exterior finish, such as centerline shingle installation, is completed on-site during installation. Utilities such as gas, electrical, plumbing, and water lines will require the installation of transition connections between sections of the home.

REVIEW QUESTIONS 1.17

1. How are materials stored outside protected?
2. Do products, such as glue, have expiration dates?
3. Define temporary blocking.
4. For a multiple-unit home, what are the expected on-site installation activities?

FIGURE 1.66 AND 1.67: THE HOME IS FINISHED AND READY FOR DELIVERY.

MODULE 2

THE QUALITY PROGRAM AND PROCESS FOR MANUFACTURED CONSTRUCTION

2.1 INTRODUCTION

A high standard of quality is very important for all manufactured products, including the products of manufactured construction. These include manufactured and modular homes, metal buildings, and building components such as structural insulated panels and trusses. In this Module, we will address the topic of quality as it applies to manufacturing in general, and specifically how it is applied in manufactured construction. We will begin by explaining the various concepts and definitions used in the quality process in manufacturing. We will then discuss the history of quality in manufacturing and how it has evolved to

FIGURE 2.1: QUALITY IN MANUFACTURED CONSTRUCTION IS BASED ON A PROGRAM THAT ASSURES HIGH STANDARDS, CHECKS THEM AND INVOLVES MANAGEMENT SYSTEMS.

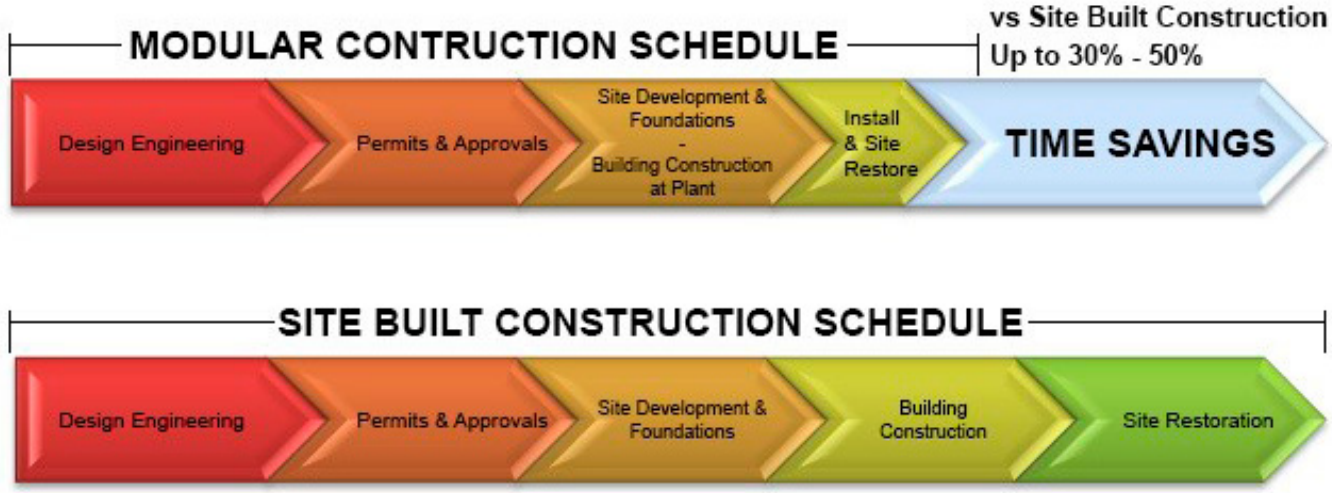

FIGURE 2.2: THIS COMPARISON SHOWS THAT TIME SAVINGS IN MANUFACTURED IS PARTLY A RESULT OF THE QUALITY BUILT INTO THE PROCESS.

the present day. The next step will be for us to discuss the various types of standards and processes used in quality control management. Finally we will address how these concepts are applied in the manufactured construction sector, specifically to manufactured and modular homes. It is important to remember that quality has a cost. A high standard of quality will result in fewer mistakes and recalls, result in lower costs, and have a positive impact on the bottom line of the organization. A low or poor standard of quality will likely cause negative impacts on both the company's bottom line and reputation.

2.2 CONCEPTS AND DEFINITIONS

Quality in manufacturing can be defined as a measure of the state of being free from defects, deficiencies, and significant variations. It is gained and maintained by strict and consistent commitment to standards designed to achieve a uniformity of product in order to satisfy specific customer or user requirements. The international standard, ISO 8402-1986, defines quality as "... the total of features and characteristics of a product required for its ability to satisfy stated or implied needs." Failure to meet quality requirements will have impacts on both the financial condition and reputation of a company. For example, in the automobile industry, a defect in manufacturing an automobile often results in the recall of millions of cars and the loss of customer faith in the business, further resulting in a decline in car sales and sales revenue. In the recent airbag recall involving the Takata Corporation, 34 million vehicles in the U.S. and 7 million more worldwide were potentially affected by defective airbags. The problem involved defective inflater and propellant devices that could deploy improperly in the event of a crash, shooting metal fragments into the vehicle's occupants. The problem of potential defects also exists in manufactured construction. A defect found in the manufacturing process can trigger a recall of manufactured buildings or building components, resulting in significant costs and the loss of production. In the case of manufactured buildings, it means crews may have to be sent to each site where the building was installed to make costly repairs.

Quality management is an approach that an organization uses to ensure its product or service is consistent. It has four main components: **quality planning, quality control, quality assurance and quality improvement**. Quality management is focused both on the product being manufactured and the process by which it is manufactured. Quality management employs quality assurance and control of both processes and products to achieve consistent quality.

A **quality management system (QMS)** is a collection of processes needed to implement quality management. It is comprised of the organizational structure, policies, procedures, processes, and resources needed for this purpose. When it was originally developed in the late 19th century, QMS focused on predicting the outcomes of an industrial production line using statistics and sampling techniques. More recently, in the 20th century, labor input, which dominates the cost of production, was used to detect problems and take corrective action. In the 21st century,

QMS is converging with sustainability and transparency initiatives so that both the manufacturer and customer have high levels of satisfaction with the product. A very important international standard series known as ISO 9000 is probably the most widely implemented QMS system in both the U.S. and worldwide. QMS is characterized by its ability to reduce quality problems by combining systematic thinking, transparency, documentation, and diagnostic tools.

Elements of a QMS include:

1. Quality policy
2. Quality objectives
3. Quality manual
4. Organizational structure and responsibilities
5. Data management
6. Processes, including purchasing
7. Product quality leading to customer satisfaction
8. Continuous improvement including corrective and preventive action
9. Quality instruments

Quality assurance (QA) is another terminology commonly used in the quality management process. QA is the systematic measurement, comparison with a standard, monitoring of processes, and an associated feedback loop designed to prevent errors. It is a method for preventing mistakes or defects in manufactured products and avoiding problems when delivering the product to the customer. It involves planning and training ahead of time before the manufacturing begins to assure a high standard of quality and then constantly adjusts the manufacturing process as needed to maintain high product quality. ISO 9000 defines QA as the part of quality management focused on providing confidence that quality requirements will be fulfilled.

As a means of preventing errors, QA has two main principles:

1. Fit for the purpose and
2. Right first time.

The first principle, fit for the purpose, means that the product should be designed to be suitable for its end use. Right first time, the second principle, simply means the mistakes should be limited. QA includes a wide range of activities including managing the quality of material inputs, assemblies, products, components, production services, and production and inspection processes. For a product to have high quality, all the components used in its manufacture must have high quality and the processes used to manufacture it must also meet high standards of quality.

Quality control (QC) is a process of reviewing all the factors involved in the production process, with a focus on meeting quality requirements.

Quality-control emphasizes three aspects:

1. **Process elements** such as controls, job management, defined and well managed processes, performance criteria, and records.
2. **Competence**, such as knowledge, skills, experience, and qualifications
3. **Non-process elements** such as personnel, integrity, organizational culture, motivation, team spirit, and quality relationships.

If any of these three elements are deficient the quality of the product will likely be at risk. Controls include inspections where every product is examined both during the production process and prior to shipment to the customer. Quality-control requires product testing to uncover and report defects to management so that they can make the decision to either allow the product to be shipped or reworked and repaired.

***Quality Assurance* happens *before* the product is manufactured and *Quality Control* occurs *during* the manufacturing process.**

REVIEW QUESTIONS 2.2

1. Define "quality" as used in manufacturing.
2. What is a Quality Management System?
3. Define the concept of Quality Assurance?
4. What is Quality Control and how does it related to Quality Assurance?

2.3 HISTORY

2.3.1 THE ORIGINS OF QUALITY AND QUALITY CONTROL

Quality control dates back many years, in fact, probably thousands of years. There is evidence in Denmark, for example, that around 3500 BC, tools used in the production of Viking boats had been rejected at the time of building the boats. The probable reason was that the Swedish flint used in the tools was unacceptable for their intended purpose. For quality control the ability to measure dimensions and weights is very important to ensure products are being manufactured to the correct tolerances. The first measurement of length occurred in Egypt in about 3000 BC and was called the **Royal Egyptian Cubit.** It was defined as equal to the length of the forearm from the bent elbow to the tip of the extended middle finger plus the width of the palm of the hand of the Pharaoh or king ruling at that time. The master copy of this standard length was carved into granite and workers transferred this measure by using wooden or granite copies. The transfer standards were very important and had to be recalibrated about once a month or whenever there was a full moon and if the workers did not bring their cubits back into compliance they could be punished by death. These length measures and other measuring equipment were used to set up the precise angles to establish the orientation of Egyptian pyramids around 2500 BC. In the ancient world quality was very important and in ancient Mesopotamia, for example, according to the Code of Hammurabi, the builder whose house later collapsed and killed the owner was subject to the death penalty. It is clear that in the ancient world quality control was especially important. There is also evidence of quality control in China in the 16th to the 11th century BC in the handicraft industries which included metallurgy, bamboo, woodworking, and textile industries. In ancient Greece construction work was subject to quality control and tools to control the quality of

joints in construction were being utilized. Specifications were used to clearly describe the exact requirements of the construction. Similar examples could be found in India around the 4th century BC and in medieval Europe. Master craftsmen emerged in Europe to produce a wide variety of goods to include armor and swords. Apprentices underwent extensive training which was long and demanding and they had to demonstrate they could produce high-quality products before they could join the field and be considered craftsmen. The process of transferring knowledge from master to apprentice was called "instructional capital." The hallmark symbol, one of the first symbols of a quality control process indicated a product was created by a master craftsman. It was used for the first time by the Goldsmiths Guild in London on products containing precious metals and is still used today.

FIGURE 2.3 STANDARD MEASURES AND SPECIAL TOOLS WERE USED TO BUILD THE GREAT PYRAMIDS OF EGYPT IN 2000-3000 BC.

2.3.2 QUALITY AND THE INDUSTRIAL REVOLUTION

It was the Industrial Revolution which started in the early 18th century when modern quality control emerged. It was during the Industrial Revolution that the factory system was developed and replaced the previous system of craftsmen in factories. Goods are produced with more **division of labor** and by specialist trades. In the late 19th century Frederick Taylor developed the concept of the division of labor. He examined the time and motion of work in the factory and designed the work to maximize the productivity of the workforce. His approach was threefold

1. Find the best practice wherever it exists.
2. Disassemble the best practice into its constituent activities.
3. Remove the activities that did not add value

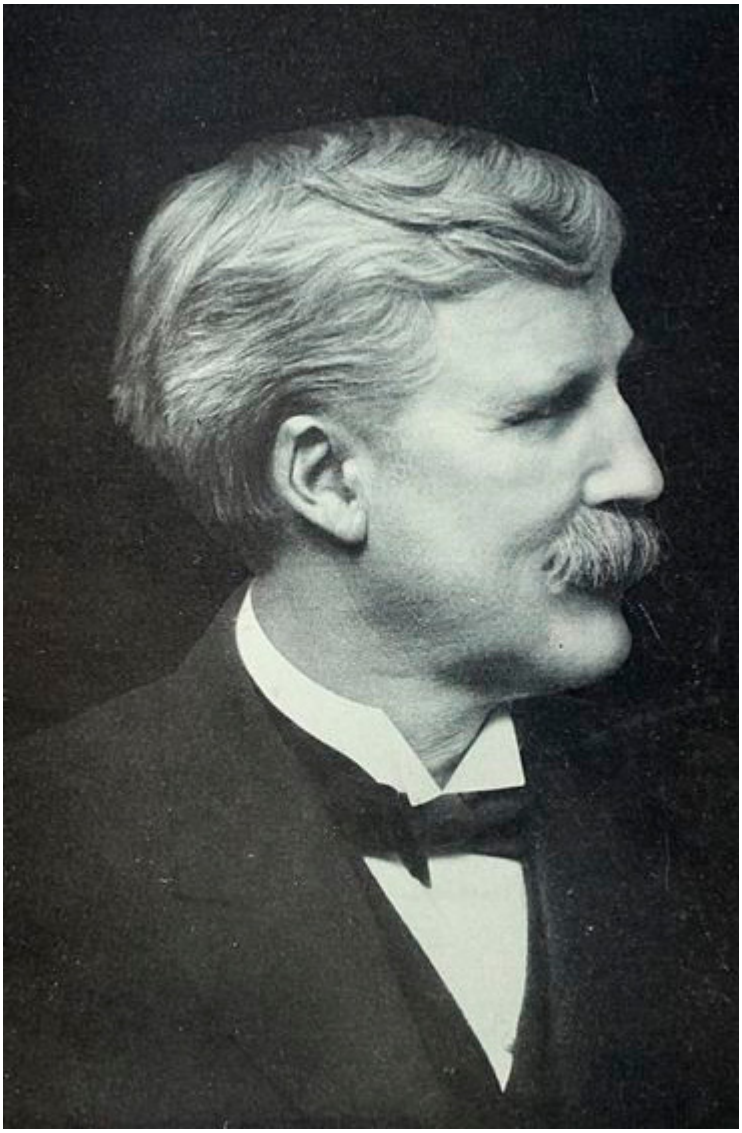

FIGURE 2.4: FREDERICK TAYLOR WAS ONE OF THE FIRST TO TURN THE MANAGEMENT OF QUALITY AND QUALITY CONTROL INTO A SCIENCE. HIS BOOK, PRINCIPLES OF SCIENTIFIC MANAGEMENT (1911), WAS A PIONEERING WORK AND GREATLY AFFECTED THE ORGANIZATION OF THE FACTORY AND ITS QUALITY PRACTICES.

At the end of the 19th century the first groups were organized to produce standards for goods and their production. The American Society of mechanical engineers (ASME) was one of the first of these bodies and was founded in 1880 because there were over 50,000 fatalities per year being caused by failures in steam pressure systems. ASME develops standards that clearly described requirements for building safe steam pressure vessels. A wide range of other similar organizations were founded to help resolve other problems emerging in the new technological age of the time. These included the American Institute of Electrical Engineers (AIEE), the American Society of Civil Engineers (ASCE), and the American Society for Testing Materials (ASTM).

FIGURE 2.5: THE EMERGENCE OF THE FACTORY IN THE LATE 18TH CENTURY RESULTED IN THE DIVISION OF LABOR IN WHICH EACH WORKER DID A SPECIFIC JOB IN THE PRODUCTION SYSTEM.

2.3.3 THE ROLE OF JAPAN IN IMPROVING AMERICAN QUALITY STANDARDS

The birth of modern quality control in the U.S. came as a direct response to events in Japan after World War II. Just after the end of the war, two Americans, Joseph M. Juran and W. Edwards Deming, visited Japan. Rather than focusing simply on inspection which was the norm in the U.S., they concentrated on improving all organizational processes by the people who use them. Deming's statistical quality control methods were taken to heart by Japanese manufacturers to help them reduce costs, improve productivity and market share, and develop manufacturing systems around his principles. When Deming

returned to the US in the late 1940s, his ideas were largely ignored and his work was not actually discovered in the US until the 1980s. By the 1970s, the US automobile industry and its supporting manufacturers were being badly outdone by Japanese manufacturers who emphasized approaches to quality management that were highly successful and resulted in the manufacturing of products of the highest quality. Chrysler Corporation, which was saved by a US government bailout of $2 billion in 1980, almost failed due to the poor quality of its products and the competition from Japanese automakers whose cars were highly reliable, safe, well-engineered, and affordable. Chrysler managed to pull itself out of the enormous hole it had created because it rapidly adopted the quality control systems developed by the Japanese and the company redesigned its entire product line. The result was that Chrysler products improved enormously and it became a profitable company once again. The other major US automobile manufacturers, General Motors and Ford, underwent similar transformations caused by the remarkable success of high-quality standards borrowed from the Japanese.

FIGURE 2.6: IT WAS W. EDWARDS DEMING'S POST WORLD WAR II TRIP TO JAPAN THAT LED TO TODAY'S CONCEPT OF QUALITY CONTROL BOTH IN THE US AND JAPAN.

REVIEW QUESTIONS 2.3

1. What is the first known historical incident of quality control?
2. Who invented the concept of "division of labor" and what were the three main ideas in his approach to maximizing the productivity of the workforce?
3. Who was the American who visited Japan just after World War II and transformed Japanese manufacturing with his method of Statistical Quality Control?

2.4 QUALITY STANDARDS

Quality is something every company strives for and which is often very difficult to achieve. Manufacturers need to ensure their products are consistently of high quality. Using standards for quality and quality control can help them manufacturers develop and make high quality products, comply with regulations and other standards, avoid product failures and recalls, and help them enter new markets. The best known and most frequently used standards for guiding and controlling quality are the **International Standards Organization (ISO) 9000** family of standards. ISO 9000 is a series of standards, developed and published by ISO for the purpose of defining, establishing, and maintaining an effective quality assurance system for manufacturing and service industries. The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best known standards. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and to ensure that quality is consistently improved. Standards in the ISO 9000 family include:

- ISO 9000:2005 - covers the basic concepts and language
- ISO 9001:2008 - sets out the requirements of a quality management system
- ISO 9004:2009 - focuses on how to make a quality management system more efficient and effective
- ISO 19011:2011 - sets out guidance on internal and external audits of quality management systems.

FIGURE 2.7 ISO 9001 IS THE STANDARD USED BY A MANUFACTURER TO DEMONSTRATE ITS ABILITY TO CONSISTENTLY PROVIDE A PRODUCT THAT MEETS CUSTOMER REQUIREMENTS, AND AIMS TO ENHANCE CUSTOMER SATISFACTION AND IT INCLUDES A PROCESS FOR CONTINUAL IMPROVEMENT OF THE SYSTEM USED FOR THIS PURPOSE.

ISO 9000 is guided by 8 principles.

1. A CUSTOMER FOCUS

The customer is the primary focus of a business. In the case of manufactured construction, the customer is the person purchasing the factory built home or building component. By understanding and responding to the needs of customers, the company can correctly target key demographics and therefore increase revenue by delivering the products and services that the customer is looking for. With knowledge

of customer needs, resources can be allocated appropriately and efficiently. Most importantly, a business's dedication will be recognized by the customer, creating customer loyalty. And customer loyalty is return business. In manufactured construction the customer is the home buyer.

2. GOOD LEADERSHIP

A team of good leaders will establish unity and direction quickly in a business environment. Their goal is to motivate everyone working on the project, and successful leaders will minimize miscommunication within and between departments. Their role is intimately intertwined with the next ISO 9000 principle. Due to the high pace of manufactured construction, leadership and the ability to develop effective teams are of utmost importance.

3. INVOLVEMENT OF PEOPLE

The inclusion of everyone on a business team is critical to its success. Substantial involvement will lead to a personal investment in a project and in turn create motivated, committed workers. These people will tend towards innovation and creativity, and utilize their full abilities to complete a project. If people have a vested interest in performance, they will be eager to participate in the continual improvement that ISO 900 facilitates.

4. PROCESS APPROACH TO QUALITY MANAGEMENT

The best results are achieved when activities and resources are managed together. This process approach to quality management can lower costs through the effective use of resources, personnel, and time. If a process is controlled as a whole, management can focus on goals that are important to the big picture, and prioritize objectives to maximize effectiveness.

5. MANAGEMENT SYSTEM APPROACH

If leaders are dedicated to the goals of an organization, they will aid each other to achieve improved productivity. Some results include integration and alignment of key processes. Additionally, interested parties will recognize the consistency, effectiveness, and efficiency that come with a management system. Both suppliers and customers will gain confidence in a business's abilities.

6. CONTINUAL IMPROVEMENT

The importance of this principle is paramount, and should be a permanent objective of every organization. Through improved performance, a company can increase profits and gain an advantage over competitors. If a whole business is dedicated to continual improvement, improvement activities will be aligned, leading to faster and more efficient development. Ready for improvement and change, businesses will have the flexibility to react quickly to new opportunities.

7. FACTUAL APPROACH TO DECISION MAKING

Effective decisions are based on the analysis and interpretation of information and data. By making informed decisions, an organization will be more likely to make the right decision. As companies make this a habit, they will be able to demonstrate the effectiveness of past decisions. This will put confidence in current and future decisions.

8. SUPPLIER RELATIONSHIPS

It is important to establish a mutually beneficial supplier relationship; such a relationship creates value for both parties. A supplier that recognizes a mutually beneficial relationship will be quick to react when a business needs to respond to customer needs or market changes. Through close contact and interaction with a supplier, both organizations will be able to optimize resources and costs.

2.5 QUALITY CONTROL PROGRAM FOR MANUFACTURED CONSTRUCTION

Each manufactured or modular home plant is required to have a quality control program. Once the manufactured or modular home is designed, the drawings are sent to a third party agency for review. Manufactured homes are commonly referred to as HUD homes. HUD homes are registered with the U.S. Department of Housing and Urban Development (HUD). HUD homes are subject to a very specific Federal regulation process whereas modular homes are subject to the state building code in which the home will be installed. Plants building both HUD and manufactured homes will have two sets of inspectors, federal for HUD homes and state for modular homes.

Each company's quality control program is slightly different. However, when a customer specifies the type of home they require, the quality process starts when the plans for the home are generated. The plans are submitted for review and approval and subject to the quality process. As part of the production process, once production of the unit beings, a **Traveler** is produced, and as its name implies, it travels along with the unit as it is being manufactured. The Traveler is a document that outlines the quality control inspections that must be accomplished at each of the stations in the manufacturing process. For example, at Station 1 there will be a list of items to be completed and checked by the responsible person. If nonconformance with quality standards is found in the process, it must be addressed, resolved, and appropriately noted on the quality control paperwork.

After all the required steps in the quality assurance and production process are completed at a station, a **unit closeout** occurs and the unit is moved to the next station in the production process. For example, at the Flooring Station, the underfloor electrical work has to be finished and inspected before the decking is installed. This inspection is performed by the in-house inspection staff. In a factory, a **Quality Control Manager** is responsible for checking compliance with quality control procedures. In a typical factory, the Quality Control Manager also audits the performance of the monitoring process. The party who is responsible for quality is the supervisor of the employees performing the tasks at a given station.

There is also an additional level of inspection audited by the state or third party, depending on whether is a modular home or a HUD home. This additional monitoring is performed by independent inspectors who audit the home assembly during production.

These inspectors are required to assess just one stage of the construction process. During this inspection, any problems that are identified as repetitive may result in an increase in the frequency of inspection. A problem that is found to be repetitive could result in every home being inspected for the defect at a direct cost to the manufacturer.

FIGURE 2.8 MANUFACTURED HUD HOMES ARE IDENTIFIED BY A HUD CODE LABEL THAT IS AFFIXED TO THE OUTSIDE OF THE HOME. IT IS A LIGHT METAL AND IS USUALLY A REDDISH COLOR AND WILL ALWAYS HAVE THE TERM "HOUSING AND URBAN DEVELOPMENT" WITHIN THE TEXT. THE CODE LABEL ATTESTS THAT THE HOME HAS BEEN MANUFACTURED USING AN EFFECTIVE QUALITY CONTROL PROGRAM.

2.5.1 IPIAS AND DAPIAS

There are 15 HUD approved state and private third party agencies that inspect a manufactured home at various stages of production. They are referred to as **Inspection Primary Inspection Agencies (IPIAs)**. An additional type of third party agencies also approves the manufacturer's designs to ensure the plans are consistent with HUD Standards. This party is referred to as the **Design Approval Primary Inspection Agencies (DAPIAs)**. Manufacturers contract directly with a state or local third party agency and pay for the design review and home inspection services. After reviewing the plans for a home, DAPIA either approves the drawings and specifications, or disapproves them and provides the reasoning behind the disapproval. Depending on the location of the future home, items such as wind zone specifications, window sizes, header sizes, floor joists, wood grading, load bearing walls, and other important features are checked.

To locate an IPIA or DAPIA, it is necessary to determine where in the state government the agency is located. For example, the third party IPIA agency that controls inspections in Florida is located in the Department of Highway Safety and Motor Vehicles:

FLORIDA TYPE: IPIA
Chuck Smith
Program Manager
Bureau of MH/RV Construction
Division of Motor Vehicles
2900 Apalachee Parkway, Room A129
Tallahassee, FL 32399-0640
PH: (850) 617-2808
FAX: (850) 617-5191

2.5.2 ON-SITE INSPECTION

When the factory built home is assembled and installed on-site, inspections are performed by the building department of the local municipality. Their inspectors apply the same techniques and use the same standards and process to inspect the factory built home as is used to inspect homes built on-site. The local municipality examines the plans and specifications and inspects the work being performed to ensure it follows these construction documents. Any deviations found by the building department inspectors are flagged and must be corrected by the team installing the home on its foundation.

REVIEW QUESTIONS 2.5

1. What should happen when a nonconformance is found in the process of manufacturing the home?
2. What is the next step in the process after completing the design drawings for the house?
3. Explain what a Traveler is and how it is related to quality control.
4. What do IPIA and DAPIA stand for? What are their roles?
5. When are DAPIA and IPIA involved in the quality control process of a manufactured house?

2.6 QUALITY CONTROL PROCESS IN MANUFACTURED CONSTRUCTION

2.6.1 QUALITY CONTROL

Quality control in the production environment means making sure products are manufactured in accordance with the plans and specifications. Some defects are likely to occur on the production line. The main task of the quality control system is to locate these defects and ensure they are corrected as early in the production process as possible.

Quality control is a process of ensuring compliance with the plans, specifications and the applicable building codes. The method for achieving the quality control varies between factories. Typically, the Quality Control Department monitors the performance level implemented at each section in the factory. Usually, the Quality Control Department is not directly responsible for the quality output, but is responsible to address the defects and issues and bring them to the attention of plant personnel. The goal is for the problems to be resolved so that they can be avoided in the future. This is referred to as the **Quality Assurance Procedure**, which can be found in the **Quality Assurance Manual**. In addition to the in-plant manufacturer quality control inspections, there are also state inspections and the federally regulated quality inspection.

The state regulated quality control agency is a third party agency that supervises the inspection during the unit's construction in the plant at least one time. That means each home is inspected at least one time by the state or third party (IPIA). If there is a pattern of nonconformance, the number of inspection may increases. If it is determined that a house with a nonconformance has left the factory and is in the possession of the customer, there may be an additional investigation required

on the home site. The sequence of inspections may continue back to the plant and through the production system until it is found and eliminated. The inspection may have to be carried out for twenty or more homes if the problem had not been eliminated for some time. Repetitive problems can be extremely expensive and must be avoided.

2.6.2 PLANT POLICY

In order to ensure that company quality standards are met, inspection of every product begins immediately at the Station 1 and the inspection process is continuous until the unit clears the final station, typically final finishing and labeling. This is referred to at the **Plant Policy.** The purpose of the Plant Policy is to establish points of inspection, inspection procedures, and responsibilities for inspection and corrective action, defect control, and record keeping.

2.6.3 PROCEDURES FOR A RECEIVING INSPECTION

Receiving Inspection is the process of inspecting all shipments of raw materials and components used in the manufacturing process. It is critical that they are inspected and tested to assure adherence to specifications and the purchase order issued by the factory to the supplier. All items receive dimensional, quality and general appearance inspection and checks for proper approval stamps, such as IAPMO, UL, Grade Stamp, AGA, and others. Records denoting acceptance or rejection of incoming items will be maintained. **Bill(s) of Lading** are also used in this inspection process. They are a detailed list of all the materials and their quantities in a shipment to the plant. Rejection of any products or materials will be marked on the Bill of Lading and a copy maintained in the invoice file. Rejected material is returned to the supplier or restricted from use until the product or material conforms to requirements. Shipments are moved into storage or the plant after the Receiving Inspection as soon as possible after acceptance. Rejected materials are identified and/or red taped and held in a separate area pending disposition action.

2.6.4 GENERAL INSPECTIONS

Assembly inspection is primarily visual and dimensional. The purpose of an assembly system is to assure that the proper components, produced per the latest approved engineering drawings and specifications, are properly installed in their correct positions as detailed and identified on the drawings. Prefabricated components and appliances are installed according to the manufacturer's installation instructions and specifications, or as shown in approved methods of installation.

Responsibility for the performance of the critical inspections is delegated by the Quality Control Manager to qualified persons of accountability. The designated quality control representatives work under the authority of the Quality Control Manager.

2.6.5 INSPECTION CHECKLISTS

The Traveler checklist indicates the items to be inspected at each inspection point. There is a QC checklist for each unit fabricated. All reports will identify each unit by its serial number and model and will include the date the unit entered the first stage of production. The unit will have the serial number affixed at Station 1. All reports accompany each unit in a readily accessible location throughout the assembly line and under limited circumstances they be removed from the unit until the unit has been completed, inspected and the Decal/Insignia is affixed. All inspection forms remain with the home until all inspections are completed and the home is labeled. Completed inspection forms will be filed with the unit file, located in the Service Department. All reports will be made available to the regulatory agency and are kept on file for a minimum of five (5) years. The Quality Manager is in-charge of the inspection forms at all times.

2.6.6 INSPECTION PROCEDURES

A designated quality control representative will inspect the items listed in each department on the QC checklist. Any defects found are noted, and responsible production personnel are notified for scheduling corrective action. When the work has been satisfactorily corrected, the designated quality control representative inspects and signs the QC checklist off as corrected. All inspections are performed before construction is covered.

The Quality Manager or his representative performs inspections on the production line at designated inspection areas at least once to verify adherence to the approved plans and specifications.

The QC Checklists are signed off at the major assembly stations when elements of work have been completed. If an item inspected is in compliance, the QC representative indicates this by initialing the Accept or "ACC" column on the shop traveler to the left of the line item. If any deviations are found, the QC representative initials the Traveler in the reject or "REJ" column and notes the deviation in the "Description of Deviation" column. The QC representative then coordinates corrective action. After the correction of a deviation, the production representative will initial the far right Corrected or "COR" column and a QC representative will re-inspect the line item. If corrective action is in compliance, the QC representative will initial the far right "ACC" column next to the line item.

Final Inspection is performed by the Quality Manager or his representative prior to affixing a label on the unit, and the QC Checklists are then signed and filed.

A **Red Tag** is issued in the event that a non-conformance is determined after the unit has been labeled. The Red Tag is issued by the Quality Manager and the transportation coordinator will be notified in order to prevent shipping the unit. The Quality Manager notes the serial number, the model number and the date, initials the tag and provides a description of the non-conformance. This tag will be attached to the front of the defective

unit. After corrective action has been taken by production personnel, the individual doing the work will date and initial at the "CORRECTED BY" line. QC will then re-inspect and, if in compliance, will initial and date red tag at "ACCEPTED BY" line. The red tag may then be removed and kept in the permanent home file.

2.6.7 DEFECT CONTROL

The foremen are initially responsible for identifying defects. It is their responsibility to notify the responsible production personnel of the defects so that corrective action can be scheduled and/or taken before the unit moves to the next area. If the defect is to be fixed in a designated area, the area in which the correction will be made will be indicated on the Traveler on the "Description of Deviation" line. The deviation will be noted on the Traveler by designated QC personnel and the corrective action will be scheduled and noted. The Quality Control Manager is responsible for evaluating the defects to determine if it is a random occurrence, or if it is related to a trend in defective material or workmanship.

2.6.8 QUALITY CONTROL DEFECT CONTROL

When defects are discovered by Quality Control Personnel, they note them on the QC Checklist, and notify the proper Production Personnel for scheduling corrective action. The Quality Manager will be responsible for evaluating the defects. If any other defects or noncompliance are present, the Quality Control Manager allows the Production Personnel to schedule repair or correction of the defects or non-compliance at any stage of the production process, provided they will not be permanently concealed and inspection of the repair can be accomplished. The Quality Manager will be responsible to make sure that any non-compliance is successfully corrected prior to affixing a Decal/Insignia on any unit manufactured by this plant.

2.6.9 LAYERS OF INSPECTION

Quality is the compliance with the drawings, specifications, and building codes. In the production industry, quality is measured by the number of noncompliances with the plans, specifications and applicable codes.

The following is the sequence of quality control in a plant:

- In-house station personnel
- In-house station supervisor
- In-house quality control department
- Third Party state inspectors
- For HUD homes, federal inspectors audit the Third Party state inspectors who are monitoring the in-house quality control personnel. If they find a concern they return to conduct additional audits.
- The local municipality inspects the quality of the installation of the house on site.

As is clear, in the Manufactured Construction industry there is a multi-level process for measuring of the quality of the produced houses.

All production defects carry consequences. Early identification of a problem indicates the quality control process is functioning properly. It is normal for people to make mistakes, and nobody expects that the outcome is always perfect. It is important to identify the problem at the earliest stage of production possible. For example, if an individual makes an error in measuring a member, it is best if a plant worker finds the problem at the station where the problem occurred. The second level for identifying the mistake is the supervisor on the floor. The third level is the quality control team in the plant. These three levels of quality control constitute the in-house process is over and then it is the Third Party inspection agency that may find the defect. Clearly it is undesirable for the problem to escalate to this level because the cost increases at each successive level. The goal in the plant is that the problem is resolved at the lowest possible level.

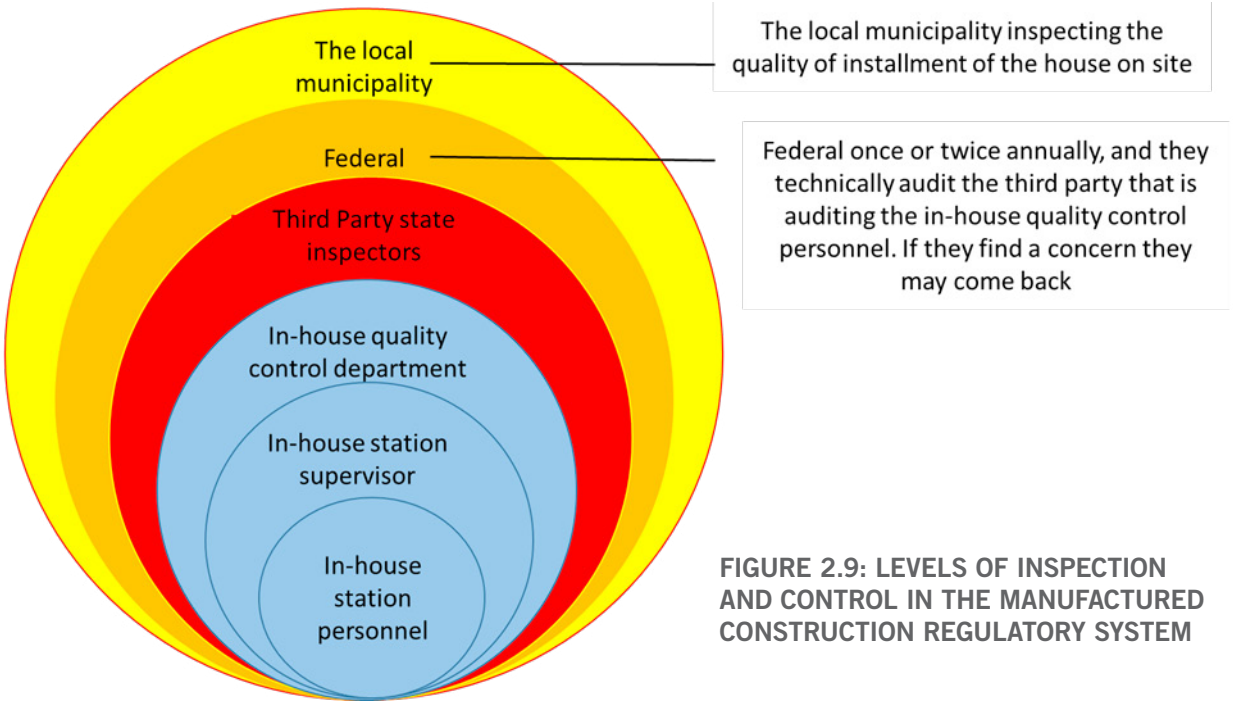

FIGURE 2.9: LEVELS OF INSPECTION AND CONTROL IN THE MANUFACTURED CONSTRUCTION REGULATORY SYSTEM

2.6.10 DESIGN REVIEW

Most states have a design approval and inspection system for modular housing similar to that used for manufactured housing, including requirements for quality control procedures and manuals, design review of all units produced, and in-plant inspections by state approved third-party agencies and/or the state itself. In such cases, a preemptive state code based on one of the model codes is most often used. Nevertheless, a major impediment faced by manufacturers who ship to multiple states is the potential need for separate procedural and design reviews and in-plant inspections of the same designs by representatives of the destination state in order to satisfy each state.

REVIEW QUESTIONS 2.6

1. Describe the quality control process in a manufactured and modular homes.
2. How many layers of inspection are required to produce a quality home?
3. In the manufactured construction regulatory system, describe who controls whom.
4. What is design review in manufactured housing and modular housing?

2.7 DEFECTS AND POSSIBLE PRODUCT RECALLS

Problems that are identified in the manufactured homes production process fall into one of four categories **noncompliance, defect, serious defect and imminent safety hazard.**

(1) NONCOMPLIANCE: A failure of the manufactured home to comply with a Federal manufactured home construction or safety standard that does not constitute a defect, serious defect, or imminent safety hazard.

(2) DEFECT: A failure to comply with an applicable Federal manufactured home safety and construction standard that renders the manufactured home or any part or component thereof not fit for the ordinary use for what was intended, but does not result in an unreasonable risk of injury or death to occupants of the affected manufactured home.

(3) SERIOUS DEFECT: Any failure to comply with an applicable Federal manufactured home construction and safety standard that renders the manufactured home or any part thereof not fit for the ordinary use for which it was intended and which results in an unreasonable risk of injury or death to the occupants of the affected manufactured home.

(4) IMMINENT SAFETY HAZARD: A hazard that presents an imminent and unreasonable risk of death or severe personal injury that may or may not be related to failure to comply with an applicable Federal manufactured home construction or safety standard.

The requirements of both the state and federal construction programs apply to buildings that are going to be located within the United States and its territories. Buildings that are for export outside the US are exempt from these requirements. However, they may be subject to the requirements of the final destination.

REVIEW QUESTIONS 2.7

1. What is a noncompliance and how is it ranked and compared to a defect?
2. What is a serious defect?
3. What is an imminent safety hazard and how is it ranked among all other defects and product recalls?
4. How do buildings for export differ from buildings that are going to be located in U.S.?

2.8 ACCURACY AND PRECISION IN MANUFACTURED CONSTRUCTION

In the factory environment, some components are built at **offline stations** and then moved into the production process. Workers at the offline stations may not be familiar with how their product connects with other elements in the building. As a result it is especially important for the workers at the offline stations to be comply with the drawings and

specifications because a high level of precision is needed for the various pieces to fit together as designed.

The plans provide the exact dimensions required for each component that will make up a completed home. If a worker places or sets a wall just ½" off from where it should be located, the adjacent wall sitting next to it will be affected. In general, a tolerance of 1/8" is normal for manufactured construction, that is, placing and cutting of components must be within 1/8" of the specified size or location. Deviations greater than 1/8" can be problematic and are therefore unacceptable. One attribute of deviations is that they are additive. For example, when an interior wall is installed with a deviation of 1/8" and the walls adjacent to the placement have a 1/8" deviation, the result is a total ¼" variation, which would be unacceptable. Precision in the manufactured construction industry is extremely important.

REVIEW QUESTIONS 2.8

1. Why is accuracy important in the process of building a manufactured home?
2. What dimension deviance is tolerable?

2.9 QUALITY SYSTEM ISSUES INVESTIGATION AND REPORTING GUIDELINES

An important set of guidelines for assuring the quality of HUD homes is the **Guidelines for Investigation and Reporting of Quality System Issues (QSI)** issued by the **Institute for Building Technology and Safety**. These guidelines lay out the quality control process and the requirements for in-plant inspections and auditing of the quality control system. HUD requires manufacturers to have a Quality System (QS) that is approved by the DAPIA agency and accepted by the IPIA agency. The QS commits the manufacturer to conduct adequate inspections and tests the record with the standards. The Quality System includes the Quality Assurance Program and the Quality Control System as reflected in the approved Quality Assurance Manual.

2.9.1 QUALITY ASSURANCE MANUALS AND IPIA ROLES

Federal Manufactured Home Procedural and Enforcement Regulations require that a manufacturer submits information about its Quality Assurance Manual to the DAPIA agency so that it can review and approve the manufacturer's Quality Assurance Manual. As a minimum the manual will include:

1. The manufacturer's Quality Assurance Program
2. An organizational chart showing accountability, by position, of the manufacturer's Quality Control personnel
3. A description of production line tests and test equipment for compliance with the Standards
4. A station by station description of the manufacturing process
5. A list of Quality Control inspections required by the manufacture of each station
6. Identification by title of each person will be held accountable for each Quality Control inspection

The manufacturer's DAPIA-Approved Quality Assurance manual outlines the programs, methods, procedures, personal responsibilities, training, checklists, forms, test equipment and documentation methods. The IPIA agency completes initial plant certification or updates its certification of a manufacturing facility. The purpose is to make sure that the quality processes are outlined in the manufacturer's Quality Assurance Manual and are adequately implemented to ensure conforming houses are being built. When the plant certification is completed, the agency makes its report to HUD and supplies the manufacturing plant with labels there are affixed to the manufactured home indicating that it has followed the Quality Assurance Program as outlined in the Quality Assurance Manual.

As problems are found on the production line the IPIA agency representatives are required to determine the source of the problem the cause the failure to conform. By doing this the agency and the manufacturer are able to determine how well the Quality Assurance Manual is being followed.

2.9.2 THE ROLE OF THE INSTITUTE FOR BUILDING TECHNOLOGY AND SAFETY

- The Institute for Building Technology and Safety (IBTS) is responsible for conducting evaluations of how well the IPIA agency is monitoring the manufacturer's Quality Assurance system. IBTS produces the **Guidelines for Investigation and Reporting of Quality System Issues** (QSI). The IBTS Audit teams evaluate the performance of the IPIA agency and how well it is ensuring the manufacturer's compliance with the Quality Assurance Manual and the conformance of the homes being built. IBTS ensures that the IPIA representatives are evaluating the key Quality Control Elements in the plant. These elements include:
- Use of approved checklists
- Thoroughness of inspections
- Quality Assurance accountability
- Production line testing
- Work process and description correspond to the Quality Assurance Manual
- Compatibility of the work process and approved checklist
- Quality Assurance Operations
- Training
- Design approvals
- Designs used by plant personnel
- Availability of all applicable designs
- Receipt and storage of materials

INSTALLATION OF MATERIALS

The bottom-line question that the IBTS audit team tries to answer when evaluating the performance of the IPIA agency is: Has the IPIA representative determined that the quality control system can ensure that conforming homes are produced on a continued basis?

REFERENCES

DOCUMENTS

QUALITY ASSURANCE PROGRAM MANUAL, Champion Home Builders, Quality Assurance Program Manual, Corporate Office Location: 755 West Big Beaver Road, Suite 1000 Troy, Michigan 48084

BOOKS

SMITH RYAN E. (2010). PREFAB ARCHITECTURE, A GUIDE TO MODULAR DESIGN AND CONSTRUCTION. NEW JERSEY: JOHN WILEY & SONS

MANUFACTURED CONSTRUCTION WEBSITES

FREE ENCYCLOPEDIA OF BUILDING AND ENVIRONMENTAL INSPECTION, TESTING, DIAGNOSIS, REPAIR. Retrieved from:
HTTP://INSPECTAPEDIA.COM/DESIGN/MODULAR_HOME_CONSTRUCTION.HTM
HTTP://INSPECTAPEDIA.COM/DESIGN/BUILDING_CONSTRUCTION_DEFINITIONS.HTM

NTERNATIONAL CODE COUNCIL, 2010 FLORIDA BUILDING CODE RESIDENTIAL. Retrieved from: HTTP://ECODES.BIZ/ ECODES_SUPPORT/FREE_RESOURCES/2010FLORIDA/ RESIDENTIAL/10FL_RESIDENTIAL.HTML

LIST OF IPIAS AND DAPIAS: MANUFACTURED HOUSING: PRODUCTION INSPECTION PRIMARY INSPECTION AGENCIES (IPIAS) AND DESIGN APPROVAL PRIMARY INSPECTION AGENCIES (DAPIAS). Retrieved from: HTTP://PORTAL.HUD. GOV/HUDPORTAL/HUD?SRC=/ PROGRAM_OFFICES/HOUSING/RMRA/MHS/MHSID

MANUFACTURED HOME CONSTRUCTION AND SAFETY STANDARDS, NORTH CAROLINA DEPARTMENT OF INSURANCE, (NCDOI). Retrieved from: HTTP://NCDOI.COM/OSFM/ MANUFACTURED_BUILDING/DOCUMENTS/PART3280.PDF

MANUFACTURED HOME CONSTRUCTION AND SAFETY STANDARDS. Retrieved from: HTTP://PORTAL.HUD.GOV/HUDPORTAL/ HUD?SRC=/HUDPROGRAMS/MHCSS

MANUFACTURED HOMES: REGULATION AND FEDERAL INSPECTION ASSURES QUALITY AND SAFETY. Retrieved from: HTTP://BLOG.MANUFACTUREDHOMES.COM/MANUFACTURED-HOMES-REGULATION-AND-FEDERALINSPECTION/

MANUFACTURED HOUSING INSTITUTE (MHI). Retrieved from: HTTP://WWW.MANUFACTUREDHOUSING.ORG/LIB/SHOWTEMP_DETAIL.ASP?ID=194&CAT=ABOUT MHI

MANUFACTURING SKILL STANDARDS COUNCIL (MSSC). Retrieved from: HTTP://WWW.MSSCUSA.ORG/PRODUCTION-CERTIFICATION-CPT/

MODULAR BUILDING INSTITUTE. Retrieved from: HTTP://WWW.MODULAR.ORG

MODULAR HOME BUILDERS ASSOCIATION OF MAINE (MHBA). Retrieved from: HTTP://WWW.MODULARHOMEBUILDERS.ORG/ MODULAR-DESIGN

NATIONAL CENTER FOR CONSTRUCTION EDUCATION AND RESEARCH (NCCER). Retrieved from: HTTP://WWW.NCCER.ORG

NOTES

BASICS OF MANUFACTURED CONSTRUCTION

Second Student Edition
August, 2017

Miami Dade College

UF UNIVERSITY of FLORIDA

POLK STATE COLLEGE

Colorado State University

SF SANTA FE COLLEGE

SEMINOLE STATE COLLEGE OF FLORIDA

UNIVERSITY OF WISCONSIN STOUT
WISCONSIN'S POLYTECHNIC UNIVERSITY