Wire Harness Assembly for Operators Instructor Guide

Visual Summary

MANDATORY MODULES

Module 1: Introduction to Wire Harness Assembly
1. What is a Wire Harness?

Module 2: Safety
1. Safety Signage and PPE
2. Chemical and Solder Safety
3. Tool and Equipment Safety

Module 3: Engineering Documentation
1. Engineering Drawing
2. Work Instructions
3. Bill of Materials (BOM)

Module 4: Materials and Components
1. Materials
2. Components

Module 5: Tools and Equipment
1. Calibration
2. Measurement Tools
3. Crimping Tools
4. Wire Stripping Tools
5. Soldering Tools
6. Other Tools

Module 6: Wire Preparation and Processing
1. Measuring and Cutting
2. Stripping
3. Tinning

Module 7: Inspection and Testing
1. Inspection
2. Testing

OPTIONAL MODULES

Module 8: Crimp Terminations
1. Introduction to Crimping
2. Open Barrel
3. Closed Barrel
4. Machined Contacts

Module 9: Soldered Terminations
1. Types of Terminations
2. Attachment Processes
3. Acceptance Criteria

Module 10: Splicing
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Module 11: Connector Assembly
1. Connector Structure
2. Connectorization
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Module 12: Coaxial Cable
1. Coaxial Cable Overview
2. Coaxial Cable Types
3. Coaxial Connector Types
4. Coaxial Cable Preparation
5. Coaxial Cable and Connector Assembly

Module 13: Labeling, Securing, and Covering
1. Labeling
2. Securing
3. Covering

Module 14: Finished Assembly Installation
1. Hardware
2. Wire Harness Installation

Wire Harness Assembly for Operators
Instructor Guide
Training at a Glance

Module 1: Introduction to Wire Harness Assembly

Objectives

- Recognize the role of IPC standards
- Describe wire harness assemblies and what led to their introduction
- Distinguish benefits of wire harness assemblies compared to individual wires
- Identify common uses of wire harness assemblies
- Explore reasons why wire harness assemblies require high quality workmanship

Sections

1. **What is a Wire Harness?**

- Description of the process, history, and uses of wire harness assemblies
- Explanation of quality, including how it is determined and why it is importance
- Definition of industry standards, product classes, and acceptability conditions

Module 2: Safety

Objectives

- Identify standard safety signage and symbols for assembly operators
- Describe standard safety procedures for protecting assembly operators and equipment
- Identify potential risks and hazards of standard materials used by wire harness assembly operators
- Describe safety concerns of using common wire harness assembly tools and equipment

Optional Instructor Materials

- Examples of common safety warnings and precautions (as available):
  - Personal protective equipment like safety glasses, gloves, shoes, hard hats, respirators, ear plugs and muffs
  - Lock-out/tag-out equipment
  - Chemical containers with NFPA labels
  - Safety data sheets
- Soldering iron or station
- Hot air gun
- Common hand tools like crimpers, strippers, and screwdrivers

Pre-Quiz

Sections

1. Safety Signage and PPE

- General overview of safety signage used in wire harness assembly
- Description of personal protective equipment (PPE) used by assembly operators

Knowledge Check: NFPA Labels

Practice: NFPA Labels

2. Chemical and Solder Safety

- Overview of Safety Data Sheets (SDS) for safe handling of chemical in wire harness assembly
- Description hazards and safety precautions for working with cleaning agents
- Description of chemical and heat hazards and safety precautions for using solder and soldering irons

Knowledge Check: Cleaning Agent Safety

Practice: Safety with Suspicious Chemicals

Knowledge Check: Solder Safety

Knowledge Check: Heat Safety

3. Tool and Equipment Safety

- Description of potential dangers and safe practices of working with automated tools and equipment
- Description of potential dangers and safe practices of working with hand tools

Knowledge Check: Tool and Equipment Safety

Practice: Safety with Automatic Tools & Equipment

Post-Quiz

Module 3: Engineering Documentation

Objectives

- Identify types of engineering documentation used in wire harness assembly
- Explain how engineering drawings are used as a build reference
- Describe relationship among work instructions, assembly sequence, and reference specifications
- Identify components of a Bill of Materials

Optional Instructor Materials

- Copy of common documents used in electronics assembly (as available):
  - Engineering/Assembly Drawing
  - Work instructions/Traveler
  - Bill of Materials (BOM)

Pre-Quiz

Sections

1. Engineering Drawing

- Description of common sections of an engineering drawing including:
  - Pictorial view
  - Notes block
  - Tolerances
  - Title block
  - Revision block
  - Parts list

Practice: Engineering Drawing Zones

Knowledge Check: Engineering Drawing Notes

Knowledge Check: Parts List

Practice: Engineering Drawing

2. Work Instructions

- General overview of the different features of a work instruction/traveler including:
  - Work/assembly sequence
  - Referenced specifications
  - Special circumstances

Practice: Work Instruction 1

Practice: Work Instruction 2

Knowledge Check: Referenced Specification

3. Bill of Materials (BOM)

- Description of different components of a Bill of Materials (BOM) including:
  - Part Number
  - Part Description
  - Material

- Notes
- Quantity

Practice: Using Your BOM

Post-Quiz

Module 4: Materials and Components

Objectives

- Identify properties of solder, flux, adhesive, and encapsulation
- Identify common wire and cable types
- Distinguish wire insulation types and wire gauge
- Recognize common terminal types
- Identify common connector types

Optional Instructor Materials

- Examples of common materials used in wire harness assembly, such as:
  - Solder wire in tin-lead and lead-free types
  - Flux
  - Adhesives
  - Potting and encapsulation
- Examples of common components used in wire harness assembly, such as:
  - Wires
  - Cables
  - Terminals
  - Connectors

Pre-Quiz

Sections

1. Materials

- General overview of consumable materials used to make wire harness assemblies including:
  - Solder
  - Flux
  - Solder wicking braid
  - Adhesives
  - Encapsulation

Knowledge Check: Solder Alloy and Reliability

Knowledge Check: Solder Alloy Names

Knowledge Check: Solder Alloy Characteristics

Knowledge Check: Lead-Free Solder Alloy

2. Components

- General overview of the parts that are used to build a wire harness assembly including:
  - Wires
  - Cables
  - Terminals
  - Connectors

Practice: Wire Anatomy

Knowledge Check: Wire Gauge

- Practice: Identifying Cables
- Knowledge Check: Identify Crimped Terminals 1
- Knowledge Check: Identify Crimped Terminals 2
- Knowledge Check: Identify Crimped Terminals 3
- Practice: Identifying Soldered Terminals
- Practice: Identifying Cable Connector Uses

Post-Quiz

Module 5: Tools and Equipment

Objectives

- Define tool calibration process
- Identify tools and equipment used in wire harness assembly
- Identify measurement tools used in cable/harness assembly
- Distinguish methods for taking accurate physical measurements

Optional Instructor Materials

- Examples of common tools used in wire harness assembly, such as:
  - Calibration
  - Measurement tools like rulers, tape measures, calipers, micrometers, and multimeters
  - Manual and machine crimping tools
  - Manual and machine wire stripping tools
  - Soldering tools like solder station, soldering irons, and solder pots
  - Other handheld tools like wire cutters, cable cutters, pliers, magnifiers, hot air guns, cable tie guns

Pre-Quiz

Sections

1. Calibration

- Definition and demonstration of calibration tools within wire harness assembly process

Knowledge Check: Calibration

Knowledge Check: Importance of Calibration

Knowledge Check: Calibration Outcomes

Knowledge Check: Verifying Calibration Labels 1

Knowledge Check: Verifying Calibration Labels 2

Knowledge Check: Verifying Calibration Labels 3

2. Measurement Tools

- General overview of measurement tools used in wire harness assembly including:
  - Rulers and tape measures
  - Calipers and micrometers
  - Multimeters

Practice: Choosing Measurement Tools 1

Practice: Choosing Measurement Tools 2

Practice: Choosing Measurement Tools 3

3. Crimping Tools

- Overview of manual, semi-automatic, and automatic tools used to crimp wires to terminals

Knowledge Check: Crimping Tools

Knowledge Check: Automatic Crimpers

4. Wire Stripping Tools

- Overview of wire stripping tools used in wire harness assembly including:
  - Mechanical strippers
  - Thermal strippers
  - Semi-automatic strippers
  - Automatic strippers.

Knowledge Check: Wire Strippers

5. Soldering Tools

- Overview of hand soldering stations, soldering irons, and solder pots used in wire harness assembly

Practice: Identify Soldering Station Parts 1

Practice: Identify Soldering Station Parts 2

Practice: Identify Soldering Station Parts 3

Practice: Choosing Soldering Iron Tips

6. Other Tools

- Overview of tools that fit into different parts of the wire harness assembly process including:
  - Wire cutters
  - Cable cutters
  - Pliers
  - Magnifiers
  - Hot air guns
  - Cable tie guns

Practice: Choosing Tools – Heat-Shrink Tubing

Practice: Choosing Tools – Wire and Cable Cutters

Activities

1. Hands-On Activity

- Using the correct wire gauge:
  - Present different gauges of wires and a wire stripper; provide steps for selecting correct gauge nest and performing strip

Post-Quiz

Module 6: Wire Preparation and Processing

Objectives

- Explain steps in wire preparation and processing
- Define requirements for measuring cables and wires
- Describe methods for measuring, cutting, stripping, and tinning wire
- Identify inspection criteria for wire preparation

Optional Instructor Materials

- Examples of common wire preparation and processing tools, such as:
  - Measurement tools like rulers and tape measures
  - Manual wire cutting tools
  - Manual and machine wire stripping tools
- Copy of wire documentation like cut list or sheet used in your facility

Pre-Quiz

Sections

1. Measuring and Cutting

- General overview of wire measurement principles including:
  - Length tolerances
  - References surfaces and locations
  - Nominal measurements
  - Breakout points
- Description of manual wire cutting tools and processes

Practice: Measuring Wires 1

Practice: Measuring Wires 2

2. Stripping

- Overview of mechanical wire stripping process like manual, thermal, and chemical stripping
- Description of machine wire stripping methods
- Definition and examples of wire stripping damage and defects

Knowledge Check: Manual Wire Stripping

Knowledge Check: Wire stripping Damage

Knowledge Check: Wire stripping Defects

Practice: Wire Stripping

3. Tinning

- Overview of purpose and processes for tinning wires after they have been cut and stripped
- Definition and examples of wire tinning damage and defects

Knowledge Check: Wire Tinning 1

Knowledge Check: Wire Tinning 2

Practice: Wire Preparation Defects

Practice: Wire Preparation Process

Activities

1. Hands-On Activity

- Wire tinning practice with a soldering iron

2. Timed Practice

- Apply Knowledge: Wire Preparation Inspection

Post-Quiz

Module 7: Inspection and Testing

Objectives

- Identify common IPC standards used by wire harness assembly operators
- Explain the need for inspection and describe the use of magnification
- Identify common electrical and mechanical tests used in wire harness assembly

Optional Instructor Materials

- Copy of IPC-WHMA-A-620 standard
- Examples of visual inspection tools like magnifiers
- Examples of acceptable and defect wires, connectors, terminals, and final assemblies

Pre-Quiz

Sections

1. Inspection

- General overview of visual inspection of wire harnesses throughout the assembly process

Knowledge Check: Standards

Knowledge Check: Visual Inspection

Practice: Magnification Power

2. Testing

- Description of common electrical and mechanical testing methods, including:
  - Continuity and shorts testing
  - Electrical tests
  - Pull force testing
  - Crimp height testing
  - Bend testing
  - Contact retention verification testing

Knowledge Check: Shorts Testing

Practice: Setting a Multimeter for Shorts Testing

Knowledge Check: Mechanical Testing 1

Knowledge Check: Mechanical Testing 2

Knowledge Check: Contact Retention Verification Testing

Activities

1. Hands-On Activity

- Continuity Testing

Post-Quiz

Final Exam for Mandatory Modules 1-7

Participants must complete the Final Exam for Modules 1 through 7 with a passing score of 80% to access and download their Qualified IPC Wire Harness Assembly Operator Certificate. Students may attempt the exam up to three (3) times. Please note that a third and final attempt is permitted after 24 hours of the second attempt.

Make sure to download your updated certificate if you complete optional modules later.

Module 8: Crimp Terminations

Objectives

- Explain the differences between crimping methods
- Identify acceptable and defect conditions for open barrel crimp terminations
- Identify acceptable and defect conditions for closed barrel crimp terminations
- Identify acceptable and defect conditions for machined crimp terminations

Optional Instructor Materials

- Examples of open barrel terminations, close barrel terminations, and machined contacts
- Examples of manual and machine crimping tools
- Examples of crimped terminations with common defect areas, such as:
  - Insulation support crimp and inspection window
  - Insulation clearance
  - Conductor crimp, bellmouth, and brush
  - Carrier cutoff tabs

Pre-Quiz

Sections

1. Introduction

- General overview of wire crimping purpose and methods

Knowledge Check: Wire Crimping

2. Open Barrel

- Description and defects of open barrel crimp terminations

Knowledge Check: Open Barrel Crimp Defects 1

Knowledge Check: Open Barrel Crimp Defects 2

Practice: Open Barrel Crimp Terminations

3. Closed Barrel

- Description and defects of closed barrel crimp terminations

Knowledge Check: Closed Barrel Crimps

Practice: Closed Barrel Crimp Defects

4. Machined Contacts

- Description and defects of machined contact crimp terminations

Practice: BIN Color Code 1

Practice: BIN Color Code 2

Practice: BIN Color Code 3

Practice: BIN Color Code 4

Knowledge Check: Machined Contact Inspection

Practice: Machined Contacts

Activities

1. **Hands-On Activity**

- Wire crimping practice with a manual crimping tool

2. **Timed Practice**

- Apply Knowledge: Crimp Terminations Inspection

Post-Quiz

Module 9: Soldered Terminations

Objectives

- Identify types of soldered terminations
- Explain processes for attaching wires to terminals
- Differentiate between acceptable and defect conditions for soldered terminations

Optional Instructor Materials

- Examples of soldered terminal types, such as:
  - Turret
  - Cup
  - Pierced
  - Bifurcated
  - Hook
- Examples of acceptable and defect soldered terminations

Pre-Quiz

Sections

1. Types of Terminations

- General overview of soldered terminal types

Knowledge Check: Soldered Terminals

Practice: Soldered Terminals

Practice: Soldered Terminal Uses

2. Attachment Processes

- Description of wire routing and placement methods for wrapped and insertion terminals
- Description of soldering methods for wrapped and insertion terminals

Practice: Terminal Anatomy

Knowledge Check: Wire Placement

Practice: Soldering Wrap Attachments

Practice: Solder Termination Process

3. Acceptability Criteria

- General overview of inspection of soldered termination
- Definition and examples of soldered termination defects

Knowledge Check: Soldered Terminations

Practice: Soldered Termination Inspection

Practice: Soldered Termination Defects

Activities

1. **Hands-On Activity**

- Practice soldering terminations using a soldering iron

2. **Timed Practice**

- Apply Knowledge: Soldered Termination Inspection

Post-Quiz

Module 10: Splicing

Objectives

- Identify the purpose of wire splices
- Explain the process of soldered, crimped, and ultrasonic wire splices
- Apply acceptance criteria for soldered, crimped, and ultrasonic wire splices

Optional Instructor Materials

- Examples of acceptable and defect soldered splices, such as:
  - Mesh
  - Wrap
  - Hook
  - Lap
- Examples of acceptable and defect barrel and double-sided crimp splices
- Examples of acceptable and defect ultrasonic splices

Pre-Quiz

Sections

1. Introduction to Splicing

- General overview of function and forms of wire splices

Knowledge Check: Splices

2. Solder Splices

- Description of process for creating mesh, wrap, hook, and lap wire splices
- Description of soldered splice inspection and defects

Knowledge Check: Soldered Splices

Practice: Soldered Splice Types

Knowledge Check: Soldered Splice Defects 1

Knowledge Check: Soldered Defects 2

Knowledge Check: Soldered Defects 3

Knowledge Check: Solder Sleeves

3. Crimp Splices

- Description of process for creating crimp wire splices
- Description of crimp splice inspection and defects

Knowledge Check: Crimped Splice Inspection 1

Knowledge Check: Crimped Splice Inspection 2

Knowledge Check: Crimped Splice Inspection 3

Knowledge Check: Crimped Splice Inspection 4

4. Ultrasonic Splices

- Description of process for creating ultrasonic wire splices

- Description of ultrasonic splice inspection and defects

KNOWLEDGE CHECK: ULTRASONIC SPLICING PROCESS

KNOWLEDGE CHECK: ULTRASONIC SPLICE INSPECTION 1

KNOWLEDGE CHECK: ULTRASONIC SPLICE INSPECTION 2

ACTIVITIES

1. Hands-On Activity

- Practice completing a crimped splice using a manual crimping tool
- Practice completing a soldered splice using a soldering iron

2. Timed Practice

- Apply Knowledge: Inspection of Splices

POST-QUIZ

Module 11: Connector Assembly

Objectives

- Describe characteristics of connectors used in wire harness technology
- Explain the purpose of strain relief and braid terminations in connectors
- Differentiate crimping and soldering methods of connectorization
- Apply methods for inspecting and testing connector assemblies

Optional Instructor Materials

- Examples of common wire harness assembly connectors, such as:
  - Circular (one contact pin and multiple pin)
  - Rectangular (D-sub/shell, IDC/IDTs, and IDC-Discrete)
- Examples of strain relief examples like wire dress, clamps, and metal braid shield terminations
- Example of hand tool for populating connectors
- Examples of crimped and soldered connector assemblies

Pre-Quiz

Sections

1. Connector Structure

- General overview of the internal structure of circular and rectangular connectors used in wire harness assembly
- Description of strain relief methods used in wire harness connectors

Knowledge Check: Connector Structure 1

Knowledge Check: Connector Structure 2

Knowledge Check: Wire Dress

2. Connectorization

- Description of process for crimping connectors
- Description of process for populating and soldering connectors

Knowledge Check: Push-Click-Pull

Practice: Population Sequence

Knowledge Check: Soldering Connectors

Practice: Connectorization

3. Inspection and Testing

- Description of acceptable or defect conditions for assembled connectors, including:
  - Connector alignment
  - Connector pins
  - Connector damage
  - Strain relief
- Overview of connector assembly testing methods like contact retention and electrical continuity

Knowledge Check: Connector Inspection

Knowledge Check: Connector Testing

Activities

1. **Hands-On Activity**

- Practice performing continuity testing on a populated connector

Post-Quiz

Module 12: Coaxial Cable

Objectives

- Describe parts of a coaxial cable
- Identify types of coaxial cables
- Distinguish most common coaxial cable connector types
- Describe common coaxial preparation steps
- Identify coaxial cable and connector assembly methods

Optional Instructor Materials

- Examples of coaxial cable types
- Examples of common coaxial connector types
- Examples of coaxial cable preparation tools like cutters and strippers

Pre-Quiz

Sections

1. Coaxial Cable Overview

- Overview of coaxial cable design
- Description of coaxial cable handling practices

Practice: Coaxial Cable Design

Knowledge Check: Concentric Circles

Knowledge Check: Bend Radius

2. Coaxial Cable Types

- Overview of different coaxial cable types used in wire harness assembly, including:
  - Flexible
  - Semi-rigid
  - Rigid
  - Conformable

Knowledge Check: Coaxial Cable Types 1

Knowledge Check: Coaxial Cable Types 2

3. Coaxial Connector Types

- Overview of different coaxial cable connector types used in wire harness assembly, including:
  - F-type
  - BNC
  - TNC
  - SMA
  - MCX
  - N-Type

Knowledge Check: Coaxial Connector Design

Practice: Coaxial Connector Characteristics

4. Coaxial Cable Preparation

- Description of methods for cutting and stripping coaxial cables for connector assembly

Practice: Manual Coaxial Cable Stripping Process

Knowledge Check: Semi-Automatic Stripping – Cut Depth

Knowledge Check: Semi-Automatic Stripping – Cut Length

5. Coaxial Cable and Connector Assembly

- Overview of process steps used to assembly coaxial cables and connectors

Practice: BNC Connector Assembly Process

Activities

1. Hands-On Activity

- Practice stripping a coaxial cable with a manual wire stripping tool
- Practice stripping a coaxial cable with a semi-automatic wire stripping tool
- Practice assembling a BNC connector

2. Timed Practice

- Apply Knowledge: Inspection of Coaxial Cables

Post-Quiz

Module 13: Labeling, Securing, and Covering

Objectives

- Describe requirements for labeling wire harness assemblies
- Identify various label types and acceptance criteria
- Evaluate label placement and location
- Identify common securing devices
- Describe effects of improper tension of securing devices
- Identify common wire harness coverings

Optional Instructor Materials

- Examples of common label types used to identify wire assemblies
- Examples of common securing methods used to identify wire assemblies
- Examples of common covering types used to identify wire assemblies

Pre-Quiz

Sections

1. Labeling

- Overview of types and locations of wire labels
- Description of acceptable and defect conditions for wire labeling

Knowledge Check: Labeling Wires

Knowledge Check: Wire Label Types 1

Knowledge Check: Wire Label Types 2

Knowledge Check: Flag Label Alignment

Practice: Labeling Problems

Practice: Label Location

Knowledge Check: Label Legibility/Readability 1

Knowledge Check: Label Legibility/Readability 2

2. Securing

- Overview of devices and processes for securing wire and cable bundles

Knowledge Check: Cable Lacing Methods

Practice: Cable Lacing Methods – Continuous Lacing

Knowledge Check: Securing Methods

Practice: Location of Securing Devices

3. Covering

- Overview of covering methods for wires and wire harnesses, including:
  - Tape coverings
  - Heat-shrink tubing
  - Fabric braid sleeves
  - Metal braid sleeves

- Wire loom tubing
- Metal conduit

Practice: Properties of Tape Coverings

Knowledge Check: Metal Braid Sleeving

Knowledge Check: Additional Protection

Activities

1. Hands-On Activity

- Practice applying wire labels
  - Wrap-around
  - Flag
  - Sleeve
  - Marking
- Practice spot lacing
- Practice continuous lacing
- Practice spiral wrapping wire loom tubing

2. Timed Practice

- Apply Knowledge: Label Inspection

Post-Quiz

Module 14: Finished Assembly Installation

Objectives

- Recognize requirements for hardware installation
- Distinguish criteria for wire harness installation
- Identify conditions for finished assembly installation

Optional Instructor Materials

- Examples of common hardware used in the wire harness assembly process, such as:
  - Screws
  - Bolts
  - Washers
  - Nuts

Pre-Quiz

Sections

1. Hardware

- General overview of hardware types and tool used for wire harness installation
- Description of hardware installation, sequence, torque drivers, and torque values
- Example of defects related to wire harness hardware

Knowledge Check: Hardware Sequence 1

Knowledge Check: Hardware Sequence 2

Knowledge Check: Thread Extension

Knowledge Check: Hardware Seating

Knowledge Check: Torque Stripe 1

Knowledge Check: Torque Stripe 2

Knowledge Check: Torque Stripe 3

Practice: Torque Values

2. Wire Harness Installation

- Overview of methods for wire harness installation
- Description of considerations within the context of wire harness installation

Knowledge Check: Stress Relief 1

Knowledge Check: Stress Relief 2

Knowledge Check: Wire Dress

Activities

1. Timed Practice

- Apply Knowledge: Finished Assembly Inspection

Post-Quiz