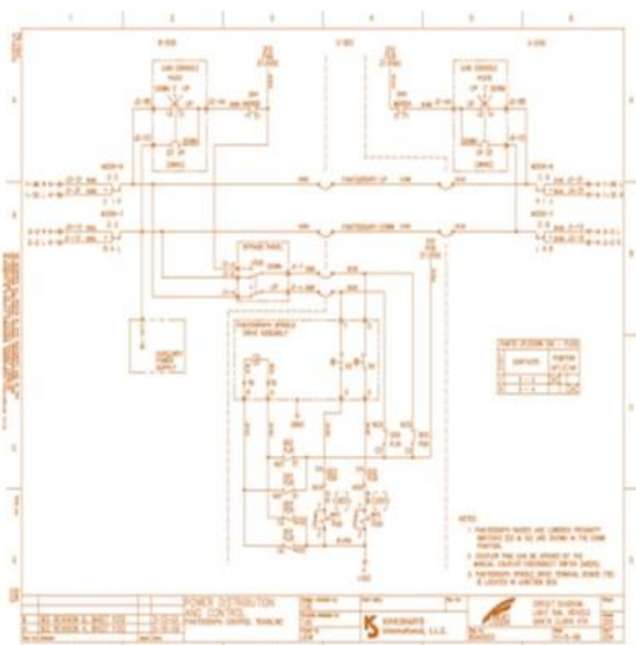
Principles of Troubleshooting and Diagnostics

Course 300



PARTICIPANT GUIDE

RAIL CAR TRAINING CONSORTIUM

Principles of Troubleshooting and Diagnostics

Participant Guide

Rail Car Maintenance Training Consortium

COURSE 300

Note: All images contained within this document were contributed by Rail Car Training Consortium members unless otherwise noted.

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Purpose of the Course

The purpose of the *Principles of Troubleshooting and Diagnostics* course is to provide an overview of the troubleshooting process along with related general strategies, tips and pitfalls.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The *outline* will discuss the main topics to be addressed in the module. A list of *key terms* identifies important terminology that will be introduced in this module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. A list of *key terms* identifies important terminology that will be introduced in each course module.

Module 1

PRINCIPLES OF TROUBLESHOOTING

Outline

1-1 Overview
1-2 The Troubleshooting Process
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Purpose and Objectives:

The purpose of this Module is to provide an overview of the troubleshooting process along with related general strategies, best practices, tips and pitfalls.

Following the completion of this Module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Define and explain the importance of troubleshooting:
- Describe a process for general troubleshooting;
- Identify and describe troubleshooting strategies; and
- Identify and describe troubleshooting tips and pitfalls.

Key Terms

- Half-Split
- Hypothesis
- Portable Test Unit (PTU)
- Root cause
- Sensory Inspection
- Subsystem
- Systematic approach
- Troubleshooting attitude

1-1 Overview

Troubleshooting is an integral part of the maintenance of rail cars. Whether a "symptom" is noticed or a report is made stating equipment is simply not working, troubleshooting gets to the heart of the problem. Troubleshooting allows corrective solutions to be found and implemented, which are key to quick solutions and excellent service.

This Module will explore general troubleshooting in terms of a basic troubleshooting process, general strategies, tips, pitfalls, and application procedures. Later, we will explore this process in the specific context of rail car systems by looking at common failures and some discussion examples.

1-2 The Troubleshooting Process

Troubleshooting is defined as a systematic approach to find the source of a problem in an effort to restore an operation or process. In other words, troubleshooting is complex problem solving in a methodical and organized manner. In situations where multifaceted systems need to be maintained, symptoms, and problems may have causes difficult to diagnose, or even have multiple causes. Multifaceted systems demand that an orderly and logical troubleshooting approach. Some may compare troubleshooting to that of a doctor who observes and lists symptoms, theorizes possible problems, performs tests, finds a prescription or solution, and then re-evaluates in order to restore optimum health to a patient. Sometimes troubleshooting requires a simple solution, and other times "symptoms" may be a sign of a larger problem that is more hidden from "surface" view. Either way, troubleshooters are like a doctor for their assigned system or rail car.

With troubleshooting, once the source or **root cause** of a problem is found, the problem can then be solved and appropriate repairs or adjustments made. Follow-up analysis is also critical to test and ensure the accurate solution was found. If the operation or process is not normal after initial repairs or adjustments are made, then the source of the problem was not found and the troubleshooting process must be repeated. Finding the source of a problem early on is important to avoid frustration and lost service.

There are many benefits to effective troubleshooting. Some of these include long-term time and cost savings, fewer failures, equipment life extension, technician job satisfaction and enhanced capabilities, better supervisor flexibility and efficiency, improved service, and increased safety.

A general systematic approach to troubleshooting involves a series of steps. The steps needed for each particular problem will most likely vary, and subsequent steps will also vary depending on results obtained during the troubleshooting process itself. Setting a goal and planning probable steps for troubleshooting a particular problem will be beneficial in remaining focused. Without a goal, improper tests may be performed, problems not readily solved, money and time wasted, and the situation can become rather frustrating. While "setting up" to troubleshoot may take a little time at first, the time and energy it will save later can make all the difference.

The following is a list of steps for troubleshooting. The list is a sample and while each problem will most likely vary and steps taken in conjunction with possible strategies may vary as well. Maintainers can follow this basic approach that models the troubleshooting process.

Troubleshooting Steps

1. **<u>Getting Started</u>:**

- **Know the system**
- **State the problem**
- **Adopt a troubleshooting attitude**

Know the system. Hopefully by the time troubleshooting begins, this step of the process will be complete. If not, then some research may need to be done in order to learn more about the system or part of the system. Knowing the system and its parts regarding normal and expected operation is crucial before beginning to troubleshoot a problem.

If we compare troubleshooting to the job of a doctor, we know a doctor would have a difficult time identifying the problem and solution for a patient if they did not have knowledge of anatomy and how the body works. The same is true for anything that needs troubleshooting, a technician must know and understand the parts of the rail car systems and how they work together in the larger system in order to identify, analyze, and find an effective solution to any problem.

Document the problem. While this may seem tedious, documenting the problem will help bring clarity and possibly additional thoughts and insights to the situation. Once again, if we compare this process to one a doctor would employ, they will almost always begin with a patient's chart and by documenting their process; stating the initial complaint and symptoms their patient is experiencing.

As you move through the process of troubleshooting, documentation should continue in the form of note taking. These notes will also help establish a goal to meet and track the steps you are taking or have taken. Complex problems will especially benefit from the process of documentation as one can get lost in the process of troubleshooting and easily forget a step taken or symptom observed. If needed later, the documentation and notes will provide an immediate resource for the problem and for any future occurrences of problems either directly or indirectly related to the current problem.

Adopt a Troubleshooting Attitude. Troubleshooting can sometimes be an easy process with a simple and obvious solution right away. Other times, troubleshooting can be complicated and more intense. Either way, keeping a "cool head" and adopting a "**troubleshooting attitude**" can be key in solving a problem, especially when the problem is complex or difficult. Important factors to keep in mind in an effort to adopt a troubleshooting attitude include:

- Stay focused.
- Block out "noise" as best as possible. Sometimes you may be required to address a problem in a heavy pedestrian traffic area with many distractions.
- Stay positive
- Deal with patrons in the area in a helpful, cheerful way.

- Keep a “cool head”
- Perseverance and patience
- Step back and take a break when needed and when possible. Sometimes those answers will come to you when you remove yourself from the situation and take a little time to reflect.
- Converse with someone about the problem. Sometimes talking it out may help bring clarity, or talking with another may bring a new perspective or ideas not yet considered derived from different experiences.
- Remember: ***You*** know the system. Confidence is important.

2. Expand Your Knowledge of the Problem:

- **Collect information**
- **Establish involved systems**
- **Define the problem**

Collect information, identify symptoms, and ask key questions. Now is the time to begin expanding the documentation process by identifying symptoms, asking key questions, and collecting information. Again, and just like a doctor, by taking a few notes and writing down this information, you will be able to “see” your path through the troubleshooting process and the particular case you are working on. This could also help later if the derived solution does not completely fix the problem or if the case is especially complex.

Collecting information is a two-step process that is actually done at the same time and continues throughout the duration of the problem. The first step is to collect information, and the second involves deciding what is relevant to the problem and what is not. If one came out to find their car unable to start, they would immediately begin this process by determining what may be the source of the problem and what is unrelated. Obviously, the driver of the car would not check the tires, deciding almost immediately that they are not relevant to the situation. However, the driver may consider and begin to think about the parts of the car that are relevant to the problem such as testing the battery, checking the starter, etc.

At this step, it is important to recognize what is normal operation. Understanding how something acts or exists under normal conditions is critical to know and identify what is not normal. Recreating a problem will also be helpful, especially if the problem is intermittent. If the problem is intermittent, it may be difficult to replicate, as a result, knowing the system and knowing what is normal is critical.

As you proceed, further clarifying the problem and enlarging the realm of possible avenues to follow in the troubleshooting process is important. Considering the example of a car not starting, troubleshooting starts when a technician looks at the level of gas or oil as they begin a closer examination, which leads to a broader look at the situation.

These two areas are not directly related and come to mind immediately when a car will not start but could certainly prevent a car from starting if levels are not as they should be or empty altogether.

Information can be gathered from countless sources; from logbooks to discussions with station agents on system disruptions, to diagnostic information that can be accessed by way of a **Portable Test Unit (PTU)**. A PTU is a laptop that can be connected to a vehicle sub-system through multiple places on the car. Through the use of diagnostic software, the technician can collect information that will be useful in the troubleshooting process such as system errors, status and logs. Module 3 of this course will cover the PTU more in depth.

Figure 1.1 Rail Car Technician Connecting a PTU to the Bus of a Rail Vehicle, Courtesy of TLC

As you begin to collect information, some key considerations or questions to ask may include:

- Gather immediate information about the situation. Ask about the situation or anyone who may have relevant knowledge about the problem or condition.
- Investigate initial complaints or situation, employ sensory inspection. Check the problem out for yourself. Use your eyes, ears, nose, touch when possible to get a feel for the problem.

- Identify the types of historical problems have there been with the generic equipment (routine breaks). Check for general problems with the type of equipment or manufacturer. If possible, ask around to others who may have previously worked on the same type of equipment.
- Check logbook for problems with the specific equipment. Determine if the equipment displayed the same symptoms previously and that perhaps the symptoms have been treated but the problem was not solved.
- Complete a **sensory inspection**. What environmentally is going on (hot, cold, rain, wind, ice, snow, etc.) that may impact performance. Have temperatures dropped too low? Is something overheated? Do you notice any unusual smells or sounds? Do any parts of the system seem unusual to the touch?
- Check the equipment manufacturer manual for manufacturer troubleshooting suggestions and recommendations.
- Characteristics of the problem. What is functioning in the vehicle and what elements are having trouble. Look at all facets and angles of the problem and filter out what may be a symptom and problem related, and what is not.
- What is the electrical data output from PLC and controller? Check electrical readings. What are the basic power or voltage readings, measurements?
- What other local equipment is having trouble? Look at the broader, larger picture?
- Determine root cause. Sometimes, a problem may lie outside of the immediate situation and beyond the specific equipment.

Establish systems and subsystems involved. This is the point where scope of the problem should be considered. You now know the symptoms and have defined the problem. Ask yourself what areas or parts of the equipment may be contributing or related to the problem at hand? Again, this is all part of the process of divide and conquer to pin point what system is causing a problem, and what issues are related and unrelated to the problem. This step involves looking at the smaller picture: The actual problem, and the bigger picture: What else may be contributing to the problem. What additional parts of the larger system may and may not be part of the problem?

3. <u>Theory & Test</u>:

- **Select best probable cause(s)**
- **Test**
- **Evaluate**

List possible causes & develop your theory. Remember the scientific method in school? This is the step to state what you think may be going on, or make a hypothesis. A **hypothesis** is an educated guess. You have educated yourself as to the nature of the problem, and now is the time to use your background knowledge of the equipment along with the new information you have gathered to make an educated guess about what is happening and what is the cause of the problem.

One way to go about developing your theory, or guess, is to list all possible causes for the problem. From there, begin a process of elimination by checking off what you think is most likely not the cause, thus eventually leaving one or two probable causes. During this step, keep in mind the systems and subsystems, being careful not to confuse symptoms with point sources for problems. In following this process for developing your theory, you will most likely come up with a cause for your problem. Additionally, if after testing the problem is still occurring, then you will have a list already developed of other possible causes to investigate.

Test. Some may want to jump to this step right away and skip other steps. However, a good troubleshooter will go through the previous steps of documentation & taking notes, establishing the problem, collecting information, sorting what is related and what is not, looking at the whole picture, and developing a theory prior to any testing. These previous steps will help determine what tests are appropriate for the situation and therefore save time, resources, and frustration in the long run. Also, be sure to consider all the symptoms and information you collected and test accordingly. Do not ignore a symptom and be sure to keep the documentation & note taking process going since recording those test results will help in deciding if you've found the solution. If a solution is not found, recorded test results will be beneficial for further consideration of the problem.

4. **Evaluate and Decide.**

Evaluate test results. Ask yourself; *What happened in the tests? What were the results?* Now is the time to look at data collected and determine if the hypothesis was correct or not. Are more tests needed? Should you "back up" and collect more information? What have you learned from the tests? Can a solution be determined? Again, be sure to document your results for future reference should the problem or something similar occur again. It will also be helpful to have the documentation if a solution was not found and test results may be needed for additional data in problem analysis.

Decide. Once you have evaluated your test results, determine if a solution was found.

5. **Go Back OR Fix, Test, & Record**

If test results indicated your theory was wrong, it will be time to go back to the troubleshooting process. If this is the case, review information you had initially collected and take another look at the system along with the problem. Was there anything missed the first time through? Was the problem identified correctly? Look at possible causes. Are there some causes you did not consider and/or should take a closer look at now? Were systems not considered that previously were possibly part of the problem?

OR

Tests were completed and a solution found. Now it is time to apply the solution and make the necessary repairs. Once the repairs have been made, it is important to re-evaluate and decide if the equipment has been adequately repaired and restored to proper working condition by testing once more.

The last step in the troubleshooting process is to record and document your conclusions. This recording and documentation should occur in two places. The first place is to conclude your final results in your own troubleshooting notes. The second place is to document in your agency's equipment maintenance log book. This is an important step and will be covered more later in the Module.

Figure 1.2 below illustrates the five troubleshooting steps. This will be helpful to quickly reference if you have any questions regarding the troubleshooting process while on the job.

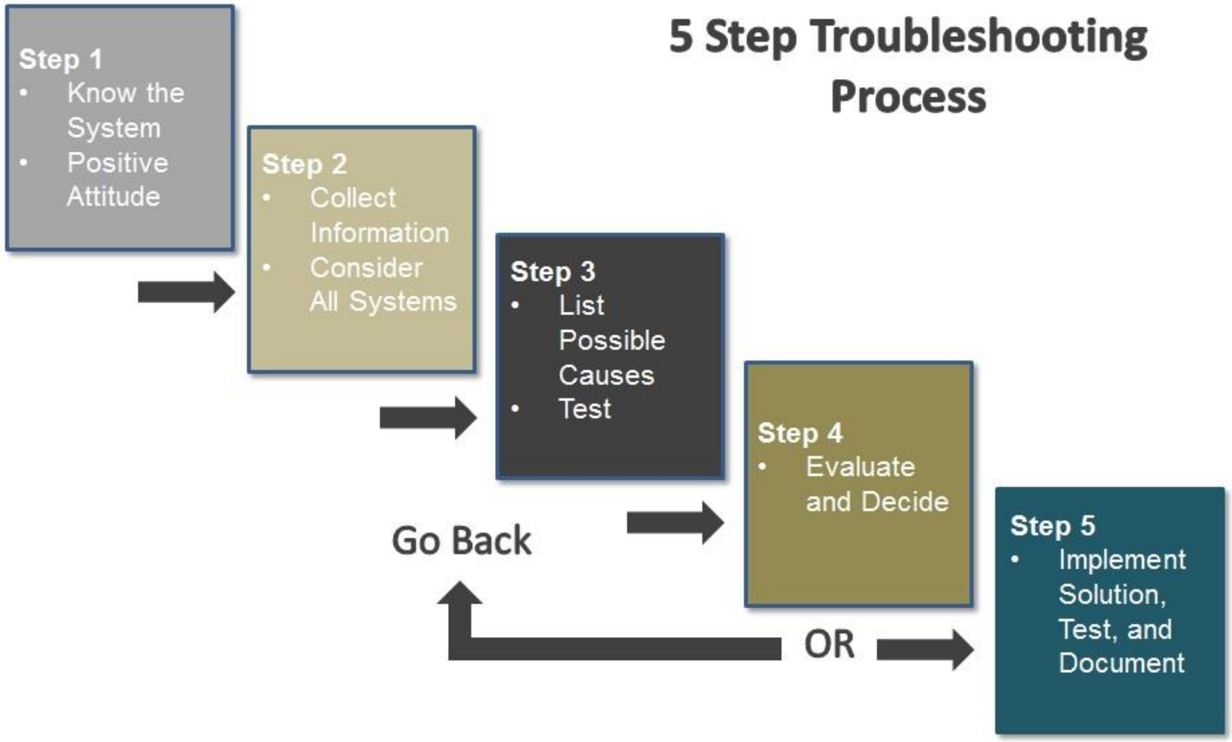


Figure 1.2 Five Step Troubleshooting Process

Learning Application 1.1 – Troubleshooting Steps
The steps explained in this section are a general approach to troubleshooting. In small groups, and then together as a class, write down the troubleshooting steps at your authority. It will be helpful to write down notes for each step to keep for future reference.

The Troubleshooting Process – Agency Specific		
Troubleshooting Step	**Questions to Ask Yourself**	**Notes**

Best Practices in Troubleshooting

The steps above are a general series of steps to utilize and follow in the troubleshooting process. Other approaches for troubleshooting are also possible. These approaches, or strategies, can be used as part of these steps or can stand on their own in the appropriate situation. Some of the various strategies to also use may include:

- **The "Half-Split" or "Half Half" Method**. The "Half-Split" method allows one to determine where a problem exists within the equipment. This strategy is characterized by a binary search across a range of dependencies. In other words, the idea behind this strategy is that with each step of the troubleshooting process, half of the system or part of the system is eliminated as a possible cause of the problem.

- **Process of Elimination or Function vs. Non-Function.** This is a simple method and typically what inexperienced/novice technicians go to first in troubleshooting. This process involves eliminating areas or possibilities that are not part of the problem. In other words, identify where the problem *is not*, and focus your efforts elsewhere. The degree of fault can often tell you what part of it is to blame. In a complex problem, or in various stages of the troubleshooting process, process of elimination can be used as part of the process itself. If the drive system is not producing the desired end result, look for what it is doing correctly.

- **Recent Alterations**. Check to see if the problem occurred immediately after some kind of maintenance or other change to the drive. Chances are the new problem could be a result of that change or adjustment.

- **KISS principle**. "Keep it Simple, Stupid" or "Keep It Short and Simple" or "Occam's Razor". Look for the easy solutions first. An example may be if something does not turn on, check to see if it is plugged in before checking the wires.

- **Inducing or Deducing.** This strategy is a top-down, deductive method which employs a logic diagram displaying the system and what parts connect directly and indirectly to others. One can use this to work backwards from the symptom source or use to look at the systems and subsystems.

Learning Application 1.2 – Best Practices Discussion
As a class, with guidance from your instructor, discuss the pros and cons regarding the five different best practices explained.

1—3 Troubleshooting Tips and Pitfalls

Troubleshooting Tips

A good troubleshooter will know and utilize specific strategies within the troubleshooting process. Good troubleshooters have learned these strategies from their own experience or the experience of others. A few strategies and tips are listed below.

- **Persistence and open-minds.** The "real world" does not always provide helpful resources. Be persistent and open minded in the troubleshooting process.
- **Re-examine previous questions**. Maybe information collected was disregarded too quickly. Go back and examine previous questions that may need to be reasked.
- **Examine prior occurrence:** Look at the maintenance log and other records to see how this problem was resolved before. If the log shows a common solution to the problem, then the technician should check that solution first. If the previous solution did not adequately and effectively solve the problem, then one can avoid repeating what hasn't already worked and use this information to start in a new direction.
- **Look for easy solutions first.** *Is it plugged in?*

Troubleshooting Pitfalls

On the contrary, a good troubleshooter knows what pitfalls to avoid which result in saved time and frustration. A few of these include:

- **Don't jump to conclusions.** Do not "fix it before you get there" and do not determine the solution before fully investigating and asking initial questions.
- **Limited investigation.** Do not rely just on past problem information. This problem could be different, or perhaps the problem was not solved correctly before.
- **Treating only symptoms.** Look for an underlying root cause to the problem, and do not just "treat" symptoms. This will result in only "putting a band-aid over a gaping wound" and will not only miss on solving the problem, but may also lead to additional problems, further equipment breakdown, and potentially compromise the safety of yourself others.
- **Poor information.** Unfortunately, this can be a problem that adds to the problem. Inadequate documentation, prints, schematics, and OEM books are sometimes not complete or even have wrong information. Be sure to use your senses, further investigate, and trace the system. Don't settle when something is incomplete.
- **Repeating.** Do not always rely on same technique over and over again. For example, do not immediately check the voltage meter when "symptoms" do not indicate a need. Give careful thought to the situation and specific symptoms before you.
- **"Not thinking"**. Not giving something enough of your attention and expecting the answer to be obvious can result in missing important information, steps, and consequently the right solution.

- **Do not "over think"**. Overthinking a situation can lead to possibly ignoring simple solutions.
- **Narrow view**. Remember to consider the bigger picture or whole system, especially important in step 4, systems and subsystems. This is the time to consider what is connected to what, and what beyond the initial scope could be contributing to the problem.

Recommendations for Troubleshooting in a Group

Troubleshooting in a group setting can offer benefits and challenges. When more than one person is involved in the troubleshooting process, the opportunity to benefit from multiple experiences and ideas can be very useful. Each person that is present brings to the group various backgrounds and experiences, offering a wider range of perspectives which can be especially helpful when a problem is particularly difficult. When more than one person is involved, the immediate chance to discuss and talk the problem out is also readily available and clarity of the problem may develop more quickly.

While troubleshooting in a group can be beneficial, there challenges that could develop from working in a group setting. When working with more than one person, and especially in a larger group, a leader for the group is important. Likewise, if other roles or duties need to be filled such as a note-taker, safety leader, tester, etc., then it is important for the group to decide and assign those roles. With various individuals responsible for different parts of the problem, communication and progress should be more efficient. In addition, when more than one person is involved, safety awareness becomes more critical especially with regard to communication. Transportation system safety regulations and procedures should be reviewed along with communication and any other task procedures. Finally, troubleshooting plans should be discusses up front before the troubleshooting process begins.

Ground Rules

- Select a leader and possibly a recorder. Everyone else is doing/testing/observing/etc.
- Review safety procedures, checklists, communication procedures, and troubleshooting plan with the entire group before starting. If a new person joins the troubleshooting group later on, update the individual with this information and the status of the problem immediately.

1-4 Troubleshooting Documentation

Troubleshooting documentation occurs in two phases: Throughout the troubleshooting process; and as part of the record keeping process. The first phase of note taking occurs during the troubleshooting process itself. This is an important step especially when a problem is complex and various systems are involved. This has been covered to some extent already in this Module. As mentioned before, writing down notes about the problem can help bring clarity to the problem, along with a record of the process to consult with if needed later. If tests are run and the solution is not found, these notes then become a record to go back to and consult with so that one knows what has been tried and what has not been tried or considered in solving the problem. Writing down details regarding the problem thus becomes critical in the troubleshooting process. If one must stop for some reason before a solution is found, then there is also a record to review before beginning again therefore preventing the possibility of repeating steps. Additionally, if more than one person is involved in the process, notes can be helpful in the communication process.

The second part of the documentation process is the last step in troubleshooting: Record keeping. Record keeping is your agency's official process of officially documenting the problem and how it was solved. Each agency usually keeps a log or record book with each system, and some may maintain records in a computer database using specific software. For long term maintenance and evaluation of a system and its parts, this document is an important part of the overall system. Follow your specific agency's procedures regarding policies on documentation.

General Troubleshooting Application

As stated before, note-taking during the troubleshooting process can be very helpful, especially for those new to troubleshooting in a given field or for a complex problem. Sometimes having a note-sheet for this process can assist in providing structure for the troubleshooting process when needed. The following document can be used for the purpose of practice exercise in your course as well as when you are in the field and on a particular job.

Troubleshooting Note Record

	Notes
Initial Problem or Complaint	
Information Collected	
Problem Reported by	
Sensory Inspection	
Environment	
Log Book Information	
Other Relevant Information	
Systems or Subsystem Involved	
All Possible Causes	
Tests to Perform	
Findings	
Solution	
2nd Test Results	

Learning Application 1.3 – Troubleshooting Documentation
Your instructor will provide a copy of the troubleshooting documentation used at your agency. Review and discuss the different components of the document. Take notes and save for future reference.

1-5 Summary

Troubleshooting is an important part of a technician's job. Like a doctor, a technician must consider initial symptoms and complaints and complete a thorough inspection to collect all possible information. The technician shall also take into consideration all potentially involved systems and subsystems, consider all possible causes, develop a theory, test, fix, and test again to determine an accurate solution to the problem was found and thus restoring the system to optimal health. This Module provided a general process along with specific strategies, tips, and pitfalls for troubleshooting.

In addition to knowing the system, knowing some common failures and problems in rail car system can help speed the troubleshooting process along in some cases. Troubleshooting information specific to each piece of equipment can be found in the equipment's manufacturer manual. Subsequent courses will provide lists of common failures and problems specific to different rail car subsystems including:

- Couplers
- Trucks and Axles
- Propulsion and Dynamic Braking
- Auxiliary Power Supplies and Batteries
- Friction Brakes
- HVAC
- Current Collection
- Car Body
- Door Systems
- Communication Systems
- Automatic Train Control

Module 2

Troubleshooting Electrical-Electronic Systems

Outline

Purpose and Objectives:

The purpose of this Module is to provide examples of electrical and electronic systems on rail cars and provide an overview on how to troubleshoot these types of systems.

Pre-Requisites:

Before beginning this course, participants should be able to:

- Define relevant electrical-electronic terminology.
- Demonstrate ability to read advanced electrical ladder drawings.
- Demonstrate ability to safely work with high voltage.
- Demonstrate ability to use meters to take readings in the field.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- Demonstrate the ability to read a multiple-page schematic;
- Describe the difference between electrical and electronic systems;
- Given a component, determine if it uses an electrical or electronic system;
- Demonstrate the ability to troubleshoot electrical components; and
- Demonstrate the ability to troubleshoot electric components.

Key Terms

- Electrical Systems
- Electronic Systems
- Footer
- Table of Contents
- Title

2-1 Overview

Troubleshooting is an integral part of the maintenance of rail cars. Whether a “symptom” is noticed, or a report is made that equipment is simply not working, troubleshooting gets to the heart of the problem so that corrective solutions are found and implemented.

This Module will explore the process of troubleshooting in the specific context of rail car systems by looking at common failures and some discussion examples.

Warning: Safety Precautions!

- All agency regulations, precautions, and procedures concerning working in the rail maintenance shop should be strictly followed.
- Only qualified personnel should handle maintenance, troubleshooting and repairs of a rail car’s propulsion system.
- Check that equipment is in no-voltage condition.
- Check that capacitors are discharged.
- Adjacent parts which are live must be covered or precautions used to ensure that they cannot be touched.
- Be aware that hazardous voltages can still be present even after equipment is disconnected from power supply

2-2 Electrical-Electronic Review

Symbols, Schematics and Ladder Drawings

In previous courses and workplace learning, you have been introduced to wiring diagrams including symbols and schematics. Most recently, you have seen these items in the context of one-page drawings that pertain to a particular subsystem (Figure 2.4).

If a review of these items is needed, please refer to the Additional Resources section of this Module.

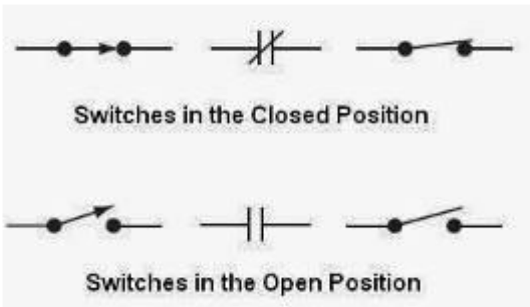


Figure 2.3 Symbols for Switches. Source: Electricalknowhow 2013

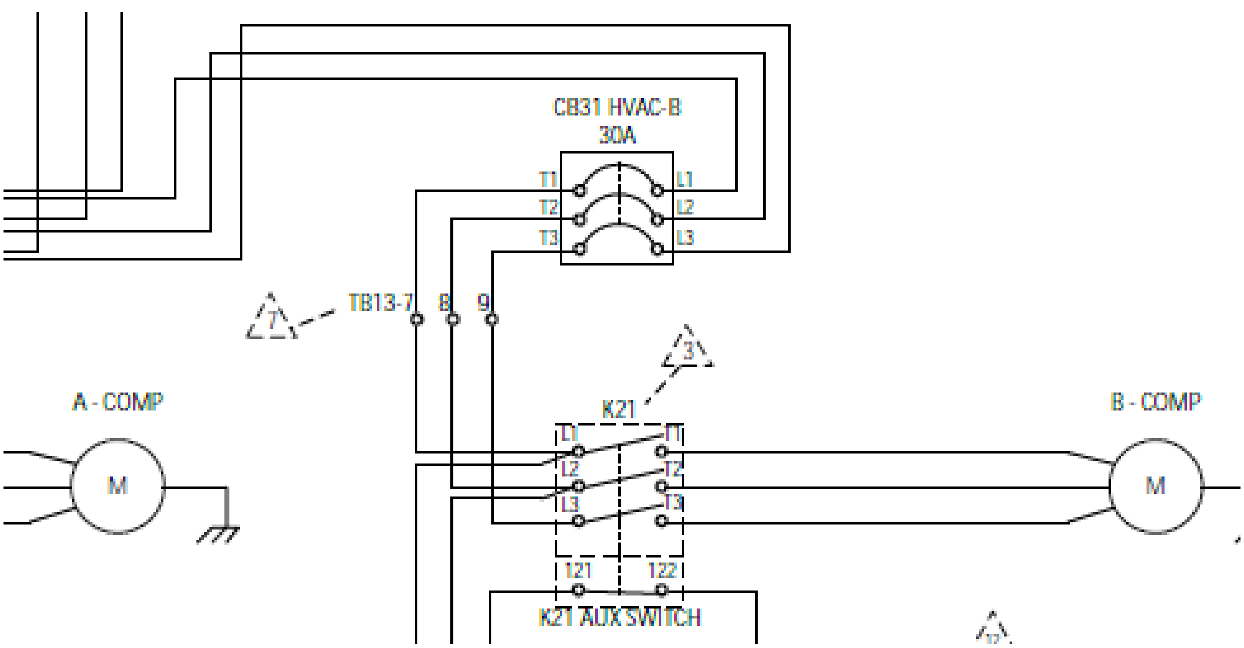


Figure 2.4 Symbols in Context for an HVAC Schematic. Courtesy of CATS

Learning Application 2.1: Reading Schematics and Identifying Key Items Using your previous knowledge on schematic symbols, work with a partner to identify the listed items on the schematic below.

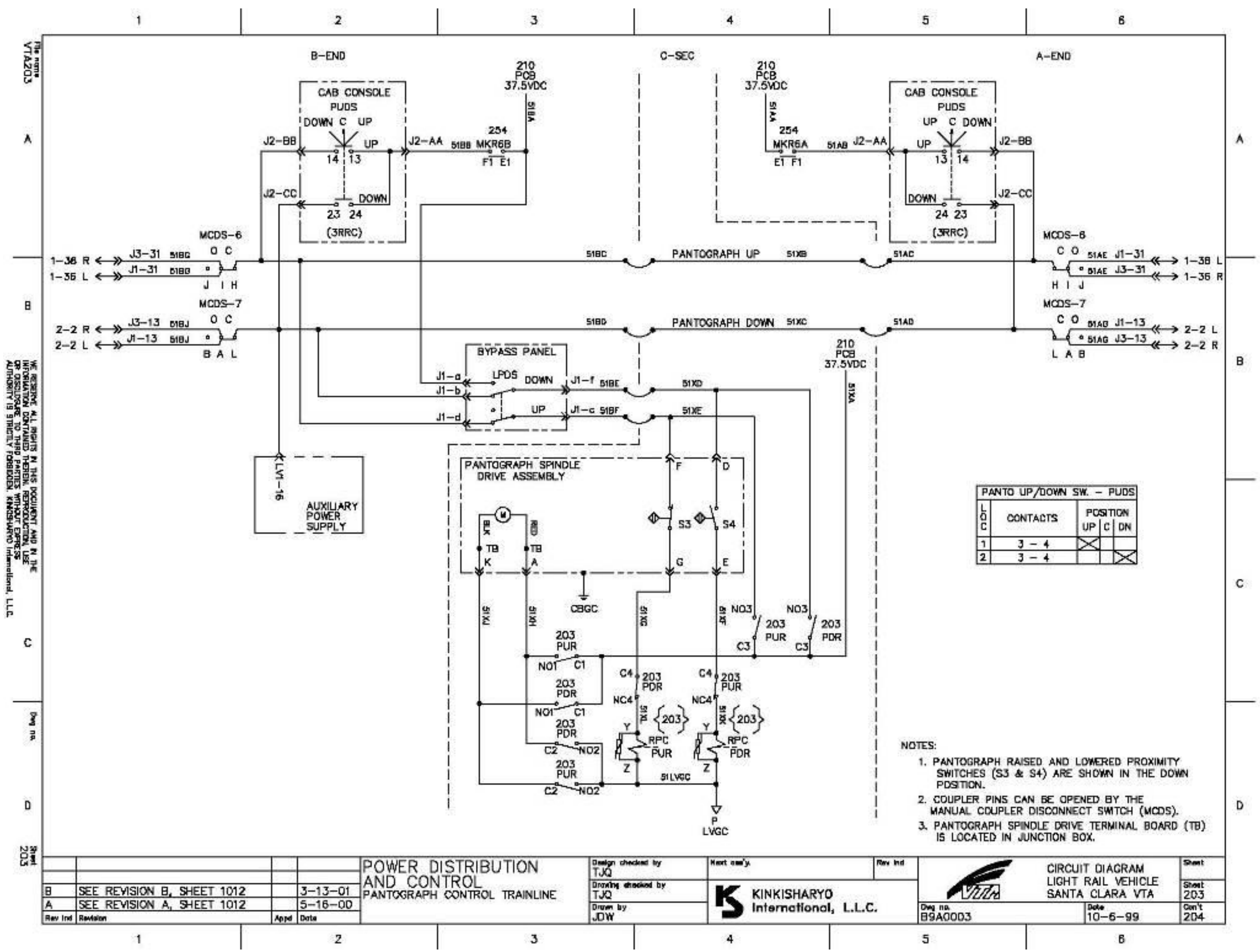


Figure 2.5 One Page Schematic

Items to Identify:

1. Engaged Connector/Junction
2. Ground
3. Push Button Switch
4. Switch (Normally Open)
5. Resistor
6. Connected Wire

Rail cars are comprised of many complex electrical and electronic systems. While a simple one-page block diagram can sometimes show the entire subsystem at a glance (Figure 2.6), the details needed for troubleshooting and repair are missing. It would be impossible to show this level of detail, as are shown on the schematics used here, for all systems and their relation to each other on one 11x17 piece of paper. As rail car maintainers, it is important to be able to piece together and read multi-page prints.

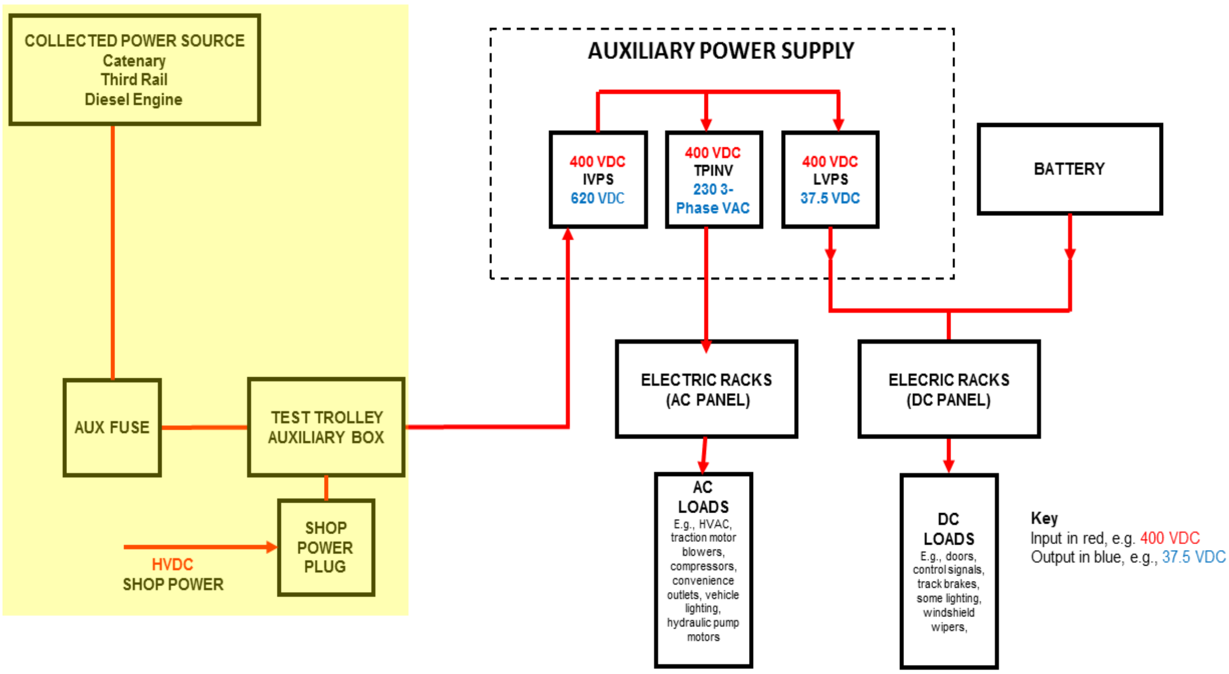
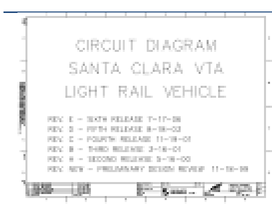


Figure 2.6 Simple Block Diagram showing Distribution of Power from Catenary to Vehicle. Courtesy of MBTA

The key to piecing together multiple page prints is to use the information found in the book of plans to determine how different pages are:

- Linked to each other
- Grouped together, and how this is signified

Let's start by identifying the parts on the lead pages of a book of plans. Note that for illustration purposes, we will use example prints from the Santa Clara Valley Transportation Authority (VTA). It is recommended that you go through a similar process of identifying parts and connections in a book of prints that is specific to your own location.



To see the full schematic example from VTA, refer to **Handout 2.1 Example VTA Schematics**

Generally, the first page will contain information such as, the authority name and a list of the revisions that have been made, along with the dates they were made (Figure 2.7).

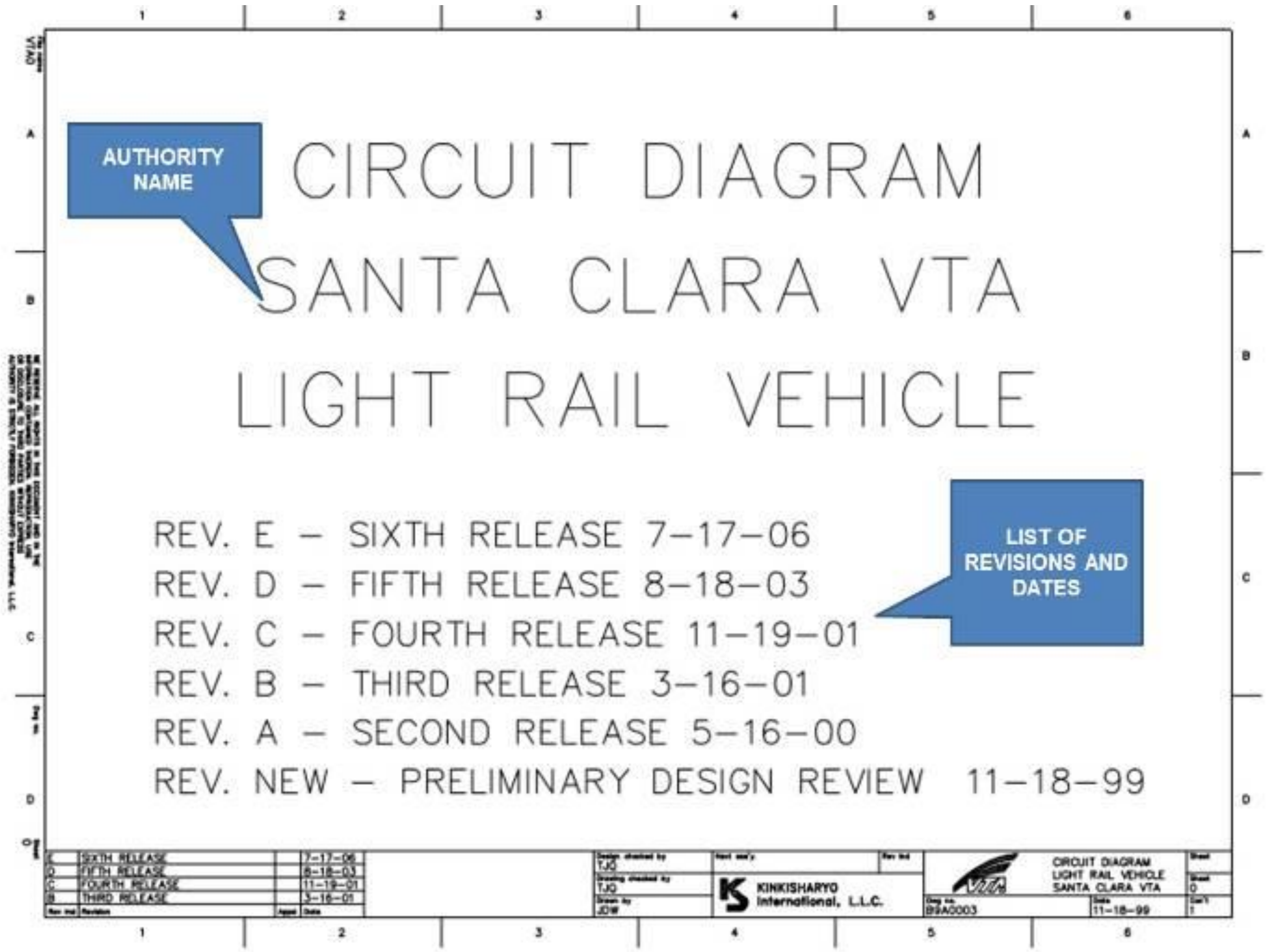
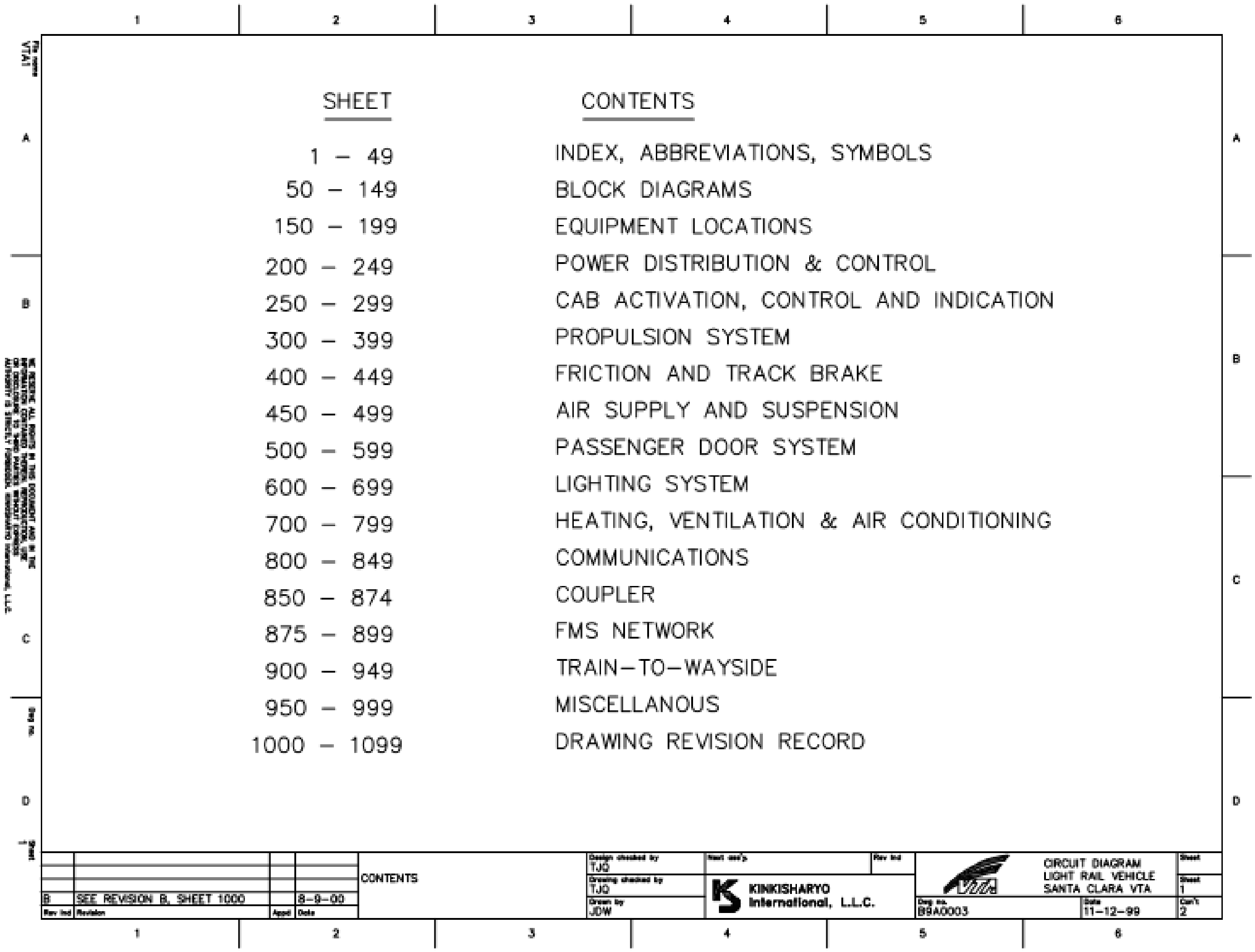


Figure 2.7 Example Lead Page of Book of Prints. Courtesy of VTA

Location Specific Differences:

On the second page, there is generally an overall table of contents that gives sheet number references for each subsystem (
Figure ***2.8***). In this course, we will use the Power Distribution and Control section (sheets 200-249) to illustrate how to read prints across multiple pages.



SHEET	CONTENTS
1 – 49	INDEX, ABBREVIATIONS, SYMBOLS
50 – 149	BLOCK DIAGRAMS
150 – 199	EQUIPMENT LOCATIONS
200 – 249	POWER DISTRIBUTION & CONTROL
250 – 299	CAB ACTIVATION, CONTROL AND INDICATION
300 – 399	PROPULSION SYSTEM
400 – 449	FRICTION AND TRACK BRAKE
450 – 499	AIR SUPPLY AND SUSPENSION
500 – 599	PASSENGER DOOR SYSTEM
600 – 699	LIGHTING SYSTEM
700 – 799	HEATING, VENTILATION & AIR CONDITIONING
800 – 849	COMMUNICATIONS
850 – 874	COUPLER
875 – 899	FMS NETWORK
900 – 949	TRAIN–TO–WAYSIDE
950 – 999	MISCELLANOUS
1000 – 1099	DRAWING REVISION RECORD

Figure 2.8 Example Overall Table of Contents for a Books of Prints Sheet 200. Courtesy of VTA

Location Specific Differences:

At the top of the first page of a section, as you will see in Figure 2.7, you will find a **title** that identifies the subsystem for which the prints relate to – for example, HVAC, Couplers, etc. In this instance, all the prints in this series will be related to the Auxiliary Power Subsystem.

In the **table of contents**, there is a list of systems within the particular subsystem. Additionally, you will find the revision versions and the sheets(s) of the print on which each particular system can be found. There are two important items to make note of regarding the table of contents:

1. All sheet numbers start with the same number – in this case 2
2. Some systems will not fit onto one sheet (ex: Low Voltage Distribution).

These items will gain more importance as we go on to see how pages are linked together.

On the first page of the section, there is also a **footer** that has the identical format as the subsequent pages. In the lower right-hand corner, you can find the number of the **current sheet** as well as the **next sheet**. The footer will most probably also contain the name of the public **transportation authority** using the prints as well as the firm which authored them.

Each footer will also list the title of this particular sheet. On this first page, the overall title will be listed ("Auxiliary Power Table of Contents"). On subsequent pages, you will see that the description used in the table of contents (or something similar) will be shown (ex: Convenience Outlets, Auxiliary Power Ready Circuits).

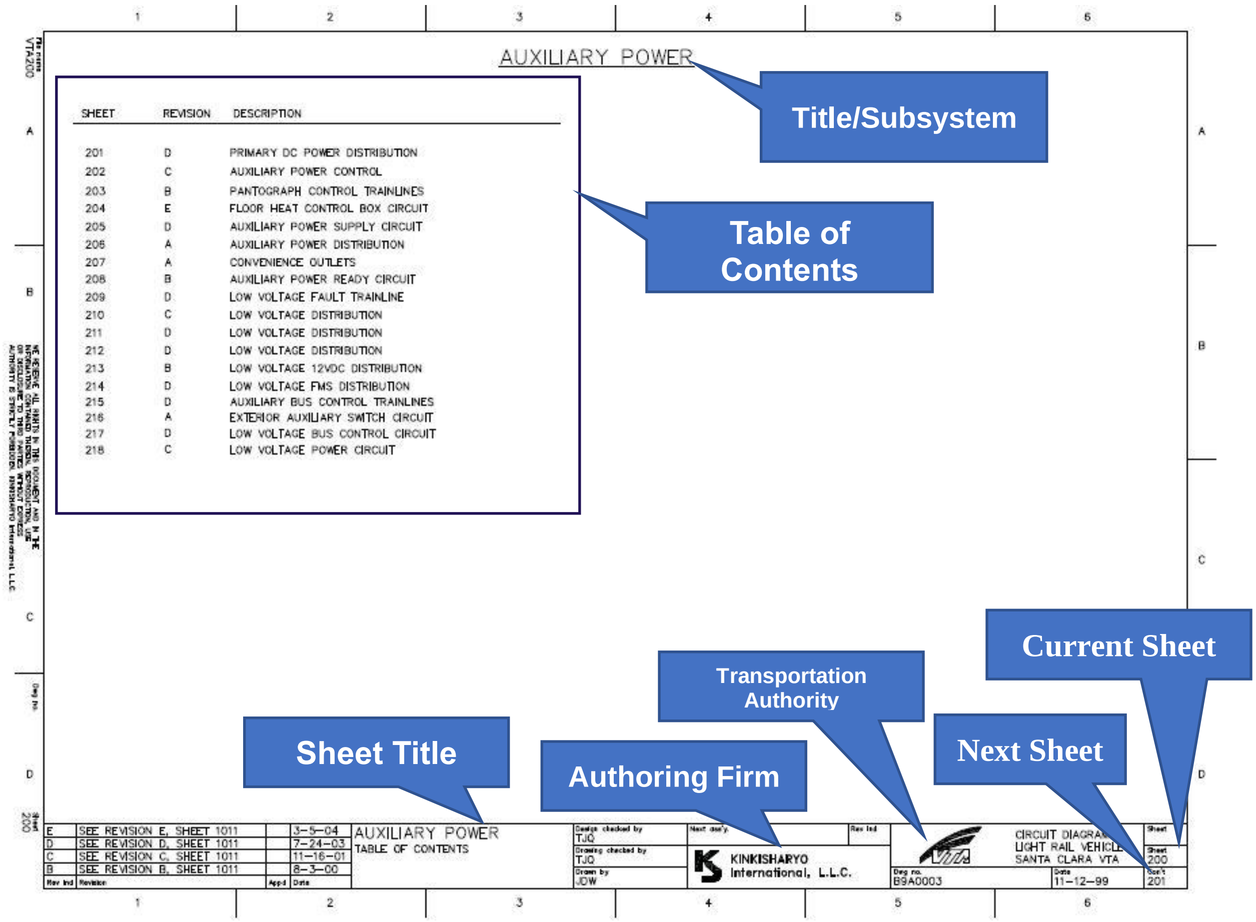


Figure 2.9 Auxiliary Power Books of Prints Sheet 200. Courtesy of VTA

Location Specific Differences:

Now, let's look at the second sheet in this book of plans. Along the edges of the print (or sometimes within the body of the print), you will see multiple three digit numbers (ex: 204, 205, 302). Sometimes those numbers are accompanied by a title (ex: 204 FLOOR HEAT). These numbers denote that this section of the print is continued on another sheet.

You will notice that some digits start with a "2." As we covered earlier, all sheets within the section for Auxiliary Power will start with the number 2. Digits starting with a number besides "2" (ex: 302) refer to sheets that are part of another subsystem. Your location may or may not follow similar protocol.

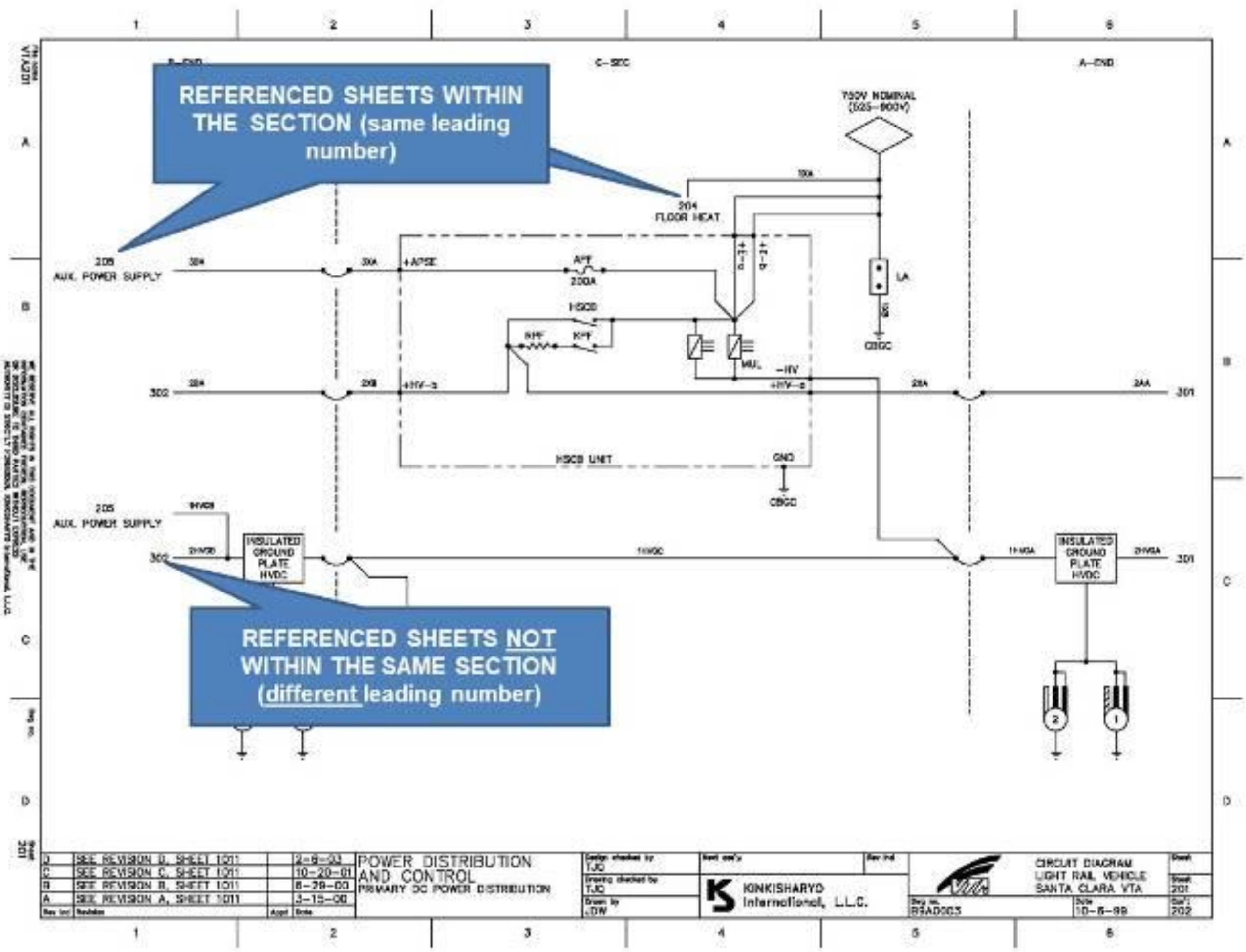


Figure 2.10 Auxiliary Power Books of Prints Sheet 20. Courtesy of VTA

Location Specific Differences:

Now, let's take a look at one of the connecting sheets that are referenced, 206 AUX POWER SUPPLY (Figure 2.11). You will notice that on the right-hand side, there is a reference to the sheet we just looked at (201). In this case, sheet 201 is known as the **originating page**. You will also notice many other references that link to other pages (Ex: 208 VAC INVERTER, 210 LOW VOLTAGE POWER SUPPLY).

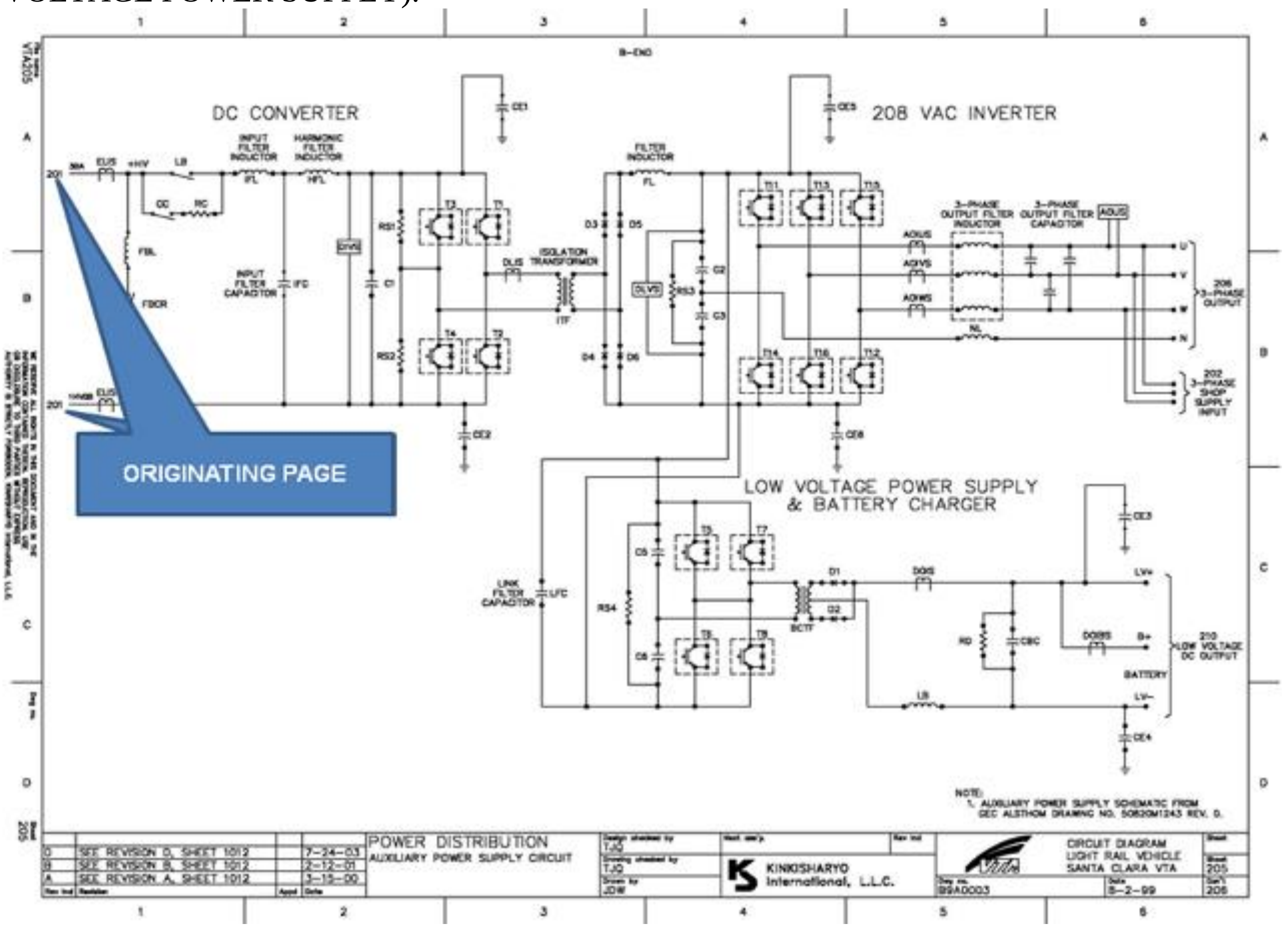


Figure 2.11 Auxiliary Power Books of Prints Sheet 206: Aux Power Supply. Courtesy of VTA

Location Specific Differences:

Learning Application 2.2 – Reading Multiple Page Prints
In small groups or pairs, use a location specific book plans provided by the instructor to identify the following elements. Discuss how the contents of each book differ from how they were presented in the VTA examples above. If there are no book of plans are available, use Handout 2.1 Example VTA Schematics for this exercise.

Identify the following elements using location specific book of plans:

1. Revision List
2. Section Title Page
3. Section Title/Subsystem
4. Overall Table of Contents
5. Section Table of Contents
6. Current Sheet Number
7. Next Sheet Number
8. Transportation Authority
9. Authoring Firm
10. Sheet Title
11. References within the same section – and locate those sheets and the connection points between the originating sheet and the referenced sheet
12. References within a different section

Using Schematics for Troubleshooting

A technician needs to know how the book plan sheets connect to each other and how they are related when connecting map pages within a book, and how to trace the roads from one location to another when working on a schematic of the rail car. Schematics are a little more complicated since there are components like switches, transformers and connection points that impact the amount and direction of electrical flow.

In order to troubleshoot and repair rail vehicles, a maintainer must be able to master this skill. In this next section, we will use the example schematics from VTA to learn how to perform two important tasks:

1. Given a certain component, trace the power back to its source
2. Determine expected voltage at multiple points on the print

You will then see how these skills translate into troubleshooting in the field where this knowledge is used to compare the expected voltages at multiple points to the actual readings taken using a meter. The information collected will help determine where there are and are not problems. Even finding a situation where the reading is as expected helps in the troubleshooting because it helps us eliminate some causes, therefore leading us closer to determining the correct cause of the failure.

Tracing Power on a Schematic

While being able to connect one page of a print to another is a valuable skill in troubleshooting, the most important skill is being able to trace a given component back to the originating power source. In most cases, the originating power source is ultimately catenary by way of pantograph or third rail, by way of on car collector shoe.

Being able to trace the flow of electricity from a component to the source is valuable because in the case of component failure, a maintainer will be able to identify all the parts along the way of the electricity flow where failure may have happened. Note that where first readings are taken is often determined by factors such as:

- How accessible each area is
- What components between the faulty component and the power source have a history of failure

If all other things are equal, the testing would be done as to split the entirety in half, and then quarters, etc., as is done with troubleshooting of circuits.

To illustrate how to trace energy flow in this way and identify intermediate components between the component in question and the power source, we will be using the same VTA schematics to trace the energy flow from the cab console to the main power supply. Note that schematics may differ by location and/or OEM. You will complete the same exercise with location specific prints later on in this Module.

In most cases, it is easiest to trace the path between the identified component and the main power supply by working backwards from the component towards the power supply. In Figure 2.12, you will see the cab consoles for both the A-end and the B-end of the train highlighted as well as the incoming path of energy. By looking at the print, you can see that incoming voltage is 37.5 VDC and that it is coming from the Pantograph Circuit Breaker (PCB). Participants learned earlier in the Module about connecting sheets of prints together, and you can also see that more detail on the PCB can be found on sheet 210.

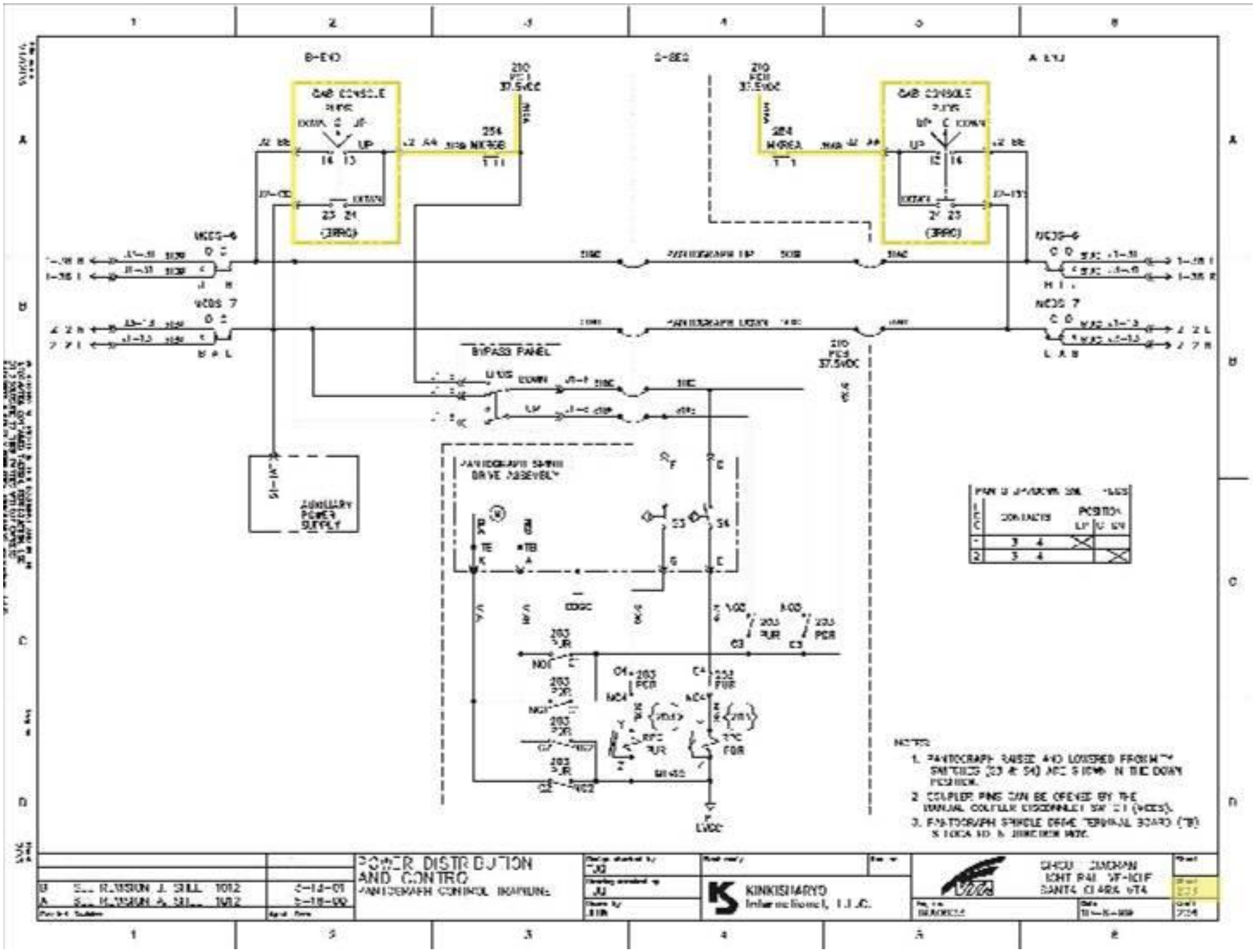


Figure 2.12 Schematic with Cab Console Highlighted. Courtesy of VTA

When looking at Sheet 210 (Figure 2.13), we can trace the energy flow back to the battery box and then to the auxiliary power supply. Note that if we were troubleshooting a problem with the cab console where there was no electrical input, given this information, the battery box may be one place to take readings at to ensure electrical flow is correct there. If there is electrical flow, then the problem is somewhere between the battery box and the cab console. If the reading at the battery box is not what it should be, the electrical flow issue goes back further – in this case, at or beyond the auxiliary power supply.

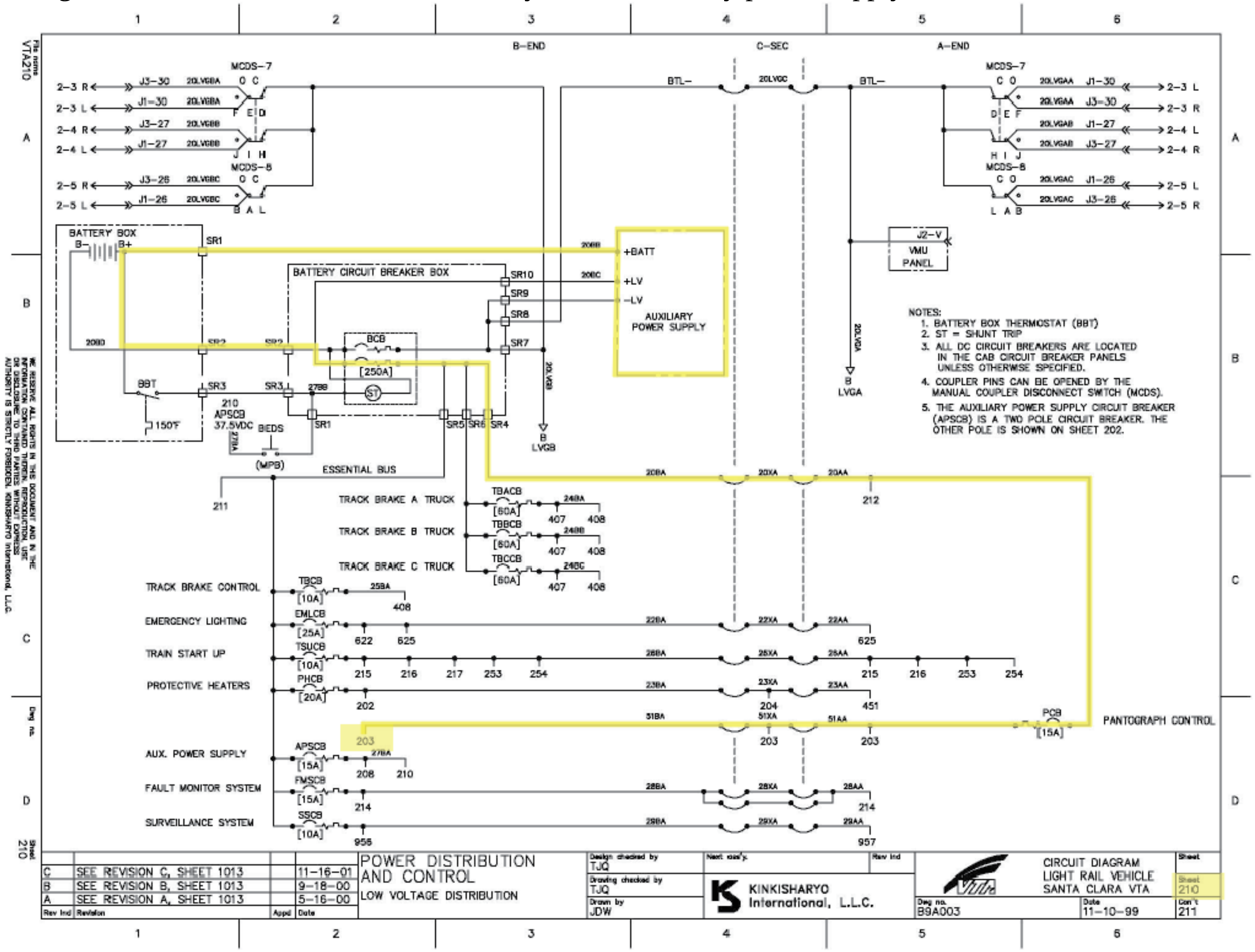


Figure 2.13 Schematic Sheet 210 . Courtesy of VTA

While it is not clearly noted on sheet 210, we know that in this case, auxiliary power supply is low voltage and also that where there is a battery box, there needs to be a battery charger. With this information, it is easy to identify in this section of prints that on sheet 205, (Figure 2.12) there is a drawing of the "low voltage power supply and battery charger." You will also notice on this page that there is a note that this sheet connects to sheet 210 – verifying that we are moving in the right direction. On sheet 205, we can see that the power for the low voltage power supply and battery charger come from the DC converter by way of an isolation transformer. We see a note here that line 3BA which feeds the DC converter with high voltage is continued on sheet 201.

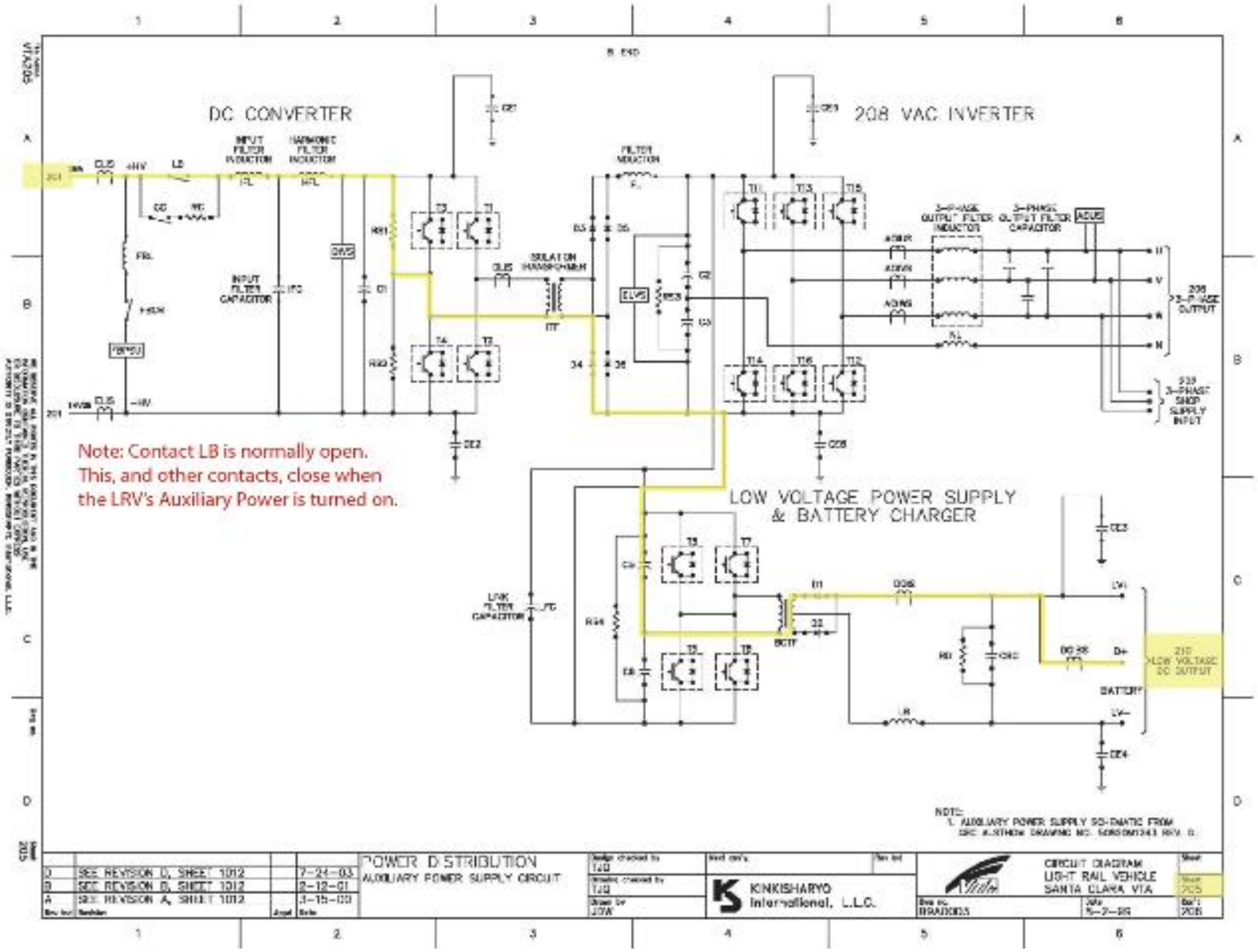


Figure 2.14 Schematic Sheet 205. Courtesy of VTA

Sheet 201 (Figure 2.13) shows that line 3BA is connected to the 525-990V originating power source (catenary or third rail) by way of a high-speed circuit breaker unit (HSCB).

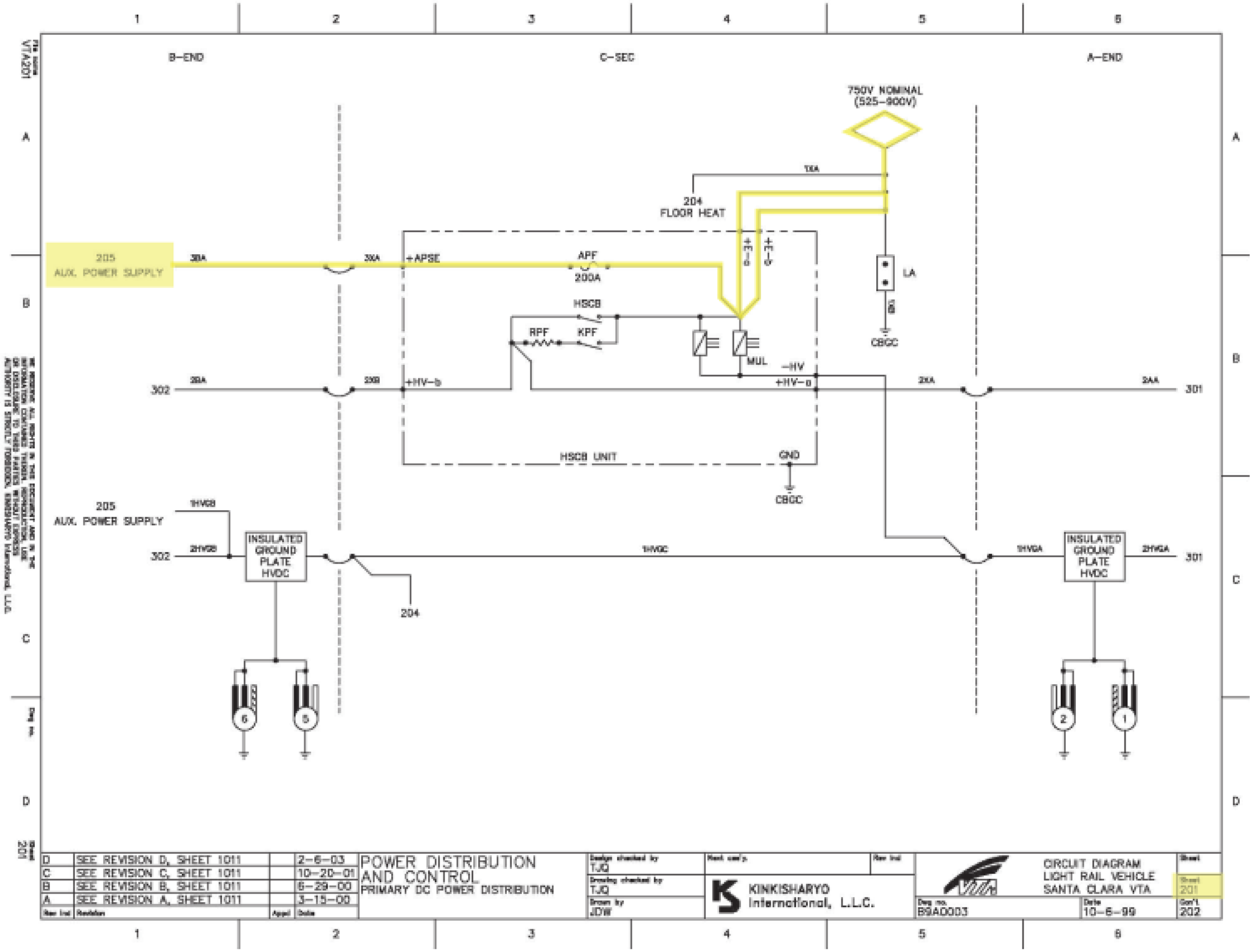


Figure 2.15 Schematic Sheet 201. Courtesy of VTA

Learning Application 2.3 – Using Multiple Page Prints to Troubleshoot
In small groups or pairs, use Figure 2.12, Figure 2.13, Figure 2.14 and Figure 2.15 to answer the following question:

Scenario: A problem with the cab console in car-A has been reported. The cab console will not turn on. Given the schematics for this system and your ability to trace the flow of electricity, please list the locations where you will take meter measurements in order to isolate where the problem may be.

Learning Application 2.4 – Using Multiple Page Prints to Troubleshoot
In small groups or pairs, use location specific schematics and a highlighter to:

1.) Highlight the flow of electricity from a given component that has been identified as not being able to power up to the power source.
2.) Identify what areas/components to take a meter reading of in order to identify the root cause

Afterwards, teams will be given an opportunity to use their newly acquired skills out on the shop floor.

Team #: ________________ **Faulty Components: ________________**

The following components/area should be tested with a meter in order to identify the root cause:

2-3 Troubleshooting Electrical and Electronic Systems

While very different, “electric” and “electronic”, are two terms which are often confused. **Electrical systems** use electricity to transmit and manipulate power. **Electronic systems** use electricity to transmit and manipulate information. The main difference between electrical and electronic circuits is that electrical circuits have no decision making (processing) capability, whilst electronic circuits do. An electrical circuit simply powers machines with electricity. Electrical equipment is made of conductive material such as metal alloys. Electronic equipment is made of semi conductive material such as silicon. Note that all electronic systems are electrically operated. Without electricity to start the movement, there would be no transmission of information.

Some examples of each are listed in the table below:

	Electrical	**Electronic**
General	• Wires • Switches • Fuses • Hair dryer • Curling iron • Electric Razor • Large Relays (No-Motion Relay)	• Capacitors • Diodes • Transistors • Rectifiers • Suppressors • Smart Phone • Digital Camera • Small Relays (Door Control Relay)
Rail Car Specific	• Pantograph • Passenger Lighting • Motors	• Door operator on rail car • Traction Control Unit • Couplers (Transmit a signal)

Figure 2.16 Examples of Electrical and Electronic Devices

Troubleshooting Electrical Systems

Rail car maintainers will occasionally need to troubleshoot the following electrical systems:

Component Type	Rail Car Example	Agency Specific Notes
AC Motors	HVAC Blowers – within an evaporator fan assembly (Figure 2.15)	
DC Motors	Door Operator (Figure 2.16)	
Electrical Motor Drives	Variable Frequency Drive (VFD) on Traction Motors for Rail Car Propulsion (Figure 2.17)	
Relays (some)	No-Motion Relay – informs the vehicle logic that rail car is at a standstill so that doors can open, etc.	

Figure 2.15 Evaporator Fan Assembly. Courtesy of CATS

Figure 2.16 Door Operator. Courtesy of NYCT

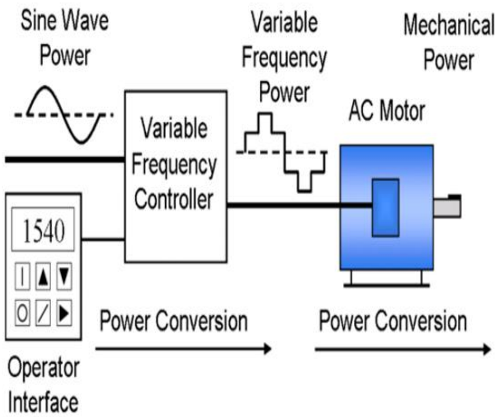


Figure 2.17 VFD System, Wikimedia

Figure 2.18 Relay

Troubleshooting Electronic Components

Rail car maintainers will occasionally need to troubleshoot the following electronic systems:

Component Type	Rail Car Example	Agency Specific Notes
Relays (some)	Door Control Relays	
Switches	Door Pushbutton Switch	
Diodes	On Relays	
Transistors	APS and Propulsion Transistor	
IGBTs		
Thyristors	Propulsion (older vehicles)	

Figure 2.19 Example of a Rail Car Specific Relay

Figure 2.20 Example of a Rail Car Specific Switch

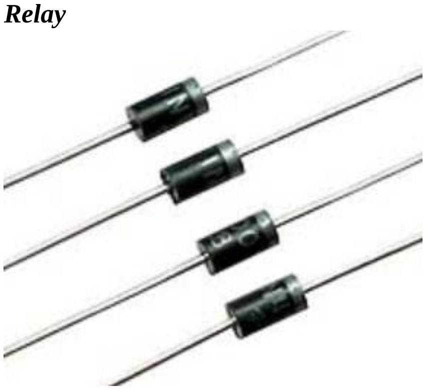


Figure 2.21 Example of a Rail Car Specific Diode

Figure 2.22 Example of a Rail Car Specific Transistor

Figure 2.23 Example of a Rail Car Specific IGBT

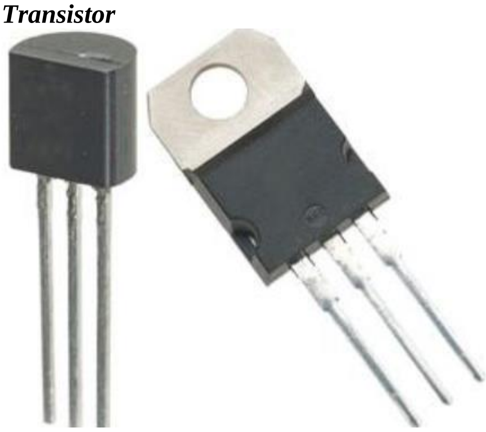


Figure 2.24 Example of a Rail Car Specific Thyristor

2-4 Summary

Troubleshooting is an integral part of the maintenance of rail cars. Whether a "symptom" is noticed, or a report is made that equipment is simply not working, troubleshooting gets to the heart of the problem so that corrective solutions are found and implemented.

This Module explored the process of troubleshooting in the specific context of rail car systems by looking at common failures and some discussion examples. For the purpose of this training, schematics from VTA were provided however, agency specific plans were inserted as much as possible to provide the participant with the most accurate and relevant resources available for their job at their individual agency.

MODULE 3

Monitoring and Diagnostics

Outline

3-1 Overview
3-2 Ways of Accessing MDS Information
3-3 Running a Self-Test
3-4 Determining the Cause of a Failure
3-5 Verifying Component Software
3-6 Summary

Purpose and Objectives:

The purpose of this Module is to provide an overview to the capabilities of monitoring and diagnostics systems when used for troubleshooting of rail vehicles.

Following the completion of this Module, the participant should be able to complete the exercises with an accuracy of 75% or greater:

- List uses for Monitoring and Diagnostics Systems.
- List different ways of accessing information and describe how they are related.
- Demonstrate ability to use the Train Display Panel to test and verify the functions of different subsystems (i.e. car body).
- Verify correct versions of software are being used.
- Demonstrate ability to analyze system with laptop.

Key Terms

- Cab Console
- Fault Indicator Panel (FIP)
- Monitoring and Diagnostics System (MDS)
- Portable Test Unit (PTU)
- Self-test
- Train Display Panel (TDP)
- Wayside Monitoring and Diagnostics System (WMDS)

3-1 OVERVIEW

While not currently in place at all properties, the use of monitoring and diagnostics systems (MDS) creates many efficiencies in the troubleshooting process. Instead of going from point to point to narrow down and identify the root cause of a failure, the MDS is a central location where all information is gathered and made available for operation and maintenance personnel.

Generally, rail vehicle technicians use the MDS in three different situations that are defined below. In each, correct use of the MDS could save the rail car technician many hours of time and frustration. These situations are:

1.) During Preventive Maintenance: A self-test is conducted to give a broad overview of the health of all subsystems.
2.) After a Trouble Call: The MDS is used to identify the failure areas and in some cases, exact component failure(s.)
3.) After Replacing a Component: The MDS verifies that the correct software version is installed.

The information collected by the MDS is accessible from several different points. These generally consist of the following:

- Cab Console
- Train Display Panel (TDP)
- Fault Indicator Panel (FIP)
- Wayside Monitoring and Diagnostics System (WMDS)
- Portable Test Unit (PTU)

Note that while most MDS will function generally the same, this Module uses the specific example of an MDS at PATCO to illustrate conceptual processes. Make use of the "location specific differences" sections throughout to take note of how the system at your location varies.

Note that each access point holds a different level of detail on the information available. The next section will go into each of these interfaces more in depth but will focus mostly on the TDP and PTU since these are the main ways rail vehicle technicians will access the system.

Subsequent sections will outline how to use these interfaces in the three situations outlined above. Of course, a tool is only useful if someone knows how to use it effectively.

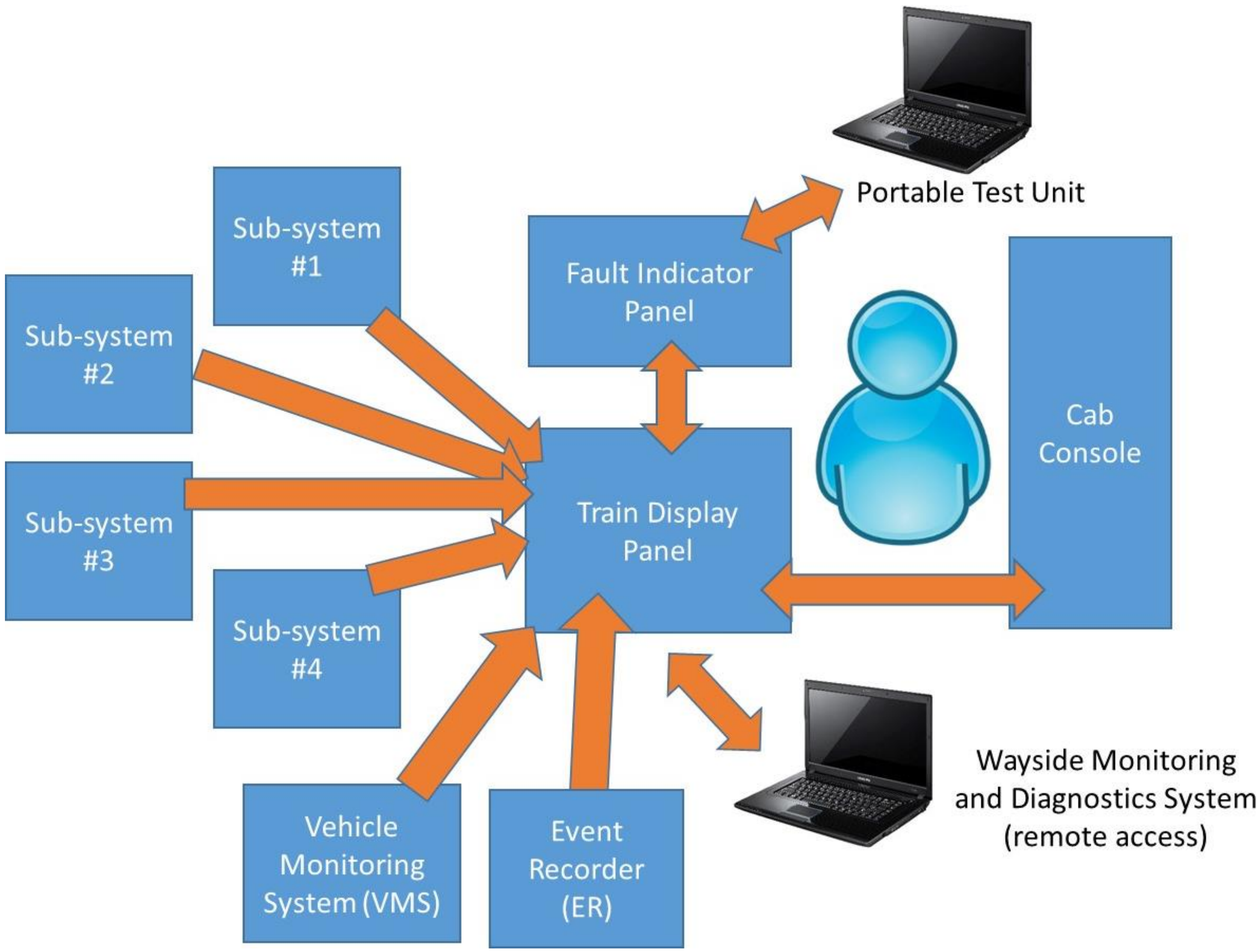


Figure 3.17 MDS Flow of Information

Location Specific Differences:

3-2 WAYS OF ACCESSING MDS INFORMATION

As covered in the overview, there are many ways to access MDS information. Each interface has varying degrees of information available and interactivity possibilities as far as filtering, sorting, etc. This section will describe each interface. Note that the term used for each interface as well as some of the functions, information, etc. will vary depending on the type of MDS in use at your location. Please use **Error! Reference source not found.** to note any location specific differences and your own notes.

Cab Console

Figure 3.18 Cab Console Highlighting MDS Areas. Courtesy of PATCO

On the PATCO cars, cab consoles are found in both the A & B cars. Only the console in the leading car will be active. There is a lot of information available on the cab console. For our purposes, we will only focus on those that are related to monitoring and diagnostics. The console in Figure 3.18 shows four such items. First, there are two lights that indicate a failure. In this instance, the failures are only divided into "minor" and "major" faults. Note that in this instance, an illuminated failure light means that there is a failure somewhere within the consist. Depending on the severity of the fault, the train may be pulled from for service for immediate maintenance or may run the rest of the route and be maintained afterwards.

Location Specific Differences:

Fault Indicator Panel (FIP)

The fault indicator panel is also located in both the A and B car, but on the wall behind the operator panel. The FIP is mostly used by the operator. There is however, slightly more detailed information here than on the cab console. In this instance, failures are split into subsystems (Dynamic Braking, Brake, HVAC, etc.). Also, if there is a failure shown here, it means that the failure exists within one of the cars in that A/B pair. On the FIP, the operator has the ability to bypass the door interlock.

The maintainer will use this panel to test the lights and to connect the PTU. Under normal operation, suppressing the "push to test" button will cause all other lights to illuminate. If they do not illuminate, there is an issue that needs to be further explored.

Figure 3.19 Fault Indicator Panel. Courtesy of PATCO

Location Specific Differences:

Train Display Panel (TDP)

The TDP is the main MDS interface that rail car technicians will use during preventive maintenance and during troubleshooting and repair/replacement. The TDP is located just below the FIP, which can also be found in all cars. The TDP should turn on whenever the train is keyed on. Like some computers, the screen may go into a "sleep" state when not used for some time. In this case, the screen can be activated by tapping the screen. The TDP has many different screens to which the user can navigate. It starts on the Main screen, which is showing in Figure 3.20.

Figure 3.20 Train Display Panel on Main Screen. Courtesy of PATCO

The top part of the panel, with the icons, is updated in real time. These icons will stay green unless there is a fault or connection is lost. See table below for more information.

Icon Color	Severity Level/ Meaning	Location Specific Notes
Gray	Connectivity not established	
Yellow	Warning. Switch status is cut out, etc.	
Orange	Minor Fault	
Red	Major Fault	

More information on faults can be found by navigating to the trouble screen which is shown in Figure 3.5.

Figure 3.21 Train Display Panel on Trouble Screen. Courtesy of PATCO

Location Specific Differences:

Even more in-depth information can be accessed by highlighting a certain fault and then clicking on “INFO.” In order to access higher levels of detail, the maintainer may need to log in using agency credentials.

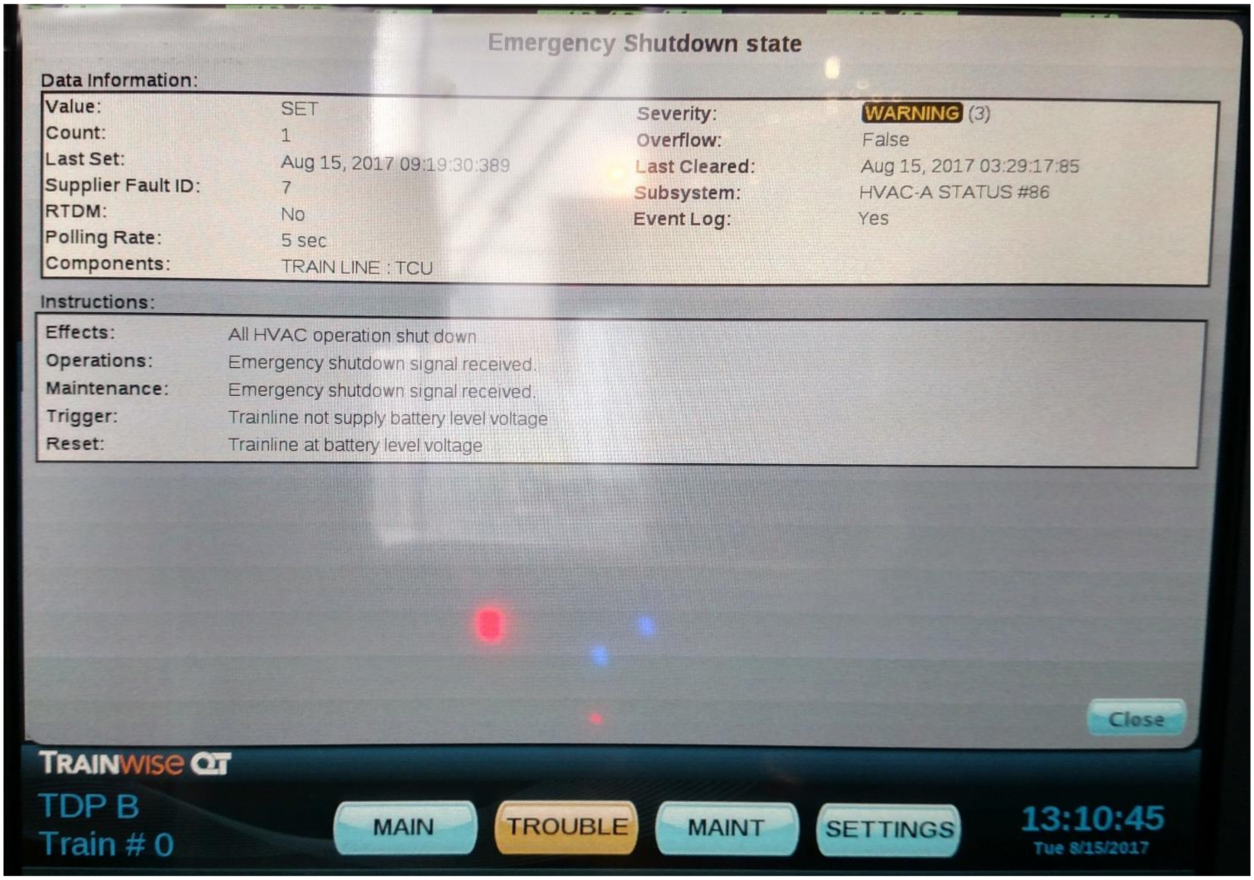


Figure 3.22 Train Display Panel on INFO Screen. Courtesy of PATCO

Location Specific Differences:

The third button at the bottom, "MAINT", allows a credentialed user to enter maintenance mode.

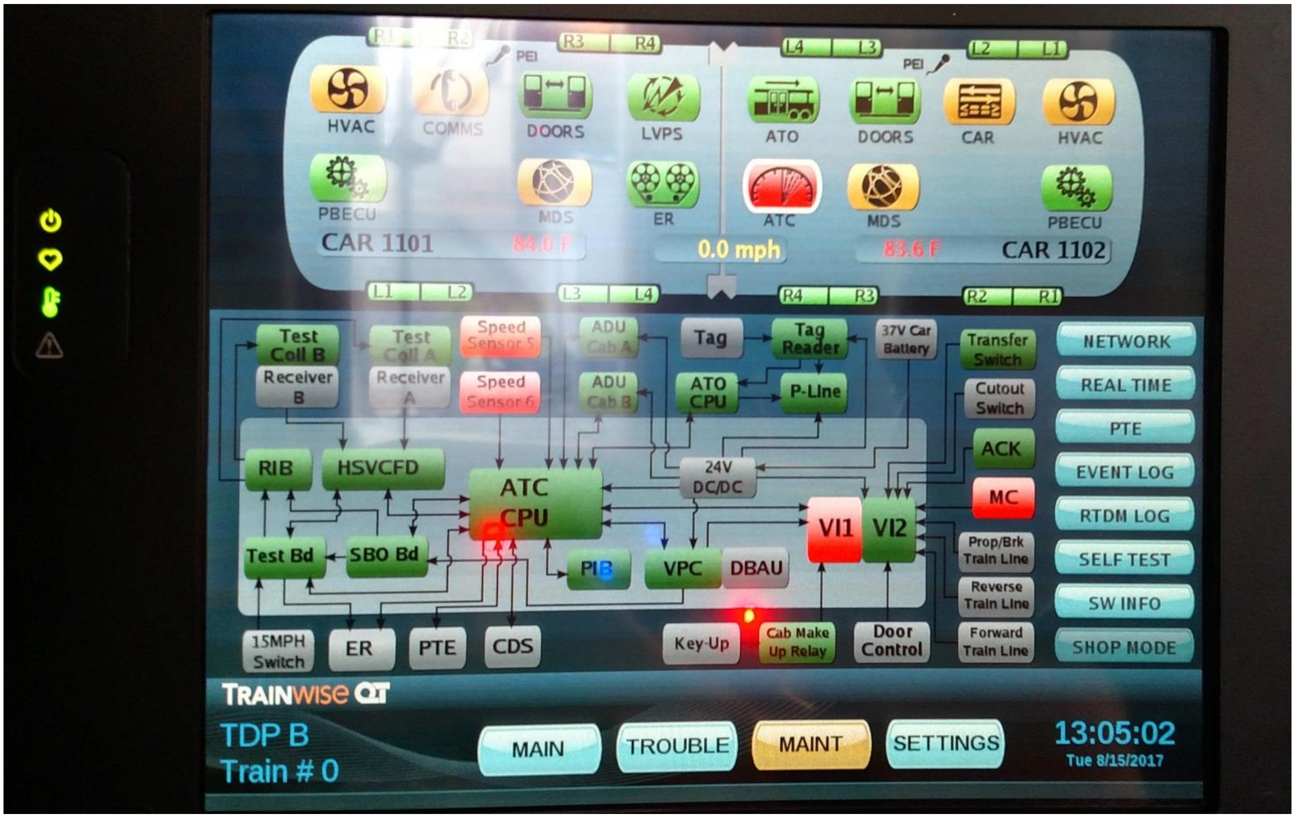


Figure 3.23 Train Display Panel on Maintenance Screen. Courtesy of PATCO

From here, a credentialed user can also navigate and run a self-test, view an event log in order to determine the cause of a failure and verify component software versions. These will be covered more in depth in later sections.

Location Specific Differences:

Portable Test Unit (PTU)

The PTU, which is a laptop loaded with diagnostics software, will be used by a smaller subset of the rail car technician workforce. By plugging the PTU into the port on the FIP, maintainers can access detailed monitoring and diagnostics data.

Figure 3.24 PTU Port on the FIP. Courtesy of PATCO

Location Specific Differences:

Wayside Monitoring and Diagnostics System (WMDS)

Where available, the WMDS allows users to login to a remote interface that is similar but not identical to that which can be accessed by the PTU.

Location Specific Differences:

Term used here	Other Names	Your Agency's Term	Component Location	Level of Diagnostics Information	Interactive?	Notes
Cab Console			A & B car in front of operator	Low – defined as "major" and "minor" faults only	Low – bypass switch only	
Train Display Unit (TDP)	Operator Display, VOD, Event Log		A & B car behind operator	Medium – full system, all sub-systems	Yes, highly – searchable, acknowledge faults, etc.	
Fault Indicator Panel (FIP)	Local Indicator Panel			All sub-systems but just this pair of cars	Some – bypass switch, light test, etc.	
Wayside MDS	Trainline MDS Station/Equipment (remote access)		Remote - any computer within the agency's network	High – more information than TDP		
Portable Test Unit (PTU)	Portable Test Equipment (PTE)					

Table 3.1 MDS Interface Summary Chart

3-3 RUNNING A SELF-TEST

A self-test is conducted as per preventive maintenance schedules. When appropriate, a rail car maintainer will run this test through the TDP by navigating to the maintenance screen and then selecting "self-test" as illustrated in Figure 3.9. Depending on which subsystem is being tested, certain pre-test conditions must be followed as per OEM and/or agency requirements.

For example, to run a propulsion self-test:

- The brake pipe must be fully charged.
- Master controller must be held in minimum brake position.
- High voltage is applied.
- Any other location specific requirements.

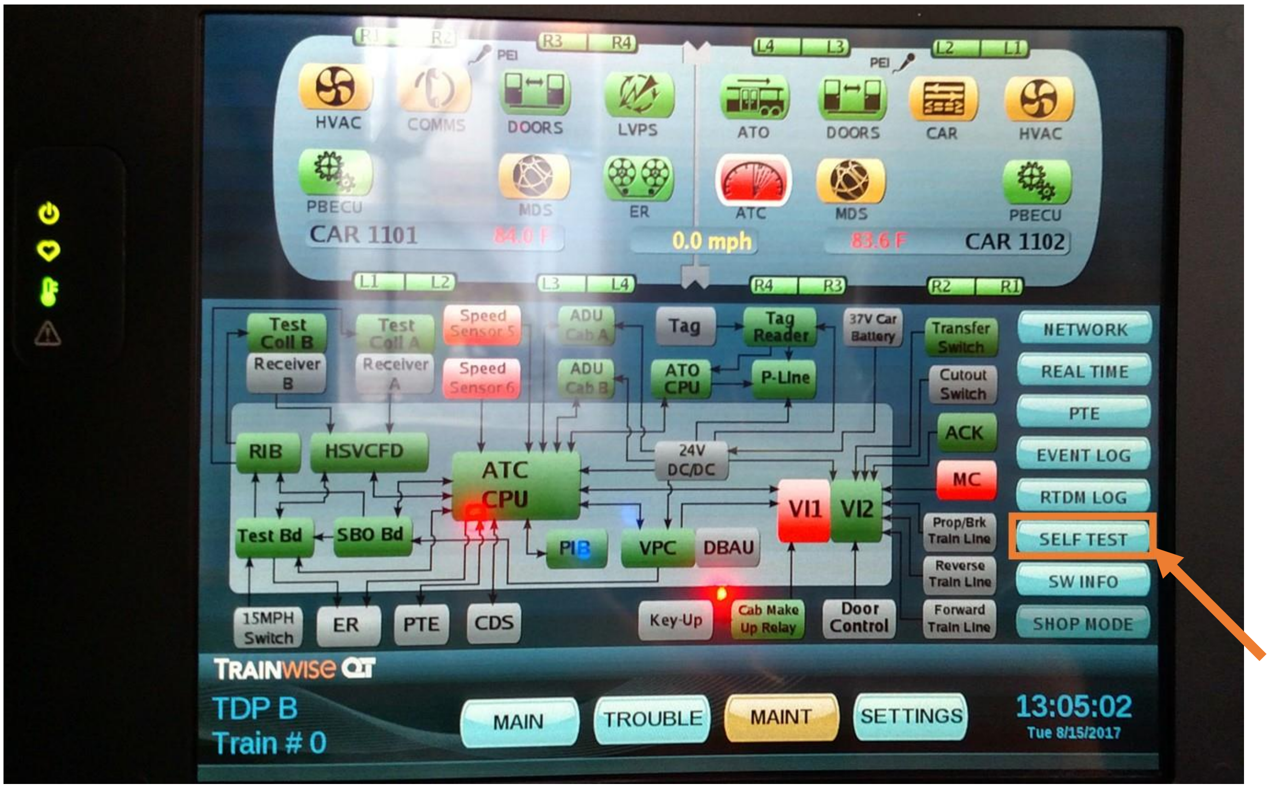


Figure 3.25 Accessing Self-Test Through the TDP. Courtesy of PATCO

Figure 3.26 Self-Test Screen on the TDP. Courtesy of PATCO

From the self-test screen in Figure 3.10, the maintainer can run tests on any subsystem listed (HVAC, Door Control Unit, etc.) by clicking on that subsystem. Once clicked, the TDP will show a “CMD ACK” alert which means “command acknowledged.”

Any errors found will be listed on the “trouble” screen. The next section covers steps to take if a fault is encountered, either through a self-test or after a trouble call.

Location Specific Differences:

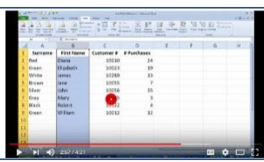
3-4 DETERMINING THE CAUSE OF A FAILURE

Maintenance personnel also use the MDS during a trouble call to identify the root cause of a failure. In many cases, the problem is identified by a train operator, conveyed to appropriate staff people and then triaged by a rail car technician. In other cases, the issue may be found during preventive maintenance and/or the MDS self-test.

To begin, look at the cab console and/or FIP to verify that the reported failure notifications are still visible. If the alerts are as reported, follow the normal protocol for the given failure. If the system is then operating correctly, test and place the rail car back into service.

If the steps taken did not clear the fault, gather more information through the TDP or PTE/PTU. Using the TDP, this is done by navigating through the different maintenance and trouble screens. While the information for both the entire system and individual sub-systems can be viewed directly by connecting a PTU/PTE, it is ideal to export this data for easier manipulation. Once data is exported, it can easily be sorted by category (time, severity, etc.). Experienced maintainers should also be comfortable in removing irrelevant data so that they can focus on the key points that will help them to identify the possible causes of the fault.

From there, follow the usual steps in the troubleshooting process as outlined earlier in this course (Figure 3.28) of deciding what the most probable cause(s) is, implementing the solution(s), test, document and restore the rail car into service. If the chosen solution does not work the first time, revisit the data and follow the troubleshooting steps until it does.



See video for illustration of how to sort data in excel (https://www.youtube.com/watch?v=IrymK7jx-34)

Figure 3.11 illustrates a troubleshooting tree, with questions to ask and steps to take. Although this will vary depending on the problem, it is a good example to familiarize yourself with the thinking behind troubleshooting.

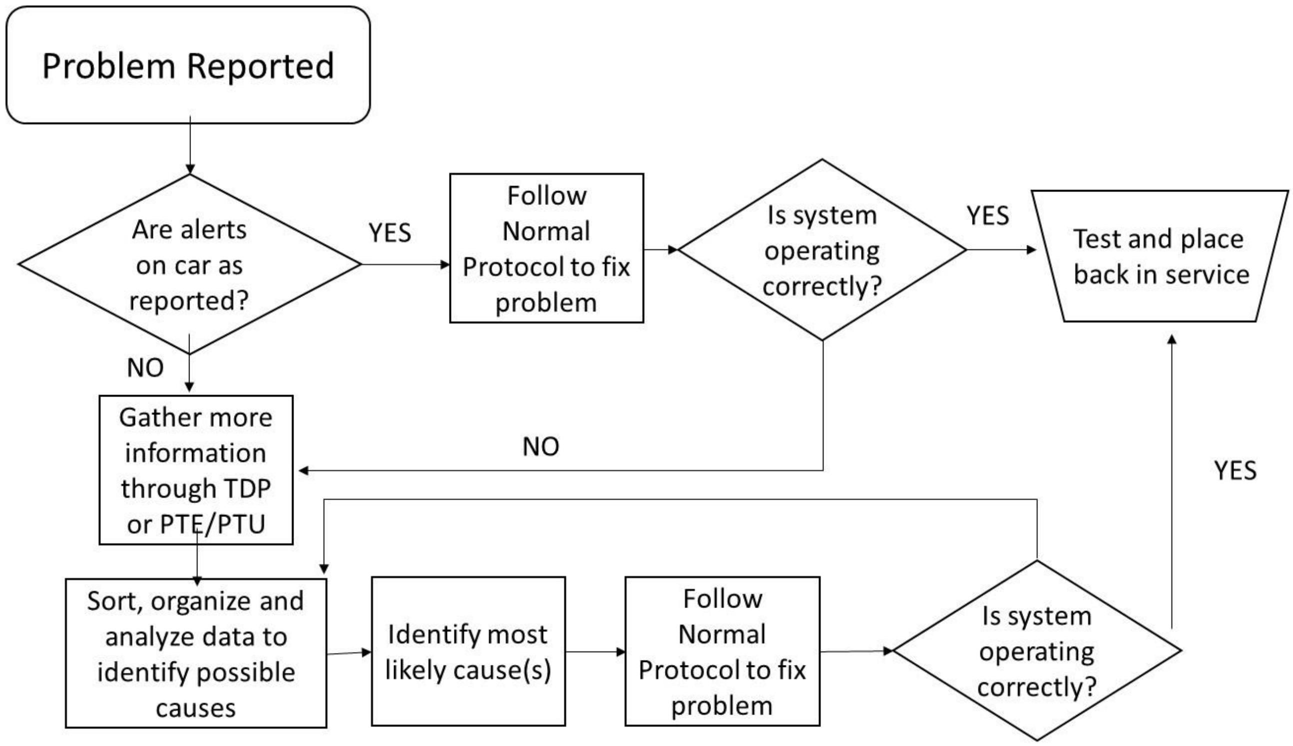


Figure 3.27 Example Troubleshooting Tree Using Monitoring and Diagnostics System

Location Specific Differences:

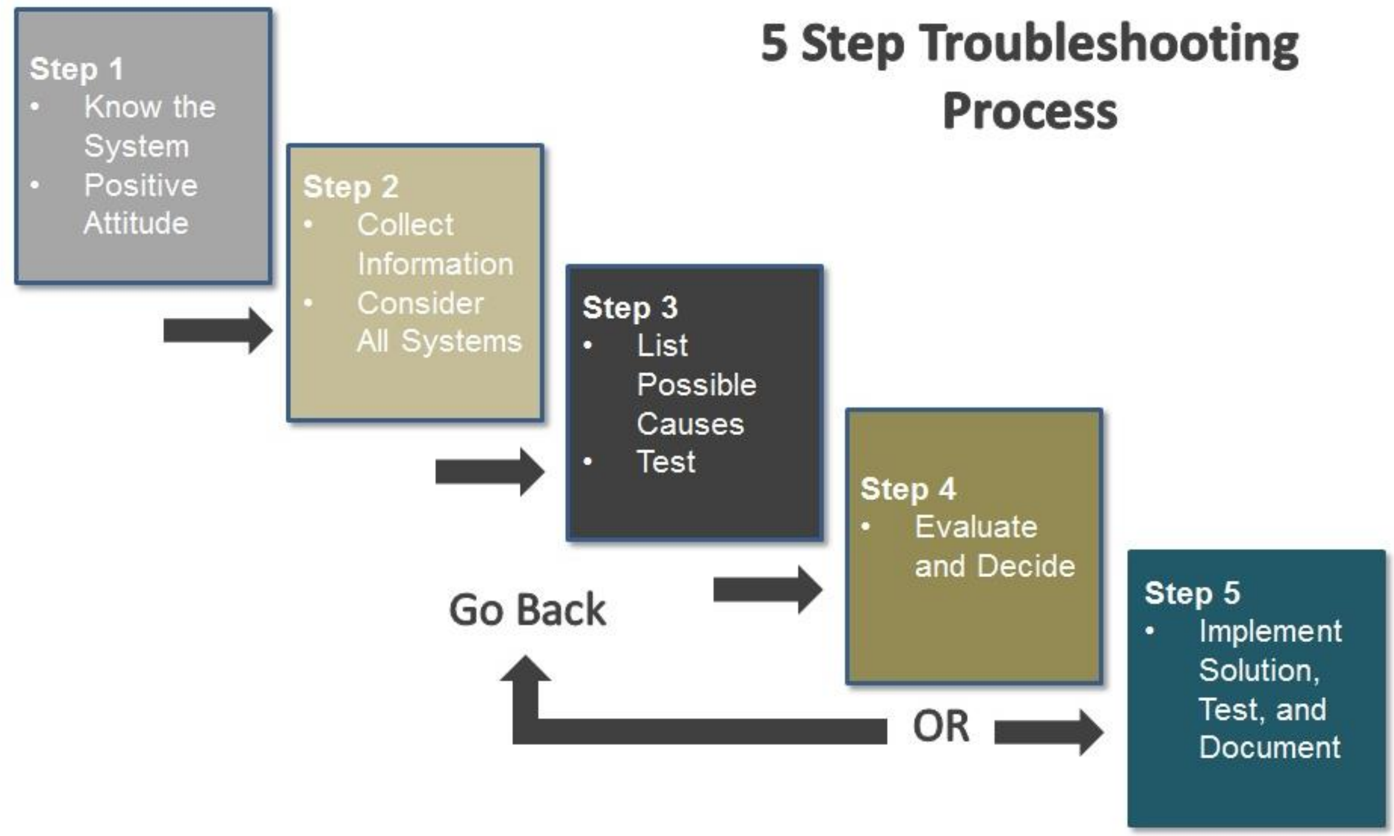


Figure 3.28 Five Step Troubleshooting Process

Case Study 3.1 – MDS/Troubleshooting Process; Real World Example – Port Authority Transit Corporation (PATCO)

The process of gathering information from the MDS and the troubleshooting steps to take, which was previously detailed, is illustrated in the following example provided from PATCO.

Report Made

8:45AM - A report is received from Train Operator (T/O) Haxter, westbound (W/B) 18 (W1095-96-1103-04-1027-28E) at Lindenwold station that he is unable to obtain a brake release with normal console indications. Transit Supervisor (T/S) Engolf advised and reports all exterior door lights extinguished on W/B 18.

8:47AM – T/O Haxter reports normal upon restoring and unstoring handles he was able to obtain a brake release and W/B 18 departed Lindenwold station, 3 minutes late. W/N 18 was held at 9th & Locust for eastbound (E/B) 40 (see U.O Item #5) and arrived at 16th and Locust at 9:17AM, 6 minutes late. T/S Alesandrini advised of defect.

Data Collected from MDS

Note: Highlights were added upon sorting and analyzation by rail car maintainer.

Date (UTC)	Time (UTC)	Date (LOCAL)	Time (LOC	Description	Subsyste	Type	Index	Bit Vector	Raw Valu	Scaled Va	Severity	Train ID	Car ID	Count
1/5/2016	13:25:21:300	1/5/2016	08:25:21:3	A-Cab Keyed	ATC	Status	47	N/A	1	1	4	186	1095	2955
1/5/2016	13:25:21:300	1/5/2016	08:25:21:3	MC - Auto Store	ATC	Status	45	N/A	1	1	4	186	1095	10862
1/5/2016	13:25:22:550	1/5/2016	08:25:22:5	Station Name	MCU	Octet Stri	5	N/A	Not in se	Not in se	4	186	1095	0
1/5/2016	13:25:23:300	1/5/2016	08:25:23:3	MC - Auto Store	ATC	Status	45	N/A	0	0	4	186	1095	10862
1/5/2016	13:25:23:400	1/5/2016	08:25:23:4	MC - Service Brake	ATC	Status	43	N/A	1	1	4	186	1095	38492
1/5/2016	13:25:23:700	1/5/2016	08:25:23:7	MC - B4	ATC	Status	42	N/A	1	1	4	186	1095	19369
1/5/2016	13:25:26:450	1/5/2016	08:25:26:4	Brake Pipe Recharge Trainline	VMS-A	Status	91	N/A	1	1	4	186	1095	12
1/5/2016	13:25:29:450	1/5/2016	08:25:29:4	Brake Pipe Recharge Trainline	VMS-A	Status	91	N/A	0	0	4	186	1095	12
1/5/2016	13:25:30:300	1/5/2016	08:25:30:3	MC - Service Brake	ATC	Status	43	N/A	0	0	4	186	1095	38492
1/5/2016	13:25:30:300	1/5/2016	08:25:30:3	MC - B4	ATC	Status	42	N/A	0	0	4	186	1095	19369
1/5/2016	13:25:30:400	1/5/2016	08:25:30:4	MC - Auto Store	ATC	Status	45	N/A	1	1	4	186	1095	10863
1/5/2016	13:26:15:460	1/5/2016	08:26:15:4	Station Name	MCU	Octet Stri	5	N/A	Not in se	Not in se	4	186	1095	0
1/5/2016	13:26:47:300	1/5/2016	08:26:47:3	MC - Coast	ATC	Status	44	N/A	0	0	4	186	1095	11368
1/5/2016	13:26:47:700	1/5/2016	08:26:47:7	ATO Start	ATO	Status	19	N/A	0	0	4	186	1095	2020
1/5/2016	13:26:53:700	1/5/2016	08:26:53:7	Penalty Brake Output Status	ATC	Status	57	N/A	0	0	4	186	1095	13579
1/5/2016	13:26:54:500	1/5/2016	08:26:54:5	Station Name	MCU	Octet Stri	5	N/A	Lindenwc	Lindenwc	4	186	1095	0
1/5/2016	13:26:57:500	1/5/2016	08:26:57:5	Manual Mode	ATO	Status	32	N/A	0	0	4	186	1095	3850
1/5/2016	13:26:57:700	1/5/2016	08:26:57:7	Manual Mode	ATC	Status	37	N/A	0	0	4	186	1095	3838
1/5/2016	13:28:14:600	1/5/2016	08:28:14:6	All Doors Closed	ATC	Status	50	N/A	1	1	4	186	1095	24871
1/5/2016	13:28:15:600	1/5/2016	08:28:15:6	All Doors Closed	ATO	Status	28	N/A	1	1	4	186	1095	24877
1/5/2016	13:28:20:800	1/5/2016	08:28:20:8	ATO Start	ATO	Status	19	N/A	1	1	4	186	1095	2021
1/5/2016	13:28:21:100	1/5/2016	08:28:21:1	ATO Start	ATO	Status	19	N/A	0	0	4	186	1095	2021
1/5/2016	13:28:25:600	1/5/2016	08:28:25:6	ATO Start	ATO	Status	19	N/A	1	1	4	186	1095	2022
1/5/2016	13:28:25:900	1/5/2016	08:28:25:9	ATO Start	ATO	Status	19	N/A	0	0	4	186	1095	2022
1/5/2016	13:28:59:00	1/5/2016	08:28:59:0	All Doors Closed	ATC	Status	50	N/A	0	0	4	186	1095	24871
1/5/2016	13:29:00:00	1/5/2016	08:29:00:0	All Doors Closed	ATO	Status	28	N/A	0	0	4	186	1095	24877
1/5/2016	13:29:40:100	1/5/2016	08:29:40:1	All Doors Closed	ATC	Status	50	N/A	1	1	4	186	1095	24872
1/5/2016	13:29:41:100	1/5/2016	08:29:41:1	All Doors Closed	ATO	Status	28	N/A	1	1	4	186	1095	24878
1/5/2016	13:29:46:800	1/5/2016	08:29:46:8	ATO Start	ATO	Status	19	N/A	1	1	4	186	1095	2023
1/5/2016	13:29:47:100	1/5/2016	08:29:47:1	ATO Start	ATO	Status	19	N/A	0	0	4	186	1095	2023
1/5/2016	13:29:50:00	1/5/2016	08:29:50:0	ATO Start	ATO	Status	19	N/A	1	1	4	186	1095	2024

Figure 3.29 MDS Data Downloaded from PTU after a Brake Release Failure

Isolate important information

@08:25:21 A-Cab Keyed On

@08:25:23 Master Controller Placed into B4

@08:25:29 Brake Pipe Recharged

@08:25:30 Master Controller Placed into Auto Store

@08:26:57 Transfer Switch is showing 0 for Manual Mode and no indication that the transfer switch is in ATO

@08:28:20, 08:28:25 & 08:29:46 Operator tried starting ATO Operation

List Possible Causes

- Operator failed to put the transfer switch into ATO mode
- The ATO mode switch is not operational
- Door summary circuit is not complete. (Door or window is open on left or right side)
- Improper Cab signal code – ATC requesting penalty brake

Evaluate and Decide on the Most Likely Cause

In this case, it is best to first see if this sequence works if the proper steps are taken – including placing the transfer switch in ATO mode before starting ATO operation.

Implement Solution and Test

The maintainer ran this sequence the correct way by putting the transfer switch into ATO mode before starting ATO operation. In this instance, no brake release error was found.

In this instance, the problem was a user error, not a problem with the equipment. No maintenance is needed at this time.

Note: if upon trying the sequence in this way, the brake release error was still found, the maintainer should revisit the list of possible causes. Possible causes should be explored until the real root cause is identified.

Document

In this instance, these actions alleviated the issue. The maintainer should report the root cause to the appropriate personnel and document appropriately.

Learning Application 3.1 – Collecting and Analyzing Data
Given a specific failure by your instructor, work in small groups or pairs to follow the steps outlined in the example provided by PATCO. Identify the following:

1. **Initial Problem:**

   ____

   ____

   ____

   ____

2. **What columns to sort by:**

   ____

   ____

   ____

   ____

3. **List of possible causes:**

   ____

4. **The most probable cause and how you arrived at this choice:**

3-5 VERIFYING COMPONENT SOFTWARE

When a component is replaced on a railcar, it may be necessary for the rail car maintainer to verify that the correct version of software is installed on it. In this case, the maintainer should log into the TDP after the equipment is installed and navigate to the maintenance section and then software info. The screen to access this information is illustrated in Figure 3.14.

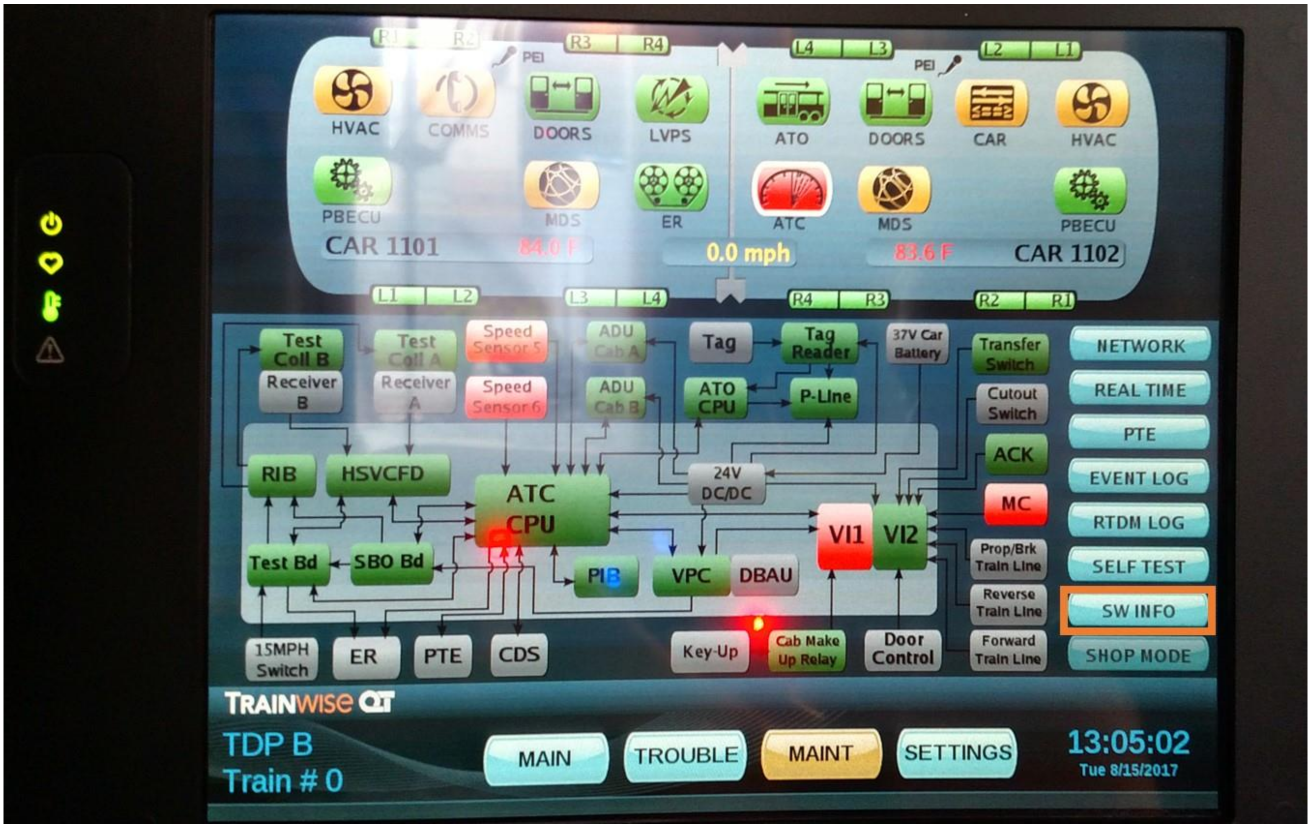


Figure 3.30 Accessing Software Version Information Through the TDP. Courtesy of PATCO

As shown in ***Figure 3.31***Figure 3.31, all software is current. In cases where the software was not up to date, a maintainer would connect the PTU to the port at the FIP, navigate to the correct sub-system and update software to the current revision.

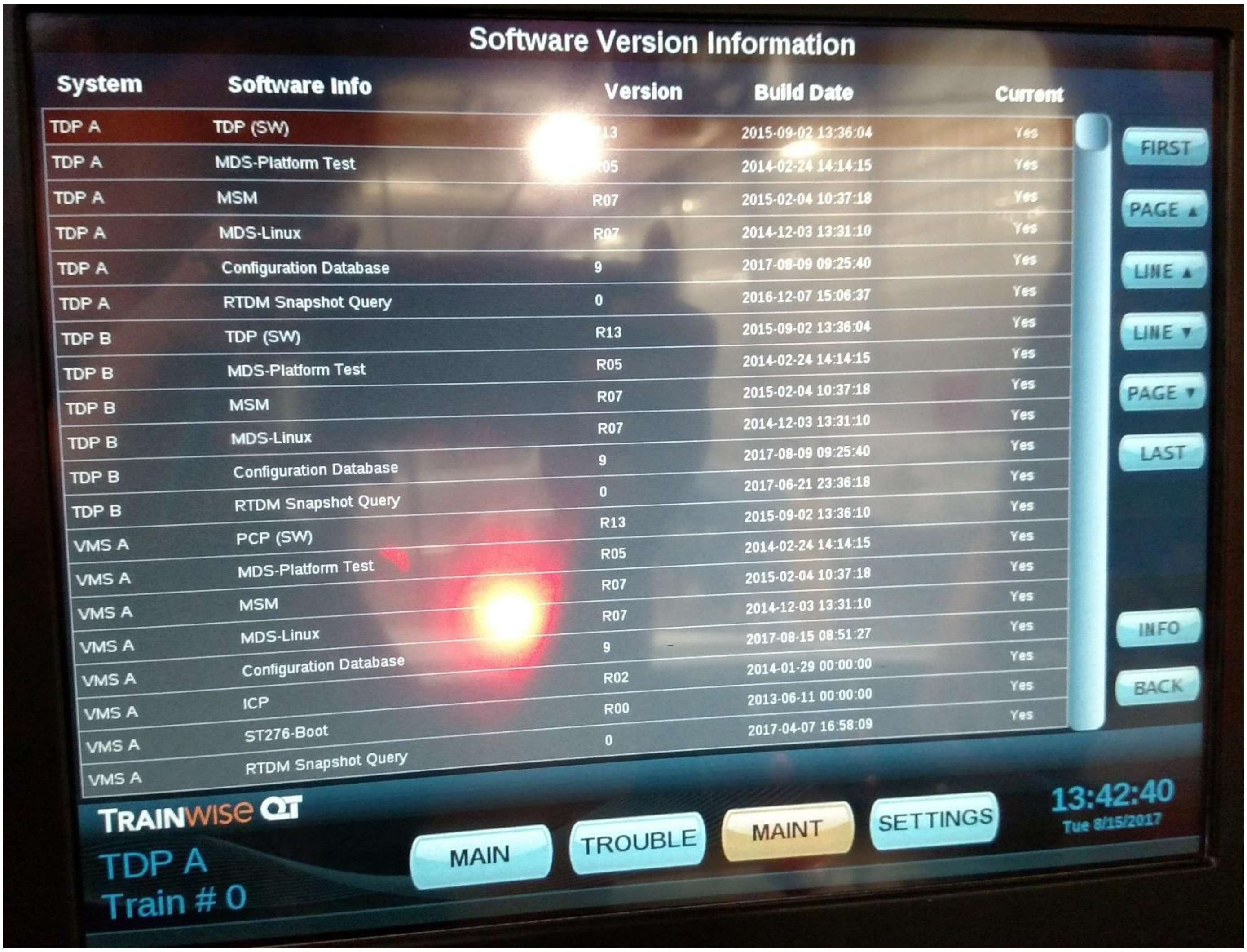


Figure 3.31 Software Version Information Through the TDP. Courtesy of PATCO

Location Specific Differences:

3-6 SUMMARY

While not currently in place at all properties, the use of monitoring and diagnostics systems (MDSs) create many efficiencies in the troubleshooting process. Instead of going from point to point to narrow down and identify the root cause of a failure, the Monitoring and Diagnostic system is a central location where all information is gathered and made available for operation and maintenance personnel.

Generally, rail vehicle technicians use the MDS in three different situations. In each, correct use of the MDS could save the rail car technician many hours of time (and sometimes frustration). These situations are:

- During Preventive Maintenance
- After a Trouble Call
- After Replacing a Component

The information collected by the MDS Diagnostics is accessible from several different points. These generally consist of the following:

- Cab Console
- Train Display Panel (TDP)
- Fault Indicator Panel (FIP)
- Wayside Monitoring and Diagnostics System (WMDS)
- Portable Test Unit (PTU)

Note that while most MDSs will function generally the same, this Module used the specific example of an MDS at PATCO to illustrate conceptual processes. Always refer to your agency for specific procedures.