E-ISSN: 2676-6167 | P-ISSN: 2538-5100

Journal of Applied Research on Industrial Engineering

www.journal-aprie.com

J. Appl. Res. Ind. Eng. Vol. 8, No. 2 (2021) 104–115.

Paper Type: Research Paper

Lean at Home: Applying RCA Techniques to Home Projects

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Citation:

Keyser, R. S. (2021). Lean at home: applying RCA techniques to home projects. *Journal of applied research on industrial engineering, 8*(2), 104-115.

Received: 25/12/2020 Reviewed: 20/01/2021 Revised: 22/02/2021 Accepted: 21/03/2021

Abstract

Root cause analysis techniques are often applied to problems in the workplace; however, they may also prove very useful when applied to home projects. This research explores the application of root cause analysis techniques in three home projects: (1) Cause-and-Effect diagram to remove Palmetto bugs in a condo dwelling, (2) Five Whys method to repair a sunroof water leak in a car, and (3) Fault Tree Analysis to repair a Toro string trimmer that starts, then dies. The effective use of root cause analysis techniques can have a meaningful impact on resolving home project issues resulting in a restoration of homeowner issues as well as reduced homeowner anxiety, repair time, and repair cost.

Keywords: Cause-and-effect diagram, Fault tree analysis, Palmetto bugs, Toro string trimmer.

1 | Introduction

The Lean philosophy has universal applications crossing all manufacturing and service sectors in the world. Womak et al. [1] is credited with coining the term 'Lean', named after the world-famous Toyota Production System, which focused on waste elimination, shorter lead times, frequent changeovers, smaller lot sizes, and reduced inventories. Though initially implemented in the automotive industry with great success, the adoption of Lean production systems soon spread across many manufacturing industries worldwide. Today, the Lean philosophy is used in many service industries as well, such as healthcare, yielding similar successes as experienced in the industrial world.

Lean can also be practiced at home and the literature reveals scant research in this area. Among the many facets of the Lean philosophy is the use of Root Cause Analysis (RCA) techniques. The RCA toolkit contains numerous analytical methods and techniques, such as the seven basic tools of quality; namely, Cause-and-Effect diagram, Check Sheet, Control Chart, Histogram, Pareto chart, Scatter diagram, and Run chart [2]. Additional RCA techniques include Brainstorming,

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10.22105/jarie.2021.263716.1234

Nominal Group Technique, Delphi Technique, Cause Map, Five Whys, Designed Experiments, Failure Mode Effects Analysis, and Fault Tree Analysis, to name a few.

This research reveals four examples of how RCA techniques (i.e., Cause-and-Effect diagram, Five Whys, Failure Mode and Effects Analysis (FMEA), and Fault Tree Analysis (FTA)) can be used to streamline problems encountered with home projects. More specifically, these techniques are used to identify possible causes leading to a failure and once all possible causes are identified, steps are then taken by the homeowner to negate these causes, thus providing a remedy for the home projects.

2 | Literature Review

The success of the Lean philosophy is well-published in industrial applications; however, its diverse applicability among other economic sectors is just as significant.

Recent examples of the use of Lean concepts abound in the healthcare industry. Lean Six Sigma methodology such as the DMAIC and PDCA methods have been used to reduce the length of stay in a hospital's emergency department [3], reducing the percentage of patients who Leave Without Being Seen (LWBS) [4], and reducing the incidence of unplanned surgery cancellations [5]. Smith et al. [6] was used to improve scheduling time of home health nurses. A focus on "waste elimination" lead to improvements in streamlining the steps required in a hip fracture surgery process [7]. Standardizing the registration and triage processes lead to improved patient care in a hospital emergency department [8].

The versatility of Lean principles has been adopted by other service industries, such as in project management endeavors [9], the use of DMAIC methods to improve and sustain humanitarian efforts [10], the use of numerous Lean concepts to improve the dining experience at full-service restaurants [11], and in education by mistake-proofing teacher mistakes at a magnet high school [12].

A wide assortment of RCA techniques is a crucial facet under the Lean umbrella towards problem resolution. Otitigbe [13], Giol [14], and Root and Small [15] suggest using a team-based approach when utilizing Cause-and-Effect diagrams to find all possible root causes leading to an effect. The team should consist of various stakeholders, both past and present. Munro and Savel [16] employed the Five Whys approach to improve critical care by identifying problematic variables to describe relationships and provide a premise for novel interventions. Moaveni and Chou [17] utilized the Five Whys method as an assignment in a civil engineering classroom at Northwestern University, whereby students used this technique to identify what they did incorrectly on homework assignments and then corrected them.

Additional RCA examples include developing a seven-step RCA process to prevent Built-In-Test (BIT) false alarms during the design and development phase [18], using designed experiments to determine the best variable settings for desired results in the manufacture of corrugated sheet stock [19], and using of the seven tools of quality by internal auditors [20]. Fishbone diagrams, Pareto charts, and the Five Whys method were used to detect errors during the preparation of histology slides [21], and for determining various causes of cost deviation in highway construction projects [22].

FMEA has been employed to reduce the risk of failures in casting and machining processes of vehicle rear spring brackets [23] and the production of automotive leaf springs [24]. FMEA has also been used to evaluate the process for recognizing and referring children exposed to domestic abuse [25] identifying vulnerabilities in a paperless radiotherapy department [26] and anesthetic equipment [27], and for identifying and prioritizing barriers in behavior health workflows [28].

Modifications of FMEA include a five-step process called Health Care Failure Mode Effect Analysis (HFMEA) [29], the use of fuzzy Adaptive Resonance Theory (ART) for clustering failure modes in the edible bird nest industry [30], and the use of Design Failure Mode and Effect Analysis (DFMEA) to identify possible causes of warranty claims [31].

FTA has been used to identify potential causes of the transport of hazardous chemicals [32] and [33], to estimate the number of refrigerant exposures of both service technicians and vehicle occupants in the U.S. [34], and in the evaluation of a drilling mud pump system [35].

Techniques used in conjunction with FTA include the use of fuzzy neural networks to diagnose faults in the Internet of Things (IoT) of aquaculture [36], and using Monte Carlo simulation to analyze allowable effluent Biochemical Oxygen Demand (BOD) in a wastewater treatment plant [37].

3 | How RCA Techniques Can Be Applied to Home Projects

Example 1. Cause-and-Effect Diagram to Rid Home of Palmetto Bugs.

This example involves the sudden appearance of Palmetto bugs in a condo in Marietta, Georgia and it could apply to many homes in the state of Georgia. A Palmetto bug (in *Fig. 1*) looks like a large cockroach and can trigger an individual's startle reflex upon first sight.

Fig. 1. Palmetto bug.

Palmetto bugs can appear in any building, not just in the home. *Fig. 2* shows a deceased Palmetto bug on the floor in a copy room in the workplace.

Fig. 2. Palmetto bug in the workplace.

Palmetto bugs are common in Georgia, particularly in the warm summer months. These bugs thrive living in warm external environments and wooded areas surrounded by pine trees and shrubs, so the summer heat in Georgia provides an excellent climate for Palmetto bugs. The observance of Palmetto bugs had become an incessant problem in the condo unit despite numerous measures that were implemented to prevent the entry of these bugs. A cause-and-effect diagram in *Fig. 3* was used to identify all possible causes of Palmetto bugs entering the condo.

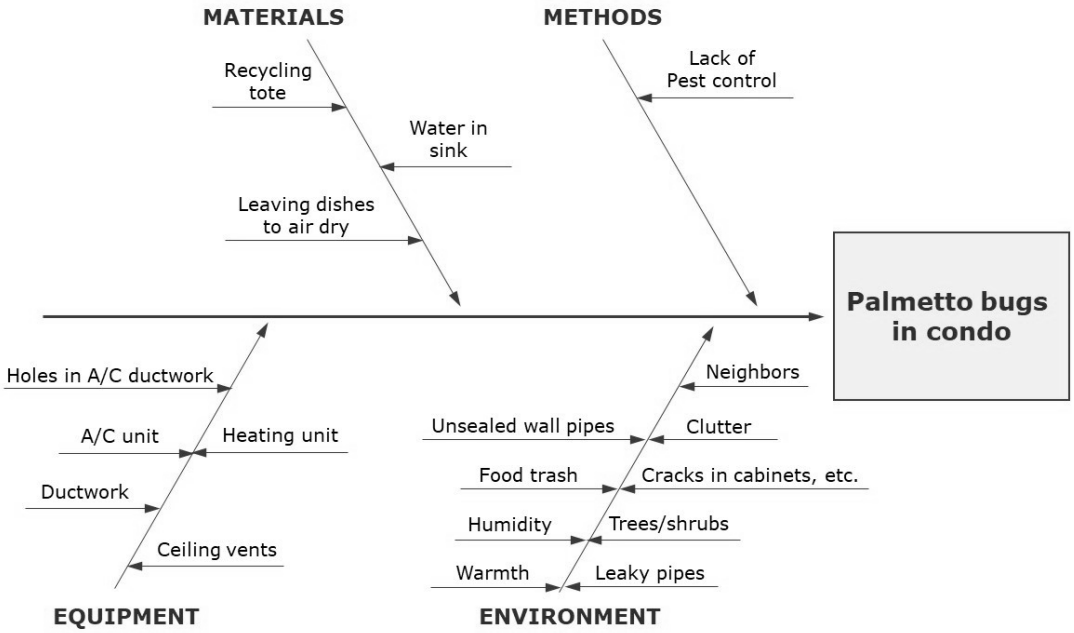

Fig. 3. Cause-and-effect diagram of palmetto bugs in condo.

An analysis of Materials in the condo revealed that a recycling tote, water left in the kitchen sink, and leaving dishes to air dry provided locations for Palmetto bugs to hide once inside the condo. Under Methods, although the homeowner sporadically sprayed the condo unit with a pesticide, the lack of applied pest control on a consistent basis contributed to the prevalence of these bugs in the condo unit.

An examination of the environment revealed that Palmetto bugs can enter the interior of a building, or condo, through any cracks in the building exterior, including the building foundation, open windows and doors, etc. Once inside a building, Palmetto bugs can penetrate the building infrastructure, then enter any room through wall cracks that are evident, but also through cracks that are not evident, such as cracks behind kitchen and bathroom cabinetry. They can enter through uninsulated pipes and holes in the wall such as under a bathroom vanity or kitchen sink, and unsealed areas around electrical outlets. This particular condo unit was the middle unit on the end of a building. It was known that two other homeowners, specifically one homeowner with an adjacent condo unit and the other homeowner immediately below, were what could best be described as "hoarders." This becomes fertile nesting ground for insects such as Palmetto bugs.

Under equipment, an inspection of the A/C unit outside the condo building revealed no abnormalities; however, a hole was discovered in the upper corner of the ductwork above the heating unit inside the condo. No anomalies were detected upon inspection of the water heater. The homeowner reached an epiphany one day in the sunroom while mulling over other possible ways a Palmetto bug could enter the condo. A Palmetto bug dropped down in front of the homeowner and landed on the carpet. Looking up at the source, the homeowner discovered that the Palmetto bug dropped down from the ceiling vent (See *Fig. 4*).

Fig. 4. Sunroom ceiling vent.

Example 2. Solutions.

The following action steps were implemented and the Palmetto bug problem is now under control; that is, a Palmetto bug now appears in the condo on rare occasions rather than on a regular basis:

- *The recycling bin has been removed and dishes are now washed in the dishwasher.*
- *The homeowner has hired a professional exterminator to use a commercial-grade pesticide on a monthly basis (See Fig. 5). Additionally, the homeowner continues to spray on a weekly basis using a name brand pesticide (See Fig. 6).*
- *All wall cracks have been patched and painted, including behind kitchen and bathroom cabinetry.*
- *All holes around pipes and all gaps around electrical outlets have been filled with insulation (See Fig. 7 and Fig. 8).*
- *Both "hoarder" neighbors eventually sold their units and moved out. Afterwards, both units were remodeled and the new homeowners do not appear to be hoarders.*
- *The hole in the corner of the A/C ductwork has been repaired (See Fig. 9). Roach powder has been applied along the floor perimeter inside the heating unit/water heater room.*
- *Storm door screening now covers the openings in all ceiling vents in the condo (See Fig. 10).*

Fig. 5. Professional exterminating co.

Fig. 6. Homeowner pest control.

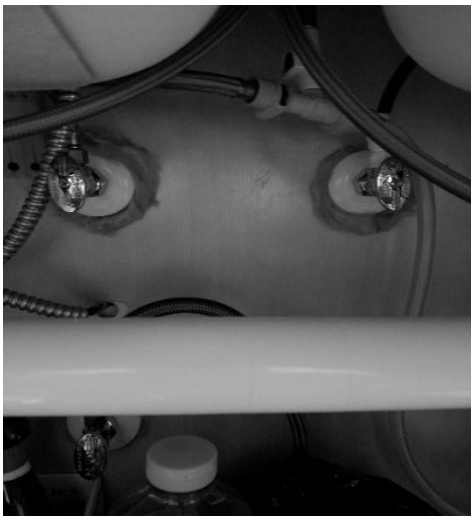

Fig. 7. Holes Sealed under kitchen sink.

Fig. 8. Holes sealed under bathroom vanity.

Fig. 9. Ductwork hole repaired.

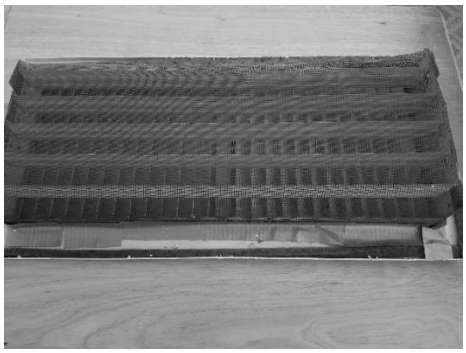

Fig. 10. Screened ceiling vent.

Example 3. Five Whys: Sunroof water leak floods floorboard in car.

Five Whys is a technique used to identify the root cause of a problem by asking "Why?" five times (more or less depending on the problem). The answers to each successive Why delves deeper towards identifying the root cause of the problem.

The floorboard in a 2001 Acura TL was flooded after a big rainfall one day. The car owner thought the car windows had been inadvertently left slightly open during the rainfall, resulting in the flooded floorboards. The next time it rained, the car windows were checked and were fully closed. After the rain ended, however, the floorboards were flooded again. Puzzled, the car owner opened the sunroof and discovered the water well filled with water and debris, such as pine needles and dirt, and that the drain ports were clogged.

Once both drain ports were cleaned, the driver's side floorboard flooded once again after the next rainfall. However, the passenger's side floorboard remained dry. After further investigation inside the car, it was discovered that the drain tube from the sunroof drain port had become unattached from the boot tube as shown in *Fig. 11*.

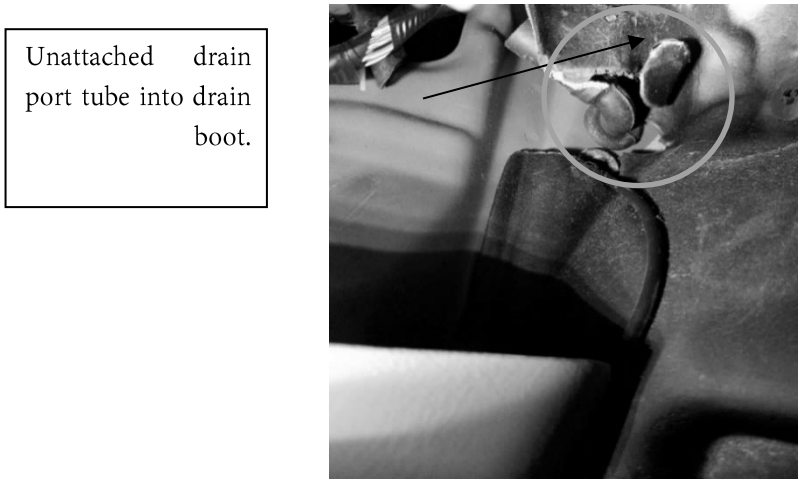

Fig. 11. Driver's side interior drain hose.

The Five Whys diagram in *Fig. 12* illustrates the analysis for this problem.

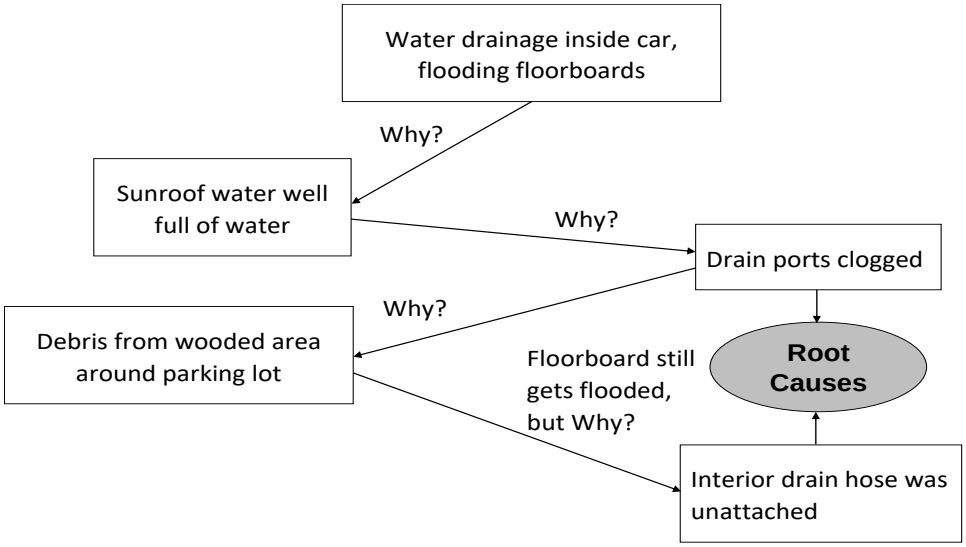

Fig. 12. Five Whys diagram for flooded floorboards in car.

Example 4. Solution.

Two solutions were required to repair this problem. First, the sunroof was opened in order to clean the water well and drain ports from water build-up and debris as shown in *Fig. 13* and *Fig. 14*.

The car is normally parked in a condo community parking lot surrounded by pine trees and bushes. Pine needles and debris were discovered all over the car, including in the sunroof water well.

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Fig. 13. Driver's side sunroof drain port.

Fig. 14. Passenger's side sunroof drain port.

Second, a new drain port tube was inserted into the drain boot (in *Fig. 15*) to allow water runoff to channel from the sunroof through the windshield pillars and through the drain boot to the outside of the vehicle.

Fig. 15. Interior drain hose repaired.

Example 5. Fault Tree Analysis: Why Toro String trimmer starts, then dies.

FTA is a top-down, deductive failure analysis technique in which an undesired state of a system is analyzed. In identifying the potential factors affecting the undesired state, FTA also allows for the evaluation of risk.

The Toro string trimmer (in *Fig. 16*) ran for many years. Then, as in many cases involving equipment, one day it unexpectedly didn't run and the troubleshooting process began. The homeowner used a Fault Tree Analysis to determine possible root causes and, in this particular example, there were many (See *Fig. 17*).

Fig. 16. Toro string trimmer.

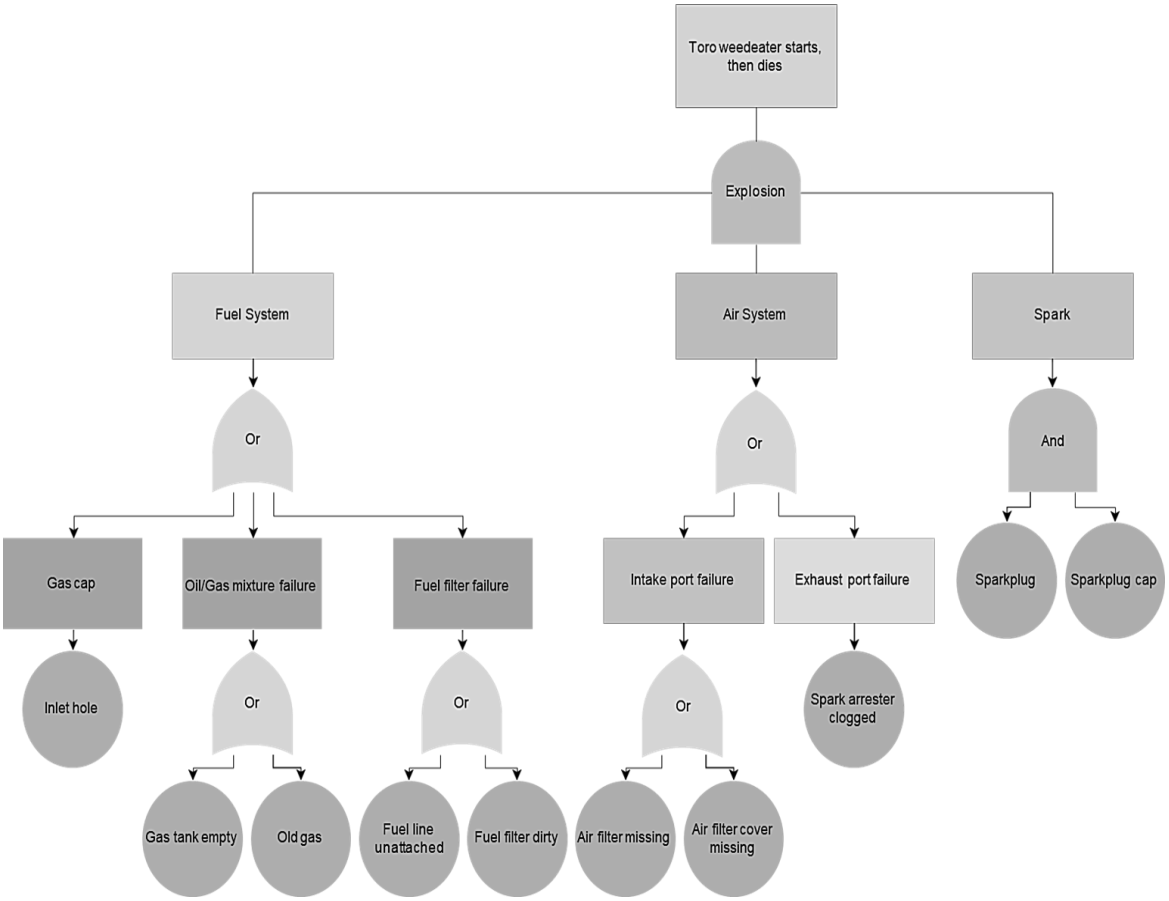

Fig. 17. Fault tree analysis of Toro string trimmer starts, then dies.

The Toro string trimmer's ability to start and run consistently is based on three things working in harmony: the fuel system, the air system, and the spark system.

The fuel system must have a gas cap with a clear inlet hole. Additionally, the gas/oil combination in the fuel tank must have the proper 50:1 gas/oil mixture level and the gas must be fresh gas. The fuel filter must be clean with the fuel line attached. The carburetor must be clean of dirt and debris. If any of these potential causes is compromised, the string trimmer could die shortly after starting.

Regarding the air system, the air intake must have a clean air filter and an air filter cover for proper operation. For air exhaust, the spark arrestor must be clean of any debris. If the air filter or air filter cover is missing, debris could enter the string trimmer causing it to die suddenly after it starts. If the spark arrester is dirty or clogged, this prevents proper air exhaust and could cause the string trimmer to die shortly after it starts.

The sparkplug must have the proper 0.025" gap, be clean of any residue, and it must be capped by the sparkplug boot cover. If the sparkplug is dirty and/or it is not capped by the sparkplug boot cover, the string trimmer will not start.

Example 6. Solution.

- *The gas cap and inlet hole were thoroughly cleaned.*
- *The carburetor was disassembled and thoroughly cleaned. (See Fig. 18)*
- *A 50:1 gas/oil mixture was used in the gas tank with fresh gas.*
- *The fuel filter was replaced by a new one. (See Fig. 19)*
- *An air filter and air filter cover were purchased to replace the missing air filter and air filter cover.*
- *The spark arrestor was cleaned on a wire wheel.*
- *The sparkplug was replaced with a new sparkplug, properly gapped at 0.025".*

Once these steps were taken, the Toro string trimmer ran like new.

Fig. 18. Carburetor disassembled and cleaned.

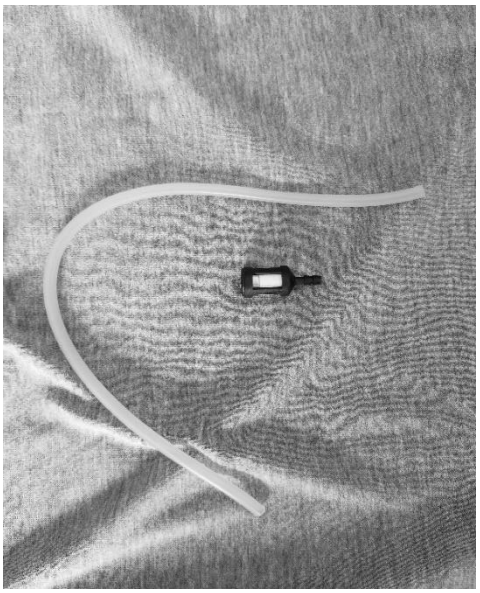

Fig. 19. New fuel line and fuel filter.

4 | Conclusions

The cause-and-effect diagram was used to list all possible causes of Palmetto bugs getting into a condo unit. This provided an impetus for corrective actions. By identifying and addressing all of the possible causes, the problem is now under control. A Palmetto bug is now observed in the condo on rare occasions rather than every day. The five Whys approach aided in deducing the root causes of sunroof rainfall water runoff onto the floorboard of a car. The sunroof water well and drain ports were thoroughly cleaned and a new driver's side interior drain tube was attached to the boot drain hose to prevent water from draining onto the floorboard. Fault Tree Analysis was used to determine possible causes for why a Toro string trimmer would start, then die. Several causes were shown under the primary branches of Fuel System, Air System, and Spark, which must work in harmony for the string trimmer to start and run. Corrective actions

were taken to negate these causes and the string trimmer now runs like new. The three root cause analysis techniques utilized in this research provides evidence that they can be successfully applied to home projects. Each technique provides a structured approach for consideration of all possible root causes leading to improved troubleshooting and problem resolution. This, in turn, can lead to a revival of previously out-of-service equipment as well as reduced aggravation, repair expense, and repair time for the do-it-yourself homeowner.

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