2. DESIGN REQUIREMENT SPECIFICATIONS

The Milwaukee RO-T8 is a custom device for testing three Milwaukee Tool fan models, the 0821, the 0886, and the 0820. The 0821, the M18 18” Brushless Fan, is the largest of the three, the 0886, the M18 Jobsite Fan, is the medium-sized fan, and the 0820, the M12 Mounting Fan, is the smallest among them. Each model has distinct RPM values that Milwaukee Tool requires testing for at different power settings. The requirements are outlined in the following sections.

2.1 Requirements

Addressing the requirements of Milwaukee Tool involves understanding the company’s specific needs. The Milwaukee RO-T8 is customized for measuring the fans’ RPMs, seamlessly transferring this data to a workstation, and ensuring the accuracy of a repair to prevent the need for second-time repairs. The design requirements for the Milwaukee RO-T8 are categorized into two main areas: marketing and engineering.

2.1.1. Marketing Requirements

The Milwaukee RO-T8 has the following marketing requirements:

1. The Milwaukee RO-T8 requires minimal training.
2. The Milwaukee RO-T8 is compatible with Milwaukee Tool’s current testbenches.
3. The Milwaukee RO-T8 records the fan’s model for data tracking.
4. The Milwaukee RO-T8 provides an easy-to-read pass-or-fail indicator.
5. The Milwaukee RO-T8 accurately measures and records RPM data.
6. The Milwaukee RO-T8 has a lightweight, compact design.
7. The Milwaukee RO-T8 has a wear-resistant casing.

The Milwaukee RO-T8 is a versatile tool that offers both convenience and reliability for testing fan performance. The marketing requirements for the Milwaukee RO-T8, as illustrated in Figure 2-1, emphasize the importance of reliability, compatibility, durability, and ease of use to improve the overall user experience. By meeting these specifications, the Milwaukee RO-T8 ensures reliable results and long-term usability.

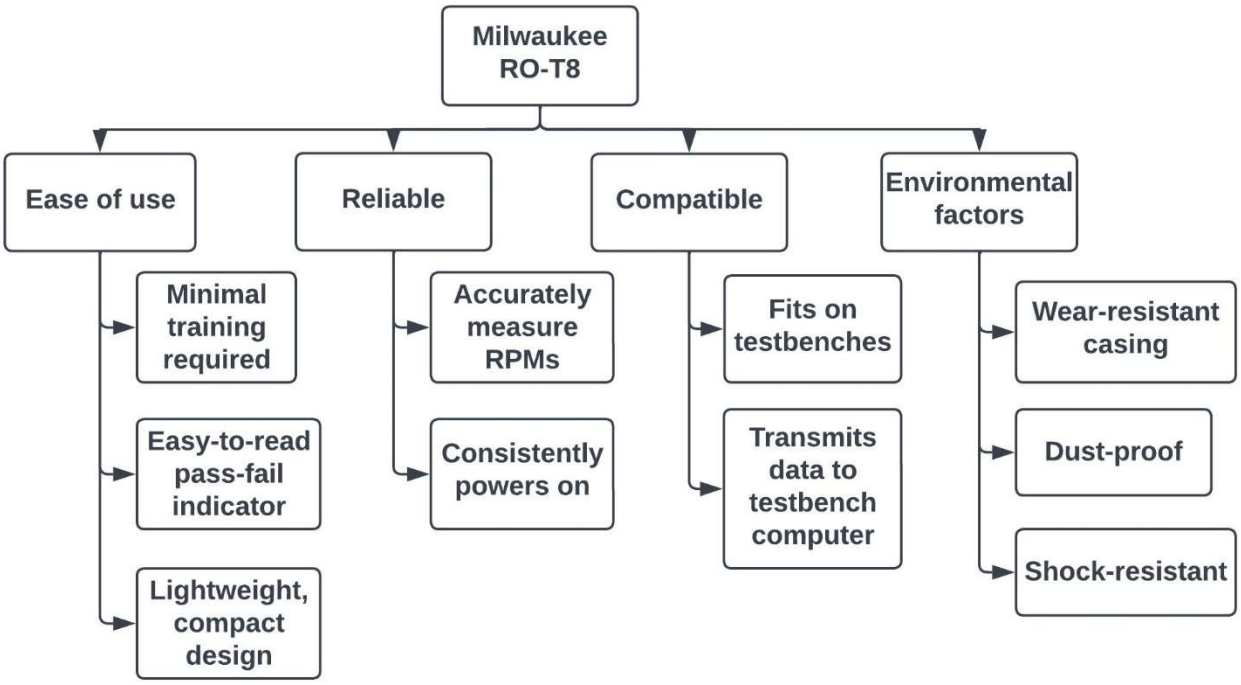

Figure 2-1. Objective Tree for the Milwaukee RO-T8

The marketing requirements for the Milwaukee RO-T8 serve as a foundation for the engineering requirements. The subsequent section will delve deeper into the marketing requirements from a technical perspective, utilizing the engineering requirements for detailed analysis.

2.1.2. Engineering Requirements

Table 2-1 shows the engineering design requirements for the Milwaukee RO-T8. The table also shows how the engineering design requirements relate to the marketing requirements. Each engineering design requirement is further justified.

Table 2-1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Justification
2, 3	The data recorded is saved and stored on the testbench desktop.	The recorded data can be later referenced to determine reoccurring design failures in Milwaukee Tool fan design.
1, 4	The LED lights provide a pass/fail indication to a technician.	A pass/fail test is programmed to determine if the calculated RPMs are within the RPM range for each setting of each model. When a passing grade is detected, a green LED indicates RPMs are within range. When a failure is detected, a red LED indicates RPMs are not within range.

7	The wear-resistant casing helps prevent damage to the product.	The system components have a 3D-printed case to provide protection. The case is made to be dust, water, and shock-resistant.
1, 6	The product is designed to be easy to use and portable.	The product is preprogrammed to reduce training time. It is portable due to its size and weight. Because the Milwaukee RO-T8 is one complete unit, it can be moved to a different testbench with ease.
1, 3, 4	The user inputs the model and fan speed settings to be tested.	The user inputs each fan model and fan speed setting to set the parameters of the passing RPM range for the pass/fail test. The user input also provides the model and fan speed tested to the database.

Marketing Requirements:

1. The Milwaukee RO-T8 requires minimal training.
2. The Milwaukee RO-T8 is compatible with Milwaukee Tool's current testbenches.
3. The Milwaukee RO-T8 records the fan's model for data tracking.
4. The Milwaukee RO-T8 provides an easy-to-read- pass-or-fail indicator.
5. The Milwaukee RO-T8 accurately measures and records RPM data.
6. The Milwaukee RO-T8 has a lightweight, compact design.
7. The Milwaukee RO-T8 has a wear-resistant casing.

The engineering design requirements listed above describe the Milwaukee RO-T8. This design meets the constraints and safety standards that Milwaukee Tool requires. The design also satisfies the marketing requirements of the customer.

2.2 Constraints

The Milwaukee RO-T8's constraints are established by Milwaukee Tool and the MSU ECE Department. The constraints include budgetary considerations, compatibility with current testbenches, time availability, the capability of testing three models of fans, and the ability to provide Milwaukee Tool with the research and models. Table 2-2 provides a detailed discussion of these constraints.

Table 2-2: Constraints

Type	Name	Description
Economic	Cost	The total budget of the project is $1000.
Economic	Time	The design team, Magnolia Electric, has until the end of the spring 2024 semester to have working subsystems for the Milwaukee RO-T8 and a finished product by the end of the fall 2024 semester.
Manufacturability	Range	Milwaukee Tool requires the Milwaukee RO-T8 to measure the RPM values for the M18 Brushless 18" Fan (0821) for a range of 700-1350 RPM with a tolerance of 50 RPM. The M18 Jobsite Fan (0886) and M12 Mounting Fan (0820) require a range of 1300-2702 RPM with a tolerance of 200 RPM.

Manufacturability	Size	The Milwaukee RO-T8 fits on 3’0”x 5’0” testbenches at the company’s facilities.
Technical	Compatible with current system/software	Milwaukee Tool requires that the data collection system be compatible with the current database.
Legality	Research	The schematics and research for the Milwaukee RO-T8 belong to Milwaukee Tool upon completion of the product.
Health & Safety	Human interaction	The Milwaukee RO-T8's design provides a safer workplace environment.

The Milwaukee RO-T8’s design constraints ensure compliance with Milwaukee Tool’s requirements. These constraints also allow the product to meet the expectations, time, and budget constraints set by Mississippi State University. Section 2.2.1 goes into more detail about the range constraints.

2.2.1. Range Constraints

The 0821 model should operate in the range of 700 to 800 RPM on the low-power setting, 900 to 1000 RPM on the medium power setting, and 1250 to 1350 RPM on the high-power setting. For the 0886 model, the target values are between 1300 to 1575 RPM for the low-power setting, 1615 to 2185 RPM for the medium-power setting, and 1998 to 2702 RPM for the high-power setting. The RPM ranges for the 0820 model are identical to the ranges for the 0886 model. These ranges are based on testing performed by Milwaukee Tool.

2.3 Standards

The Milwaukee RO-T8 ensures reliable, safe performance by adhering to applicable industry standards and regulations. These standards and regulations encompass various aspects of the product's design, functionality, safety, and quality. Table 2-3 summarizes the main standards and regulations with which the Milwaukee RO-T8 complies.

Table 2-3: Engineering Standards

Specific Standard	Standard Document	Specification / Application
47 CFR Part 15	The device follows the Federal Communications Commission regulations for radio frequency devices as outlined by Title 47 CFR Part 15 [1].	The Milwaukee R0-T8 complies with the FCC labeling requirements for a digital device that may inadvertently produce innocuous radio frequency energy while processing data.
10 DOE Part 429	The device follows the Department of Energy regulations regarding the en-	The Milwaukee RO-T8 uses a Class A external power supply that complies

	ergy conservation program for consumer products as outlined in Title 10 CFR Part 429 [2].	with certification and testing requirements under the Energy Policy and Conservation Act.
IP-54	The device meets the International Electrotechnical Commission's (IEC) Ingress Protection Standard 60529 [3].	The Milwaukee RO-T8's enclosure protects against dust and splashing water.

Following the engineering standards listed in Table 2-3 is crucial for ensuring the safety and reliability of the Milwaukee RO-T8. These standards provide clear guidelines and specifications for the materials and testing methods used in electrical devices for consumer and industrial products. The standards listed are discussed further in 2.3.1.

2.3.1 Radio Frequency Device Standards

The Milwaukee RO-T8 uses an Arduino microcontroller and other peripheral electrical components. The Federal Communications Commission (FCC) defines these digital devices and peripherals as unintentional radiators [1]. An unintentional radiator is a device that outputs radio frequency energy but is not specifically designed to emit radio frequency energy. To prevent unintentional frequencies from interfering with radio and television signals, the Milwaukee RO-T8 uses individual products that comply with FCC regulations. The original FCC label and identification marker for each device used in the system remain unchanged.

2.4 REFERENCES

[1] *47 CFR Part 15 Subpart A*, Electronic Code of Federal Regulations, November 2017. [Online]. Available: https://www.ecfr.gov/current/title-47/part-15/subpart-A

[2] *10 CFR 430.2 "External power supply",* Electronic Code of Federal Regulations, June 1977. [Online]. Available: https://www.ecfr.gov/current/title-10/part-430#p-430.2(External%20power%20supply)

[3] *Degrees of protection provided by enclosures (IP Code)*, IEC 60529, January 2019. [Online]. https://www.iec.ch/ip-ratings