

# **ANTI-THEFT SYSTEM FOR CATALYTIC CONVERTER**

## **Team: Theft-Away**

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## **Functional Specifications**

## **I. Design Goals for Anti-Theft System for Catalytic Converter**

Project Definition: The Anti-Theft Catalytic Converter (ATCC) team's goal is to design and improve an electromechanical, ultra-defensive theft prevention system for catalytic converters to deter thieves and reduce the number of converters stolen each year.

### Approach:

- a. The system will consist of multiple sensors and mechanisms to detect thefts with high accuracy and minimal latency.
- b. The system will have an alarm which will immediately trigger in case of theft to discourage the thieves and notify the owners.
- c. The alarm sub-system will consist of loud horns for discouraging thieves and a module to notify owners via text messages.
- d. The system includes a steel case to house the converter. The mechanical layer will make cutting the converter more difficult.
- e. The project design will be documented in such a way that will allow for easy replication and adaptation to different regions.

## **II. Functional Specifications**

### **1. *Electrical (E)***

Electrical specifications consist of the following:

#### **1.1. Power Consumption:**

##### Spec description:

**E01:** Without any power input, the electronics operation shall last more than 14 days and should last more than 21 days.

##### Validation method:

The power consumption of electronics can be measured by measuring voltage applied to the system and current consumed. Knowing the battery capacity and its voltage, the duration of which the system can last up to can be analytically calculated.

##### Reason:

Because the system is operating on battery, this spec will ensure that the system can continue to operate over a certain period before draining out battery.

#### **1.2. Arriving time of phone messages:**

##### Spec description:

**E02:** From the time of triggering, it shall take less than 40 seconds and should take less than 20 seconds for messages to arrive at owner's phone.

##### Validation method:

Phone messages will be manually triggered. Using timer, the time of which phone messages arrive at the phone after triggering will be measured. The whole process will also be recorded using camera for affirming the results.

##### Reason:

This spec ensures that user can be notified within a reasonable time after detecting theft.

### **1.3. Responsiveness of the alarm system:**

#### Spec description:

**E03:** After detecting thieves, the alarming system shall turn on in less than 1 second and should turn on in less than 0.5 seconds.

#### Validation method:

The system's detection will be manually triggered, i.e. waving hands at motion sensor or unplugging the conductive sensing mechanism. When triggering, the console (on computer) will be logged with a message confirming successful trigger. Using timer from that moment until the alarm turn on, the duration between triggering and firing up the alarm can be measured. The whole process will be recorded using camera for affirming the results.

#### Reason:

This spec ensures that alarm system can quickly fire up in case of detecting theft.

### **1.4. Detection accuracy of the motion sensor (Statistic spec):**

#### Spec description:

**E04:** The motion sensor shall accurately detect 80% of all attempts and should accurately detect >95% of all attempts.

#### Validation method:

The motion sensor will be manually triggered 20 times by waving in front of the sensor for 3 seconds. At each attempt, it will then be recorded that if the system can accurately detect the motion or not. After 20 times, a percentage of success will be calculated based on tabulated recordings.

#### Reason:

This spec ensures motion sensor can accurately detecting thefts.

### **1.5. Detection accuracy of the conductive sensing mechanism (Statistic spec):**

#### Spec description:

**E05:** The conductive sensing mechanism shall accurately detect 80% of all attempts and should accurately detect >95% of all attempts.

#### Validation method:

The conductive sensing mechanism will be manually triggered 20 times by unplugging it from circuit. At each attempt, it will then be recorded that if the system can accurately detect the motion or not. After 20 times, a percentage of success will be calculated based on tabulated recordings.

#### Reason:

This spec ensures the conductive sensing mechanism can accurately detecting thefts.

### **1.6. Protection against overcurrent (Industrial spec):**

#### Spec description:

**E06:** The electronics shall be protected against current larger than 5A and should be protected against current larger than 3A

#### Validation method:

A fuse, which will be used to isolate the system from direct contact with power source, will be tested by running current through it. The current, which will be continuously measured by a multimeter, will be slowly adjusted to gradually increase. When the fuse break, the current is then measured.

#### Reason:

This specification is designed to meet the regulation set by NFPA, International Electrotechnical Commission (IEC) standard 60364-1 Section 131.4, which specifies standard protection against overcurrent:

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## **2. Mechanical (ME)**

Mechanical specifications consist of the following:

### **2.1. Mechanical Housing Protection:**

#### Spec description:

**ME01:** The mechanical housing shall increase the time it takes the thief to cut out the catalytic converter by greater than or equal to 60 seconds and should increase said time by greater than or equal to 90 seconds

#### Validation method:

This Specification will be validated through the physical cutting of the housing with a reciprocating saw (or similar method) until a catalytic converter can be cut and freely pulled out. This test will be timed for accuracy and filmed.

#### Reason:

The mechanical housing will need to physically protect the catalytic converter from thieves by impairing its ability to cut directly at the exhaust pipe. The Mechanical housing will need to be separately cut out by the thief before they are able to reach the catalytic converter.

### **2.2. Catalytic Converter Heat:**

#### Spec description:

**ME02:** The Catalytic converter shall operate at less than or equal to 800F on average with the mechanical housing installed. The Catalytic converter should operate at a temperature no greater than 500F with the mechanical housing installed.

#### Validation Method:

This Specification will be validated with a digital heat gun while the converter is under load and the car has reached operating temperature. An average of multiple readings taken over a few minutes will give the average reading that will be used to verify the temperature of the converter.

#### Reason:

The mechanical housing should not impair the operating ability of the catalytic converter; it should not stop the converter from dissipating heat, nor should it cause the converter to overheat. If the catalytic converter were to run much over its normal operating temperature range of 500-1200 Fahrenheit for a prolonged period of time, it could destroy the converter or melt into the car's interior

### **2.3. Electrical Housing IP Rating:**

#### Spec description:

**ME03:** The electrical housing shall meet IP22 standards or higher. The electrical housing should meet IP65 standards or higher

#### Validation Method:

This spec will be verified by testing the housing as per IP rating standards by team theft away.

#### Reason:

This specification is designed for the electrical housing that will be mounted within the car's interior, hopefully keeping it isolated from most hazards.

## **2.4. Number of Cars:**

### Spec description:

**ME04:** The mechanical housing or housings shall be able to properly fit and function on two of the most targeted vehicles. The mechanical housing should be able to properly fit and function on three of the most targeted vehicles.

### Validation method:

This specification will be validated by proof of successful installation and functionality on specified car or through proof of detailed proof of concept.

### Reason:

. This specification is important for determining the scope of team theft-aways senior design project as a whole and determining a realistic direction for the project.

## **3. General (G):**

The general specifications consist of the following:

### **3.1. Cost:**

#### Spec description:

**G01:** The cost of manufacturing shall be less than \$1200 and should be less than \$600.

#### Validation Method:

A prototype of the functional system will be built. The cost of each part is recorded in an Excel spreadsheet. The total cost of manufacture can then be determined by summing up cost of parts.

#### Reason:

The cost of manufacturing must be minimized such that the system can compete on market.

### **3.2. Installation Time:**

#### Spec description:

**G02:** A professional technician will be able to install it in less than 1 hour.

#### Validation method:

A prototype of the system that fits under a chosen car will be built. A team member will install the system while timing the installation time.

#### Reason:

The installation time must be within a reasonable time, such that installation cost and time can be minimized.

**Table 1.0 Functional Specifications Summary**

ID	Spec	Threshold (Shall)	Objective (Should)	Validation Method
E001	Power Consumption	>14days	>21days	Measure voltage and current applied to the system. Then analytically calculate the time.
E002	Phone SMS	<40s	<20s	Timer / video footage
E003	Responsiveness of the alarming system	<1s	<0.5s	Analyze video footage/use timer
E004	Detection accuracy of the motion sensor	>80%	>95%	Counting number of successes out of 20 attempts
E005	Detection accuracy of the conductive sensing mechanism	>80%	>95%	Counting number of successes out of 20 attempts
E006	Protection against overcurrent	≥5A	≥3A	A tested DC current will be applied to the fuse. The current at which the fuse trips is measured.
ME01	Mechanical Housing Protection	Increase time to cut out catalytic converter by > 60s	Increase time to cut out catalytic converter by > 90s	Cut housing, as a thief would, with a reciprocating saw while being timed.
ME02	Catalytic Converter Heat	Catalytic converter shall operate at no greater than 800°F with mechanical housing installed.	Catalytic converter should operate at no greater than 500°F with mechanical housing installed.	Assess with temperature gun without housing for average normal operating temperature and repeat with mechanical housing installed.
ME03	Interior Electrical Housing Ip Rating	Electrical Housing shall meet IP22 standards or higher	Electrical Housing should meet IP65 standards	Test IP rating as per standard
ME04	Number of Cars	The mechanical housing or housings shall fit 2 of the most targeted cars	The mechanical housing or housings should fit 3 of	Validation of installation on car or proof of concept

			the most targeted cars	
G01	Cost	<\$1200	<\$600	Excel spreadsheet
G02	Installation time	Mechanical housing is installable by a professional in 1 hour or less.		Record the installation time on a chosen car