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# Low Cost Electronic Seal for Tanker Truck in Indonesia

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***Abstract*—The amount of loss of petroleum product in transit has always been an ubiquitous problem in Indonesia. This system using RFID, microcontroller, Raspberry PI and specially designed mechanical sensors aims to answer the safe delivery of petroleum product from depot to the gas stations. The electronic seal is created at the depot using authorized RFID key, along the way to destinations the system installed in the truck will be monitoring all status of the manholes and bottom loaders. The seal is broken if any of the sensors detect an open event or a power failure of the system.**

***Keywords—tanker truck; electronic seal; RFID***

## I. INTRODUCTION

In April 2017 Police in Jakarta arrested a driver of a tanker truck and an illegal buyer[1]. Evidently this illegal activities has been going on for the last two year. They break the seal and pump the payload and sell it to the illegal buyer with a much lower price. In turn the buyer will sell it to the market. After they break the mechanical seal, somehow they managed to replace the seal without being detected. A simple search on www.google.co.id for "illegal petroleum tanker truck", will give us a number of similar news on how common and widespread the effort to steal the payload from a tanker truck in Indonesia[1]–[3]. The methods of stealing payloads and seals forgery are varied but the main idea are the same.

The main idea of this paper is to provide an effective and economical electronic seal as a tool to guarantee the quantity and the quality of the petroleum goods being delivered. The main advantages of the system being offered are:

- Electronic seal using unique RFID tag, is simple, effective, economical and difficult to forge.
- LCD display provides a simple but effective information regarding id of seal, time, sensors status and seal status
- Mechanical sensor design is conformed to IP-67 (no ingress of dust or water) and intrinsically safe
- Sensors are designed so it will not wear out and will not generate any spark or increasing temperature that could cause an explosion or fire
- Stakeholders can easily see whether the seal is void or valid.
- Relatively easy to install and low cost.
- Provide guarantee on quality and quantity of the payload.

## II. METHODS

### A. Sensor Design

A mechanical sensor unit is designed and built incorporating opto coupler to detect an open/close status. This sensor will be triggered by a cam connected to manholes and bottom loaders of tanker truck. Manholes and bottom loaders can not be open without triggering the sensor(s). Housing of the sensor gas/water proof, and tampered proof. Optocoupler is used to avoid sparks and mechanical wear. This sensor unit has passed IP-67 Test by Sucofindo (Government Owned Indonesia's Inspection Institution), along with other Health Safety and Environment (HSE) tests required by Pertamina (Government Owned Indonesia's National Energy Company), performed by Testing Technology Laboratory, Indonesia Institute of Science, P2SMTP LIPI Indonesia (http://smtp.lipi.go.id).

*Fig. 1 Sensor Unit*

This sensor unit will be installed for each compartment's manhole and bottom loader. Based on early experience we provide a much simpler design for manhole and bottom loader locking mechanism in order to achieve robustness and fail proof operation. No electrical lock is used to increase durability.

### B. *Sensor and lock for bottom loader*

Each bottom loader will be equipped with a sensor and a specially designed locking mechanism as shown at Fig. 2.

Fig. 2 Bottom Loader Unit

### C. *Sensor Lock for manholes*

A simple locking mechanism is also designed to give a durable and failproof lock/unlock operation for manholes as shown at Fig. 3.

Fig. 3 Manhole Unit

### D. *Controller Unit*

Beside the mechanical sensors above, the system also incorporate a controller unit using two Atmel microcontrollers, an RFID reader and Raspberry Pi equipped with a WIFI dongle. The functions of this controller is as follows:

- Store unique id of each tanker truck.
- Monitoring status of each sensor (open/close).
- Manage seal status (valid or void) triggered by status input from sensor(s) or RFID key.
- Provide web access and user interaction for data interchange with other devices and sealing or opening legally.

Each controller is also equipped with a Raspberry Pi2, single board computer (SBC) that provide web access to the system. Microcontroller manage all the panel interaction/display. Status of seal and monitoring of the sensors is also done by microcontroller. Raspberry communicates with microcontroller trough RS232-serial communication. Python is the language chosen to run in Raspberry SBC. A simple protocol is designed for Raspberry-microcontroller communication, all command are typically following the <STX> command <ETX> <LF> form, except for the first open communication command <SOH><ETX><LF>.

### E. *Controller Configuration*

The system consist of a controller installed inside the driver cabin and a sensor on each compartment manhole and bottom loader. Each sensor is connected to a metal bar/portal that will act as a closure to manhole and bottom loader. This portal is designed to fit on existing standard for Pertamina's tanker trucks. Controller's block diagram is shown at Fig. 4. As we can see, from the block diagram, we have controller, Led-Button interface

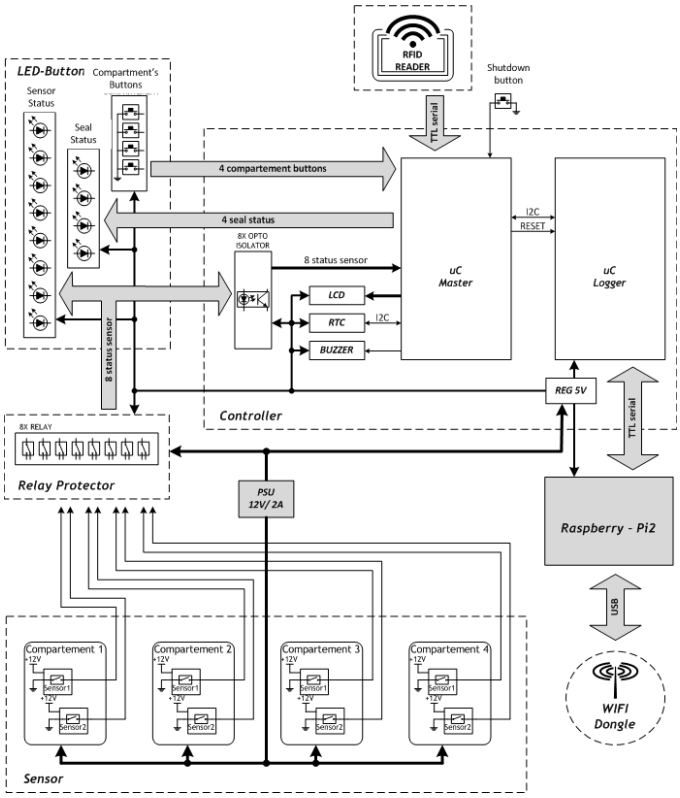


Fig. 4 Controller's Block Diagram

Our present controller shown in Fig.5 is made for four compartments because Pertamina tank trucks mainly have four compartments. Three LED is provided for each compartment, indicating Seal status, manhole's door, and bottom loader's door. An LCD is provided also to give more information. This control unit will be installed at the driver cabin.

Fig. 5 Control Unit

Fig. 6 shows a typical display when all compartment are sealed, with information of the name of depo as the origin of the cargo, including time and date of seal created.


Fig 6 LCD display

If we want to know the condition of a particular compartment, we can push the red button for that particular compartment.

### F. Electronic Seal

Our definition on a particular Electronic Seal is actually a unique number created as a function of time, delivery order and ID of a container. Each seal has a status of either VOID or VALID. Seal is created at the depo and it's status will be changed to 'forced open', 'normally open' or 'power failure'.

### G. Product Backlog Items

Following the Scrum[4] approach we define the features of the system as user stories where users get benefits from the (software) system. This approach is popular for many developers and users because of its simplicity and clarity of features offered. Table 1 shows Product Backlog Items for this work.

Table 1 Product Backlog Items

| Product Backlog Items | User story |
|---|---|
| 1. Upload Delivery Order | As a Depo officer, I can upload delivery order (DO) for today's delivery, already exist in my phone/tablet/laptop for a certain tanker truck, so that it is registered in the controller unit of the truck. |
| 2. Browse Deliver Order | As a Depo officer, I can see delivery order on a particular truck using my phone/tablet/laptop |
| 3. Create seal for all compartments | As a depo officer, I can seal all compartments on truck, so that all seal's status is VALID, a SEAL event is recorded, provided all sensors are closed |
| 4. Legally Open a particular compartment | As a depo officer, I can legally open a particular compartment using the right RFID tag, so that an 'legally open' event is registered. Only people with designated RFID tag can legally open a compartment |
| 5. Record a SEAL event | System record a SEAL event |
| 6. Record a legal Open Event | System records every legal open event from each or all compartment |
| 7. Record Illegal Open Event | System records each illegal/forced open event from each compartment |
| 8. Browse event log | As a depo officer, I can browse all events recorded on the system via phone/tablet/laptop |
| 9. See status of seals | As a stakeholder I can see seal status of each compartment from the LED display on the control unit |
| 10. Download Events Log | As a depo officer, I can download event log files from the system to be analyze as needed |
| 11. Login | As a registered user I can login to the system to access the available menu |
| 12. Shutdown | As an authorized user I can shutdown the system via browser on my gadget |

### H. Events

There are twelve events that will be recorded for the system as depicted in Table 2. Code of Events.

Table 2 Code of Events

| Event Id | Description |
|---|---|
| AF | Power On |
| FF | Power Off/System fail |
| A1 | Seal all compartments |
| A0 | Normally open all compartment |
| 10 | Normally open compartment 1 |
| 20 | Normally open compartment 2 |
| 30 | Normally open compartment 3 |
| 40 | Normally open compartment 4 |
| 1F | Forced open compartment 1 |
| 2F | Forced open compartment 2 |
| 3F | Forced open compartment 3 |
| 4F | Forced open compartment 4 |

Events are generated by sensors, RFID readers, and system failures. Microcontroller is responsible to capture or generate the event and then send it to the Raspberry for easier access and management of the data.

GPS (Global Positioning System) unit is not included in this system since GPS system is already installed in most of Pertamina's tanker trucks. Geographic location of events can be inferred from time stamp of the event and information from the existing GPS system.

## III. Typical Flow of Works

Typical flow of works start at the depo, delivery order is first downloaded from depo's server using web services API, and then uploaded to the system using smart phone or tablet. Tanker truck is loaded with the payload, registered RFID tag tapped to the controller and create a seal provided all manholes and bottom loader is properly closed. System will store the seal created for each container and monitor status of each sensor on the way destination. Status of seals and sensors can be read from the LCD panel of the controller. A main menu for depo's officer is shown on Fig.7 that can be accessed using smartphone or tablet.

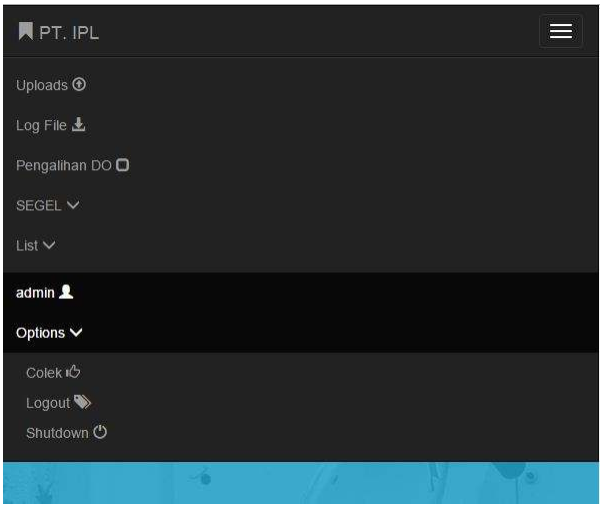


Fig. 7 Depo's Main Menu

We can see from the above menu that as a depo's officer or admin, (s)he can uploads delivery order, downloads log file, performs sealing, or changes the destination of a delivery order.

A typical menu of uploading a DO file is shown below on Fig.8.

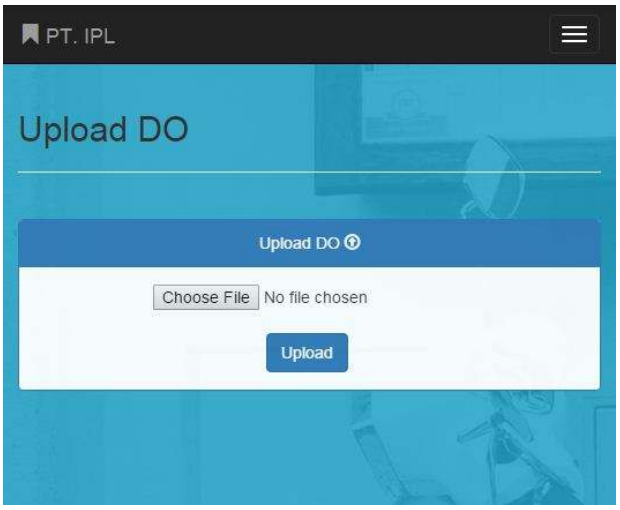


Fig. 8 Upload DO

Operator can also download an event log from a tank truck where (s)he already log in as shown in the following Fig.9.


Fig. 9 Download Event Log File

On the way to destination, if any sensor detect a 'forced open event' the system will set the seal's status to void, and record the event with time stamp. Reclosing the sensor(s) will not change the void status. The seal is also set to void after any power failure to the system.

At destination, operator may check the status of the seal of each container. If the seal is still intact, operator may normally open container(s) designated for them, and the system records a 'normally open event', otherwise operator may filed a report stating that the cargos has been compromised. To open the compartment destined to a particular gas station. Operator just push the button of the compartment, and then tap in the RFID tak, assigned for them, as shown in the following figure for compartment -1. Whenever the seal is already void, the LED will turn off for that particular compartment.


Fig. 10 Normally Open Compartment 1

The LCD and the LEDs give us status of seal, destination of compartment. Fig.11 showing only compartment four is sttill sealed, destined for UJUNGBERUNG1 (the name of the gas station).


*Fig. 11 Only Compartment 4 is intact*

On the way to destination, if any sensor detect a 'forced open event' the system will set the seal's status to void, and record the event with time stamp. Reclosing the sensor(s) will not change the void status. The seal is also set to void after any power failure to the system. The system provide an event log that can be downloaded via web from the tank truck to see the chronological events, as shown on the following Fig. 12. We can see the chronological events here. All important events regarding the seal, status of each door can be seen on this log to be used as needed.


Fig. 12 Events Log

To ses destinations of each compartment and each related RFID tag, we can also download from the track via web. Fig. 13 showing RFID serial number and name of gas stations.


*Fig. 13 ID, Destination Stations and Compartment*

## IV. RELATED WORKS

Previously in 2005, in Lampung, Bangka, Jambi and Lahat, we implemented a similar electronic seal (46 tank trucks total), incorporating a specially made mechanical sensors within a metal enclosures plus electronic lock for manholes and bottom loaders for transporter's tanker trucks use to deliver petroleum products from a depot to gas stations. Each tanker truck is equipped with a mobile unit (a small foot print personal computer), a GPS and WIFI equipment but not RFID. The main problem with this system is from emergency break glass provided for each manholes/bottom loader. The original purpose of this break glass is to provide an emergency open in case the electronic lock is jammed. As it turn out, drivers especially from remote areas may file a false report stating that they can't open the electronic lock so they have to use the break glass to open the container. The system records the event, but before a new break glass is reinstalled, the system is practically not operational. Small footprint PC that we used along with the WIFI card is also prone to system crash due to vibrations and relatively unfriendly environment to a PC. Another issue is the mechanical design of the enclosure for the manholes and bottom loaders. The enclosure and it's electronic lock is relatively hard to install and prone to mechanical jams. Based on this field experience, we opt not to use electronic lock and propose a new mechanical design as described above.

RFID technology are popular alternative for common mechanical seal. A study evaluating the use of RFID as alternative for mechanical seal in a 10-year period on shipping containers proved that it could provide better efficiency and improve security[5]. The study shows RFID is used on a specially made padlock along with the reader. Beside the benefits, the study also showed operational barriers regarding the installation and programming the E-seals. They also suggest that data entry process should be done using a wireless data transfer. Realizing this potential problems, our approach use Raspberry Pi-2 as a small foot print web server on each truck. Operator of this system can do daily chores regarding delivery order, data maintenance are done using simple menus that relatively easy to operate via smartphone/tablet/laptop.

Many patents are also filed showing implementation of alternatives electronic RFID seal with different arrangements as our work here[6]–[8].

## V. DISCUSSION

This work aimed to make a robust and economical electronic seal system for petroleum tank trucks. A simple mechanical design approach is used for reliability and easy installation. Raspberry-Pi is used to improve a faster and user friendly interaction with the system where data must be transferred among different system using WIFI and common web standards.

Further works are needed to ensure that the system can easily adapt to future changes on Information System at various depo. Experiences shows that changes in regulation from Pertamina is relatively frequent. REST[9] software architectural style is very popular and a very likely candidate for accommodating various changes among multiple system that must do data interchange or supporting interoperability. Study from other field[10] shows that REST approach practical and clean enough to be used as an architectural style for interoperability

Integration among various system on Pertamina tank trucks is also need a clear and informed regulation. Our experience shows that not all vendors are willing to openly discuss or provide interoperability. For example the existing GPS system should be open to other system for its services, maybe using RESTfull API, or its connectivity (wired or wireless).

Limitation of the works being offered must still be tested and modified accordingly. Our approach using Agile Scrum methodology in developing the system prove to be more welcoming to future changes. Creativity on how to beat the system is also an on going process that forced us also to devise a better way to guarantee the quality and quantity of the goods being transported.

Although the system is designed to be used for tank trucks, the system potentially can also be used for other types of containers, by modifying the mechanical cam to match the form of the containers.

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