



DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

[Docket No. NHTSA-2020-0104]

Denial of Motor Vehicle Defect Petition

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation.

ACTION: Denial of petition for a defect investigation.

SUMMARY: This notice sets forth the reasons for the denial of a petition submitted on September 17, 2019, by Mr. Edward Chen (the petitioner), requesting that the Agency “initiate a Defect Investigation into the recent set of software updates, including software updates 2019.16.1 and 2019.16.2 and all subsequent updates issued by Tesla, Inc. to its Model S and Model X vehicles, which have been alleged to be issued by Tesla in response to the alarming number of car fires that have occurred worldwide.” On October 1, 2019, ODI opened Defect Petition DP19-005 to evaluate the petitioner’s request. After reviewing the information provided by the petitioner, information provided by Tesla in response to an information request letter from NHTSA, and field data regarding non-crash vehicle fires in model year (MY) 2012 through 2019 Tesla Model S and Model X vehicles, NHTSA has concluded that the issues raised by the petition do not warrant a defect investigation at this time. Accordingly, the Agency has denied the petition.

FOR FURTHER INFORMATION CONTACT: Mr. Kareem Habib, 202-366-8703, Vehicle Defects Division - D, Office of Defects Investigation, NHTSA, 1200 New Jersey Avenue, SE, Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

1.0 Introduction

Pursuant to 49 CFR 552.1, interested persons may petition NHTSA requesting that the Agency initiate an investigation to determine whether a motor vehicle or an item of replacement equipment fails to comply with applicable motor vehicle safety standards or contains a defect that relates to motor vehicle safety. Upon receipt of a properly filed petition, the Agency conducts a technical review (49 CFR 552.6) of the petition, material submitted with the petition, and any appropriate additional information. After the technical review and considering appropriate factors, which may include, among others, Agency priorities, and the likelihood of success in litigation that might arise from a determination of noncompliance or a defect related to motor vehicle safety, the Agency will grant or deny the petition (49 CFR 552.8).

2.0 The Petition

In a September 17, 2019 letter, the petitioner requested that the Agency “initiate a Defect Investigation into the recent set of software updates, including software updates 2019.16.1 and 2019.16.2 and all subsequent updates issued by Tesla, Inc. to its Model S and Model X vehicles, which have been alleged to be issued by Tesla in response to the alarming number of car fires that have occurred worldwide.” The petitioner’s letter alleges that Tesla “is using over-the-air software updates to mask and cover-up a potentially widespread and dangerous issue with the batteries in their vehicles.” He associated the updates with a loss of range and requested that the investigation include model year (MY) 2012 through 2019 Tesla Model S and Model X vehicles:

“The fact pattern for most, if not all, of the affected owners is the same and begin in or around late May 2019, where Tesla issued its 2019.16.1. and 2019.16.2 software updates. For most owners, it was shortly discovered after updating their cars that the cars had suffered from a sudden and significant decrease in the amount of rated miles available. On average, affected owners have reported losing anywhere between 25-30 miles, with 50 miles of range loss at the higher end of the spectrum.”

“There is evidence to suggest that Tesla issued these updates in response to an increasing number of battery fires that have occurred worldwide. Tesla has taken the position

and made statements to the public regarding the same, that the updates were issued in order to promote the health and longevity of their batteries. Additionally, despite some media coverage and news outlets having covered the issue and taking interest in the litigation, it is clear that there is widespread confusion and uncertainty regarding the true purpose of the software updates in question and the safety of the affected vehicles.^{1,2,3}

In a class action lawsuit complaint submitted as an attachment to the petition, the petitioner cited five non-crash fires in Tesla vehicles summarized in Table 1.⁴

Date	Vehicle	Location
June 15, 2018	2012 Model S 85	West Hollywood, California
April 21, 2019	2014 Model S P85	Shanghai, China (Xuhui District)
May 3, 2019	2014 Model S 85	San Francisco, California
May 12, 2019	2015 Model S 85D	Hong Kong, China
July 30, 2019	2015 Model S 85D	Ratingen, Germany

Table 1. Fires Cited by Petitioner.

3.0 Analysis

On October 1, 2019, ODI opened Defect Petition DP19-005 to evaluate the petitioner's request. On October 24, 2019, ODI sent an information request (IR) letter to Tesla to gather information to assist the Office in its evaluation of DP19-005. The letter included requests for production data, over-the-air (OTA) firmware updates, non-crash fire incidents, and Tesla's investigations related to the fires. In evaluating the petition, ODI:

1. Analyzed the scope of the petition and the alleged defect;
2. Analyzed the non-crash fire incidents cited by the petitioner;

¹ <https://www.reuters.com/article/tesla-battery/tesla-hit-by-lawsuit-claiming-thousands-of-owners-lost-battery-capacity-after-software-update-idUSL2N25418A>

² <https://electrek.co/2019/08/08/tesla-owner-range-slashed-software-update-class-action-lawsuit/>

³ <https://insideevs.com/news/364347/tesla-model-s-update-lawsuit/>

⁴ *Rasmussen v Tesla*, 5:19-cv-04596, United States District Court for the Northern District of California, filed August 7, 2019.

3. Reviewed over-the-air updates to the Battery Management System (BMS) released by Tesla from May 2019 to date; and
4. Reviewed all relevant Vehicle Owner Questionnaires (VOQs) received through August 2021.

3.1 Subject Vehicles

Tesla sold approximately 225,000 MY 2012 through 2019 Model S and Model X vehicles in the United States. This petition evaluation will focus on vehicles receiving the firmware update that could limit maximum brick voltage.

Voltage Limiting Firmware Installed	Model Years	Model		Total
		Model S	Model X	
Yes	2012-2016	61,781	0	61,781
No	2016-2019	93,163	69,801	162,964
Total	2012-2019	154,944	69,801	224,745

Table 2. Petition Scope and Subject Vehicle Population.

The subject firmware was installed in certain MY 2012 through 2016 Model S vehicles that were equipped with the first two generations of the Panasonic 18650 battery cell (subject vehicles). Tesla sold approximately 62,000 subject vehicles in the United States (Table 2). The firmware update limiting maximum brick (defined below) voltage is a dynamic algorithm that is enabled in vehicles with high Supercharging use histories.^{5, 6} Through August 20, 2021, that firmware had been enabled in approximately 2,062 vehicles, or about 3.5 percent of the subject vehicles.

3.2 Subject System

⁵ When the firmware is “enabled,” the maximum cell voltage is limited.

⁶ “Supercharger” is Tesla’s name for its DC fast charging network. The terms Supercharging and fast charging are used interchangeably in this report.

The subject vehicles are equipped with high voltage (HV) battery packs containing first- and second-generation nickel cobalt aluminum (NCA) Panasonic 18650 form factor cells. The packs contain up to 16 modules, with each module containing 6 series elements (bricks) comprising 74 cells connected in parallel.⁷ Each module in the battery pack has a battery monitoring board (BMB) to monitor module brick parameters. The battery cooling system distributes ethylene glycol/water coolant to each module through front, left and right manifolds. Coolant enters and exits the battery pack through connections at the front of the pack. Each module has a single ribbon-shaped cooling tube that snakes through the rows of battery cells, placing the tube in contact with each cell in the module. The cooling tubes for all modules are connected in parallel.

The BMS monitors system voltages, currents and temperatures to control the HV battery within safe operating limits and maximize battery capacity. The BMS receives information from sensors at the brick and module levels, including voltage signals from each of the BMBs and temperature signals from two sensors in each module. The BMS controls a system of switches and resistors to manage current “bleed” from each brick to maintain the bricks in balance and maximize the capacity the battery pack can provide.

The BMS in the subject vehicles has hundreds of diagnostic routines to monitor for anomalies in the HV battery, including diagnostics for state-of-charge (SOC) brick-to-brick imbalances.⁸ When anomalies are detected, the BMS may initiate an internal compensation (e.g., to balance brick voltages), trigger mitigations (e.g., range reduction or limits on vehicle restart or charging), or trigger warnings, such as, “Car needs service; Contact Tesla Service” or, for the most serious conditions, “Car shutting down; PULL OVER IMMEDIATELY.”

⁷ The battery packs in the subject vehicles contain up to 7,104 cells.

⁸ These diagnostics were part of the BMS prior to the release of the subject firmware updates that are the focus of this defect petition and have continued to be updated through Tesla’s standard practices in the months since the subject updates (see Section 3.5 “Tesla Updates”).

At the cell level, the subject vehicles contain design features that may disable the cells in response to certain short conditions, including separator shutdown, Current Interrupt Device (CID) activation, and cell interconnect fusing. Should single cell runaway occur, the subject battery packs are designed to prevent propagation to surrounding cells (Passive Propagation Resistance) by releasing the hot gasses through the top of the initiating cell and venting them away from the module.

3.3 China Fires

On April 21, 2019, a 2014 Model S experienced a battery fire in a parking garage in the Xuhui District of Shanghai, China, shortly after recharging the HV battery. Tesla's investigation of the fire identified several factors in common with other non-crash battery fires in China, including a fire in a 2015 Model S in Hong Kong, referenced by the petitioner, that occurred three weeks later. First, each of the fires occurred shortly after completing a Supercharging session to a high SOC. Second, the fires occurred when the vehicles were parked with the cooling systems off and the HV batteries remaining at high SOCs. Third, the vehicle histories showed high percentages of fast charging, average depth of discharge (DoD), and other stress factors for the HV battery packs (e.g., "top off" charging⁹ above 90 percent SOC).¹⁰ Lastly, the vehicles were equipped with battery packs using first or second-generation battery cells. Reviews of the Shanghai-Xuhui and Hong Kong fire investigations are provided in the following summaries:

Shanghai–Xuhui Fire. On April 21, 2019, a 2014 Tesla Model S P85 caught fire in a parking garage approximately 75 minutes after completing a Supercharging session to 96 percent SOC.¹¹ The vehicle had a high percentage of fast charging use (78 percent). Tesla's

⁹ "Top off" charging refers to the practice of re-initiating charging from a very high SOC after the system has completed the initial charge.

¹⁰ Tesla also noted other unique factors in the China non-crash fires, including a broken AC compressor in one vehicle and a remanufactured battery pack with a recent fault detection in another.

¹¹ Tesla provided ODI with a technical review of its investigation of the China fires on June 12, 2019.

investigation, conducted in conjunction with China’s safety regulators, did not find a root cause. However, the company believed the fire likely resulted from a combination of factors, including charging history and thermal conditions following a Supercharging session. Battery charging histories that include high stress conditions such as Supercharging increase the likelihood of developing internal cell failures that can lead to “weak short” conditions.¹² Thermal conditions following the Supercharging session may create conditions in which a single cell failure may propagate to neighboring cells, resulting in thermal runaway of the affected module.

Hong Kong Fire. On May 12, 2019, a 2015 Tesla Model S 85D caught fire in a parking garage approximately 74 minutes after completing a Supercharging session to 96 percent SOC. The vehicle’s charging history was almost exclusively fast charging (94 percent). The vehicle had previously been repaired as part of a unique process in China and Hong Kong in which a vehicle’s battery pack is removed, remanufactured and reinstalled.¹³ The vehicle had triggered a warning “car needs service” and a voltage fault was confirmed at a Tesla service center. However, the issue was not considered urgent and the repair was scheduled for the week after the fire occurred. The incident vehicles’ battery charging history and recent Supercharging session increase the likelihood that it may have shared characteristics with the Shanghai-Xuhui fire.

3.4 Other Non-Crash Vehicle Fires Cited by Petitioner

Apart from the incidents in China, Tesla stated that it is not aware of any non-crash HV battery fires associated with fast charging in the United States or any other country. The three incidents cited by the petitioner that did not occur in China include one HV battery fire that was not related to fast charging and two that were external to the HV battery. Reviews of the investigations of each of those incidents and a fourth non-crash fire incident that occurred in December 2018¹⁴ are provided in the following summaries:

¹² Frequent fast charging, high SOC, large swings in SOC (e.g., going from a high depth of discharge to a high SOC), specific patterns of rest intervals at low SOC, and “top-off” charging all result in high stress to the HV battery.

¹³ This process is not used in the United States.

¹⁴ <https://electrek.co/2018/12/19/tesla-model-s-fire-towing/>

West Hollywood Fire. On June 15, 2018, a 2012 Tesla Model S 85 experienced thermal runaway in Module 14 while driving on Santa Monica Boulevard in West Hollywood, California.¹⁵ Unlike the China fire incidents reviewed by ODI, there was no fast charging event prior to this fire, the vehicle was driving with the cooling system in operation when the fire occurred, and the vehicle had no fast charging in its service history.¹⁶ Tesla's investigation evaluated multiple potential causal factors in the affected module, but was unable to determine a root cause. Tesla has advised the Agency that it has not seen another similar fire. Because there was no fast charging prior to the incident and no history of fast charging, this incident is not believed to be related to the 2019 fires investigated in China.

Los Gatos Fire. On December 18, 2018, a 2018 Tesla Model S experienced runaway in Modules 13-16 after being towed to a tire repair shop in Los Gatos, California.¹⁷ The vehicle was not at a high SOC when the incident occurred and the vehicle had a low frequency of fast charging in its history (13 percent). In addition, the incident vehicle was equipped with a battery pack using later generation cells, putting it outside the scope of the subject vehicles for this petition evaluation. Tesla's investigation was unable to identify a root cause, but could not rule out physical damage. This incident is not relevant to this petition because it used different cells than what is at issue in this petition.

San Francisco Fire. On May 3, 2019, a 2014 Tesla Model S 85 caught fire while parked in a residential garage.¹⁸ Tesla's investigation determined that the fire originated in the rear drive unit. The fire did not originate in the HV battery and is not relevant to this petition.

Ratingen, Germany Fire. On July 30, 2019, a 2015 Tesla Model S 85D caught fire in Ratingen, Germany while parked in a parking lot. The vehicle was at a low SOC (approximately 40 percent) and had been parked for at least 14 hours when the fire occurred. The cause of the

¹⁵ Tesla provided ODI with a technical review of its investigation of the West Hollywood fire on September 6, 2018.

¹⁶ The vehicle had completed a slow AC charge at the owner's residence earlier in the day and then driven to a SOC of less than 89 percent at the time of the fire incident.

¹⁷ Tesla provided ODI with a technical review of its investigation of the Los Gatos fire on June 12, 2019.

¹⁸ Tesla provided ODI with a technical review of its investigation of the San Francisco fire on June 12, 2019.

fire is undetermined, but Tesla has determined that the origin of the fire was external to the HV battery pack.

3.5 Tesla Updates

As background, Tesla provides regular OTA updates to add new features or enhance existing functions to systems throughout the vehicle, including updates to optimize charging rate, charging capacity, and thermal management of the HV battery.¹⁹ The updates are numbered by the year and week of release and wave.²⁰

In May 2019, while continuing its investigation of the Shanghai-Xuhui fire, Tesla issued OTA firmware updates 2019.16.x revising fast charging and thermal management strategies at high SOC's for all Model S vehicles. Tesla has indicated that these changes were implemented as improvements to battery health, longevity and safety. In addition, OTA 2019.16.1, released May 15, 2019, included a dynamic algorithm that enables a limit on maximum brick voltage if the vehicle has a high ratio of DC fast charging in its history. This update was limited to vehicles equipped with first and second-generation battery cells. Tesla stated that the cell voltage limit was implemented as a precaution while Tesla continued to investigate the causes of the fires in China. A subsequent update, released in August 2019, restored some of the voltage capacity to affected vehicles.²¹

Staggered updates, released to targeted sub-populations of subject vehicles in November 2019 and December 2019, activated a new “weak short” detection algorithm designed to identify shorts months before they could potentially result in cell runaway. Vehicles in which the voltage

¹⁹ <https://www.tesla.com/support/software-updates>.

²⁰ The Safety Act imposes an obligation on manufacturers of motor vehicles and motor vehicle equipment to notify NHTSA when they determine vehicles or equipment they produced contain defects related to motor vehicle safety or do not comply with an applicable motor vehicle safety standard. *See* 49 U.S.C. 30118. This notice, referred to as a Safety Recall Report, must be filed no more than five working days after the manufacturer knew or should have known of the defect or noncompliance. *See* 49 C.F.R. 573.6(b); *see also United States v. General Motors Corp.*, 656 F. Supp. 1555, 1559 n.5 (D.D.C. 1987). NHTSA recognizes that over-the-air updates are issued for a variety of reasons including to offer new product features, fix software bugs, and to optimize vehicle performance. NHTSA, however, expects any manufacturer issuing an over-the-air update that mitigates a defect that poses an unreasonable risk to motor vehicle safety to file an accompanying Safety Recall Report pursuant to 49 CFR part 573.

²¹ OTA 2019.28.x.

limiting firmware had been enabled have received further incremental restoration of maximum-allowed brick voltage after receiving the “weak short” detection update.

3.6 VOQ Analysis

Through August 2021, ODI identified 67 complaints from consumers alleging reductions in battery capacity or charging speed in Model S and Model X vehicles, all but 4 of which were received after DP19-005 was opened.²² Six of the complaints involved Model S or Model X vehicles that are not in the scope of the subject vehicles (i.e., vehicles equipped with battery packs using later generation battery cells that were not affected by the firmware update with the algorithm that could limit maximum brick voltage). Of the 59 complaints involving subject vehicles through December 2020, 52 alleged reductions in battery capacity and driving range after receiving the subject OTA updates and 7 alleged reduced DC fast charging speeds.

Data provided by Tesla indicate that the maximum brick voltage firmware had been enabled in 30 of the 52 vehicles alleging reduced charging capacity. Of those vehicles, by the end of August 2021, Three had received a new battery under warranty, 26 had received full restoration of maximum brick voltage, and 4 continued to have maximum brick voltage limited at approximately 93 percent.²³ None of the vehicles have reported any thermal incidents or other safety hazards related to the HV battery.

4.0 Manufacturer Position

Tesla’s investigation of the non-crash fires in China did not identify a root cause or positively link the incidents to any design or manufacturing defect conditions.²⁴ The company identified a potential concern with internal cell shorts that may occur within a narrow range of resistance values that were below BMS diagnostic thresholds. Tesla stated that while such shorts occur very rarely, they can be caused by multiple factors and high-stress use can contribute to

²² The three complaints received before DP19-005 was opened were submitted by the petitioner or his client (see NHTSA complaint ID’s 11240787, 11246770 and 11246771).

²³ No data was available for two vehicles due to a lack of recent communication with Tesla’s remote diagnostics.

²⁴ Tesla’s investigation included forensic analysis of battery packs from incident vehicles and reviews of cell manufacturing process issues that may affect intercalation kinetics during fast charging.

their formation and growth. Internal cell shorts usually result in cell failure without leading to a thermal incident, but can progress to cell runaway. According to Tesla, under certain thermal conditions most likely to occur shortly after completion of a Supercharging session, cell runaway may overcome the passive propagation of the system and lead to module runaway. Tesla indicated that the latter has only been observed in China.

Tesla released several OTA firmware updates to improve the thermal management, fast charging strategy, and BMS diagnostics to detect early signs of internal cell shorts. Per the company, the updates will improve the durability and health of batteries subjected to high-stress use conditions, as well as providing an added margin of safety.

5.0 Observations

ODI's analysis of the petition allegations, information provided by Tesla, and information contained in consumer complaints finds the following:

- The voltage limiting firmware that is the focus of the petition was installed in just 27 percent of the vehicles cited by the petitioner and enabled in less than 1 percent.
- The subject OTA firmware is a dynamic algorithm that may limit maximum brick voltage based on battery usage stress. The voltage limit is based on fast charging history. Frequent fast charging is recognized as a stress factor that can adversely affect battery health, longevity, durability, lithium plating aging conditions and overall safety of lithium-ion batteries.²⁵
- Approximately 80 percent of the vehicles in which the firmware limiting maximum brick voltage was enabled have had the maximum voltage restored by August 2021 and almost all the remaining vehicle population had the maximum voltage partially restored to 93 percent or higher.

²⁵ A. Tomaszewska, Z. Chu, X. Feng, S. O'Kane, X. Liu, J. Chen, et al. (2019). *Lithium-Ion Battery Fast Charging: A Review*. eTransportation. 100011. 10.1016/j.etrans.2019.100011.

- A small number of vehicles have received new battery packs after receiving alerts triggered by the new “weak short” detection algorithm.²⁶
- There are many potential causes of non-crash battery fires in vehicles equipped with lithium ion batteries.^{27, 28} ODI looks for indications of a common cause or pattern of incidents when assessing evidence of a potential defect that may warrant investigation. While a pattern of fires occurring shortly after completing Supercharging sessions was observed in China, no similar fire incidents have been identified in the United States.
- The available data indicate that non-crash battery fires in Tesla vehicles are rare events. The fires occurring in vehicles parked at high SOCs shortly after completing Supercharging sessions have only been observed in China. High stress use factors appear to be more common in China. For example, the population of subject vehicles in China is approximately 6 percent that of the United States, but China has 51 percent more vehicles with fast charging histories of 80 percent or greater.
- The three fires cited by the petitioner that occurred outside China include two that did not originate in the battery (San Francisco and Ratingen) and a third that is unrelated to a fast charging event.
- No fires related to the subject condition have been observed globally since three fires in China and Hong Kong over a 48-day period from late-March to mid-May 2019.
- There have been no fires in the United States related to the subject condition.
- ODI will continue to monitor the battery performance of the subject vehicles.

6.0 Conclusion

²⁶ The weak short alert algorithm is independent of charging history. HV battery pack replacements have occurred in vehicles with the brick voltage limiting firmware enabled and in vehicles where it had not been enabled. The likelihood of receiving an alert was higher in the vehicles with the maximum brick voltage firmware enabled.

²⁷ Brewer, J., Nasser, A., Hommes, Q. V. E., Najm, W., Pollard, J., & Jackson, C. (2018, November). *Safety management of automotive rechargeable energy storage systems: The application of functional safety principles to generic rechargeable energy storage systems* (Report No. DOT HS 812 556). Washington, DC: National Highway Traffic Safety Administration.

²⁸ Stephens, D., Shawcross, P., Stout, G., Sullivan, E., Saunders, J., Risser, S., & Sayre, J. (2017, October). *Lithium-ion battery safety issues for electric and plug-in hybrid vehicles* (Report No. DOT HS 812 418). Washington, DC: National Highway Traffic Safety Administration.

NHTSA is authorized to issue an order requiring notification and remedy of a defect if the Agency's investigation shows a defect in the design, construction, or performance of a motor vehicle that presents an unreasonable risk to safety. 49 U.S.C. 30102(a)(9), 30118. Given the absence of any incidents in the United States related to fast charging, and the absence of any such incidents globally since May 2019, it is unlikely that an order concerning the notification and remedy of a safety-related defect would be issued due to any investigation opened as a result of granting this petition. Therefore, upon full consideration of the information presented in the petition, and the potential risks to safety, the petition is denied. The denial of this petition does not foreclose the Agency from taking further action if warranted, or the potential for a future finding that a safety-related defect exists based upon additional information the Agency may receive.

Authority: 49 U.S.C. 30162(d); delegations of authority at CFR 1.95 and 501.8.

Joseph Kolly,

Acting Associate Administrator for Enforcement.

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