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Tesla Motors Model S car catches fire on road

Incident occurred on October 1, 2013 near Seattle, WA

While nothing is totally conclusive yet, circumstances are suspicious re battery

Large Lithium-based EV batteries are potentially risky

Lewis Larsen

President and CEO
Lattice Energy LLC

October 3, 2013

abc NEWS

Tesla Stock Tumbles After Model S Catches Fire

SEATTLE October 3, 2013 (AP)

By MIKE BAKER Associated Press

AP

Shares of electric car company Tesla sank more than 6 percent Wednesday after an Internet video showed flames spewing from one of the company's vehicles near Seattle.

Source: http://www.king5.com/news/local/Tesla-stock-tumbles-after-Model-S-catches-fire-near-Seattle-226207191.html

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Key take-aways

- ✓ In July 2010, Lattice began to issue public warnings about thermal runaway risks with large, scaled-up Lithium-based battery packs; on Slide #54 in an August 6, 2013 Lattice presentation subtitled "A Fool's Paradise" we questioned whether Tesla's engineering had solved problematic runaway issues, or whether they had just been lucky - so far
- ✓ October 1, 2013 fire incident (really a form of battery runaway) with Tesla Model S that occurred near Seattle, WA suggests that they had merely been lucky to date --- battery thermal runaway issues have not yet been truly solved by Tesla Motors or anyone else
- ✓ As seen in the progression of news stories quoted from herein, Tesla began the news cycle by trying to assert that the battery pack had nothing to do with the hot fire that consumed the front end of a $70,000 car. By Wednesday evening they finally admitted that the battery was in fact the culprit, but that the incident had been triggered by the vehicle's impact with "metal debris" that had been lying on the road surface and that consequent mechanical damage to battery cells triggered the thermal runaway fire event; they are emphatically asserting that the battery did not catch fire spontaneously
- ✓ While Tesla's theory of the incident is plausible, it is inconsistent with statements made by the highway patrol officer --- trained to be keenly observant --- who first investigated the accident scene and found no evidence whatsoever of any claimed "metallic debris"
- ✓ Unless conclusive physical evidence is revealed that proves otherwise, Lattice believes it is more likely that the fire was caused by a spontaneous heat-event inside the battery

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LENRs are a very new type of green nuclear technology

Combustion of fossil fuels (strictly chemical processes involving outer valence electrons of nuclei):

Comments: emits copious quantities of CO_2, a greenhouse gas; comprises vast majority of mankind's energy production today

Scale of energy release: eVs (chemical regime)

Alternate natural sources of fuel: primarily oil, coal, and biomass; basic reaction: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ + energy

Controlled release of nuclear binding energy (fission and fusion; mainly involve strong interaction):

Comments: no CO_2 emission; emit dangerous *energetic* radiation (γ, neutron); today <10% of global energy production

Scale of energy release: MeVs (nuclear regime) > 1,000,000x all chemical energy sources

Heavy-element fission (involves shattering heavy nuclei to release stored nuclear binding energy):

Comments: requires massive shielding and containment structures to handle radiation; major rad-waste clean-up

Alternate natural sources of fuel: today, almost entirely Uranium; Thorium-based fuel cycles now under development

Heavy element U-235 (fissile isotope fuel) + neutrons → (complex array of lower-mass fission products; some are very long-lived isotopes) + energetic gamma radiation + energetic neutron radiation + energy

Fusion of light nuclei: (involves smashing light nuclei together to release stored nuclear binding energy):

Comments: present multi-billion $ development efforts (e.g., ITER, NIF, Tokamaks) focusing mainly on D+T fusion reaction; requires massive shielding/containment structures to handle 14 MeV neutron radiation; minor rad-waste clean-up $ vs. fission

Natural sources of fuel: Deuterium and Tritium (two heavy isotopes of hydrogen)

Most likely commercial fusion reaction involves: D + T → He-4 (helium) + neutron + energy (total 17.6 MeV; ~14.1 MeV in neutron)

Low energy neutron reactions (LENRs - key distinguishing feature is neutron production via weak interaction; neutron capture + gamma conversion to IR + decays [α, β] release nuclear binding energy):

Comments: early-stage technology; no emission of energetic neutron or gamma radiation; no long lived rad-waste products; LENR systems do not require massive and expensive radiation shielding and containment structures → much lower $ cost

Natural sources of fuel: any element/isotope that can capture ULM neutrons and release >0.78 MeV in nuclear binding energy

Involves complex, branching LENR nucleosynthetic transmutation networks that begin with neutron captures on seed nuclei then proceed from lower to higher values of atomic mass (A); very similar to what happens in stars, only at low temps/pressures

LENRs are neither fission nor fusion but something rather different

Low energy nuclear reactions (LENRs) are a uniquely green nuclear technology: no deadly energetic gamma or neutron radiation and no production of long-lived radioactive wastes

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Relevant Lattice documents

Convergence of advanced batteries, energetic materials and LENRs :

"Large increases in battery energy densities drive convergence between energetic materials, LENRs and batteries"

L. Larsen, Lattice Energy LLC, September 6, 2013 [110 slides with detailed table of contents]

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-increased-energy-densities-drive-convergence-of-batteries-and-lenrssept-6-2013

Document concerns great difficulties in containing and extinguishing thermal runaways:

"Systems to contain Lithium-based battery thermal runaways and fires; is it a feasible engineering goal or just a fool's paradise?"
L. Larsen, Lattice Energy LLC, August 6, 2013 [93 slides – includes detailed table of contents]

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-containment-of-lithiumbased-battery-firesa-fools-paradiseaug-6-2013

Index to large collection of documents re LENR theory, experimental data, and the technology:

"Index to key concepts and documents" v. #14
L. Larsen, Lattice Energy LLC, May 28, 2013 [88 slides] Updated and revised through September 12, 2013

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013

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Selected news stories: Oct. 1, 2013 Tesla Model S incident

abcNEWS

Source URL: http://abcnews.go.com/US/wireStory/tesla-stock-tumbles-model-catches-fire-20450475

Tesla Stock Tumbles After Model S Catches Fire

SEATTLE October 3, 2013 (AP)

By MIKE BAKER Associated Press

AP

Shares of electric car company Tesla sank more than 6 percent Wednesday after an Internet video showed flames spewing from one of the company's vehicles near Seattle.

Quoting directly: The incident happened Tuesday after 8 a.m. as the driver was traveling southbound on state Route 167 through Kent, said Trooper Chris Webb of the Washington State Patrol. The driver stated that he believed he had struck some metal debris on the freeway, so he exited the highway and the vehicle became disabled.

The driver told authorities he began to smell something burning and then the vehicle caught fire. Firefighters needed several attempts to extinguish the flames because the blaze kept reigniting, Webb said. A trooper who responded to the scene was unable to locate any objects on the roadway, but Department of Transportation workers did observe some debris near the scene.

Continuing quote: Webb said there was too much damage from the fire to see what damage the debris may have caused.

The automobile site Jalopnik.com posted photos of the blaze that it says were taken by a reader, along with a video. The video shows the front of the Tesla Model S in flames.

In a statement issued Wednesday, Tesla said the fire was caused by "substantial damage" to the car when the driver hit a large metal object in the road. The flames, the company said, were contained to the front of the $70,000 vehicle due to its design and construction.

"All indications are that the fire never entered the interior cabin of the car. It was extinguished on-site by the Fire Department," the statement said.

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Selected news stories: Oct. 1, 2013 Tesla Model S incident

Source URL: http://jalopnik.com/this-is-what-fiery-tesla-model-s-death-looks-like-1440143525

This Is What Fiery Tesla Model S Death Looks Like (UPDATED)

Incident video source URL: http://www.youtube.com/watch?feature=player_embedded&v=q0kjl08n4fg

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Selected news stories: Oct. 1, 2013 Tesla Model S incident

JALOPNIK

Image below: freeze-frame from amateur video of incident shows entire front-end of Tesla Model S completely engulfed in flames

Incident video source URL: http://www.youtube.com/watch?feature=player_embedded&v=q0kjl08n4fg

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Selected news stories: Oct. 1, 2013 Tesla Model S incident

KING5.com

Source URL: http://www.king5.com/news/local/Tesla-stock-tumbles-after-Model-S-catches-fire-near-Seattle-226207191.html

Local News

Tesla stock tumbles after Model S catches fire near Seattle

Credit: YouTube

by MIKE BAKER / Associated Press
Posted on October 2, 2013 at 2:52 PM
Updated today at 4:19 PM

SEATTLE - Shares of electric car company Tesla sank more than 6 percent Wednesday after an Internet video showed flames spewing from one of the company's vehicles near Seattle.

Quoting: The incident happened Tuesday after 8 a.m. as the driver was traveling southbound on state Route 167 through Kent, said Trooper Chris Webb of the Washington State Patrol. The driver stated that he believed he had struck some metal debris on the freeway, so he exited the highway and the vehicle became disabled.

The driver told authorities he began to smell something burning and then the vehicle caught fire. Firefighters needed several attempts to extinguish the flames because the blaze kept reigniting, Webb said. A trooper who responded to the scene was unable to locate any objects on the roadway, but Department of Transportation workers did observe some debris near the scene.

Webb said there was too much damage from the fire to see what damage the debris may have caused.

The automobile site Jalopnik.com posted photos of the blaze that it says were taken by a reader, along with a video. The video shows the front of the Tesla Model S in flames.

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Selected news stories: Oct. 1, 2013 Tesla Model S incident

abcNEWS **Source URL: http://abcnews.go.com/US/wireStory/tesla-stock-tumbles-model-catches-fire-20450475**

APNewsBreak: Tesla Says Car Fire Began in Battery

SEATTLE October 3, 2013 (AP)

By MIKE BAKER and TOM KRISHER Associated Press

AP

A fire that destroyed a Tesla electric car near Seattle began in the vehicle's battery pack, officials said Wednesday, creating challenges for firefighters who tried to put out the flames.

Company spokeswoman Liz Jarvis-Shean said the fire Tuesday was caused by a large metallic object hitting one of the battery pack's modules in the pricey Model S. The fire was contained to a small section at the front of the vehicle, she said, and no one was injured.

Quoting directly: In an incident report released under Washington state's public records law, firefighters wrote that they appeared to have Tuesday's fire under control, but the flames reignited. Crews found that water seemed to intensify the fire, so they began using a dry chemical extinguisher.

After dismantling the front end of the vehicle and puncturing holes in the battery pack, responders used a circular saw to cut an access hole in the front section to apply water to the battery, according to documents. Only then was the fire extinguished.

The incident happened as the Tesla's driver was traveling southbound on state Route 167 through the Seattle suburb of Kent, said Trooper Chris Webb of the Washington State Patrol. The driver said he believed he had struck some metal debris on the freeway, so he exited the highway and the vehicle became disabled.

Continuing quote: The driver, who did not return a phone call seeking comment, told authorities he began to smell something burning and then the vehicle caught fire.

Firefighters arrived within 3 minutes of the first call. It's not clear from records how long the firefighting lasted, but crews remained on scene for 2 1/2 hours.

Tesla said the flames were contained to the front of the $70,000 vehicle due to its design and construction.

"This was not a spontaneous event," Jarvis-Shean said. "Every indication we have at this point is that the fire was a result of the collision and the damage sustained through that."

There was too much damage from the fire to see what damage debris may have caused, Webb said.

The automobile website Jalopnik.com posted photos of the blaze that it says were taken by a reader, along with a video.

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Tesla Motors Model S

Overview of body, front/rear axle assemblies, electric motor and battery

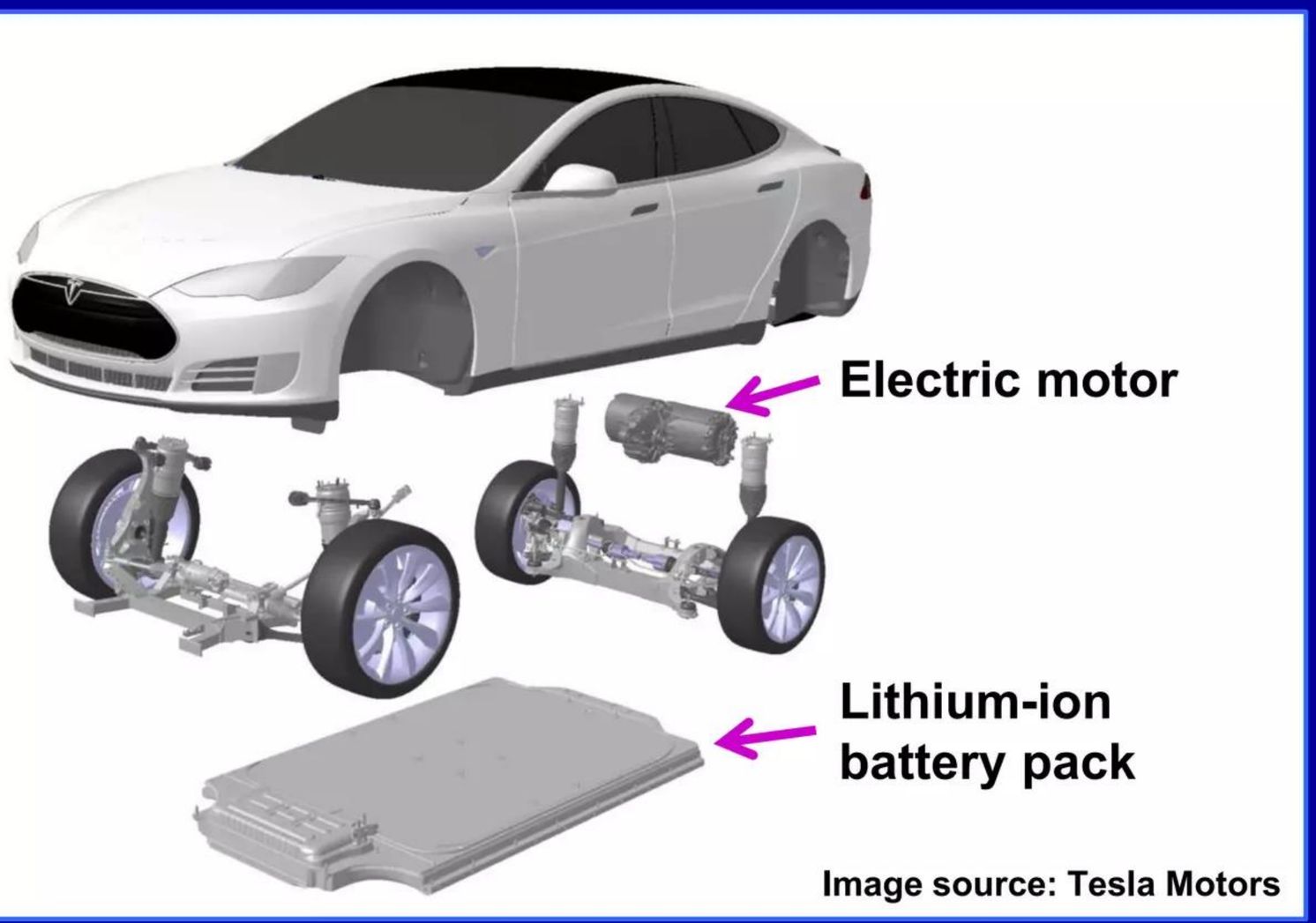

Image source: Tesla Motors

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Tesla Motors Model S

Front/rear axle assemblies integrated with battery pack and wheels

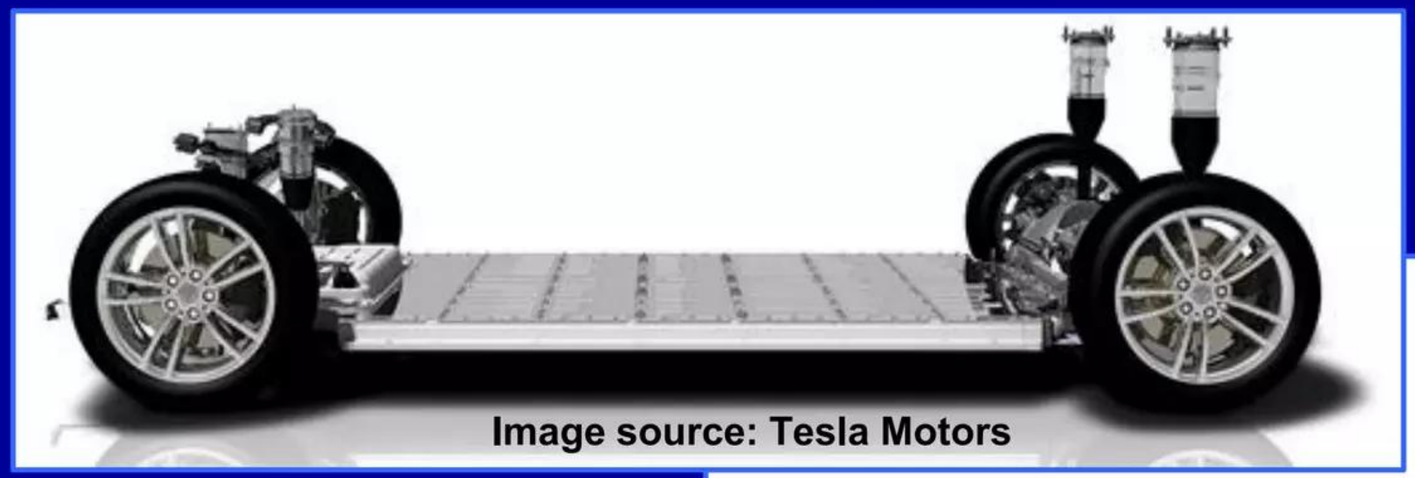

Image source: Tesla Motors

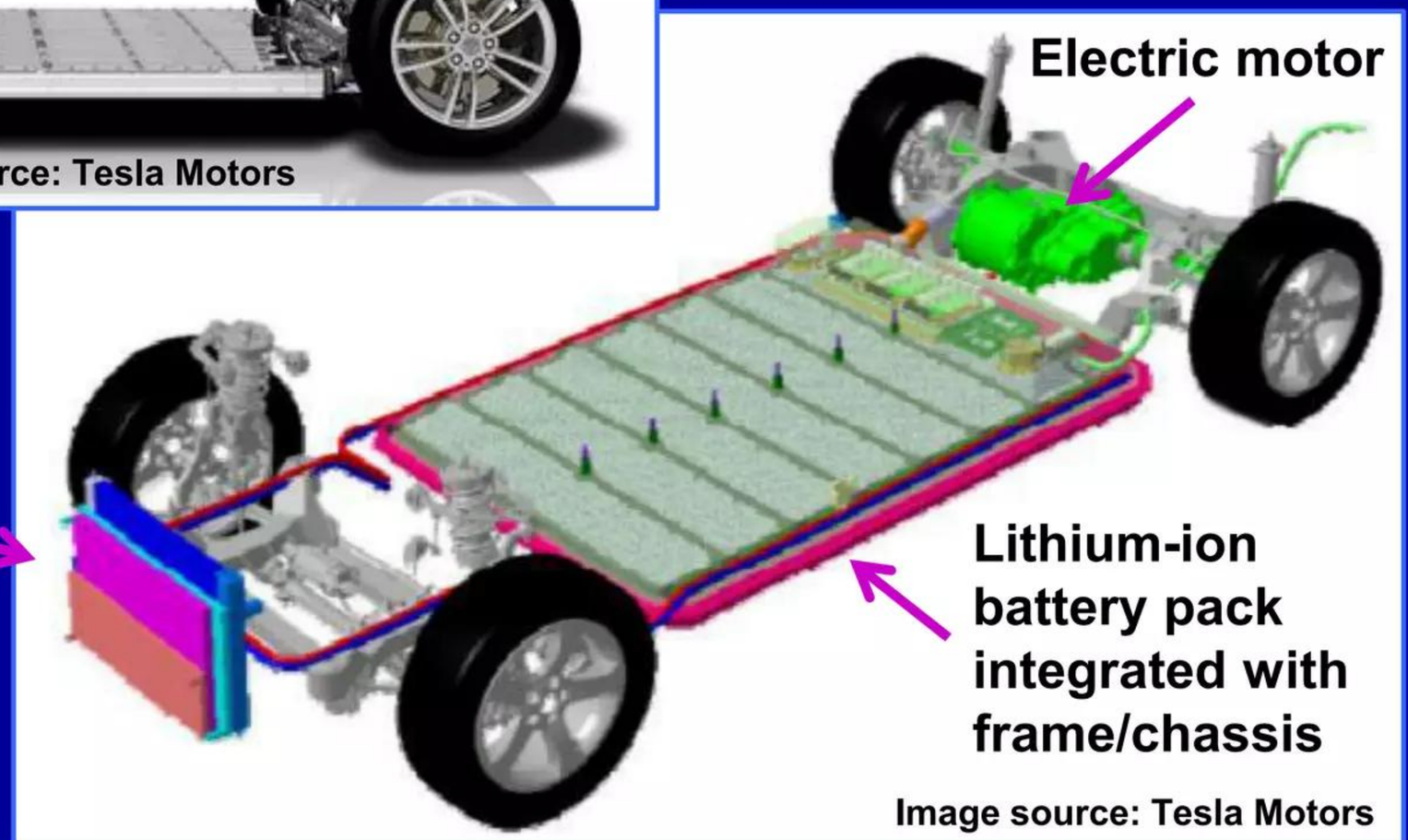

Image source: Tesla Motors

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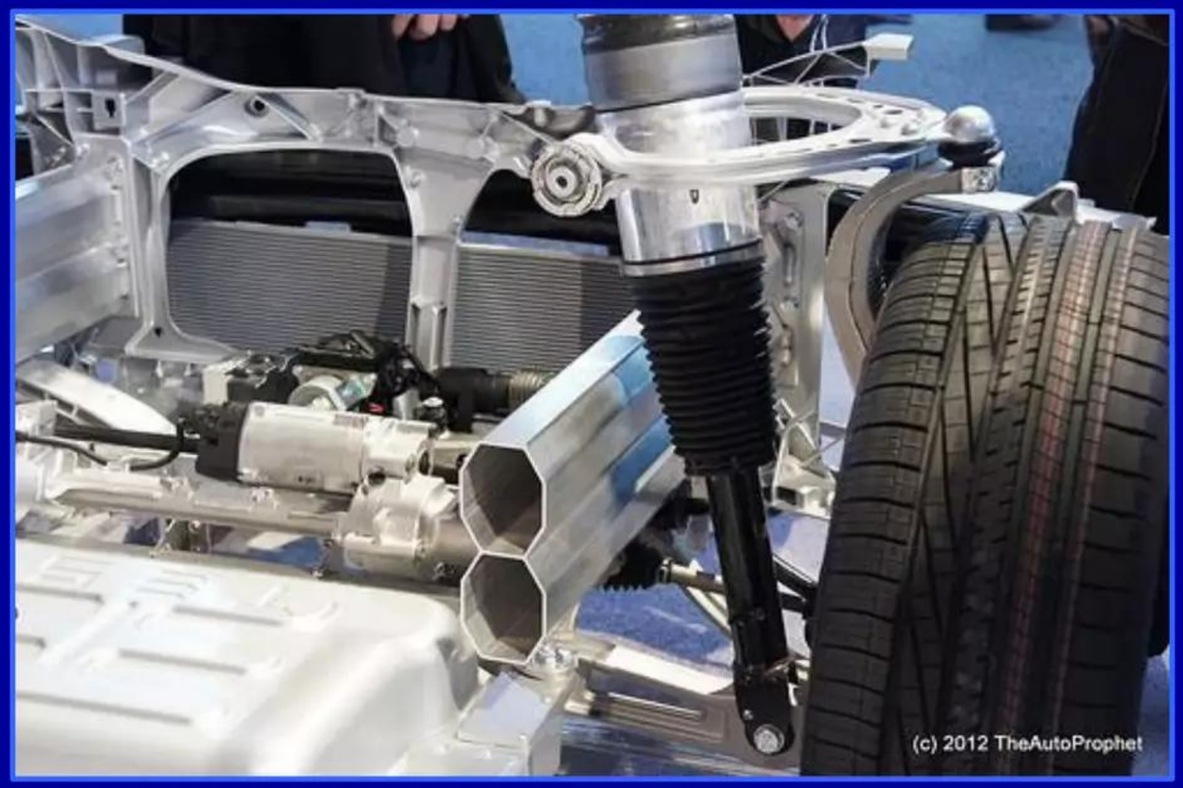
Tesla Motors Model S

Close-up images of front and rear ends of the vehicle



Front

Rear

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Tesla Motors Model S

Panning image shot from rear of vehicle shows integrated components

Image credit: GT Carlot

Thermal runaways:

batteries behaving badly

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Thermal runaways on mobile platforms

New applications for Lithium-based batteries in autos and aircraft

Fires and other dramatic types of incidents have received much media attention

LENRs may have served as triggers for an unknown % of these incidents

Within the past several years, there have been battery-caused:

- Incinerations of hybrid and all-electric consumer vehicles
- Houses burned to the ground (EVs, laptop computers)
- Cargo aircraft destroyed in flight with crew fatalities
- Thermal runaways on passenger aircraft (Boeing 787)
- Bizarre explosion of lithium-ion battery recycling plant
- Unexplained destruction of US Navy all-electric minisub
- And a myriad of other mishaps that have been reported

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Thermal runaways vary in Lithium-based batteries

- ✓ **Typically well-controlled electrochemical reactions in batteries ordinarily generate a certain amount of process heat which is dissipated harmlessly simply by emitting invisible infra-red radiation from the battery case out into the local environment; contents of battery cells still remain well-within proscribed boundaries of designed range of optimal thermochemical operating temperatures**
- ✓ **On rare occasions, for a variety of different reasons, a battery cell's electrochemical reactions can suddenly start running at greatly elevated rates that create more process heat than normal thermal dissipative mechanisms can easily handle, which then starts raising the temperature of battery cell contents out beyond their ideal safe operating range; threshold for out-of-control danger not yet crossed**

At key point --- call it a battery cell's Rubicon river --- a dangerous positive feedback loop is created: whereby, increasing cell temperatures further accelerate electrochemical reactions in cells which produces even more heat, boosting local cell temperatures even higher, etc.

Thermal runaways are thus born: only question is how bad they get before destroying enough of a battery to stop accelerating reactions

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Thermal runaway severity varies in Lithium-based batteries

"Garden variety" thermal runaways:

- Temps: ~300° C up to 600° C (Lattice's criteria)
- Reasonably well understood failure events
- Triggered by substantial over-charging or excessively deep discharges of Li batteries
- Triggered by external mechanical damage to battery cells, e.g., crushing, punctures; growth of internal dendrites pierces plastic separators

Field-failure thermal runaways can also include electric arc internal shorting:

- Temps: > 600° C - can go up to thousands of ° C with arcs
- Much rarer and comparatively poorly understood by industry
- Many believe triggered and/or accompanied by electrical arc discharges (internal shorts); what causes initial micro-arcs?
- Much higher peak temperatures vs. garden variety events
- Lattice suggests: super-hot low energy nuclear reactions (LENRs) could well be initial triggers for some % of them

Thermal runaways: batteries behaving badly

Thermal runaway severity varies in Lithium-based batteries

Garden variety single-cell thermal runaways can be as little as a battery that just heats-up a bit and simply stops functioning … or a battery's case can bulge significantly from internally generated heat without designed venting and releasing of contents from the inside before it stops functioning and then starts cooling down on its own

A slightly worse variant of a garden variety thermal runaway results in just a single cell venting or rupturing, but (in cases of flammable electrolytes) there are no hot, flaming battery contents spewed-out that could potentially ignite local combustibles and adjacent cells

In worst-case garden variety runaway, hot flaming electrolyte erupts from a ruptured battery cell, which may ignite nearby materials and cells; in this event variant **(that is still not the worst-of-the-worst),** internal peak temperatures usually not yet hot-enough to melt metals

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Thermal runaways: batteries behaving badly

Field-failures are truly catastrophic events in chemical batteries

Battery industry definition of a field-failure thermal runaway event:

> Safety concerns have been heightened by highly publicized safety incidents and ensuing widespread recalls of lithium-ion batteries used in laptop computers and cell phones [14, 15]. When these rare safety incidents occur, lithium-ion batteries operating under otherwise normal conditions undergo what appear to be spontaneous thermal runaway events, often with violent flaming and extremely high temperatures. Moreover, these failures usually involve cells and cell designs that have passed extensive abuse testing, including the standardized abuse safety tests. *Most such Li-ion safety incidents in the field are not preceded by any obvious external abuse*. We refer to these spontaneous safety incidents as "field-failures".

Source: "Batteries for Sustainability – Selected Entries from the Encyclopedia of Sustainability in Science and Technology," Ralph J. Brodd, Ed., Chapter 9 by B. Barnett et al., "Lithium-ion Batteries, Safety" Springer ISBN 978-1-4614-5791-6 (2012)

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Thermal runaways: batteries behaving badly

Absolute worst-case Armageddon runaways involve burning metals

Field-failure category of thermal runaways can reach extremely high peak temperatures of thousands of degrees Centigrade along with big electric arcs

Such temperatures are hot-enough to melt metallic structures inside batteries and combust almost anything and everything located within a battery case

If initiating spark is hot-enough, battery materials containing chemically bound oxygen will release it as O_2; by creating its own oxygen supply, combustion process becomes self-sustaining, self-propagating flame front that consumes all burnable battery materials. Progressive thermal fratricide between cells can reduce batteries to unrecognizable debris; such fires could burn in a vacuum

In absolutely worst-case events, even METALS can start burning in very fast, thermite-like reactions that can boost temps up to ~ 4,000° C; this is nightmare scenario wherein even deadly explosions with shrapnel can potentially occur

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Battery industry is encountering LENRs

Detailed description of LENR processes in batteries

Please note that as little as a single blazing hot LENR-active site measuring only 30 microns in diameter --- if it happens to occur in vulnerable physical location deep inside a battery cell and adjacent to the surface of a plastic separator only 25 microns thick --- can effectively vaporize a tiny local region of the separator, almost instantly turning it into a dense, micron-sized ball of highly conductive plasma. This would in turn create an electrical short between anode and cathode at that location, triggering a large inrush of electrical arc current through the breach in the separator dam. Intense local Joule heating would ensue from the arc current, further enlarging the breach and spatially expanding the superheated region inside a given battery cell. Depending on many complex, event-specific details, such a conflagration may or may not grow to engulf an entire cell; thus rare LENR events do not inevitably cause catastrophic heat runaways.

Under just the right conditions, a single microscopic LENR site can trigger a chain of energetic electrical (Joule heating) and chemical (exothermic reactions) processes that together create spatially autocatalytic, very macroscopic thermal runaway events that destroy battery cells billions of times larger than volumes of LENR site(s). In course of such runaways, 99.9^{+}% of total energy released is non-nuclear; hot spark LENRs are just an effective triggering mechanism. Also note that internal electrical shorts - whatever their cause - can also trigger runaways.

“I have learned to use the word ‘impossible’ with the greatest caution.”

Wernher von Braun