Incident Summary #II-1249163-2021 (#23871) (FINAL)

SUPPORTING INFORMATION	Incident Date		August 25, 2021
	Location		Richmond
	Regulated industry sector		Electrical - Low voltage electrical system (30V to 750V)
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Internal metal and plastic components of the main service switch were melted and damaged beyond repair. Two of the three fuses also had a black charred ring.
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		The 800 Amp 208 Volt main electrical service switch had two of its three metal switching mechanisms overheated and melted during periodic overloading.
INVESTIGATION CONCLUSIONS	Site, system and components		• The incident occurred in the electrical room of a commercial building that has multiple warehouse and office tenant spaces. • Main electrical service gear for the building consists of a three phase 800 Amp 208 volt service switch with fuses, metal conductor termination components, friction fit metal connection points, and insulating barriers made of thermoset polymer, which is a hardened type of plastic. • These connection points are the main disconnect means for the utility power to the building electrical system. • The connection point mechanisms have a flat piece of metal that swings to connect between two flat pieces of metal when the manual lever for the spring loaded switch is moved in the upward direction. When moved in the downward direction, the lever disconnects the switching mechanisms. • The 800A service switch is rated for a maximum of 80% continuous loading when feeding other than motor loads, which would be 640A, given the 800A fuse rating. If a lower amperage fuse was employed on the 800 Amp switch, the maximum continuous load would be 80% of the rating of the respective fuse. • Preventative maintenance methods for service switches may include periodic activities such as physical examination, termination tightening, and thermographic heat scans. **Applicable BC electrical code rule excerpts** **Section 14 – Protection and control** **14-010 Protective and control devices required** “Except as otherwise provided for in this Section or in other Sections dealing with specific equipment, electrical apparatus and ungrounded conductors shall be provided with devices for the purpose of automatically opening the electrical circuit thereto if the current reaches a value that will produce a dangerous temperature in the apparatus or conductor”

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	Section 8 – Circuit loading and demand factors • *Continuous load is defined in the BC electrical code below under 8-104, 3)* **8-104 Maximum circuit loading** "1) The ampere rating of a consumer's service, feeder, or branch circuit shall be the ampere rating of the overcurrent device protecting the circuit or the ampacity of the conductors, whichever is less. 2) The calculated load in a circuit shall not exceed the ampere rating of the circuit. *3) The calculated load in a consumer's service shall be considered a continuous load unless it can be shown that in normal operation it will not persist for a total of more than 3 h in any 6 h period if the load exceeds 225 A.* 6) Where a fused switch or circuit breaker is marked for continuous operation at 80% of the ampere rating of its overcurrent devices, the continuous load as determined from the calculated load shall not exceed the continuous operation marking on the fused switch or circuit breaker and shall not exceed 80% of the allowable ampacities of conductors selected in accordance with Section 4." **8-106 Use of demand factors** "8) Where additional loads are to be added to an existing service or feeder, the augmented load shall be permitted to be calculated by adding the sum of the additional loads, with demand factors as permitted by this Code, to the maximum demand load of the existing installation as measured over the most recent 12-month period" **8-210 Other types of occupancies** "The calculated load for the service for other types of occupancies shall be based on a basic load in watts per square meter based on the outside dimensions of the occupancy; plus special loads based on the ratings of the equipment installed with demand factors permitted by this code." Maintenance standards recommended by the manufacturer • NEMA KS-3: Guidelines for Inspection and Preventive Maintenance of Switches Used in Commercial and Industrial Applications (available online at www.nema.org) • NFPA 70B: Recommended Practice for Electrical Equipment Maintenance (available online at www.nfpa.org)
Failure scenario(s)	The 600 Amp service switch from the original build was upgraded to 800 Amp in 2013 as there were additional loads planned for a tenant space in the warehouse building. The upgrade to an 800 Amp service switch was proposed based on increased loads planned in a portion of the building fed from the main service but did not include a main service switch load calculation or historical load calculation data. A maintenance plan was proposed for the site at time of the service switch install but it did not include maintenance of the 800 Amp service switch. The warehouse building had air conditioning loads added since its original construction that were found to make up 57% of a service load calculation performed post incident. The calculated amount included air conditioning loads that had been added after the 800 Amp service upgrade. During high temperature climate events such as the heat dome in mid-2021,

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	the air conditioning units performed frequently and simultaneously to maintain temperature set-points in the building. Individual phases of the service switch were likely loaded over 80 percent of the equipment and fuse ratings periodically and possibly for continuous periods (over 3 hours in a 6 hour period). The overloading resulted in the metal connection points in the switch experiencing excessive heat and high resistance until eventually the metal components degraded to failure and the surrounding plastic insulators melted. One of the metal connection points eventually lost connection and tenant space power was affected, which prompted investigation by an electrician.
Facts and evidence	**Site observations** • Two of the three knife blade connection points for the service switch had degradation of the metal switching mechanisms and melting of the surrounding plastic insulating barrier components (Image 3). • The service switch was rated at 800 Amps. It has a label that states continuous load current is not to exceed 80% of the fuses employed in other than motor circuits (Image 2). The service switch fed a combination of various loads and was not limited to motor loads. • The service switch fuses were rated at 800 Amps. Two of the fuses had heat damage with circumferential ring charring with one ring quite darker than the other (Image 3). While the fuses were damaged, they had not blown. • The electrical room had a thermostat controlled exhaust fan. • Records indicate the main service switch was replaced in 2013. • Overhead images show rooftop/ air conditioner units added to the building since it was built including some after the service was upgraded to 800 Amp (Image 7). • There were no visual indications of loose terminations (such as a backed off Allen lug) or of heat damage at the line or load conductor termination points in the service switch (Image 1). • The area is subject to climate warming and events such as the 2021 heat dome. **Installing contractor statements** • The electrical contractor upgraded the service switch from 600A to 800A in 2013/2014. • As part of an upgrade of a sub service for a tenant space from 100A to 400A, the contractor made a general recommendation to upgrade from the 600 Amp switch to an 800 Amp switch. • 3 phase, 1 second increment load monitoring was performed and recorded for three days after the installation of the 800 Amp switch and the loads did not go above 80% of the 800 Amp rating. • The utility service conductors consisted of two 500 Kcmil aluminum conductors which the contractor found to be hot to the touch from use after installation of the 800 Amp service switch. These conductors were the same in place when the service was previously rated at 600 Amps. • Load readings were taken when the utility conductors were found to be hot to the touch and the service switch was loaded under 80% of its rating. • Roughly 2 years after the 800 Amp switch was installed, the contractor noticed that the electrical room was “stifling” and notified a tenant who arranged for installation of an air intake grill installation and an exhaust fan for the electrical room.

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- The contractor had proposed a maintenance plan to a facility representative which was not undertaken. The plan did not include maintenance on the 800 Amp switch.
- The 800 Amp switch had three parallel 500 Kcmil aluminum conductors per phase on the load (non-utility) side.

Repairing contractor evidence

- The electrical contractor performed a main service load calculation after the incident and the result was a calculated load of 1600 Amp based on equipment in place at the time of the incident, double that of the 800 Amp service switch.
- Roof top HVAC units made up 57 percent of the load calculation and a steam generator made up 16 percent of the load calculation.
- Post incident load testing in August 2022 for the main service indicated the highest current draws at 663.8 Amps (83%) and 646.9 (81%) Amps on two separate switch mechanisms, which is over 80% of the fuse and equipment ratings (Image 4).
- The contractor had not done maintenance on this switch prior to the incident.
- There was no evidence of any moisture ingress in the service switch.

Strata representative

- There are various air conditioning units on the rooftop of the building that were not there when the building was originally built.
- There was no history of the service switch overcurrent protection being tripped such as blown fuses or of the switch having to be re-energized.

Power usage information

- Utility metering data (Image 6) taken for a one year period (August 2020 to August 2021) including the date of the incident indicates an average peak load of 509.99 Amps. This is based on a load average of all three phases in 1 hour measurement periods and does not indicate the maximum loading per phase. Using the average of three phases does not provide accurate loading for each phase, for example if phase ‘A’ had 400A, phase ‘B’ had 600A, and phase ‘C’ had 800A, the loading data would show 600 Amps, with no awareness of an 800 A overloading on phase ‘C’.

Manufacturer statements

- The switch was manufactured on Feb 26 2013.
- The switch could conceivably experience failure given non motor loading over 80% of the fuse and equipment rating if it has a continuous load (over 3 hours).
- In the vast majority of cases, failure is [due] to application/ environment condition beyond the switch rating, errors during installation, or inadequate preventative maintenance.
- The label in the switch that states “Continuous load current not to exceed 80% of the fuse rating for other that motor circuits” applies when the switch feeds a combination of various circuits (heaters, motors, power, lighting, HVAC, etc.).
- For maintenance we recommend industry guidelines:
    - NEMA KS-3: Guidelines for Inspection and Preventive Maintenance of Switches Used in Commercial and Industrial Applications (available online at www.nema.org)
    - NFPA 70B: Recommended Practice for Electrical Equipment Maintenance (available online at www.nfpa.org)

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	Manufacturer product data • The data sheet available online for the HFC367N includes an environmental conditions section with an ambient temperature minimum -29 degrees Celsius to maximum 85 degrees Celsius.
Causes and contributing factors	**Cause** The failure of internal components of the service switch was likely caused by loading beyond 80 percent of the fuse and nameplate ratings periodically and possibly for continuous portions (over 3 hours in a 6 hour period). **Contributing factors** • The amount of air conditioning added to the building since it was built including after the service was upgraded likely contributed to the periodic overloading. • The service switch failing in an unsafe fire condition below its 800 Amp rated capacity is a contributing factor to the incident. • The upgrade to an 800 Amp service switch without a complete service load calculation or any historical load data was a possible contributing factor to the overloading. • The air conditioning units performing frequently and simultaneously during climate events was a reasonable contributing factor to the overloading. • The absence of service switch maintenance may have allowed for the heat and degradation to persist unnoticed. • The service switch conductor terminations had no visual indications of loose terminations or heat damage most likely ruling out loose conductor terminations within the service switch as a contributing factor. • Moisture ingress was not a plausible contributing factor.

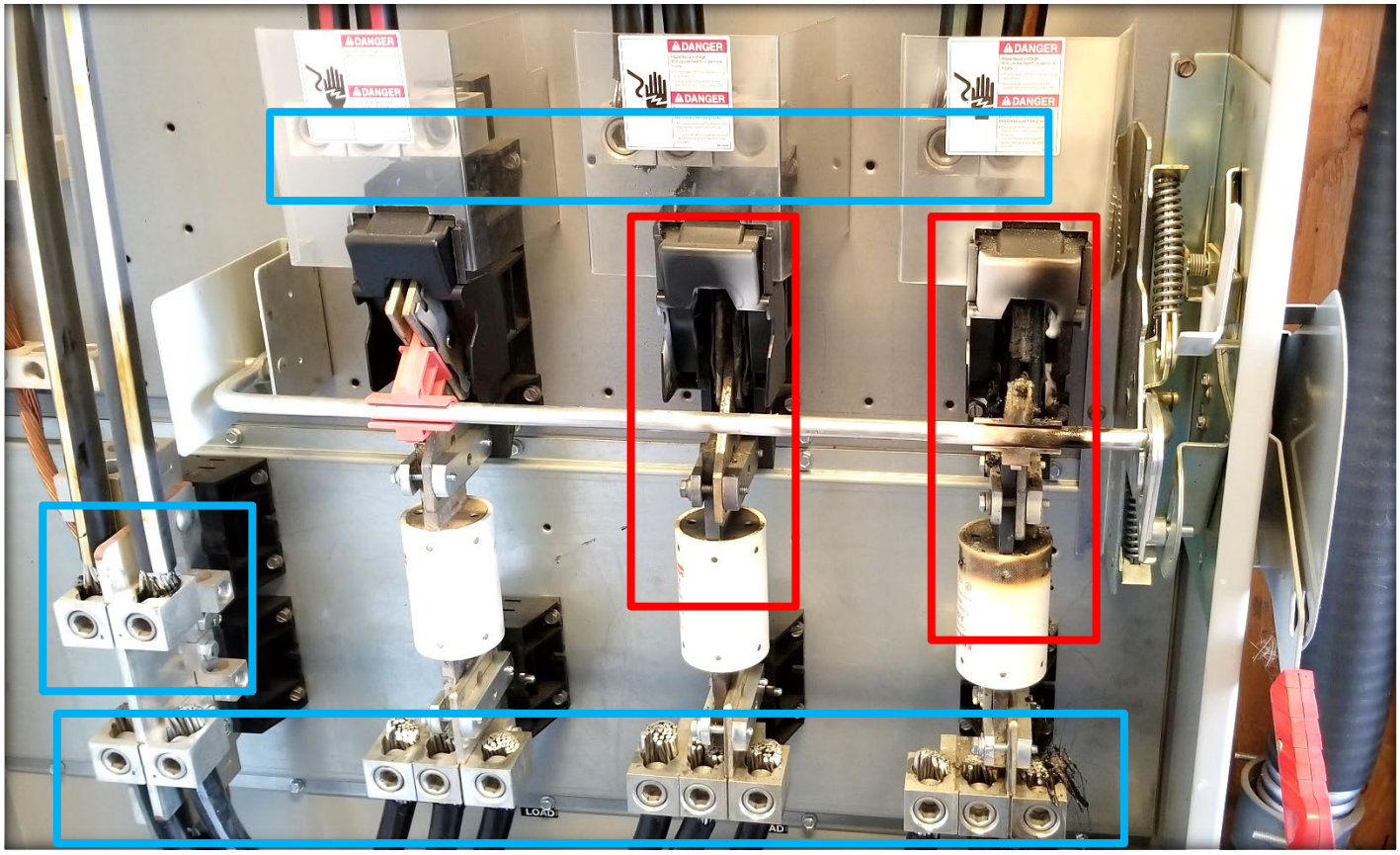
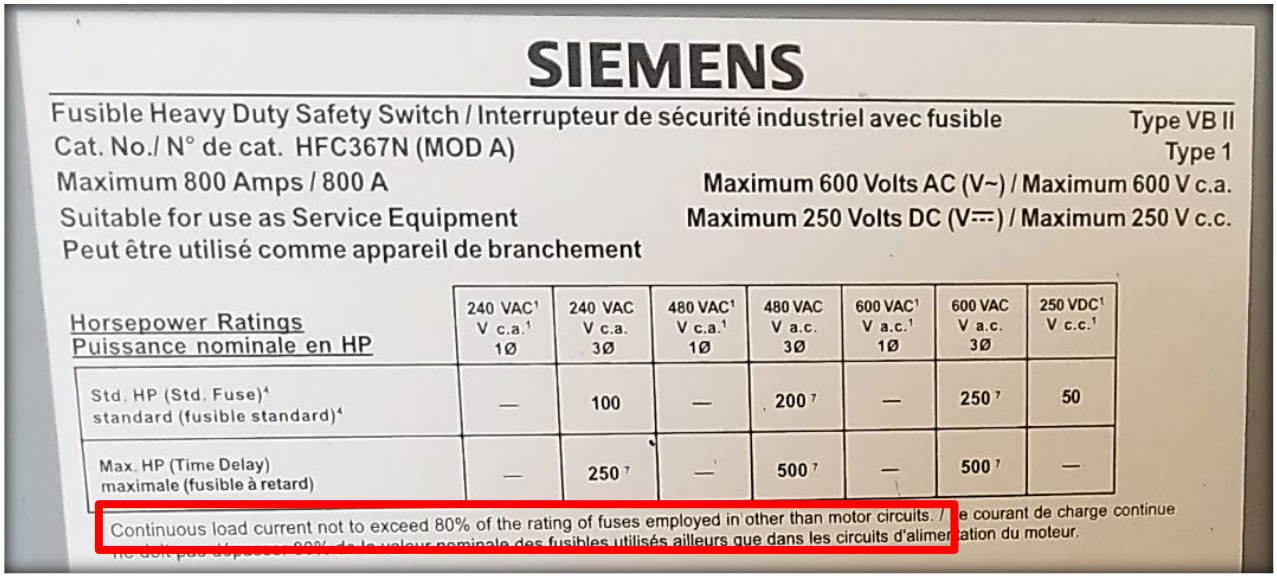


Image 1 - Service switch damage (red rectangles). No visual indications of loose terminations or heat damage at the conductor terminations (blue rectangles).



SIEMENS

Fusible Heavy Duty Safety Switch / Interrupteur de sécurité industriel avec fusible — Type VB II
Cat. No./ N° de cat. HFC367N (MOD A) — Type 1
Maximum 800 Amps / 800 A — Maximum 600 Volts AC (V~) / Maximum 600 V c.a.
Suitable for use as Service Equipment — Maximum 250 Volts DC (V⎓) / Maximum 250 V c.c.
Peut être utilisé comme appareil de branchement

Horsepower Ratings / Puissance nominale en HP	240 VAC[1] V c.a.[1] 1Ø	240 VAC V c.a. 3Ø	480 VAC[1] V c.a.[1] 1Ø	480 VAC V a.c. 3Ø	600 VAC[1] V a.c.[1] 1Ø	600 VAC V a.c. 3Ø	250 VDC[1] V c.c.[1]
Std. HP (Std. Fuse)[4] standard (fusible standard)[4]	—	100	—	200[7]	—	250[7]	50
Max. HP (Time Delay) maximale (fusible à retard)	—	250[7]	—	500[7]	—	500[7]	—

Continuous load current not to exceed 80% of the rating of fuses employed in other than motor circuits. / e courant de charge continue
ne doit pas dépasser 80% de la valeur nominale des fusibles utilisés ailleurs que dans les circuits d'alimentation du moteur.

Image 2 - Nameplate for service switch with amperage limit note for non-motor circuits.
Continuous load current not to exceed 80% of the rating of fuses employed in other than motor circuits.

Image 3 - 800 Amp service switch fuses and mechanisms with heat/ melting damage

Voltage [V]	AN	BN	CN	N
Max	122.2 V 8/6/2022 1:33:43 AM	121.8 V 8/6/2022 2:11:22 AM	121.8 V 8/6/2022 2:11:54 AM	
linear Avg	119.4 V	119.3 V	119.4 V	
Min	109.3 V 8/11/2022 4:58:33 PM	110.9 V 8/11/2022 4:49:08 PM	103.1 V 8/11/2022 1:18:17 AM	
Current [A]	**A**	**B**	**C**	**N**
Max	663.8 A 8/8/2022 2:48:32 PM	646.9 A 8/8/2022 2:48:32 PM	599.5 A 8/8/2022 2:48:32 PM	108.7 A 8/11/2022 8:48:53 AM
linear Avg	326.4* A	302.4 A	312.7 A	34.9 A
Min	207.1 A 8/12/2022 6:41:36 AM	178.7 A 8/10/2022 10:44:58 PM	157.7 A 8/11/2022 1:18:17 AM	18.4 A 8/10/2022 5:33:30 PM
Frequency [Hz]	**AN**			
Max	60.06 Hz 8/10/2022 5:33:31 PM			
linear Avg	60.00 Hz			
Min	59.83 Hz 8/11/2022 1:18:23 AM			

Image 4 – Post incident (Aug 2022) contractor testing indicating max current readings of 663.8 (83%) and 646.9 Amps (81%) on switch mechanisms above 80% of the fuse and equipment ratings.

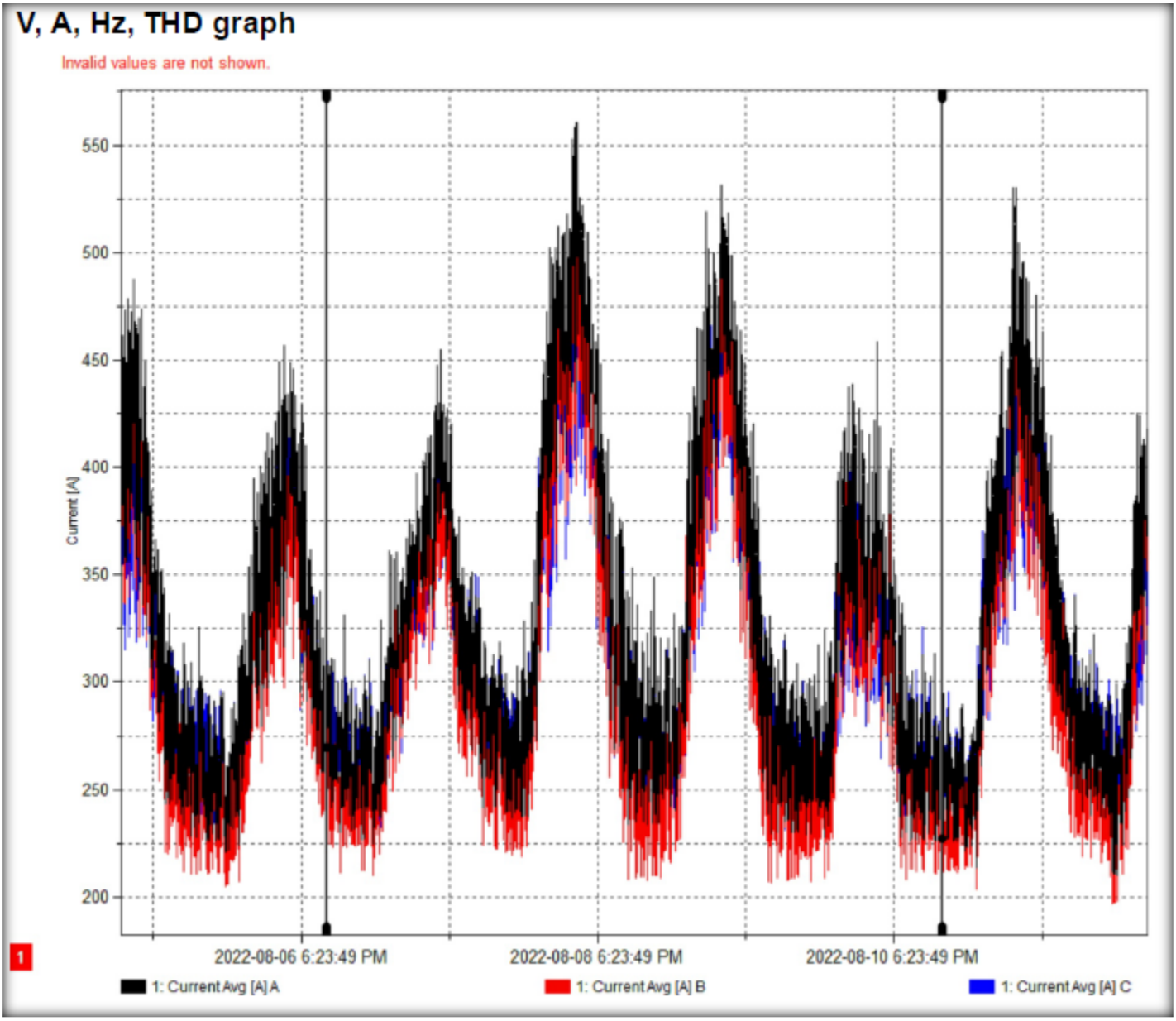


Image 5 - Post incident (Aug 2022) contractor testing indicating average current readings over 7-day testing.

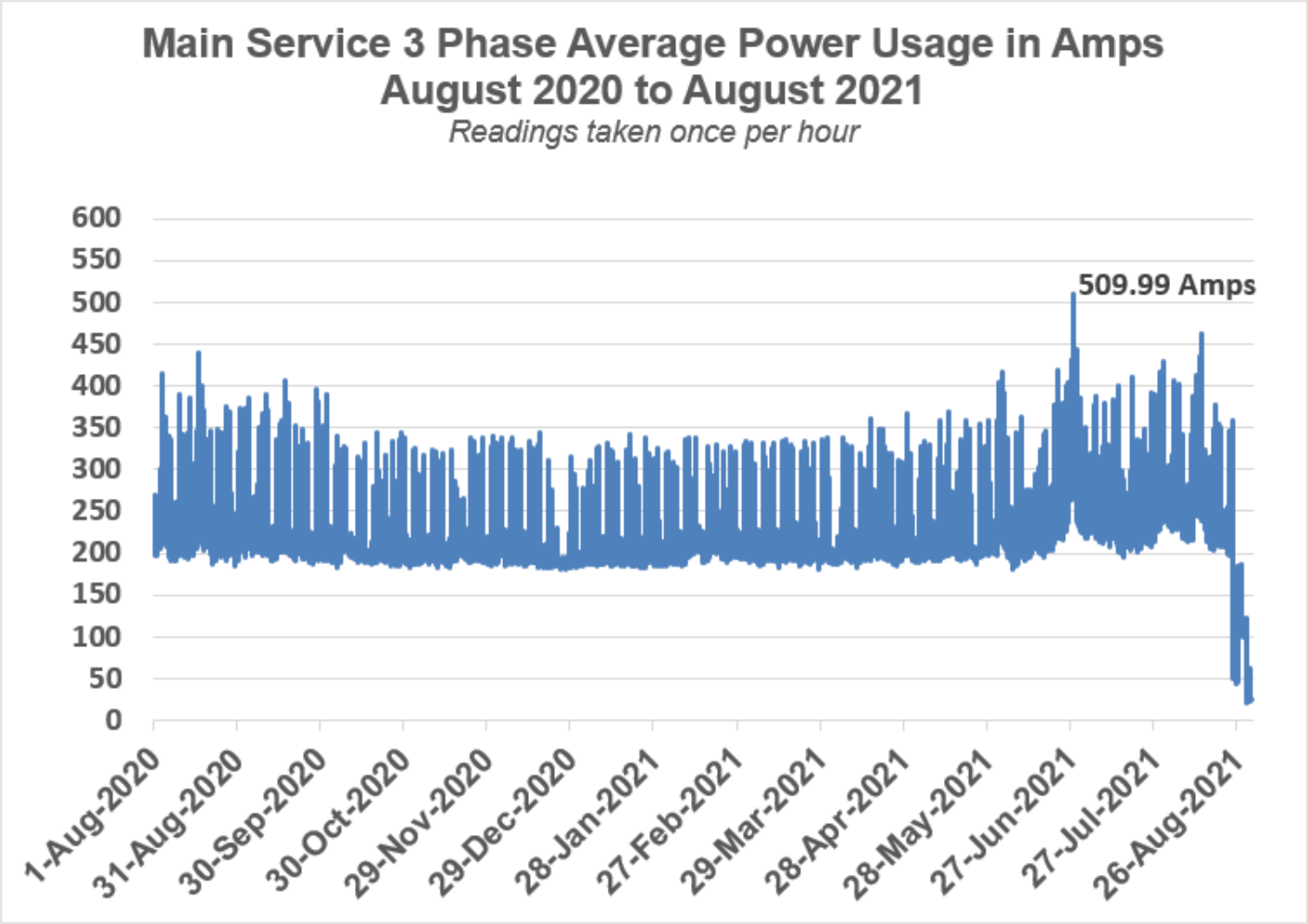


Image 6 – 3 phase power usage for 1 year prior to the incident with average peak at 509.99 Amps. Note that this indicates the average of the three phases and not the maximum power per phase.

Image 7 (2022) - Rooftop/air conditioner units added 2002 to 2014 (yellow) and 2014 to 2017 (red)

Image 8 – Reference image used to produce image 7 showing timeline.