Emergency Stops on Aircraft Gate Equipment
<u>Are Not</u> Intended for Normal Stopping of Machinery

Abstract

The objective of this paper is to explain the basics of airport gate ground support equipment operation, intended design (essentially), and why a continuous practice of stopping machines with their emergency stop buttons is not an appropriate or sustainable practice.

Introduction

Emergency stops, also called E-stops, are installed on machinery with a designed purpose to stop the equipment (entirely) during the occurrence of a catastrophic event. Generally, the consideration is to avoid; or mitigate, human injury. However, equipment and/or property damage can also be a consideration. The emergency stop could be used to "cut off" power to equipment in the event of a human caught in moving parts. Unusual electrical events, fires, and mechanical malfunctions, which could cause more damage if allowed to continue operating, can also be considerations. The design of emergency stop circuitry, within a machine, is governed by various safety related organizations. OSHA (Occupational Safety and Health Association), NFPA (National Fire Protection Association), ISO (International Organization for Standardization), IEC (International Electrotechnical Commission) and others. One design principle of an emergency stop is that it must "stop a process as quickly as possible without causing additional hazards" (from ISO). For many types of machinery, this simply means opening the main electrical input contactor and stopping the entire machine's operation. The following paragraphs will describe why stopping equipment, using an E-stop, is not an acceptable standard practice. It can impact the day-to-day reliability of airport gate equipment, use of the gate itself, and the overall life expectancy of the machines.

Normal Machinery Operations

Under normal circumstances, machines have an orderly sequence of shut-down operations that must be carried out. This orderly operation function could be controlled by instruction code written into a PLC (Programable Logic Controller) or a VFD (Variable Frequency Drive), installation of a series of permissive relay switch circuits; or combination of all. The reason for this orderly shut down sequence, instead of a complete "machine off" type of shut down, is for protection of various internal components in the machine. Electrical and electronic components can get hot while the machine is operating. Sometimes, cooling fans need to continue to run, for a period, to cool these components. Some electronic components need to "bleed off" stored electrical energy, to earth ground, to reach an equal electrical potential with ground (e.g., make components safe to handle without shock risk). Some types of electrical loads will induce a high voltage "spike", through the system, if circuit continuity is abruptly interrupted by E-stopping during operations. This won't be a complete Electrical 101 paper, so simply understand that some components store energy, by design, and need time to dissipate the stored energy before machine shut down. Some components in a machine need to remain pre-heated. E-stops are designed to remove all power and can remove power to some necessary component heaters. In the following paragraphs, I'll explain specific gate equipment and possible impacts of using E-stops as a standard means of stopping specific equipment.

GPUs

The GPU (Ground Power Unit) supplies electrical power to an aircraft at a gate. Often, solid state type power converters are utilized and that is what I'll be referring to in this paragraph. A standard and widely used commercial infrastructure power configuration in the United States is 480 Volts/3 Phase/ 60 Hertz. A fixed gate mounted GPU will utilize this standard electrical input power and convert it to 3 separate outputs of 115-117 Volts/Single Phase/400Hertz. Hertz is a unit of measure used to describe alternating current cycles. Again, this is not an Electricity 101 document, so just know that 400 HZ is the current cycle frequency that commercial aircraft

electrical systems employ. To convert 480V/3PH/60HZ power into 115 Volt/400 Hertz, the GPU may use input and output transformers, a means of AC to DC power conversion (Rectifier), and a DC to AC converter (Inverter). There are lots of other sub-components operating simultaneously within and about these main components, but this is an abridged description. There can be lots of high frequency switching, circuit filtering (capacitive and resistive), and energy-storage-and-release happening while the unit is operating. If an E-stop is activated while these things are going on in the equipment circuitry, catastrophic damage can occur to one or several components. Even if sudden damage doesn't occur, component life can be shortened by E-stop use. If human life or property damage is at risk, the trade of damaged equipment over risk to life/property is, of course, warranted. The E-stop should not; However, be used as the "normal" means of machine stoppage. When the standard stop button (the designed machinery stopping means) is pressed, the input contactor is not necessarily opened right away. Several internal checks are going on in the circuitry before input power is dislocated from the machine. This is a designed and purposeful sequential shutdown using feedback and permissive instruction to let the machine's main controller know everything is stable and ready to disconnect input power. Some possible issues with E-stopping are:

- Voltage spikes that can cause arcing of input contactor contacts.
- Voltage spikes that can blow fuses.
- Higher than normal (excited) voltage across transformer windings possibly causing premature wear/failure to down-stream components.
- Stored capacitor energy not being able to orderly and expediently bleed to ground, causing premature capacitor or resistor failure.
- Voltage spikes that can prematurely damage diodes and transistors.
- Power transformer, rectifier and inverter electronic components can generate heat that must be removed. Cooling fans are abruptly shut off during an E-stop, possibly causing high temperature damage.
- It's conceivable for a voltage spike from an E-stop to damage several interconnected components or circuits from a "domino effect".
- Considering the recent world supply chain issues, damage to sensitive electronic components (from using E-stops) should be avoided as gate equipment down-time could be lengthy.

PCAs

A PCA (Pre Conditioned Air) is used to Heat, Cool and Ventilate aircraft while parked at a gate. PCA and GPU machines are used as an on-ground alternative to aircraft auxiliary power units, onboard power systems, and onboard ventilation systems. They promote aviation fuel savings and cabin air quality. Gate mounted, DX (Direct Refrigerant Expansion) type of Pre Conditioned Air units are very common and that is what this paragraph is referring to. The PCA conditions ambient air that it draws-in from the zone near the aircraft gate. This incoming air is filtered, and temperature controlled, before being supplied to the aircraft cabin. This won't be a refrigeration and HVAC 101 paper, so this is a condensed explanation. Again, an orderly shut down is purposely designed into the stop circuit for a number of important reasons. The E-stop, by design, will disregard all the "normal" shut down sequences and interrupt power to the unit abruptly. This is perfectly acceptable if there is viable safety reason; However, not acceptable for everyday operational use. When the input power source is abruptly removed from a PCA, the same issues bullet pointed in the GPU section are true. Additional problems could also be introduced:

- E-stopping while in cooling mode can damage compressors and Variable Frequency Drive components (if used in the PCA design).
- E-stopping while in cooling mode can disconnect power to necessary refrigerant compressor crank case heaters. Compressor oil needs to remain warm and refrigerant in the compressor needs to be in vapor state before start-up. Catastrophic compressor damage can result if cold starting a refrigerant compressor.
- E-stopping in any mode can damage the blower rotation speed control system and/or blower motor.

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- E-stopping during heat mode causes excess heat build-up in the PCA's plenum (internal ductwork) due to airflow removal when the blower is stopped. There is a high temperature switch that will completely stop all function of a PCA. This is a safety circuit. Without the blower being able to cool the switch, because of how this safety circuit is meant to work, one must simply wait for the switch to cool naturally. This can take up to 4 hours. This is self-imposed down time
- Many, if not most, PCAs today are using staged/switched DC heaters. E-stopping during heat mode can cause catastrophic damage to DC heater elements and electronic staging components. Heater elements can get damaged from overheating due to lack of airflow. The designed shut down cycle will keep the blower operating until elements are cooled. The DC voltage resistance heaters can also lose their engineered path for the electrical energy's return to ground without input power for switching. Remember, input power gets abruptly removed when E-stopping. High voltage direct current energy, attempting to flow to ground without the designed switch path available, may open or weaken a connection and cause a "short circuit", thus ruining the heating elements and possibly other components.

The PCA heat mode orderly shut down process can take 2 to 3 minutes but understand that it is necessary. At times ramp operators may be tempted to use the E-stop to speed up the process of aircraft pushback. It's recommended to devise a system of departure operations, which allows for the engineered shut down sequence designed into the machinery. Perhaps begin the process of ground equipment stopping a bit earlier before an aircraft is pushed off the gate.

<u>Conclusion</u>

An emergency stop button is only to be used in the event of some type of human or property emergency. Gate equipment, such as PCAs and GPUs have a pre-engineered means of orderly shut down sequence of operations. This can only occur when the "normal" stop button is used. Any other means of shutting off the equipment risks possible machine damage and possible lengthy equipment downtime. There are also the unnecessary costs involved in repairing the damages of the equipment misuse. There are various reasons for people pressing equipment E-stop buttons at a gate. Some may not realize that it is only for emergency use. Some may be purposely using it to stop a machine immediately for an expedient aircraft pushback process. Whatever the reason, an E-stop should never be the "normal" daily means of stopping equipment. Other efforts to speed up a gate turn should be developed, while still allowing for the normal equipment shut down processes. The airline industry is interested in acting with more environmental awareness by reducing jet fuel use. Reducing fuel use also supports a profitable operation. Keeping PCAs and GPUs in proper working condition can assist that effort. Fixed gate electrically powered PCAs and GPUs are an environmentally responsible alternative to running an APU. Self-imposed gate equipment down time, due to frequent use of E-stops, can impair the environmental responsibility effort. In many cases the emergency stop can be moved to an alternate location which keeps it usable, for emergencies, but also isn't directly at a control station making it an easy option as a first means of stopping a unit.

The intension of this composition was to briefly explain, in layman's terms, harmful results of continuous equipment emergency stop usage. Hopefully this was achieved.

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