Elevator control system manufacturers began using static DC drives in the early 1970s on gearless mid and high-rise elevators, and also to some degree on low-rise geared elevators. The first type of static drive used was the SCR full wave bridge rectifier type, configured for four quadrant operation. The term “static” (no moving parts) was borrowed from the industrial drive industry and refers to the contrast with MG sets which are “rotating” drives, i.e. MG set = non-static drive.

The “SCR drive” as it was known, provided an alternative to the traditional motor generator set as the power source for elevator machines with DC motors and continues to be used in the elevator industry today primarily for modernization applications. The controlling circuitry of today’s commodity elevator drives have evolved considerably, moving from analog technology to digital signal processing, but the basic power transfer operation is the same as the original 1970 era OEM drives.

One type of “static power converter” not commonly recognized as a “drive”, is the single phase AC-DC converter supplying power to the MG-set shunt field. They are referred to as *generator field regulators*, because they replaced the traditional open loop rheostat controls. Other examples of smaller versions of static drives used within elevator control systems are variable voltage hoist motor field regulators and variable frequency AC drives used in closed loop door operator controls. Typically, each of these examples are typically small KW, single phase converters. The use of these smaller static converters in elevator controllers predates the use of large static drives on driving machine motor armatures.

Other types of “static” drives developed for the purpose of driving a hoisting machine are listed below:

- Variable voltage AC SCR Drives (Typically used on low-rise geared applications).
- AC non-regenerative VVVF IGBT Drives (Low-rise geared applications).
- 12-Pulse SCR DC Drives (Mid-rise and high-rise DC gearless applications).
- AC line-regenerative VVVF IGBT Drives (AC gearless applications).
- DC IGBT line regenerative chopper Drives (DC gearless applications).

In the historic sequence of elevator application, the DC SCR drive is most widely associated with AC line distortion. Other drive types may also produce line distortion and cause electrical system phenomenon, but it is the DC “SCR” drive used for elevator applications that is having a negative impact on the AC power system within buildings.

In transferring power between the three phase AC line and the hoist machine, the DC SCR drive exhibits significantly different electrical characteristics than that of an MG set. In the context of this guideline, the discussion is limited to those characteristics associated with and related to IEEE-519, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*. Some of these characteristics are listed below:

- Notch (line voltage notching).
- Harmonic Current Distortion Limits.
- Harmonic Voltage Distortion Limits.

IEEE-519 was originally published in 1981 as a set of guidelines for electrical utilities designers to properly design distribution systems that would have static drives as loads. IEEE-519 has been revised several times since its original publication in 1981. IEEE-519 continues to be a very thorough and well written document that explains line distortion effects at a very high technical level.

In the 1980s, references to IEEE-519 began to appear in elevator specifications because of the voltage and current distortions produced by the elevator drive system that interfered with other building systems. In some cases the IEEE-519 recommendations became “requirements”.

It is important to note as related to the elevator industry, that IEEE-519 is a recommended practice published by a technical trade organization. IEEE-519 is not a reference standard in A17.1/B44.

IEEE-519 sets recommended limits for harmonic distortion and line voltage notching energy at a specifically chosen physical location in an AC distribution system. This physical location is important because the effects of harmonic distortion and line voltage notching are changed by the impedance characteristics within the wiring of the building. The difficulty lies in defining the location of the Point of Common Coupling (PCC). From the point of view of the distribution designer, the PCC is the point on a public power supply system, electrically nearest to a particular load, at which other loads are, or could be, connected. The PCC is a point located upstream of the considered installation.

Identifying the appropriate PCC complicates the applicability of the IEEE-519 distortion limits for the elevator equipment specification. As a rule, the levels of line distortion that do occur at the PCC are not under the design control of the elevator equipment manufacturer or installer.
Predicting line distortion is difficult, because it depends on system impedances, those of the feeders and those of the source transformer. Since the elevator supplier does not design the distribution components, the elevator equipment supplier cannot guarantee specific levels of voltage distortion.

NEII recommends the use of Power Supply Confirmation Data Forms to define the electrical loads of the elevator system to the building power distribution system designer. These forms make reference to the drive type, which then alerts the power distribution engineer to be aware of the line distortion characteristics of the elevator drive system loads. Each drive type is well documented in the literature as to its electrical distortion characteristics.

Some benchmark guidelines and industry lessons learned related to elevators and IEEE-519 are listed below for reference:

- Elevators in general are proportionally a small load compared to other types of building loads. They therefore generate far less distortion as a proportion of total load on the power lines than HVAC, pumps and other systems.
- The PCC for elevators should be considered to be located at a tapable source for other equipment in the building. The location should be based on good design judgment and the likelihood that other equipment would, or would not be, affected by the operation of the elevators. The PCC should never be chosen as being at the elevator mainline disconnect switch in the near physical proximity to the mainline disconnect switch.
- If other building equipment could be affected by line distortion produced by elevator drives, it is best to apply dedicated feeders to the elevator equipment.
- The AC system source impedance, and therefore the resultant THD changes dramatically under emergency power operation with a building emergency power generator. Distribution designer PCC selection and feeder isolation may be critical related to other building loads.
- DC SCR drives draw current directly from the AC line proportionally to the DC current flowing in the motor armature. This is very different as compared to an MG set, which draws AC line current proportional to load KW. In an SCR drive, the current drawn during acceleration of the elevator could cause magnetic effects in feeders resulting in audible noise and ringing. It is commonly recommended to use conductor bracing and sound isolation for elevator feeders supplying equipment with static power converters.
- To gauge the influence within a distribution system, total harmonic distortion (THD) is most appropriately considered as a distortion of voltage, not current, and is therefore a function of building power distribution impedance from the drive to the PCC.
- Harmonic current distortion is most appropriately described in terms of total demand distortion (TDD), which implies a TDD as a percentage of all building loads on a common feeder. It is a term used in the design and analysis of utility distribution systems. It represents the amount of harmonic content, as a ratio of the total distribution system capacity.
- IEEE-519 limitations of harmonic content assume diversity in the load, and therefore should be considered when applying loads within a system.
- For DC SCR type drive systems, per elevator isolation transformers are usually very effective in limiting the effects line notching voltage distortion to acceptable levels at the secondary of the building system transformer, i.e. the most appropriate PCC. Again, system impedance and impedance ratios effect the level of line notch energy appearing at the PCC.
- For AC motor elevators with VVVF IGBT non-line regenerative drives, the harmonic current content is actually larger than that of SCR drives. This point is not widely recognized in the elevator industry, as IGBT AC-VVVF drives are thought to be “cleaner” than SCR drives.
- For AC motor elevators with VVVF IGBT non-line regenerative drives, experience has shown that individual elevator isolation transformers are not a "must need" requirement.
- Line regenerative AC VVVF IGBT drives can be configured to produce essentially zero harmonic current distortion at the lower harmonic frequencies. However, there may be higher frequency ripple currents produced by these drives, in the 5-15 kilo-hertz range of frequency.
- Line regenerative SCR drives produce harmonic current both when hoist machine is operating as a motor (lifting full load) and also when the machine is acting as a generator (lowering full load), and the drive is regenerating power to the line.
• Harmonic trap filters can be used to reduce distortion, but they have to be tuned for specific harmonic frequencies. They can not be assumed to eliminate all line distortion effects of elevator applied drives.

• An electro-Hydraulic elevator utilizing a soft starter may produce some nominal AC line distortion during start. After the starting period in the up direction, harmonic content can be assumed to be zero. On an RMS basis, any effect of a soft starter is negligible, and can be disregarded.

• Escalators can be assumed to not have harmonic content unless a soft starter is applied (or an inverter is applied for starting and / or inspection operation). Both of these operation modes are near balanced load condition. On inspection-type operation, if an inverter is used, only about 10% of full load current is drawn. Starting and inspection operation are infrequent operation modes, so the effect in terms of RMS is small, and probably could be disregarded. If the inverter is bypassed during continuous running, the harmonic content is zero during in service time.