



Department of Development Services

Building Division

4701 W. Russell Rd • Las Vegas NV 89118
(702) 455-3000
Ron Lynn, Building Official

July 11, 2007

TO: INDUSTRY

SUBJECT: Variable Frequency Drives Used In Smoke-Control Systems

This handout has been developed by the Clark County Department of Development Services Building Division (CCDDS-BD) to assist manufacturers, designers, contractors and special inspection agencies (MQAA) in understanding code requirements applicable to the use of variable frequency drives (VFDs) in smoke-control systems. These guidelines only apply to projects permitted under the 2006 International Building Code as amended and adopted by Clark County. The following subsections are summarized from Section 909, which regulates the design, installation and acceptance testing of smoke-control systems. VFDs used in smoke-control systems must meet the following requirements.

909.2 General design requirements. ... smoke control systems shall ... (be) designed in accordance with ... Section 909 ... and well-established principles of engineering.... Construction documents shall include sufficient information ... to demonstrate compliance...

909.3 Special inspection and test requirements. ... smoke control systems ... shall undergo special inspections and tests ... to verify proper commissioning ... in its final installed condition ... under ... Section 1704.

The MQAA is required to confirm smoke-control systems meet the applicable requirements of Section 909.

909.4.6 Duration of operation. All portions of ... smoke control systems shall be capable of continued operation ... for ... 20 minutes...

It is the designers' responsibility to design and protect all portions of a smoke-control system within the intent of this section. To meet the intent of this section, sensitive electronic equipment, such as VFDs, need to be in protected locations. When mechanical rooms are not used as plenums, VFDs and other sensitive electronic equipment within the mechanical room are considered protected within the intent of this section. When VFDs and other sensitive equipment are installed within the smoke zone they serve (including mechanical rooms serving as plenums), the designers must provide protection within the intent of this section.

The MQAA is responsible to confirm that VFDs and other sensitive equipment are installed in protected locations, or otherwise protected from smoke and heat.

909.10 Equipment. ... shall be suitable for its intended use, suitable for the probable exposure temperatures ...

VFDs are required to be installed so that the expected temperatures do not exceed the limitations of the device. In most cases, it will be necessary to install VFDs in a temperature controlled portion of the building. Installing a VFD within an air-conditioned enclosure on a roof will only be considered by CCDDS-BD when it can be assured that the enclosure will be maintained within the limitations of the device at all times.

It is the designer's/contractor's responsibility to ensure that VFDs are properly protected and are appropriate for the intended use (including probable temperatures at the installed location). VFDs to be used for a specific project are required to be specified on the construction documents and smoke-control diagram details.

The MQAA is responsible for confirming that compliant VFDs have been used and that they are installed in a suitable location. A statement of compliance is also required in the final report.

909.10.5 Fans. ... shall be selected for stable performance ... Motors driving fans shall not be operated beyond their nameplate horsepower ... and shall have a minimum service factor of 1.15.

Compliance with these constraints shall be taken into account by the designer/contractor when selecting equipment. VFDs are not allowed to be used when their setting will either create unstable performance or exceed a fan's horsepower rating. Additionally, a minimum service factor of 1.15 must be designed into the system, but is required as a safety factor and is not allowed to be taken advantage of for system's operation (See Section 909.16.3).

Confirmation of compliance is the responsibility of the MQAA.

909.11.1 Power sources and power surges. Elements ... relying on volatile memories ... shall be supplied with uninterruptible power sources ... to span a 15 minute primary power interruption ... Elements ... susceptible to power surges shall be suitably protected ...

VFDs with volatile memories are required to be connected to an uninterruptible power supply (UPS). Potential power surges from both the municipal supply and transfer to secondary power supplies need to be taken into account by the designer/contractor when selecting equipment. The designer/contractor must clearly specify on the construction documents and smoke-control diagrams whether a VFD contains nonvolatile memory or that a UPS will be used. When a UPS is to be used, the performance criteria of the UPS must also be clearly specified on the construction documents/control diagrams.

Testing by the MQAA is required to confirm transfer to secondary power, protection from power surges and either nonvolatile memories or a UPS.

909.12 Detection and control systems. Fire detection systems ... shall comply with ... Section 907. Such systems shall be equipped with a control unit complying with UL 864 and listed as smoke control equipment.

Control systems ... shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override, the presence of power downstream of all disconnects and, through a preprogrammed weekly test sequence... report abnormal conditions...

Underwriters Laboratories (UL) Standard 864 was originally developed to confirm the integrity of fire alarm control panels (FACPs) and was later modified to include UUKL as a subcategory for smoke-control system equipment. The primary intent of UL 864 is to focus on the integrity of the overall system. When a FACP transfers alarm signals to a building management system (BMS), a listing in accordance with UL 864 (and UUKL when transferring smoke-control commands) is required for the BMS.

Provided VFDs are used as end devices only (motor starters for example) and failure of one VFD to perform properly would only affect the associated fan, VFDs are not required to be listed under UL 864-UUKL. In these cases, an electrical listing in accordance with UL 508/508C is required for the VFD. A VFD is required to be listed in accordance with UL 864-UUKL when its failure will affect smoke-control equipment or operations other than the end device. VFDs listed in accordance with UL 864-UUKL can be expected to resolve some of the concerns addressed in this guideline and as such, a UUKL listing for VFDs may be beneficial to all parties even when not specifically required.

CCDDS-BD interprets that the verification required by Section 909.12 need only be confirmed when the system is activated (configured) in a smoke-control mode (including the preprogrammed weekly test sequence). Fan supervision is typically provided by pressure or current sensors calibrated to distinguish proper operation from a fault condition.

Confirmation of appropriate listing is to be included with the construction documents and MQAA final report. The MQAA is responsible to confirm that compliant VFDs have been installed; fan supervision sensors are properly calibrated to distinguish proper operation from a fault condition and the preprogrammed weekly test sequence functions correctly.

909.15 Control diagrams. ... *showing all devices in the system and identifying their location and function shall be maintained current and kept on file...*

909.16.3 Control action and priorities.

1. ... *control actions (from the firefighter's smoke-control panel) shall have the highest priority of any control point within the building. ... no automatic or manual control from any other control point ... shall contradict the control action. Where automatic means are provided to interrupt normal, non-emergency equipment operation or produce a specific result to safeguard the building or equipment ..., such means shall be capable of being overridden by the firefighter's control panel. The last control action ... by each firefighter's control panel switch position shall prevail. ...*

EXCEPTION: *Power disconnects required by the ... Electrical Code.*

2. *Only the AUTO position of each ... firefighter's control panel switch shall allow automatic or manual control actions from other control points within the building.*

This section does not intend that manual overrides be able to bypass internal safeties of VFDs or motor starters. The minimum service factor of 1.15 required for motors driving fans in conjunction with the limitation to not exceed the fan's name plate horsepower (see Section 909.10.5) provide the level of protection intended by Section 909.16.3.

VFDs are typically designed with faceplate keypads for programming and control. When the smoke-control system is activated, this keypad must be overridden and all faceplate control/programming functions must be disabled. When all faceplate control/programming functions are not automatically overridden upon activation of the smoke-control system, the keypad must be removed and stored in an approved location where it can only be attached when necessary.

Furthermore, these keypads are frequently designed with an “Off” feature. CCDDS-BD has determined that this “Off” feature does not meet the power disconnect requirements of the electrical code. Activation of the smoke-control system is required to disable all faceplate control/programming functions of the VFD, including this “Off” feature. Due to this, CCDDS-BD recommends that the keypad be removed, so that the keypad with a non-functional “Off” feature will not be misinterpreted to imply a safety override that does not exist (i.e. off means off). Other options for designating a non-functional face plate can be proposed for CCDDS-BD consideration. This might include an automatic description on the faceplate readout that appears whenever the smoke-control system is activated, such as “FIRE OVERRIDE MODE”.

When the keypad is to be removed and a blank cover plate is required by the listing of the VFD to protect the connections, the cover plate must be installed. This will also restrict replacement with a spare keypad that could inadvertently be used to take control of the VFD when the smoke-control system is activated. When a blank cover plate is not required by the listings, the designers must determine what protection of the connections, if any, is necessary and address the method of protection to restrict installation of a spare keypad.

The designers must specify on the construction documents/control diagrams and MQAA final report if the keypad will be overridden or if it will be removed. If the keypad will be removed, these documents must specify if it will be replaced by a blank cover plate and if not, why not, as well as where it will be stored.

The MQAA is responsible to confirm that VFDs comply with Section 909.16.3 through testing automatic and manual controls. When the keypad is not removed, the MQAA is expected to confirm that the VFD control/programming functions are not operable when the drive is in smoke-control mode.

909.17 System response time. *Smoke control system activation shall be initiated immediately after receipt of an appropriate ... command ... Upon receipt of an alarm condition at the fire alarm control panel, fans, dampers and automatic doors shall have achieved their expected operating state and confirmation of proper operation shall be indicated at the smoke control panel within 60 seconds.*

The MQAA is responsible to confirm that VFDs comply with this section through testing.

909.18 Acceptance Testing. *Devices, equipment, components and sequences shall be individually tested...*

909.18.5 Fans. *Fans shall be examined for correct rotation. Measurements of voltage, amperage, revolutions per minute...*

909.18.7 Controls. *... Control sequences shall be verified ... including ... override from the firefighter's control panel and simulation of standby power conditions.*

The MQAA is responsible to confirm that VFDs are thoroughly tested and perform as intended.

909.18.8 Special inspections for smoke control. *Smoke control systems shall be tested by a special inspector.*

909.18.8.3 Reports. *A complete report of testing shall be prepared by the special inspector or special inspection agency. The report shall include identification of all devices by manufacturer, nameplate data, design values, measured values and identification tag or mark. ...*

909.18.9 Identification and documentation. *... documents identifying and locating each component of the smoke control system, and describing its proper function and maintenance requirements shall be... an attachment to the report ... Devices shall have an approved identifying tag or mark ...*

The MQAA is responsible to ensure the requirements, performance and information mandated by the preceding code sections are complete and included in the final report.

Revisions to these Guidelines:

It is the designer's responsibility to confirm that they meet the most recent edition of these guidelines. Revisions will become effective as of the date of the revision and will not apply to designs that were approved by CCDSD-BD prior to the date of the revision.

Please call 455-3000 if you have any questions or comments regarding these guidelines.



NEIL BURNING, CBO
Manager of Plans Examination