

COOLING TECHNOLOGY INSTITUTE

Variable Frequency Drive Application Guidelines for Cooling Towers



May 2013

ESG-151 (13)

This document was developed using the consensus procedure outlined in the CTI Operating Procedure 304
and has been approved for publication by the CTI Board of Directors



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This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



This document has been reviewed and approved as part of CTI's Five Year Review Cycle. This document is again subject to review in 2018.

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CTI-Bulletin
ESG-151 (13)
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1.0 System Responsibility

1.1 It is recommended that the cooling tower manufacturer first be consulted as to whether the cooling tower is suitable for variable speed operation. The VFD supplier must confirm that the VFD selected is compatible with the tower drive system and properly applied for cooling tower applications.

1.2 Final set-up and adjustment of the VFD is to be performed by the VFD supplier or an authorized factory service technician.

1.3 The VFD drive must be adjusted so that tower fan drive train does not experience cogging or torque ripple. These torque fluctuations can occur at various frequencies over the operating speed range (ref. MG-1 Part 30, sect. 30.02.2.8)

2.0 Fan Operating Characteristics

2.1 Cooling tower fans are of the axial flow propeller type. This means their performance follows the affinity laws for centrifugal fans, compressors and pumps

where:

$$\left(\frac{n_2}{n_1}\right) = \left(\frac{q_2}{q_1}\right) = \left(\frac{d_2}{d_1}\right)$$

Where:

n = RPM
q = Capacity
d = Diameter
t = Torque
h = Head
p = Horsepower

$$\left(\frac{n_2}{n_1}\right)^2 = \left(\frac{h_2}{h_1}\right) = \left(\frac{t_2}{t_1}\right) = \left(\frac{d_2}{d_1}\right)^2$$
$$\left(\frac{n_2}{n_1}\right)^3 = \left(\frac{p_2}{p_1}\right) = \left(\frac{d_2}{d_1}\right)^3$$

Therefore, at 1/2 speed the fan will produce 1/2 the air flow at 1/4 the pressure and consume 1/8 the horsepower.

2.2 Cooling towers should be designed to match the required duty to avoid temperature control problems. Towers with excess capacity (for future expansion, etc.) should be designed and set up to avoid excessive cycling i.e. the fans pitched to match the present duty. Variable speed controls should include the capability to cycle the variable speed drive on/off at minimum speed when required to keep cold-water temperatures from excessively dropping below the set point.

3.0 Motor Speed Control

3.1 Single & Two Speed Motors

Refer to CTI Manual, Chapters 10 and 11 for guidance and recommendations for single and two speed motor controls. Proper time delays need to occur prior to any speed change. This includes Off/On, High to Low, and Low to

High. Refer to CTI technical paper TP97-10 for information on damage that occurs from fast switching.

3.2 Variable Frequency Drives and Features

The following minimum features and specifications should be included on any variable frequency drive that is applied to cooling tower fan drives. These features minimize excessive vibration and accelerated gear, motor and drive shaft fatigue in general operating conditions:

3.2.1 Cooling tower fans are variable torque applications. It is recommended that the VFD be of the variable torque type. Constant Torque drives are not recommended.

3.2.2 To minimize motor cogging a vector control type drive (shall be used. A Volts/Hertz drive is unacceptable.

3.2.3 A VFD bypass feature is recommended) to operate the motor at 100% speed in the event of a drive failure or to properly test the tower performance. A bypass feature is not required if total loss of the cooling tower is acceptable.

3.2.4 An adjustable current/torque limiting feature shall be included.

3.2.5 The VFD shall include separate adjustments for acceleration and deceleration ramps. These ramps shall be adjusted as required to prevent a trip caused by the torque characteristics of high inertia loads. The programmed deceleration time should be greater than the time required for the fan to coast to a stop when the motor is de-energized.

3.2.6 The VFD shall include adjustments to eliminate objectionable drive induced motor noise.

3.2.7 The VFD shall include a critical frequency lockout function for at least three speeds. The bandwidth shall be adjustable.

3.2.8 The VFD shall have the capability to ride-through a momentary power outage without tripping.

3.2.9 The VFD shall have a flying start function to permit the VFD to restart into a motor spinning forward or reverse, without tripping.

3.2.10 The VFD shall be programmable to remain tripped or automatically restart following a trip.

3.2.11 The VFD shall be capable of being disconnected from the motor under load without damage.

3.2.12 The VFD shall include U.L. approved overload protection for single motor applications.

3.2.13 Although not generally recommended; in applications where one VFD supplies multiple motors, special operating procedures may be required. Consult the VFD manufacturer. To meet NEC requirements, each motor must have its own overload protection. The VFD supplier should supply detailed instructions to insure a correct installation.