The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

June 2026
Vol. 03, No. 06

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho\overline{U}\overline{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U}_i}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho\overline{U}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ biomedical research facilities.

Variable Frequency Drive (VFD) Installation and Compliance Requirements

The upcoming *Design Requirements Manual (DRM)* revisions outline a significant shift in how variable frequency drive (VFD) systems must be designed, reviewed, commissioned, and accepted. The primary change is that VFD design is no longer limited to selecting equipment that appears compliant at the component level. The architect-engineer (A/E) and the Office of Research Facilities (ORF) must evaluate the VFD as part of the complete electrical, mechanical, controls, and operational system. The designer is now accountable for demonstrating that the selected VFD topology, harmonic mitigation approach, control interface, bypass strategy, and commissioning plan will support safe, reliable, and measurable system performance under both normal and abnormal operating conditions.

A major requirement is the evaluation of system-level electrical impact. For new installations, retrofits, and replacements, the A/E must evaluate applicable system impacts such as transformer capacity, thermal loading, available short-circuit strength at the point of common coupling, generator interaction, uninterruptible power supply (UPS) compatibility, protection coordination, and potential mis-operation risk. Manufacturer data sheets alone are not sufficient to establish compliance. The design must include an engineering analysis to demonstrate that the proposed VFD installation will not create unacceptable electrical distortion, instability, nuisance tripping, equipment overheating, or adverse interaction with existing infrastructure. ORF review must confirm that these studies are included in the design scope and verify that the assumptions, system boundaries, and acceptance criteria are clearly identified and documented.

Harmonic compliance is now defined at the point of common coupling rather than at the VFD terminals. This is a critical change. Drive-level total harmonic distortion of current (THDi) values may be useful for comparison, but they do not establish system compliance. The A/E must evaluate aggregate harmonic distortion from all relevant nonlinear loads, including the interaction of multiple drives on the same distribution system. The design must include harmonic analysis during the design phase (i.e., basis of design) and field verification after installation. ORF must ensure that the commissioning scope includes harmonic measurements, documentation of actual field conditions, and confirmation that the installed system performs as modeled.

The revised requirements also make VFD topology selection a documented engineering decision. The A/E must evaluate available options such as 6-pulse drives with mitigation, 12-pulse or 18-pulse configurations, active front end (AFE) drives, and other low-harmonic technologies. Selection must be based on life-cycle cost and system performance, not initial cost alone. Energy efficiency, harmonic performance, physical footprint, maintenance requirements, reliability, spare parts availability, motor compatibility, and operational risk must also be considered. This revision means that low-harmonic and AFE-based solutions are no longer unusual or exceptional options. They must be considered where appropriate and either selected or rejected with a documented technical basis.

Revised requirements also emphasize transient system behavior in pressure-critical, containment, and mission-critical environments, including biosafety level (BSL)-2, animal biosafety level (ABSL)-2, BSL-3, ABSL-3, BSL-4, aseptic processing facilities (APFs), operating rooms, airborne infection isolation rooms (AIIs), and other spaces where airflow, pressure relationships, or containment are essential for safety, research, or clinical operations. The design must maintain airflow and pressure stability during startup, shutdown, failure, transfer, restart, and recovery conditions. Steady-state operation alone is not sufficient. Control sequences must prevent unsafe pressure excursions, and fan speed changes must be coordinated to avoid instability. For these applications, building automation system (BAS)-to-VFD control must include hardwired point-to-point interfaces where deterministic operation is required. Network-only control is not

'Design Requirements Manual (DRM) News to Use' is a monthly ORF publication featuring salient technical information that should be applied to the design of NIH biomedical research laboratories and animal facilities. NIH Project Officers, A/E's and other consultants to the NIH, who develop intramural, extramural and American Recovery and Reinvestment Act (ARRA) projects will benefit from 'News to Use'. **Please address questions or comments to:** megan.teague@nih.gov

The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

June 2026
Vol. 03, No. 06

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho\overline{U_i}\overline{U_j})=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U_i}}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho\overline{U_i}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ biomedical research facilities.

acceptable where communication latency, failure, or loss of integration could compromise safety or containment.

Bypass selection shall be based on a documented evaluation of system behavior following VFD failure. Bypass shall be provided for VFD-driven motors serving critical systems where loss of the drive would result in unacceptable impact to life safety, mission-critical operations, research continuity, or essential facility functions, unless operation at full speed would result in unsafe conditions, loss of required control, loss of containment, system instability, or unacceptable operational impact. In some applications, operating across-the-line during VFD failure may create unacceptable airflow, pressure, starting current, protection, or operational risks. The A/E must identify what happens during VFD failure and determine whether bypass, redundancy, standby equipment, or another strategy is the correct solution. ORF must review bypass decisions carefully, especially where failure behavior could affect critical environments, laboratories, containment spaces, or essential facility operations.

The revised *DRM* also clarifies responsibility across chapters:

- Chapter 6 establishes the application context and required system behavior
- Chapter 7 and Section 13.9 address controls, sequencing, and integration
- Chapter 10 governs electrical performance, harmonics, topology, and system impact

A/E submissions must therefore be coordinated across disciplines, not prepared as isolated mechanical, controls, and electrical sections. ORF review will verify that the mechanical sequence of operation, BAS integration, electrical design, harmonic study, commissioning requirements, and failure-mode response are consistent with one another.

Retrofit and replacement work must no longer be treated as simple like-for-like equipment substitution. Existing systems may not have sufficient transformer capacity, short-circuit strength, harmonic tolerance, feeder capacity, motor compatibility, grounding integrity, or control architecture to support new VFD installations. Before replacing or adding drives, the A/E must evaluate the existing infrastructure and identify required upgrades, mitigation, or operational limitations. ORF must ensure that retrofit projects include adequate investigation and do not rely on outdated assumptions based only on the previous installation.

Finally, Appendix D shall be treated as guidance only and not as the governing compliance source. Compliance decisions must be based on the applicable *DRM* chapters and project-specific engineering analysis. The overall direction of the revised requirements is performance-based. The A/E and ORF must ensure that assumptions are validated, system interactions are analyzed, design decisions are justified quantitatively, and commissioning acceptance criteria are measurable. Examples may include verification of VFD operation under load, BAS point-to-point control, hardwired safeties and interlocks, alarm reporting, communication-loss response, restart after power loss, restart into a coasting motor where required, emergency power transfer and retransfer, bypass or standby-equipment operation, pressure and airflow recovery, and harmonic measurements at the defined Point of Common Coupling.

References

1. National Institutes of Health (NIH), *Design Requirements Manual* (*DRM*), Chapters 6, 7, 10, and 13 and Appendix D (upcoming Revision 2.2).