U.S. NUCLEAR REGULATORY COMMISSION

April 1982

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.68.3
(Task RS 709-4)

PREOPERATIONAL TESTING OF INSTRUMENT AND CONTROL AIR SYSTEMS

A. INTRODUCTION

General Design Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires that structures, systems, and components important to safety be tested to quality standards commensurate with the importance of the safety functions to be performed. Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires that a test program be established to ensure that all testing, including preoperational testing, required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed. Instrument and control air systems supply pressurized air to operate various loads, including components and systems that are required to perform functions important to safety. This guide, which is a revision of and replaces Regulatory Guide 1.80, describes a method acceptable to the NRC staff for complying with the Commission's regulations with respect to preoperational testing to verify that instrument and control air systems[1] and the loads they supply will operate properly at normal system pressures and to ensure the operability of functions important to safety in the event that system pressure is lost, reduced below normal operating level, or increased above the design pressure of the air system components to the upstream safety valve accumulation pressure.

B. DISCUSSION

Instrument and control air systems typically furnish pressurized air to a wide variety of equipment in nuclear power plants. The extent to which such air systems are used varies with different designs of both the nuclear and the balance-of-plant portions of the facility.

Because of the diversity of loads normally supplied, there is a possibility for unsafe interactions. Therefore, it is important that testing be done to verify proper functioning during normal operation and to determine the effects of total loss, reduction, or increase of the pressure within the entire instrument and control air distribution system and portions thereof.

It is essential that testing verify that the system will respond appropriately to both normal operation of the plant and upset, faulted, or emergency conditions with consideration being given to (1) complete and sudden loss of pressure resulting from such postulated events as inadvertent valve operation in the supply system, severance of a system pipe, loss of offsite electric power, loss of d.c. power, and component malfunction; (2) partial or gradual loss of system pressure to the entire distribution system or portions thereof resulting from such events; and (3) increases in pressure due to component malfunction or failure.

Air-operated valves and other air-operated components are normally designed to respond in a given manner, i.e., fail open, fail closed, or fail as is, if the instrument and control air supply is lost or its pressure is reduced or increased. Verification of system response to a loss-of-air-pressure event is an essential part of testing at the preoperational stage, at which time it can be accomplished with a minimum risk to power plant equipment and personnel. Testing also provides a means for determining the adequacy of operating and emergency procedures for coping with a loss of air supply.

Preoperational testing of the instrument and control air system following construction of the plant and installation of the instrument and control air system will help ensure that the air supply equipment (compressors and associated controls and backup air supplies) and the equipment provided to maintain the quality of air supplied (e.g., filters and dryers) will function within design requirements.

[1] The recommendations of this guide should also be applied to (1) compressed gas systems that, although not designated as instrument and control air systems, supply loads that could affect the overall safety and performance of the plant, (2) compressed gas systems that supply loads only to specific systems that are important to safety, and (3) systems important to safety that use compressed gases other than air.

The applicant is responsible for developing a suitable preoperational test program for the instrument and control air system. This includes preparing adequate procedures for carrying out the program, properly conducting the preoperational tests, and establishing the validity of the test results by adequate review and approval.

C. REGULATORY POSITION

As part of the initial preoperational testing program and also after major modifications or repairs to the instrument and control air system or portions thereof (e.g., where air-flow-rate requirements are significantly altered or where opened systems are subject to contamination), the system and loads should be tested as described below to verify that all components function properly at normal pressures and following possible pressure increases and that the systems respond as designed to a loss-of-air-pressure event.

1. The test program for the instrument and control air system and associated equipment should include the applicable prerequisite checks, verifications, and tests provided in Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."

2. Compressors, aftercoolers, oil separator units, air receivers, and pressure-reducing stations should be tested to verify proper operation according to system design. The operation of compressor unloaders, automatic and manual start and stop circuits of standby compressors, high- and low-pressure alarms, pressure indicators, and temperature indicators should be checked. Relief valve settings should be verified.

3. Air dryer units should be tested for proper functioning, and the units should be operated through at least one regeneration cycle. Acceptable operation at maximum flow rates should be verified. The appropriate differential pressures and proper operation of pressure switches, high- and low-pressure alarms, safety and relief valves, bypass valves, and alarms and resets should be verified.

4. It should be verified by test that the instrument and control air system will meet system design specifications relating to flow, pressure, and temperature of the product air.

5. It should be established by appropriate measurements or observations that the total air demand at normal steady-state conditions, including leakage from the system, is in accordance with design.

6. The ability of the system to meet the quality requirements of the system design should be verified. ANSI/ISA S7.3-1975, "Quality Standard for Instrument Air,"* is an acceptable standard with respect to oil, water, and particulate matter contained in the product air. The quality should be verified by analyzing the air at the end of each feeder line using continuous flow techniques or by analyzing a discrete sample.

7. When redundant components and air supplies are provided in the facility design to meet the single-failure criterion for a given safety function, it should be verified by test that the single-failure criterion is met.

8. It should be verified by tests that the air-operated or air-powered loads that are a part of (or support the operation of) portions of the facility important to safety respond in accordance with design to a loss of air pressure. Testing should be sufficiently comprehensive to determine the response of loads to complete loss of system pressure, both sudden and gradual, and to partial reductions in system pressure. For valves that use multiple air connections (e.g., 30 psi to pilot and 100 psi to positioner or booster relay), if failure of less than all air supply sources is credible, the tests should verify that the valve responds safely to all failure modes. The tests should verify the adequacy of design requirements relating to system pressures at which supplied loads change state (e.g., fail open, fail closed, fail as is, fail upscale, fail downscale, or fail to perform other required functions). Testing should also verify that the backup supplies for the protected loads supplied by the system, e.g., accumulators and backup bottled gas supplies, will maintain sufficient air pressure to permit these loads to perform their design function.

As part of the above testing, loss-of-air-supply tests should be conducted on all branches of the instrument and control air system simultaneously, if practicable, or on the largest number of branches of the system that can be adequately managed. For each test, the valves to be tested should be placed in their normal operating position, and the rest of the plant should be maintained in as close to normal conditions as is practicable. (It should be noted that not all valves can be placed in the required normal operating position because of operating procedure requirements or personnel or equipment safety factors.) The following tests should be performed:

a. Shut off the instrument and control air system in a manner that would simulate a sudden air pipe break and verify that the affected components respond properly.

b. Repeat test a., but shut the instrument and control air system off very slowly to simulate a gradual loss of pressure.

9. Tests should be conducted, as appropriate, to demonstrate that plant equipment designated by design to be supplied by the instrument and control air system is not being supplied by other compressed air supplies (such as service air) that may have less restrictive air quality requirements.

10. Plant components requiring large quantities of instrument and control air for operation (such as large valve operators) should be operated simultaneously while the system is operating at normal steady-state conditions (unless it can be shown that simultaneous operation is prohibited by interlock or appropriate procedure) to verify that pressure transients in the distribution system do not exceed acceptable values.

*Copies may be obtained from the Instrument Society of America, P.O. Box 12277, Research Triangle Park, North Carolina 27709.

11. Functional testing of instrument and control air systems important to safety should be performed to ensure that credible failures resulting in an increase in the supply system pressure will not cause loss of operability.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described in this guide (which is a revision of and replaces Regulatory Guide 1.80) will be used in licensing actions on or after May 24, 1982.

The staff will continue to honor prior commitments pertaining to instrument air systems based on Regulatory Guide 1.80 or on other programs found acceptable to the NRC staff or will reconsider such commitments on a case-by-case basis if requested by the applicant or licensee. However, if major modifications or repairs have the potential for degrading system performance, the licensee's proposed restart testing program following such modifications or repairs will be evaluated according to the recommendations of Regulatory Guide 1.68.3.

VALUE/IMPACT STATEMENT

BACKGROUND

Regulatory Guide 1.80 provides methods for preoperational testing of instrument air systems to ensure that the instrument air systems and components as designed and installed will function properly and that they are free from foreign matter that could cause malfunctions during operation. The guide also contains provisions for tests to demonstrate that the systems will respond as expected to a loss-of-instrument-air accident.

Experience in using the guide has shown that there have been problems in applying the guide where there is a relationship between the instrument air system and the control air system. Therefore, the scope of Regulatory Guide 1.80 was expanded to include the control air system because of the possibility that it may be associated with systems important to safety. However, the expanded guide is being issued as Regulatory Guide 1.68.3 in order to group it with other guides in the initial test program subseries, and Regulatory Guide 1.80 is being withdrawn.

VALUE/IMPACT

1. The scope of the guide has been expanded to include control air systems as well as instrument air systems.

Value - This change will make it clear that some testing is needed for all instrument and control air systems. Some applicants have taken the position that their plants are so designed that failure of the instrument air system (i.e., total loss of pressure) will cause no safety problems. The instrument air system of these plants has not been designated as important to safety and therefore, by this logic, Regulatory Guide 1.80 is not applicable. This argument ignores the fact that, although loss of system pressure may not be serious, malfunction of the air system (e.g., introduction of dirt, oil, or moisture also addressed by Regulatory Guide 1.80) could lead to failure of loads that are important to safety. The revised guide makes it clear that the testing applies to *all* air systems that supply air to loads that are important to safety.

Impact - There may be some impact if applicants have not been testing because their systems have been identified by names different from those used in the guide. However, the staff position has always been that systems important to safety should be tested to demonstrate proper operation and to ensure that the functioning of loads important to safety is not jeopardized by failure of associated systems.

2. Regulatory Position 5, which calls for verification by tests that the total air demand at normal steady-state conditions, including leakage from the system, is in accordance with design, was added.

Value - The tests called for by this provision will verify actual air demands so that air supply capacity can be verified as adequate with the necessary margin to account for peak loads and increased leakage that may occur as the system is used.

Impact - Although not specifically mentioned, it has been the intent that the tests called for in this position be accomplished. The position is stated explicitly to improve guidance. For those plants that were not already obtaining the information, the impact should be minimal as the data can be obtained by normal system observations and simple measurements.

3. Regulatory Position 9, which calls for tests, measurements, and observations to be conducted to demonstrate that air supplies such as the service air supply are not inadvertently tied into the instrument and control air systems, was added.

Value - The tests called for in this position will demonstrate that air systems with poor quality air are not inadvertently tied into the systems that supply air to loads that are important to safety. Since air systems are generally field run, verification of independence by test is essential.

Impact - The impact will be minimal. The demonstration that there are no crossties from the service air system can be accomplished by cutting off the instrument and control air source with all other air systems under pressure and showing that no air is being introduced into the system.

4. Regulatory Position 10, which states that plant components requiring large quantities of air for operation should be operated simultaneously to establish that pressure transients created by such operation do not exceed acceptable values, was added.

Value - This test will demonstrate that the maximum operating transients on the system are within limits that will not adversely affect the operation of loads that are important to safety.

Impact - There should be minimal impact since the test can be run by simple operational procedures and data observations.

5. The regulatory position that provided for a test of the loss of air with valves placed in other than the failed position was deleted.

Value - An unnecessary system test was deleted. The response of components to a loss of air pressure (when the valves are placed in a position other than the failed position) can be verified, where required, on an individual component basis.

Impact - There is no impact since no new position is imposed.

6. The regulatory position calling for the test results to be included in the startup report was deleted.

Value - An unnecessary reporting provision was removed. This provision was inappropriate since preoperational testing precedes the startup test program. The test results should be retained as part of the plant historical record.

Impact - There is no impact since no new position is imposed.

7. Regulatory Position 11, which provides for functional testing to ensure that credible failures resulting in an increase in the supply system pressure will not cause peak transient pressures above the design pressure of the system components, was added.

Value - Operating experience (e.g., Pilgrim) has shown that pressure transients above the design pressure of some components can cause those components to malfunction, which could cause unsafe conditions to exist.

Impact - There should be minimal impact. Additional testing will be required. However, the test setup should be no different from that needed to conduct the loss-of-pressure tests, hence increased test time would be the only factor.