AMERICAN NATIONAL STANDARD
REACTOR PLANTS AND THEIR MAINTENANCE

Cleaning of Fluid Systems and Associated Components During Construction Phase of Nuclear Power Plants

ANSI N45.2.1 - 1973

SECRETARIAT

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED BY

IE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ited Engineering Center 345 East 47th Street New York, N. Y. 10017

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This standard was approved by the American National Standards Committee N45 and its Secretariat, and it was subsequently approved and designated N45.2.1-1973 by the American National Standards Institute on February 26, 1973.

FOREWORD

(This foreword is not a part of American National Standard Cleaning of Fluid Systems and Associated Components during Construction Phase of Nuclear Power Plants).

This standard delineates the requirements for cleaning fluid systems and associated components in a nuclear power plant during its construction phase. The standard was developed under the sponsorship of the American Society of Mechanical Engineers (ASME) as an effort by the American National Standards Institute's (ANSI) committee N45 on Reactor Plants and Their Maintenance. This committee has been chartered to promote the development of standards for the location, design, construction and maintenance of nuclear reactors and plants embodying nuclear reactors, including equipment, methods and components specifically for this purpose.

In May, 1969, the N45 Committee of ANSI established an ad hoc committee (N45-2.1) on Cleaning of Fluid Systems and Associated Components. The purpose of the committee was to prepare a standard for general industry use that would define the cleaning activities for fluid systems and components during the construction phase. The ad hoc committee was composed of representatives of key segments of the nuclear industry including utilities, reactor suppliers, architect-engineers and government sponsored agencies.

The initial draft of this standard was prepared in November, 1969. Since then five revisions have been made to reflect comments received from committee members, other ad hoc committees, selected individuals from the nuclear industry and the United States Atomic Energy Commission.

In April of 1970, the N45 Committee of ANSI established a subcommittee N45-2 to guide the preparation of nuclear quality assurance standards. This subcommittee is responsible for establishing guidelines and policy to govern the scope and content of the various standards; monitoring the status of standards in process; recommending preparation of additional standards; and final approval of standards prior to their submittal to the N45 Committee for balloting. Working with the N45-2.0 Subcommittee and concurrently with the development of this standard by the N45.2.1 ad hoc committee, other ad hoc committees of N45 are developing a series of standards that set forth both general and detailed requirements for certain activities to assure quality of nuclear power plants. These requirements will be coordinated with the requirements of this standard as they are developed.

In September 1971, these ad hoc committees were changed to work groups. In October 1972, the N45-3 Subcommittee was renamed N45-2, and the work groups were renamed accordingly. As of February 1973, the following associated standards were in preparation or issued:

Working Group	Standard in Preparation or Issued	
–	N45.2	Quality Assurance Program Requirements for Nuclear Power Plants
N45-2.2	N45.2.2	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants (During the Construction Phase)
N45-2.3	N45.2.3	Housekeeping During the Construction Phase of Nuclear Power Plants
N45-2.4	N45.2.4	Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations
N45-2.5	N45.2.5	Supplementary Quality Assurance Requirements for Installation and Testing of Structural Concrete and Structural Steel During the Construction Phase for Nuclear Power Plants

N45-2.6	N45.2.6	Qualifications of Inspection, Examination and Testing Personnel for the Construction Phase of Nuclear Power Plants
N45-2.8	N45.2.8	Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Mechanical Equipment and Systems for the Construction Phase of Nuclear Power Plants
N45-2.9	N45.2.9	Requirements for Collection, Storage and Maintenance of Quality Assurance Records
N45-2.10	N45.2.10	Quality Assurance Terms and Definitions
N45-2.11	N45.2.11	Quality Assurance Requirements for the Design of Nuclear Power Plants
N45-2.12	N45.2.12	Quality Assurance Program Auditing Requirements for Nuclear Power Plants
N45-2.13	N45.2.13	Supplementary Quality Assurance Requirements for Preparation of Procurement Documents for Nuclear Power Plants
N45-2.4	N45.2.14	Supplementary Quality Assurance Requirements During the Manufacture of Class 1E Instrumentation and Electric Equipment for Nuclear Power Generating Stations

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the Secretary, American National Standards Committee N45, The American Society of of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

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CLEANING OF FLUID SYSTEMS AND ASSOCIATED COMPONENTS DURING CONSTRUCTION PHASE OF NUCLEAR POWER PLANTS

1. INTRODUCTION

1.1 Scope

This standard covers on-site cleaning of materials and components, cleanness control, and preoperational cleaning and layup of important nuclear power plant fluid systems during construction. These systems include those whose satisfactory performance is required for safe and reliable operation of the plant. The requirements may also be extended to other parts of nuclear power plants when specified in contract documents. The standard covers requirements necessary to ensure an adequately clean system upon completion of construction activities, and covers the period from which the materials and equipment are removed from storage or receiving for installation at the construction site until the systems are ready for pre-operational testing.

The intent of this standard is to require close attention to cleanness control during erection of a nuclear power plant so that only water flushing or rinsing of an installed system is required to render it ready for service. When more than a water flush or rinse is needed to produce the specified cleanness, additional cleaning, in accordance with this standard may be necessary.

This standard is intended to be used in conjunction with ANSI N45.2 Quality Assurance Requirements for Nuclear Power Plants.

1.2 Applicability

The requirements of this standard apply to the work of any individual or organization that participates in the construction phase cleaning of items to be incorporated into nuclear power plants as discussed in Subsection 1.1. The extent to which the individual requirements of this standard will apply will depend upon the nature and scope of work to be performed and the importance of the item or service involved. The requirements are intended to ensure that only proper cleaning materials, equipment, processes and procedures are utilized during the construction of power plants and that the quality of items is maintained as a result of the use of proper cleaning practices and techniques during construction.

1.3 Responsibility

The organization or organizations responsible for the activities covered by this standard shall be identified and the scope of their responsibility shall be documented. Such responsibility should be assigned at the earliest practical point in time so as to facilitate incorporation of cleaning requirements in design drawings and purchase specifications. The establishment of practices and procedures and provision of resources, in terms of personnel, equipment, and services necessary to implement the requirements of this standard, may be delegated to other organizations and such delegations shall also be documented. Each organization participating in site construction activities shall comply with procedures and instructions issued for the project and with those requirements of this standard applicable to his work.

The organization responsible for performing the cleaning shall identify and document detailed cleaning procedures unless they are specified in the procurement documents. Requirements for review and/or approval of such procedures shall be specified in the procurement documents.

1.4 Definitions

The following definitions are provided to assure a uniform understanding of select terms as they are used in this standard.

Acid Cleaning The removal of metal oxides by either dissolution of the oxide or undercutting the oxide by dissolution of the base metal with an acid solution.

Alkaline Cleaning The removal of organic contaminants by converting them to an emulsion with an alkaline solution such as trisodium phosphate.

Chelate Cleaning The removal of slightly solu-

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ble compounds such as iron oxide, by complexing the metallic ions with organic chelating compounds such as ethylene diamine tetra-acetic acid (EDTA).

Chemical Conditioning The addition of chemicals in low concentration to flush, rinse, or layup water to prevent precipitation of dissolved solids, inhibit corrosion, etc.

Cleaning The removal of any contaminants that might have a deleterious effect on plant safety and reliable operation.

Contractor Any individual or organization entering into a contract to furnish items or services to a purchaser. The term contractor includes the terms Vendor, Supplier, and Subcontractor or sub-tier levels of these where appropriate.

Contamination Any undesirable foreign material on the surface of an item, in the atmosphere, or in process liquids or gases.

Corrosion Resistant Alloys Materials, such as stainless steel, nickel-base, or cobalt-base alloys, that inherently resist oxidation or chemical attack in water, air, and the operating environment.

Crevice Any narrow opening in a surface or any open juncture between mating surfaces in which solutions can be trapped and not readily removed during rinsing or flushing operations; for example, the annular spaces in threaded connections and socket assemblies, tube-to-tube sheet joints, and tube-to-tube support joints.

Dead Leg Any area that does not have flow during the cleaning operation or which cannot be drained without special provisions.

Documentation Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures or results.

Flushing Flowing water through a component or system at adequate velocity to suspend and carry away anticipated contaminants.

Inhibitor A chemical additive which retards some specific chemical reaction.

Inaccessible Area An area or opening in an item which is not directly accessible for cleaning or inspection.

Item Any level of unit assembly, including structure, system, subsystem, subassembly, component, part or material.

Layup The protection of an item after it has been cleaned, to prevent corrosion of interior surfaces while the item is out of service or awaiting subsequent operations.

Mechanical Cleaning A method in which contaminant removal is accomplished solely by mechanical means, including wiping, abrasive blasting, brushing, grinding, sanding, chipping, etc.

Pitting Localized corrosion resulting in surface defects.

Purchaser The agency responsible for issuance and administration of a contract, subcontract, or purchase order imposing this standard or portions hereof.

Rinsing (1) Filling and draining an item with water until contaminants in the effluent water are reduced to some predetermined concentration, or (2) flowing water through the system or component at low velocity until contaminants in the effluent water are reduced to some predetermined concentration.

Rust Corrosion products, consisting largely of iron oxide. Such oxides may vary in color from red to black and may form a loosely adherent heavy covering to a tightly adherent light film. Pitting or general surface roughening may or may not be present.

Sensitized Corrosion Resistant Alloy Any alloy which has been subjected to heating that causes intergranular precipitation of chromium carbides in quantities sufficient to be detected by methods of ASTM A262-68, Recommended Practices for Detecting Susceptibility to Intergranular Attack in Stainless Steel or ASTM A393-63, Recommended Practices for Conducting Acidified Copper Sulfate Test for Intergranular Attack in Austenitic Stainless Steel.

Solvent Cleaning Dissolving organic contaminants with an organic solvent.

1.5 Referenced Documents

Other documents that are required to be included as part of this standard are either identified at the point of reference or described in Section 10 of this standard. The issue or edition of the referenced document that is required will be specified either at the point of reference or in Section 10 of this standard.

Other terms and definitions are contained in ANSI N45.2.10.

2. GENERAL REQUIREMENTS

This section contains requirements that are to be fulfilled by the contractor who is responsible for performing any segment of work described in paragraphs 3 through 9 of this standard. Cleanness classification

for an item shall be specified in accordance with paragraph 3.1 of this standard.

The work and quality assurance requirements for the cleaning of items and systems to be incorporated in the nuclear power plant and control of cleanness thereof shall be established in order to (1) ensure the removal of any deleterious contaminants, (2) minimize recontamination of cleaned surfaces, and (3) minimize the cleaning required after installation.

2.1 Planning

The cleanness and cleanness control activities shall be planned and outlined to define cleaning and inspection operations to be used. It shall detail the systematic, sequential progression of cleaning operations for each item or system, the responsibilities of parties concerned for each operation, and measures to be employed to preserve the cleanness of cleaned surfaces. Planning for cleaning activities shall include a review of the system and component design specifications and drawings and of the construction work plans and schedules to ensure that provisions for cleaning have been incorporated; that they can be accomplished as specified; and that time and resources are sufficient to accomplish the required actions. This review shall consider the following items as appropriate.

1. Adequacy of vents and drains, inspection access points, bypass or recirculation lines;
2. Facilities for filters, and flushing and/or drain connections, in locations where dead legs are unavoidable;
3. Piping system design and installation in a manner which minimizes the necessity for installation of temporary piping during the cleaning operations; (Where possible, divide the system into a number of separate cleaning circuits to facilitate cleaning).
4. Sequencing of the installation operations to provide for visual inspection (crawl through) of the inside surfaces of large diameter piping;
5. Control of the installation operations so that piping and components which have already been installed are not subject to contamination when subsequent installation operations are performed;
6. Adequate pumping and heating capacities when these are important factors in the cleaning operations.

2.2 Procedures and Instructions

Cleaning procedures as well as procedures or work instructions for cleanness control practices and inspections, examinations or tests to verify cleanness of items shall be prepared.

These documents shall include as appropriate

1. Detailed cleaning cleanness control procedures
2. Personnel safety considerations
3. Structure or facility protection consideration
4. Inspection and test equipment requirements
5. Sequence of work activities, inspections and tests
6. Sequential steps for a given activity
7. Acceptance criteria including methods for verifying cleanness
8. Preparatory checks
9. Approvals
10. Responsibilities
11. Data report forms

The preparation of the actual working procedures or instructions to be used should consider:

1. Work practices, housekeeping, access control, and prevention of contamination and recontamination;
2. Effectiveness of cleaning procedures for removal of the contaminants.
3. Corrosiveness of cleaning solutions in contact with the material of an item, particularly in the case of dissimilar metals.
4. Chemical composition, concentration, and temperature limits of cleaning solutions to avoid deleterious effects;
5. Proposed solution and metal temperatures, solution concentrations, velocity, and contact times during cleaning;
6. Methods for monitoring cleaning solution concentration and temperatures during cleaning operations;
7. Identification of the systems and subsystems with which the procedures are to be used.
8. Proposed sequence of operations and methods of filling, system circulation, draining, and flushing;
9. Proposed equipment isolation, location of temporary piping and valves, location of strainers and where possible, the location of temporary equipment;
10. Construction operations prohibited during cleaning operations;
11. Methods for rinsing and neutralizing including number of rinses;
12. Methods for verifying cleanness;
13. Methods of drying and layup of the system.
14. Methods for protecting installed equipment which are not used in the cleaning operations.

15. Methods for disposal of cleaning solutions;

2.3 Results

Inspection and test results shall be documented in a suitable test report or data sheet. Each report shall identify the item to which it applies, the procedures or instruction followed in performing the task and the identification of the following:

1. Conditions encountered which were not anticipated, including nonconformance.
2. Identity of inspector or tester.
3. Completion date.

Test reports and data sheets shall include an evaluation of the acceptability of inspection and test results and provide for identifying the individual who performed the evaluation.

2.4 Personnel Qualifications

Those personnel who perform inspection, examination or testing activities required by this standard shall be qualified in accordance with ANSI N45.2.6 Qualifications of Inspection, Examination, and Testing Personnel for the Construction Phase of Nuclear Power Plants.

2.5 Test Equipment

2.5.1 Selection. Inspection and test equipment used to implement the requirements of this standard shall be selected to have sufficient accuracy and sensitivity tolerance to determine conformance to specified requirements.

2.5.2 Calibration and Control. Test equipment shall be adjusted and calibrated at prescribed intervals against certified equipment having known valid relationships to nationally known standards. If no national standards exist, the basis of calibration shall be documented. Records shall be maintained and equipment suitably marked to indicate calibration status. When inspection and testing equipment is found to be out of calibration, an evaluation shall be made of the validity of previous inspection or test results and acceptability of items previously inspected or tested.

2.6 Housekeeping

In areas, facilities and environments where the cleanness controls of this standard are required, the housekeeping requirements shall be in accordance with ANSI N45.2.3, Housekeeping During Construction Phase of Nuclear Power Plants.

3. CRITERIA FOR CLEANING

It is intended that systems that have been cleaned in accordance with this standard should require only water flushing or rinsing as a final cleaning step in preparing them for service. However, where more than normal water flushing or rinsing is required to produce the specified cleanness, additional cleaning in accordance with this standard may be necessary.

While this standard is primarily concerned with the cleaning and cleanness of internal surfaces, external surface cleanness may be of equal importance in some cases and should be recognized during the cleaning operations. Internal and external surfaces may have different cleaning and cleanness requirements.

3.1 Cleanness Classifications

The degree of cleanness required is a function of the particular item under consideration. The assignment of a cleanness classification shall consider the susceptibility to corrosion of the material, the consequences of malfunction or failure of the item and the probability of contaminants contributing to or causing such malfunction or failure. This standard does not establish the cleanness classification of any specific item. However, typical examples are presented as a guide. The specification for the required cleanness class shall be the responsibility of the purchaser. The class of cleanness required for any given application shall be specified in design drawings or specifications associated with the cleaning of items, and the method of verification of cleanness shall be documented.

NOTE

The following cleanness classifications are not directly related to component classifications assigned by the ASME Boiler and Pressure Vessel Code for design and inspection or for other purposes.

3.1.1 Class A – A very high level of cleanness in which there is no evidence of contamination of a surface either under visual examination, with or without magnification, or with the aid of sensitive detection methods. Class A cleanness applies to special items such as fuel elements, control rod drive mechanisms, delicate instruments, and other close tolerances or carefully controlled surfaces or assemblies. Such items should receive their required level of cleanness at the point of manufacture and cleanness must be maintained at the construction site. For these reasons, requirements of this level of cleanness are considered to be outside of the scope of this document.

3.1.2 Class B–A high level of cleanness applicable to reactor coolant systems, components, and other items, such as the reactor coolant purification system, which have similar cleanness requirements.

Piping and components in systems which are designed as requiring Class B cleanness shall meet the following requirements:

1. The surface shall appear "metal clean" when examined without magnification under a lighting level (background plus supplementary lighting) of at least 100 foot candles. Scattered areas of rust are permissible provided the aggregate area of rust does not exceed 2 square inches in any one square foot area.

NOTE

Localized rusting may indicate pitting of the surface and should be evaluated metallurgically). Thin temper films resulting from welding or post-weld heat treatment are acceptable.

2. The surface shall be free of particulate contaminants such as sand, metal chips, weld slag, etc.
3. The surface shall be free of organic films and contaminants such as oils, paint, and preservatives as determined by a visual examination or an organic solvent-dampened white cloth or an equivalent alternate method.
4. When a visual inspection is not possible and the surfaces are accessible, a dry white-cloth wipe, followed by a solvent-dampened white-cloth wipe, may be used to evaluate the cleanness of the surface. If either cloth exhibits indications of contamination, the system shall either be recleaned or the specific contaminant shall be determined and evaluated as to its potential deleterious effect.
5. If flushing is the only practical means for determining system cleanliness, the system shall be evaluated by examining a 20-mesh (ASTM E11-70, Specifications for Wire Cloth Sieves for Testing Purposes) or finer filter, or the equivalent, installed on the outlet of the cleaning circuit. The system shall be flushed at its normal design velocity (or other velocity if specified by procurement documents) until the screen shows no more than slight particle speckling and no more than slight rust staining. There shall be no particles larger than $^1/_{32}$ inch in any dimension, except fine hairline slivers of less than $^1/_{32}$ inch thickness are permissible up to $^1/_{16}$ inch long. There shall be no evidence of organic contamination in the effluent water or on the filter.

3.1.3 Class C–An intermediate level of cleanness generally applicable to closed service-water systems that cool components containing reactor coolant, engineered safety systems, and other high integrity systems. Surfaces shall meet the requirements for Class B cleanness, except:

1. Thin uniform rust films are acceptable on carbon steel surfaces.
2. Scattered areas of rust are permissible provided that the area of rust does not exceed 15 square inches in any 1 square foot on corrosion resistant alloys.
3. Flush-test filters may exhibit considerable rust staining.

3.1.4 Class D–The level of cleanness applicable to fire-protection, open service water, and similar systems requiring only a nominal degree of cleanness. The following are acceptable on items which meet Class D cleanness:

1. Tightly adherent mill scale on carbon steel surfaces.
2. Paint or preservative coatings on carbon steel surfaces that will not peel or flake when exposed to cold-water flushing.
3. Rust films on carbon steel and stainless steel surfaces that resist removal by scrubbing with a bristle brush.
4. If flushing is the only practical means of determining system cleanness, the system shall be evaluated by examining a 14-mesh (ASTM E11-70, Specification for Wire Cloth Sieves for Testing Purposes) or fine filter, or the equivalent, installed on the outlet of the cleaning circuit. The system shall be flushed at its normal velocity until the screen shows no more than occasional particle speckling. There shall be no particles larger than $^1/_{16}$ inch in any dimension, except hairlike slivers of less than $^1/_{16}$ inch thickness are permissible up to $^1/_8$ inch long. There shall be no evidence of organic contamination on the screen; considerable rust-staining is acceptable.

3.2 Water Quality Requirements

The selection of the water quality for a specific application shall be made by the organization responsible for the cleaning operations unless otherwise specified in the purchase document. In cases where the water quality for operating systems is lower than that

specified below (e.g., open service water systems), the water used for cleaning can be equivalent to the quality of the operating system water. When cleaning water quality is not otherwise specified, it shall comply with the following specifications.

Fresh Water

Fresh water shall meet the following requirements:

pH at 25 C (77 F)	5.5 to 8
Chloride	Less than 100 ppm
Fluoride	Less than 5 ppm
Sulfide	Less than 1 ppm
Total Dissolved Solids	Less than 500 ppm
Turbidity	Less than 5 Jackson Turbidity Units

Demineralized Water

Demineralized water shall meet the following requirements:

ph at 25 C (77 F)	5.5 to 8
Chloride	Less than 1 ppm
Fluoride	Less than 1 ppm
Sulfide	Less than 1 ppm
Conductivity at 25 C (77 F)	Less than 3 micromho/cm
Silica	Less than 0.05 ppm
Turbidity	Less than 1 Jackson Turbidity Unit

4. PRE-INSTALLATION CLEANNESS

Items should not be delivered to the point of installation site sooner than necessary unless the installation location is considered a better storage area. Inspections, examinations, and tests as appropriate shall be performed immediately prior to installation to determine the cleanness of the item. If contaminants are detected, they shall be removed if it is judged that they will not be removed in subsequent cleaning operations. Items having surfaces to which temporary paint or preservative coatings have been applied shall be identified, the composition of the coating and methods for its removal shall be determined and removal of coatings, where required, recorded in the inspection report. Unless otherwise required by the job specifications, the temporary coatings shall be removed prior to installation of items.

5. INSTALLATION CLEANING

The installation process represents an opportunity for the introduction of contaminants into a cleaned item and care should be taken to minimize contamination. Operations which generate particulate matter, such as grinding and welding, should be controlled. Local cleanup of contaminated areas is recommended as installation progresses, rather than one cleanup operation when installation is completed. Consideration should be given to sequencing installation and erection operations, when practical, to facilitate cleaning and cleanness control. Where visual inspection of internal surfaces of a portion of a system can be blocked, that part of the system should be fabricated as a complete unit and a visual inspection should be performed just before the access points are closed.

Openings and pipe ends shall be sealed at all times except when they must be unsealed to carry out necessary operations. Fitted and tack-welded joints (which will not be immediately sealed by welding) shall be wrapped with polyethylene or other non-halogenated plastic film until the welds can be completed.

Precautions shall be taken to avoid contamination of crevices, blind holes, dead legs, undrainable cavities, and inaccessible areas. When grinding, sanding, chipping or wire brushing, the item shall be so oriented that chips fall away from the openings or covers shall be provided for the openings.

Marking materials containing sulfur, lead, zinc, mercury and other low melting alloys as a basic chemical constituent shall not be brought into contact or shall not be used on the surfaces of corrosion resistant alloys. Low-sulfur, low fluorine, and/or low-chlorine compounds may be used on austenitic stainless steels. Low-sulfur, low lead compounds may be used on nickel-base alloys. Paints, chalk and other temporary marking materials shall be removed by solvent-wiping or mechanical means.

Surfaces should be cleaned after completion of work on them, before proceeding to the next installation or construction step. The use of mineral acids and organic acids on austenitic stainless steels and nickel alloys should be avoided except when the material is in the solution annealed condition. Pre-cleaning and post-cleaning of weld joint areas and welds shall be performed by wire brushing and scrubbing with a solvent-moistened clean cloth unless specified otherwise.

Local rusting on corrosion resistant alloys should be removed by mechanical methods.

Large openings, such as the open reactor vessel shall be protected against falling and windblown contaminants.

6. MAINTENANCE OF INSTALLATION CLEANNESS

After any isolable system has been installed in a clean condition and cleanness control measures have been established, access control into the system is essential to minimize the introduction of contaminants between the time of system isolation and pre-operational testing. Access control shall be established to exclude personnel and contaminants. Where environmental contamination could cause degradation of quality, seals must be installed which must be hermetically tight and difficult to remove. Gasketed metal seals with welded metal strap closures, or seal welded metal caps are recommended for Class B systems and components. Items in this condition shall be tagged with identifications and instructions for seal removal.

If access to a sealed system is required, precautions shall be taken to prevent introduction of contaminants. Prior to opening the seals, the immediate surroundings should be cleaned to remove solid contaminants which might be introduced in the system. Personnel entering the system should wear clean outer clothing and shoe covers. When the necessary work is completed, the interior surface shall be locally cleaned to its original condition and the system should be re-sealed.

7. PRE-OPERATIONAL CLEANING

7.1 Preparations

Cleaning and flushing operations shall be scheduled so as to minimize interference from other plant operations. Areas in which cleaning operations are being performed shall be isolated to the extent that personnel performing other construction phase operations are aware that the cleaning operations are being conducted.

Personnel shall be familiarized with the intended procedure and associated hazards. Means for communicating shall be provided between the local areas in which the cleaning is performed and any remote areas (e.g., control rooms) that may be related to the cleaning operations. Loose tools should be attached to either the workman or the exterior of the system with a lanyard.

The actual circulating flow path shall be checked for agreement with specified requirements in regard to location, position and status of all components. Critical valves, controls and switches shall be tagged to prevent inadvertent actuation during the cleaning operation. The interior of all accessible components (e.g., tanks) and large diameter piping shall be inspected for cleanness; all debris and contamination shall be removed.

Demineralizers, filters, instruments, valve internals and other items that may be damaged by the cleaning process shall be blanked off, bypassed or removed. Protective screens shall be installed on the suction side of all pumps and other components that may be subject to damage during the cleaning operations. Instrumentation (e.g., pressure temperature and flow) shall be used where possible to monitor the cleaning operations. All other permanently installed instrumentation shall be isolated where possible. Cleaning should be completed before installation of fuel, reactor vessel internals and control rods.

Provisions shall be made to collect leakage and to protect insulation from being wetted.

Where the use of installed plant components, such as pumps, may be affected by the cleaning operations, recommendations shall be obtained from the component manufacturers regarding the use of their components. Procedures used to protect installed components which are not used in the cleaning operations but which are included in the cleaning circuit should be reviewed.

7.2 Flushing and Cleaning Methods

7.2.1 Water Flushing. If the intended level of cleanness has been maintained during erection of the plant, only water flushing will be required. The system shall be filled with water of the quality specified and flushed in accordance with approved procedures. Completion of flushing shall be determined by filter, turbidimetric or chemical analyses.

If the final flushes for removal of particulate contaminants are directed toward the reactor vessel, soluble contaminants shall be removed from the system by first flushing away from the reactor vessel until a specified water quality is achieved on the effluent from the system. At this time, high velocity flushes may be made toward the reactor vessel. This procedure is not recommended unless reactor vessel internal surfaces are accessible for subsequent mechanical cleaning and inspection, or unless provisions are made to collect particulate contaminants at some accessible location within the reactor vessel by filtration or other technique.

After system flushing is completed, but before system drain, all pockets and dead legs shall be flushed through their drain connections. If conditioned water is used, particular attention should be given to assure that large volumes of solution do not remain trapped in the system. Care shall be taken to assure that organics do not remain on the surfaces. A final flush

with demineralized water is desirable, but is not necessarily required at this time.

The system shall be sealed to prevent the subsequent entry of contamination. If no further cleaning is required, system layup may be performed.

7.2.2 **Alkaline Cleaning.** Although it shall be the intent of those involved in erecting the nuclear plant to install piping systems in a clean condition, this may not be achieved. One relatively common source of organic contamination in piping systems is lubricating oils from air tools. When local cleanup is not performed following grinding operations on internal surfaces of piping welds, full system cleaning to remove organic contaminants may be necessary. If required, the cleaning shall be performed according to the cleaning procedures established for the operation and the procedure shall assure that quantities of organics do not remain on the surfaces.

Alkaline cleaning should consist of the circulation of an appropriately heated solution until a selected area or a coupon contaminated with the expected contamination is cleaned by the cleaning solution.

After system cleaning is completed, a flush with water of a quality consistent with the system requirements shall be performed to remove the cleaning agents. In particular, all pockets and dead legs should be flushed and attention should be given to assure that large volumes of solution do not remain in the system.

The system should be sealed to prevent the subsequent entry of contamination. If no further cleaning is required, system layup may be performed.

Precautions related to the use of alkaline cleaning solutions are listed in paragraph 7.3.

7.2.3 **Chelate Cleaning.** Chelate cleaning of carbon or low-alloy steel surfaces to remove light corrosion product films is not a required cleaning operation. If chelating cleaning is used, flushing with water of a quality consistent with the system requirements should be performed to remove the chelating agents. All pockets and dead legs in particular should be flushed and attention should be given to assure that large volumes of the chelating solution do not remain in the system.

The system should be sealed to prevent the subsequent entry of contaminants. If no further cleaning is required, layup may be performed.

Precautions related to the use of chelating agents are listed in paragraph 7.3.

7.3 Cleaning Precautions

There are a number of precautions that should be observed during cleaning operations. The following should be considered as appropriate.

1. The addition of a suitable chloride stress cracking inhibitor is recommended if fresh water flushing of systems containing austenitic stainless steels is planned.
2. The use of alkaline cleaning compounds which contain free caustic is not recommended on components or systems in which cleaning solutions may be entrapped. Cleaners based on compounds which produce hydroxyl ions by hydrolysis, such as tri-sodium phosphate, are recommended. If heavy organic solids are present, the addition of an emulsifier and a wetting agent may be considered.
3. The use of acid-chelating agents on welded or furnace sensitized stainless steels and nickel base alloys is not recommended.
4. The use of halogenated organic solvents is not recommended, except upon crevice-free, open, freely-evaporating surfaces. This recommendation is not intended to prohibit the use of such solvents under other conditions, providing adequate removal is assured prior to any subsequent operations.
5. Acid cleaning of installed systems is not recommended. However, if used, particular attention shall be given to:
   (a) Avoiding the entrapment of acids in the crevices.
   (b) Avoiding contact with either welded or furnace sensitized corrosion resistant alloys, and non-ferrous materials.
   (c) Complete removal of any residual acid solution from the system.
   (d) Neutralization treatment as a final operation.

7.4 Control of Cleaning Solutions

Cleaning solutions should be prepared in accordance with the applicable cleaning procedure and shall be checked for proper chemical composition and effectiveness of inhibitors (if used). Solution temperatures must be maintained and controlled to assure adequate cleaning and to prevent decomposition and possible damage to the system.

8. LAYUP AND POST-LAYUP CLEANING

8.1 Upon completion of pre-operational cleaning, unless the system is to be released for the next series of operations or tests, the system should be placed in layup condition, if required, by filling with dry inert

gas, the process fluid that will be used in the system during operation, water of purity equivalent to that used to make up the system, or chemically-conditioned water.

8.2 Prior to the next series of operations or tests residual cleaning solutions or layup chemicals shall be removed from the system by flushing, or draining and filling until the effluent water from the system meets the pre-operational test water quality requirements for the system.

9. RECORDS

Record copies of completed procedures, reports; personnel qualification records; test equipment calibration records, test deviation or exception records, inspection and examination records shall be prepared. These shall be placed with other project records as required by code, standard, specification, or project procedures.

Collection, storage and maintenance records shall be in accordance with ANSI N45.2.9.

10. REVISION OF ANSI STANDARDS REFERRED TO IN THIS DOCUMENT

When the following standards referred to in this document are superseded by a revision approved by the American National Standards Institute, the revision shall apply.

N45.2 Quality Assurance Program Requirements for Nuclear Power Plants

N45.2.3 Housekeeping During the Construction Phase of Nuclear Power Plants

N45.2.6 Qualification of Inspection, Examination, and Testing Personnel for the Construction Phase of Nuclear Power Plants

N45.2.9 Requirements for Collection, Storage and Maintenance of Quality Assurance Records

*N45.2.10 Terms and Definitions

*These Standards are being approved by The American National Standards Institute and they should be available in 1973.

U.S. ATOMIC ENERGY COMMISSION

3/16/73

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.37

QUALITY ASSURANCE REQUIREMENTS FOR CLEANING OF FLUID SYSTEMS AND ASSOCIATED COMPONENTS OF WATER-COOLED NUCLEAR POWER PLANTS

A. INTRODUCTION

Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," requires, in part, that measures be established to control the cleaning of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration. This guide describes an acceptable method of complying with the Commission's regulations with regard to quality assurance requirements for on-site cleaning of materials and components, cleanness control, and preoperational cleaning and layup of water-cooled nuclear power plant fluid systems. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

Working Group N45-2.1 (formerly ad hoc committee N45-3.1) of the American National Standards Institute (ANSI) Standards Committee N45, Reactor Plants and Their Maintenance, has prepared a standard which includes quality assurance requirements for on-site cleaning of materials and components, cleanness control, and preoperational cleaning and layup of nuclear plant fluid systems. The standard was approved by subcommittee N45-2, Nuclear Quality Assurance Standards, of the ANSI Standards Committee N45 and the full committee and its Secretariat. It was subsequently approved and designated N45.2.1-1973 by the American National Standards Institute on February 26, 1973.

C. REGULATORY POSITION

The requirements and recommendations for on-site cleaning of materials and components, cleanness control, and preoperational cleaning and layup of water-cooled nuclear power plant fluid systems that are included in ANSI N45.2.1-1973, "Cleaning of Fluid Systems and Associated Components During Construction Phase of Nuclear Power Plants,"[1] are generally acceptable and provide an adequate basis for complying with the pertinent quality assurance requirements of Appendix B to 10 CFR Part 50, subject to the following:

1. Subdivision 1.5 of ANSI N45.2.1-1973 states that other documents required to be included as a part of the standard are either identified at the point of reference or described in Section 10 of the standard. The specific applicability or acceptability of these listed documents has been or will be covered separately in other regulatory guides or in Commission regulations, where appropriate.

2. Although subdivision 1.2 of ANSI N45.2.1-1973 states that the requirements promulgated apply during the construction phase of a nuclear power plant, many of the requirements and recommendations contained in the standard are also appropriate to cleaning of fluid systems and associated components during the operation phase of a nuclear power plant, and they should be used when applicable. In this regard, however, it should be particularly noted that decontamination and cleanup of radioactively contaminated systems and components are not addressed by ANSI N45.2.1-1973. These operations will be considered separately in future regulatory guides.

3. Subdivision 3.2 of ANSI N45.2.1-1973 states that the selection of the water quality for a specific application shall be made by the organization responsible for the cleaning operations unless otherwise specified in the purchase document. The water quality

[1] Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

for final flushes of fluid systems and associated components should be at least equivalent to the quality of the operating system water.

4. Section 5 of ANSI N45.2.1-1973 states, in part, that low sulfur, low fluorine, and/or low chlorine compounds may be used on austenitic stainless steels and that low sulfur and low lead compounds may be used on nickel-base alloys. Chemical compounds that could contribute to intergranular cracking or stress-corrosion cracking should not be used with austenitic stainless steel and nickel-base alloys. Examples of such chemical compounds are those containing chlorides, fluorides, lead, zinc, copper, sulfur, or mercury where such elements are leachable or where they could be released by breakdown of the compounds under expected environmental conditions (e.g., by radiation). This limitation is not intended to prohibit the use of trichlorotrifluoroethane which meets the requirements of Military Specification Mil-C-81302b for cleaning or degreasing of austenitic stainless steel provided the precautions of subdivision 7.3(4) of ANSI N45.2.1-1973 are observed.

5. Section 5 of ANSI N45.2.1-1973 states, in part, that operations such as grinding and welding which generate particulate matter should be controlled. Adequate control of tools used in abrasive work operations such as grinding, sanding, chipping, or wire brushing should be provided. Specifically, tools which contain materials that could contribute to intergranular cracking or stress-corrosion cracking or which, because of previous usage, may have become contaminated with such materials should not be used on surfaces of corrosion-resistant alloys. Examples of such materials are listed in Regulatory position 4.

6. Subdivision 1.4 of ANSI N45.2.1-1973 suggests the use of ASTM A 262-68 or ASTM A 393-63 for detection of intergranular precipitation of chromium carbides in corrosion-resistant alloys. ASTM A 393-63 has been withdrawn by ASTM and is no longer considered a valid test.