JANTI-SANE-G2 Version1

Post-Earthquake Equipment Integrity Assessment Guideline

[Inspection Method: Pipes, Foundation Bolts]

(Tentative Translation of Main Text)

March 2012

Japan Nuclear Technology Institute

Disclaimer

This guideline was enacted after discussions by committee members and participants with expert knowledge and interest at the "Structural Integrity Assessment for Nuclear Power Components experienced Niigata-ken Chuetsu-oki Earthquake Committee" (SANE) which was established by the Japan Nuclear Technology Institute (JANTI).

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Introduction

At the "Structural Integrity Assessment for Nuclear Power Components experienced Niigata-ken Chuetsu-oki Earthquake Committee" (SANE), which was established in the fall of 2007 following the Niigata-ken Chuetsu-oki Earthquake, learned and experienced experts specializing in structural strength, inspection, earthquake resistance, etc., have been gathering with relevant parties from electric power companies and manufacturers to conduct integrity assessments and reviews of important equipment at the Kashiwazaki-Kariwa Nuclear Power Station which was affected by the earthquake. In order to allow relevant parties to widely share valuable findings obtained at this committee to prepare for future earthquakes, these findings were put together as the "Post-Earthquake Equipment Integrity Assessment Guideline."

In order to inspect the innumerable station equipment when an earthquake far exceeding design predictions occurs, an inspection plan covering basic inspections (visual inspection and activation tests commonly conducted for each equipment) and additional inspections (disassembling inspection / non-destructive tests) performed based on basic inspections or seismic response analysis results must be created to clarify relevant laws and standards that needs to be observed and skill levels required of inspectors and evaluators, and to undergo equipment inspections by precisely predicting parts that may be damaged. Therefore, the SANE committee established an working group to deliberate standards to be adhered to and qualifications of inspectors and evaluators. It also performs plastic strain assessment along with nondestructive inspections and compiles the assessment method of, foundation bolt integrity assessment into a guideline.

The Great Tohoku earthquake and tsunami of March 11, 2011, saw serious accidents at the TEPCO Fukushima Daiichi Nuclear Power Station. Deliberations by this committee were mainly implemented prior to this earthquake and cover damage caused by earthquake motion, or felt earthquake. Accordingly, this guideline covers only damage caused by earthquake motion.

We hope this guideline will be used to aid safe and stable nuclear power station operations, serving as reference for deliberations of general industrial equipment inspection methods.

Finally, I would like to give a special thanks to the committee members, participants, and all the parties involved for taking the time in their busy schedules to participate in the discussions and for their tremendous contributions.

March, 2012

JANTI SANE Committee
Chairman, Toshiharu Nomoto

Post-Earthquake Equipment Integrity Assessment Guideline

[Inspection Method: Pipes, Foundation Bolts] Contents

Main Text

1. Objective, scope

1.1 Objective

This guideline shows the scope of inspections for static equipment, especially piping and foundation bolts, to be conducted by the nuclear power station when an earthquake occurs. The inspection guideline shown here is the codification of applicable items to the nuclear power station following the Niigata-ken Chuetsu-oki earthquake. The objective is to contribute to safe and stable operation via use in integrity assessment plans for each nuclear power station.

1.2 Scope

Equipment and parts requiring post-earthquake inspection will be selected according to the post-earthquake equipment integrity assessment guideline [pre-earthquake plans, and post-earthquake inspection and assessment] (JANTI-SANE-G1). The inspection method for the selected equipment / parts will be determined according to the predicted damage type. When the inspection objective and scope coincide, the inspection method shown here may be applied.

2. Equipment inspection basic policy

Equipment inspection will be classified as shown below for implementation.

(1) Basic inspection: Comprised of visual inspection and activation tests (function verification, vibrational confirmation, leakage confirmation); performed for selected equipment.

(2) Additional inspection: Comprised of non-destructive tests and plastic strain measurement; performed based on basic inspection and seismic response analysis results. Includes confirming the presence of abnormality check through open vessel inspection and measurement control equipment characteristic tests.

The post-earthquake equipment integrity assessment guideline [pre-earthquake plans, and post-earthquake inspection and assessment] (JANTI-SANE-G1) lists the conclusive approach on post-earthquake equipment integrity assessment of the nuclear power station , pre-earthquake plans, and post-earthquake response according to damage level.

3. Basic inspection

3.1 Inspection method and decision standard

The equipment inspection procedures and decision standards utilize the regulation / policy used for maintenance inspections (see Table 3-1), and adopt items found to be technologically sound, to be stipulated for each SSC for inspection.

Table 3-1 List of sample decision standards for inspection / assessment methods (basic inspection)

Inspection method	Procedure / decision standard
Visual inspection	・JSME Codes for Nuclear Power Generation Facilities: Rules on Maintenance VT-3 ・JIS Z 3090 Visual testing method of fusion-welded joints ・NDIS 3414 Method of visual test ・NDIS 3415 Method of inspections for equipment and device
Leakage test	・JSME Codes for Nuclear Power Generation Facilities: Rules on Maintenance VT-2
Activation test	・Regular testing performance values ・Procedures and decision standards of function / performance tests (regular operator inspection) ・LBWR station operation maintenance policy (JEAC 4803)
Function verification	・Procedures and decision standards of function / performance tests (regular operator inspection)

3.2 Inspectors / evaluators

Inspectors / evaluators shall be workers possessing skills shown in Table 3-2.

Table 3-2 Skills required of inspectors / evaluators (basic inspection)

Inspection method	Skill
Visual inspection	・Workers confirmed to have no vision problems through checks of close-up vision required of non-destructive testing personnel as per JIS Z 2305 “Non-destructive testing – Qualification and certification of personnel” utilized in NDIS 3413 “Method of vision and color sight tests for non-destructive testing personnel.” ・Workers with years of work experience, internal certification, record of education / testing reception, and other appropriate skills.

4. Additional inspection of pipes and foundation bolts

Knowledge based on the examples of the non-destructive inspection method and hardness measurement method used after the Chuetsu-oki earthquake were organized to be able to be applied to additional inspections of pipes and foundation bolds, which comprise the majority of static equipment, when needed during post-earthquake structural integrity assessment. Testing guideline details were compiled in Appendices A through D.

4.1 Inspection method / decision standard

(1) The inspection method and decision standard for pipes are shown in Tables 4-1 through 4-5.

Table 4-1 Visual testing method and decision standard for pipes (additional inspection)

Item	Details
Objective	Confirm presence of warping or surface abnormalities on pipes.
Scope of inspection	Select systems where damage was discovered during basic inspections and systems with results that do not satisfy allowable value during the seismic response analysis of seismic resistance S class pipes that uses observed waves. These are subject to visual testing (VT). Scope will cover all exteriors of each selected system. Thermal insulation will be removed to perform VT for all scope items.
Inspection method	Based on IA-2523 VT-3 testing of the Rules on Maintenance (JSME S NA1-2004), directly perform VT on the pipe surface.
Applicable regulation / applied regulation	Rules on Maintenance (JSME S NA1-2004)
Decision standard	No pipe warping or other surface abnormalities. If abnormality is detected, perform non-destructive testing according to abnormality type.

JSME S NA1-2004: Codes for Nuclear Power Generation Facilities: Rules on Maintenance (JSME)

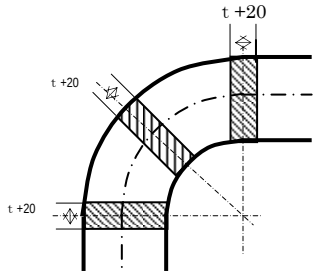
Table 4-2 Liquid penetrant testing method and decision standard for pipes (additional inspection)

Item	Details
Objective	Confirm presence of cracks on external surface of pipes.
Scope of inspection	Select areas that do not satisfy allowable values from the seismic response analysis that uses observed waves, for liquid penetrant testing (PT). Subject areas are within the scope of the figure below.
Inspection method	Based on IA-2532 penetration testing of Rules on Maintenance (JSME S NA1-2004), conduct PT on the external surface of pipes.
Applicable regulation / applied regulation	Rules on Maintenance (JSME S NA1-2004)
Decision standard	No cracking-related indicators. If cracking indicators are found, perform non-destructive testing such as UT.

JSME S NA1-2004: Codes for Nuclear Power Generation Facilities: Rules on Maintenance (JSME)

(1) Scope overview of PT on the elbow part

All frequencies for ends and bend of the elbow part at t+20mm scope (t: piping thickness)

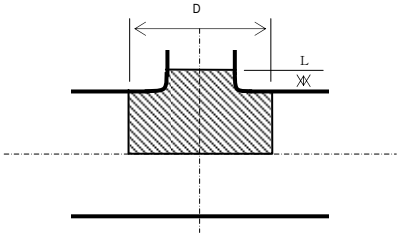


(2) Scope overview of PT on the T part

Saddle part with same scope as header outside diameter (D)

(branch pipe side radius + branch straight pipe)

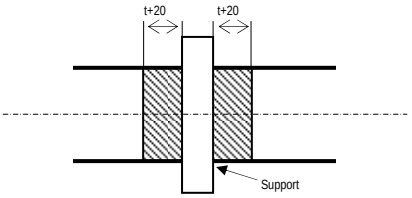
L: distance from header to branch pipe R

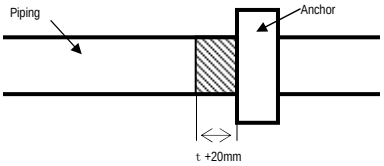


(3) Scope overview of PT on the straight pipe

t+20mm from the support, weld and anchor scope where PT is possible as shown in the figure on the right

(t: pipe wall thickness)





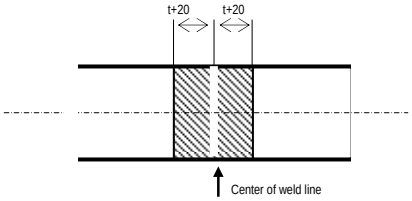


Table 4-3 Ultrasonic testing method and decision standard of pipe weld joints(additional inspection)

Item	Details
Objective	Check for cracks on the internal surface of pipe weld joints.
Scope of inspection	Select weld joints that do not satisfy the allowable value during the seismic response analysis that uses observed waves. These are subject to ultrasonic testing (UT).
Inspection method	Perform UT on whole circumference of the internal surface of pipe weld joints from both the axial and circumferential directions.
Applicable regulation / applied regulation	Rules on Maintenance (JSME S NA1-2004) JEAG4207-2004
Standard sensitivity	Conform to the standard sensitivity stipulated in JEAG4207-2004. Create DAC arcs using the skip points of the internal surface. 1) Thickness under 25mm: 2S/8 & 6S/8 2) Thickness over 25mm: 3S/8 & 5S/8
Flaw detection sensitivity	Flaw detection sensitivity is as shown below: 1) Manual flaw detection: more than twice the standard sensitivity (+6dB) 2) Automatic flaw detection: standard sensitivity
Record level	Indicators exceeding DAC20%.
Decision standard	No indicators exceeding DAC20%. When internal echo exceeding DAC20% is detected, assess the reflection source type. Conduct additional testing and other non-destructive testing as needed for assessment. When it is deemed to be an internal crack, discuss separately.

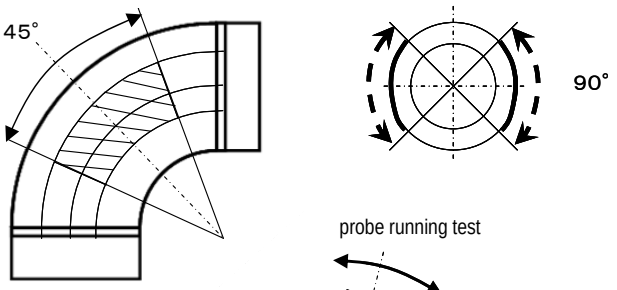
JSME S NA1-2004: Codes for Nuclear Power Generation Facilities: Rules on Maintenance (JSME)
JEAG4207-2004: Ultrasonic testing policy for in-service inspection of LBWR nuclear power generation equipment (JEA)

Table 4-4 Ultrasonic testing method and decision standard for pipe inspection (elbow part) (additional inspection)

Item	Details
Objective	Confirm presence of cracks on the internal surface of the pipe elbow part.
Scope of inspection	Select areas (elbow part) that do not satisfy allowable value during the seismic response analysis that uses observed waves, for ultrasonic testing (UT). Scope of subject areas is shown in the figure below.
Inspection method	Perform UT on the internal surface of the pipe elbow part from the circumferential direction.
Applicable regulation / applied regulation	Rules on Design and Construction (JSME S NC1-2005)
Standard sensitivity	Standard sensitivity is the sensitivity derived by adjusting the reflected echoes from the internal slits of contrast testing parts to 80% of the value on the flaw detector screen.
Flaw detection sensitivity	Flaw detection sensitivity is as shown below: 1) Manual flaw detection: more than twice the standard sensitivity (+6dB) 2) Automatic flaw detection: standard sensitivity
Record level	Indicators standard sensitivity exceeding 40% of the value on the display device.
Decision standard	No indicators exceeding 40% of the value on the display device. When internal echo exceeding 40% of the value on the display device is detected, assess the reflection source type. Conduct additional testing and other non-destructive testing as needed for assessment. When it is deemed to be an internal crack, discuss separately.

JSME S NC1-2005: Codes for Nuclear Power Generation Facilities: Rules on Design and Construction (JSME)

(1) Scope overview of UT on the elbow part



(2) Flaw detection method

Flaw detection in circumferential direction at 45° angle (lateral wave, 5MHz)

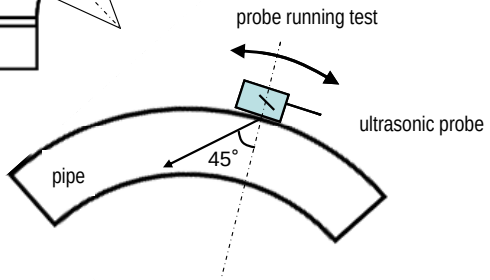
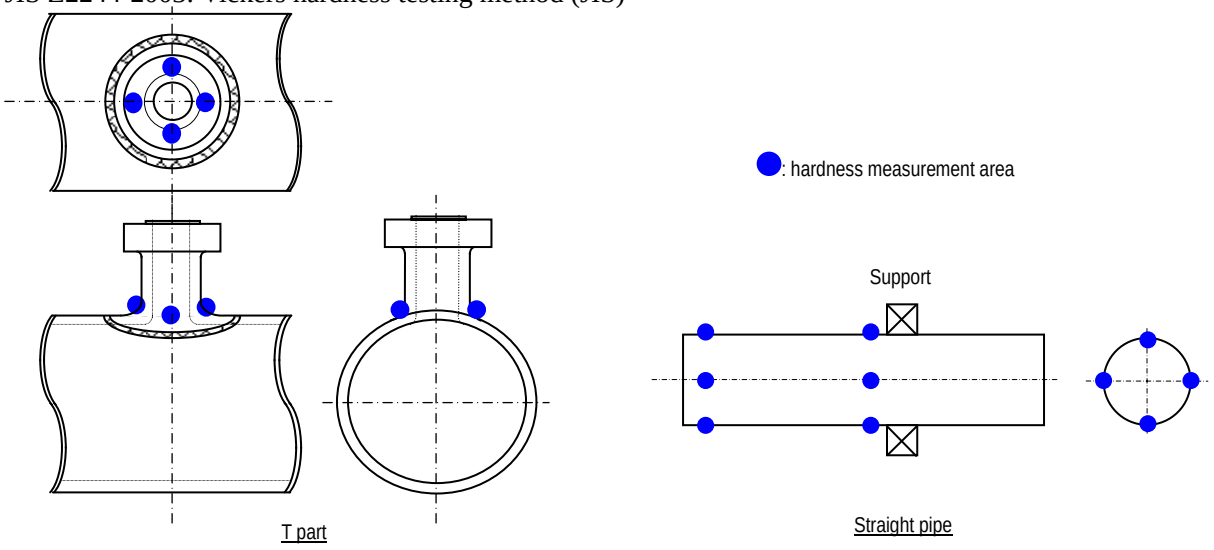


Table 4-5 Surface hardness testing method and decision standard for pipes (additional inspection)

Item	Details
Objective	Confirm presence of plastic strain that will affect wear intensity.
Scope of inspection	Select areas that do not satisfy allowable values during the seismic response analysis that uses observed waves. These will be subject to surface hardness testing. Select areas where the maximum stress does not satisfy the allowable value (assessment parts) and where impact is small (comparison parts) for testing.
Inspection method	Measurement areas of assessment and comparison parts shall be equal in diameter, form, material, manufacturing method, and direction. A portable Vickers hardness instrument shall be used to measure surface hardness. ・T part (see fig. below) ・Straight pipe (see fig. below)
Applicable regulation / applied regulation	JIS Z 2244-2003
Testing guideline	Remove surface hardening layer. Use #400 as final surface polishing conditions.
	Use standard hardness testing piece to confirm a significant difference does not exist between standard hardness and measurement value, before and after testing.
	Assume the score for each measurement area is 40 points to derive the average value and standard deviation.
Decision standard	Find the maximum and minimum value for each assessment or comparison part. Compare all maximum values and minimum values. Both the maximum and minimum values of assessment parts must be less than those of comparison parts, or within the scope of allowable dispersion (standard deviation). If decision standard is exceeded, conduct overall assessment upon deliberation of measurement value dispersion, manufacturing history, and possibility of material non-uniformity.

JIS Z2244-2003: Vickers hardness testing method (JIS)



(2) Inspection methods and decision standards equipment foundation bolts are shown in Tables 4-6 through 4-8.

Table 4-6 Visual testing method and decision standard for foundation bolts (additional inspection)

Item	Details
Objective	Confirm presence of warping, loosening, detachment or surface abnormalities on foundation bolts.
Scope of inspection	Select systems where damage was discovered during basic inspections or systems with results that do not satisfy allowable value during the seismic response analysis of seismic resistance S class pipes that uses observed waves. These will be subject to visual testing (VT).
Inspection method	Directly perform VT on foundation bolts.
Applicable regulation / applied regulation	Rules on Maintenance (JSME S NA1-2004)
Decision standard	No warping, loosening, detachment or surface abnormalities on foundation bolts. If abnormalities are found, perform overall assessment through percussion testing, torque check testing and UT results.

JSME S NA1-2004: Codes for Nuclear Power Generation Facilities: Rules on Maintenance (JSME)

Table 4-7 Ultrasonic testing method and decision standard for foundation bolts(additional inspection)

Item	Details
Objective	Confirm presence of cracks on foundation bolt screws.
Scope of inspection	Select systems where damage was discovered during basic inspections or systems with results that do not satisfy allowable value during the seismic response analysis of seismic resistance S class pipes that uses observed waves. Foundation bolt screws will be subject to UT.
Inspection method	Vertical deflection method (bottom echo method) used on foundation bolt screws.
Applicable regulation / applied regulation	Rules on Design and Construction (JSME S NC1-2005)
Standard sensitivity	Standard sensitivity is as shown below: 1) Screws on the ultrasonic echo incidence side: sensitivity derived by adjusting the reflected echoes from the bottom of sound parts to 80% of the value on the flaw detector screen. 2) Screws on the opposite of the ultrasonic echo incidence side: four times (+12dB) the sensitivity derived by adjusting the reflected echoes from the bottom of sound parts to 80% of the value on the flaw detector screen.
Flaw detection sensitivity	Flaw detection sensitivity will be the standard sensitivity + 6dB.
Record level	Indicators where echo height exceeds 5%.
Decision standard	No effective indicators where echo height exceeds 5%. Discuss separately if effective indicators are confirmed.

JSME S NC1-2005: Codes for Nuclear Power Generation Facilities: Rules on Design and Construction (JSME)

Table 4-8 Torque check testing method and decision standard for foundation bolts (additional inspection)

Item	Details
Objective	Confirm whether foundation bolts have lost fastening ability.
Scope of inspection	Select systems where damage was discovered during basic inspections or systems with results that do not satisfy allowable value during the seismic response analysis of seismic resistance S class pipes that uses observed waves. These will be subject to torque check testing.
Inspection method	Tools (torque wrench) will be used for torque check testing (loosened side). Torque value will be decided for each part using design requirement bolt axial force.
Applicable regulation / applied regulation	
Decision standard	Nuts not spinning during torque check testing. If nuts spin, conduct overall assessment through the percussion test, VT and UT results.

4.2 Inspector / evaluator

Inspectors / evaluators shall be workers possessing skills shown in Table 4-9.

Table 4-9 Skills required of inspectors / evaluators (additional inspection)

Inspection method	Skill
Visual inspection	・Workers confirmed to have no vision problems through checks of close-up vision required of non-destructive testing personnel as per JIS Z 2305 “Non-destructive testing – Qualification and certification of personnel” utilized in NDIS 3413 “Method of vision and color sight tests for non-destructive testing personnel.” ・Workers with years of work experience, internal certification, record of education / testing reception, and other appropriate skills.
Non-destructive testing	Workers with qualifications and skills shown below for non-destructive testing: ・Above Level 2 in JIS Z 2305 “on-destructive testing – Qualification and certification of personnel” ・Skill level equivalent to above certification
Pipe surface hardness testing	・Workers with years of work experience, record of education / testing reception, and other appropriate skills.
Foundation bolt torque test	・Workers with years of work experience, record of education / testing reception, and other appropriate skills.

Appendix A: Plastic strain detection and measurement guideline (Index only)

(Description)

(Description.-1.1) Definitions of assessed parts, compared parts, measured part and measured area

(Description.-2.1) Ferrite steel annealed with low-temperature or normally

(Description.-2.2) Austenite stainless steel treated with solution heat

(Description.-2.3) Materials with similar hardness

(Description.-2.4) Polishing workers

(Description.-2.5) Hardness measurers

(Description.-2.6) Hardness measuring instruments

(Description.-2.7) Inspection of repetition and errors

(Description.-2.8) Work hardened layer confirmation method

(Description.-2.9) Checking error pre/post-testing

(Description.-2.10) Evidence for measured area of each measured part

(Description.-2.11) Space between measured areas

(Description.-3.1) Decision method

(Description.-4.1) Recording guideline

(Description.-5.1) Assessment of earthquake impacts on plastic strain

(Description.-5.2) Knowledge regarding equipment subject to testing

Appendix B Ultrasonic testing method for foundation bolts guideline (Index only)

(Description)

(Description.-1.1) Impairment caused by earthquake

(Description.-1.2) Guidelines stipulated in this Appendix

(Description.-2.1) Adjusting standard sensitivity around terminal area

(Description.-3.1) Extracted standards

(Description.-3.2) Impression impact

(Description.-3.3) Determining whether impairment was caused by the earthquake

Appendix C Torque check testing method for foundation bolts guideline (Index only)

Appendix D Ultrasonic testing method for pipe (elbow part) guideline (Index only)

Post-Earthquake Equipment Integrity Assessment Guideline
[[Inspection Method: Pipes, Foundation Bolts]] Main Text

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