

May 19, 2009

Mr. Suk Kwan Kim  
Doosan Heavy Industries  
555 Gwigok-Dong  
Changwon, Gyeongnam  
641-792 Korea

SUBJECT: NRC INSPECTION REPORT NO. 99901373/2009-201 AND NOTICE OF  
NONCONFORMANCE

Dear Mr. Kim:

From March 30 to April 3, 2009, the U.S. Nuclear Regulatory Commission (NRC) conducted an inspection at the Doosan Heavy Industries (Doosan) facility in Changwon, Gyeongnam, Korea. The enclosed report presents the results of this inspection.

This was a limited scope inspection, which focused on assessing your compliance with the provisions of Part 21 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 21) "Reporting of Defects and Noncompliance," and selected portions of Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants." This NRC inspection report does not constitute NRC endorsement of your overall quality assurance (QA) or 10 CFR Part 21 programs.

During this inspection, NRC inspectors found that implementation of your QA program failed to meet certain NRC requirements contractually imposed on you by your customers. The NRC inspectors noted a deficiency for a failure to perform an adequate root cause evaluation for a significant condition adverse to quality. The specific finding and references to the pertinent requirements are identified in the enclosures to this letter.

Please provide a written explanation or statement within 30 days of this letter in accordance with the instructions specified in the enclosed Notice of Nonconformance.

In accordance with 10 CFR 2.390 of the NRC's "Public Inspections, Exemptions, Requests for Withholding," a copy of this letter, its enclosures, and your response will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's document system (ADAMS), accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. To the extent possible, your response should not include any personal privacy, proprietary, or Safeguards Information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request that such material is withheld from public disclosure, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for

withholding confidential, commercial, or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

Sincerely,

***/RA Andy du Bouchet for/***

Juan Peralta, Chief  
Quality and Vendor Branch 1  
Division of Construction Inspection  
& Operational Programs  
Office of New Reactors

Docket No.: 99901373

Enclosures: 1. Notice of Nonconformance  
2. Inspection Report 99901373/2009-201

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**NRO-002**

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<b>DATE</b>	5/19/2009	5/19/2009	5/19/2009	

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## NOTICE OF NONCONFORMANCE

Doosan Heavy Industries  
555 Gwigok-Dong  
Changwon, Gyeongnam  
641-792 Korea

Docket Number 99901373  
Inspection Report No. 99901373/2009-201

Based on the results of a U.S. Nuclear Regulatory Commission (NRC) inspection conducted March 30 – April 3, 2009, of activities performed at Doosan Heavy Industries (Doosan), certain activities were not conducted in accordance with NRC requirements, which were contractually imposed upon Doosan by NRC licensees.

Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50 states, in part that measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition.

Contrary to the above, as of April 3, 2009:

Doosan repeatedly failed to record pre-heat data for welding on the Sequoyah nuclear power plant replacement steam generator project. Doosan's corrective actions, including measures associated with Root Cause Analysis RCA-080084, Revision 1, dated August 8, 2008, failed to determine the cause of the condition and preclude repetition of this significant condition adverse to quality.

This issue has been identified as Nonconformance 99901373/2009-201-01.

Please provide a written statement or explanation to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001 with a copy to Juan Peralta, Chief, Quality and Vendor Branch 1, Division of Construction Inspection and Operational Programs, Office of New Reactors, within 30 days of the date of the letter transmitting this Notice of Nonconformance. This reply should be clearly marked as a "Reply to a Notice of Nonconformance" and should include for each noncompliance: (1) the reason for the noncompliance, or if contested, the basis for disputing the noncompliance; (2) the corrective steps that have been taken and the results achieved; (3) the corrective steps that will be taken to avoid non-compliances; and (4) the date when your corrective action will be completed. Where good cause is shown, consideration will be given to extending the response time.

Because your response will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's document system (ADAMS), accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>, to the extent possible, it should not include any personal privacy, proprietary, or Safeguards Information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will

create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If Safeguards Information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

Dated this 19<sup>th</sup> day of May 2009.

U.S. NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
DIVISION OF ENGINEERING  
VENDOR INSPECTION REPORT

Docket No.: 99901373

Report No.: 99901373/2009-201

Vendor: Doosan Heavy Industries (Doosan)  
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Vendor Contact: Suk Kwan Kim  
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Nuclear Industry: Doosan is one of the world's largest manufacturers of reactor vessels, steam generators, reactor internals, and balance of plant components for the nuclear industry worldwide. Doosan manufactures safety-related and American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code items and components.

Inspection Dates: March 30 – April 3, 2009

Inspection Team Leader: Kerri Kavanagh, CQVP/DCIP/NRO

Inspectors: Samantha Crane, CQVP/DCIP/NRO  
Aladar Csontos, CIB/DE/RES  
Victor Hall, CQVP/DCIP/NRO  
Eric Reichelt, CIB1/DE/NRO

Approved by: Juan Peralta, Chief  
Quality and Vendor Branch 1  
Division of Construction Inspection  
& Operational Programs  
Office of New Reactors

## EXECUTIVE SUMMARY

Doosan Heavy Industries  
99901373/2009-201

The purpose of this inspection was to review selected portions of Doosan's quality assurance (QA) and 10 CFR Part 21 (Part 21) programs. The inspection was conducted at Doosan's facility in Changwon, Korea.

The NRC inspection bases were:

- Title 10 of the *Code of Federal Regulations* (10 CFR) Part 21, "Reporting of Defects and Noncompliance;" and
- Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Part 50 of Title 10 of the *Code of Federal Regulations*

Representatives from the Korean Institute of Nuclear Safety (KINS) and the Canadian Nuclear Safety Commission (CNSC) observed the inspection. These observations fostered the sharing of international experience with the construction of new reactors and oversight of vendors consistent with the objectives of the Multinational Design Evaluation Program (MDEP).

The results of this inspection are summarized below. The previous NRC inspection performed at Doosan's facility in Changwon, Korea, was conducted from May 26 – 29, 2008. That inspection is documented in inspection report 99901373/2008-201.

### 10 CFR Part 21 Program

The inspectors concluded that Doosan's Part 21 process and applicable procedures conformed to the regulatory requirements of Part 21. The inspectors determined that Doosan implemented its Part 21 program in accordance with its procedures. No findings of significance were identified.

### Corrective Action

The inspectors identified Nonconformance 99901373/2009-201-01 for failure to determine the cause of the condition and prevent reoccurrence of a significant condition adverse to quality. The inspectors concluded that Doosan's procedure for performing root cause analyses was inadequate. With the exception of the above noted nonconformance, the inspectors determined that Doosan's corrective action program was consistent with the regulatory requirements of Criterion XVI "Corrective Action," of Appendix B to 10 CFR Part 50.

### Design Control

The inspectors concluded that Doosan's Customer Document Review and Design Control processes and practices were consistent with Criterion III "Design Control," of Appendix B to 10 CFR Part 50, and American Society of Mechanical Engineers (ASME) Section III NB code requirements. The inspectors concluded that Doosan's implementation of these processes and practices provided appropriate design controls. No findings of significance were identified.

### Commercial-Grade Dedication

The inspectors concluded that Doosan's commercial-grade dedication (CGD) procedures were consistent with industry guidance. The inspectors concluded that Doosan had adequate engineering involvement in its dedication process and conducted its CGD activities consistent with its procedures. No findings of significance were identified.

### Control of Special Processes

The NRC inspectors concluded that Doosan had established an appropriate means to control fabrication activities and special processes such as welding, non-destructive evaluation (NDE), and heat treatment for supply of replacement reactor vessel closure heads and replacement steam generators. The inspectors concluded that the Doosan Quality Assurance Manual (QAM) and associated fabrication and special process procedures and activities were being adequately implemented by qualified personnel, using qualified equipment and processes. No findings of significance were identified.

### Control of Measuring and Test Equipment

The inspectors concluded that Doosan had established appropriate and effective means to control measuring and test equipment. No findings of significance were identified.



## REPORT DETAILS

### 1. 10 CFR Part 21 Program

#### a. Inspection Scope

The inspectors reviewed the Doosan Quality Assurance Manual (QAM) QM-200, Revision 17, dated March 17, 2009, and implementing policies and procedures that govern the Part 21 process to determine compliance with Part 21. Specifically, the inspectors focused on Quality Procedure (PQAP) PQAP-1602, "Reporting of 'Defects' and Failures to Comply Pursuant to 10CFR21," Revision 6, dated March 23, 2009 and the following documents:

- Corrective Action Report (CAR) 080092, August 12, 2008
- Internal audit report IAR-0903-01, "Implementation and Effectiveness of the Quality Assurance Program," March 25, 2009

The inspectors also reviewed Doosan's procedures that govern corrective action, the control and correction of nonconforming items, and QA audits to verify an adequate link to the Part 21 process.

The inspectors reviewed a mock-Part 21 scenario developed by Doosan which demonstrated how Doosan's Part 21 process functioned. Finally, the inspectors reviewed the corrective actions implemented by Doosan to address the Part 21 findings from the NRC's previous inspection and discussed the Part 21 process with Doosan staff.

#### b. Observations and Findings

PQAP-1602 outlined the process used at Doosan for the reporting of defects. The procedure provided for the review of deviations by a group consisting of representatives of the Design Engineering (DE) department and the Nuclear Quality Control (NQC) department. The inspectors noted that the group decided whether identified deviations could create a substantial safety hazard and would be reportable under Part 21. The inspectors noted that Doosan's procedures that govern corrective action, the control and correction of nonconforming items, and QA audits provided a link to the Part 21 process.

CAR 080092 described the corrective actions associated with Notice of Violation (NOV) 99901373/2008-201-01. CAR 080092 included training records of training completed on June 13, 2008 on Revision 5 of procedure PQAP-1602, which addressed the NRC concerns stated in NOV 99901373/2008-201-01. In addition, CAR 080092 included the requirement of an internal audit by QA to confirm implementation of 10 CFR Part 21. The inspectors confirmed that the corrective action had been completed. Based on its review, the inspectors closed NOV 99901373/2008-201-01.

The inspectors noted that Doosan had not performed any Part 21 evaluations. However, Doosan developed a mock scenario to demonstrate its capability to evaluate and report defects. The scenario included a fictitious nonconformance report, recommended disposition sheet, and a Part 21 notification which assumed that incorrect material had

been welded onto a steam generator primary nozzle safe end for a U.S. nuclear power plant. The inspectors found that Doosan's fictitious scenario adequately identified a deviation, and properly evaluated the deviation to determine whether it could create a substantial safety hazard. The NRC inspection team concluded that the Part 21 demonstration adequately reflected the requirements of Part 21.

c. Conclusions

The inspectors concluded that Doosan's Part 21 process and applicable procedures conformed to the regulatory requirements of Part 21. The inspectors determined that Doosan implemented its Part 21 program in accordance with its procedures. No findings of significance were identified.

2. Corrective Action

a. Inspection Scope

The inspectors reviewed the Doosan implementing policies and procedures that govern the control of conditions adverse to quality, and significant conditions adverse to quality to verify compliance with the requirements of Criterion XVI, "Corrective Action," of Appendix B to 10 CFR Part 50. The inspectors reviewed the corrective actions in response to the NRC's 2008 inspection, the corrective actions and root cause analyses associated with two Westinghouse stop work notices related to pre-heat issues in 2008, and sampled additional CARs and nonconformance reports (NCRs). Specifically, the following Nuclear BG Quality Control Procedures (NQCPs), and Quality Control Procedure (QCP) were reviewed:

- NQCP-1602 "Control of Corrective Actions," Revision 1, dated March 20, 2009,
- QCP-1602, "Quality Control Procedure QCP-300 Control of Corrective Action," Revision 3, dated April 16, 2008
- NQCP-1501 "Control and Correction of Nonconforming Items and Activities," Revision 11, dated March 20, 2009
- QCP-0701, "Vendor Evaluation," Revision 7, October 21, 2008
- Annual Evaluation of Vendors report, October 7, 2008
- Vendor Evaluation Report, VER-0808-08, August 23, 2008
- CAR 080096, August 13, 2008
- CAR 080095, August 12, 2008
- CAR 080097, August 13, 2008
- CAR 080094, August 12, 2008
- CAR 080098, August 13, 2008
- CAR 080052, May 28, 2008
- CAR 080053, May 28, 2008

b. Observations and Findings

The inspectors noted that Doosan's policies and procedures for corrective actions had not significantly changed since the previous inspection. Section 16 of the Doosan QAM described the corrective action process for Doosan and delineated the responsibilities and controls used to assure that conditions adverse to quality were promptly identified and corrected.

QCP-1602 defined responsibilities and procedures for handling nonconformances identified by Doosan’s customers. The procedure described the process for verifying the validity of deficiencies, evaluating the causes of the deficiencies, and documenting the actions to be taken to prevent recurrence.

b1. Corrective Action Associated With 2008 NRC Inspection

The inspectors determined that Doosan took appropriate corrective actions in response to NRC inspection report 99901373/2008-201. The CARs and their dates of completion are listed in the table below:

<b>Finding from NRC Inspection Report 99901373/2008-201</b>	<b>Doosan CAR No. &amp; Completion Date</b>	<b>Description</b>
Violation (Part 21) 99901373/2008-201-01	CAR 080092 August 13, 2008	Inadequate Part 21 procedure
Nonconformance (Criterion III) 99901373/2008-201-01	CAR 080094 October 24, 2008, & CAR 080098 October 23, 2008	Inadequate dedication procedures and sampling practices
Nonconformance (Criterion VII) 99901373/2008-201-02	CAR 080096 October 24, 2008	Lack of a QA Audit for purchased material, equipment, and services
Nonconformance (Criterion VII) 99901373/2008-201-03	CAR 080095 October 24, 2008	Lack of annual evaluation for ASME-certified suppliers
Nonconformance (Criterion VII) 99901373/2008-201-04	CAR 080097 October 24, 2008	Failure to adequately maintain approved vendors database
Nonconformance (Criterion XV) 99901373/2008-201-05	CAR 080052 June 13, 2008	Failure to evaluate NCRs for Part 21 applicability
Nonconformance (Criterion XVI) 99901373/2008-201-06	CAR 080053 May 29, 2008	Failure to evaluate CARs for Part 21 applicability

The inspectors noted that Doosan’s CARs provided records of training when applicable, listed corrections to Doosan’s procedures, and additional steps that were taken. The inspectors determined that Doosan’s corrections to its quality procedures were adequate to address the identified findings. Based on its review, the inspectors closed NONs 99901373/2008-201-02 through 99901373/2008-201-06.

Regarding Nonconformance 99901373/2008-201-01, and CARs 080094 and 080098, the inspectors identified that Doosan’s corrective actions did not fully address the deficiency. The inspectors noted that Doosan corrected its procedures for future audits and surveys of sub-suppliers, performed a root-cause analysis, and training. However, Doosan did not document its justification of acceptance of material from the suppliers for past projects in the CARs. Following discussions with the inspectors, Doosan completed a technical evaluation to adequately document its engineering judgment. The evaluation included historical vendor evaluations, and noted that the suppliers had been previously evaluated for lot and batch traceability. The inspectors determined the technical and vendor evaluations and associated documents provided reasonable assurance that the items procured would have lot and batch traceability. The inspectors found Doosan’s technical evaluation to be adequate documentation to support closing its CARs. Based on its review, the inspectors closed NON 99901373/2008-201-01.

b2. Corrective Action Associated With Westinghouse Stop Work Notices

The inspectors noted that Doosan initiated multiple NCRs and CARs regarding missed pre-heat events which led to two Westinghouse Stop Work Notices in 2008. The pre-heat events are summarized below:

1. On January 15, 2008, a Doosan employee failed to record pre-heat data on a replacement steam generator project for the Sequoyah nuclear power plant. This was viewed as an isolated, low-significance event, and was documented in NCR 2008-01-14.
2. On July 17, 2008, another Doosan employee failed to record pre-heat data on the Sequoyah steam generator project, as noted in NCR 2008-07-17. This was discovered by representatives from Westinghouse and the Tennessee Valley Authority (TVA). The Westinghouse and TVA representatives later noted that the data had been filled in by a Doosan foreman. Westinghouse issued a Stop Work Notice shortly thereafter for this project. Doosan issued CAR 080084, which included Root Cause Analysis (RCA) RCA-080084. Westinghouse lifted its Stop Work Notice following Doosan completion of corrective actions.
3. On August 11, 2008, a different Doosan worker failed to record pre-heat data on the Sequoyah steam generator project, as noted in NCR 2008-08-12. Doosan had also experienced issues with cracking on tubesheet welding on another AP1000 project. Due to these issues, Westinghouse issued another Stop Work Notice for all TVA and AP1000 projects.

The inspectors determined that Doosan failed to prevent reoccurrence of missed pre-heat conditions for welding on Sequoyah nuclear power plant's replacement steam generator project. Doosan's corrective actions, including measures associated with RCA-080084, Revision 1, dated August 8, 2008, failed to preclude repetition of this significant condition adverse to quality. This issue has been identified as an example of Nonconformance 99901373/2009-201-01.

The inspectors noted that following the August 2008, missed pre-heat, Doosan revised RCA-080084, and included a more thorough analysis. The inspectors noted that Doosan's corrective action procedures did not provide the necessary level of detail regarding root cause analyses consistent with the latest revision to RCA-080084. Through discussion with Doosan and Westinghouse staff, the inspectors determined that Westinghouse provided extensive assistance and training for the revised RCA.

On August 28, 2008, Westinghouse lifted the Stop Work Notice for TVA projects, based on successful completion of extensive corrective actions. This included analyses by Doosan showing that all affected components were verified by alternate means, such as non-destructive examination (NDE), and were not affected by the missing pre-heat data.

As a point of interest, the NRC inspectors noted that Doosan initiated NCRs 080571, revision 0, and 080571, revision 1, and CAR-080104 (including RCA-CAR-080104, revision 1) for the tubesheet cracking issues on another AP1000 project. Doosan determined that the cracking was not related to pre-heating, and has taken successful corrective actions to prevent recurrence. However, the inspectors noted that Doosan's RCA provided conflicting conclusions, and was not supported by objective evidence.

This was another example of NON 99901373/2009-201-01 for an inadequate RCA being performed in response to a significant condition adverse to quality.

c. Conclusion

The inspectors identified Nonconformance 99901373/2009-201-01 for failure to prevent reoccurrence of a significant condition adverse to quality. In addition, the inspectors concluded that Doosan's procedure for performing root cause analyses was inadequate. Therefore, the inspectors determined that Doosan's corrective action program was not being implemented in accordance with the regulatory requirements of Criterion XVI "Corrective Action," of Appendix B to 10 CFR Part 50.

3. Design Control

a. Inspection Scope

The inspectors reviewed the Doosan implementing policies and procedures that govern design control to verify compliance with the requirements of Criterion III, "Design Control," of Appendix B to 10 CFR Part 50. Specifically, the inspectors reviewed Section 3, "Order Entry, Customer Document Review, and Design Control" of the Doosan QAM and implementing procedures to ensure appropriate design reviews and controls of ASME Section III fabricated components. The inspectors also reviewed Westinghouse design specifications, requirements, and drawings for three components and verified the accurate transfer of information to the pertinent Doosan manufacturing drawings, purchase specifications, and assembly quality plans. Documents reviewed:

- Westinghouse:
  - AP1000 Steam Generator Tubesheet Base Metal, Welding, and Machining Drawings, APP-MB01-V2-051-6 Rev. 3
  - AP1000 Steam Generator Design Specification, APP-MB01-Z0-101
  - Additional Requirements for AP1000 Steam Generator Welding Consumables, APP-MB01-VW-021
  - AP1000 Steam Generator – Engineering Requirements for Welding Procedure Qualifications for ASME Code Section III-NB Pressure Boundary Overlay and Attachment Welds, APP-GW-VW-011
  - APS Palo Verde Replacement Reactor Vessel Closure Head (RRVCH) Interim Design Features Report, APSPV-RRVCH-IDFR Rev.0
  - RRVCH Design Specification for Palo Verde Units 1, 2, and 3 Reactor Vessel Head, DS-ME-06-3
  - Westinghouse AP1000 Reactor Vessel Design Specifications, APP-MV01-Z0-101
  - Design Specification, DS-ME-06-3, Replacement Reactor Vessel Closure Head (RRVCH)
- Doosan:
  - AP1000 Steam Generator Tubesheet Forging Drawings, D-CA-21146-M01/2
  - AP1000 Steam Generator Tubesheet Assembly Drawings, D-CA-21146-M02/5
  - Quality Plan of the China AP-1000 Projects SG Tubesheet Assembly Quality Plan, QP-CASG46 pg1-4

- Material Purchase Specification for Inconel 690 Welding Strip Electrode and Flux for Overlay Cladding, EPS-A43-116
- Material Purchase Specification for EQ309L and EQ308L Strip/Flux for Weld Deposit Weld Overlay of Multi-Layers, EPS-A08-134
- Palo Verde RRVCH Manufacturing Drawings
  - General Arrangement, D-PV-11101-M01
  - Reactor Vessel Closure Head Penetrations, D-PV-11102-M03 pg 1-2
- AP1000 China Project Reactor Vessel Manufacturing Drawings
  - Upper Vessel Assembly, D-CA-11120-M03
  - Inlet Nozzle Assembly, D-CA-11124-M01
  - Inlet Nozzle, D-CA-11124-M02
  - Outlet Nozzle Assembly, D-CA-11125-M01
  - Outlet Nozzle, D-CA-11125-M02
- Palo Verde Units 1, 2, 3 RRVCH design plan, PV-PVRC-DP-01, Revision 6, December 2, 2008
- Design Specification Checklist, PV-HEAD-DSC-01, Revision 4, January 29, 2009
- Calculation No. PV-111CN-130, "Design Analysis of Closure Head & Vessel Flange Ass'y," Revision 2, February 4, 2009
- Design Verification Checklist No. RCN-C-130, Revision 2, February 4, 2009
- Design Report Number, PV-111AR-001, "Design Report for Palo Verde Units 1, 2, and 3 Replacement RV Closure Head," Revision 1, February 10, 2009
- Procedure NQCP-0301, "Design Control," Revision 8, July 23, 2008

b. Observations and Findings

Section 3 of the Doosan QAM provided the requirements for fabrication of components as an ASME "NPT" Certificate Holder with design responsibility and without design responsibility. The inspectors noted that Doosan was required to verify that the Customer Design Specification and drawings contained a complete basis for the construction of the item in accordance with the ASME Code when Doosan had design responsibility for components.

For the U.S. components being manufactured by Doosan, Doosan had design responsibility for only the Palo Verde replacement reactor vessel closure heads. The inspectors confirmed that all design control requirements were met for the Palo Verde replacement reactor vessel closure heads.

The inspectors compared selected sections of the Westinghouse and Doosan AP1000 Steam Generator, AP1000 Reactor Vessel, and Palo Verde replacement reactor vessel closure heads design requirements, design and manufacturing drawings, and welding, NDE, and post weld heat treatment specifications to the 1998 ASME Section III Division I Subsection NB Code requirements. All selected review areas of Doosan specification documents and manufacturing drawings were confirmed to conform to the code requirements and Westinghouse customer documentation and specifications. The inspectors also found that Doosan's document review and design control developed satisfactorily detailed manufacturing drawings appropriately signed off and approved from corresponding Westinghouse specifications and design drawings.

c. Conclusion

The inspectors concluded that Doosan's Customer Document Review and Design Control processes and practices were consistent with Criterion III "Design Control," of Appendix B to 10 CFR Part 50, and American Society of Mechanical Engineers (ASME) Section III NB code requirements. The inspectors concluded that Doosan's implementation of these processes and practices provided appropriate design controls. No findings of significance were identified.

4. Commercial-Grade Dedication Process

a. Inspection Scope

The NRC inspectors reviewed the Doosan QAM and implementing procedures that govern the dedication of commercial-grade items (CGIs) provided by Doosan for use in safety-related applications to verify compliance with applicable regulatory requirements.

Specifically, the inspectors reviewed PQAP-0701, Revision 2, "Designation, Dedication and Control of Commercial Grade Item," dated September 3, 2007, and Palo Verde (PV) dedication procedure for Control Element Drive Mechanisms (CEDMs) PV-CEDM-CGI-001, Revision 2, "Commercial Grade Item (CGI) Dedication Procedure for Palo Verde Unit 1, 2, & 3 – CEDM Motor Assemblies," dated December 8, 2008.

The inspectors reviewed detailed work instructions and drawings used to verify critical characteristics of a sample of parts used in the CEDM assembly. The inspectors observed work being performed in the dedication lab, and interviewed Doosan personnel responsible for dedication activities.

b. Observations and Findings

Doosan procedures PQAP-0701 and PV-CEDM-CGI-001 provided the details and instructions describing the authority, responsibilities, and methods to be implemented by Doosan or its supplier to designate, dedicate, and control CGI in safety-related applications. PQAP-0701 included the guidance provided in EPRI NP-5652, "Guidelines for Utilization of Commercial Grade Items in Nuclear Safety Related Application (NCIG-07)," dated June 1988, for dedication activities.

The inspectors noted that Doosan's dedication procedure PV-CEDM-CGI-001 listed the critical characteristics for the piece parts used in the fabrication of the CEDMs. The inspectors noted that material was listed as a critical characteristic for all parts. Springs were the only parts which had an additional critical characteristic; spring rate. The inspectors noted that EPRI guidance for dedication of springs recommended dimensions as critical characteristics. The inspectors found that Doosan used to list free length as a critical characteristic, but removed it following an audit by Arizona Public Service. Arizona Public Service approved Doosan's removal of free length, and found that material and spring rate were adequate critical characteristics for the springs. The inspectors concluded that Doosan's selection of critical characteristics was performed by Doosan engineering, and was accepted by Arizona Public Service. The inspectors also noted that the CEDM assemblies were comprehensively tested, and that any dimensional issues would be apparent during assembly or testing. The inspectors did not identify any issues with Doosan's dedication plans.

As noted in the above section on Corrective Actions, the inspectors determined that Doosan performed an adequate technical evaluation to justify the use of items and materials procured for its dedication activities. The inspectors noted that Doosan corrected its procedures for future projects to assure that commercial suppliers were appropriately surveyed.

c. Conclusion

The inspectors concluded that Doosan's CGI dedication procedures were consistent with industry guidance. The inspectors concluded that Doosan had adequate engineering involvement in its dedication process and conducted its CGI dedication activities consistent with its procedures. No findings of significance were identified.

5. Control of Special Processes

a. Inspection Scope

The inspectors reviewed the Doosan QAM and implementing policies and procedures that govern the control of production and special processes. Specifically, the inspectors reviewed Doosan QAM Section 9.0, "Control of Processes," of the Doosan QAM, Revision 13, dated January 31, 2008.

The inspectors reviewed Doosan's implementing policies and procedures for welding, NDE, and heat treating. Specifically, for welding activities, the inspectors reviewed shop travelers, weld procedure specifications, supporting procedure qualification records, pre-heat data, welder qualifications, and the calibration certificates of the measuring equipment. For NDE, the inspectors reviewed magnetic particle testing (MT) procedures, MT reports, MT examiner qualifications, Ultrasonic Testing (UT) procedures, UT Level II inspector qualifications, and the calibration certificates of the measuring equipment. Specifically, the following documents were reviewed:

- QCP NQCP-0901, "Control of Production Processes," Revision 5, dated April 16, 2008
- QCP-0206, "Qualification of Welding and Brazing Personnel," Revision 4, dated February 27, 2009
- QCP-0907, "Control of Nondestructive Examination Operations," Revision 1, dated January 10, 2006
- QCP-0908, "Qualification and Demonstration of Nondestructive Examination Procedures," Revision 1, dated January 10, 2006
- NQCP-0905, "Control of Heat Treatment Operations," Revision 1, dated September 21, 2006
- NQCP-0207, "Qualification of Heat Treatment Operators," Revision 0, dated July 26, 2005

For informational purposes, the inspectors observed NDE activities for the Korean Shin-Kori Units 4 steam generator. For heat treating activities, the inspectors reviewed work instructions, heat treatment records, heat treatment charts, the qualification and training records of the heat treat operators and the calibration certificates of the measuring equipment.



The inspectors observed J-groove Inconel buttering on the Palo Verde Unit 1 replacement reactor pressure vessel head, and inter shell to lower shell welding on the Sequoyah unit 2D replacement steam generator. The inspectors witnessed UT on the inner diameter of the Sequoyah Unit 2C replacement steam generator. This UT inspection was observed by the American Society of Mechanical Engineers (ASME) Authorized Nuclear Inspector (ANI). The inspectors reviewed the heat treatment data for the Sequoyah Replacement Steam Generator 2C Lower Shell to Inter Shell Assembly.

The inspectors reviewed the Doosan process for welding material control, interviewed personnel at the Welding Material Crib, and reviewed applicable records used for material control process implementation, including the welding material control log and Welding Material Issue Cards.

b. Observations and Findings

QAM Section 9 described the system used to control special processes used for the manufacture of casting and forging materials and fabrication operations for the construction of ASME Code Section III items. Section 9.3 described the process for preparation, issue, distribution, and implementation of shop travelers for manufacturing operations. Section 9.6 described the general welding process requirements and limitations, and Section 9.8 described controls for performance of NDE activities and for qualification and certification of NDE personnel.

QCP NQCP-0901 detailed the authority, responsibilities, and methods implemented to control production processes such as welding, heat treatment, and NDE. This procedure also provided additional details for the preparation and implementation of quality plans and shop travelers for manufacturing operations.

QCP-0206 provided the guidelines to assure each welder and welding operator qualifies and maintains their qualifications as required by Section IX of the ASME Code.

QCP-0907 provided the details describing the authority, responsibilities and prescribed the methods to be implemented to conduct NDE activities for acceptance of the product as required by applicable Code, standards, product specifications and Customer requirements. QCP-0908 provided the details describing the authority responsibilities and prescribed the methods to be implemented by Doosan to qualify nondestructive examinations for use.

NCQP-0905 described the authority, responsibilities, and methods to control heat treatment and post-weld heat treatment operations. The procedure included heat treatment operations, heat treatment by approved subcontract services, and documentation and records.

NCQP-0207 described the authority, responsibilities and necessary procedural details and controls to train and qualify Heat Treat Operators to ensure suitable proficiency. The procedure included the qualification requirements, certification of qualification, maintenance of qualification, and necessary documentation to qualify heat treatment operators.

The inspectors confirmed that the Doosan manufacturing process used shop travelers to control shop production activities. The shop travelers incorporated witness and hold

points for the customer, ANI, and Doosan quality control inspectors, and identified the applicable drawings, material specifications, work instructions, and procedures applicable to the manufacturing activity being performed.

The inspectors found that the shop travelers assured that the fabrication activities were accomplished in accordance with specified requirements and conducted in the correct sequence.

The inspectors determined that Doosan's welding on ASME Code materials and fabrication of ASME Code items was performed by qualified welders and welding operators in accordance with approved welding procedure specifications. The inspectors noted that Doosan's welding procedure specifications, welders, and welding operators were qualified in accordance with the requirements of the QAM and ASME Section III and Section IX, "Welding and Brazing Qualifications."

The inspectors verified the adequacy of Doosan's process for the withdrawal and release of covered electrodes and flux from the welding crib. Welding material was controlled by the welding material issuance card and the welding material control log. The inspectors noted that welding material issue cards were added to the welding quality management system, which was used to update the table of qualified welders and extend their qualifications for the given welding process listed on the welding material issue cards as required by Section IX of the ASME Code.

Regarding NDE, the inspectors noted that the Level III non-destructive examiners were qualified to Level III in accordance with ASNT-TC1A. The inspectors noted the inspectors completed additional training required by Doosan to qualify them as Doosan Level III examiners. The NRC inspectors also noted that several ASNT-TC1A qualified Level III examiners were also classified as Doosan Level II inspectors.

The inspectors found Doosan's NDE procedures to be consistent with the ASME Code. The inspectors determined that the observed UT and MT activities were conducted consistent with Doosan's QA program and procedures.

Regarding heat treatment, the inspectors found Doosan's heat treatment procedures to be consistent with the ASME Code. The inspectors determined that the heat treatment activities observed were conducted consistent with Doosan's QA program and procedures.

c. Conclusion

The inspectors concluded that Doosan had established an appropriate means to control fabrication activities and special processes such as welding, NDE, and heat treatment for supply of replacement reactor vessel closure heads and replacement steam generators. The inspectors concluded that the Doosan QAM and associated fabrication and special process procedures and activities were being adequately implemented by qualified personnel, using qualified equipment and processes. No findings of significance were identified.

## 6. Control of Measuring and Test Equipment

### a. Inspection Scope

The inspectors reviewed the Doosan QAM and implementing policies and procedures that govern the control of measuring and test equipment. Specifically, the inspectors reviewed Section 12, "Control of Measuring and Test Equipment," of the Doosan QAM. The inspectors also reviewed QCP-1201A, "Control and Calibration of Measuring and Test Equipment," and QCP-1201B, "Control of Calibration of Meter & Indicator."

In addition, the inspectors reviewed certificates of calibration for thermocouple probes, digital thermometers, DC arc welders, gage blocks, dryer ovens, and heat treatment chart recorders.

### b. Observations and Findings

The inspectors noted that QAM Section 12 defined the control system used to assure that measuring and test equipment used for verifying activities affecting quality are maintained, controlled and calibrated at specified periods to maintain accuracy. QAM Section 12 provided details describing the general requirements, equipment control, calibration control, calibration records, calibration services, and discrepancies in measuring or test equipment.

QCP-1201A provided the details describing the authority, responsibilities, and methods implemented by Doosan to calibrate measuring and test equipment used for quality verification and quality acceptance activities. The procedure explained the process for initial calibration, equipment identification, issue and return of measuring and test equipment, calibration control, handling of equipment discrepancies, use of calibration standards, and calibration documentation including the master equipment list and master calibration schedule, the calibration certificate, issue and return cards, notification for calibration, and "DO NOT USE" tag control logs. Specifically, QCP-1201A, Section 6.5.1 states that, "After initial satisfactory calibration, a Calibration Certificate Label shall be attached to each item of equipment, if practicable, and shall indicate the equipment identification number and recall (or expiration) date as a minimum."

QCP-1201B described the authority, responsibilities and the method to calibrate and control volt and ampere meter of welding equipment, temperature indicator controller and temperature recorder of the furnace and temperature indicator of the welding material baking or holding oven issued to control manufacturing processes. The procedure explained the processes for calibrating new equipment, equipment identification, calibration control, handling of discrepant equipment, use of calibration standards, and calibration documentation.

The inspectors verified the implementation of the control of measuring and test equipment through direct interview with Doosan personnel, and the review of certificates of calibration for thermocouple probes, digital thermometers, DC arc welders, gage blocks, dryer ovens, and heat treatment chart recorders.

The inspectors found two heat treatment chart recorders with missing calibration expiration dates. Doosan personnel provided documentation that demonstrated that the calibration of the heat treatment chart recorders had not expired. Doosan stated that the heat treatment chart recorders were the property of a sub-supplier and the label was

filled out by the sub-supplier. Doosan acknowledged that the labels should have been filled out completely as required by its QAM and procedure QCP-1201A.

The inspectors noted that Doosan took immediate corrective action, documented in CAR 090055, by adding the expiration date to the calibration labels. The inspectors noted that the CAR included a revised subcontractor procedure, training session record, calibration control log, and photos of the completed calibration labels. In addition, Doosan reviewed and verified that the calibration labels on other chart recorders controlled by sub-suppliers had properly completed calibration labels.

c. Conclusion

The inspectors concluded that Doosan had established appropriate and effective means to control measuring and test equipment. Since Doosan was able to demonstrate that the two chart recorders were properly calibrated, the inspectors determined that this was an administrative error of minor significance and no other findings of significance were identified.

9. Exit Meeting

On April 3, 2009, the inspectors presented the inspection scope and findings during an exit meeting with Doosan Vice President of Nuclear Power Plant Quality Control, Sang Jin Kim, and other Doosan personnel.

## ATTACHMENT

### 1. PERSONS CONTACTED

S. J. Kim, Vice President, Nuclear Power Plant Quality Control, Doosan  
H. H. Baek, QC Manager, Doosan  
H. J. Chang, NDE Department General Manager, Doosan  
I. J. Cho, QA Team Manager, Doosan  
J. H. Choi, Casting and Forging Materials Engineer, Doosan  
K. S. Choi, Senior Manager, QA, Doosan  
M. K. Choi, QA Team Manger, Doosan  
J. Ford, Project QA Lead, Westinghouse  
J. Y. Hong, Senior Manager, NDE Department, Doosan  
N. Y. Hur, Nuclear QC, General Manager, Doosan  
S. I. Hwang, Assistant Manager, Doosan  
Y. J. Hwang, U.S. AP1000 PM General Manger, Doosan  
B. C. Kim, Manager, Casting & Forging Quality Control, Doosan  
B. K. Kim, Nuclear Production Control, Doosan  
B. Y. Kim, Authorized Inspector, HSB Global Standards Asia Pacific  
D. K. Kim, Nuclear Outsourcing Team, Doosan  
J. J. Kim, Planning Team Staff, Doosan  
J. S. Kim, Manager, QA Team, Doosan  
O. S. Kim, Nuclear Purchase Team, Doosan  
S. H. Kim, HE Design Team, Doosan  
S. H. Kim, Senior Manager, Nuclear Manufacturing Engineering Department, Doosan  
S. H. Kim, NQC Engineer, NQC Department, Doosan  
S. W. Kim, QA Engineer, Doosan  
S. W. Kim, Nuclear Manufacturing Engineering Team, Doosan  
Y. C. Kim, NQC Manager, Doosan  
Y. K. Kim, Reactor Vessel Design Team, Doosan  
Y. S. Kim, CFQC General Manager, Doosan  
C. R. Lee, Nuclear Overseas Project Management, Vice President, Doosan  
D. S. Lee, Project Manager, Doosan  
J. E. Lee, Steam Generator Design Team, Doosan  
J. Y. Lee, Interpreter  
K. H. Lee, Nuclear Production, Vice President, Doosan  
M. L. Lee, Manager, Doosan  
W. M. Lee, Senior Manager, NQC, Doosan  
Y. D. Lee, Nuclear Shop, General Manager, Doosan  
Y. K. Lee, Production Control, General Manager, Doosan  
M. T. Lim, Assistant Manager, Doosan  
M. J. Oh, Manager, Steam Generator Design, Doosan  
H. G. Park, Nuclear Design, Vice President, Doosan  
J. W. Park, Senior Manager, QA, Doosan  
S. W. Park, QA Team, General Manager, Doosan  
S. W. Ryu, Senior Manager, Quality Assurance Non-Destructive Examinations, Doosan  
J. M. Son, Manager, QC Department, Doosan  
K. Y. Son, Senior Manager, Nuclear Overseas Project Management, Doosan  
S. H. Yoo, Assistant Manager, Overseas Marketing, Doosan

The following individuals observed the inspection from March 30 – April 3, 2009:

S. W. Kim, Principal Engineer, KINS  
P. Wong, Quality Management Specialist, CNSC  
S. Yang, Head, Quality Evaluation Department, KINS

2. INSPECTION PROCEDURES USED

IP 43002, “Routine Inspections of Nuclear Vendors”

IP 36100, “Inspection of 10 CFR Parts 21 and 50.55(e) Programs for Reporting Defects and Noncompliance”

IP 38703, “Commercial Grade Dedication”

IP 43004, “Inspection of Commercial-Grade Dedication Programs”

3. LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

The previous NRC inspection performed at Doosan’s facility in Changwon, Korea, was conducted from May 26 – 29, 2008. That inspection is documented in inspection report 99901373/2008-201. There were no open items from that inspection.

<u>Item Number</u>	<u>Status</u>	<u>Type</u>	<u>Description</u>
99901373/2008-201-01	Closed	NOV	21.21 Evaluations
99901373/2008-201-01	Closed	NON	Criterion III
99901373/2008-201-02	Closed	NON	Criterion VII
99901373/2008-201-03	Closed	NON	Criterion VII
99901373/2008-201-04	Closed	NON	Criterion VII
99901373/2008-201-05	Closed	NON	Criterion XV
99901373/2008-201-06	Closed	NON	Criterion XVI
99901373/2009-201-01	Opened	NON	Criterion XVI

4. LIST OF ACRONYMS USED

ADR	Audit Deficiency Report
ANI	Authorized Nuclear Inspector
ASME	American Society of Mechanical Engineers
CAR	Corrective Action Report
CFR	Code of Federal Regulations
CEDM	Control Element Drive Mechanism
CGI	Commercial-Grade Item
CIB	Component Integrity Branch
CIB1	Component Integrity, Performance, & Testing Branch 1
CQVP	Quality and Vendor Branch 1
CNSC	Canadian Nuclear Safety Commission
DCIP	Division of Construction, Inspection, & Operational Programs
DE	Division of Engineering
EQVB	Quality and Vendor Branch
IP	Inspection Procedure

KINS	Korea Institute of Nuclear Safety
MDEP	Multinational Design Evaluation Program
MT	Magnetic Particle Testing
NCR	Nonconformance Report
NDE	Non-Destructive Examination
NRC	Nuclear Regulatory Commission
NRO	Office of New Reactors
NON	Notice of Nonconformance
NQCP	Nuclear BG Quality Control Procedure
PQAP	Quality Procedure
PV	Palo Verde
QA	Quality Assurance
QAM	Quality Assurance Manual
RCA	Root Cause Analysis
RES	Office of Research
RRVCH	Replacement Reactor Vessel Closure Head
SG	Steam Generator
TVA	Tennessee Valley Authority
UT	Ultrasonic Testing