UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
2443 WARRENVILLE ROAD, SUITE 210
LISLE, IL 60532-4352

August 30, 2012

LICENSEE: Entergy Nuclear Operations, Inc.

FACILITY: Palisades Nuclear Plant

SUBJECT: SUMMARY OF THE AUGUST 24 AND AUGUST 28, 2012, MEETINGS REGARDING PALISADES NUCLEAR PLANT CONTROL ROD DRIVE MECHANISM (CRDM) 24

On August 24, 2012, the U.S. Nuclear Regulatory Commission (NRC) held a Conference Call Meeting with members of the Palisades management team at the NRC's request. Discussions were related to the recent work that was performed on the CRDM 24 housing, its current status, and the tentative path forward.

The licensee stated that the 45 CRDMs at Palisades were made of Stainless Steel, were 14 feet long and contained several welds along the CRDM housing. There are two main parts to the assembly: there is a seal housing which is on the top part of the mechanism, which contains the seal assembly and leakoff areas; and there is the upper housing which contains the gear assemblies and connects to the reactor vessel head. The licensee mentioned that the rack and pinion style CRDM housings were unique to Palisades and Fort Calhoun nuclear plants and are the only plants that had housing leaks. In 1986, 1998, 1999, and 2001, leaks were reported on the CRDM seal housing at the Palisades nuclear plant. The material of the housing at that time was 347 Stainless Steel. Transgranular Stress Corrosion Cracking (TGSCC) was ultimately determined to be the failure mechanism of some of these CRDMs due to a susceptible metal in an environment favorable to this form of cracking (Oxygen and Chlorides). In 2001, the licensee changed the seal housing to Alloy 600 Stainless Steel, a material not susceptible to this failure mechanism; and the failures appear to have been eliminated. Later in 2001, the licensee noted a through-wall leak in the upper housing of CRDM 21. Leakage had not been seen before in the upper housings of any CRDM. The crack was primarily axial, and was located near the butt weld of weld no. 3 (near the flange connection to the vessel head) (ML020650367). The licensee shut down the plant. The cause was determined to be related to TGSCC and multiple CRDMs had cracks (LER Palisades 01-004-01, March 14, 2002). The licensee stated that these failures were related to manufacturing issues arising from machining and grinding in addition to a susceptible material (347 Stainless Steel) and TGSCC. All the CRDM assemblies were replaced with a redesigned upper housing made of 316 Stainless Steel, and reduced pipe stresses.

The licensee shut down the plant on August 12, 2012, due to unidentified leakage exceeding 0.3 gallons per minute. After the shut down, the licensee identified the CRDM 24 upper housing as the source of the leakage with a pinhole leak of 1/8"x1/16" rough dimensions and located approximately 2 feet above the reactor head. This was pressure boundary leakage. The licensee indicated that they performed detailed boric acid walkdowns, performed visual inspections of all the CRDMs, and performed post walkdowns of all the CRDMs. The licensee stated that, through the use of manual ultrasonic testing (UT), they identified an axial crack emanating from an onlay weld (weld no. 5) which is located inside the upper housing on CRDM 24. The location of this crack is different from the previous CRDM 21 fault from 2001 in that it is not from a butt weld. During their extent of condition evaluation, the licensee assumed that all the CRDM housings were subjected to a similar environment and that they were all susceptible to stress corrosion cracking. The licensee stated that the primary stress in the area of the failure was hoop stress. Hoop stress leads to axial cracks. Due to the lower axial stresses in the area, circumferential cracking was not expected. In addition, the onlay area where the fault was identified was close to a witness point, a machined area used to make accurate measurements, resulting in a slightly reduced wall thickness of the CRDM housing for an axial length of approximately 1 - 1.5 inches. The licensee also acknowledged that the area of the CRDM 24 fault was a higher stress area and was a heat affected zone of weld no. 5.

Based on the location of the fault and destructive analysis of CRDM 24, the licensee concluded that CRDM 24 experienced a failure due to TGSCC. The licensee described the extent of condition examination. The licensee reported that the ASME Code In Service Inspection (ISI) requirements did not apply in this case as the weld in question (weld no. 5) was not a pressure retaining weld addressed by the Code. This weld was an overlay located inside the housing. However, they applied the guidance in the ASME Code to inspect 10 percent of the CRDM housings. They stated that although less than five CRDMs (10 percent) were required to be inspected per the ASME Code, they were conservative in selecting eight peripheral CRDMs for additional inspections. Based on their knowledge of the history related to previous CRDM failures (most failures in both the upper housing and seal housing occurred on the peripheral), they selected CRDM 25 (which experienced a seal housing leak), CRDM 22 (which experienced a seal housing crack), CRDM 21 (which experienced the upper housing crack in 2001), CRDM 2 and 26 (which experienced a seal housing leak) and CRDMs 23, 27, and 28.

The licensee worked with Westinghouse to develop a tool for UT inspection encoder that had shear wave technology capabilities to confirm and identify cracks. They stated that the overall radiological dose to workers as a result of these inspections was several Rem. Their examinations of the eight peripheral CRDMs and the CRDM 24 (prior to shipping for offsite testing) involved testing the onlay welds and witness point areas. They stated that they identified no indications, axial or circumferential, in the eight CRDMs. In addition to the UT, they performed destructive testing of CRDM 24 at an independent Babcox & Wilcox (B&W) facility to confirm the TGSCC indications. The destructive examinations at the independent B&W facility were still in progress. The independent facility also performed dye penetrant testing (PT) on the CRDM 24 structural welds. The PT revealed nine cracks in the area of weld no. 5, of which seven were previously identified by Palisades personnel by the UT performed on site. When the NRC questioned the licensee why they had not identified the two cracks, the licensee stated that these cracks were outside of the area of their scan. The NRC also observed that the licensee's examinations did not identify any cracks above the location of the weld. The licensee confirmed that their sample of the eight CRDMs only considered the area near the witness point and did not include 100 percent of the weld or inclusive area of base metal above and below the weld. The NRC expressed concern that the licensee's examination did not cover 100 percent of the inclusive area.

The licensee stated that the thru wall leak identified on CRDM 24 was related to a sub-surface defect in the onlay area with the flaw growing over six refueling cycles. The NRC stated that, for TGSCC to start, it was likely to be on the surface versus below the surface (as pockets will accumulate the impurities in oxygenated atmosphere) and that the flaw could be growing in a time period that was less than six refueling cycles because of the temperature changes experienced by the CRDMs when the plant heated up or cooled down. The NRC added that the licensee would have to show that the CRDMs were unaffected by the temperature cycles that were experienced in between refueling cycles. In addition, the NRC asked the licensee if they had a crack growth analysis prior to entering Mode 4 to ensure that the crack will not progress to a thru wall leak during plant operations. The licensee indicated one was complete or almost complete. The SIT had not seen this analysis.

The NRC also asked the licensee if they had made a correlation between pre-existing indications (these are indications reported in the quality receipt records prior to installation in 2001, which met the ASME code, but were recorded) and the thru wall leak. The licensee responded that two out of the four CRDM receipt indications were outside the CRDM 24 crack area and the failure of the component due to these indications was an unlikely scenario. These indications were rounded and not likely a source of stress. The NRC noted small pockets could exist where impurities could accumulate and start the cracking. The NRC also said that the licensee had inspected CRDMs 25 and 22 based on one pre-existing indication from 2001, but had not inspected other CRDMs that had more than one pre-existing indication. The licensee stated that they reviewed their radiological dose assessments for inspecting the center CRDM and concluded that they would have to cut out 4 CRDMs and remove support tubes for approximately 10-12 CRDMs to inspect the center rod and that their expected radiological dose for this task was 75-85 Rem. In addition, there was no need to do that evaluation since it was not a likely cause. The NRC stated that since all the 45 CRDMs are similar to CRDM 24, it seemed unlikely that CRDM 24 was the only one with the fault, unless CRDM 24 was unique, which neither had been shown nor disproved. The licensee responded by stating that their examinations related to the eight CRDMs revealed no indications, they made a conservative decision to ship CRDM 24 off site for additional inspections, and that they reviewed all the regulatory requirements and industry standards and concluded that they met all the regulatory requirements. The licensee stated that there was no driving force to cause the crack propagation. The NRC stated that this was an axial crack and that the 2000+ pounds per square inch (psig) pressure from the reactor coolant system (RCS) could likely cause the crack to propagate.

The NRC acknowledged that the majority of the CRDM leaks experienced at the plant were located on the periphery CRDMs, however, many cracks were found on the inner CRDMs during 2001 inspections related to the upper housing through-wall leak on CRDM 21 as noted in the LER and other assessments. The NRC asked if there was a distinction between the environments to which the internal and periphery rods were subjected. The licensee stated that although the internal rods had indications of cracks, they were of a different design then and all were replaced with a new design in 2001. The NRC stated that the pictures from B&W showed some indications of contact wear on the CRDMs. The licensee stated that the CRDMs had no impact from the contact wear and it appeared to be light, but would follow up to evaluate the CRDMs for contact wear. The NRC had a concern in this area and with the extent of condition in general.

The NRC concluded that the licensee has not determined the operability of the other CRDMs, nor adequately assessed the extent of condition which would have been appropriate for the through-wall leak on the CRDM 24 housing. The NRC reported that, based on the information provided, the licensee, in their extent of condition, has not inspected all the appropriate areas on the eight housings, nor necessarily the appropriate CRDM housings and the flaw propagation has not been analyzed to provide reasonable assurance that unacceptable flaws do not exist in the CRDMs which could lead to a potential hazard impacting the RCS pressure boundary. The licensee asked if this was considered a safety concern; the NRC said that it was.

The call lasted approximately 2 hours. Enclosure 1 is a list of attendees for the meeting.

Below was not part of the meeting, but is included to show closure of open items a couple days after this call:

[In response to the above meeting, the licensee re-performed inspections of the eight peripheral CRDM housings over the entire area of interest (including the entire weld no. 5 and parts of the base metal) and determined that no flaws were present. The licensee provided additional information regarding possible contact between the housing and the weld and provided additional information on the pre-existing indications. The licensee also completed a flaw propagation analysis. This analysis is currently being reviewed by the NRC Special Inspection Team (see follow-up call below), but determined based on worse case heat-up and cool down cycles, a crack would propagate to unacceptable proportions in approximately 2 years. The licensee will also complete a root cause analysis which will be reviewed by the NRC. Based on these further evaluations, the NRC had no open safety concern prior to site's startup.]

On August 28, 2012, the NRC held another Conference Call Meeting with members of the Palisades engineering team. The meeting was requested by the NRC after the licensee provided CRDM 24 evaluations to the NRC staff. This meeting sought to gain further understanding of the issues related to crack propagation and the scope of the inspections that would be required to detect cracking on weld no. 5, a weld that would require no ASME Code inspection since it was not a pressure boundary weld. The NRC noted this was not a startup issue, because the worse case propagation rates, even with safety margin would indicate the material would be acceptable until a scheduled outage. Discussions during the meeting were related to the CRDM upper housing crack propagation analysis. The licensee indicated that they used the Inter Granular Stress Corrosion Cracking (IGSCC) method from BWRs to determine the rate of crack growth. Since the licensee determined the CRDM 24 upper housing failure mechanism to be TGSCC, the NRC stated that the standard IGSCC crack growth evaluation was not the appropriate methodology in this case. The licensee compared this to the 2001 TGSCC event. The licensee stated they used the best method they had which is high oxygenated water with no impurities; and that the independent B&W facility identified six rings in the CRDM 24 upper housing (similar to tree rings) that ranged from deep brown to light brown in color. They stated that the range of colors could be correlated to the thickness of oxides that affected the housing related to refueling outages. The NRC, however, stated that, it could be caused by change in temperatures and stresses caused by the thermal stresses experienced by the plant during heatup and cooldown, rather than differing oxygen levels (this would be a faster propagation than six refueling outages, which would be almost 10 years). Six heatup cycles would be counted back to July 2010. The NRC added that Pressurized Water Reactors (PWRs) had lower RCS oxygen levels compared to Boiling Water Reactors (BWRs), and, therefore, the affect of plant heatups and cooldowns was more prominent than effects from oxygen. The NRC also considered the crack to be very tight and therefore, concluded that it was unlikely the bands were correlated to separate oxygen transition events. The NRC mentioned the crack growth analysis will be an important determining factor of the timeline of the licensee's inspections of the CRDMs. The NRC evaluated the conservative timeline for the CRDM inspections to be approximately 24 months with six heatup cycles and about 18-20 months, then, for an undetected crack to propagate, while the licensee evaluated the timeline to be approximately 40-50 months based on their analysis method. The NRC stated that, pursuant to 10 CFR 50, Appendix B, Criterion XVI, the crack growth analysis is important to determine that the licensee's corrective actions are adequate to prevent recurrence of the issue. The licensee stated that they would evaluate the complete results provided by the independent B&W facility to determine the accurate crack growth rate as part of their root cause. Further follow up would be conducted within about a week.

The call lasted about an hour. Enclosure 2 is a list of attendees for the meeting.

Enclosure 3 is simplified drawing of the CRDM housing.

Sincerely,

/RA/

John B. Giessner, Chief
Branch 4
Division of Reactor Projects

Docket No. 50-255
License No. DPR-20

Enclosures:
1. List of Meeting Attendees for the August 24, 2012, Conference Meeting
2. List of Meeting Attendees For the August 28, 2012, Conference Meeting
3. Simplified Drawing of the CRDM Housing

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Enclosure 1

LIST OF MEETING ATTENDEES FOR THE AUGUST 24, 2012 CONFERENCE MEETING

<u>NRC Attendees</u>

Kenneth O'Brien, Acting Division Director, Division of Reactor Projects, RIII
Richard Skokowski, Acting Division Director, Division of Reactor Safety, RIII
Patrick Hiland, Director, Nuclear Reactor Regulation, Division of Engineering
John Giessner, Chief, Division of Reactor Projects, Branch 4
David Hills, Chief, Division of Reactor Safety, Engineering Branch 1
Timothy Lupold, Branch Chief, Nuclear Reactor Regulation, Piping and NDE Branch
April Scarbeary, Palisades Resident Inspector
Charles Phillips, Special Inspection Team Leader
Elba Sanchez Santiago, Reactor Engineer, Division of Reactor Safety, Engineering Branch 1
Atif Shaikh, Reactor Engineer, Division of Reactor Safety, Engineering Branch 1
David Alley, Senior Materials Engineer, Nuclear Reactor Regulation, Piping and NDE Branch
Jay Collins, Senior Materials Engineer, Nuclear Reactor Regulation, Piping and NDE Branch
Mahesh Chawla, Project Manager, Nuclear Reactor Regulation, Plant Licensing Branch III-1
Peter Tam, Senior Project Manager, Nuclear Reactor Regulation, Plant Licensing Branch III-1
Jay Lennartz, Project Engineer, Division of Reactor Projects, Branch 4
Swetha Shah, Reactor Engineer, Division of Reactor Projects, Branch 4
Mauri Lemoncelli, Senior Attorney, Office of General Counsel
Gerald Gulla, Senior Enforcement Specialist, Office of Enforcement
Patricia Lougheed, Senior Enforcement Specialist
Claire Wellinghoff, Health Physicist

<u>Licensee Attendees</u>

Anthony Vitale, Palisades Site Vice President
Anthony Williams, Palisades General Manager Plant Operations
Barry Davis, Entergy Nuclear General Manager Engineering
William Simms, Entergy Fleet Programs
Charles Arnone, Palisades Nuclear Safety Assurance Director
Dave Mannai, Entergy Nuclear Northeast Fleet Sr. Manager, Nuclear Safety and Licensing
Michael Sicard, Palisades Special Inspection Team Lead
Otto Gustafson, Palisades Licensing Manager
Darrell Corbin, Palisades Assistant Operations Manager, Support
Jim Miksa, Palisades Programs Engineering Manager
Chris Plachta, Quality Assurance Manager
Barb Dotson, Licensing Specialist
Bob VanWagner, Dry Fuel Storage Manager
Bert Stacks, Senior Engineer
James Hyres, Babcock & Wilcox
Warren Bamford, Westinghouse
Richard Smith, Structural Integrity Associates
Dave Mattson, Structural Integrity Associates
Paul Bruck, Lucius Pitkin, Inc.

Enclosure 2

LIST OF MEETING ATTENDEES FOR THE AUGUST 28, 2012
CONFERENCE MEETING

NRC Attendees

John Giessner, Chief, Division of Reactor Projects, Branch 4
David Hills, Chief, Division of Reactor Safety, Engineering Branch 1
Charles Phillips, Special Inspection Team Leader
Elba Sanchez Santiago, Reactor Engineer, Division of Reactor Safety, Engineering Branch 1
Atif Shaikh, Reactor Engineer, Division of Reactor Safety, Engineering Branch 1
David Alley, Senior Materials Engineer, Nuclear Reactor Regulation, Piping and NDE Branch
Mahesh Chawla, Project Manager, Nuclear Reactor Regulation, Plant Licensing Branch III-1
Jay Lennartz, Project Engineer, Division of Reactor Projects, Branch 4
Swetha Shah, Reactor Engineer, Division of Reactor Projects, Branch 4

Licensee Attendees

Barry Davis, Entergy Nuclear General Manager Engineering
David MacMaster, Design Engineering Supervisor
Dave Mannai, Entergy Nuclear Northeast Fleet Sr. Manager, Nuclear Safety and Licensing
Otto Gustafson, Palisades Licensing Manager
Terry Davis, Licensing Specialist
James Hyres, Babcock & Wilcox
Richard Smith, Structural Integrity Associates
George Licina, Structural Integrity Associates

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Letter to Entergy Nuclear Operations, Inc. from J. Giessner dated August 30, 2012.

SUMMARY OF THE AUGUST 24 AND AUGUST 28, 2012, MEETINGS REGARDING PALISADES NUCLEAR PLANT CONTROL ROD DRIVE MECHANISM (CRDM) 24

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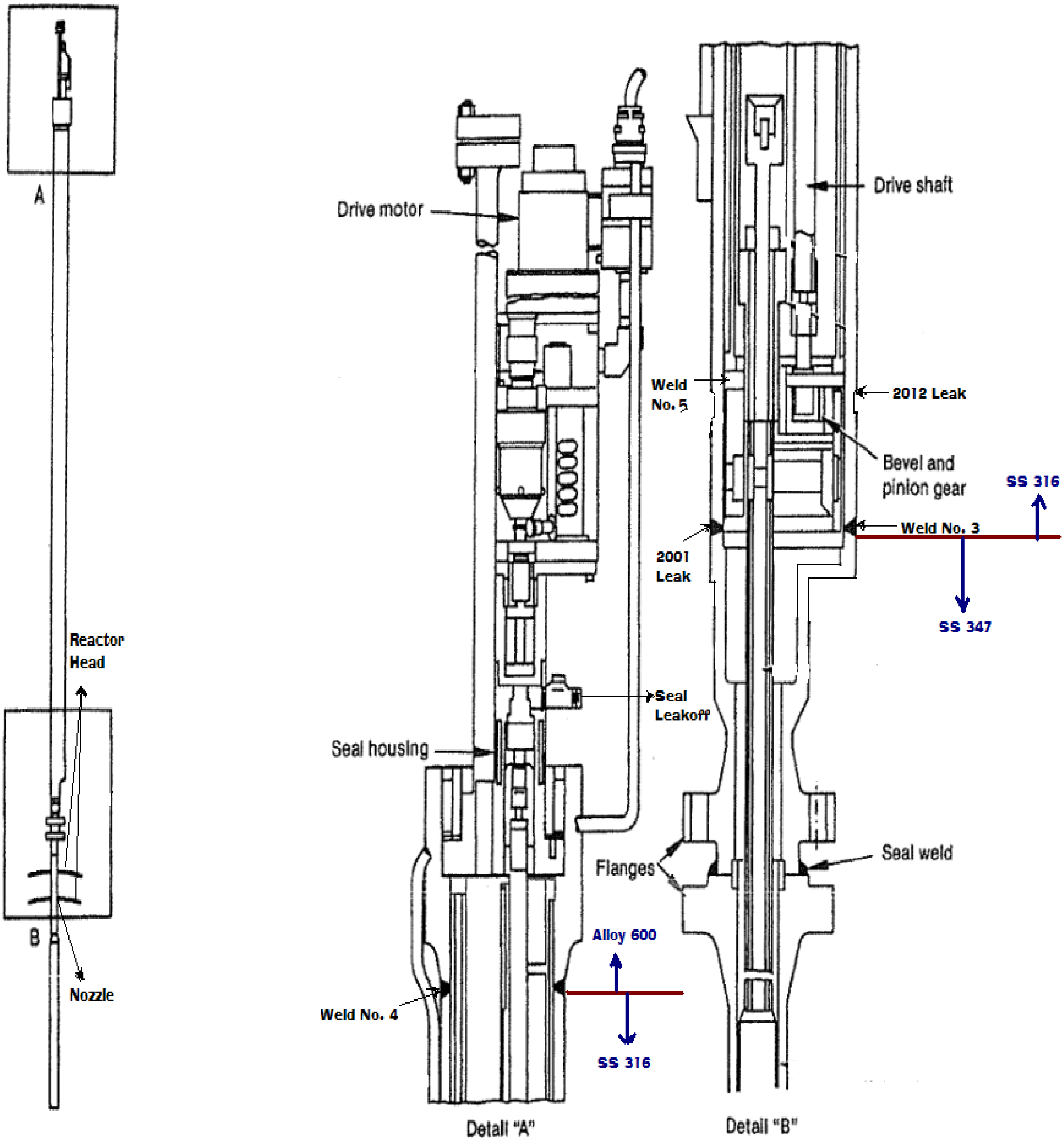
Palisades Rack and Pinion CRDM



Enclosure 3