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Steam Generator Drain Line Leakage

Ref.: 1. Email, D. G. Holland (NRC), to G. F. Elliott (Framatome ANP), "B&W Owners Group Response to Catawba SG Drain Line Cracking," December 6, 2004.

In Reference 1, the NRC requested a copy of the information summary discussing the drain line leakage in certain Westinghouse designed recirculating steam generators and its applicability to the B&W designed once-through steam generators. On behalf of the B&W Owners Group, Framatome ANP is providing the response to this request in the attachment to this letter, which is non-proprietary.

Very truly yours,

James F. Mallay, Director
Regulatory Affairs

cc: D. G. Holland
Project 693

T010

November 3, 2004

Alloy 600/182/82 Recirculating Steam Generator Drain Line Leakage Information Summary

Prepared by

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An AREVA and Siemens Company

THE ISSUE

- Reactor coolant system (RCS) primary water leakage has occurred in the vicinity of several drain lines located at the center of the bottom of the channel head bowl in certain Westinghouse-design recirculating steam generators (RSGs).

- Is this a concern for the primary drain nozzles located at the center of the bottom of the lower heads in operating B&W-design once-through steam generators (OTSGs)?

WHAT WE NOW KNOW

In 1988, after approximately one year of operation, boric acid deposits were observed on the lower channel heads of two of the three Shearon Harris Unit 1 steam generators. Inspections showed that the leakage was coming from the Alloy 600 drain nozzles that were installed in the channel head shell, hard-roll expanded in place, and then seal welded on the inside surface. The leakage was attributed to PWSCC assisted by residual stresses from the hard-rolling operation. The reported hot leg temperature at Shearon Harris Unit 1 was 619°F.[1]

In September 2001, visual inspection of the channel head bowl drain area indicated boron deposits on the piping below one of the four steam generators at Catawba Unit 2. The unit had been in operation for approximately 15 years of operation and the reported hot leg temperature was 617°F. Additional investigations identified cracking, which has been attributed to PWSCC, of the Alloy 182 weld metal connecting a coupling to the steam generator for the drain line. Repairs were made to the affected steam generator.[2]

In September 2004, after approximately 18 years of operation, visual inspection of the channel head bowl drain area again identified boric acid leakage around two of the remaining three steam generators at Catawba Unit 2. (As noted above, one of the four steam generators had been previously repaired due to leakage in 2001.) Once again, cracking was observed in the Alloy 182 weld metal, which presumably was associated with PWSCC.[3]

WHAT'S NEXT

To date, there have been no reported steam generator primary drain nozzle leakage events at the operating units with B&W-design OTSGs. To the best of our knowledge, below is a summary of the currently existing designs at the operating units with OTSGs:

- ONS – Replacement OTSGs have been installed that do not contain primary drain lines.
- TMI-1 – There are two primary drain line nozzles (one per OTSG), see Figure 1.
- ANO-1 – There are two primary drain line nozzles (one per OTSG), see Figure 2. Replacement OTSGs are scheduled for installation in 2005 that no longer require primary drain line nozzles.
- CR-3 – There are two primary drain line nozzles (one per OTSG), see Figure 3.
- D-B – There are two primary drain line nozzles (one per OTSG), see Figure 4.

The primary drain nozzle design (for the originally installed OTSGs at all the operating units) consists of an Alloy 600 nozzle (SB-167 material), which is buttered and J-groove welded into the lower OTSG shell with Alloy 182 material. The nozzle was also hard-rolled into the shell following final stress relief of the OTSG. There is also a full penetration field weld (butt weld) using either Alloy 182 or 82 material between the nozzle and the piping or valve that exists at each unit.

It is difficult to provide a one-to-one comparison between the OTSG and RSG drain nozzle designs, since AREVA currently does not have access to detailed RSG design information. However, the most obvious difference between the two designs is that the OTSG primary drain line connection operates at the cold leg temperature (~550°F) and the RSG drain line operates at approximately the hot leg temperature. In addition, the hard-roll (after OTSG final stress relief) conceivably may increase the PWSCC susceptibility of the Alloy 600 nozzle material in the OTSG drain line as it did at Shearon Harris Unit 1.

SUGGESTED ACTIONS

A number of recommended actions have been provided to the owners of RSGs by Westinghouse. These were also provided as a courtesy to AREVA. Following a review by AREVA of these recommended actions, it has been concluded that the following actions should be considered by the owners of B&W-design OTSGs:

1. Each plant needs to confirm the existence and configuration (as shown in Figures 1-4) of primary drain line nozzles in their OTSGs.

2. If primary drain line nozzles of a similar design, Alloy 600/182/82 materials, and configuration are not present, no further actions are needed.

Once the existence and configuration of primary drain nozzles has been confirmed, then:

3. Perform a bare metal visual examination of each steam generator primary drain nozzle and surrounding area at the next refueling outage. Consideration should also be given to developing an inspection plan for performing this inspection at future outages.

4. Should evidence of leakage exist, an evaluation should be performed to determine the source of the boric acid deposits. This evaluation could include a chemical analysis of the boric acid residue to determine its source.

5. Should the evaluation in item 4 conclude that the boric acid deposit is or may be the result of primary drain nozzle or weld leakage, conduct further evaluations to establish the location of the leakage and the root cause. These evaluations could include any or all of the following:

    - Visual inspection of the nozzle bore and weld(s)
    - Ultrasonic examination of the nozzle volume
    - Eddy current examination of the nozzle inside diameter and weld(s) surfaces
    - Dye-penetrant examination of the weld(s) surfaces

6. The currently recommended repair procedure for this location is the "1/2-nozzle repair." This repair approach involves depositing an Alloy 52 circular weld pad around the perimeter of the existing nozzle bore on the steam generator. The existing Alloy 600 nozzle is then removed by machining to a depth of approximately halfway through the shell thickness and reinstalling an Alloy 690 nozzle with a new structural weld to the Alloy 52 pad. Alternative repair configurations may also be applicable.

QUESTIONS?

Please contact Bill Gray (434-832-2783) or Steve Fyfitch (412-264-1610) to address questions, to obtain more in-depth technical information, or to discuss plant-specific issues.

Figure 1. TMI-1 Steam Generator Primary Drain Nozzle Design

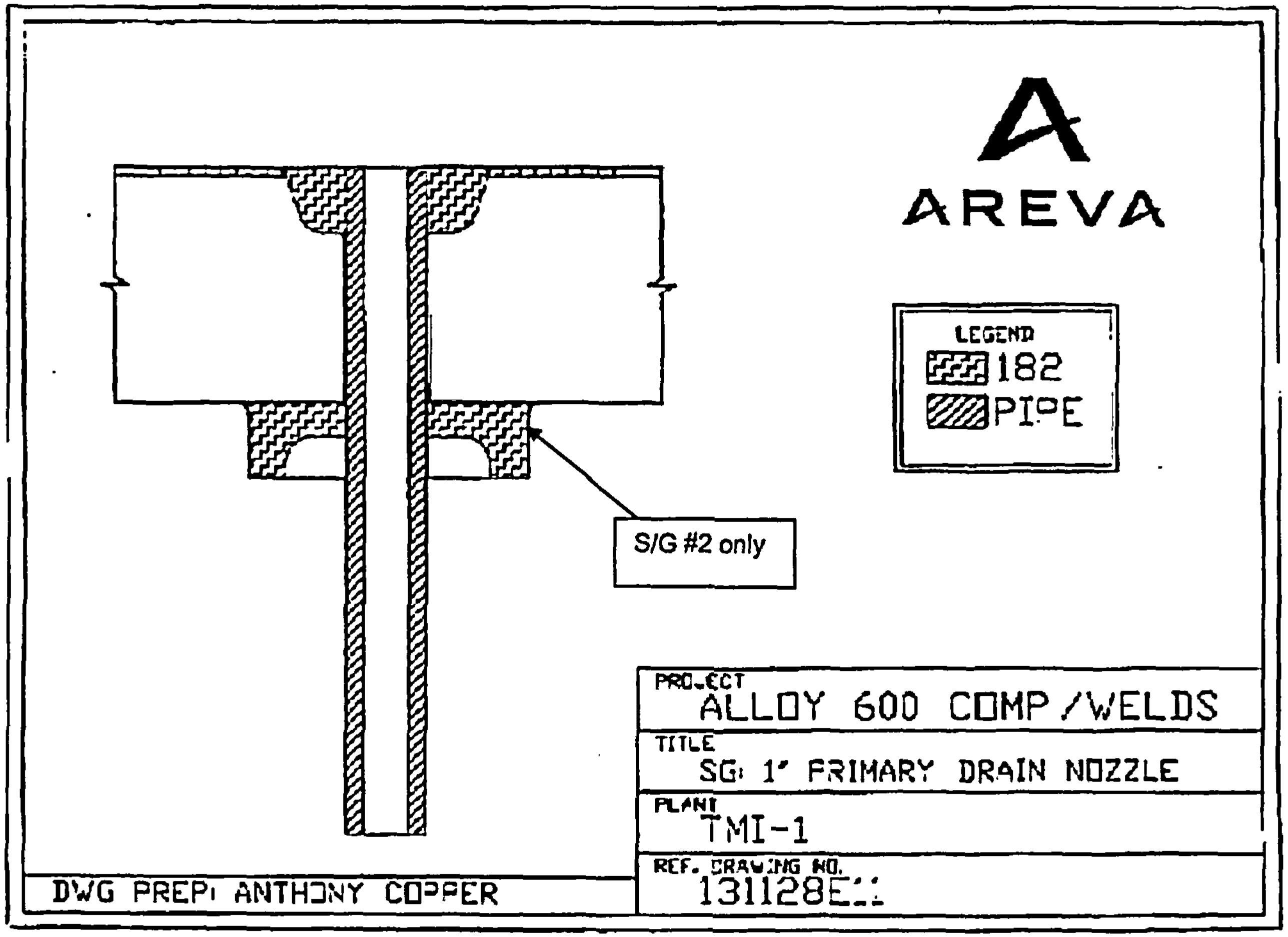


Figure 2. ANO-1 Steam Generator Primary Drain Nozzle Design

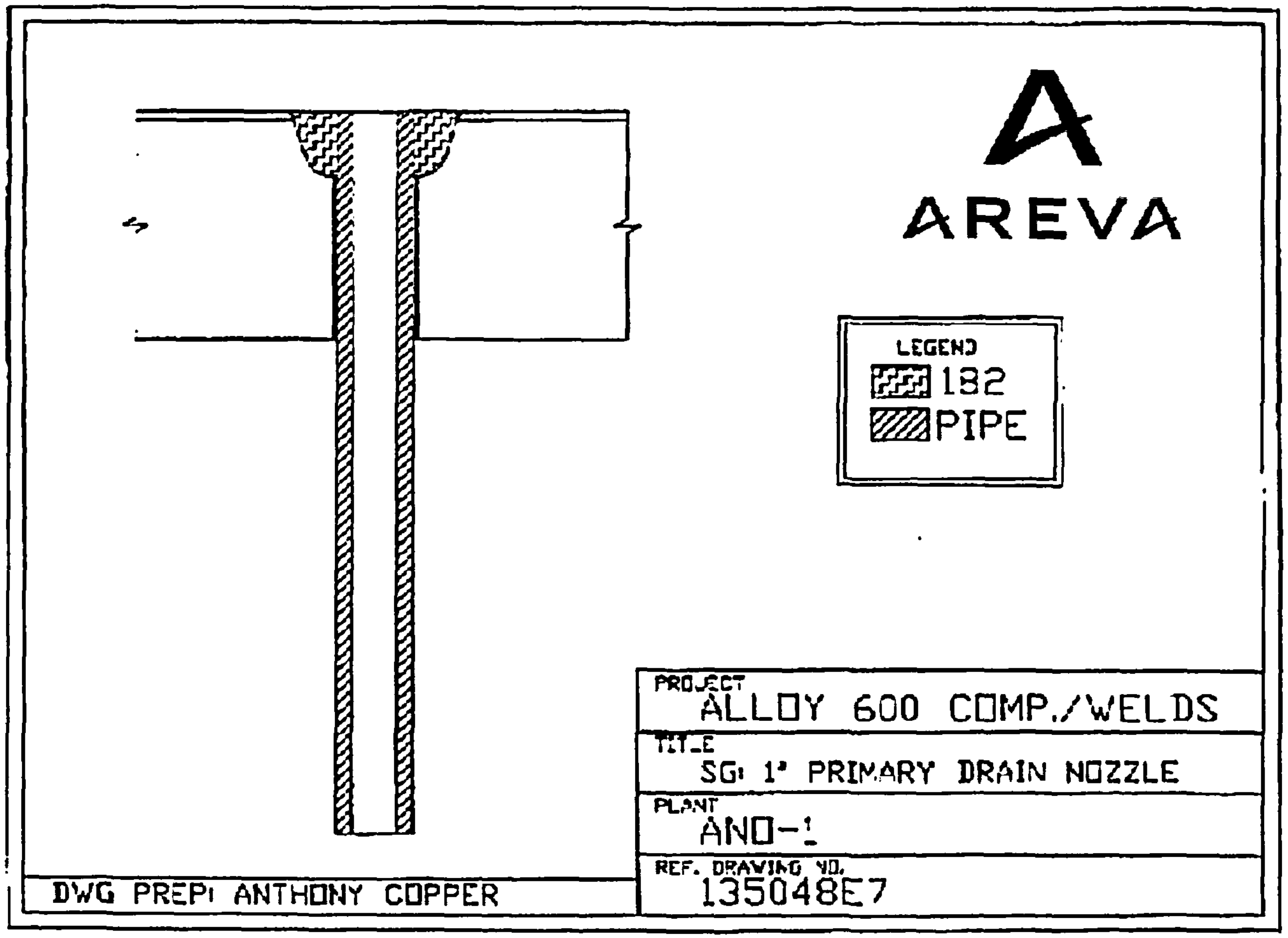


Figure 3. CR-3 Steam Generator Primary Drain Nozzle Design

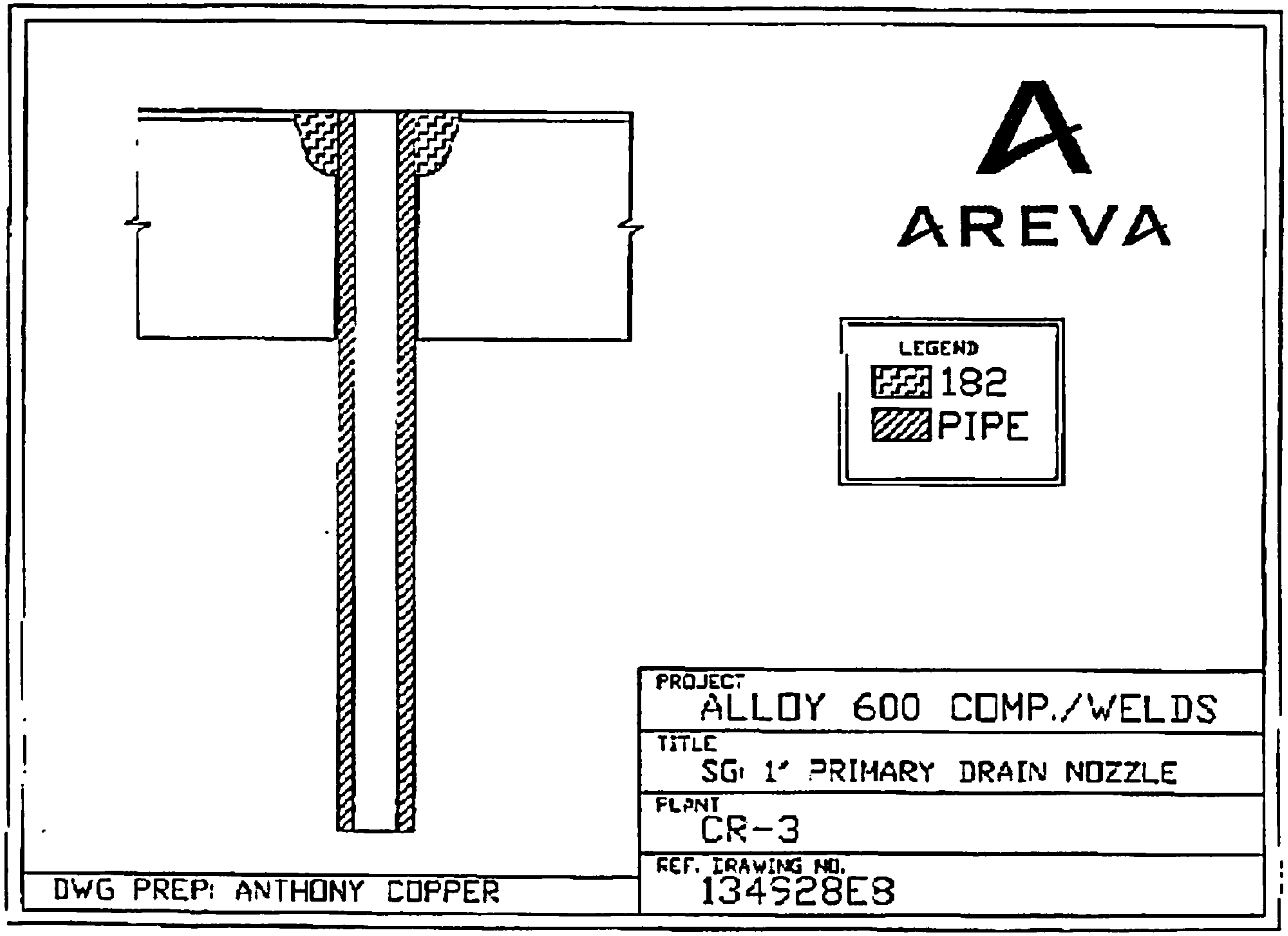
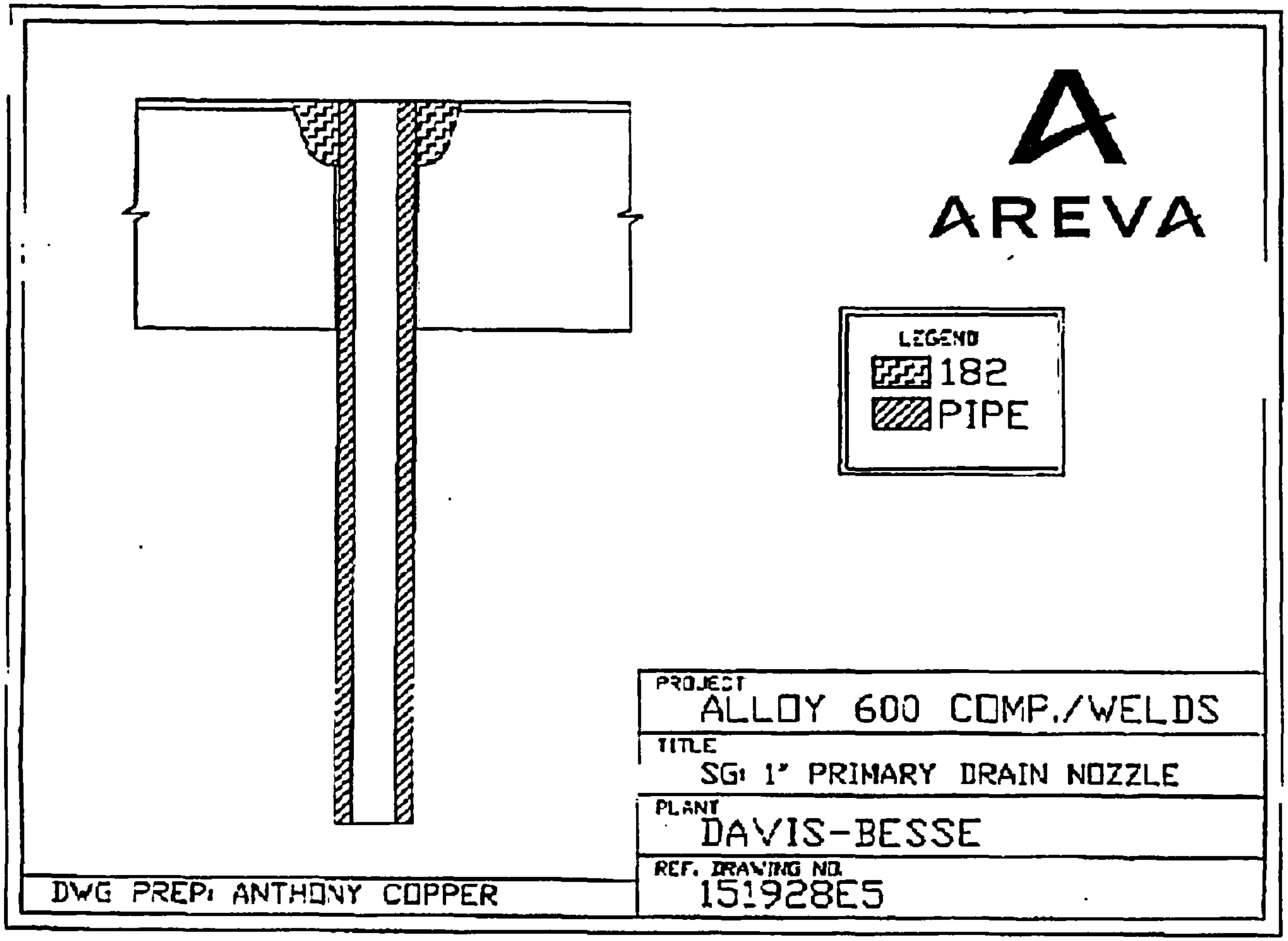


Figure 4. D-B Steam Generator Primary Drain Nozzle Design



REFERENCES

1. "PWSCC of Alloy 600 Materials in PWR Primary System Penetrations," TR-103696, EPRI, July 1994.
2. E-mail from C.R. Frye, Duke Energy to S. Fyfitch, AREVA, August 29, 2002.
3. "Apparent Pressure Boundary Leakage Identified on Steam Generator Bowl Drains," NRC Event Notice 41048, September 17, 2004.