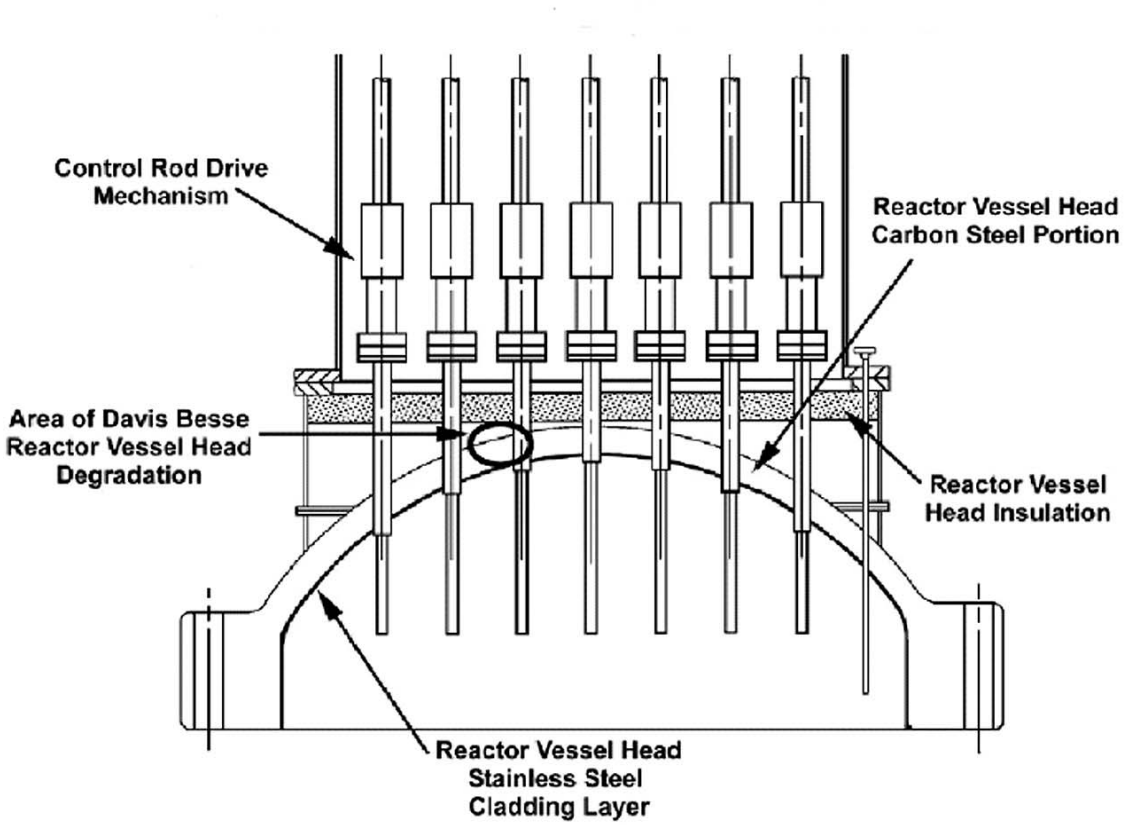
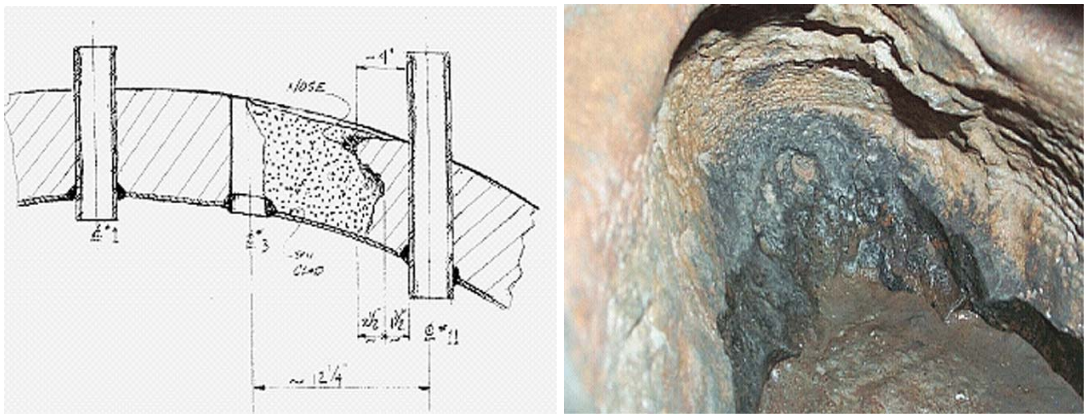
**LESSONS-LEARNED FROM DAVIS-BESSE REACTOR VESSEL HEAD DEGRADATION**

Reference: *Davis-Besse Reactor Vessel Head Degradation Lessons-Learned Task Force Report*, September 20, 2002

**Near-Miss Occurrence**

On March 5, 2002, a cavity with a surface area of approximately 20 to 30 square inches was found in the reactor pressure vessel (RPV) head at the Davis-Besse Nuclear Power Station in Ohio. The cavity extended completely through the 6.63 inch thick carbon steel RPV head down to a thin internal liner of stainless steel cladding. The stainless steel cladding had withstood the primary system pressure over the cavity region during operation, however the cladding is not designed for this. Had the cavity not been found by chance while repairing cracks in the nozzle, continued operation of the reactor may have resulted in a loss-of-coolant accident. The RPV head degradation that created the cavity was caused by cracking of a reactor pressure vessel head penetration (VHP) nozzle, leakage of primary coolant water through the cracks, and subsequent corrosion of the carbon steel RPV head by boric acid in the water. (See figures below.)






Sketch and photo of cavity in reactor vessel head.

**Task Force Analysis**

A lessons-learned task force investigated this near-miss occurrence and concluded that it was preventable. The VHP nozzle leakage and RPV head degradation occurred because: (1) the NRC, the reactor owner, and the nuclear industry failed to adequately review, assess, and follow-up on relevant operating experience; (2) the owner failed to assure that plant safety issues would receive appropriate attention; and (3) the NRC failed to integrate known or available information into its assessments of reactor's safety performance.

The discovery of the Davis-Besse reactor head wastage caused by boric acid-induced corrosion took the NRC and industry by surprise. Only two such cases had occurred before (both in 1987), and none involved the Alloy 600 nozzles used at Davis-Besse. However, cracking of such nozzles was commonplace and there was much operating experience involving boric acid-induced corrosion of other components. The task force summed up this experience as follows:

> "About 10 years ago, the NRC and industry recognized the potential for an event such as the one that occurred at DBNPS [Davis-Besse]. In spite of the wealth of information, which includes extensive foreign and domestic PWR plant operating experience, as well as research activities involving tests and engineering analyses, the DBNPS event occurred. Events involving the material wastage of components stemming from primary system leaks have been reported for more than 30 years. For more than 15 years, Alloy 600 nozzle leakage events in U.S. PWR plants have been reported. In 1993, the industry and NRC specifically addressed the possibility of extensive RPV head wastage stemming from undetected VHP nozzle leaks involving axial cracking caused by PWSCC [primary water stress corrosion cracking]. The industry concluded and the NRC agreed that the likelihood of such an event was low because VHP nozzle leaks would be detected before significant RPV head degradation could occur."

Because the NRC and nuclear industry concluded that related nozzle cracking was not an immediate safety concern, the NRC and the industry's efforts to further evaluate this issue became prolonged. The NRC and industry continued to rely on visual inspections of VHP nozzles, which are incapable of characterizing the extent of nozzle cracking and damage. While the industry initiated actions to improve non-visual inspection capabilities, the requirements governing inspections remained unchanged.

The task force issued 51 separate recommendations. Many are specific to technical issues involving reactor component cracking and corrosion, however some are more universally directed at improving the NRC's generic issue process and the NRC and industry's review and use of operating experience. The task force noted that the NRC's Generic Issues Program had failed to specifically addressed nozzle cracking and boric acid leakage and corrosion. The number of candidate generic issues had declined over the last few years. Some felt the generic issue process took to long and was thus "useless."

The task force also noted that the NRC's Office for Analysis and Evaluation of Operating Experience (AEOD) had been eliminated in 1999. "The scope of a number of specific NRC operating experience programs has been reduced or eliminated following recent program evaluations, but the impact of these changes on effectiveness have been not effectively assessed."

**Lessons Learned for DOE**

While the specific degradation phenomena experienced at Davis-Besse is somewhat unique to the materials and design of commercial nuclear reactors, there are some generic lessons learned that DOE could draw from this occurrence. The occurrence demonstrates the need for robust operating experience, lessons learned, and generic issue programs. DOE should continue its development of such programs and maintain them in the future.

The Davis-Besse event is somewhat different from the Challenger and Columbia space shuttle accidents in that the precursor events experienced were not so obviously related to the actual occurrence/accident. With the benefit of hindsight, the space shuttles' previous o-ring failures and foam debris impacts were obvious predictors of eventual trouble ahead. On the other hand, the discovery of the reactor head degradation was more of a first-of-a-kind occurrence, particularly if one focuses on specific components in specific reactor designs, as the NRC tends to do. The lesson learned here is that one should look beyond the direct experience of like components, and consider the experience from less correlated events in judging the hazards and risks of component failures.