DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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December 1, 1999

The Honorable David Michaels
Assistant Secretary for Environment,
Safety, and Health
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0119

Dear Dr. Michaels:

The Defense Nuclear Facilities Safety Board (Board) has recently observed several welding quality deficiencies at Department of Energy (DOE) sites. The deficiencies appear to confirm the more general quality assurance issues identified by the Office of Independent Oversight in the special topical report on *Quality Assurance*, a part of the 1998 special assessment report, *DOE Safety Performance Within Key Topical Areas*.

An inadequate quality assurance program has the potential to degrade safety. In the interest of supporting any efforts you may have under way to evaluate the status of quality assurance by the Office of Independent Oversight, the Quality Assurance Working Group, or the Office of Enforcement and Investigations, the Board is providing the enclosed staff issue report on *Deficiencies in Welding Quality Assurance*. This report illustrates a specific area where it appears that the quality assurance programs are either not in place or not being aggressively pursued.

The Board would like a briefing on the status of any actions that DOE is taking to address the quality assurance issues identified by the Office of Independent Oversight, and any steps which you believe may be necessary to identify and correct quality assurance weaknesses, such as those identified in the enclosed report.

Sincerely,

A.J. Eggenberger
by AJE FOR
John T. Conway
Chairman

c: Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

September 8, 1999

MEMORANDUM FOR:	G. W. Cunningham, Technical Director J. K. Fortenberry, Deputy Technical Director
COPIES:	Board Members
FROM:	W. Yeniscavich and W. Linzau
SUBJECT:	Deficiencies in Welding Quality Assurance

This report documents an issue reviewed by members of the staff of the Defense Nuclear Facilities Safety Board (Board) R. Daniels, M. Helfrich, W. Linzau, J. MacEvoy, and W. Yeniscavich. This issue relates to a breakdown in weld quality assurance that has occurred during the past several years at various Department of Energy (DOE) defense nuclear facilities.

Summary. Recently within the DOE defense nuclear complex, there have been several cases in which welded piping and components passed all the specified inspections and were ready for installation or use, but were found at the last minute to contain defective welds. These discoveries were typically made by workers or observers in the area who noticed the defective welds. Such last-minute discoveries of defective welds result in additional costs and schedule delays. However, a far greater concern is the breakdown in the weld quality assurance program, and the implication that there may be defective welds in operating systems with a potential impact on facility safety.

Background. During the past several years, a number of components and piping systems that appeared to have met all the specified requirements for fabrication and receipt inspection were about to be placed in service when defective welds were discovered by chance. In one case, which involved a safety-class liquid nitrogen system at the Savannah River Site, the defective welds were discovered when a leak occurred after about 6 months of service. The number of these recurring weld incidents indicated a complex-wide pattern of weld quality assurance problems and prompted this review by the Board's staff.

Discussion. It can be difficult to make acceptable welds consistently, so inspections are a vital feature of weld quality assurance. Some welding defects are to be expected, particularly with manual welding. About 5 percent of the welds made by the best welders will require repair, and this figure may rise to as much as 15 percent when difficult materials are involved. Consistent, high-quality welds are assured through the performance of timely and thorough inspections as the welding progresses. In a properly functioning program, when a defect is found, it is repaired, and the welder receives feedback for correcting the technique used. If a specific welder continues to produce defective welds, he or she is retrained or taken off the job. It is important that inspections for consistency with the required weld quality be done, and for these inspections be performed as soon as possible after the weld has been completed. Another means of achieving weld quality is oversight at the fabricator's shop to ensure that the work is being done properly. The final check is the customer's receipt inspection program. The customer's inspections should typically include at least a sampling inspection of the welds and a review of the fabricator's weld data, such as radiographs.

The weld incidents reviewed in this report occurred at several different DOE defense nuclear facility sites and involved a variety of components and piping. The causes of these incidents were in general related to three factors:

- Inadequate oversight by owners
- Inadequate fabrication inspection
- Inadequate receipt inspection

In specific cases the following additional factors also contributed to the defective welds:

- Inadequate specification of inspection requirements
- Failure to qualify vendor
- Poor engineering judgment with regard to weld joint design
- Unqualified welder
- Application of incorrect code
- Unqualified inspector
- Inadequately trained welder

The following paragraphs provide additional information on some specific weld quality problems.

Liquid Nitrogen System at the Savannah River Site (SRS)—In November 1996, a nitrogen leak occurred in a weld on an aluminum discharge line of one of the vaporizers at the Defense Waste Processing Facility (DWPF). There are five vaporizers at DWPF and they are used to provide backup nitrogen for preventing or mitigating certain accident scenarios. There is a single entrance and discharge line per vaporizer, and each of the lines has a weld similar to the one that leaked. Following the discovery of the leak, all welds were inspected radiographically. Eight of the 10 welds, including the one that leaked, showed weld penetration of only 20 to 50 percent of the wall thickness, as compared with the requirement of 100 percent penetration. The vaporizers were leased, and the defective welds had been made during installation by a subcontractor of the vaporizer's owner. The subcontractor was not qualified to make these welds, and did so without the knowledge of SRS personnel.

Anhydrous Hydrogen Fluoride Transfer System at Oak Ridge—The previous anhydrous hydrogen fluoride (HF) transfer system at the Oak Ridge Y-12 Plant had a history of leaks that prompted the design of a new system. The new system consists of a confinement chamber at the receiving dock where the HF is vaporized and 450 feet of jacketed transfer piping that carries the HF to the building where it is used. During installation of the new system in March 1998, a visual inspection of the inside diameter of four completed transfer line welds was performed by a DOE Facility Representative. This inspection revealed one weld with inadequate penetration and excessive oxidation, while the other three showed excessive underbead reinforcement. These four welds had been inspected and accepted by the Y-12 operations contractor, Lockheed Martin Energy Systems (LMES). As a result of the discovery of these defective welds, additional welds in the system were inspected, and more defective welds were found. A search of the records showed that one welder had made the majority of the defective welds.

The defects had gone undetected because of the inadequate inspection procedure that was used. The piping was fabricated to American Society of Mechanical Engineers (ASME) B31.3, Category M Service, which requires that a minimum of 20 percent of the welds, randomly selected, be radiographically or ultrasonically inspected. LMES originally selected radiography because they did not have a qualified ultrasonic inspection crew. Subsequently, radiography was canceled because of the potential to activate criticality alarms if a radiographic source were exposed in the area. Radiographic or ultrasonic inspection would have revealed the lack of penetration. In place of these volumetric inspections, a visual inspection of the pipe was conducted. However, inspection of the weld root on the inner diameter was required only when the weld root was "accessible," interpreted to mean within about 2 inches of the end of the pipe. Hence the substitute inspection did not include roots of welds made between long lengths of pipe. In addition, the substitute inspection was not implemented effectively for accessible welds near pipe ends, as demonstrated by the fact that the inspectors overlooked defective welds which were discovered later by the DOE Facility Representative.

Additional inspections were then conducted on other welds in the HF system. Some of the welds on elbow sections of the jacket piping that had been made at a vendor's shop were found to have inadequate penetration, cracks, and porosity on the inner diameter. Other problems with welds made by the vendor were discovered on the containment chamber of the vaporizer. Cracked seal welds were discovered on the jacket piping penetrating the chamber wall. These welds were not specified on the drawing and had been made by the vendor on his own initiative. The jacket piping is a nickel-copper alloy, and the vendor had made the welds with a stainless steel filler metal—incorrect filler metal for nickel-copper—that not surprisingly, resulted in the cracked welds. In addition, some of the welds specified on the drawing for the containment chamber of the vaporizer were not made. These problems reflect inadequate fabricator inspection, inadequate oversight by the owner, and inadequate receipt inspection.

The above problems indicated a breakdown in weld quality assurance at the Y-12 Plant, including a defective contractor procurement system. A letter from the Board to the DOE

Assistant Secretary for Defense Programs, dated August 24, 1998, identified these problems. In December 1998, LMES assessed the Y-12 welding program and identified a series of issues requiring corrective action (Report Y/QS-0005). A subsequent LMES assessment of the HF Supply System (Y/MA-7534, July 1999), conducted almost a year later, noted that these corrections from the prior assessment were not completed and the prior assessment did not address all the welding concerns raised by the construction contractor.

Anhydrous Hydrogen Fluoride Sensing Lines at Oak Ridge—There are a number of 1/4-inch and 3/8-inch sensing lines in the new HF system described above, as well as in the fluid bed system. These lines are joined together with butt welds. In May 1999, during testing of the systems with surrogate materials, an operator leaned against one of the sensing lines and broke a butt weld. These welds had been inspected and accepted. Consequently, a visual reinspection of the butt welds was performed, and about 10 percent of the approximately 600 welds were judged to be rejectable. To replace the rejectable welds, approximately 100 "good welds" were removed. Several of these were destructively examined to validate their acceptability. These examinations revealed several welds with less than 50 percent penetration. As a result, all the sensing line welds will be replaced. The causes of this problem were an inadequately trained welder, and an inadequate inspection technique that failed to detect lack of penetration in these welds.

During an initial management critique of the butt weld problem, it was found that the welds had originally been specified as socket welds. In small-diameter tubing, high-quality welds can more easily be achieved using socket joints because they are easier to fit up correctly, and a large, structurally strong weld can be made without concern for over penetration and blocking of the tube. The situation was further aggravated by the fact that the material was Hastelloy, a metal in which it is inherently difficult to obtain a high quality weld. The reason for the change to the butt welds was not identified, but it is clear that poor welding engineering judgment was used in selecting a butt weld joint for this small tubing.

As mentioned above, this problem together with other issues, compelled LMES to conduct a rigorous, broad-based assessment of the HF supply system in June–July 1999. LMES identified numerous issues in the areas of vendor selection and qualification, equipment calibration and inspection, and design and hardware change control, as well as specific issues with the welding program. A LMES corrective action plan is still being developed.

Hanford Spent Nuclear Fuel Project—The Integrated Water Treatment System (IWTS) for the Spent Nuclear Fuel Project at Hanford is designed to provide a means of filtering the water in the K-Basins during cleaning of fuel elements. Pipe sections for IWTS were fabricated by a subcontractor. During receipt inspection, approximately 40 defective welds were found in the pipe sections, and these were repaired. Most of the defective welds had lack of penetration on the inside diameter and were located near pipe ends, where they were observed by visual inspection. No actions were taken on the basis of these receipt inspection results to inspect welds away from open pipe ends.

During installation, the piping was cut. Cutting of the pipe revealed a weld with heavy oxidation, porosity, and lack of penetration. This observation triggered additional inspections of the piping. A borescope inspection of welds within the pipe sections was conducted, and additional welds with lack of penetration were found. The piping was fabricated to the requirements of ASME B31.1, Pressure Piping Code. The ASME Code requires full-penetration welds, but for low temperature applications it does not require verification by radiography, which would have identified the lack of penetration. In contrast, a code such as ASME B31.3, Process Piping Code, requires radiographic inspection to verify full penetration welds are obtained when the piping contains radioactive material, even at low temperature.

Idaho National Engineering and Environmental Laboratory (INEEL), Transuranic Packaging Transporter Model 2 (TRUPACT-II) Standard Waste Boxes—The TRUPACT-II Standard Waste Box (SWB) shipping containers were procured under a fixed-price contract by Lockheed Martin Idaho Technologies Company (LMITCO). The contract was awarded to the lowest bidder. After the first several SWBs had been fabricated, LMITCO performed the first-article inspection at the manufacturing facility. The SWBs were subsequently delivered to INEEL in several shipments and were receipt inspected upon arrival. LMITCO became aware of problems with the SWBs in January 1997, when notified that Argonne West and the Rocky Flats Environmental Technology Site had discovered problems with SWBs received from the same vendor. Visual inspection of the boxes revealed a number of obvious deficiencies: (1) the welded seams had gaps through which light could be seen, (2) welds had undercut and poor contours, and (3) unmelted welding rods were found protruding from some welds.

A number of factors contributed to the poor-quality welds on the SWBs. The vendor was selected on the basis of a low bid, and without an audit to ensure that he was qualified to perform the work. The vendor's history of poor fabrication quality was not considered. The first-article inspection at the manufacturing facility was performed by an inspector certified to do general inspection, but not visual examination of welds. Receipt inspection was limited to item accountability and shipping damage.

Tritium Storage Tanks at Savannah River Site—As part of the Non-nuclear Reconfiguration Project at SRS, 28 stainless steel tanks for storage of tritium gas were purchased. The tanks were purchased to meet the requirements of ASME Boiler and Pressure Vessel Code Section VIII, Division I, and were code stamped. On March 5, 1997, a construction craftsman was preparing to weld a flange onto a nozzle of an installed tank when he noticed while looking into the nozzle that the nozzle-to-tank weld did not have complete weld penetration on the inside diameter. Reinspection of the 28 tanks was conducted using a borescope, and the radiographs used by the vendor to accept the welds were reexamined. These examinations revealed unacceptable (incomplete) penetration in the nozzle-to-shell welds in 26 tanks and incomplete penetration in the girth welds of five tanks. In addition, the quality of the radiographic film for eight tanks was found to be unacceptable, and the radiographs were missing for girth welds in nine tanks. Oversight inspections at the fabrication shop were inadequate, as were the specified receipt inspection requirements.