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US Nuclear Regulatory Commission
Washington, DC 20555

Dear Sirs:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Plasma Arc Cutting

Attached are GPU Nuclear responses to the NRC comments regarding the proposed plan to size end fittings in the Reactor Vessel using a plasma arc torch.

Sincerely,

F. R. Standerfer
Director, TMI-2

FRS/CJD/eml

Attachment

cc: Regional Administrator - Office of I&E, Dr. T. E. Murley
Director - TMI-2 Cleanup Project Directorate, Dr. W. D. Travers

A001

NRC QUESTION

During plasma arc cutting, temperatures of 20,000 to 50,000°F may be achieved in the central zone of the plasma. At these temperatures, material being cut is vaporized. What is the potential for heavy metal (including fissile materials) poisoning of personnel exposed to these vapors, and what protective measures will you employ to prevent this.

GPU NUCLEAR RESPONSE

The high temperatures developed by the plasma torch will vaporize some fissile material. However it is not expected that any non-condensable heavy metal or fissile material gas will be created because the energies available strongly favor the formation of condensable gases. The only non-condensable gas which may be released due to vaporization of fuel would be Krypton. Recent drilling into the fuel rubble has clearly shown that there is little or no Krypton remaining. Most condensable gases will, when exposed to the Reactor Coolant System (RCS) water will quickly condense. Therefore, 1) no non-condensable gases will be formed; and 2) if condensable gases are formed, they will condense in the reactor vessel (RV) water prior to the gas bubble breaking the water surface.

As documented above, heavy metal gases are not expected to be formed. An additional heavy metal concern involves health and safety issues regarding waste water contamination from industrial processing operations that include Cd, Cr, Cu, Ni, Pb, and Zn with a limiting potable water concentration of 1.0 ppm total heavy metals. However, this issue is not relevant to the plasma arc cutting as the RCS water can hardly be considered as a potable water supply.

Plasma arc cutting may also generate gases such as carbon monoxide and oxides of nitrogen. Carbon monoxide would be generated only when carbon dioxide is used as a shielding gas. As metal vapor is oxidized by carbon dioxide, carbon monoxide is produced. Carbon monoxide will dissolve slightly in water and may be oxidized to some extent in the RCS water. The oxides of nitrogen will react with or be miscible with water. The RCS water becomes a wet scrubber for these gases. Gases that escape from the water surface will be captured by the off-gas system and diluted to insignificant concentrations in the reactor building (RB).

NRC QUESTION

During the November 20, 1986 meeting you stated that you planned to store the inert gases (nitrogen and carbon dioxide), needed to support plasma arc cutting, in the reactor building. Describe the quantities and locations of the stored gases and discuss the safety implications of an accidental release of the gas into the reactor building atmosphere. In addition, describe the hazards and protective measures to be employed related to oxygen displacement by the gases used during plasma arc cutting.

GPU NUCLEAR RESPONSE

Compressed gases have been routinely used inside the RB for years without incident. These gases include nitrogen, carbon dioxide, oxygen, and acetylene; and most recently argon cylinders have been used during the past year for dewatering of the fuel canisters in the RV. For plasma arc cutting, no more than ten (10) cylinders will be in the RB. Storage areas for full and empty cylinders are located on the 305' elevation of the RB. Compressed gases are contained in 3AA cylinders that measure 9" in diameter by 51" in length and hold a volume of about 2 cubic feet of gas at approximately 2200 psi. All compressed gas cylinders are inspected, tested and maintained by the supplier according to Occupational Safety and Health Administration (OSHA) and Department of Transportation (DOT) regulations adopted from Compressed Gas Association (CGA) Standards. All hoses, fittings, valves, and regulators are used according to CGA Standards. Compressed gas cylinders leaks will most often occur in the regulator or hose during use. The user is quickly aware of the leak through sounds of leaking gas or noticing a drop in cylinder pressure. Quick actions by the user to close the cylinder and exit the area prevent safety consequences.

Oxygen displacement is a concern during the use of gases. In all cases, sufficient ventilation is always provided in the RB for dilution in order to ensure safe oxygen concentrations. For example, with normal RB ventilation, the accidental release of the entire contents of one compressed gas cylinder would have a negligible effect of oxygen concentrations. One compressed gas cylinder will release about 270 cubic feet of gas at atmospheric pressure. While this will have an effect on the oxygen concentration in the immediate area for a very short time, the excellent mixing of the RB air by the operation of the fans would quickly mix and dilute this gas. 270 cubic feet of gas released into a building of about 2,000,000 cubic feet will have an insignificant effect on oxygen concentrations (lower oxygen concentrations from 20.9% to 20.89%). About 100 compressed gas cylinders (27,000 cubic feet) would have to release their contents at one time for oxygen levels to drop to 19.5%. This does not take into account the operation of the RB purge (18,000 to 38,000 cfm).

The use of compressed gases for underwater plasma arc cutting inside the RV will be controlled by the use of approved procedures that are in accordance with OSHA and DOT regulations. GPU Nuclear is confident that the use of compressed gases and any accidental release that may occur will be safely controlled, posing no safety hazard to defueling personnel or others inside the RB.

NRC QUESTION

Some of the technical literature on plasma arc cutting and other forms of melting vaporization techniques indicate that nickel carbonyl ($Ni(CO)_4$) may be generated during the cutting process. Provide the staff with additional information, including available analytical and experimental data, related to the formation of this highly toxic substance. Describe the potential health effects of nickel carbonyl and your proposed measures to protect personnel from this material.

GPU NUCLEAR RESPONSE

The technical literature in question refers to the plasma arc torch tests, performed by EG&G. Gas samples taken during the testing of plasma arc torches provided reason to suspect the presence of nickel carbonyl <$Ni(CO)_4$>. However, closer examination of the test results indicate a strong possibility that the existence of $Ni(CO)_4$ was not accurately determined.

A review of the analytical procedure used to detect the presence of $Ni(CO)_4$ will assist in understanding this point. The analytical procedure utilized in the gas sample analysis performed by EG&G is similar to that of the National Institute for Occupational Safety and Health (NIOSH). This analysis involves collecting an off-gas sample from plasma arc cutting and passing it through a prefilter and sorbent tube containing two sections of acid-washed activated charcoal. The chemical principal involved is that the organic material, metal carbonyl, will be retained by the charcoal. The material collected is then desorbed with nitric acid and analyzed for elemental nickel (Ni) by atomic absorption spectrometry. Thus, this analytical procedure does not distinguish between $Ni(CO)_4$, other possible nickel compounds or elemental particles of nickel.

Particle physics indicates that generation of particulate sizes by plasma arc cutting of metals will follow a log-normal distribution. Given this distribution, elemental nickel particles of the size range that could pass through the prefilters and be retained on the charcoal utilized in the EG&G test are not only possible but reasonably probable. Additionally, water vapor aerosols were probably carried to the charcoal filters in the EG&G test. The gaseous by-products of the EG&G plasma arc torch tests were directed into a funnel immediately above the water level. This physical arrangement would tend to trap water vapor or water droplets as they left the water surface and carry them to the charcoal filters. Also, the gas velocity in this physical arrangement would increase from the water surface to the escape pipe. This is opposite to what will happen above the water surface of the TMI-2 RV as the velocity of any water droplets will continuously decrease due to gravity as it moves above the water surface. Obviously, its velocity will decrease to the point where it will fall to zero and the water droplets fall back into the RV.

The reason the NIOSH analytical procedure is used is because it: a) conservatively predicts the $Ni(CO)_4$, b)the technique can be performed in many laboratories, c) the technique accurately predicts the elemental nickel concentration, d) the technique is not overly expensive. Conversely, to determine the actual presence of $Ni(CO)_4$ by an analysis such as gaseous electron diffraction would be subject to potential inaccuracies, significant expense and laboratory limitations.

In addition to the non-discrimination of chemical compounds by the EG&G test, the bounding physical and chemical parameters of the RCS system (5300 ppm B and pH 7.5) will dictate the resulting equilibrium reaction products, concentrations, and temperatures. The primary source term for compounds anticipated from the cutting will be materials being cut (i.e., stainless steel) and/or adherent material (i.e., fuel debris). The elemental composition for typical stainless steel such as 304 is given below:

Element	Weight %
S	0.03
P	0.045
C	0.08
Si	1.0
Mn	2.0
Ni	8
Cr	18
Fe	Balance
Total	100.00

Consequently, the major components available for reaction with plasma gases would be Fe, Cr, and Ni, all of which can theoretically form carbonyls (Reference 1). However, carbonyl formation for these elements under RCS solution chemistry conditions ranks less favorably, thermodynamically, than other reaction products (Reference 2). Furthermore, the chemical stability of such carbonyls in the current TMI-2 environment would be unfavorable even if they were formed, i.e., $Ni(CO)_4$ exhibits a boiling temperature of 42°C (108°F) and, therefore, would revert to a liquid in the reactor coolant (current average temperature of 72°F).

The major concern with the generation of $Ni(CO)_4$ are the potential health effects of the organic. Reference 3 provides significant data on this subject. Along with being a potential carcinogen, the following other potential health effects would be expected if exposure to $Ni(CO)_4$ occurred.

- eyes and skin burning
- giddiness
- headache
- shortness of breath
- vomiting
- high nickel content in blood

The GPU Nuclear Industrial Safety and Health Department has researched the potential for generation of $Ni(CO)_4$. Plasma arc cutting has been used at TMI for at least four (4) years. It is estimated that this cutting method has been used hundreds of times in the TMI shops on steels containing nickel and none of the medical effects reported above have been evident. TMI-2 Procedure 4730-IMP-7220.02, "Operation of Plasma Arc Cutting Inside TMI-2 Reactor Building" is used to control the use of this cutting device inside the TMI-2 RB. It has been used inside the building almost weekly for two (2) years.

The GPU Nuclear Industrial Safety and Health Department has also reviewed many welding technical manuals along with safety and health information sources and could not find any reference to $Ni(CO)_4$ being generated during plasma arc cutting or other welding/cutting processes on stainless steel. Other Industrial Hygienists have been consulted and none were aware of $Ni(CO)_4$ generation being a potential health hazard during cutting or burning of stainless steel or other nickel-containing metals. In virtually all operations, nickel vapor is oxidized by oxygen or carbon dioxide and condensed into a nickel oxide fume.

In summary, GPU Nuclear concludes that:

- The EG&G test quantified elemental nickel not $Ni(CO)_4$.
- Log normal particle distribution would tend to produce elemental nickel particles on the charcoal filter of the EG&G test.
- Water vapor aerosols were probably carried to the charcoal filter in the EG&G test.
- Carbonyl formation in the TMI-2 reactor environment is chemically less favorable than the formation of other compounds.
- $Ni(CO)_4$ gas condenses at temperatures significantly above that of the RCS environment in which the cutting will occur.
- No evidence of the presence of $Ni(CO)_4$ has been observed by GPU Nuclear safety personnel during previous plasma arc cutting operations at TMI.

Based on the above conclusions, GPU Nuclear believes that the presence of $Ni(CO)_4$, due to plasma arc cutting, has not been conclusively demonstrated. Therefore, GPU Nuclear believes it can safely continue to use plasma arc cutting in the same manner and with the same personnel safety precautions that have been employed in the past. These safety precautions include respiratory protection, protective clothing, gloves, face shields, and adequate ventilation as deemed necessary by the GPU Nuclear Safety and Health and Radiological Controls Departments in accordance with established regulatory and scientific guidelines.

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