**Particle Prediction from
Plasma Torch Cutting
on Stainless Steel, Carbon Steel, and Aluminum**

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Decontamination and Decommissioning (D&D) operations mark the end of a nuclear facility's effective service life. An integral portion of the decommissioning effort is the disassembly of structural components, and the associated equipment inside the facility. Generally, these structures must be assumed to be either radioactive, or contaminated, presenting unique personal and environmental hazards when planning for their disassembly. The potential for exposure to whole-body doses of radiation requires that the disassembly operations be performed as fast as possible. However, the fastest cutting tools generally produce more aerosol particles, noxious gasses, and secondary waste. Clearly, the need to reduce one hazard must be weighed against the creation of additional hazards generated by different cutting techniques. Since the main hazard of cutting is generation and release of potentially contaminated airborne particles, it is important to have a clear understanding and quantification of the aerosols produced by the various cutting tools.

Until recently, industrial cutting operations have been considered to be generally non-hazardous, and the incentive to collect data on the particle size distributions, total quantities of particulate produced, and recommended filtering or control measures has been minimal. Therefore, the main purpose of this project is to quantify particle size and generation rates for common cutting tools and materials used in the dismantling of nuclear facilities. This information will be compiled in a database to aid in the planning of both D&D and standard cutting operations. The data will be taken from controlled laboratory experiments on non-contaminated metals, samples taken in the field during D&D operations at ANL nuclear facilities, and from previous operations documented by others.

Eventually, this database will provide an extensive compilation of cutting experiences, and will furnish a D&D project with guidelines in terms of predicting total aerosol production, aerosol generation rates, suggested tool operating settings, and the minimum HEPA filtration area necessary to contain the expected aerosol release. D&D contractors, planners, and ES&H personnel will be able to use this information in conjunction with the specifics of the application, and site-specific safety guidelines to determine the

appropriate cutting tool for the job, and the necessary pollution controls required, including filtering, personal protection, and air monitoring.

Laboratory cutting tests are conducted inside of a closed, filtered chamber where a remotely activated cutting tool is held stationary as the material is moved past it at a constant speed. The aerosols generated by the cutting process are collected by a High Efficiency Particulate Air (HEPA) filter. The particulate size distributions are determined by isokinetically sampling the exhaust duct using a cascade impactor. The mass median aerodynamic diameter (MMAD) is calculated for reference in the database. Secondary waste (slag and dross) is collected in a pan underneath the cutting head, while any loose particles are collected with a HEPA filter equipped vacuum. Currently, laboratory tests have been completed using a 100 Amp Plasma Arc Torch to cut Carbon Steel, Stainless Steel, and Aluminum.

A plasma torch cut produces particles by condensation of metal vapors, and droplet formation from liquid metal shear forces. The measured particle size distribution for a particular cut is determined by a complex interaction between the rate of energy input (torch power and cutting speed) and the flow of the cutting gas (pressure, flow, nozzle size, and kerf width). In general, as energy input increases, either through higher torch power or slower cutting speed, the temperature of the cut is increased and so is the quantity of metal vaporized. Higher energy input also increases the kerf size, which results in a lower gas velocity. This decreases the atomization of the molten metal. At this time the cutting process is affected by too many variables, and so the particle size distribution and quantity for a given cut cannot be predicted and must be measured.

Most measured particle size distributions are bimodal with one mode at about .2 microns, attributed to the condensation of metal vapors, and the other at about 10 microns, attributed to the atomization of the molten metal. Because of the plasma torch operating conditions of relatively high temperature and relatively low gas flow, the resulting MMAD's are typically less than .5 microns.

In order to provide an empirical prediction of the aerosol quantity produced, a testing plan consistent with the principles of risk assessment was devised to determine the worst case scenario in terms of maximum aerosol production for a given material. This was done by determining the cutting torch power, and then the cutting speed at that power that generate the maximum level of aerosols. Once these parameters were defined, varying length cuts were made on samples of different thickness' typically used, and the quantity of aerosols generated was plotted against the length x the thickness of cut.

The levels of maximum aerosol generation on 3/8" thick samples were found at 80 Amps power and 5 mm/s (.2 in/sec) speed for carbon steel, 100 Amps and 2.5 mm/s (.1 in/s) for stainless, and 100 Amps at 4 mm/s (.16 in/s) for aluminum. Varying length and thickness cuts showed no observable dependance on material thickness for carbon steel as seen in Figure 1, but revealed that both stainless and aluminum samples do appear to have some dependance on thickness, with thinner materials producing more aerosols.

Information collected from the laboratory scale cutting with the Plasma Torch has been compiled and entered into the database along with the available information from outside sources that contain information on the aerosols produced, the MMAD, along with the length and thickness of the material being cut. Oxy-Acetylene torch and CO₂ laser cuts are planned for FY96, and additional information on other tools will be added as it becomes available.

Figure 1
Aerosols Generated vs. Length x Thickness of Cut - 1018 Carbon Steel

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