Draft Screening Tables for Rule 219 Plasma Arc and Laser Cutting Equipment

Proposed Rule 1445 - Control of Toxic Emissions from Laser and Plasma Arc Metal Cutting (PR 1445) applies to laser or plasma arc cutting equipment used for Metal Cutting that is either permitted or required to obtain a South Coast AQMD permit.

Subparagraph (d)(5)(H) of Rule 219 - Equipment Not Requiring a Written Permit Pursuant to Regulation II provides a permit exemption for hand-held plasma arc cutting equipment and hand-held laser cutting equipment rated at 400W or less. Equipment that is used exclusively for maintenance or repair operations are exempt from a permit regardless of the type of metals cut, while equipment used for other purposes are only exempt if the equipment does not cut any stainless steel, or alloys containing 0.1 percent by weight or more of chromium, nickel, cadmium, or lead. Rule 219 paragraph (e)(2) provides an exception to this and other permit exemptions when:

(A) The risk from uncontrolled emissions will be greater than identified in paragraphs (d)(1), (d)(2), or (d)(3) in Rule 1401 - New Source Review of Toxic Air Contaminants;

(B) The equipment may not operate in compliance with all applicable South Coast AQMD rules and regulations, including but not limited to Rule 402 – Nuisance; or

(C) The equipment or the air pollution control system venting the equipment has been modified, operated, or maintained in a manner that:

(i) Is inconsistent with the applicable exemption under any provisions of this rule; or

(ii) Results in otherwise preventable excess emissions that have been detected or observed by the Executive Officer.

Given that equipment used for maintenance or repair operations could cut any metal or metal alloys, there is a possibility that the health risks from uncontrolled emissions would be greater than the Rule 1401 thresholds contained in paragraph (d)(1), (d)(2), or (d)(3) and the equipment would require a permit. Therefore, a screening table has been developed as an easy reference to determine whether equipment used for maintenance or repair operations would continue to qualify for the Rule 219 paragraph (d)(5)(H) exemption from the requirement to obtain a permit or if a permit application is required pursuant to Rule 219 paragraph (e)(3) to demonstrate that the Rule 219 paragraph (e)(2) exception does not apply.

Based on staff's review of the compositions of various types of metal alloys cut, and a review of the most used stainless steel and Inconel alloys, four different metal alloys were used to provide a representative range of metal alloys that could be cut. The alloy selection was made to show the broad range in health risk impacts for different types of metals alloys based on the relative toxicities of the component metals. For example, a sensitivity analysis showed that the cancer risk driver is hexavalent chromium (formed when chromium is subject to high heat and a portion converts to hexavalent chromium) and the acute risk driver is nickel. The metal alloys assessed, and their respective toxic metals composition values are shown in Table 1.

Table 1 – Composition of Metal Alloys

	Metal Alloy Name, Composition %, and Density			
Metal	**EN24T Mild Steel**	**1045 Carbon Steel**	**Stainless 304**	**Inconel 718**
Chromium	1.4%	0%	19.5%	18.5%
Nickel	1.7%	0%	10.5%	53.0%
Manganese	0.7%	0.9%	2.0%	0%
Density (lb/in^3)	0.289	0.284	0.286	0.287

The composition of each metal alloy was based on information from the following sources:

- EN24T mild steel composition data is from ASTM SAE AISI 1018 Carbon Steel Chemical Composition, Mechanical Properties (theworldmaterial.com).
- 1045 Carbon Steel composition data is from ASTM SAE AISI 1045 Carbon Steel Heat Treatment, Chemical Composition, Properties (theworldmaterial.com).
- 304 stainless steel composition data is the 304 Stainless Steel Properties: SS304 Composition, Density, etc. (theworldmaterial.com).
- Inconel 718, (Ni718), composition data is from the VDM Metals 2015 SDS.

The densities for each of the metal alloys were determined using general internet queries.

For hand-held plasma arc cutting equipment, the following assumptions were used to determine the uncontrolled emissions rates:

- Metal particulate fume emissions are 7 percent of the cut weight for stainless steel and nickel alloys and 5 percent of the cut weight for mild steel and aluminum alloys.
- Metal composition in the fume is proportional to the metal composition of the alloy being cut.
- Hexavalent chromium, which is created in the cutting process, is 0.0622 fraction of the total chromium emissions.
- The maximum kerf width of the cut for a hand-held plasma arc cutter is 10 millimeters (mm).
- The maximum material thickness for hand-held plasma arc cutters is 16 mm for stainless steel, nickel alloys, and aluminum, and 30 mm for mild steel.

For hand-held laser cutting equipment, the following assumptions were used to determine the uncontrolled emissions rates:

- Metal particulate fume emissions are 11.43 percent of the cut for all metal alloys.
- Metal composition in the fume is proportional to the metal composition of the alloy being cut.

- Hexavalent chromium, which is created in the cutting process, is 0.00723 fraction of the total chromium in the cut, which is equivalent to 0.0633 fraction of the total chromium emissions.
- The maximum kerf width of the cut for a 400 watt hand-held laser cutter is 1 mm.
- The maximum material thickness for 400 watt hand-held laser cutters is 2 mm for aluminum, 3 mm for stainless steel and nickel alloys, and 4 mm for mild steel.

Plasma Arc Units

Using these assumptions, in order to be exempt from permitting pursuant to Rule 219, the maximum allowable cut rates for a hand-held plasma arc cutter, with short-term rates that are based on acute health risk, and annual cut rates based on long-term cancer health risk are shown in Table 2 below.

Table 2 - Rule 219 Plasma Arc Cutting Rates Allowed

Receptor	EN24T Mild Steel		1045 Carbon Steel		Stainless 304		Inconel 718	
	in/hr	in/yr	in/hr	in/yr	in/hr	in/yr	in/hr	in/yr
@25M	0.327	3.84	No Limit	19,229	0.072	0.378	0.014	0.381
@50M	0.541	9.69	No Limit	48,507	0.118	0.95	0.023	0.96
@100M	1.01	25.2	No Limit	126,331	0.222	2.48	0.044	2.50
@200M	2.15	67.2	No Limit	336,531	0.470	6.61	0.093	6.67
@300M	3.50	125	No Limit	623,451	0.766	12.2	0.151	12.4
@500M	6.70	279	No Limit	1,396,751	1.47	27.4	0.290	27.7
@1000M	16.9	861	No Limit	4,307,516	3.70	84.6	0.731	85.4

If the metal alloy being cut is unknown, then one half of the worst-case metal cut rate limit (maximum linear inches cut per hour or per year) results should be used to determine applicable cut rate limits. See Table 3). If the metal type is known to be a carbon steel and not stainless steel or Inconel, but the exact composition is unknown then the EN24T results should be used since that alloy represents a high chrome and high nickel content carbon steel.

Table 3 - Rule 219 Plasma Arc Cutting Rates Allowed for Unknown Metal

Receptor	Unknown Metal	
	in/hr	in/yr
@25M	0.007	0.189
@50M	0.012	0.475
@100M	0.022	1.24
@200M	0.047	3.31
@300M	0.076	6.1
@500M	0.15	13.7
@1000M	0.37	42.3

Laser Units

Using these assumptions, in order to be exempt from permitting pursuant to Rule 219, the maximum allowable cut rates for a hand-held laser cutter, with short-term rates that are based on acute health risk, and annual cut rates based on long-term cancer health risk are shown in Table 4. If the metal alloy being cut by a laser cutter is unknown, then one half of the worst-case metal cut rate limit (maximum linear inches cut per hour or per year) results should be used to determine applicable cut rate limits. See Table 5)

Table 4 - Rule 219 Laser Cutting Rates Allowed

Receptor	EN24T Mild Steel		1045 Carbon Steel		Stainless 304		Inconel 718	
	in/hr	in/yr	in/hr	in/yr	in/hr	in/yr	in/hr	in/yr
@25M	10.7	124	No Limit	630,862	2.34	12.1	0.46	12
@50M	17.7	313	No Limit	1,591,440	3.87	31	0.76	31
@100M	33.3	815	No Limit	4,144,718	7.25	80	1.43	80
@200M	70.4	2,170	No Limit	11,041,030	15.4	212	3.03	214
@300M	115	4,020	No Limit	20,454,422	25.0	393	4.94	397
@500M	220	9,007	No Limit	45,825,156	48.0	882	9.47	890
@1000M	554	27,777	No Limit	141,322,709	121	2,719	23.9	2,744

Table 5 - Rule 219 Laser Cutting Rates Allowed for Unknown Metal

Receptor	Unknown Metal	
	in/hr	in/yr
@25M	0.23	6.05
@50M	0.38	15.5
@100M	0.715	40
@200M	1.515	106
@300M	2.47	196.5
@500M	4.74	441
@1000M	11.95	1359.5

The results in Tables 2 through Table 5 show that the Rule 219 subparagraph (d)(5)(H) exemption allowable cut rates are higher for laser cutters due to smaller kerfs and thinner cuts for 400W and smaller hand-held laser cutters compared to hand-held plasma arc cutters. The cut rate limits for metals that do contain considerable amounts of chrome or nickel are restrictive, particularly if there are receptors located near the cutting location. These results also show that the allowable cut rates for steels that do not contain chrome or nickel have cut rate limits that would not be restrictive. This would also be true for aluminum alloys that do not contain chrome or nickel.

Each plasma arc cutter or laser cutter can have a different maximum kerf width, and the facility may not be cutting materials as thick as the maximum thicknesses assumed. To correct table values for different kerfs and/or different maximum cut thickness the following equation can be used:

Allowable Cut limit = Table cut limit x kerf width assumption/actual kerf width x thickness assumed/actual thickness

Metal alloys with known chrome and/or nickel contents that are different than the alloys assessed above can be addressed based on compositional content. Where the short-term cut rate limits can be determined based on a ratio of the nickel content difference between the alloy and Inconel 718 and the long-term cut rate limit can be based on a ratio of the chrome content difference between the alloy and 304 stainless. For non-ferrous alloys, such as aluminum and copper alloys, the ratio of the metal densities should also be addressed. The following equations can be used:

Long-Term Cut Limit = SS304 cut limit x SS304 19.5%Cr / Alloy X %Cr x 0.286 lb/in^3/ Alloy density

Short-Term Cut Limit = Ni718 cut limit x Ni 718 53%Ni / Alloy X %Ni x 0.287 lb/in^3/ Alloy density

For copper alloys that do not contain other TAC metals cut rate limits, there would be no long-term cut rate limits only a short-term limit and that limit can be determined based on the ratio of the Acute REL for copper versus the acute REL for nickel using the following equation:

Cu Alloy Short Term Cut Limit = Ni718 cut limit x 100/0.2 x Ni 718 53%Ni / Alloy X %Cu x 0.286 lb/in^3/ Cu Alloy density

For standard copper pipe, which is 99.9 percent copper and has a density of 0.325 lb/in3, this would result in a short-term cut rate limit that is 233 times higher than the short-term cut rate limits shown for Inconel 718.

Also, a specific plasma arc cutter or laser cutter may cut more than one of these alloy types. To determine that the health risk thresholds are not exceeded in that circumstance a summation of the different metal cut rates divided by their table values can be performed:

$$\text{Cut limit} = \sum \text{Actual cut rate}^i / \text{Table value}^i \leq 1$$

Where i = metal alloy i

When the summation for all alloys is less than one, then the cutting equipment would not have health risks that could trigger the need for a permit application under the Rule 219 paragraph (e)(2) exception.

The Tier 1 analysis assumes the worst-case modeled short-term and long-term dispersion results (highest X/Q values) based on a conservative outdoor 2-meter by 2-meter volume source release. The metal cut rate limits are based on the distance from the edge of the volume source to the nearest receptor, which is conservatively assumed to be a residential receptor. The modeling was performed using the most recent South Coast AQMD approved meteorological data sets (for a five-year period ending with 2023) for all meteorological stations.

The short-term risk and cut rate limits are dominated by the alloy's nickel content. If a source is cutting mild steel and/or aluminum with no more than a trace of nickel content, then as can be seen in the specific alloy tables there is no short-term risk concern for these two types of alloys.

The long-term risk and cut rate limits are predominately based on the chromium contents assumed, so if the source is cutting mild steel or aluminum with no more than a trace of chromium content, then the cut limits would not be restrictive.

Cutters that are cutting different alloys than the four types assumed may have compositions of different toxic metals than those evaluated or higher compositions than those evaluated, such as copper alloys that can include arsenic or beryllium or other alloys that may have high lead or cadmium concentrations. The exception in Rule 219 paragraph (e)(2) for these metal alloys will need to be evaluated on a case-by-case basis. Engineering and Permitting staff are in the process of developing an emissions and screening risk calculator that can be used to aid in the evaluation.

The health risks of additional toxic metals will need to be addressed in the future. Specifically, Rule 1401 is proposed to be amended to include additional toxic compounds added by OEHHA and CARB since the last rule approval date, which will include trivalent chromium and cobalt.