IARC Monograph Volume 118: Welding, Molybdenum Trioxide, and Indium Tin Oxide
Neela Guha for the IARC Monographs Programme
(IMO Group / ESC Section - International Agency for Research on Cancer)

SUMMARY OF EVALUATIONS

<table>
<thead>
<tr>
<th>Evaluations</th>
<th>Welding fumes</th>
<th>UV radiation from welding</th>
<th>Molybdenum trioxide</th>
<th>Indium tin oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans (cancer)</td>
<td>Sufficient (luminal)</td>
<td>Sufficient (ocular melanoma)</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Animals (evaluation)</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
</tr>
<tr>
<td>Mechanisms (eye characteristics)</td>
<td>Strong (chronic inflammation)</td>
<td>Strong (immunoglobulin)</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
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<tr>
<td>Overall evaluation</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
<td>Data insufficient</td>
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</tbody>
</table>

| Previous evaluation                           | Data insufficient | Data insufficient | Data insufficient | Data insufficient |

Occurrence/Exposure

| Clay exposure based on "limited evidence" in humans and no compelling evidence in experimental animals | Data insufficient |

Overall evaluations: Group 2, Carcinogenic to Humans; Group 3b, Possibly carcinogenic to Humans

BACKGROUND: Welding

- Welding is the process of joining metals through coalescence
- Predominant techniques: gas (fuel gases used to generate heat), arc (electricity used to generate arc)
- Predominant metals welded: mild steel, stainless steel (SS), titanium and nickel compounds which are Group 1 carcinogens
- Tobacco smoking and asbestos are potential confounders for assessing lung cancer
  - Welders may smoke more than the general population
  - Asbestos exposure: work in shipyards, electrodes, heat protective equipment worn by welders
- Welders are co-exposed to several substances already evaluated by IARC (Table 2)
- Exposure assessment methods of epidemiologic studies were reviewed systematically to inform the evaluation (Table 4)

EXPOSURE DATA: WELDING

- The IARC Working Group (WG) estimated 11 million workers worldwide and ~110 million workers incur welding related exposures in jobs that routinely or intermittently weld (Table 3)
- Workers are exposed to over 1% of the maximum occupational exposure population using US national exposure data obtained from 60 countries from 2009-2011

- Increased lung cancer risk was associated with welding in the majority of studies
  - >20 case-control, >20 cohorts, some overlapping, some of high-quality
  - Increased risks were observed regardless of welding technique, study design, occupational setting, geographic region, time period, adjustment for tobacco smoking and asbestos exposure

- The WG conducted a meta-analysis to quantitatively characterize the risks and explore heterogeneity (Figures 1-3)

WELDING AND OCULAR MELANOMA

- Ocular melanoma is a very rare cancer (ASR <1 per 100,000)
- Ultraviolet radiation (UVR) emitted from tanning devices causes ocular melanoma
- Welders are exposed to UVR over the full spectrum (UVa, UVb, UVC) from the welding arc, regardless of the industry or the technique used
- UVR exposures are very intense within a few meters of the welding arc; exposure guidelines can be exceeded in a matter of seconds to minutes
- Sufficient evidence that “UVR from welding” causes ocular melanoma
- Partially overlapping case-control studies and 2 meta-analyses based cohort studies reported on ocular melanoma in welders; most reported increased risks
- UVR exposure from welding was not characterized in any of the studies but 2 studies reported on eye burns, a proxy of UVR exposure
- Adjustment for other sources of UV exposure (e.g., sun exposure, sun bed use) in several studies indicated that these factors could not explain the observed associations between welding and ocular melanoma
- Welders report frequent occurrence of skin erythema (sunburn) and photo-keratoconjunctivitis (welder’s flash)
- UVR associated with arc welding is generally much more than other artificial UVR generating processes (e.g., germicidal lamps, photocuring, tanning lamps), and typically orders of magnitude higher than natural sunlight (solar radiation)
- Unprotected bystanders can be exposed to UVR

REFERENCES/ACKNOWLEDGEMENTS