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Isocyanate exposure, emission and control in small motor vehicle repair premises using spray rooms: Phase 1

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Isocyanate exposure, emission and control in small motor vehicle repair premises using spray rooms: Phase 1

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A mock up spray room was constructed within the HSL spray booth with dimensions, ventilation conditions, extraction rates etc set to represent typical MVR spray room conditions. A robotic sprayer was used to simulate paint spraying of car parts under a range of conditions; including spray orientation relative to the extraction duct, spray gun type, ventilation (air in) set up and extraction rates. Real and near time monitors were used in conjunction with the HSL standard method for airborne isocyanate monitoring (MDHS 25/3).

The main findings were:

- High isocyanate (NCO) levels (~ thousands of µg NCO/m^3 during the spraying period) arise in spray rooms during spraying.
- Airborne NCO levels were homogeneous throughout the spray room. Tracer gas studies confirmed this finding.
- Factors affecting the amount of airborne NCO are; gun type (eg HVLP give ~ 2 to 5x lower levels than conventional types), gun condition and set-up, spray pattern and isocyanate formulation. Spraying in the direction of the extract fan did not decrease airborne NCO.
- Airborne NCO took a significant time (~20+ minutes) to clear the spray room.
- The majority of air in the spray room was close to perfect mixing (tracer gas experiments) but short-circuiting (ie inlet air that is extracted without mixing with the main body of air in the room) occurred. This agrees with HSL/HSE field observations.
- Tracer gas studies found that the clearance time was proportional to the air-flow rate. If this is the case for spray rooms in general, then the clearance rate may be estimated by calculation from the perfect mixing equation.
- The addition of false walls and filters to the spray room did not decrease airborne NCO levels in the room but the filters did remove most (94–98%) of the NCO from the vented air and so reduced the risk of re-circulation of the NCO mist back into the spray room, adjacent workplaces and the environment.
- The near time monitor (paper tape reader) underestimated significantly (~10x) the amount of airborne NCO but both the real time (photo-ionization detector) and near time monitors (paper tape reader) gave clearance times that were comparable with the HSL standard method.
- Spraying solvent through the guns to clean them produces high levels of airborne isocyanate (~ thousands of µg NCO/m^3) and should not be undertaken unless full control procedures are in place.

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- Tracer gas studies on an industrial spray room showed that whilst the majority of the air in the room was close to perfect mixing, there was a high degree of "short-circuiting" that occurred close to the fan (short-circuiting is defined as inlet air that is extracted from the room before mixing with the main body of room air). This is in agreement with field observations made by HSL/HSE staff.
- Orientation of spraying relative to the extraction fan had little effect on the uniformity of the isocyanate dispersion. There is no significant benefit from spraying in the direction of the extraction fan.
- Overlapping the car bonnet when spraying gave decreased (by ~ 2x) airborne concentrations of isocyanate in comparison to spraying with no overlap of the bonnet when using the standard spray gun i.e. spray pattern has a slight effect on airborne isocyanate levels. This is presumably because of increased "bounce back" of aerosol form the bonnet in the "no-overlap" experiments.
- Gun type, gun condition and gun set-up are important factors in the levels of airborne isocyanate detected.
- The isocyanate formulation used is an important factor in the levels of airborne isocyanate detected.
- Use of the HVLP spray guns reduced airborne isocyanate concentrations in comparison to spraying using a standard gun (conventional high-pressure gun) and there was no difference between the overlapping and non-overlapping spray pattern for the HVLP gun. The HVLP gun gave decreased (by ~ 2 to 5x - depending on spray pattern) airborne concentrations of isocyanate in comparison to spraying with the conventional gun.
- Increased room extraction rates (airflow) reduced airborne isocyanate concentrations (by ~ 2x for a 2x increase in air-flow) and so shortened clearance times for the HSL spray room.
- Addition of filters and false internal walls to the spray room had no effect on airborne isocyanate levels and clearance times inside the spray room.
- For the "false wall and filters" experiments (spray room configuration 2), the measured airborne isocyanate levels on the extract fan grill were lower (~30x) than those for the spray room without the false walls/filters added. The addition of the filters and false walls may therefore be beneficial for environmental reasons i.e. to reduce the risk of re-circulation of vented isocyanate aerosol (mist) back into the spray room or into adjacent business units and the environment.
- Measurements taken either side of the filter panels showed that the filter material used removed 98 to 94% of the airborne NCO aerosol from the air.
- The paper tape reader evaluated underestimated the amount of airborne isocyanates present (~ 10x) when compared to MDHS 25/3. This is as expected as HSL has found that the paper tape readers are not suitable for quantification of NCO aerosol without extensive recalibration.
- The paper tape reader evaluated gave reasonable indications of air clearance rates (clearance times for the HSL spray room ~20 minutes by

paper tape reader compared to ~30 minutes by MDHS 25/3). The clearance time is defined as the time, after finishing spraying, when no airborne isocyanate can be detected. This value is important for the safety of staff leaving, or re-entering the spray room, after spraying.

- The photo-ionization detector (PID), which was measures total particulate, gave a clearance time of ~ 10 minutes which is shorter than those for the paper tape reader or measured by MDHS 25/3 but in agreement with a theoretical value of ~ 12 minutes for 99% clearance calculated from the tracer gas test decay curve for the HSL room. It should be noted that the theoretical value is calculated from an exponential decay and so the time to "no detectable airborne isocyanate" using this method will be longer than 12 minutes (time to 99% clearance).
- Spraying solvent through the guns to clean them produces high levels of airborne isocyanate (~ thousands of μg NCO/m^3 during the spraying period) and should not be undertaken unless full control procedures are in place.
- Other work was undertaken during this project on brush and roller application of paints and sanding and NCO emissions during baking of NCO painted car parts. This work has already been reported (HSL, 2005a; HSL, 2005b).
- Video and still photography was carried out during the project and this and other material was used to support the HSE Safety and Health Awareness Days (SHADs) on NCO spraying.
- The results of the work presented in this report will be used by HSE to update the NCO guidance sheets on NCO use (e.g. MR01 - isocyanate from mixing 2-pack paint etc., MR02 – spraying 2-pack products in a spray/bake booth, MR03 – isocyanate from cleaning 2-pack paint spray guns, MR04 – isocyanate from brush and roller application of 2-pack products, HSE (2005a)).
- Because other survey work has provided information on typical spray room conditions and potential exposures, the field monitoring exercise (objective 3) was not undertaken. The results of previous field-work are summarised in this report (appendices 3 and 4).

Recommendations

- This work has shown that high isocyanate levels (~ thousands of μg NCO/m^3 during the spraying period) arise in spray rooms during spraying and that the airborne isocyanates take a significant time to clear (20+ minutes) to clear these spray rooms. A variety of factors affecting the amount of airborne NCO aerosol have been identified (see - Main Findings above). These findings are important and should be brought to the attention of the MVR industry.
- This work has shown that the clearance time is proportional to the air-flow rate and that the air-flow in the spray room, investigated in this report, is close to perfect mixing. If this is the case for spray rooms in

general, then it is suggested that the clearance rate may be estimated by calculation from the perfect mixing equation.

- Further work is required to define and test minimum control and running standards, in particular ventilation configurations that would prevent short-circuiting occurring. HSE would be in a stronger position to enforce improved standards of exposure control if it could, for example, point to a well evaluated example of a commercial spray room retro-fitted with improved ventilation, filtration, exhaust discharge, pressure monitoring etc.
- It is therefore recommended that further work be carried out to retro-fit an existing commercial MVR spray room with improved ventilation and other controls, and measure and characterize the improvement in performance and to examine cost implications.
- Gun cleaning has been identified as having a major potential for worker isocyanate exposure and HSL should undertake work on automated gun cleaning devices to see if they emit significant airborne isocyanate aerosol.