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Mercury Contamination, Rutherford/Coupland 1 Building, University of Manchester

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DISTRIBUTION

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EXECUTIVE SUMMARY

Objectives

HSL were asked to corroborate measurements of mercury vapour in air in two rooms on the second floor of the Rutherford (now Coupland 1) building of the University of Manchester. If the University's own measurements were substantiated advice was to be given on the issues to be considered and the remediation options available.

Main Findings

During a site visit on 12th January 2009 Mercury vapour was measured in airflows emerging from beneath the floors of the rooms formerly numbered 2.62 and 2.63. The air in the breathing zone in room 2.62 was not significantly contaminated but 18 $\mu g.m^{-3}$ of mercury vapour was measured in the air in 2.63 (although subject to caveats about the instrument's cross-sensitivity to organic vapours and humidity.). The measurements should be compared with a proposed Indicative Occupational Exposure Limit Value of 20 $\mu g.m^{-3}$.

Recommendations

Parts of the floors of the rooms and underfloor areas in the rooms had been decontaminated some years previously to address radioactive contamination and at that time mercury had been found and removed to some (unknown) extent. On 13th January it was recommended that the staff in the affected rooms should be accommodated elsewhere to allow removal of the furniture and intrusive investigation below the floors to establish where any further mercury residues might be.

The methods selected to achieve effective decontamination will need to address the materials used in the construction of the building. The materials are probably such that the ceilings of the rooms below would have to be removed to achieve a satisfactory result. Any work (including further intrusive investigation) would need to be informed by details of the decontamination work performed earlier and preceded by the preparation of a thorough radiological risk assessment and a robust method statement. Thorough planning and careful application of methods would be needed to ensure that contamination was not dispersed during the work.

1 INTRODUCTION

In early January 2009 an enquiry was received from Dr D Barker, Head of Risk at the University of Manchester (UOM), as to whether HSL could assist with the investigation of apparent mercury vapour contamination of some rooms in one of the University's buildings. He explained that the building now known as Coupland 1 was previously known as the Rutherford Building because it was where Ernest Rutherford had worked on alpha radiation and atomic structure from 1907 to 1919.

It had been reported that an employee working in the building had a biological monitoring result for mercury in urine that gave concern (although the result was subsequently shown to have probably been erroneous.) The employee had been occupying an area known to have been contaminated by radioactive materials from the earlier research. This was remediated around 2004, but in the course of that work contamination by liquid mercury was discovered. A report of a survey by Casella Winton at that time showed 6 $\mu g/m^3$ mercury vapour in the ambient air in room 2.62 (average 46.3 $\mu g.m^{-3}$ underfloor) and 4.9 $\mu g/m^3$ mercury vapour in the ambient air in room 2.63 (average 109.2 $\mu g.m^{-3}$ underfloor.)

It is known that Room 2.62 was subsequently cleaned to replace contaminated floorboards and remove underfloor radioactive contamination and the floor was then sealed. The wider extent of the decontamination work is unknown. After the apparent evidence of mercury exposure the floor in room 2.62 was sealed more thoroughly by the application of a layer of plywood over the floorboards and sealant at the joins of the plywood sheets. However localised monitoring of mercury vapour carried out by the University then showed higher concentrations in room 2.63. In January 2009 the UOM monitoring with a direct-reading instrument revealed mercury concentrations above the former UK OES and draft IOELV in airflows from under the floors of both rooms 2.62 and 2.63.

HSL were asked to measure mercury vapour concentrations independently to corroborate the values indicated by the instrument used by University and to support the Corporate Services Division in the identification of an appropriate way forward.

The measurements made have to be assessed in the context of the facts that the UK Exposure Limit, which was formerly 25 $\mu g.m^{-3}$, was withdrawn in 2005. A Europe-wide Indicative Occupational Exposure Limit Value is currently proposed at 20 $\mu g.m^{-3}$.

This report addresses only the issues in rooms 2.62 and 2.63 and those immediately adjacent laterally or below.

2 SITE VISIT, 12TH JANUARY 2009

On 12th January Mr Easterbrook of HSL's Occupational Hygiene Unit attended the site where an initial briefing was given and the data from the Casella-Winton report was made available. The offices concerned were then visited and a brief "walk-round" survey was conducted of the offices and those on the floor beneath. A Shaw City MVI mercury vapour indicator (serial no. W10125-3) was used to measure localised mercury concentrations.

HSL and UOM instruments both showed approximately 1 to 2 $\mu g.m^{-3}$ in room 2.62, less than 1 $\mu g.m^{-3}$ at cracks in the skirting board at the bay-window end of the room, but 90 $\mu g.m^{-3}$ in the entrance doorway at a crack where the wood floor abuts the corridor. Similar concentrations were measured at a hole in the skirting where heating pipes ran through to 2.63, but it was not clear whether this airflow was emerging from beneath the floor or within the studding wall. This wall was made of noticeably lightweight materials, suggesting relatively recent construction.

In room 2.63 the airflow emerging from heating pipe holes (from 2.62) was measured at 200 to 360 $\mu g.m^{-3}$, other floor/wall join measurements were 13 to 16 $\mu g.m^{-3}$, but a measurement at approximately 1.5 metres in the room (head height when seated) was consistently 18 $\mu g.m^{-3}$. Room 2.63 was occupied by 2 or 3 staff.

Mercury vapour was found to be below 1$\mu g.m^{-3}$ in the next room, 2.64, except that 18 $\mu g.m^{-3}$ was detected in the air current at the entry of the heating pipes from 2.63.

Both humidity and some organic vapours (particularly naphthalene) can cause positive interference in instrumental measurements. Naphthalene was not smelt on the second floor but significant variations were noted in room temperature (hence probably humidity) between rooms. The instrumental results must therefore be treated with a degree of caution, as they may exaggerate or underestimate actual concentrations.

It is noteworthy however that all measurements of mercury on the first floor (below the contaminated rooms) indicated 0.5 ± 1 $\mu g.m^{-3}$ mercury despite a strong smell of naphthalene, i.e. in these circumstances naphthalene was not causing significant positive interference in the instrument readings. No offices are situated above the contaminated second floor rooms.

It was noted that where floorboards could be seen they ran at a right angle to the corridor and it can therefore be deduced that the joists run parallel to the corridor. The joists for adjacent rooms therefore probably lie next to each other in the dividing walls between the rooms. In similar buildings this has been seen to provide routes for airflow and thus contamination migration between the underfloor spaces of adjacent rooms. Assuming that there is no lower level of support it is also likely that the spaces between the floor joists are relatively well isolated from each other, with implications for air movement patterns (and the options for creating or influencing air movements) below office floors.

Exposure Limits etc. for mercury are as follows:

Former UK Occupational Exposure Standard 2003 (withdrawn 2005): 25 $\mu g.m^{-3}$ 8-hr Time-Weighted Average

Draft IOELV: 20 $\mu g.m^{-3}$

UK BMGV: 20 µmol Hg/ mol creatinine

3 DISCUSSION

It is understood that mercury has been used in quantity for a variety of purposes in the laboratories in the building. Spilt mercury is both very mobile and dense, so globules travel a significant distance on a smooth floor and penetrate vertical crevices. The radioactive materials might have been in any form, so those that might have penetrated the structure could have been as powders, solutions or suspensions in aqueous or organic liquids or even as mercury amalgams. These types of material would have spread into the building structure in different ways. Spilt mercury might have lodged in cracks in the surface of floorboards, or penetrated through cracks then sat on sound insulation (if any was present then) or filtered down through the fibrous material and sat on the upper surface of the ceiling of the room below. The varied physical forms of the contaminants, and especially the potential differences between the behaviour and mobility of mercury and some of the other media, should be borne in mind when considering both the likely locations of contamination of different sorts and the relative effectiveness of decontamination aimed at one contaminant type on another.

The highest concentrations of mercury vapour were detected in rooms 2.62 (away from the bay window end of the room) and in 2.63 at points where cracks or other openings could be seen around the skirting boards. The vapour would therefore seem to have had its source below the floor level and would have been moving with the air currents through the building structure. It is not possible to infer the exact source of the vapour, i.e. under which room the contamination remains. It also has to be recognised that concentrations might vary considerably under other weather conditions (such as with a different wind direction, relative room and external temperatures or even which doors were open.)

The details of the work methods used in the remediation of 2.62 are apparently not known, or whether anything was done in 2.63. An important aspect would be which floorboards had been lifted and if so, whether reinstated or replaced with new. This is significant because of the possibility that mercury droplets could remain in the upper crack between undisturbed tongued-and-grooved boards.

It is believed that the ceilings of the building, including those of the first floor (i.e. immediately beneath the rooms involved) are of lath and plaster construction. The reported presence of mineral wool and chicken wire in the floor void beneath room 2.62, apparently installed after the 2004 remediation as replacement sound insulation, suggests that the consideration of the locations of contamination should take into account a possible previous form of sound insulation.

The upper surface of a lath and plaster ceiling is usually porous and very uneven, with rough-sawn laths, “upstands” of plaster and vertical crevices wherever the plaster did not adhere to the laths. It is difficult to imagine a method of decontamination that could be applied effectively to such a surface.

The decontamination which has been done was apparently principally to address a radiological problem, although the discovery of liquid mercury prompted the 2004 Casella-Winton mercury vapour survey. It can be surmised that the remediation to address radioactive contamination proceeded as far as was necessary to reduce the radiological hazard to an acceptable level and would have taken into account the shielding provided by the overlying structure, i.e. the dense mineral wool and the floorboards.

The potential remaining sources of mercury vapour in the offices are as follows:

- droplets of liquid mercury remaining trapped in the cracks between floorboards in any room where spillage has occurred and the boards have not been taken up
- mercury which has penetrated beneath the floor and not been in an area where radioactive contamination was identified and remediated
- mercury which is in an area that was decontaminated but remains finely divided in the structure of the ceiling materials or attached to the sides of floor joists or rough walls.

Remediation options:

The mercury affecting a room could be addressed in several ways. One would be to divert the flow of vapour in the way radon is dealt with, by creating a barrier to movement into an occupied area and extracting contaminated air from below. However this has the disadvantages that

A it may be difficult to achieve control of air movement (with the need to drill lots of holes through joists)

B it will entail energy costs to extract air on a continuous basis

C there will also be extra energy costs to heat the structure chilled by a winter air flow, possibly with condensation problems too.

The approach also begs the question of whether “dilute and disperse” is ethically or environmentally acceptable.

Wholesale removal of contamination would deal with problem, but assumes the sources have been correctly identified and decontamination will be thorough enough to resolve the problem (i.e. technically feasible.)

There are some parts of the building’s structure that might cause difficulties during decontamination. One example would be where there are large cornices at the edges of ceiling on the floor below, where they would probably create a substantial narrow pocket between the outside wall and the adjacent joist. To achieve full effectiveness the ceiling removal (if done) will have to involve removing the cornice too, especially as the skirting/floor gap might be one of the more important routes for mercury penetration into the building’s structure. The potentially narrow gap between the joist and the exterior wall will require special attention if decontamination of the vertical faces is to be effective.

There will be other issues of this type to consider.

4 CONCLUSIONS

Mercury contamination might remain beneath the floor of 2.62 despite the remediation and vapour may be being carried on air currents to emerge above the floor at the down-wind end of the room.

The effective sealing of the floor in 2.62 could have increased the ambient concentration in 2.63 if air flowing from under 2.62 emerged in 2.63 instead.

The mercury contamination that was identified under the floor of room 2.63 in the 2004 Casella Winton report may not have been removed. The vapour detected at floor level along the walls in 2.63 could either be from this source alone or from this source in addition to vapour from 2.62.

A reservoir of contamination under room 2.63 could in fact be the major remaining source of the vapour, including that emerging at the foot of the wall in 2.62.

The vapour measured at the crack between the boards and the concrete corridor floor at the door of 2.62 could be the result either of mercury in the structure at that point or of a flow of contaminated air.

The structure of the wall between 2.63 and 2.64 seems to be effectively preventing vapour migration. A small airflow exists between the two rooms around the heating pipes.

5 RECOMMENDATIONS

Full details of the work previously done in both rooms should sought to identify whether areas have been treated to the extent that contamination can no longer be suspected.

The underfloor areas in (possibly) 2.62 and (probably) 2.63 should be remediated with the removal of mercury contamination as the primary aim. It would be advisable to employ a specialist contractor with experience of such work. They should be able to competently prepare risk assessments and method statements, operate appropriate specialised equipment and work with the attention to detail needed to avoid causing further dispersal of contamination in the course of the work.

The detail of the earlier work in 2.62 should be established so that it is clear whether items such as the vacuum-cleaning of floor joist surfaces has been done, or whether these potentially rough surfaces might still hold mercury.

A radiological risk assessment will be needed before disturbance or removal of materials still contaminated with mercury, as it is unlikely that decontamination to address radioactivity that left so much mercury was exhaustive. The method adopted for the ceiling removal will need to ensure that contamination is not allowed to migrate lower in the structure of the building (so the floor of the room should be sealed with plastic extending a few tens of cm up the walls and the walls should also be covered to prevent contamination.)

A record should be kept of the locations of mercury observed during the decontamination work. This could be a photographic record, which should be built up to document the appearance of the surfaces which are uncovered and the condition of completed areas as work progresses

After the ceilings have been removed beneath 2.63 and the floor joists have been exposed and cleaned it is possible that mercury vapour monitoring might show that the contamination has been removed to the point where further aggressive intervention such as dealing with the floor boards in room 2.63 is unnecessary. It will be difficult to establish whether this has addressed the potential residual mercury contamination on room 2.62 however.

The following recommendations were made in an interim report issued on 14th Jan 2009:

1 Room 2.63 should be taken out of use pending resolution of the source of the vapour and appropriate remediation.

2 Room 2.62 should not be re-occupied until the position is better understood.

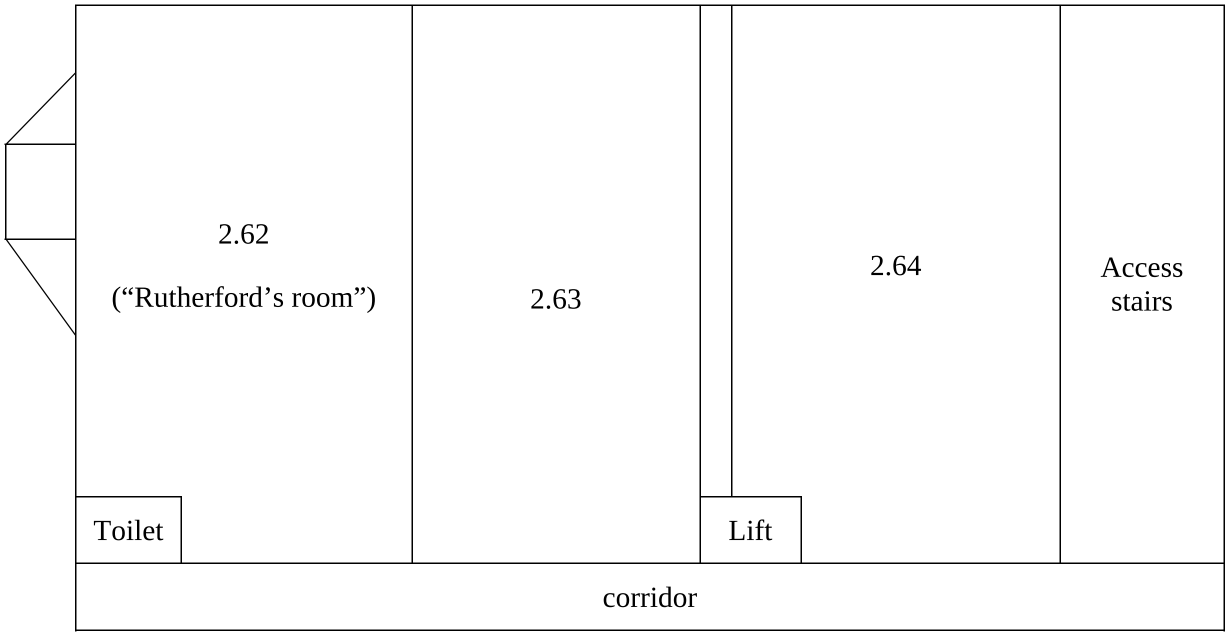
3 The heating pipe opening between 2.63 and 2.64 should be sealed to prevent the (slight) air movement.

4 Details of the cleaning and reconstruction of 2.62 should be sought to allow a better interpretation of current observations and measurements.

5 A more thorough examination of the building, including tracing air movements in different weather conditions and through the full height of rooms, is required if the present measurements are to be adequately explained. Intrusive investigation is needed to establish whether a reservoir of contamination remains in 2.63 and whether further work might be required in 2.62.

6 APPENDIX - SKETCH PLAN OF SECOND FLOOR

(not to scale



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