R & D report

Working Environment Study

RÄDDNINGS VERKET

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Working Environment Study

Report on the study carried out at the four Swedish Rescue Services Agency colleges on the possible presence of isocyanates in the air or in personnel

The study was carried out by the working environment group along with experts from the Clinical Chemistry Department of Lund University

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Preface

On a daily basis at the Swedish Rescue Services Agency's (SRSA) four colleges training is provided for fire & rescue service personnel on how to tactically extinguish various types of fires.

In recent years, primarily amongst instructors and college employees responsible for this training, anxiety has been growing about whether or not personnel and trainees are being exposed to hazardous substances that can be formed and be present in the smoke from the fire exercises.

This relates mainly to smoke from products containing isocyanates and polyurethane, which have become more and more common. Isocyanates are mainly used in the manufacturing and handling of PUR products such as foam, elastomers, glues, resins, and lacquers. The good technical properties of polyurethane have led to a considerable increase in its use in recent years. In addition, it is one of the components of flammable products that are used for training on vehicle fires (foam plastics, lacquers, and other plastics), as well as resins in, for example, chipboard.

In the last few years methods (for example, used by the Clinical Chemistry Department at the University Hospital in Lund) for measuring isocyanates in the air, blood, urine, and materials have been improved so that it is now possible to monitor variations after exposure to these substances.

At an extraordinary meeting of the SRSA's Central Protection Committee it was decided to carry out a working environment study at the SRSA's colleges as soon as possible. This study was to include the sampling of possible isocyanates in the air in certain environments, the measuring of isocyanates in the blood and urine of exposed personnel, and in materials. Additionally, the flammable substances that the colleges used for training, and how protective equipment was handled was also to be studied.

The project manager was Tommy Häggroth. The following members of the working environment group also worked on the project: Bert Ove Johansson, Hans Edvardsson, Bjarne Wester, Bernt Blomgren and Claes Göran Claesson. Marianne Dalene, Assoc. Prof. at Lund University, was the expert responsible for chemical analysis of the samples.

On completion of the study this report was submitted to the SRSA's Central Protection Committee and the SRSA management.

Contents

Summary

From a working environment viewpoint it is extremely important to ascertain what risks we as employees might be subjected to and how we can minimise them and the subsequent various types of industrial injuries that can arise in the workplace.

This now completed study, on the possible presence of isocyanates in the training areas of the SRSA's colleges, has provided us with increased knowledge about the risks that are and are not present, and what measures we can take to improve the situation.

Flammable substances

As regards the most common types of training fires we knew that the material in the vehicles set alight contained polyurethane products, which emit high levels of isocyanates. Therefore measures have also been taken at some of the colleges to reduce the presence of isocyanates by, prior to fire exercises, removing materials such as, seat fillings, tyres, oil, and plastic fittings from the cars.

The isolating material in the most common containers ought to be taken into consideration as well, because when the roof and walls are heated to very high temperatures during exercises the isolating material can emit methyl isocyanate.

The most surprising result of the study was the discovery of the very high percentage of isocyanates emitted from chipboard during combustion. It was thought that there was a very high concentration of isocyanates in the glue and resin used during manufacture. Unfortunately chipboard is one of the most common materials used in the various fire exercises at the SRSA's colleges. The vast majority of chipboard used by the SRSA bears the environmental Swan Mark, which might lead people to believe that it is not hazardous. But the Swan Mark refers to general environmental requirements and is therefore irrelevant in this context.

Safety regulations and protective equipment

Safety instructions with local amendments have been improved and work very well for the personnel that follow them. During the various types of fire exercises that the project group performed and in which complete body protective equipment was used (Breathing apparatus) there was a 100% percent level of protection. This was also proved by the analysis of the biological samples taken during the study. The only exceptions to this were two service personnel who had traces of isocyanates in their urine as a result of cleaning fire exercise locations without wearing protective masks (which, by the way, isn't obligatory).

Biological samples

Apart from the two service personnel, who had traces of the degradation products of isocyanates in their urine, no one else had any traces in their urine or blood. It ought to be noted that measuring methods for biological samples can still not cover all types of isocyanates.

Recommendations

The working group for working environment issues, which was the project group for the study suggests the following:

- The current use of chipboard for fire exercises should gradually be phased-out. This can be replaced by untreated wood in various forms.
- The burning of scrapped vehicles should eventually be phased-out, and replaced by an alternative and equivalent training arrangement.
- All materials that emit high levels of isocyanates should be removed from scrapped vehicles before they are used for fire exercises.
- Until the aforementioned recommendations are implemented all personnel who may be subjected to smoke/ashes will wear a complete respiratory protective device.

The SRSA's environmental policy was taken into consideration during the formulation of these recommendations.

Introduction

The SRSA is a government authority that works towards making society safer. We concentrate on preventive work to reduce the number of accidents and their consequences. Our work is characterised by our closeness to the fire & rescue service and our international commitments.

The SRSA management and central administration offices are located in Karlstad. All municipal fire & rescue service personnel are trained at one of the four colleges: Revinge, Rosersberg, Sandö and Skövde. Rosersberg also provides training for chimney sweeps, technicians, and engineers. The SRSA employs about 900 people; 600 of which work at the colleges.

Every work place has its own Protection Committee, whose main task is to safeguard the working environment. The Central Protection Committee, which is situated at the SRSA's central administration offices, has overall responsibility for working environments. The chair of the Central Protection Committee is the SRSA's Director-General.

On 31st January 2000 the Central Protection Committee decided to carry out a working environment study at the SRSA's colleges as soon as possible, to ascertain whether or not hazardous levels of isocyanates were present in air or had been absorbed by personnel. Working environment co-ordinator Tommy Häggroth was appointed as project manager.

ISOCYANATES are a group of reactive substances which contain one or more functional nitrogen – carbon – oxygen – groups. Isocyanates have been in use for more than 50 years, mainly in the manufacture of various plastics, for example, polyurethane.

During the thermal breaking down of polyurethane the original monomers along with a number of new isocyanates are formed.

Isocyanates are present in a number of everyday products, for example, hard and soft foams, glues, lacquers, various types of bonding agents, and paints.

Isocyanates can cause the following health problems: allergic reactions, irritation of mucous membranes, asthma, eczema, and various types of insidious debilitations of the lungs. Some isocyanates are carcinogenic.

Planning for the isocyanate study

The target group for the study was the instructors who on a daily basis conduct the various fire exercises that are part of the training – at the SRSA's colleges – for all municipal fire & rescue service personnel.

Apart from the instructors, who ensure that safety is maintained during practical exercises, some service personnel are also used on certain fire exercises to prepare the fire site, to ignite the fire, then after the fire has been extinguished to clean up the fire site, and to be of general assistance.

It was important that those concerned submitted their medical history and previous employment details, so that irrelevant effects that may have been caused earlier didn't influence the results of the study.

In most cases, interviews were held with the test subjects during the study in order to provide supplementary personal information.

The details of all flammable materials used by the colleges during fire exercises were to be recorded, and samples of the materials analysed.

Air samples were to be taken throughout the course of the exercise, i.e. from the time of ignition to extinguishing to subsequent clean up of the fire site.

Finally, it was vitally important to ascertain the level of protection protective equipment provides and how it is used. Additionally, there will be a follow up on the SRSA's central and local working environment regulations.

That all personnel at all four colleges were to participate, in some way, in the study was a prerequisite. Primarily because anxiety about having been exposed to hazardous substances existed among personnel at all the colleges, and also because despite carrying out the same types of fire exercises, there are differences from college to college when it comes to local conditions, venues used, flammable materials, and topography etc.

Employed on the study were some of the country's leading experts, who had developed and possessed the resources necessary for the analysis of those samples that were of fundamental importance to of the study. The main expert was Assoc. Prof. Marianne Dalene, who could consult the entire Clinical Chemistry Department at the University of Lund. Isocyanate research is her usual full time job.

After a short learning period a sample taking programme was planned for each of the colleges, which would entail 3 – 4 test subjects during a standard fire exercise.

The following standard fire exercises were performed:

Rosersberg – Car fire on tarmac

Skövde – A fibrous substances fire in a container

Revinge – Garage fire: a car on fire in a closed garage

Sandö College submitted only blood samples from the test subjects.

During the standard fire exercises air, blood, and urine samples were taken. As regards urine samples, two were taken: one before and one after the person was exposed.

The details of all materials used during fire exercises were recorded. There was also a run-through of local safety instructions and how they are applied at the four colleges. Samples of the various materials used during the fires, and from the container insulation, and of car paints were also analysed.

Execution

The basis for the study's fire exercises was that they should imitate as far as possible the fire exercises usually carried out at the colleges. Therefore, the test subjects were asked to act exactly as they ordinarily would. So if a person was usually careless with the recommended protective equipment, so should they also be careless during the study exercises etc. The material used in and the extent and intensity of the fire, and extinguishing materials were also to be the same.

Rosersberg College – Car fire on tarmac

The sample taking began at Rosersberg on the afternoon of 18.4.2000.

The test subjects were two instructors and three service personnel.

Weather: cloudy with sunny intervals. Temperature: 18° C. Wind: southeasterly 1-2 metres per second.

Type of exercise: car on fire after an accident.

Fire object: a 1984 Saab 900 GL.

The day began when Marianne Dalene and Tommy Häggroth delivered an information briefing, to the test subjects and others involved, outlining the basis for the study and how the day would progress, and how those involved were to conduct themselves. After which, each test subject submitted their personal details and a urine sample. Each urine sample was later compared with another urine sample taken at the conclusion of the day's exercises.

A whole car had been placed at the exercise site that is used for simulating road traffic accidents. The first task was to position the measuring devices, which comprised a test tube with accompanying tube and pump for the taking of air samples. The measuring device was sometimes attached to lampposts and other suitable places, and sometimes on the test subjects. After that, one of the service personnel – who was also a test subject – began to load the car in readiness for the fire, i.e. the car passenger compartment was loaded with pieces of fibreboard fire-lighting fluid to enable the fire to take hold. After the fire had reached the required level (after approximately 7 minutes) the instructors gave the order to commence extinguishing.

Neither the instructors nor service personnel had any protective equipment other than protective overalls, boots, and helmets. And they stood a long way off from the fire during ignition and extinguishing. The development of the fire and extinguishing of it went very quickly, it was all over in less than 15 minutes; and the whole exercise was filmed.

After the fire exercise the college nurse took a blood sample from each of the test subjects. Before concluding the day's activities the test subjects submitted their second urine sample. All samples were analysed at Lund University, University Hospital (Institutet för Kemisk Analys Norden AB). See appendix.

Comments on the experiment and analysis results

Air samples:
A total of ten air samples were taken at Rosersberg. The two stationary points for sample collection were situated 5 and 15 metres from the seat of the fire; and in those samples the isocyanates PHI (1-4 µg/m3) and MIC (0-4 µg/m3) were detected. No isocyanates were found in the six samples collected from the devices worn by test subjects. The instructors and one female member of the service personnel did not stand upwind therefore no exposure was expected.

Biological samples:
Blood and urine samples from two service personnel and two instructors were analysed. No isocyanate degradation products were found in the blood samples.

Traces of 2.4 – TDI were found in the urine samples of the service woman. The same level was found in both the before and after samples, which would indicate that the woman was exposed on an earlier occasion. During an interview it was revealed that she had, on the previous day, swept out ashes, without wearing protective gear.

Skövde College – Fire in a container

The exercise was performed on 4.5.2000 in connection with an ordinary exercise in which BA (breathing apparatus) was used.
The test subjects were one instructor and one student.
Weather: overcast. Temperature: approximately 16° C. Wind: gusty and variable from east to south-east 3 – 4 metres per second.
Type of exercise: fire in a container.
Exercise object: approximately 7-8 m2 of 12mm chipboard, some broken up into smaller pieces, and bearing the environmental Swan Mark. One litre of fire-lighting fluid was used for ignition.

After introducing the study, and obtaining the personal details of the test subjects, the instructors loaded the container for the exercise. The point of this type of exercise is to generate as much smoke as possible. Full body protective equipment and BA was used. Skövde College doesn't have specific service personnel to prepare these kinds of exercises.

A total of 18 air samples were taken during the exercise. No biological samples were taken, and the reason for that is that there are no biological methods for MIC and ICA, which were the isocyanates expected in the smoke. Eight air samples were taken from the devices worn by test subjects, and 10 from the stationary devices. The samples taken by the devices on the test subjects were taken in two pairs, i.e. two pairs for the instructor and two for the student.

Of the 10 samples taken from stationary devices, some were taken inside the container and some from points from between 5 metres to 100 metres from the container. Two samples were taken during subsequent cleaning up of the exercise site.

It took about 15 minutes, after ignition, before the smoke had reached the level required for the purposes of the exercise, despite there being a regulated vent. The fire burned for approximately 50 minutes. The instructor and seven students wore full protective equipment (RB 90 with compressed air BA). The RB 90 (rescue coveralls, boots, hood, gloves, underwear, and inner garment) series of protective equipment is generally what nearly all fire & rescue service personnel wear during fire & rescue operations.

Comments on the experiment and analysis results

Air samples:
Very high levels of MIC and ICA were present in the two samples taken, during the fire, from fixed positions in the container. The levels were still very high, approximately 6 – 18 times the occupational exposure limit (OEL) in the four samples taken from fixed positions approximately 5 metres from the container.
In the two samples taken from fixed positions up to about 100 metres from the container the levels were still surprisingly high at approximately 4 times the OEL.
When the ashes were cleaned out the level of isocyanates in the soot dust was measured at 70 times the OEL. These high levels of isocyanates, chiefly MIC and ICA, were the most surprising of the whole study.

On this occasion all personnel wore the prescribed protective equipment, including masks and BA, which was proved to provide an excellent level of protection. No biological samples were taken during this exercise.

Revinge College – Garage fire

The last fire exercise experiment for the study was conducted on 11.5.2000.
The test subjects were two instructors and one member of the service personnel.
Weather: sunny with light clouds. Temperature: approximately 20°C. Wind: southwesterly 2 metres per second.
Type of exercise: garage fire
Fire object: a 1983-84 Saab GL
After a briefing from Marianne Dalene and Tommy Häggroth the test subjects submitted their personal details and a urine sample.

So as to prevent a too extreme fire the filling was removed from the car's back seat. The measuring points were decided upon and the sample taking sets were attached both to stationary points and to test subjects. A total of eight air samples were taken from the sets worn by test subjects and five from the stationary points.

An instructor without a respirator started the fire in the vehicle, and then shut the doors to enable the fire to develop for approximately 7 minutes. Subsequent extinguishing took about 18 minutes. During the extinguishing operation one instructor remained in the container, while the other stayed outside, and on several occasions opened the door slightly to check on the progress of the operation. When the extinguishing operation was completed a member of the service personnel cleaned up the fire site, which took about 7 minutes.

The college nurse took venous blood samples from all test subjects after the exercise. And about one hour after that the second urine sample was provided.

Comments on the experiment and analysis results

Air samples:
The samples taken from the device worn by the instructor who was in the container contained very high levels of isocyanates (50 – 170 times the OEL). This instructor had been wearing full protective equipment and BA.

The samples taken from the device worn by the instructor who was outside the container, and who only slightly opened the door during the car fire, also contained relatively high levels (4 – 5 times the OEL). This instructor did not use a respirator.

The samples taken from the device worn by the serviceman, who entered the container after the fire had been extinguished, contained, despite that, a considerable level (1 – 6 times the OEL). The serviceman did not use a respirator.

The samples taken from fixed points 7 metres from the container contained a level about 8 times the OEL. The samples taken, after the fire, 1 metre from the burned out car contained levels 3 times the OEL. During this experiment several types of isocyanates were detected, but MIC and ICA dominated.

Biological samples:
Urine and blood from the two instructors and the serviceman was analysed. No isocyanate degradation products were found in any of their blood samples.

Traces of 2.4 – TDI were found in the urine samples of the serviceman. The same level was found in both the before and after samples, which would indicate that he been exposed on an earlier occasion.

Sandö College submitted biological samples only

On 18.5.2000 Tommy Häggroth informed three instructors and three service personnel, all responsible for fire training, about the current study. After submitting the obligatory personal details the college nurse took a blood sample from each of them, which was then, in the form of blood plasma, despatched to the laboratory in Lund.

Analysis did not detect any degradation products of isocyanates in the blood samples.

Analysis of material samples from the colleges

To ascertain whether isocyanates were present in any of the materials used for exercises or other materials in containers or similar samples of materials were taken during the exercises and later analysed at the Institute for Chemical Analysis (Institutet för Kemisk Analys Norden AB).

The following samples were taken:
From Sandö College – pieces of insulating material from the fire containers, a piece of polystyrene, and a piece of mineral wool.

From Revinge College – taken from a Saab car: paint, material from the back seat, foam filling, and soot from the boot. In addition to samples of various ropes used, and samples of the roof insulation from the containers that were used.

The procedure for the analysis was to use a heating gun to heat up the samples to between 300-400 °C and to then analyse the smoke from the samples for isocyanates.

The presence of isocyanates in the various samples of materials is covered by appendix 6.

Appendices

Instructions for the analysis of biological, air, and material samples

Air samples

4.2 Sampling technique

The sampling equipment comprised an air-sample pump calibrated to a flow of 1.0 litre per minute, a tube filled with active carbon to protect the pump from solvent fumes, and an impinger bottle containing 10 ml reagent solvent of 0.01 M dibutylamine dissolved in toluene. An unimpregnated fibreglass filter was connected behind the impinger bottle. Immediately after a sample was taken the filter was removed from its holder and transferred to a test tube containing the reagent solvent from the impinger bottle. A total of 16 samples were collected in this way. The length of time available to take samples depended on the length of time required to complete the exercise element in question. The samples were collected by the isocyanate group of the Clinical Chemistry Department of Lund University.

4.3 Method of analysis

The collected samples went through work-up procedure and were then analysed by liquid chromatography – mass spectrometry (LC-MS-ESP+, see reference 3-8). This analysis measured the total amount of gas and particle borne isocyanates. The qualifying limit for TDI, MDI, IPDI and HDI with this method is 0.005 mg. That is equivalent, for a 5-minute air sample, to approximately one hundredth of the ceiling limit. The qualifying limit for MIC, EIC, PIC and PHI with this method is 0.01 mg. That is equivalent, for a 5-minute air sample, to approximately one tenth of the ceiling limit. The work- up procedure and analysis of the collected samples was carried out by the isocyanate group of the Clinical Chemistry Department of Lund University.

Biological samples

Biomarkers for isocyanates were determined as corresponding amines in hydrolysed urine and plasma taken from the test subjects. The amines were determined, after derivatisation with pentafluropropionic anhydride, using gas chromatography – mass spectrometry with chemical ionisation, monitoring negative ions. (see ref. 9).

Analysis

This type of analysis can be used to establish exposure to the following isocyanates: 4.4'-MDI, 1.5-NDI, 2.4-TDI, 2.6-TDI and their related amines. The level stated in the analysis result doesn't however say anything about the health risk, it only states whether exposure can be demonstrated or not. But the level stated in the analysis result can be important for the analysis of further samples, in that, for example, the effectiveness of protective measures taken can be assessed. If there has been exposure to 4.4'-MDI, 1.5-NDI, 2.4-TDI, 2.6-TDI then the level of exposure is measured by determining the content present of that isocyanate's related amine, i.e. 4.4'MDA, 1.5-NDA, 2.4-TDA and 2.6-TDA.

Blood

Each sample filled two sodium-heparinised tubes. Where possible the tubes were centrifuged to separate the plasma from the erythrocytes. Then the plasma was despatched to the laboratory. Analysis required at least 2.0 ml of plasma.

Urine

The urine was submitted in a plastic cup or bottle and was then poured into a plastic tube. Analysis required at least 3.0 ml urine.

Material

This analysis is used to indicate whether or not there is a risk of exposure to isocyanates during the heating up of the material in question. Pieces of the material are placed in a glass tube, which is then heated up with a heating gun for 3 to 5 minutes. The temperature in the glass tube is approximately 300-400^{0}C. While the heating up process was going on the gases being emitted were collected via the impinger-filter method and the reagent dibutylamine. (See section: Air samples –sample taking method.)

The samples collected were worked-up and then analysed using liquid chromatography – mass spectrometry (LC-MS-ESP$^+$, see reference 3-8.) The analysis can determine the quality of the following isocyanates: 4.4´-MDI, 2.4-TDI, 2.6-TDI, NDI, IPDI, HDI, PhI, PIC, EIC, MIC and ICA. It is important to make clear that the heating up of the material (as regards temperature and time) that was done at the laboratory isn't directly comparable to the treatment that was considered. Therefore, the results should only be used as a guide to where exposure to isocyanates might occur.

Compilation of air samples – Rosersberg

Sample ID	Sample type	Sampling time (minutes)	Flow (litres/min.)	Sample from
1	Filter + reagent	1.50	1.0	Servicewoman, Linn Anders-, son igniting car fire – device worn on person
2	Filter + reagent	1.50	1.0	Servicewoman, Linn Anders-, son igniting car fire – device worn on person
3	Filter + reagent	6.62	1.0	Instructor 1, Rolf Hellström - device worn on person
4	Filter + reagent	6.62	1.0	Instructor 1, Rolf Hellström - device worn on person
5	Filter + reagent	6.62	1.0	Instructor 2, Jan Lindström - device worn on person
6	Filter + reagent	6.62	1.0	Instructor 2, Jan Lindström - device worn on person
7	Filter + reagent	10.85	1.0	Lamppost, approx. 5 m from the seat of the fire, 2 m above the ground – stationary device
8	Filter + reagent	10.85	1.0	Lamppost, approx. 5 m from the seat of the fire, 2 m above the ground – stationary device
9	Filter + reagent	10.85	1.0	Ground level, approx. 15 m from the seat of the fire – stationary device
10	Filter + reagent	10.85	1.0	Ground level, approx. 15 m from the seat of the fire – stationary device

Sample ID	2.4 - TDI (µg/m3)	2.6 - TDI (µg/m3)	4.4' - MDI (µg/m3)	PHI (µg/m3)	HDI (µg/m3)	MIC (µg/m3)	EIC (µg/m3)	PIC (µg/m3)	IPDI (µg/m3)	ICA (µg/m3)
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	3.9	-	4.1	-	-	-	85
8	-	-	-	4.0	-	4.1	-	-	-	91
9	-	-	-	1.2	-	-	-	-	-	44
10	-	-	-	1.3	-	0.9	-	-	-	41

Compilation of air samples – Skövde

Sample ID	Sample type	Sampling time (minutes)	Flow (litres/min.)	Sample from
1	Filter + reagent	22.25	1.0	Börje Reimertsson, device worn on person (instructor)
2	Filter + reagent	22.25	1.0	Börje Reimertsson, device worn on person (instructor)
3	Filter + reagent	21.5	1.0	Student, device worn on person
4	Filter + reagent	21.5	1.0	Student, device worn on person
5	Filter + reagent	44.2	1.0	Stationary device in container (back)
6	Filter + reagent	44.2	1.0	Stationary device in container (back)
7	Filter + reagent	16.08	1.0	Stationary device outside
8	Filter + reagent	16.08	1.0	Stationary device outside
9	Filter + reagent	45.18	1.0	Börje Reimertsson, device worn on person (instructor)
10	Filter + reagent	45.18	1.0	Börje Reimertsson, device worn on person (instructor)
11	Filter + reagent	43.45	1.0	Student, device worn on person
12	Filter + reagent	43.45	1.0	Student, device worn on person
13	Filter + reagent	10.7	1.0	Stationary device outside (a long way off)
14	Filter + reagent	10.7	1.0	Stationary device outside (a long way off)
15	Filter + reagent	12.45	1.0	Stationary device outside
16	Filter + reagent	12.45	1.0	Stationary device outside
18	Filter + reagent	10.05	1.0	Cleaning out of ashes after the fire
19	Filter + reagent	10.05	1.0	Cleaning out of ashes after the fire

Sample ID	2.4 - TDI (µg/m3)	2.6 - TDI (µg/m3)	4.4' - MDI (µg/m3)	PHI (µg/m3)	HDI (µg/m3)	MIC (µg/m3)	EIC (µg/m3)	PIC (µg/m3)	IPDI (µg/m3)	ICA (µg/m3)
1	-	-	-	-	-	480	5.5	0.9	-	330
2	-	-	-	0.7	-	1 400	13	5.4	-	2 400
3	-	-	-	-	-	160	2.6	1.5	-	390
4	-	-	-	0.5	-	1 100	14	3.7	-	880
5	-	-	-	0.6	-	710	17	4.1	-	1 200
6	-	-	-	0.7	-	990	20	8.3	-	1 500
7	-	-	-	-	-	120	-	0.7	-	280
8	-	-	-	-	-	140	-	0.9	-	300
9	0.5	-	-	0.7	-	600	14	4.6	-	960
10	-	-	-	1.2	-	890	13	4.8	-	1 500
11	-	-	-	0.4	-	320	8.0	1.2	-	360
12	-	-	-	0.8	-	700	7.7	2.6	-	330
13	-	-	0.9	-	-	8.9	-	3.2	-	62
14	-	-	-	-	-	7.2	-	-	-	71
15	-	-	-	-	-	80	-	-	-	99
16	-	-	-	-	-	80	-	-	-	93
18	-	-	-	-	-	270	14	1.7	0.6	1 100
19	-	-	-	-	-	320	19	2.4	-	1300

Compilation of air samples – Revinge

Sample ID	Sample type	Sampling time (minutes)	Flow (litres/min.)	Sample from
1	Filter + reagent	20	1.0	Pump to the left of the garage. Approx 7 metres away.
2	Filter + reagent	20	1.0	Pump to the left of the garage. Approx 7 metres away.
3	Filter + reagent	Max 15	1.0	Device on person – J Klause, using BA.
4	Filter + reagent	18	1.0	Device on person – J Klause, using BA.
5	Filter + reagent	18	1.0	Device on person – B A Albertsson, instructor inside the fire venue.
9 (6)	Filter + reagent	14	1.0	Device on person – B A Albertsson, instructor inside the fire venue.
7	Filter + reagent	24	1.0	Device on person – S Svensson, instructor outside the fire venue.
8	Filter + reagent	Max 15	1.0	Device on person – S Svensson, instructor outside the fire venue.
11	Filter + reagent		1.0	Blank sample – from the luggage compartment of the bus i.e. where samples were handled, processed and stored.
12	Filter + reagent	15	1.0	Next to the burned out car, after extinguishing. Approx 1 metre away.
13	Filter + reagens	15	1.0	Next to the burned out car, after extinguishing. Approx 1 metre away.
14	Filter + reagens	7	1.0	Device on person, K E Dahl – serviceman.
15	Filter + reagens	< 7	1.0	Device on person, K E Dahl – serviceman.

Sample ID	2.4 - TDI (µg/m3)	2.6 - TDI (µg/m3)	4.4' - MDI (µg/m3)	PHI (µg/m3)	HDI (µg/m3)	MIC (µg/m3)	EIC (µg/m3)	PIC (µg/m3)	IPDI (µg/m3)	ICA (µg/m3)
1	2.5	1.0	-	1.8	-	0.7	-	-	-	140
2	2.7	1.0	-	1.9	-	1.2	-	-	-	170
3	1.0	-	-	2.1	-	1.1	-	-	-	220
4	0.3	-	-	1.7	-	0.6	-	-	-	190
5	5.1	1.4	-	11	1.2	6.7	2.1	-	-	980
9 (6)	17	4.4	2.9	43	1.4	34	6.3	1.1	-	3 100
7	1.0	0.3	-	1.0	-	1.3	-	-	-	80
8	1.3	0.4	-	1.3	-	1.5	-	-	-	97
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	56
13	-	-	-	-	-	-	-	-	-	65
14	-	-	-	-	-	1.4	-	-	-	113
15	-	-	-	-	-	-	-	-	-	24

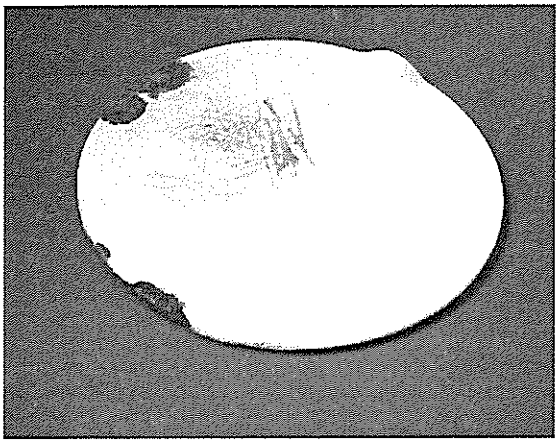
Compilation of biological samples (2)

Biological sample	Job	2.4 - TDA	2.6 - TDA	1.5 - NDA	1.6 - HDA	4.4 - MDA	Content unit	Comments
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Plasma	Service	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Urine	Service	0.03 µg/mmol	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Service	0.03 µg/mmol	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Urine	Service	0.02 µg/mmol	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Service	0.02 µg/mmol	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Plasma	Service	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	Before work
Urine	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	After work
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Service	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Service	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Service	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	
Plasma	Instructor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	µg/L	

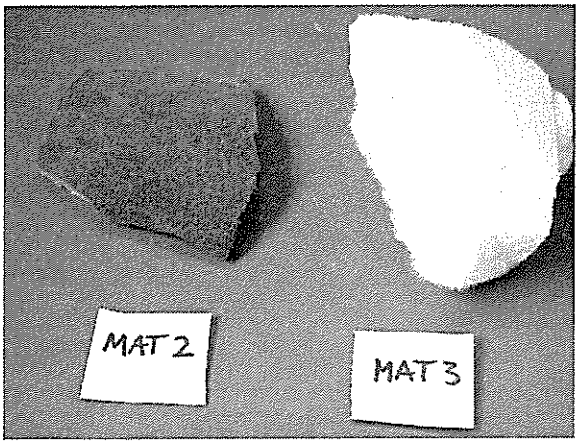
Compilation of material samples

Order ID	Sample ID	Type of material and how used	2.4 -TDI	2.6 -TDI	4.4' - MDI	IPDI	PHI	HDI	MIC	EIC	PIC	ICA
9683167	1	Large sample from the roof insulation of a container in Revinge's training area	-	-	-	-	-	-	X	-	-	X
9683167	2	Small sample from the roof insulation of a container in Revinge's training area	-	-	-	-	-	-	X	-	-	X
9683187	1	Thin rope, pink base with a green-yellow pattern	-	-	-	-	-	X	X	X	X	X
9683187	2	Thick rope, black	-	-	-	-	-	X	X	X	X	X
9683187	3	Thick rope, white base with a blue-pink pattern	-	-	-	-	-	X	X	X	X	X
HE	1	Polystyrene	-	-	-	-	-	-	-	-	-	-
HE	2	Mineral wool	-	-	-	-	-	-	X	-	-	X
Revinge MAT	1	Paint from a burned out 1983-85 Saab 900 GL, white	-	-	-	-	-	X	X	X	X	X
Revinge MAT	2	Material from the back seat of a 1983-85 Saab 900 GL, white	X	X	-	-	X	-	X	-	-	X
Revinge MAT	3	Foam filling from the back seat of a 1983-85 Saab 900 GL, white	X	X	-	-	-	-	-	-	-	X

Isocyanates in materials – pictures

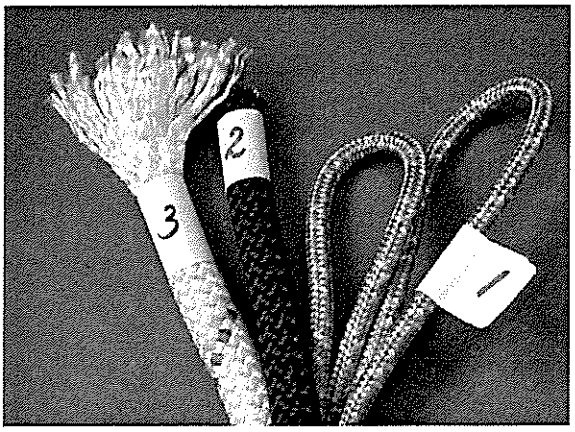


Picture 1. Material sample 1 from Revinge.

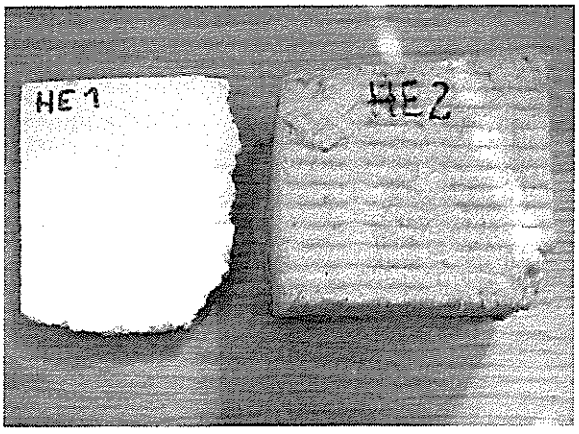


Picture 2. Material samples 2 and 3 from Revinge.

Picture 9683167. Samples 1 and 2.



Picture 9683187. Samples 1, 2 and 3.



Picture HE samples 1 and 2.

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