ISOCYANATES

BASELINE HEALTH MONITORING BEFORE STARTING WORK IN AN ISOCYANATE PROCESS

Note: People with a history of asthma, atopic conditions, hay fever, recurrent acute bronchitis, interstitial pulmonary fibrosis, pulmonary tuberculosis, occupational chest disease or impaired lung function are at greater risk of adverse health effects and should be warned against risk of exposure to isocyanates. Current evidence suggests a history of atopy or asthma does not preclude working with isocyanates. However, exposure to isocyanates is likely to cause respiratory irritation and may aggravate pre-existing asthma.

1. **Collection of demographic data**
2. **Work history**
3. **Medical history**

Administration of a standardised respiratory questionnaire. Two examples are the International Union Against Tuberculosis' *Bronchial Symptoms Questionnaire 1986* [1] **or** the Medical Research Council's *Questionnaire on Respiratory Symptoms 1986* [2].

4. **Physical examination**

A physical examination will be conducted, with emphasis on the respiratory system and skin.

5. **Investigation**

Standardised respiratory function tests* will be performed. The tests are FEV_1[1], FVC[2] and FEV_1/FVC[3]. The normal ranges for predicted values should be stated. A physical examination for work-related dermatitis should also be performed.

DURING EXPOSURE TO AN ISOCYANATE PROCESS

6. **Medical examination**

A medical examination should be performed at six weeks and then at six monthly intervals during continued exposure. Where monitoring after 12 months shows no adverse health effects the medical practitioner may choose to carry out annual monitoring. The medical examination will include:

- physical examination for work-related dermatitis
- standardised respiratory function tests.

There is no existing evidence pre- and post-shift changes in lung function are either sensitive or specific for the validation or exclusion of work-related asthma [3].

Note: the United Kingdom Health and Safety Executive (HSE) provides guidance for working with isocyanate paints in motor vehicle repair. For spray painters who are new workers, lung-function testing and a questionnaire are recommended at the beginning of work, after six weeks, twelve weeks and then yearly [4]. Also, skin checks for dermatitis should be conducted. Biological monitoring is recommended at least yearly and for new workers during the first few months as well as a check on control measures and working practices.

* Spirometry equipment should be calibrated regularly according to a standard protocol.

1 Forced expiratory volume in one second

2 Forced vital capacity

3 Tiffeneau index

7. Assessing exposure to isocyanates

The registered medical practitioner may choose to assess isocyanate exposure by a urinary isocyanate metabolite level test. The urine sample should be taken following the isocyanate task.

Where urine analysis is performed, the following values should be used as a guide for assessing exposure to PAH:

Biological Level	Source
1 µmol of isocyanate-derived diamine/mol creatinine in urine	NSW Workcover Biological Occupational Exposure Limit
10 µg methylenediamine (MDA)/L (~4 µmol MDA/mol creatinine) in urine	German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area Biologischer Leit-Wert (BLW) value

Note: The absorbed isocyanates are metabolised and excreted in urine as the corresponding diamine and conjugates. The half-lives are usually short (two to four hours) so samples only reflect recent exposure.

AT TERMINATION OF WORK IN AN ISOCYANATE PROCESS

8. Final medical examination

A final medical examination will be conducted and will include:

- physical examination for work-related dermatitis
- standardised respiratory function tests.

9. Health advice

Workers sensitised to isocyanates should be strongly advised against further exposure.

SUPPLEMENTARY INFORMATION ON ISOCYANATES

10. Work activities that may represent a high risk exposure

Isocyanates are compounds containing one or more -N=C=O groups which can combine with other compounds containing alcohol groups. The largest volume use of isocyanates is in the production of polyurethane foams.

Examples of work activities involving isocyanates which require special attention when assessing exposure include:

- all stages of manufacture and use where free isocyanates are released as vapours, aerosols and mists
- spray painting, using two-pack paints with an isocyanate hardener, like in vehicle paints
- processes where heat decomposition of polyurethane products occurs, like welding, heat removal of electrical insulating varnishes and hot wire cutting of foam.

Special attention should also be given to acute exposures that may occur in the above processes.

POTENTIAL HEALTH EFFECTS FOLLOWING EXPOSURE TO ISOCYANATES

11. Route of entry into the body

The primary route of isocyanate entry into the body is through inhalation.

The most commonly used diisocyanates are toluene diisocyanate (TDI), methylene diphenyl diisocyanate (MDI) and hexamethylene diisocyanate (HDI). The risk of exposure depends on the volatility of the compound and the application process. The most volatile of the isocyanates are those with low molecular weight like HDI and TDI used in spray painting and polyurethane foam manufacturing. More recently isocyanates like HDI have been partially polymerised into the form of pre-polymers so they are less volatile, however, the spray painting process creates a mist of easily inhaled fine particles.

12. Target organ/effect

Respiratory tract – irritation, sensitisation with work-related asthma.

Eyes – irritation.

Skin – irritation, sensitisation.

CNS – headache, loss of consciousness, coma.

13. Acute effects

HDI and TDI and other volatile isocyanates are acute irritants of the eyes, mucous membranes, respiratory tract and skin. Isocyanate splashes in the eyes can cause severe chemical conjunctivitis.

In mild cases there may be slight irritation of the nose and throat. Headaches can also occur from inhalation of low concentrations of isocyanates. With higher exposure there may be acute bronchial irritation with coughing, shortness of breath and bronchospasm, abdominal distress, nausea and vomiting, chemical pneumonitis and pulmonary oedema. Reactive airways dysfunction syndrome (RADS) is new onset asthma which begins within hours following a single exposure to inhaled irritants at very high concentrations and continues to be symptomatic at three months or longer. Evidence is emerging that RADS can be seen as one end of a spectrum of irritant effects on the airways.

Acute dermatitis results from either massive skin contamination or a hyper-responsiveness of the skin

Oral toxicity appears to be low.

14. Chronic effects

Chronic exposure to isocyanates can cause contact dermatitis, immune sensitisation and asthma and less commonly hypersensitivity pneumonitis.

Diisocyanates appear to be weak human skin irritants and sensitisers. 4,4'-diisocyanate dicyclohexyl methane is an exception, being a potent skin sensitiser. Sensitisation of the skin is not common and if this occurs it is usually due to inadequate work hygiene giving rise to extensive skin contamination with diisocyanates, solvents and additives. Sensitised people react with symptoms of skin irritation like blistering and swelling.

There is growing evidence skin exposure can induce isocyanate respiratory sensitisation although this is still under debate. Skin exposure may be especially important with less volatile diisocyanates like polyisocyanates and MDI where skin exposure may be the main route of exposure [5].

The estimated prevalence of work-related asthma in the isocyanate exposed workforce has most commonly been reported in the range five to 10 per cent. There is no evidence atopy influences susceptibility. Smoking has been identified as increasing the risk of work-related asthma in workers exposed to isocyanates.

Spray painters using two-pack polyurethane paints are the group at highest risk. The repair and refinishing of cars entails the sprayed on application of isocyanate-containing coatings on almost every vehicle. There is a latent (sensitising) period of exposure to isocyanates that is highly variable: from several weeks, often less than two years but in 20 per cent of cases, 10 years or more. Exposure to higher concentrations from spills may increase the risk of sensitisation. Once sensitisation has occurred, then subsequent exposure to airborne concentrations well below the exposure standard can cause asthmatic reactions like chest tightness, wheezing and shortness of breath, and increases in the background level of airway responsiveness. Exposure of sensitised workers may initiate reduction in respiratory capacity immediately on exposure, some hours later or both. Some workers become extremely sensitive to isocyanates and the high likelihood of chronicity of work-related asthma (depends on duration of symptoms prior to cessation of exposure) places a high priority on primary prevention of sensitisation.

A rare consequence of chronic isocyanate exposure is hypersensitivity pneumonitis, a granulomatous inflammatory reaction in terminal airways, alveoli and surrounding interstitium. Symptoms are dyspnoea, malaise and fever occurring several hours after work with isocyanates. Diagnosis is confirmed by restrictive ventilatory patterns, reticular or nodular lung patterns on chest X-ray.

Other health effects may include liver and kidney dysfunction. Interstitial pulmonary fibrosis has been reported as a long-term hazard.

Adverse health effects resulting from exposure to isocyanates normally arise during the ordinary working period, soon after contact occurs. Occasionally, as with hypersensitivity pneumonitis, symptoms may not appear for several hours following exposure. Because of this, symptoms are often not correlated with workplace exposure. It is important workers are informed of the potential for the delayed onset of adverse health effects and they should report adverse health effects which they think may be related to isocyanate exposure so the root-cause can be investigated.

15. Carcinogenicity

The International Agency for Research on Cancer concluded there is sufficient evidence TDI is carcinogenic in experimental animals and there is limited evidence for a carcinogenic effect of MDI in animals. Increased incidence of lung tumours in rats resulted from inhalation of a mixture of monomeric and polymeric 4,4'-MDI. Inhalation of freshly generated polyurethane dust has been reported to generate lung tumours in rats [6].

16. Carcinogen classifications[4]

The following isocyanates are classified according to the GHS as Carcinogenicity Category 2 (Suspected of causing cancer):

- 4,4'-Methylene diphenyl diisocyanate
- 2,2'-Methylene diphenyl diisocyanate
- *o*-(*p*-Isocyanatobenzyl)phenyl isocyanate

4 This classification information is provided on an advisory basis and is taken from the European Union's Annex VI to Regulation (EC) No 1272/2008, updated by the 1st Adaption to Technical Progress to the Regulation. Other hazard classes and categories may apply – see http://esis.jrc.ec.europa.eu/index.php?PGM=cla. These classifications are legally binding within the European Union.

- Methylene diphenyl diisocyanate (MDI)
- Toluene-2,4-diisocyanate
- Toluene-2,6-diisocyanate
- Toluene diisocyanate (TDI).

REFERENCED DOCUMENTS

1. Respiratory Disease Committee of the International Union Against Tuberculosis, *IUAT Bronchial Symptoms Questionnaire*, International Union Against Tuberculosis, 1986.
2. Medical Research Council Committee on Research into Chronic Bronchitis, *MRC Questionnaire on Respiratory Symptoms*, Medical Research Council, 1986.
3. BOHRF, *Occupational Asthma: Evidence Review*, British Occupational Health Research Foundation, London 2010.
4. Health and Safety Executive (UK), *Safety in Motor Vehicle Repair, Working with Isocyanate Paints*, Leaflet INDG388(rev1), Health and Safety Executive, London, Dec, 2009
5. Bello D, Woskie SR, Streicher RP, Liu Y, Stowe MH, Eisen EA, Ellenbecker MJ, Sparer J, Youngs F, Cullen MR, Redlich CA, 'Polyisocyanates in Occupational Environments: A Critical Review of Exposure Limits and Metrics', *American Journal of Industrial Medicine*, vol 46, pp 480-491, 2004.
6. Mikoczy Z, Welinder H, Tinnerberg H, Hagmar L, 'Cancer Incidence and Mortality of Isocyanate Exposed Workers from the Swedish Polyurethane Foam Industry: Updated Findings 1959-98', *Occupational and Environmental Medicine*, vol 61, pp 432-437, 2004.

FURTHER READING

Allport D, Gilbert D, Outterside S, *MDI and TDI: Safety, Health and the Environment: A Source Book and Practical Guide*, John Wiley and Sons, New York, 2003.

American Conference of Governmental Industrial Hygienists (ACGIH), *Documentation of the Threshold Limit Values for Chemical Substances*, 7th Ed, Cincinnati, 2011.

Bernstein DI, Jolly A, 'Current Diagnostic Methods for Diisocyanate Induced Occupational Asthma', *American Journal of Industrial Medicine*, vol 36, pp 459-468, 1999.

Burge S, 'Respiratory Symptoms', *Occupational Medicine*, vol 47, pp 55-56, 1997.

HSE (UK), *COSHH Essentials: General Guidance, G408, Urine sampling for isocyanate exposure measurement*, Health and Safety Executive, London.

Lauwerys RR, Hoet P, *Industrial Chemical Exposure Guidelines for Biological Monitoring*, 3rd Ed, Lewis Publishers, Boca Raton, 2001.

Occupational asthma in Australia, Australian Institute of Health and Welfare Bulletin 59, April 2008 www.aihw.gov.au

WorkCover NSW, *Chemical Analysis Branch Handbook*, 8th edition. Available at www.testsafe.com.au.

This health monitoring report is a confidential health record and must not be disclosed to another person except in accordance with the Work Health and Safety Regulations or with the consent of the worker.

There are two sections. Complete both sections and all questions if applicable.

Section 1 is to be forwarded to the PCBU who has engaged your services. A copy of laboratory report(s) must be attached > > > >

Section 2 may contain confidential information which may not be relevant to the health monitoring program being carried out. This section should be retained by the medical practitioner. Information which is required to be given to the PCBU should be summarised in part 7 of section 1.

SECTION 1 – THIS SECTION TO BE RETURNED TO THE PCBU			
1. PERSON CONDUCTING A BUSINESS OR UNDERTAKING			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
2. OTHER BUSINESSES OR UNDERTAKINGS ENGAGING THE WORKER			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
3. WORKER		(✓) all relevant boxes	
Surname:		Given names:	
Date of birth: DD/MM/YYYY		Sex: ☐Male	☐ Female
Address:			
Suburb:			Postcode:
Current Job:	Tel(H):		Mob:
Date started employment : DD/MM/YYYY			
4. EMPLOYMENT IN ISOCYANATE RISK WORK		(✓) all relevant boxes	
1. ☐ New to isocyanate work			
2. ☐ New worker but not new to isocyanate work			
3. ☐ Current worker continuing in isocyanate work			
4. Worked with isocyanate since DD/MM/YYYY			
5. Satisfactory personal hygiene (for example nail biting, frequency of hand washing)		☐ Yes	☐ No
6. Risk assessment completed		☐ Yes	☐ No

5. WORK ENVIRONMENT ASSESSMENT	(✓) all relevant boxes		
Date of assessment: DD/MM/YYYY			
Isocyanate Industry			
☐ Isocyanate Manufacture	**Controls:**		
☐ Foam Manufacture	Eye protection	☐ Yes	☐ No
☐ Spray Painting	Wear gloves	☐ Yes	☐ No
☐ Welding/Fabrication	Respirator use	☐ Yes	☐ No
☐ Automotive Industry	Local exhaust ventilation	☐ Yes	☐ No
☐ Furniture Industry	Overalls / work clothing	☐ Yes	☐ No
☐ Flooring Industry	Laundering by employer	☐ Yes	☐ No
☐ Other (specify):	Wash basins & showers (with hot & cold water)	☐ Yes	☐ No
	Smoking or eating in workshop	☐ Yes	☐ No
	Personal hygiene:		
	Clean Shaven	☐ Yes	☐ No
	Clean hands with thinners	☐ Yes	☐ No
	Shower & change into clean clothes at end of shift	☐ Yes	☐ No

6. BIOLOGICAL MONITORING RESULTS Include at least the previous two test results (if available)		
Date	**Tests performed**	**Recommended Action and/or Comment**
1. DD/MM/YYYY	Spirometry	Results: FEV_1 _____; FVC_____; FEV_1/FVC_____
2. DD/MM/YYYY		
3. DD/MM/YYYY		
4. DD/MM/YYYY		
5. DD/MM/YYYY		
6. DD/MM/YYYY		
7. DD/MM/YYYY		
8. DD/MM/YYYY		

7. RECOMMENDATIONS (by Medical Practitioner) (✓) all relevant boxes		
1. ☐ Suitable for work with isocyanates		
2. ☐ Counselling required		
3. ☐ Review workplace controls		
4. ☐ Repeat health assessment (including any tests) in _____ month(s) / ____ week(s) Specify tests to be repeated: _____		
5. ☐ Removal from work with isocyanates	On DD/MM/YYYY	
6. ☐ Medical examination by Medical Practitioner	On DD/MM/YYYY	
7. ☐ Fit to resume work with isocyanates	From DD/MM/YYYY	
8. ☐ Referred to Medical Specialist (respiratory/dermatology/other):	On DD/MM/YYYY	
Specialist's name:		
Additional comments or recommendations arising from health monitoring:		

Medical Practitioner (responsible for supervising health monitoring)		
Name:	Signature	Date: DD/MM/YYYY
Tel:	Fax:	Registration Number:
Medical Practice:		
Address:		
Suburb:		Postcode:

SECTION 2 – THIS SECTION TO BE RETAINED BY THE MEDICAL PRACTITIONER			
This questionnaire also allows for recordings of a more general health assessment at the end, if applicable.			
1. PERSON CONDUCTING A BUSINESS OR UNDERTAKING			
Company / Organisation name:			
Site address:			
Suburb:		Postcode:	
Site Tel:	Site Fax:	Contact Name:	
2. OTHER BUSINESSES OR UNDERTAKINGS ENGAGING THE WORKER			
Company / Organisation name:			
Site address:			
Suburb:		Postcode:	
Site Tel:	Site Fax:	Contact Name:	
3. WORKER		(✓) all relevant boxes	
Surname:	Given names:		
Date of birth: DD/MM/YYYY	Sex:	☐ Male	☐ Female
Address:			
Suburb:		Postcode:	
Current Job:	Tel(H):	Mob:	
Date started employment : DD/MM/YYYY			

This questionnaire is based on the MRC (UK) Respiratory Questionnaire 1986, which has been extensively validated. This questionnaire is intended to be completed by an interviewer rather than by the patient. Additional questions have been added to cover clinical aspects of bronchial hyper-responsiveness validated by the Department of Occupational and Environmental Medicine, National Lung Institute[1].

The British Occupational Health Research Foundation (BOHRF)[2] concluded that in the clinical setting, questionnaires that identify symptoms of wheeze and/or shortness of breath which improve on days away from work or on holidays have a high sensitivity, but relatively low specificity for occupational asthma.

Preamble

I am going to ask some questions, mainly about your chest. I would like you to answer **yes** or **no** whenever possible.

If the subject is disabled from walking from any condition other than heart and lung disease, please begin questionnaire at **Question 5** and mark the adjacent box.

1 Venables KM, Farrer N, Sharp L, Graneek BJ, Newman Taylor AJ, 'Respiratory Symptoms Questionnaire for Asthma Epidemiology: Validity and Reproducibility', *Thorax*, vol 48, pp 214-219, 1993.

2 The British Occupational Health Research Foundation (BOHRF), *Guidelines for Prevention, Identification and Management of Occupational Asthma: Evidence Review and Recommendations*, London 2004. www.bohrf.org.uk

4. BREATHLESSNESS AND WHEEZING		
During the last month:		
1. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?	☐ Yes	☐ No
2. **If Yes to 1** - Do you get short of breath walking with other people of your age on level ground?	☐ Yes	☐ No
3. **If Yes to 2** - Do you have to stop for breath when walking at your own pace on level ground?	☐ Yes	☐ No
4. If you run, or climb stairs fast do you ever		
a. cough?	☐ Yes	☐ No
b. wheeze?	☐ Yes	☐ No
c. get tight in the chest?	☐ Yes	☐ No
5. Is your sleep ever broken		
a. by wheeze?	☐ Yes	☐ No
b. difficulty in breathing?	☐ Yes	☐ No
6. Do you ever wake up in the morning (or from your sleep if a shift worker)		
a. with wheeze?	☐ Yes	☐ No
b. difficulty with breathing?	☐ Yes	☐ No
7. Do you ever wheeze		
a. if you are in a smoky room?	☐ Yes	☐ No
b. if you are in a very dusty place?	☐ Yes	☐ No
8. **If Yes to either Q5, Q6, Q7** - Are your symptoms better		
a. at weekends (or equivalent if shift worker)?	☐ Yes	☐ No
b. when you are on holidays?	☐ Yes	☐ No
If **Yes to Question 8**, please record details of any occupational exposure to respiratory hazards e.g. isocyanates, wood dust, aluminium pot room or asbestos, in **Additional notes**.		
5. COUGH		
9. Do you usually cough first thing in the morning in winter?	☐ Yes	☐ No
10. Do you usually cough during the day/ or at night / in the winter?	☐ Yes	☐ No
11. **If Yes to Q9 or Q10** – Do you cough like this on most days for as much as three months each year?	☐ Yes	☐ No
6. PHLEGM		
12. Do you usually bring up phlegm from your chest first thing in the morning in winter?	☐ Yes	☐ No

13. Do you usually bring up any phlegm from your chest during the day / or at night / in winter?	☐ Yes	☐ No
14. **If Yes to Q12 or Q13** – Do you bring up phlegm like this on most days for as much as three months each year?	☐ Yes	☐ No
7. PERIODS OF COUGH AND PHLEGM		
15. In the past three years, have you had a period of (increased) cough and phlegm lasting for three weeks or more?	☐ Yes	☐ No
16. **If Yes to Q15** – Have you had more than one such episode?	☐ Yes	☐ No
8. CHEST ILLNESSES		
17. During the past three years, have you had any chest illness that has kept you from your usual activities for as much as a week?	☐ Yes	☐ No
18. **If Yes to Q17** – Did you bring up more phlegm than usual in any of these illnesses?	☐ Yes	☐ No
19. **If Yes to Q18** – Have you had more than one illness like this in the past three years?	☐ Yes	☐ No
9. PAST ILLNESSES		
20. Have you ever had, or been told that you have had any of the following?		
a. An injury, or operation affecting your chest?	☐ Yes	☐ No
b. Heart problems?	☐ Yes	☐ No
c. Bronchitis?	☐ Yes	☐ No
d. Pneumonia?	☐ Yes	☐ No
e. Pleurisy?	☐ Yes	☐ No
f. Asthma?	☐ Yes	☐ No
g. Other chest trouble?	☐ Yes	☐ No
h. Hay fever?	☐ Yes	☐ No
10. TOBACCO SMOKING		
21. Do you smoke?	☐ Yes	☐ No
If No to Q21		
22. Have you ever smoked as much as one cigarette a day for as long as one year?	☐ Yes	☐ No
23. How old were you when you started smoking regularly? _____		
24. a. Do (did) you smoke manufactured cigarettes?	☐ Yes	☐ No
If Yes to Q24a: How many do (did) you usually smoke per day? _____		
b. on weekdays? _____ c. at weekends? _____		

25. Do (did) you smoke any other forms of tobacco? ☐ Yes ☐ No **If Yes to Q25, record details under Additional notes**			
11. FOR EX-SMOKERS			
26. When did you give up smoking? Month _____ Year _____			
Additional notes:			
12. GENERAL HEALTH ASSESSMENT (if applicable)			
Symptoms of:	**Comments**	**Further testing?**	
Skin disorders		☐ Yes	☐ No
Headaches, dizziness		☐ Yes	☐ No
Respiratory disorders (asthma, wheezing, etc)		☐ Yes	☐ No
Irritation of eyes, nose or throat		☐ Yes	☐ No
Cough		☐ Yes	☐ No
CNS		☐ Yes	☐ No
Others		☐ Yes	☐ No
Height _____cm Weight _____kg Bp _____/___mmHg		☐ Yes	☐ No

13. OTHER MEDICAL HISTORY, FAMILY MEDICAL HISTORY, CURRENT MEDICATION, COMMENTS, TESTS OR RECOMMENDATIONS (use separate sheet if necessary)			
Medical Practitioner (responsible for supervising health monitoring)			
Name:	Signature		Date: DD/MM/YYYY
Tel:	Fax:	Registration Number:	
Medical Practice:			
Address:			
Suburb:		Postcode:	