

Allergic contact dermatitis caused by epoxy resin systems in industrial painters

OLVE RØMYHR¹, ALLAN NYFORS², HÅKON LASSE LEIRA¹ AND HANS THORE SMEDBOLD¹

¹Department of Occupational Medicine, St Olav University Hospital, 7006 Trondheim, Norway and ²Department of Occupational Medicine, Haukeland University Hospital, 5021, Bergen, Norway

A group of industrial painters employed in 6 companies of the Norwegian oil industry was followed to assess the incidence of allergic contact dermatitis (ACD) caused by exposure to epoxy resin systems. The study lasted from 1 September 1997 to 31 August 2001 and included 2236 workers, contributing 5113 person years. Commercially available patch test series were supplemented with a special study series based on known or suspected sensitizers present at the workplaces. Of 57 patch-tested workers, 23 with ACD caused by epoxy resin systems were found, indicating an incidence rate of 4.5/1000 person years. In our study patch test series, 4 workers (17%) were identified solely by patch tests to 2,4,6-tris-(dimethylaminomethyl)phenol (tris-DMP), m-xylene- α,α -diamine (XAD), and/or 2,2,4 trimethylhexamethylenediamine. Positive patch tests to tris-DMP and XAD were seen in 7 and 8 workers, respectively, indicating that the 2 chemicals are important sensitizers in industrial painters. They are, however, not classified as skin sensitizers according to the European regulations on the classification and labelling of dangerous chemicals. The results show the usefulness of including patch tests based on an investigation of known and suspected skin sensitizers present at the workplaces.

Key words: allergic contact dermatitis; epoxy resin systems; hardeners; incidence; industrial painter; occupational; m-xylene- α,α -diamine; 2,2,4 trimethylhexamethylenediamine; 2,4,6-tris(dimethylaminomethyl)phenol. © Blackwell Munksgaard, 2006.

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In the Norwegian oil industry, there are approximately 5000 industrial painters who regularly work with epoxy resin systems.

Epoxy resin based on diglycidylether of bisphenol A (DGEBA) is one of the most common causes of occupational allergic contact dermatitis (ACD). Epoxy resin is widely used in adhesives, paints, coatings, sealants, inks, materials for moulds and composites, and for encapsulation.

The annual incidence of occupational dermatosis in exposed workers in Finland due to epoxy resin systems (epoxy resins, reactive diluents, and hardeners) is estimated to be 1% (1). The prevalence of ACD caused by epoxy resin systems has been described for various groups of workers; 56% in aircraft manufacturing workers (2), 45% in marble workers (3), 29% in grouters (4), 27% in ski factory workers (5), 20% in construction workers (6), 21% in paint manufactory workers (7), and 6% in windmill factory workers (8). Some of the studies did not include patch tests with reactive diluents (2, 4, 6, 7), and others did not include patch tests with hardeners (2–4).

Exposure to paints and surface coatings is reported to be the most frequent cause (39%) of dermatoses induced by epoxy resin systems (1). Industrial painters are heavy users of epoxy-based coatings, but to our knowledge, there are no previous studies on the incidence of contact dermatitis in industrial painters.

The primary aim of this study was to assess the incidence of ACD caused by epoxy resin systems in a group of Norwegian industrial painters.

Subjects and Methods

The study population

The investigation included employees with corrosion-protective coating, blast cleaning, and fire protection as their main job in 6 companies in the Norwegian petroleum industry.

At the start of the study period, which lasted from 1 September 1997 to 31 August 2001, 1160 workers were employed in these companies. Once every month, the employers reported name, address,

and date of birth of workers who were hired or who quit working in the previous month. Workers with corrosion-protective coating, blast cleaning, and fire protection as their main job and employed for more than 2 months were included in this study.

The companies estimated that in the study period, 56% of the working time was spent on protective coating. Blast cleaning and fire protection accounted for approximately 24% and 17% of the total working time, respectively.

3 of the companies had all their activities onshore, involved with the construction of installations for oil production, mainly in the North Sea. The employees in the other 3 companies were involved both in construction work onshore and in maintenance work offshore. Onshore workers had normally 8-hr shifts and work periods of 9 days, followed by 12 days off. Offshore workers had normally a work period of 14 days, with 12-hr shifts, followed by 3, alternately 4, weeks off.

Especially during corrosion-protective coating and fire protection, the workers were exposed to epoxy resin systems and other sensitizing compounds. According to the main paint suppliers, epoxy-based paint accounted for about two third and the use of polyurethane-based paint for 10%–15% of the total paint volume used by the 6 companies in the study period. Other products included Zn-silicates and siloxane-based paints. Most of the products used for fire protection were based on epoxy resins.

Case ascertainment

Several routines were established to identify new cases of occupational ACD in the study period:

- (1) All workers employed in the companies at the start of the study period were sent a personal letter with information about the study. The workers were encouraged to contact their occupational health service (OHS), their own personal physician, or our study physician (specialist in occupational medicine) if they experienced any kind of skin problems caused by work. Workers employed later received the same information within their first 2 months of employment.
- (2) All workers who quit their job during the study period were sent a personal letter and asked if skin problems were the reason for quitting. Workers who confirmed skin problems were telephoned by our study physician and offered a dermatological examination if he, on the basis of the clinical picture and the case history, considered a occupational ACD possible.
- (3) During the first year of the study period, the employers reported monthly to us about all workers on sick leave for more than 2 weeks. At the start of the study, the workers had been asked to give us a written consent to let our study physician consult their doctor in case of a sick leave. If the doctor confirmed that the sick leave was caused by a skin problem, the worker was offered a dermatological examination.
- (4) In 1998, letters were sent to all dermatologists/dermatological clinics in the parts of Norway where the workers lived. We asked whether the dermatologists had diagnosed cases of ADC caused by epoxy resin products in industrial painters during the previous 2 years.

Dermatological examination

The workers underwent both physical and dermatological examinations. Of the 23 workers with ACD, 15 were examined by a professor of dermatology, 2 by a consultant in dermatology, and 6 by registrars in the section of dermatology led by the professor.

As part of the dermatological examination, the workers were interviewed about their work history and, in particular, about their skin exposure to epoxy resin systems, the use of protective equipments, symptoms of dermatitis, and time since their first exposure to epoxy resin systems.

The workers were patch tested with:

- European standard series (TRUE-test; Pharmacia, DK-3400, Hillerød, Denmark) including DGEBA.
- Epoxy series (E-1000; Chemotechnique Diagnostic AB, Malmö, Sweden) including hexamethylenetetramine, diaminodiphenylmethane, triethylenetetramine, phenylglycidylether, diethylenetriamine, isophorondiamine, cycloaliphatic epoxy resin, and ethylenediamine dihydrochloride. From May 1999, this series was supplemented with 3-dimethylaminopropylamine.
- Isocyanate series (I-1000; Chemotechnique Diagnostic AB) including toluenediisocyanate, diphenylmethane-4,4-diisocyanate, diaminodiphenylmethane, isophoronediiisocyanate, isophoronediamine, and 1,6-hexamethylene-diisocyanate.

The epoxy resin systems used by the companies during the study period included more than 200

trade names. To reduce the number of false-negative patch tests, the Material Safety Data Sheets of approximately 100 of the most used epoxy-based protective coatings were examined to identify epoxy compounds and hardeners not included in the 2 commercial patch test series. 9 known or suspected sensitizing epoxy compounds or hardeners were identified and included in a study patch test series in the following concentrations (% in petrolatum):

- DGEBA/F: 1.0*
- diglycidyl ether of bisphenol F (DGEBF): 1.0*
- chresylglysidylether (26447-14-3): 0.25
- glycidylether of C13-15 alcohols: 0.25*
- tetraethylene pentamine (112-57-2): 1.0
- 2,4,6 tris-(dimethylaminomethyl)phenol (tris-DMP (90-72-2): 1.0
- m-xylene- α,α -diamine (XAD) (1477-55-0): 1.0
- 2,2,4 trimethylhexamethylenediamine (2,2,4 TMD) (25620-58-0): 1.0
- n-aminoethylpiperazine: 0.25*.

4 patch tests (indicated by *) were based on raw materials from a paint supplier. The rest of the patch tests were based on chemicals provided and prepared by Chemotechnique Diagnostic AB. At first, patch tests, concentrations were based on recommendations in the literature (1) and second, on recommendations from R. Jolanki (personal communications).

The patch tests were applied on the upper back according to guidelines of the International Contact Dermatitis Research Group (9) and read after 3 days. The patients were given a diagnosis of allergic dermatitis if the patch test showed a 3-plus reaction comprising erythema, oedema, and vesicles.

Case definition

A new case of occupational ACD caused by epoxy resin systems had to fulfil the following requirements:

- (1) No diagnosis of ACD caused by epoxy resin systems prior to the study period.
- (2) Remitted for dermatological examination in the study period.
- (3) A positive patch test to DGEBA epoxy resin in the TRUE-test or to any of the compounds included in 1 of the 2 other series (E-1000 and the study series).

Results

Study population

A total of 2336 workers were included in the study population during the 4-year study period,

contributing a total of 5113 person years. There were 50 women in the study, contributing 88 person years (1.7% of the total person years).

The mean age of the 1160 workers employed at the start of the study period was 37.3 years. At the end of the study period, the mean age of the 1075 workers was 40.3 years.

Some of the workers ($n = 228$) contributed to the number of person years in more than 1 employment period; 192 workers had 2 employment periods and 30 had 3 employment periods for different study companies within the study period. A number of employment periods were of short duration; 25% lasted for less than 9 months and 50% for less than 27 months.

Within the study period, 1512 employment periods ended and 1427 employment periods started.

We do not have the complete work history for all workers prior to the study period. In a questionnaire, we asked 1199 workers (all workers in the study group in February 1998) about their work history and 849 of them (72%) responded. They had worked as industrial painters for 11 years (mean) by that time. For the remaining workers, we only have data on their employment period within the study companies.

Case ascertainment

The OHS of the companies remitted 41 workers with suspected occupational ACD and 8 were remitted from other medical doctors.

A personal letter was sent to the 1500 workers who finished an employment period in 1 of the study companies. The letter was not sent to 12 workers who had quit working for 1 company but had already started to work for another study company before the end of the month. We received answers from 605 workers (40%). Of the non-responders, 11 workers were dead, 99 workers had restarted work in another study company, and 106 letters were returned because of unknown address. Of the responders, 65 workers confirmed that skin problems were the reason for quitting. They were telephoned by the study physician, and in 20 of them, occupational ACD was considered possible on the basis of the clinical picture and the case history. These 20 workers were offered a dermatological examination. Of the other 45 workers, 12 had an ADC caused by epoxy resin systems confirmed prior to the start of the study and 33 had skin problems not suspected of being occupational ACD.

In the first year of the study, the employers reported 252 workers on sick leave for more than 2 weeks. Of these workers, 128 had previously given their written consent, for us to contact their

doctor in case of a sick leave. In 90 of the 128 cases, we succeeded in contacting the doctor. 2 of these workers had ACD caused by epoxy resin systems, verified by patch test before the study period, and 1 had dermatitis but with a negative patch test to DGEBA epoxy resin (not included in the study as he refused to have more patch tests done). For the remaining 87 workers, the sick leaves were not caused by skin problems at work. Due to lack of case ascertainment, this method was discontinued after the first year.

We received 19 answers (65%) to the letters sent to 29 dermatologists/dermatological clinics in the part of Norway where the workers lived. 1 industrial painter with ACD caused by epoxy had been diagnosed but not with a work history in 1 of the companies in the study group.

In total, our routines identified 69 workers with suspected occupational ACD in the study population.

Dermatological examination

Of the 69 workers identified, 12 could not be contacted or did not want to participate, leaving 57 for the dermatological examination (Table 1).

There were 23 cases, among them 1 woman, with allergic reactions to epoxy resin systems (incidence rate 4.5/1000 person years). The most frequent positive patch test was to the DGEBA resin in the European standard patch test (TRUE-test), which was able to identify 74% (17 workers) of the cases. The E-1000 series identified 1 additional case, and our study patch test series identified 4 additional cases (17%). These 4 workers had a positive patch test to tris-DMP, XAD, and/or 2,2,4 TMD. The study patch test was used in 20 of the 23 workers with ACD caused by epoxy resin systems.

5 of the 23 workers with occupational ACD caused by epoxy resin systems (22%) developed their symptoms less than 1 year after their first exposure. We have no information as to the duration of dermatitis, but most workers had experi-

enced work-related symptoms on and off for years. The ACD to epoxy resin systems in the 23 workers started as follows: on hands, with spread to face in 8 workers; in face, with spread to hands in 6; in face only in 3; both on hands and face in 2; on feet in 2; and widespread in 3.

Discussion

The incidence rate of ADC caused by epoxy resin systems in this study (4.5/1000 person years) should be regarded as a minimum.

The workers had been employed as industrial painters for an average of approximately 10 years at the start of the study. Previous studies indicate that approximately half of the cases of ACD caused by epoxy resin systems develop within the first year of exposure (10). Sensitization to epoxy resin has been described even after 1 single accidental exposure (11). Workers who develop ACD will tend to leave the industry for non-exposed employment. Thus, our study population must be considered heavily selected.

Although we developed several routines to identify incident cases of ACD, we cannot guarantee that all relevant cases were found. Most workers lived far from the OHS of their companies and might have had difficulties in seeing their OHS for proper examination. The contracts of the companies on construction or maintenance work on the oil installations were often of limited duration, and workers often changed jobs between the companies in the industry. It was therefore difficult for the OHS to follow their workers over time, and their routines would probably not identify all workers who developed symptoms of ACD. Our supplementary routines identified 28 (41%) of the 69 workers with suspected occupational ACD. In Norway, workers who have to leave their work because of occupational disease are entitled to compensation of costs and anticipated loss of future income. In such cases, it is likely that affected workers would want a confirmation of the diagnosis. We believe that our personal contact with the workers who quit their job has identified most of the workers with suspected occupational ACD.

Our incidence rate in industrial painters is approximately half of the estimate based on registered cases of ACD caused by epoxy resin systems in Finland (1).

High prevalence figures of ACD caused by epoxy resin systems have been published in several studies from different industries and groups of workers (2–8, 12, 13). Data on incidence rates of ADC caused by epoxy resin systems are scarce. A study in 8 factories employing 422 workers (type

Table 1. Diagnosis of 57 examined workers

Diagnosis	Number of workers
Occupational ACD caused by epoxy resin systems	23
Occupational ACD caused by isocyanate compounds	1
Occupational contact dermatitis with negative patch tests to epoxy	24
ACD not related to work	2
Other skin disease not related to work	7

ACD, allergic contact dermatitis.

of production not specified) reported 65 cases of ACD caused by epoxy resin systems in a 7-year period (14). In a study in a ski-stick factory employing 221 workers who handled epoxy resin systems on a daily basis, 7 cases of ACD caused by epoxy resin systems were reported to the insurance company of the factory over a 3-year period (15). In a study in 2 factories for the manufacture of thermosetting coating paints, 5 cases of ACD caused by epoxy resin systems were reported within the first 12 months after the introduction of epoxy powder paints (16). Our study design is different from the design in these studies, so the incidence rate in our study of industrial painters is not directly comparable.

4 workers were only identified by positive tests to compounds in the patch test series developed especially for this study. In a recent study in windmill workers, 43% of the 60 workers with positive patch test to epoxy compounds or hardeners reacted to compounds in a specially profiled occupational patch test series and not to the epoxy resin in the European Standard patch test series (8). This finding underlines the importance of including patch tests based on known and suspected skin sensitizers present at the workplaces.

The 4 workers who were identified solely by our study patch test series reacted to tris-DMP, XAD, and/or 2,2,4 TMD. Positive patch tests to tris-DMP and XAD were seen in 7 and 8 workers, respectively (40% of the 20 tested workers), indicating that the 2 chemicals are important sensitizers in industrial painters. None of these 3 compounds is classified as skin sensitizers according to the European regulations on the classification and labelling of dangerous chemicals (17), although allergy to these amines has been described in several previous studies (18–22).

Conclusions

The study shows that industrial painters in the Norwegian petroleum industry have a considerable risk of developing ACD caused by exposure to epoxy resin systems. The incidence rate of 4.5/1000 person years must be regarded as a minimum. Of the 23 cases, 17% would not have been found if only the European standard series and the commercially available epoxy patch test series had been used to examine the workers. The results show the usefulness of including patch tests based on an investigation of known and suspected skin sensitizers present at the workplaces. Skin contact with epoxy coatings should be avoided by all relevant protective measures, including individual protective devices.

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Address:
Håkon Lasse Leira, MD
Department of Occupational Medicine
St Olav University Hospital
7006 Trondheim
Norway
Tel: +47 73 86 75 15
Fax: +47 73 86 89 70
e-mail: hakon.lasse.leira@stolav.no