

Patch testing with metalworking fluids from the patient's workplace

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In view of the wide variety of components currently used in metalworking fluids (MWF), relevant contact sensitizations may be overlooked, because commercially available MWF test series cannot cover the full spectrum. Hence, patch testing with MWF from the patient's workplace is an important additional diagnostic tool. However, recommendations on how to perform such patch tests vary. We retrospectively analyzed patch test data of the Department of Dermatology in Dortmund, 1992–2003. In 141 metalworkers tested because of suspected occupational contact dermatitis due to MWF, 829 patch tests with 306 samples of MWF were performed. Water-based MWF (wb MWF) were mainly tested in 2 dilution series, i.e. pure (workplace concentration), 10% aq. and 1% aq., and pure, 50% aq. and 10% aq. Positive reactions to wb MWF occurred in 27 patients. Patch testing with wb MWF at workplace concentration resulted in 16.1% (39/242) positive reactions, with a positivity ratio of 69% and a reaction index of 0. From the analysis of reaction patterns and concomitant reactions, we conclude that most of these positive reactions indicated true contact allergy. With lower concentrations, relevant allergic reactions may be missed. Neat oils were tested as is or diluted from 1 to 50% in olive oil, but no reactions at all were observed. For optimum benefit of patch testing with MWF from the patient's workplace, breakdown testing is recommended. To overcome the time-consuming difficulties associated with this procedure, we propose a centre for information and documentation of contact allergies due to occupational exposure. Furthermore, full declaration of MWF ingredients is desirable.

Key words: contact allergy; metalworking fluids; occupational contact dermatitis; patch testing.
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Metalworking fluids (MWF) are used in metal processing for cooling and lubricating purposes, for corrosion inhibition and for flushing away of metal chips. 2 groups of MWF can be distinguished: water-based MWF (wb MWF) are prepared at the metalworking company by aqueous dilution of a concentrate delivered by the lubricant producer, and neat oils which are non-water-miscible oily preparations used as obtained from the manufacturer. The composition of MWF, particularly of wb MWF, is complex: the main components are usually mineral oils or (semi) synthetic hydrocarbon compounds, to which – according to the respective needs – emulsifiers, stabilizers, buffers, surfactants, tensides, antifog additives, foam inhibitors, lubricants, rust preventives, extreme-pressure additives and biocides (bactericides and fungicides) are added (1–6). In the comments on the German occupational exposure threshold limit values ('MAK-Werte') pub-

lished in 2000, more than 200 components used in MWF are listed (3). Biocides other than those contained in the original MWF may be added during the working process, and slideway oils or hydraulic oils from the processing machines may be introduced into the MWF by leakage (1, 4–7).

MWF may cause occupational skin disease, with irritant contact dermatitis being observed more frequently than allergic contact dermatitis (8–15). Against the above-mentioned background, it seems evident that, in spite of patch testing with MWF test series containing currently used ingredients, relevant contact allergies may be overlooked, because these test series cannot cover every possible MWF component (7, 16). Hence, patch testing with MWF from the patient's workplace is an important additional diagnostic tool in patients with suspected MWF dermatitis, as reported in several studies on occupational dermatitis in metalworkers (10, 12, 13, 17).

However, in these studies, as in published recommendations for patch testing with MWF, test concentrations and vehicles have varied (Table 1). In Dortmund, patch tests with MWF from the patient's workplace have been performed for years according to the recommendations published in 1997 (18). In 2001, after discussions in the working party on allergy diagnostics in the metal branch, the scheme for testing wb MWF was modified to: pure (as is), 50% aq. and 10% aq. In this article, we present a retrospective analysis of patch test results obtained with these MWF concentrations.

Patients and Methods

During the years 1992–2003, 5123 patients altogether were patch tested in the Department of Dermatology of the Municipal Hospital Dortmund (Klinikum Dortmund) which, at the same time, is the Department of Dermatology of the University of Witten Herdecke, Germany. Of these patients, 268 were metalworkers tested because of suspected occupational contact dermatitis. 1 or more samples of MWF from the workplace were patch tested in 141 of these patients (52.6%) who were therefore selected as study group. In the remaining 127 patients, no MWF samples could be obtained or other occupational exposures were suspected as allergen source. Of the study group, 134 patients (95.0%) were men. Age ranged from 18 to 60 years (mean 39.3 ± 11.0

years; median 39 years). 28 patients (19.9%) had past or present atopic dermatitis.

Patch tests were applied for 2 days and read at day 2 (D2) and day 3 (D3) according to the guidelines of the ICDRG and the DKG (20, 21). In single cases, additional late readings were performed. Patch test substances were obtained from Hermal, Reinbek, Germany. Samples of MWF from the patients' workplaces were tested pure and in dilutions freshly prepared at the Allergy Unit of the Department of Dermatology.

Because the Department of Dermatology in Dortmund is a member of the Information Network of Departments of Dermatology (IVDK), patch test results and clinical data of the patients tested are stored in the central IVDK database. We performed a retrospective data analysis at the IVDK data centre using the statistical program system SAS (version 8.2, SAS Institute, Cary, NC, USA) (22). Evaluation of patch test results was based on the reactions at D3. Reaction indices (RIs) and positivity ratios (PRs) were calculated according to the original formulae (23, 24). Differences in proportions of positive reactions to fresh and used MWF samples obtained in the same patients were tested for statistical significance using the exact McNemar test. To quantify the risk of sensitization to particular allergens associated with a positive patch test to MWF from the workplace, odds ratios (ORs) with exact 95%-confidence intervals (CIs) were calculated from collapsed 2×2 contingency tables,

Table 1. Patch test concentrations and vehicles used in studies or recommended for patch testing with metalworking fluids (MWF) from the patient's workplace

MWF	Test concentration/vehicle*	Reference
Concentrate of wb MWF	10% aq.	(17)
wb MWF	as is	
Neat oil	50% o.o.	
wb MWF, fresh	as is, 50% aq., 10% aq.	(10)
wb MWF, used	as is	
Neat oil	as is, 50% o.o.	
wb MWF	as is, 10–50% aq.	(12)
Neat oil	as is, 10–25% MEK	
wb MWF	as is, 10% aq., 1% aq.	(18)
Neat oil	50% o.o., 10% o.o.	
Concentrate of wb MWF	1–10% pet.	(19)
wb MWF, used	as is	
Neat oil	as is, 10% pet.	
wb MWF	as is, 50% aq., 10% aq.	(6)
Neat oil	as is, 50% MEK, 10% MEK	
Concentrate of wb MWF	4% pet.	(13)
wb MWF, used	50% aq., 25% aq.	
Neat oil, fresh	50% pet.	
Neat oil, used	30% pet., 25% pet.	

*aq., water (aqua); MEK, methyl ethyl ketone; o.o., olive oil; pet., petrolatum.

cross-tabulating positive/non-positive reactions to the allergen and to the MWF from the workplace, respectively.

Results

Altogether, 829 patch tests with 306 samples of MWF (255 wb MWF, 51 neat oils) in different concentrations were performed. A more detailed listing of these tests is given in Table 2. Of the 255 wb MWF samples, 238 (93.3%) were tested in dilution series of 3 concentrations, namely from 1992 to June 2001 pure (as is = 100%), 10% aq. and 1% aq. in 185 patients (77.7%), and from June 2001 onwards pure, 50% aq. and 10% aq. in 50 patients (21.0%). Other combinations were tested in 3 patients (1.3%) only. All these concentrations are relative to the workplace concentration, i.e. the ready-diluted wb MWF (not the concentrate). The remaining 17 samples of wb MWF (6.7%) were tested in 2 concentrations ($n=14$) or 4–5 concentrations ($n=3$), including testing at workplace concentration in 6 of these cases. Workplace concentrations of the wb MWF, i.e. the dilution of the concentrate in water, were given for 113 samples (44.3% of 255). While ranging from 2 to 10%, the most common concentrations were 6% (59 samples = 52.2% of 113), 5% (24 samples = 21.2%) and 2% (14 samples = 12.4%). Neat oils were mainly tested in 1 concentration only (37 of 51 samples = 72.5%). 9 neat oil samples were tested in 3 concentrations and 5 in 2 concentrations. Test concentrations, related to the pure neat oil, ranged from 100% (9 patch tests) to 1% in olive oil (7 tests). However, most of these tests were performed with 10% neat oil in olive oil (44 tests = 59.5% of the 74 neat oils tests) and with 50% neat oil in olive oil (12 tests = 16.2%).

Table 2. Number of patients and MWF (metalworking fluids) samples tested, and of patch tests performed

	Patients	Samples	Tests
water-based metalworking fluids			
Fresh	52	68	196
Used	68	88	263
Not stated	72	99	296
Total	134*	255	755
Neat oils			
Fresh	2	2	6
Used	5	5	12
Not stated	28	44	56
Total	32*	51	74

*The total number of patients does not correspond to the sum of the column because, in several patients, samples of fresh as well as used MWF were tested.

Positive reactions to samples of MWF from the workplace occurred in 27 patients (19.1% of the study group). Table 3 gives an overview of the test reactions to differently concentrated wb MWF samples. With wb MWF at workplace concentration, 16.1% positive reactions (39/242) were seen at D3, with a PR of 69% (27/39). The RI was about 0. Of the 39 positive reactions, 26 had a crescendo pattern from D2 to D3, 12 a plateau pattern and 1 reaction was decrescendo. The pattern distribution of the 40 erythematous or irritant reactions at D3 was: 21 crescendo, 15 plateau and 4 decrescendo. Of the 163 reactions negative at D3, 156 were also negative at D2, and 7 were erythematous at D2. On testing wb MWF 50% aq., 12.5% (7/56) positive reactions occurred, with a PR of 71% and a RI of 0. Patch testing with wb MWF 10% aq. resulted in 8.0% weak-positive reactions (20/251). Hence, the PR was 100%. The RI was -0.1. Finally, only 2.5% positive reactions (5/200), resulted from patch testing wb MWF at 1% aq., and all of the 5 positive reactions were + only (PR = 100%). The RI was -0.4. In general, reactions to fresh and used wb MWF, respectively, differed only slightly. Hence, this data is not presented in detail here. Instead, we focused on the comparison of those tests where the same wb MWF was tested as fresh and as used sample in the same patient (see below).

Reaction patterns of tests with the 3 concentrations 'as is, 10% aq. and 1% aq.' and 'as is, 50% aq. and 10% aq.', respectively, are shown in Table 4. In the first dilution series, 123 tests remained negative with all 3 test concentrations. There were 44 concordant reactions to 10% aq. and 1% aq., which is a proportion of 71.0% of the remaining 62 non-negative reactions. In contrast, there were only 15 concordant reactions to the wb MWF as is and the 10% aq. dilution (24.2% of 62). Of the 29 positive reactions to the wb MWF as is, only 2 would have been detected with the 1% aq. dilution and 12 with 10% aq. In the second dilution series, 11 concordant reactions to 50% aq. and 10% aq. were observed, which is 36.7% of those 30 reactions which were not negative with all test concentrations. Concordant reactions to the pure wb MWF and the 50% aq. dilution occurred in 7 cases (23.3% of 30) and to the pure wb MWF and the 10% aq. dilution in 6 cases (20.0% of 30). 4 of the 9 positive tests to the wb MWF at workplace concentration also were positive to the 10% dilution and so were 6 of the tests with the 50% aq. dilution.

In 43 patients, 51 samples of the same wb MWF were patch tested in duplicate, namely fresh and used, at different test concentrations (144 patch tests). Mostly, wb MWF as is (43

Table 3. Reactions at D3 to 255 samples of wb MWF (water-based metalworking fluids) tested at different concentrations. (Not every sample was tested at each concentration listed.)

Test concentration	Pure (242 samples)		50% (56 samples)		10% (251 samples)		1% (200 samples)	
	Count	%	Count	%	Count	%	Count	%
Negative	163	67.4	42	75.0	206	82.1	184	92.0
?	27	11.2	7	12.5	23	9.2	10	5.0
Irritant	13	5.4			2	0.8	1	0.5
+	27	11.2	5	8.9	20	8.0	5	2.5
++	8	3.3	2	3.6				
+++	4	1.7						
total	242	100.0	56	100.0	251	100.0	200	100.0

samples tested in duplicate) and a 10% aq. dilution (50 samples) was tested. The results obtained with wb MWF as is are listed in Table 5. In all, 12 patients reacted positively to the used wb MWF, and of these, 6 patients also reacted to the fresh sample. Of the remaining 6 patients with positive reactions to the used wb MWF sample, 4 had an erythematous and 1 an irritant reaction to the fresh

sample, while 1 patient did not react at all to the fresh wb MWF. Vice versa, no positive reactions to the fresh wb MWF without reaction to the used sample occurred. The difference in positive vs. non-positive reactions to the 2 groups of pure MWF samples was statistically significant (exact McNemar test; $P = 0.03$). With those 50 wb MWF samples tested in 10% aq. dilution, the following

Table 4. Reaction patterns in patch tests with the same samples of wb MWF (water-based metalworking fluids) tested at different concentrations

Test concentrations: pure (100%), 10% aqueous and 1% aqueous (185 samples): reaction to ...				
Pure (100%)	10% aqueous	1% aqueous	Count	%
+++	+	+	1	0.5
+++	?	?	1	0.5
++	+	?	1	0.5
++	+	negative	3	1.6
++	negative	negative	3	1.6
+	+	+	3	1.6
+	+	negative	4	2.2
+	?	?	3	1.6
+	?	negative	4	2.2
+	negative	negative	6	3.2
?	?	?	2	1.1
?	?	negative	4	2.2
?	negative	negative	15	8.1
Negative	?	?	1	0.5
Negative	?	negative	1	0.5
Negative	negative	negative	123	66.5
Irritant	irritant	Irritant	1	0.5
Irritant	?	?	1	0.5
Irritant	irritant	negative	1	0.5
Irritant	negative	negative	7	3.8
		total	185	100.0
Test concentrations: pure (100%), 50% aqueous and 10% aqueous (50 samples): reaction to ...				
Pure (100%)	50% aqueous	10% aqueous	Count	%
+++	++	+	2	4.0
+	+	+	1	2.0
+	+	?	1	2.0
+	?	+	1	2.0
+	+	negative	2	4.0
+	?	?	1	2.0
+	negative	negative	1	2.0
?	?	+	1	2.0
?	?	?	2	4.0
?	negative	negative	3	6.0
Negative	?	negative	2	4.0
Negative	negative	negative	30	60.0
Irritant	negative	negative	3	6.0
		total	50	100.0

Table 5. Patch test results with fresh and used samples of the same wb MWF (water-based metalworking fluids) in the same patients. Test concentration: pure (100%).

	Negative	?	Fresh Irritant	sample +	+++	Total
Used sample						
Negative	22	1	1			24
?	2	1				3
Irritant	2	1	1			4
+	1	4		4	1	10
++			1	1		2
Total	27	7	3	5	1	43

dichotomized results were obtained (fresh/used sample; – = negative, doubtful or irritant reaction; + = positive reaction): in 41 patients –/– and in 3 patients each –/+, +/- and +/+.

All patch tests with neat oil samples remained negative at all readings.

Proportions of positive patch test reactions to MWF-related allergens in the 2 subgroups with ($n = 27$) and without ($n = 114$) positive reactions to wb MWF from the workplace, are presented in Table 6. Additionally, the relative risk of sensitization to the respective allergen for those patients reacting positively to wb MWF from their workplaces, expressed as OR with exact 95%-CI, is shown. Only those allergens are listed which elicited positive reactions in at least 3 patients, i.e. 2% of the study group. Patients with positive reaction to wb MWF from the workplace had a significantly increased risk of sensitization to diethanolamine (DEA) (OR = 18.1), abietic acid (OR = 13.0), fragrance mix (OR = 6.6) and monoethanolamine (MEA) (OR = 3.7). However, one has to be aware that the 95%-CIs are huge, particularly for DEA and abietic acid, due to the small number of patients with a positive reaction. All other differences in reaction frequencies between the 2 subgroups in Table 6 – although partly conspicuous – were not significant.

Discussion

Data analyzed in this article clearly shows that the use of wb MWF as is (pure, at workplace concentration) can be recommended for patch testing metalworkers with suspected MWF dermatitis. From the observation that in patients with a positive reaction to their wb MWF, significantly more contact allergies to several well-known MWF allergens were observed than in patients who did not react to their wb MWF, we conclude that the positive reactions to wb MWF observed very probably indicate contact sensitiza-

tion in the majority of the cases and are not false-positive reactions. This is supported by the reaction pattern analysis which revealed that only 1 reaction was decrescendo while 2/3 of the positive reactions had a crescendo pattern. However, as can easily be seen from Table 3, doubtful (erythematous) and irritant reactions occur as frequently as positive reactions on patch testing with pure wb MWF, and about half of the erythematous reactions were crescendo from D2 to D3, which could mean that they were weak allergic reactions. Hence, the assessment as to whether an individual test reaction is truly allergic, or not, has to be made cautiously.

With a 50% aqueous dilution of the wb MWF, results were similar to pure wb MWF. However, only a limited number of patients have been tested this way, so this test concentration cannot be fully evaluated. In view of the encouraging results with pure wb MWF, we would not recommend testing with a 50% dilution only, instead of undiluted workplace wb MWF, though in some cases testing this dilution in addition to the pure wb MWF might be helpful.

Our findings support recent recommendations of the interdisciplinary working party on allergy diagnostics in the metal branch (5), which are reported in summarized form at the end of this article. A comparison of our results with investigations published in the 1980s is difficult because reports on these studies focused on other items, and test results with MWF from the workplace are usually not reported in detail. Clearly, we saw far less positive reactions than Alomar et al. (17), who reported positive reactions in 80% of patients tested with MWF from the workplace, but more than de Boer et al. (10), who saw only 1 of 40 patients reacting positively to his wb MWF. In the first case, this may be explained by the fact that Alomar's patients were specially selected (no details given). Additionally, the composition of MWF has changed since then, and irritant properties of MWF have certainly diminished. In the second case, the explanation may be the completely different study design: the authors performed a cross-sectional study on occupational dermatoses in 10 metalworking companies and patch tested 40 metalworkers with past or present dermatitis. Hence, it can be assumed that the indication for patch testing was not as strict as in our study, where exclusively metalworkers with suspected MWF dermatitis were selected, resulting in a higher yield of positive reactions.

No allergic reactions were seen to the neat oils tested, irrespective of test concentration. Clearly, these neat oils had only a low irritant potential. However, the number of patch tests with neat oils

Table 6. Proportions of positive patch test reactions to those metalworking fluid (MWF)-related allergens which elicited positive reactions in at least 3 patients (2%) of the total study group, and relative risk for sensitization to the respective allergen for those patients reacting positively to their MWF, compared to those who did not. Relative risk is expressed as odds ratio (OR), supplemented with the exact 95%-confidence interval (CI).

Allergen	Test concentration* (%)	Patients with positive reaction to wb MWF (<i>n</i> = 27)			Patients without positive reaction to wb MWF (<i>n</i> = 114)			OR (95%-CI)
		patients tested	<i>n</i> positive	% positive	patients tested	<i>n</i> positive	% positive	
Monoethanolamine (MEA)	2	27	7	25.9	105	9	8.6	3.7 (1.0–12.7)
Colophonium	20	26	4	15.4	107	5	4.7	3.7 (0.7–18.6)
Formaldehyde	1	26	2	7.7	107	7	6.5	1.2 (0.1–6.8)
<i>N,N'</i> -Methylene-bis-5-methyl-oxazolidine	1	27	4	14.8	107	5	4.7	3.5 (0.6–17.7)
<i>p</i> -Aminoazobenzene (PAAAB)	1	26	4	15.4	100	4	4.0	4.4 (0.7–25.0)
Myroxylon pereirae resin (MPR; balsam of Peru)	25	26	2	7.7	107	6	5.6	1.4 (0.1–8.5)
Fragrance mix	8	25	4	16.0	107	3	2.8	6.6 (1.0–47.4)
4,4-Dimethyl-1,3-oxazolidine/3,4,4-Trimethyl-1,3-oxazolidine (Bioban CS 1135 ^(B))	1	27	2	7.4	106	4	3.8	2.0 (0.2–15.1)
Methyl dibromo glutaronitrile (MDBGN)	0.3	22	1	4.5	100	4	4.0	1.1 (0.0–12.3)
Diethanolamine (DEA)	2	27	4	14.8	105	1	1.0	18.1 (1.6–898.8)
(Chloro-)Methylisothiazolinone (MCI/MI)	0.01	26	3	11.5	107	2	1.9	6.8 (0.7–84.6)
Benzylhemiformal	1	27	2	7.4	107	3	2.8	2.8 (0.2–25.3)
Abietic acid	10	27	3	11.1	105	1	1.0	13.0 (1.0–688.7)
7-Ethylbicyclooxazolidine (Bioban CS 1246 ^(B))	1	27	2	7.4	107	2	1.9	4.2 (0.3–59.7)
Coconut diethanolamide	0.5	26	3	11.5	103	0	0	not calculable
Methyl dibromo glutaronitrile/2-Phenoxyethanol (MDBGN/PE)	1	26	1	3.8	107	2	1.9	2.1 (0.0–41.6)
1,3,5-Tris(2-hydroxyethyl)-hexahydrotriazine (Grotan BK ^(B))	1	27	2	7.4	107	1	0.9	8.5 (0.4–504.8)

*Vehicle, petrolatum, except for formaldehyde and MCI/MI, which were tested in water.

was limited in our material, so no premature conclusions should be drawn. From the studies conducted by Alomar et al. (17) and Gruvberger et al. (13), it is evident that neat oils can cause allergic reactions; hence, they should be patch tested in exposed patients. In view of our results, the recommendation of the working party on allergy diagnostics in the metal branch to test neat oils at 50% in olive oil (5) should at least guarantee that false-positive or frank irritant results are unlikely (upper end of the exact 95%-CI for 0/51 test reactions: 5.7%).

Patch testing with fresh and used wb MWF from the patient's workplace proved to be useful, because additional cases of contact allergy were detected by testing with the used product. Probably, the sensitizations in these cases were directed against additives or reaction products which were not present in the original wb MWF. Another possible explanation is a weak sensitization to MWF components which is not detected by testing with the correctly concentrated fresh sample, but only with the used sample, which may have a higher concentration due to vapourization of water during the working process. According to our results, samples of used wb MWF can be patch tested without an undue risk of irritant reactions.

The maximum benefit from patch testing with MWF from the patient's workplace can only be achieved if (i) complete information on the ingredients and additives of the MWF is available, and (ii) a breakdown test with single components of the MWF can be performed. To obtain detailed allergologically useful information about the ingredients and additives of a MWF is a very time-consuming business. First, the patient and his employer have to cooperate in providing information about the workplace exposure, in particular correct names of the products used and their manufacturers. In the material safety data sheets of the MWF, far from all the components which might be responsible for the individual patient's disease are listed. Usually, only those chemicals are named which are known sensitizers and are present above a threshold concentration which requires labelling with the risk phrase R 43. If mentioned at all, chemicals may be denoted using synonyms not known to the clinician. Some lubricant producers are very cooperative and readily supply additional information, others are not. As time is limited in the hospital routine, these difficulties are presumably one reason why additional diagnostics are rarely performed, and why the clinical relevance of positive reactions to standardized MWF allergens often remains unclear in the individual case. Per-

forming a breakdown test with the single MWF components is hampered by uncertainty concerning correct patch test concentrations (on the producer's as well as on the physician's part), and consequently, uncertainty about interpreting test reactions with these preparations. Often, the producers cannot deliver chemically-defined components, because reaction products may be formed in the production process of the MWF which are not completely characterized. In this connection, reaction products of boric acid and alkanolamines may serve as an example: usually, more than one alkanolamine such as MEA, diglycolamine, etc. is added to the MWF base which contains boric acid, and the reaction products are not analyzed. Hence, contact allergy to these reaction products – although well known from several case reports (25, 26) – is not easy to diagnose.

Against this background, we propose a centre for information and documentation of contact allergies due to occupational exposure (German acronym: IDKB, from 'Informations-und Dokumentationsstelle für Kontaktallergien durch Berufsstoffe'), which could provide:

- (1) Support in obtaining information on, and samples of, single constituents of the occupational material (workplace MWF);
- (2) Help in finding adequate patch test preparations;
- (3) Central documentation of patch test results;
- (4) Quality control of patch testing by continuous adaptation of test recommendations;
- (5) Detection of new allergens.

This proposed IDKB should work like the IDOK which successfully does the same work in the field of cosmetics and skin care products (27).

To further promote patch testing with MWF from the patient's workplace, the essential points of the recommendations of the working party on allergy diagnostics in the metal branch (5) are reported, which are as yet published in German only: of every MWF used by the patient, 2 samples should be taken, i.e. 1 fresh and 1 used sample. In the case of wb MWF, a sample of the fresh, undiluted MWF concentrate should be obtained. The used samples are to be taken from the inflows of the machines (and not from the so-called sumps) to avoid contamination with metal chips which might cause irritant patch test reactions. Samples of used wb MWF must be stored in a refrigerator and be tested within 3–5 days because otherwise microbial contamination will change or even destroy the emulsion. Fresh concentrate of the wb MWF should be tested 5% aq., which is an average workplace concentration,

according to our results also. Used wb MWF can be patch tested as is, provided the concentration at the workplace is $\leq 8\%$. In the case of higher workplace concentrations, further dilution to an end concentration of 4–8%, as required, is recommended. As a rule of thumb, this can be achieved by a 1:1 aqueous dilution of the wb MWF. Usually, wb MWF are alkaline (pH 8.6–9.5), but experience shows that this is tolerated by patients on patch testing. Neat oils should be tested 50% in olive oil. Used wb MWF samples must be accompanied by information about concentration and pH at the time of sampling, date of the last change of the MWF, system cleaner used, date of last preservation, name of bactericide and fungicide used, name of other additives and date of addition, material processed in the machine, and possible influx of hydraulic oils, slideway oils or other oils by leakage. For neat oils, only data on the last change of the MWF, additives, material processed in the machine and possible influx of other oils needs to be documented.

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