Developments in reproductive risk management

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Abstract

Internationally, the debate on aims for occupational health policy is expanding its horizons. Included among the issues are not only concerns about safety for workers, but also for their progeny. Equality among the sexes is also assuming a prominent position.

In several countries, existing and proposed legislation already considers these matters. In the course of this article it is argued that this legislation and its implementation are inadequate. There are several reasons for this. Firstly, what constitutes health risks for workers exposed to chemical substances is subject to different interpretations. This is further complicated when one includes risks to reproductive function and to the progeny: the reproductive risks of toxicity. The different interpretations of the concepts of safety and equality are also discussed. There are differences in regulations and in standards about whether or not safety factors should be used when knowledge is uncertain. The operation of reasonable measures with a generic or sex specific policy also differs. Secondly, the current occupational exposure limits are set too high. These aspects are considered and it is probable that the policy aims should be made more specific. An elaborated approach that includes the "precautionary principle" in safety standards is proposed. To advise employers in their role as managers of reproductive risks of toxicity, a recently developed system for occupational health and safety services is described. This system is based on two criteria: effectiveness and reasonableness of proposed measures. The effectiveness criterion includes the precautionary principle; the reasonableness criterion includes equal rights and opportunities for men and women. Finally, a supportive governmental policy that is consistent with the most recent international developments is recommended.

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In the 1970s the American battery manufacturing business, Johnson Controls, had a fetal protection policy that barred all fertile women from jobs that involved lead exposure. The United States Supreme Court decided that this was an illegal case of sex discrimination.[1] Bertin *et al* argued that this decision could be characterised as a first step towards the development of an occupational health policy that combines both safety and equality, regardless of sex.[2] This principle was also recommended in Europe.[3]

At the same time, the precautionary principle was adopted internationally as a starting point for environmental policy in 1992 at the global United Nations conference on environment and development (UNCED) in Rio de Janeiro, Brazil. This principle stipulates that "where there are threats of serious or irreversible environmental damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent degradation".[4]

We questioned whether existing and proposed national and international legislation incorporated the internationally intended aims "safety" and "equality" at an operational level—that is, at the level of working conditions and social policies in the companies. We studied three questions:

(1) From the standpoint of both health and equal treatment, are current governmental policies adequate to assess and manage reproductive risks of toxicity?

(2) From the perspective of the inter-national debates on safety and equality, are the governmental aims about the working environment adequately formulated?

(3) How can insights gained from studying the first two questions be implemented at company level?

The concept "safety" is intended to be used in a broad sense, including health. The concept "health" will also be used. In fact, the concepts as used here—"safety", "health" and "health and safety"—are interchangeable. The same can be seen in current governmental directives and legislation.

We firstly describe and discuss the current political aims, criteria, and policies on reproductive risks in the workplace. We illustrate this with Dutch examples, and with additional examples from other countries if they are better. Next, we propose a system to assess reproductive toxicity that can be applied by occupational health and safety services.

Finally, we give an outline of how a supportive governmental policy could be developed.

The current occupational health policy

In The Netherlands, the Working Environment Act on occupational health, safety and wellbeing, was originally passed in 1980.[5] With its more recent safety implementing orders,[6 7] it obliges employers "to ensure the greatest possible degree of health and safety protection, and to promote the greatest possible attention to wellbeing in the light of the best existing principles of technology and the current state of occupational health care, ergonomics, and industrial sociology, unless this cannot reasonably be required".[8] In the Dutch safety implementing order[6] the definition of protection of health is further elaborated. It includes the reproductive functions and the potential progeny of employees. Two basic criteria are incorporated in the legislation, *effectiveness* in preventing health injury, and *reasonableness* of measures.[9]

The criterion of effectiveness with regard to the prevention of exposure to chemicals in the workplace means the use of occupational exposure limits (OELs). In The Netherlands, these are called MACs (maximum accepted concentrations). These standards explicitly include preventing reproductive risks. In the first list,[10] published in 1978, the MACs were copied from an American Conference of Government Industrial Hygienists (ACGIH) list of threshold limit values (TLVs).[11] In the most recent Dutch list, compared with the first one, in total 96 ACGIH values were replaced by new values. These values are established according to a three phased procedure[12] consisting of: (*a*) a scientific stage, in which the Dutch Expert Committee on Occupational Standards drafts a health based recommended occupational exposure limit (OEL); (*b*) a policy making stage, in which the Commission for MACs, which consists of representatives of employers, employees, and government, evaluates the technical and socioeconomic feasibility of the proposed health based recommended OEL, and recommends an operational OEL; (*c*) an administrative stage, in which the Ministry of Social Affairs and Employment sets the MAC as a standard. Since 1990, also in the European Union (EU) a three phased procedure has been accepted. Recently, the first list of the European Scientific Expert Group with recommendations on 26 OELs was published.[13]

As well as national standards, the Dutch safety implementing order mentions company specific OELs (often referred to as in house OELs). These in house OELs, which should take into consideration combined exposures, as well as characteristics of the population, must be set in individual companies. In house OELs must be equal to or lower—that is, safer—than national standards. In the absence of national standards and in house OELs, the exposure needs to be "as low as reasonably achievable".[6 7]

Reasonableness of measures is defined as technical, operational, and economic feasibility.[14] The criterion of reasonableness of measures is expressed in a prescribed strategy that consists of four levels of measures corresponding to a decreasing priority from one to four: (*1*) source directed measures; (*2*) collective measures; (*3*) individual measures; and (*4*) personal protective equipment. If it is reasonably possible to manage risk, measures should be taken at the first level. If not, the employer may take supplementary measures at other levels.[6 7]

As well as the Working Environment Act, the Equal Treatment Act was implemented in The Netherlands.[15 16] This act prohibits a direct or indirect distinction between men and women unless protection to motherhood or pregnancy is required. These rules stem from those established in the Treaty of the United Nations that ban all discrimination against women.[17 18]

Because of these sex specific risks the Dutch government recently published an order to protect pregnant and lactating women at the workplace.[19] It was intended as a clarifying measure within the context of the Working Environment Act, because of the uncertainties of risks and the potentially serious effects. This order fully corresponds to the uniquivocal EU directive.[20] Article 4 obliges employers—or representatives appointed by them—to evaluate the risks for pregnant and lactating women employees exposed to some specifically listed substances: substances designated by R40 (irreversible effects cannot be excluded), R45 (may cause cancer), R46 (may cause genotoxic effects), R47 (may cause developmental risks), substances that can be absorbed by the skin, and some substances specifically mentioned: auramine, polycyclic aromatic hydrocarbons, nickel and nickelpropyl alcohol, mercury and mercury compounds, antimitotic drugs, and carbon monoxide. Occupational exposure to lead (compounds) is forbidden during pregnancy and lactation. If the evaluation shows a risk of negative impact on the pregnancy or the lactation, the employer must adapt the working conditions accordingly. If this cannot be done, the employer has to offer alternative tasks that are safer. When both adaptation and transfer are impractical or impossible, the workers concerned should be granted paid leave for a period judged necessary for the protection of their progeny. Workers' rights should be maintained throughout this period. With this directive, it may be noticed, two new categories of measures that are especially designed for pregnant and lactating women have been added to the four levels of measures already mentioned: (*5*) alternative safe tasks and (*6*) paid leave. Figure 1 summarises Dutch governmental aims, criteria, and policies on reproductive risks of toxicity.

Preceding this EU directive, in the Nordic countries—for example, Finland and Denmark—other sex specific laws were made to prevent harm to the health of the unborn child during pregnancy, by allowing women to switch to a safe job if they are exposed to

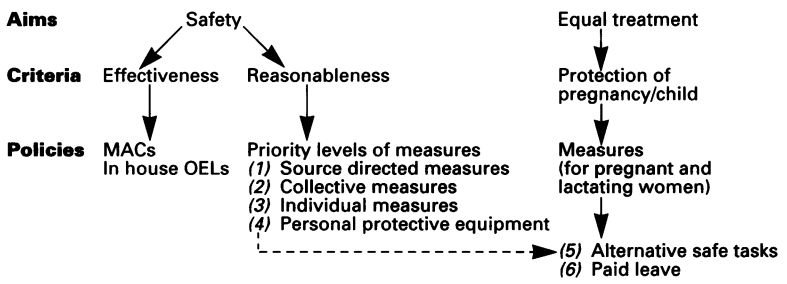

Figure 1 Current Dutch governmental aims, criteria, and policies related to reproductive toxicity.

agents that were considered to be harmful to pregnancy. If such a job cannot be offered, the woman may be entitled to a special maternity leave and benefits. Exposure to organic solvents is considered potentially harmful during pregnancy if it exceeds 10% of the current exposure limits.[21 3]

Assessment of the current governmental policies

Can current government policies be considered adequate to protect health and to guarantee equal treatment? Internationally the agreed aims for an occupational health policy are "safety and equality". Alternatively we could therefore ask whether current government policies are adequate to reach these aims. We have two reasons to disagree.

Firstly, in most EU countries from 75–90% of the present MACs were copied from the United States TLV list of 1978, and have not been changed since then.[11] Because of what many people consider to be undue corporate influence in the original setting of these standards, the TLVs have been challenged. According to its critics, the TLV standards do not guarantee the protection of employees' health.[22-25] Furthermore, as the TLV definition does not specifically mention risks of reproductive toxicity, it is not at all clear that they have been considered. In the next section we comment on the 15% new values that were drafted in The Netherlands according to the three phased procedure. Also, in house OELs are only an intention: methods for drafting them have not yet been prescribed by the government.

Secondly, the selective attention to the period of pregnancy and lactation of women may mask potential dangers for men and their offspring, and for women before pregnancy is recognised. In the 18th amendment to the EU directive about the classification of hazardous substances, new categories are introduced that involve the fertility of men and women and lactation. The code R47 was substituted by R60 (may harm fertility), R61 (may harm the unborn child), R62 (potential risk of less fertility), R63 (potential risk to the unborn child), R64 (may harm lactation).[26-28] Since then only the substances classified in the R47 category were relabelled; R (risk) qualifications were not given to other substances.[27] Moreover, no comparable assessment or management rules are available for the new categories (concerning reproduction) described in the directive on pregnant and lactating women. Also, methods for evaluating whether there is a risk or not have not yet been made operational.

So, the current occupational health policies surely are an improvement relative to the previous situation without standards established through the three phased procedure, and without extra preventive measures against harm to progeny. Nevertheless, there are reasons to conclude that these policies as currently implemented are insufficient to reach the internationally intended aims of safety and equality for the risks of reproductive toxicity. Our general proposal to reach those aims would be that (*a*) the occupational exposure limits should be adapted soon to the current knowledge about risks of reproductive toxicity, and that (*b*) the two extra levels of the order—that is, alternative safe tasks and paid leave—are used for both men and women who are in the fertile years.

Further, in all countries the aims safety and equality have been made operational in two separate laws. We find this a problem (see next section), and recommend that connections are made between the laws.

The concepts safety and equality

The aims of occupational health policies have been phrased somewhat differently in several countries. Here we compare the Dutch interpretation with the concepts safety and equality and propose a more specific interpretation in view of recent international discussions.

THE CONCEPT OF SAFETY

In Dutch legislation within the context of occupational exposure to chemical substances, "health and safety protection" is intended to prevent health impairment as far as present knowledge allows. This can be concluded from the description of the MAC: an administrative value, to which—at its inception—as much as possible the principle is used that the concentration of the substance in the air at the workplace, according to the state of knowledge during the establishment of the standard, does not harm the health of the workers and their progeny.[12] The problem we consider centres around how and when the standards are set and how often they are revised. The MAC list does not mention the date when each standard was established. In fact, more than 75% of the present standards were established between 15 and 40 years ago, based, one presumes, on the state of knowledge at those times.

Perhaps, more importantly, in different areas of health protection the question when "safe" can be considered "safe enough" is approached differently. Especially for situations in which only uncertain indications of risk are available, discussions arise. The issue is about when indications are "sure enough" to warrant measures. For food additives and drugs, substances are considered guilty until proved innocent. With substances in the workplace, where exposure is often much

higher, the reverse is true: they are innocent until proved guilty. This means that new food additives and drugs are submitted to severe toxicity tests. Only when they have passed these tests are they allowed on the market. With substances in the workplace the opposite has been the case. Up to 1986, new substances were permitted unless someone could prove that they actually represented risks to workers' health. Fortunately, recent environmental legislation has done something to correct this imbalance. Depending on the amount produced each year, new substances must be subjected to more or less comprehensive toxicity tests.[29] This does not, however, alter the situation for existing substances—that is, for those already on the market in 1986—or for volatile substances that are newly formed during production processes. Because the stimulus for research into existing substances is lacking, many gaps in knowledge exist, and will continue to exist.

It is not clear how large a part gaps in knowledge, indications about risks, and conflicting data have played in the Dutch three phased standard setting process. Analysis of 15 recent Dutch criteria documents, in which—in the first step of the standard setting procedure—the Dutch Expert Committee on Occupational Standards gave health based recommendations for specific exposure limits, showed that gaps in knowledge were disregarded, and were not reflected in their conclusions.[30] Analysis of eight other Dutch criteria documents showed inconsistent approaches in dealing with gaps in knowledge and indications of risks.[31] For example, in the criteria document on cyclohexanol[32] there were some indications of spermatotoxic effects, and few indications of effects on the fetus through the woman. A generic—uniform for men and women—low limit was proposed (based on the spermatotoxic effect) that was taken up in the next steps of the procedure. In contrast, in the criteria document on xylene[33] there were, in 17 studies, substantial indications of risks of reproductive toxicity to progeny through women. The Dutch Expert Committee on Occupational Standards, however, deemed the data insufficient to establish an exposure limit for women. No studies were found about the risks of reproductive toxicity to progeny through men. Only a provisional limit for men was recommended (based on effects other than reproductive effects); for women no limit at all was given. Although additional research on the reproductive toxicology of xylene was urgently recommended, no special recommendations were made to protect women and their progeny from it. In the next steps of the procedure, the limit on xylene for men was taken over as the MAC, with a footnote in the list that pregnant women should avoid exposure.

From this scenario we conclude that "safe enough" and "sure enough" should be reconsidered and made operational relative to occupational exposure.

Based on the studies of Douglas and Wildawsky[34] and Sabatier[35] three prototypes of attitudes towards risk can be distinguished: (*a*) a risk avoidance attitude, (*b*) a risk acceptance attitude, and (*c*) a risk regulation attitude. From the perspective of the risk avoidance attitude, research is needed on substances with any kind of risk. In the case of indications of health risk, stringent policies should be implemented. The risk acceptance attitude stresses that risks can never be absolutely excluded. From that perspective, research into the size, seriousness, and nature of the risk is important, as is comparison with other risks. The risk regulation attitude asks for research in which a "no effect level" (NEL) can be determined.

Recent international policy developments in thinking about prevention can be helpful to make the concept "safety" more specific. At the 1992 UNCED in Rio de Janeiro, Brazil, the precautionary principle was internationally adopted as a starting point.[4] This principle states that if serious or irreversible effects threaten the environment, uncertainty about those effects should not be used as an argument to postpone measures. The precautionary principle, although mostly used in relation to environmental risks, can also be brought to bear on occupational safety. It offers a way of gauging how indications of risk from certain substances, as indicated in the peer reviewed literature, should be dealt with. Compared with today's standard setting practices in which the risk regulation and risk acceptance attitudes are so apparent, the precautionary principle asks for a standard setting approach for occupational exposure that fits the risk avoidance attitude. Taking the precautionary principle as the starting point, indications of risk should be sufficient to eliminate or reduce exposure to those substances. The choice of this starting point defines more explicitly how the interpretative space in the concept of safety can be used. This definition will have direct consequences for the operation of the criterion of effectiveness and for related policies: the OELs should take into account indications of risks, not only proved risks.

In summary, considering the recent developments in thinking, the precautionary principle in the safety concept and, consequently, in the procedure for setting standards is recommended.

THE CONCEPT OF EQUALITY

Equality, although internationally used, is not the concept used by the Dutch government, which uses "equal treatment".[16] If one uses the concept equality it is unclear whether men and women should be treated equally when risks are unequal for both sexes. Strict equality may ignore possible biological differences between men and women. Thus at first hand, equal treatment seems to be a better concept to deal with sex related differences. For risks of reproductive toxicity, a generic policy would imply that, despite potential biological sex related differences in risks, there should be uniform standards for men and women. A sex specific policy implies that differences are highlighted and different standards or measures operate.

But how is equal treatment elaborated in Dutch legislation? The Dutch safety implementing order[6] prescribes uniformity in standards for men and women (sex neutral policy). In contrast, the Equal Treatment Act and the United Nations antidiscrimination rules do make distinctions between the sexes: extra preventive measures for pregnant and lactating women (sex specific policy). Differentiation of risks between groups has been built in. How can we assess the use of each of those concepts and how can they be made more specific to make them operational?

Developments in thinking about equality and difference that stem from women's studies and policies can be helpful in reconsidering equality and equal treatment. Two traditions abound in women's studies and policies. In one tradition, equality is a goal in itself. As it must be pursued as something good, men and women should be treated as equals. In the other tradition, the emphasis is on the culture bound differences between men and women. The current dominance of men in society necessitates creation of conditions in which women and their qualities can be re-evaluated.[36 37]

The current Dutch policy on workplace exposure to potentially toxic substances shows elements from both traditions: on the one hand uniformity of standards, on the other hand specific notes for pregnant women in some of the current standards, and specific measures only for pregnant and lactating women. In our opinion, the ambivalence stems from a number of factors. Medical science and women's studies recognise biological, sex specific, differences between men and women. For both men and women, and their respective progeny, reproductive risks exist. In theory, some substances may be more harmful towards men, and others may be more harmful towards women. In practice, however, the current scientific literature on reproductive risks, which focuses mainly on the risks *to the fetus* during pregnancy, makes it seem as if women are more susceptible to risk than men. From that perspective, it is conceivable—but unjustifiable—to see women exclusively as a problem group. This misconception stems from a failure to distinguish between two types of risks: the *direct risks* to the workers, and the *indirect risks through* the workers to their progeny. The woman's alleged greater vulnerability vanishes largely when one makes this distinction. For this reason, authors from the United States argue for distinctions to be made in developmental disorders (to progeny through men or women) and in reproductive disorders (to men or women).

But even if reproductive health risks to both sexes are found, such as for lead, a sex specific focus is seen—that is, only the risks to or through women were indicated—the risks to or through men were neglected, according to a study by Paul and Kurtz on an analysis of the information given in material safety data sheets.[38]

Based on these considerations, we stress that equal treatment, although perhaps more useful than equality, is still not adequate for distinguishing between situations where sex neutral or sex specific policies are appropriate. Too much emphasis on sex neutral policy from the viewpoint of equal treatment may facilitate a choice for a generic high limit, leading to unsafe circumstances for one sex. On the contrary, too many exceptions to the rule of equal treatment may make the concept of equal treatment an empty one.

We think that differences between men, women, and fetuses should be taken into account. In that case the concept of equal rights and equal opportunities, which is in use in the United States legislation, seems more helpful. This concept furnishes flexibility in how sex specific risks should be managed, provided that the opportunities—for example, for work—are equal. It leaves room for both uniform measures, and for selective measures. Therefore, we propose substituting the aim of equal rights and equal opportunities for those of equality and equal treatment.

Another principal point concerns the question of whether the generally used distinction between men and women is the most appropriate in managing reproductive risk. In recent changes of the EU regulation about classification of substances we saw that the attention, formerly focused on reproductive outcomes through women, was broadened to the fertility of men and women.[28] This notion has as yet not been translated in supplementary directives. It is conceivable that a distinction—if unavoidable—can be better made between people (men and women) who want to have children, and those who do not want to have children, because the risks to the progeny may occur as a consequence of exposure to chemicals in susceptible periods preceding conception, or in the first weeks of an unrecognised pregnancy. It is clear that this approach may touch the field of privacy. We prefer, from motives of precaution concerning damage to progeny's health, the distinction that is based on the wish to have children than that based on sex alone. That means that a substance with indications of risk for only one sex, should be considered as a substance that could cause reproductive effects also through the other sex, until it can be proved otherwise.

The question is often asked at which level a distinction can be made when unavoidable: at the level of drafting health based limits (the first step of the standard setting procedure), at the level of setting standards (sex specific MACs or generic MACs, the third step of the procedure), or at the next level (measures in practice, in which the criterion of reasonableness of measures plays a part). Whatever the choice about the level at which a distinction is made; if distinction is unavoidable—for example, between people who want to have children and those who do not—equal rights and equal opportunities still are the definite aim—for example, potential loss of opportunities for members of that group in one area of the company or branch of industry should be compensated for with extra opportunities for those members elsewhere.

Finally, it is conceivable that equal opportunities, translated as uniform measures, allow unsafe circumstances. For that reason, it is preferred that both aims, safety based on the precautionary principle, and equal rights and equal opportunities, are coupled in one legislation.

A new system to assess risks of reproductive toxicity

To support changes of practices on the shop floor, so as to better include the specific concepts of safety and equality already discussed in the preceding section, we developed a system to help occupational health and safety services to assess risks of reproductive toxicity and to advise employers and employees on managing those risks. The system was developed and subsequently tested by 19 OHS services.[39] Comments were incorporated into the final version.[40] The system describes (*a*) aims and criteria, and (*b*) a proposed strategy.

AIMS AND CRITERIA

The system aims to prevent reproductive risks, taking equal rights and equal opportunities as a starting point. It includes the criteria, effectiveness with inclusion of the precautionary principle, and reasonableness with inclusion of equal rights and equal opportunities.

PROPOSED STRATEGY

The system includes a strategy to prevent risks of reproductive toxicity. The strategy consists of (*a*) a risk assessment protocol, comprising a toxicity assessment and an exposure assessment, and (*b*) a risk management protocol in the company.

In the next sections only two elements of the system are to be dealt with: the toxicity assessment protocol and the risk management protocol. The importance and the pitfalls of exposure assessment should, of course, be recognised.[41 42] These aspects are not specific to risks of reproductive toxicity.

Reproductive toxicity profile for xylenes[42]

	Animal			*Human*		
Category of effects	*Studies (n)*	*Evidence*	*NEL (mg/m³)*	*Studies (n)*	*Evidence*	*NEL (mg/m³)*
Female fertility, reproductive glands, or hormones	1	S	<3000/24h	0	—	—
Female pregnancy (outcome)	22	S	<150/24h	0	—	—
Male fertility, reproductive glands, or hormones	0	—	—	0	—	—
Male pregnancy (outcome through male)	0	—	—	0	—	—
Weighing animal and human data, and knowledge against the gaps (to draft an HBR-OEL)	Effects: post-implantation loss, decreased fetal weight, skeletal retardation, and cleft palate. Exposure of the newborn by lactation theoretically probable. In this case, the next elements of a safety factor should be used: differences between species; differences within species; extrapolation from LEL to NEL; extrapolation for exposure time/day; compensation for the lack of data for two categories.					

S = sufficient; L = low; I = insufficient; LEL = lowest effect level; NEL = no effect level; HBR-OEL = health based recommended occupational exposure limit for reproductive effects.

Toxicity assessment protocol

Toxicity assessment should be based on the current public international peer reviewed literature. Elsewhere a systematic method will be proposed in detail, the critical health based recommended OEL method, based on criteria of validity, verifiability, and practicability,[43] is only summarised here. As a first step, human and animal studies must be distinguished, and clustered into four categories of effects. Those effects are: (*a*) the fertility and reproductive glands and hormones of the female, (*b*) pregnancy outcome through the female, (*c*) the fertility and reproductive glands and hormones of the male, and (*d*) pregnancy outcome through the male. In the category (*b*) the effects through lactation are included. The second step is the evaluation of the separate studies with newly developed assessment criteria. The quality of the study is valued as sufficient, low, or insufficient quality. Next, for each effect category an integrated appraisal of the evidence of reproductive toxicity is given for both the combined animal studies and for the combined human studies as sufficient, low, or insufficient evidence of reproductive toxicity. Finally, the data, effects and judgements about the level of evidence of risks of reproductive toxicity are represented in a profile. Annexed to the profile of reproductive toxicity a table can be made with further details about the selected studies. If the appraisal is sufficient, a quantitative appraisal about the NEL for risks of reproductive toxicity might be given. If a NEL for one effect category is lower than that for another, the lowest NEL will be used to draft—with a safety factor consisting of eight elements—a health based recommended OEL based on reproductive toxicity. As an example, the table shows the profile of reproductive toxicity of xylenes.

If all data are judged as insufficient, no health based recommended OEL should be set. In those cases, and in all cases where no comprehensive toxicity assessment has been done, we propose a strategy departing from the current MAC—if available—by the use of a safety factor (SF), based on the precautionary principle. This leads to a precautionary OEL. Thus, a precautionary OEL equals 1/SF × MAC. To justify the proposal to use such a safety factor, we refer to Koeter[44] who found in a study of 49 substances with extensive toxicity data that the reproductive toxicity was (one of) the critical effect(s) in 50% of the substances. Also, we refer to Londo[45] who compared 42 substances from the current MAC list of which lowest effect levels for reproductive effects were available in a specified database, and lowest effect levels for at least one other organ system; reproductive effects were in 35 of those substances (one of) the critical effect(s), and in only seven substances other effects were the critical effect. Although the size of the safety factor is somewhat arbitrary, we propose a factor of 10 for several reasons (the factor 10 method). In Denmark, the exposure limit for pregnant women of organic solvents is 1/10 of the

current OEL[21]; the same holds for Finland.[3] In several large national and multinational companies 1/10 of the current OEL is regarded in practice as the exposure limit for all workers (personal communication; Hamel A, OHS Services Shell Netherlands, Amsterdam 1992).[46] Progeny are usually more susceptible to health impairment than the working population.

An alternative method to draft an exposure limit based on the precautionary principle, which refers not only to reproductive toxicity, is worked out in the accompanying article (the RTECS method).[47] This method is a refinement of the factor 10 method, but is less extended than the comprehensive toxicity assessment method leading to a health based recommended OEL. Our method uses the database of the National Institute of Occupational Safety and Health Registry of Toxic Effects of Chemical Substances (RTECS). The OELs are developed, with the inhalatory animal reproductive toxicity data of the RTECS database combined with three safety factors, derived from Zielhuis and Van der Kreek.[48] The RTECS has a database consisting of 79 000 chemicals. Paul and Welch[49] reported evidence of reproductive toxicity for 16% of those chemicals.

The health based recommended OEL or the precautionary OEL for reproduction constitutes the exposure limit. Management of the risk is required if in a specific working place the real or predicted exposure exceeds the exposure limit.

Most occupational health and safety services do not have enough expertise to conduct the comprehensive toxicity assessment summarised above. Therefore, we recommend that the toxicity assessment should be done by a central or national agency. In the near future our resources should be combined in an international agency.

We recommend that occupational health and safety services start the procedure for substances that are suspected of causing risks of reproductive toxicity. Substances should be placed on an unlimited list if they are put forward in the EU classification of reproductive toxicity, in other "policy sources", or in critical reviews of reproductive toxicity. Stijkel made the first effort to compile a list[40] based on four reviews.[50–53] In that study it was already indicated that these reviews were only a first step in the development of a list of chemicals that are involved in reproductive toxicity. It was recommended, then and now, that other critical reviews should be screened as well to supplement the list, especially recent reviews on risks to or through men. Also, two internationally authoritative policy sources with substances suspected of being reproductively toxic should be added: the German list of foetotoxic agents,[54] and the Californian list containing substances that should be evaluated for their potential properties of reproductive toxicity[55] (see accompanying article for more details[47]).

When chemical substances are on this unlimited list of reproductive toxicity, the national agency is consulted for a health based recommended OEL for reproduction. This list should be revised and supplemented regularly, according to new knowledge.

A precautionary OEL for reproduction should be given to: (*a*) substances on the list, judged for health based recommended OEL, where all evidence is judged to be insufficient for reproductive toxicity; (*b*) substances on the list, as long as no health based recommended OEL is available, for instance, because of the absence of a national or international agency; (*c*) substances not on the list. Figure 2 summarises the reproductive risk assessment strategy.

Protocol for risk management in a company

If the real or predicted exposure in the workplace exceeds the exposure limit (health based recommended or precautionary OEL for reproduction), the six hierarchical levels of risk management should be examined. Again, according to the criterion of reasonableness with inclusion of equal rights and equal opportunities, they are: (*1*) source directed measures, (*2*) collective measures, (*3*) individual measures, (*4*) personal protective equipment, (*5*) alternative safe activities, and (*6*) paid leave. In several levels differentiation between groups is possible. Susceptible people or groups—pregnant and lactating women and both men and women who might eventually wish to have children—could be offered special protective measures such as ventilation devices, safe tasks, and extra personal protective equipment—for example, gloves.

The strong, and at the same time weak, spot of this management protocol is the elastic concept of reasonableness. Eventually, the interpretative space should probably be narrowed down in the light of equal rights and equal opportunities for both sexes. To date, only general rules can be set for several reasons, including big differences between the NELs for reproduction of men and women, the small size of susceptible groups, and considerable costs for lowering the exposure to the health based recommended OEL for reproduction. Therefore, we propose that employers make their choices about reproductive policy explicit in a public policy plan. One of the points of attention should concern the measures to be taken to compensate for the loss of work for the group at risk. Employers should develop consensus in the company about a tailor made strategy. If controversies about strategy in companies persist, it will then be necessary to call in outside mediators.

Discussion: supportive governmental policy

The current policy does not sufficiently fulfil the intended double aims of "safety and equality", if interpreted as "safety based on the precautionary principle" and "equal rights and opportunities". We have proposed a system that accommodates those aims more satisfactorily. An inventory of present know-

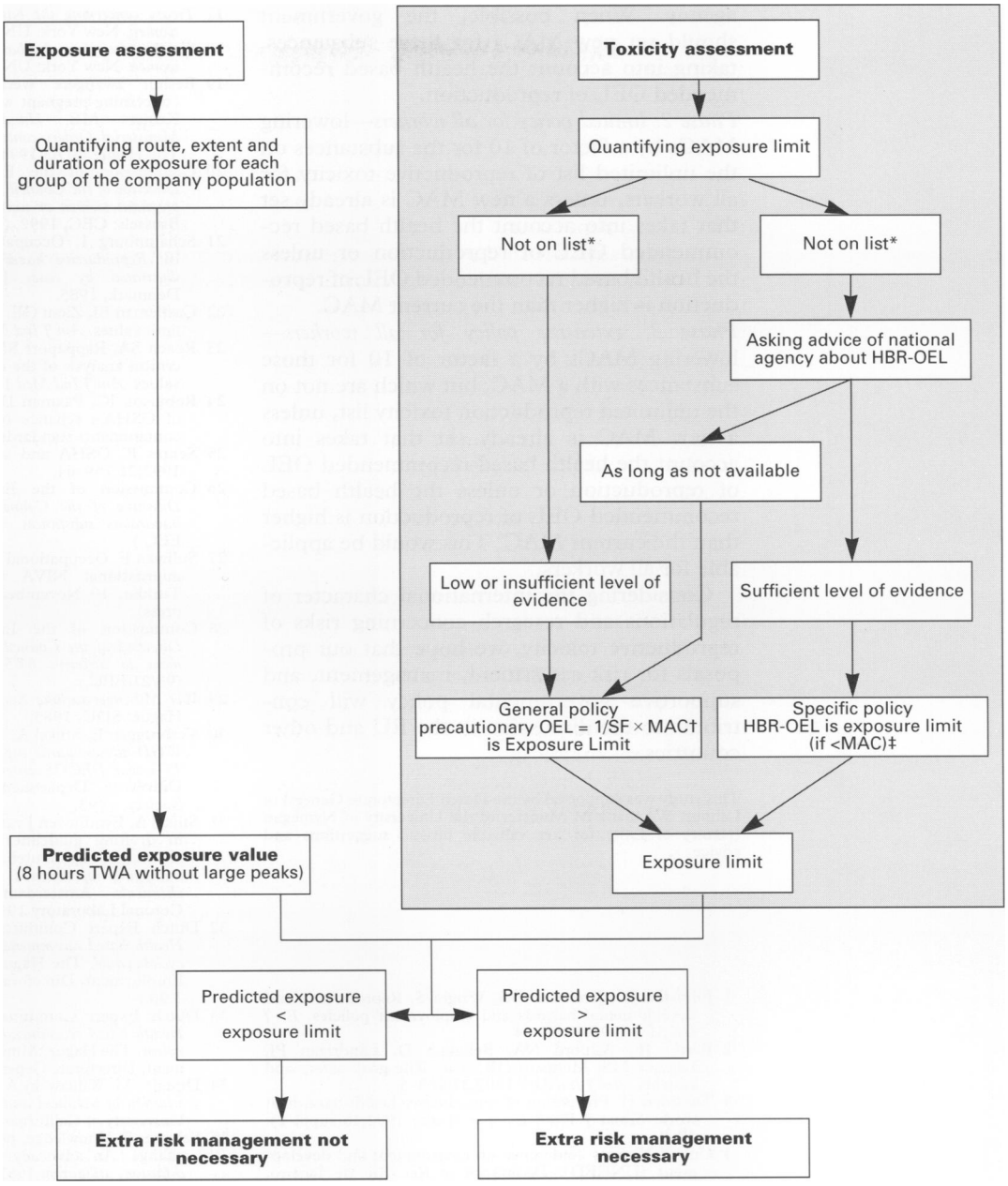

Figure 2 The reproductive risk assessment strategy in a company.
**This list of reproductive toxicity is unlimited, and consists at first instance of the substances from the reviews, extended with the substances indicated in the EU directive "Pregnant and lactating women",[20] the German list,[54] and the Californian list.[55] This list should be revised regularly with growing knowledge.*
†If there is no MAC available, the exposure should be as low as possible. In our companion article we propose precautionary OELs for the list of substances with reproductive toxicity of 0·1 mg/m³ if inhalatory reproductive toxicity data are lacking. HBR-OEL = health based recommended occupational exposure limits based on reproductive toxicity.
‡If HBR-OEL > MAC, the MAC should be used as the exposure limit.

ledge, policy, and practice with respect to risk assessment and management of reproductive toxicity, nationally and internationally, was described in a background document,[56] mainly based on scientific literature. It included the currently used assessment strategies, a list of suspected substances, and several gaps in the knowledge. We found many differences in risk management strategies for reproductive toxicity currently in use between companies. This might be explained by differences in attitudes towards risks and conceptions of the different positions between men and women, leading to different perspectives of this issue. The current legislation, being insufficiently clear, also provides much interpretative space and leads to different approaches and strategies. Several examples, including those of sex discrimination, were given. Considering the limitations and inconsistencies in the current approaches, we developed a new system that provides clearer choices.

If our specific use of the interpretative space in the aims of safety and equality as elaborated in our system is broadly accepted, implementation of this system needs supportive governmental policy, as already indicated by the occupational health and safety services where the system was pretested.[39] In those cases where data on reproductive toxicity are inadequate—which are many—and as long as no extensive assessment of toxicity has been done, we propose that the government adds an extra safety factor to the current standards, factor 10. This proposal can be carried out gradually, if necessary. We propose the following, phased, approach:

Phase 1: limited policy for susceptible groups—lowering the MAC by a factor of 10 for the unlimited list of substances with reproductive toxicity for pregnant and lactating women and both men and women who may eventually want to have children. During this first phase, the data on reproductive toxicity of those substances should be evaluated by a central

agency. When possible, the government should set new MACs for these substances, taking into account the health based recommended OEL of reproduction.

Phase 2: limited policy for all workers—lowering MACs by a factor of 10 for the substances on the unlimited list of reproductive toxicity for all workers, unless a new MAC is already set that takes into account the health based recommended OEL of reproduction or unless the health based recommended OEL of reproduction is higher than the current MAC.

Phase 3: extensive policy for all workers—lowering MACs by a factor of 10 for those substances with a MAC, but which are not on the unlimited reproduction toxicity list, unless a new MAC is already set that takes into account the health based recommended OEL of reproduction or unless the health based recommended OEL of reproduction is higher than the current MAC. This would be applicable for all workers.

Considering the international character of regulations and research concerning risks of reproductive toxicity, we hope that our proposals for risk assessment, management, and supportive governmental policy will contribute to the discussion in the EU and other countries.

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