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NO. 63923-4-I

IN THE COURT OF APPEALS OF THE STATE OF WASHINGTON
DIVISION I

JAMES and KAY MORGAN, husband and wife,
Appellants/Plaintiffs,

v.

AURORA PUMP COMPANY, et al.,
Respondent/Defendant.

Appeal from the Superior Court of Washington
for King County
(Cause No. 07-2-28464-8 SEA)

REPLY BRIEF

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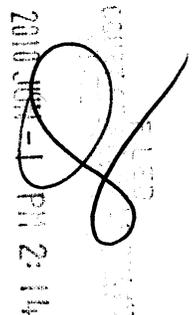
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I. INTRODUCTION

Plaintiffs' opening brief identified evidence of Mr. Morgan's exposure to asbestos for which each of seven defendants was responsible under current Washington law.¹ Crucial evidence (not available in Braaten, who never worked around new asbestos-containing equipment) was that Mr. Morgan worked around defendants' new pumps and valves when asbestos-containing packing and gaskets, supplied by defendants, were installed and released asbestos. Much of that evidence came from Jack Knowles, who witnessed Mr. Morgan near workers installing new asbestos-containing packing and/or gaskets on new equipment from defendants, who supplied such packing and gaskets along with the new equipment. Dr. Millette, an industrial hygienist, also submitted evidence (including articles) showing that most of the packing and gaskets contained asbestos, which was released when the packing or gaskets were installed. Defendants' efforts to argue against this evidence misreads the record, which is correctly set forth at pages 5-13 of this Reply.²

¹ Braaten v. Saberhagen Holdings, 165 Wn.2d 373, 198 P.3d 493 (2008), and Simonetta v. Viad, 165 Wn.2d 341, 197 P.2d 127 (2008). After reviewing defendant Elliott's response, plaintiffs agree to dismiss the appeal against Elliott but continue this appeal against the remaining seven defendants.

² The record must be viewed in the light most favorable to plaintiffs as the non-moving party to the summary judgments. Owen v. Burlington RR, 153 Wn.2d 780, 787, 108 P.3d 1220 (2005).

The trial court's reason for "reluctantly" granting summary judgment was:

I think that there is insufficient evidence that the new material internal to the product here would be enough to be a substantial factor in the tragic mesothelioma that Mr. Morgan suffered.

RP 160 (emphasis added). Plaintiffs made two arguments that the evidence demonstrated proximate cause for summary judgment purposes. Their primary argument was that the facts in this case could not fairly be distinguished from the facts in Lockwood v. A C & S, 109 Wn.2d. 235, 744 P.2d 605 (1987), which, defendants acknowledge, is the leading Washington case. In the event this Court did not find Lockwood applicable to this case, plaintiffs' alternative argument was that the proximate cause test set forth in Hue v. Farmboy Spray Co., Inc., 127 Wn.2d 67, 896 P.2d 682 (1975), and discussed by this Court in Mavroudis v. Pittsburg-Corning Corp., 86 Wn. App. 22, 935 P.2d 684 (1997), should be applied in this case.

This reply at pages 17-24 discusses how defendants repeatedly mischaracterize Lockwood in an effort to create distinctions between Lockwood and this case where none exist. It also explains at pages 35-38 that Hue was properly raised in the trial court and provides an alternative proximate cause analysis supported by Washington law, and

recommended by PROSSER AND KEETON'S THE LAW OF TORTS § 41 (5TH Ed.), p. 268.³ See Mavroudis, 86 Wn. App. at 30.

Much of defendants' more than 250 pages of briefing in this Court are devoted either to arguing for the exclusion of the testimony of Melvin Wortman, the Puget Sound Naval Shipyard ("PSNS") supervisor, and Dr. Mark, the Harvard pathologist (which the trial court had properly considered) or to re-arguing several affirmative defenses⁴ relating to military contract specifications,⁵ superseding cause, and sophisticated user that had been rejected by the trial court. Defendants have the burden of proof on affirmative defenses. Locke v. City of Seattle, 133 Wn.App. 696, 713, 137 P.3d 52 (2006); Gleason v. Metro Mortgage, 15 Wn. App. 481, 551 P.2d 147 (1976).

This reply explains at pages 14-18, that the trial court properly denied defendants' motion to strike Mr. Wortman's declaration for lack of foundation, since it and his deposition establish his foundation both from his personal observation and from his many years as a supervisor at PSNS.

³ Some defendants argue that somehow it is premature to discuss the proper proximate cause analysis because this case was decided before jury instructions were given. See Buffalo Br., p. 32, n. 14. That argument ignores the fact that defendants raised proximate cause when they moved for summary judgment, e.g., CP 1407-8 [Buffalo Mot. pp. 12-13], [Aurora Mot. p. 4-5, CP 1441-2].

⁴ See, e.g., various defendants' answers at CP 17, 28, 33, 34, 685 (government specifications affirmative defense), CP 15, 26 (superseding cause affirmative defense), CP 20, 27, 688 (sophisticated user affirmative defense).

⁵ As discussed, infra, defendants never raised that defense related to plaintiffs' warnings claims.

It also explains at pages 25-28, that the trial court properly found that the Frye⁶ rule does not apply to Dr. Mark's testimony, which is similar to testimony accepted in more than a dozen appellate cases in Washington and around the country, and that, even if that rule applied, there would have been no good basis for excluding the testimony.

As explained at pages 38-43 of this reply, defendants' motions for summary judgment based on the military contract specifications defense were correctly denied by the trial court because there were disputed material issues of fact. Moreover, defendants' superseding cause defense is inconsistent both with controlling Washington law including Crowe v. Gaston, 134 Wn.2d 509, 519-520, 951 P.2d 1118 (1996), and Hoglund v. Raymark Indus., 50 Wn. App. 360, 749 P.2d 164 (1987), and with the considerable majority of out of state appellate cases in the asbestos context.

Several defendants raise the sophisticated user defense, which has never been adopted in Washington (see Buffalo Br., p. 46). The Washington Supreme Court in Little v. PPG, 92 Wn.2d 118, 121, 594 P.2d 911 (1978), rejected, in the strict liability context, the use of Restatement (Second) of Torts § 388, which was the primary basis for the adoption of that defense in California. Moreover, in the asbestos context, that defense

⁶ Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

has been rejected repeatedly in both negligence and strict liability by appellate and trial courts throughout the United States.⁷

II. MR. KNOWLES AND DR. MILLETTE RAISE DISPUTED ISSUES OF MATERIAL FACT REGARDING MR. MORGAN'S EXPOSURE TO ASBESTOS FROM PACKING AND/OR GASKETS FOR WHICH EACH DEFENDANT IS LIABLE

A. Warren Pumps.

Warren Pumps acknowledges that Mr. Knowles testified that he was sure that he saw “Mr. Morgan in the presence of other people who were working with packing on brand-new Warren Pumps. CP 5520.”

Warren Br., p. 7. Warren further acknowledges that:

If the pumps are “brand-new,” the only “work” Mr. Knowles could be referring to must be installation of the new packing that he claims was supplied with the “brand-new” pump. *Id.* Indeed, he confirmed this fact upon later inquiry when he testified that he saw Plaintiff in the presence of others when new packing was installed in new Warren pumps. CP 4856. He explained that this work occurred when pump manufacturers supplied packing rings alongside the pumps, not installed. CP 4858.

⁷ Defendants rely on RAP 2.5 and 10.1(g) to justify each of them raising claims on appeal that were not brought by all defendants at the trial court level. Plaintiffs believe that RAP 9.12 relating specifically to summary judgments should take precedence over the other more general RAP 2.5 and 10.1(g). *State v. J.P.*, 149 Wn.2d 444, 69 P.3d 318 (2003). The facts of this case illustrate why a contrary result would be fundamentally unfair. For example, Leslie was the only defendant that raised arguments about either superseding cause or sophisticated user in its motion for summary judgment. CP 1002-6.⁷ An argument raised by only one defendant reasonably will produce a different response than an argument raised by all defendants. Moreover, plaintiffs would have no reason to respond to these arguments with particular defendant-related facts when the arguments are not raised by other defendants. Allowing the summary judgment record to be limited to a fact-based record raised by one defendant, but then allowing multiple defendants to jump on board the argument is not fair.

Id. (emphasis added). See also Warren Br., p. 23. Plaintiffs agree with this analysis of Mr. Knowles' testimony which also applies to the installation of "brand new" packing in other defendants' products.⁸

Plaintiffs disagree, however, with Warren's claim that Mr. Knowles' testimony is irrelevant because "Dr. Millette Testified that Brand-New Packing is Not Friable." Warren Br., p. 8. Warren and others rely entirely on one sentence of Dr. Millette's report:

Asbestos packing, although not friable in original, unused condition, can become friable after use in valves and can release asbestos fibers into the air during valve packing removal operations.

CP 4590 (emphasis added). Defendants ignore other portions of Dr. Millette's evidence regarding packing, including a publication he co-authored attached at CP 4638-4673.⁹ That publication discusses "Published Literature on Asbestos Fiber Release from Packing":

The GCA Corporation Report of 1982 reported on one 1979 study of packing material, where six different packings were tested over a 4-day period. . . . In general, the installation activity samples showed slightly higher concentrations than the removal activity samples.

Published results of simulated valve packing operations showed personal exposure to fiber levels ranging from 0.05

⁸ Moreover, Buffalo, Leslie, IMO, Aurora, Powell and Weir joined in Warren's Brief and thus joined in Warren's analysis. See, e.g., Buffalo Br., p. 5; Leslie Br., p. 49; IMO Br., p. 1.

⁹ Other defendants similarly misread the record regarding Dr. Millette. See, e.g., Powell Br., pp. 10-11; IMO Br., p. 29.

to 1.01 f/cc (PCM) for removal and 0.04 to 0.52 for installation. (End Note Omitted; Emphasis Added.)¹⁰

CP 4652. Dr. Millette's evidence taken as a whole thus (a) provides substantial evidence that the installation of new packing generates significant amounts of asbestos, and (b) applies equally to all defendants whose new packing Mr. Knowles saw being installed in Mr. Morgan's presence.¹¹

Plaintiffs also disagree with Warren's argument (citing State v. Scott, 20 Wn.2d 696, 699, 149 P.2d 152 (1944), that Mr. Knowles' testimony regarding Warren was inadmissible because he was asked leading questions on direct examination. Warren is wrong for at least two separate reasons. First, the court in State v. Scott held that:

[T]he trial court has a wide discretion in determining what is a proper form of question and as to permitting the asking of a question that is leading.

Id. at 699. Therefore, even assuming the questions were leading, Warren makes no showing that the trial court abused its discretion in this summary judgment proceeding, by permitting the testimony. Secondly, Warren submitted Mr. Knowles' direct testimony as part of its reply at CP 5511-5541, and thus waived any basis to object to testimony it submitted.

¹⁰ Buffalo's Br, p. 29, n. 11, relied on CP 4651 in this same article.

¹¹ Dr. Millette also recited Mr. Knowles' testimony regarding packing. CP 4605-6. Mr. Knowles testified that "new pumps a lot of times the packing came with the pumps, not installed." CP 4858 (emphasis added). That testimony applies to each of these defendants. Moreover, he testified at CP 5138 that he could identify new pumps.

B. IMO (DeLaval) Pumps.

IMO erroneously claims that with “respect to packing, there is no evidence that Mr. Morgan ever worked with or in the vicinity of such material originally supplied by IMO/DeLaval or that such material contained asbestos.” IMO Brief, p. 27. Such evidence is contained, however, in Mr. Knowles’ testimony, including his testimony at CP 4854-55, e.g.,

Q. [D]o you recall seeing other people work with packing in Mr. Morgan’s presence on brand new DeLaval pumps.

A. Yes.

Mr. Knowles also testified that the conditions of the air when that occurred were “dusty and dirty.” Id. and that such packing “was probably a little bit on the dusty side at times.” CP 4993.¹²

IMO also argues at page 25, citing CP 5904-06, that Mr. Knowles only observed Mr. Morgan working around IMO and DeLaval “fuel oil and lube oil pumps,” and that Richard Salzman, its corporate representative, testified that the “vast majority” of such gaskets and packing were non-asbestos materials. However, the jury would not have to credit that testimony, particularly because there is conflicting evidence. For example, IMO’s claim is contradicted by Mr. Knowles’ testimony that

¹² This testimony is equally applicable to showing Mr. Morgan’s exposure to asbestos from new packing installed on brand-new Warren, Buffalo, and Aurora pumps. See also discussion infra.

“most of that [packing] was a pliable asbestos.” CP 5116. This testimony is also applicable to each of the other defendants. Additionally, Dr. Millette testified that “most of the gasket and packing materials used with defendants’ products to which Mr. Morgan was exposed contained asbestos.” CP 4588 (emphasis added). “Most” means more than 50%, so it is more probable than not that packing in the brand new DeLaval pumps to which Mr. Morgan was exposed contained asbestos. The same is also true for each of the other defendants.

C. Weir (Atwood & Morrill) Valves.

Citing CP 4702, 4704, and 4715, Weir falsely claims “Jack Knowles also failed to provide evidence that Morgan was ever exposed to a new Atwood & Morrill valve with original packing or gaskets.” Weir Brief, p. 25. That claim is refuted by CP 4704, the very CP cited by Weir,¹³ where Mr. Knowles testified with respect to packing from brand new Atwood valves:

- Q. Now, did you have occasion to see Mr. Morgan in the presence of others who were working with packing on brand-new Atwood valves?
- A. I am sure that I did, just off the top of my head.
- Q. When you saw those other people working with packing on brand-new Atwood valves in the

¹³ Mr. Knowles’ testimony was introduced by various parties and the same testimony appears at different CP numbers. For example, CP 4702-4704, is the same portion of Mr. Knowles’ deposition contained at CP 5121-5123.

Morgan's presence, could you tell us what you saw the conditions in the air to be?

A. Dusty and dirty.

Not only did Weir ignore that testimony in its brief, but its cross examination of Mr. Knowles focused on what Mr. Morgan himself did and avoided asking him about observing Mr. Morgan being around others working with new Weir gaskets or packing. See CP 4715-17.

D. Leslie Controls.

Leslie backhandedly acknowledges that Mr. Knowles' testimony supports that "Mr. Morgan would have been exposed to gaskets and packing provided by Leslie before those consumable parts were replaced by products manufactured and supplied by others." Leslie Br., p. 6, citing CP 6558-560.¹⁴ Leslie's attack on this testimony relies on CP 6568-69:

Q. Did you ever see a brand-new Leslie Valve? Or other equipment?

A. I don't think so, no, to the best of my recollection. (Emphasis added)

Leslie argues there is "thus no foundation for Mr. Knowles to testify that Mr. Morgan worked on or around new Leslie equipment." Leslie Br., p. 7.

¹⁴ At Footnote 3 of its brief, Leslie indicates that it objected to Mr. Knowles deposition testimony "on various grounds, including the leading nature of the questioning by plaintiffs' counsel." However, while objecting to virtually every question asked at CP 6558-60, Leslie only objected to one question based on "leading." CP 6559, line 11. Nor can Leslie plausibly argue that an objection to "form" includes "leading," since it differentiated between those objections. Id. at lines 10-11. Moreover, the trial court overruled its motion to strike based on those objections, and Leslie has failed to demonstrate an abuse of discretion by the trial court in so ruling. See RP 27.

Leslie ignores Mr. Knowles' earlier testimony that he saw Mr. Morgan work around brand-new Leslie valves "numerous" times.¹⁵ There is not a flat contradiction between the two statements because Mr. Knowles qualified the statement relied upon by Leslie as being only to be "to the best of my recollection." However, even if the two statements were contradictory, plaintiffs, as the non-moving parties in this summary judgment, are entitled to the more favorable statement. See Owens. Put differently, this Court cannot properly determine that Mr. Knowles' statement at CP 5254 should be disregarded in favor of his statement at CP 6568-69.¹⁶

E. Powell Valves.

Powell misreads the record by claiming that "Mr. Knowles did not provide any testimony regarding the Decedent's work with new packing in relationship to a Powell valve." Powell Br., p. 9. Mr. Knowles (at CP 5121 with objections omitted), actually testified to Mr. Morgan's work around others working with packing on brand-new Powell Valves:

¹⁵ Q. ... but how many times do you recall seeing Mr. Morgan work with and around brand-new Leslie Valves?

A. Again, I would say numerous.

CP 5254.

¹⁶ Marshall v. AC&S, Inc., 56 Wn. App. 181, 185, 782 P.2d 1107 (1989), and similar cases do not apply in this situation both because there was no flat contradiction and because the two arguably contradictory statements appear in the same deposition rather than in a deposition and a declaration. Moreover, Leslie had the opportunity in the deposition to clear this up when questioning Mr. Knowles, but chose not to do so.

Q. Did you have occasion to see others working with packing on brand-new Powell valves in the presence of Mr. Morgan?

A. I – I installed, yeah.

Q. When that was taking place, would you tell us what the conditions in the air were like?

A. Dirty and dusty. (Emphasis added)

Powell's quotation at page 10 of its brief, relates only to what Mr. Morgan himself was doing or "would have done" with a new Powell valve, and ignores the work being done with such asbestos-containing material in his vicinity.¹⁷

F. Aurora Pumps.

Aurora Pumps acknowledges that Mr. Knowles testified that "he saw Morgan in the presence of individuals who were working with packing in connection with 'brand-new' Aurora pumps." Aurora Pumps Br., p. 6.¹⁸ That testimony leads "to the potential inference that he

¹⁷ Powell also argues that "Powell Steel Valves Utilized Teflon Packing." Powell Br., p. 11. The actual testimony which is quoted on that same page from Joseph McClure was that the packing in "stainless steel" valves were primarily Teflon. Powell then points out at p. 11 that Mr. Knowles only recalled Powell valves made of "steel." If stainless steel and steel were the same thing, Powell might have a point. But they are not.

¹⁸ Mr. Knowles testified:

Q. Did you have occasion also to see Mr. Morgan in the presence of other individuals who were working with packing in connection with brand-new Aurora Pumps?

A. Yes.

Q. When you saw that take place, would you describe for us what the conditions in the air were like?

A. They was still dusty and dirty.

CP 4852 (objections omitted):

[Morgan] was exposed to packing material that was originally supplied by Aurora's manufacturing facility." *Id.*, p. 16. Aurora then attempts to refute this inference by arguing that testimony from its corporate representative that, to his present knowledge, only one Aurora pump was sent to PSNS should trump Mr. Knowles' testimony. That is not proper argument in a summary judgment since the jury could well credit Mr. Knowles rather than Mr. Franklin, Aurora's corporate representative.

G. Buffalo Pumps.

In their opening brief, at page 9, note 6, plaintiffs quoted Mr. Knowles' testimony at CP 5125 that he saw "other people working with packing in connection with brand-new Buffalo Pumps" and that the air was dusty when that occurred. Buffalo never directly disputes that testimony, although it twice references other testimony at CP 5125. Buffalo Br., pp. 16, 23, n.8. As discussed above, there was substantial evidence from Mr. Knowles and from Dr. Millette's publication that the installation of asbestos packing on new pumps gave off asbestos fiber, and that most of such packing was asbestos. At pages 24-25, Buffalo argues that Mr. Knowles' testimony about packing on "brand-new Buffalo pumps" should not be credited because the three aircraft carriers he worked on with Mr. Morgan were not new ships and were not built at PSNS. That would only impeach his testimony if already constructed

Navy ships never had new pumps installed. That seems improbable, and certainly was never shown.¹⁹

III. THE TRIAL COURT DID NOT ERR IN REFUSING TO STRIKE THE WORTMAN DECLARATION

IMO, joined by Buffalo, Powell, and Leslie, challenges portions of Mr. Wortman's declaration, but does not challenge Mr. Wortman's deposition, which was offered by defendants (CP 5838-54), as well as by plaintiffs (CP 6657-6746).²⁰ Defendants' motion to strike Mr. Wortman's declaration was denied. CP 6754. His testimony included that (a) pumps manufactured by Buffalo, DeLaval, and Warren were "extensively used on aircraft carriers which each used hundreds of pumps (CP 4821), (b) almost all the pumps aboard Navy Ships from 1967-71 "contained asbestos gaskets and packing" (CP 4822), (c) that it was the standard operating procedure to procure gaskets and packing from the equipment manufacturers via the Navy supply system (CP 4823), and that (d) 50% of the replacement parts for pumps and valves, including packing and gaskets, came from the original manufacturers. CP 4823. Mr. Wortman's testimony thus dovetails with Mr. Knowles' and also covers periods of

¹⁹ For example, Mr. Knowles testified at CP 5006 and 5138 that he had seen and could recognize new pumps.

²⁰ Many of the topics discussed in Mr. Wortman's declaration are also discussed in his deposition. Since defendants do not challenge this Court's consideration of Mr. Wortman's deposition, their efforts to exclude consideration of portions of his declaration are largely moot. However, as discussed below, this Court may properly consider his declaration.

time during which Mr. Morgan would have been aboard ships and thus exposed to asbestos.²¹ It also dovetails with admissions from defendants, including Buffalo's instruction at CP 2376, stating: "DO NOT PACK WITH BULK PACKING UNDER ANY CIRCUMSTANCES"²² and Leslie's instructions at CP 5321.

Defendants challenge Mr. Wortman's foundation for some of his declaration, so the logical starting point is ER 602, the basic foundation rule, and cases interpreting that rule. Plaintiffs' opening brief quoted from Herring v. DSHS, 81 Wn. App. 1, 21, 914 P.2d 67 (1996):

Under ER 602, "testimony should be excluded only if, as a matter of law, no trier of fact could reasonably find that the witness had firsthand knowledge." *State v. Vaughn*, 101 Wash.2d 604, 611-12, 682 P.2d 878 (1984), citing 5 Karl Tegland, *Wash. Prac.* § 219 (2d ed. 1982).

Defendants do not dispute that Herring sets the correct standard.²³

Even assuming the standard of review is *de novo*, there is no good basis for excluding Mr. Wortman's declaration under the Herring standard. First, his declaration itself states that his testimony about

²¹ Mr. Knowles testified at CP 4587 that he and Mr. Morgan worked aboard ships when they worked in the design shop in later years.

²² In other words, do not pack with generic, bulk packing as opposed to packing manufactured to fit specific pumps.

²³ Defendants argue that this Court should review the trial court's decision, *de novo*, citing *inter alia* Folsom v. Burger King, 135 Wn.2d 658, 663, 958 P.2d 301 (1998), and Seybold v. Neu, 105 Wn. App. 666, 678, 19 P.3d 1068 (2001), but never satisfactorily distinguish Oltman v. Holland American Line, 163 Wn.2d 236, 247, 178 P.3d 981 (2008), which calls for an abuse of discretion standard of review for evidentiary decisions in connection with summary judgments.

manufacturers supplying replacement parts was “based on my observations of the replacement parts we received ...” CP 4965. Secondly, Mr. Wortman, quoted by IMO at p. 14 of its brief, testified that “in later years” “approximately 50 percent of the replacement parts obtained from PSNS were obtained from manufacturers.” His foundation was “observation and experience.” CP 5851-52.²⁴

IMO argues from the portions of Mr. Wortman’s deposition quoted at pages 12-15 of its brief, that Mr. Wortman somehow lacked personal knowledge because he didn’t talk to anyone in the purchasing department about how it obtained replacement parts or review any documents on that subject.²⁵ That argument doesn’t make sense. If I regularly walk around a restaurant kitchen and regularly see empty cans of Heinz Pork & Beans, that observation supports an inference that the kitchen regularly uses

²⁴ He later explained that as superintendent, he would tour the machine shop every day and while passing through the machine shop, he would see the packaging of the replacement products from the original manufacturers. CP 6732. Seeing the discarded wrappings is personal knowledge supporting the inference that, since the discarded wrappings had the manufacturer’s name on them, then the products inside the wrappings were from the manufacturer.

²⁵ Leslie acknowledges in its brief joined by IMO that “Mr. Wortman testified that his knowledge about other equipment manufacturers was based on observing the actual packaging from these manufacturers as he walked through the machine shop he supervised.” Leslie Br., p. 12. (Emphasis added). Similarly, at page 12 of its brief, Warren acknowledges that Mr. Wortman’s “experience” included “seeing packaging” from manufacturers.

Heinz Pork & Beans, even if I don't see the grocery receipts or talk to the person whose job it is to order pork and beans.²⁶

Plaintiffs' opening brief, at pages 36-37, also cited half a dozen federal cases interpreting FRE 602²⁷ to allow personal experience for upper level managers such as Mr. Wortman, to include information gained by interactions with subordinates. IMO takes no issue with those cases, but instead argues that because Mr. Wortman supervised the planners within the machine shop, but not the Planning and Estimating Division, he would have no way of knowing what the latter division did. *Id.* at 23-24. That argument ignores that planners within the machine shop (whom he supervised) were in contact with the Planning and Estimating Division, as part of their and his job duties. Mr. Wortman thus would know about Planning and Estimating actions by talking with his subordinates as part of

²⁶ Similarly, IMO also complains that Mr. Wortman:

only "believed" that fifty percent (50%) of all replacement parts came from original manufacturers, a conclusion he could only articulate as coming from "the upper part of [his] head."

IMO brief, p. 16. Those complaints have no force for two reasons. First, testimony based on "belief" is admissible. See the Judicial Council comments to ER 602, as well as the discussion in Tegland, *Washington Practice 5A*, Evidence, 5th Ed., pp. 339-340, 345-346. Secondly, the portions of the brain which govern memory are in the upper part of the head, so Mr. Wortman was simply colorfully saying that it was based on his memory of what he observed. Similarly, IMO's discussion at pages 17-18 of its brief about Ingersol-Rand (a non-appellant, non-pump manufacturer), has little, if anything, to do about Mr. Wortman's observations about DeLaval (IMO), Warren or Buffalo pumps.

²⁷ Burlington N.R. Co. v. Nebraska, 802 F.2d 994, 1005 (8th Cir. 1986); United States v. Cantu, 167 F.3d 198, 204 (5th Cir. 1999); United States v. Neal, 36 F.3d 1190, 1206 (1st Cir. 1994); Farner v. Paccar, Inc., 562 F.2d 518, 520 (8th Cir. 1997); Gravelly v. Providence Partnership, 549 F.2d 958, 961 (4th Cir. 1977); Agfa-Gevaert, A.G. v. A.B. Dick Co., 879 F.2d 1518, 1523 (7th Cir. 1989).

his duties. This is directly analogous to the federal cases cited by plaintiffs.

IV. THE EVIDENCE HERE IS AT LEAST AS STRONG AS THE EVIDENCE IN LOCKWOOD

Warren Pumps, joined by five other defendants, admits at page 25 of its Brief that:

[T]he ‘substantial factor’ test for causation, as set forth by the Supreme Court in *Lockwood, infra*, is the appropriate standard for causation in asbestos claims in Washington.

IMO Brief, p. 35, Weir Brief, p. 42, and Buffalo Brief, pages 32-33, agree that Lockwood is the leading Washington case on causation in the asbestos context. As plaintiffs pointed out at pages 31-32 of the opening brief, the facts of Lockwood are important because they are so close to this case.

Lockwood involved the appeal of only one defendant – Raymark Industries, Inc. – the successor to a manufacturer of asbestos cloth. Buffalo’s characterization of the evidence in Lockwood quoted below is generally accurate except for the underlined portion:

For instance in *Lockwood*, evidence that [1] all exposure to asbestos has a cumulative effect in contributing to the contraction of asbestosis was admitted. In addition to that evidence, there was evidence that [2] defendant’s asbestos cloth was used on the same vessel on which the plaintiff worked, [3] that the handling of defendant’s asbestos cloth created dust, and [4] that the dust released from asbestos insulation products like those manufactured by defendant drifted throughout the shipyard where it could be inhaled

by bystanders. Based on the combined evidence, the trial court was deemed sufficient to send the case to the jury, and the Supreme Court agreed. *Lockwood*, 109 Wn.2d at 247-248.

Buffalo Pumps Br., pp. 39-40. There was no evidence in the Lockwood opinion of shipyard-wide drift of asbestos from the Raymark cloth; rather the court stated that the evidence supported an inference that it drifted throughout one ship, the GEORGE WASHINGTON. Id. at 247-48 (emphasis added). Other defendants' characterization of Lockwood's facts and holdings are very inaccurate.²⁸

1. The evidence of Mr. Lockwood's exposure to Raymark cloth was only aboard one ship – THE GEORGE WASHINGTON. 109 Wn.2d at 244. The Supreme Court's analysis of the facts was at pages 247-48. Warren mischaracterizes the evidence to be that Raymark's product was used on "the ships which Lockwood worked aboard." Warren Br., p. 23. Leslie goes even farther claiming that "other witnesses identified large amounts of Raymark asbestos-containing cloth at Mr. Lockwood's worksites during his career to which he was exposed. Id. at 244-45." Leslie Br., p. 24 (emphasis added).²⁹ This Court can review pages 243-248 of Lockwood to see whether the Supreme Court relied on "large

²⁸ Warren, Leslie, Buffalo, IMO and Weir discuss, but mischaracterize Lockwood. Neither Aurora nor Powell even cite Lockwood despite its obvious importance.

²⁹ At page 25, Leslie reiterates that "the Supreme Court agreed that Mr. Lockwood had presented "evidence" of exposure to 'substantial amounts' of Raymark asbestos-containing products on numerous projects at various worksites."

amounts” of Raymark cloth at his “worksites” during his entire “career,” or unspecified amounts of Raymark cloth on one ship.

2. Buffalo and Leslie (see Leslie Br., p. 33, n. 11) claim that there was proof in Lockwood of shipyard-wide exposure. The actual evidence in Lockwood of asbestos “fiber drift” was that when “asbestos dust was released, it drifted in the air and could be inhaled by bystanders who did not work directly with asbestos,” so that it could be inferred that it drifted throughout THE GEORGE WASHINGTON. 109 Wn.2d at 247. Lockwood does not discuss expert testimony concerning shipyard-wide exposure. Presumably, defendants wish to argue that, because there was no explicit testimony of shipyard wide drift in the present case, the evidence in the present case is not comparable to that in Lockwood. The evidence in this case, however, is comparable to the actual evidence in Lockwood. See, e.g., CP 3067 (Morgan would be exposed to asbestos substantially above ambient levels whenever he remained in air spaces contaminated by work conducted by others that involved gasket removal, fabrications, and replacement, CP 4652, CP 3889 [Forman Dec., p. 14] (Shipyard workers sustain asbestos contact “when working in plant areas in which an environmental pollution of the air exists due to asbestos.”)).

3. Leslie argues at pages 26-27 and 32 of its Brief that the Lockwood decision was made “in light of evidence that ‘Mr. Lockwood’s

exposure to asbestos from Raymark's product was sufficient in and of itself to have caused his asbestosis.' ...” That argument is important to defendants' attempt to distinguish the holding in Lockwood from this case. Unfortunately for defendants, their argument is flatly untrue.

Nowhere in Lockwood is there any evidence or holding that Mr.

Lockwood's exposure to Raymark cloth while on THE GEORGE

WASHINGTON was “sufficient in and of itself to cause his asbestosis.” As

Buffalo admits in its brief quoted supra, the material evidence was that

“all exposure to asbestos has a cumulative effect in contributing to the

contraction of asbestosis.” See 109 Wn.2d at 247-48 (emphasis added).

In neither Lockwood nor this case is it necessary to show that any

defendant's product is sufficient in and of itself to cause the claimed

asbestos-related disease.

4. Weir's Brief at page 42 asserts that to prove substantial factor causation, plaintiffs must show both (1) frequent, regular and proximate exposure to Weir's asbestos-containing products, and (2) quantitative evidence that the exposure increased the risk of developing his asbestos-related disease. Leslie at pages 34-35 of its brief makes a similar argument, citing Borg-Warner v. Flores, 232 S.W. 3d 765 (Tex. 2007) and State v. Meekins, 125 Wn. App. 390, 396-97, 105 P.3d 420 (2005).

Contrary to these defendants' arguments and as plaintiffs explained at pages 26-27 of the opening brief, Washington, along with states such as Oregon, Hawaii, and Ohio, has not adopted the "frequency, regularity, proximity" test. That test requires that there must be "evidence of exposure to a specific product on a regular basis over some extended period of time in proximity to where the plaintiff actually worked." Lohrmann v. Pittsburgh Corning Corp., 782 F.2d 1156, 1162-63 (4th Cir. 1986). As explained by the Ohio Supreme Court in Horton v. Harwick Chemical Corp., 653 N.E.2d 1196, 1202 (Ohio 1995):

The Lohrmann test resolves doubts about causation mechanically in favor of the defendant from the outset. It stacks the deck against plaintiffs by foreclosing all but one avenue of a proof of causation.

For each defendant in a multidefendant asbestos case, the plaintiff has the burden of proving exposure to the defendant's product and that the product was a substantial factor in causing the plaintiff's injury. A plaintiff need not prove that he was exposed to a specific product on a regular basis over some extended period of time in close proximity to where the plaintiff actually worked in order to prove that the product was a substantial factor in causing his injury. (Emphasis added)

The Lockwood test differs significantly from the Lohrmann "frequency, regularity, proximity" test because there is no requirement under Lockwood that the exposure must be "on a regular basis," or be "over some extended period of time," or be "in proximity to where the plaintiff actually worked." For example, in Lockwood, while one of the

factors to be considered is “the extent of time plaintiff was exposed to the product;”, the Lockwood test did not require that the exposure to the product be “frequent,” but merely requires that the “frequency” be evaluated. Nor do the facts in Lockwood demonstrate that Mr. Lockwood’s exposure to Raymark products was “frequent.”³⁰ Rather, as plaintiffs pointed out in their opening brief, Lockwood has been recognized as establishing a relatively broader standard than exists in some other states. See, e.g., In re Hawaii Federal Asbestos Cases, 960 F.2d 806 (9th Cir. 1992), and Ingram v. ACandS, Inc., 977 F.2d 1332 (9th Cir. 1992).³¹ Indeed, the Washington Supreme Court later characterized Lockwood as holding that “(plaintiffs need establish only that defendant’s asbestos products were among those in the plaintiff’s work environment)”. Hue, 127 Wn.2d at 92, n. 22.

Furthermore, nothing in Lockwood required that plaintiffs provide “quantitative evidence” of exposure to Raymark cloth.³² Given that asbestos exposure often took place decades ago when typically no one was

³⁰ Similarly, under the Lockwood test, the asbestos exposure does not have to be “in proximity to where the plaintiff worked” in the sense of “close to” where the plaintiff worked. Rather, proximity is determined by evidence as to how far airborne asbestos dust spreads. See also Allen v. Asbestos Corp., 138 Wn. App. 564 (2007).

³¹ Leslie admits at page 27, n. 10 of its brief, that those two cases correctly “conclude[d] that Lockwood created a less rigid approach to presenting evidence of product identification at a plaintiff’s worksite.”

³² Plaintiffs in this case did supply some quantitative information when Dr. Millette opined that “breathing visible dust arising from asbestos packing and gaskets reflects an exposure to quantities of asbestos fiber above background levels.” CP 4591.

doing quantitative measurements at the relevant worksites, imposing such a quantitative requirement is simply a way to ensure that plaintiffs never can get a mesothelioma case to the jury. Only Texas among the 50 states has imposed such a requirement.³³

5. Dr. Mark's testimony at CP 4565 that "all of the asbestos to which [Mr. Morgan] reportedly was exposed to caused the diffuse malignant mesothelioma" is essentially the same as the testimony in Lockwood that "all exposure to asbestos has a cumulative effect in contributing to the contraction of asbestosis." 109 Wn.2d at 247-48.³⁴ This directly supports plaintiffs' position that she meets the Lockwood standard so this Court should reverse summary judgment.

V. THE TRIAL COURT CORRECTLY REJECTED DEFENDANTS' FRYE MOTIONS

A. Introduction.

Lacking a substantive basis for distinguishing Dr. Mark's evidence from the evidence in Lockwood, some but not all, defendants argue that

³³ See e.g., Southern Methodist University Law Review, Spring 2008, Thomas L. Arnold, *Toxic Tort—Causation In Asbestos Claims—The Texas Supreme Court Creates New Causation Requirement And Leaves Numerous Victims Without Remedy*.

³⁴ Buffalo acknowledges this at pages 40-41 of its Brief where it admits that the court in Mavroudis "had before it opinion evidence from Dr. Hammar similar that to expressed by Dr. Mark," i.e., "all of Mr. Mavroudis' exposure to asbestos probably played a role in causing the mesothelioma. 86 Wn. App. at 27."

Dr. Mark's testimony either should be ignored by this Court³⁵ or should be rejected under the Frye standard.³⁶

Leslie takes the lead for the defendants on this issue at pages 36-48 of its brief. While Leslie relies on Ruff v. DLI, 107 Wn. App. 289, 28 P.3d 1 (2001), Ruff holds at page 300 that:

[A] *Frye* analysis need not be undertaken with respect to evidence that does not involve new methods of proof or new scientific principles from which conclusions are drawn.

Leslie, at page 40 of its brief, also cites several medical articles not submitted in the trial court. That is appropriate under Ruff at page 300, which does not limit the appellate court to the trial court record.

Therefore, if, contrary to the trial court's ruling, this Court believes that Frye is implicated, plaintiffs herewith submit as Appendix A substantial testimony and medical articles, pursuant to the same authority.

In his supplemental declaration dated April 7, 2009, Dr. Mark gives opinions relating to the analytically distinct topics of the effects of asbestos exposure (a) in causing mesothelioma generally and (b) in

³⁵ That suggestion is inconsistent with the rule that evidence should be read most favorably to plaintiffs as the non-moving party. Owen, supra.

³⁶ Defendant Powell incorporates other briefs that raise Frye, but expressly withdrew its motion to strike Dr. Mark's testimony. RP 28. Pursuant to RAP 2.5, Powell may not properly appeal an issue it withdrew at the trial court level.

causing Mr. Morgan's mesothelioma.³⁷ Dr. Mark's opinion on the first topic is that:

There is no known safe level of asbestos exposure. All special exposures to asbestos that occur prior to the development of a diffuse malignant mesothelioma contribute to its pathogenesis. A "special exposure" means an exposure for which there is scientific reason to conclude it created or increased the risk of developing the disease.

CP 4560. His opinions relating specifically to Mr. Morgan include:

All of the exposures which occurred prior to the occurrence of the malignancy together contributed to cause the diffuse malignant mesothelioma;

CP 4560.

The generally accepted principle of dose-response indicates that all additional asbestos exposure increases the risk. That is why, in Dr. Mark's opinion relating specifically to Mr. Morgan, he says that "[a]ll of the exposures ... together contributed to cause the ... mesothelioma."³⁸

³⁷ Some courts refer to these topics as "general causation" and "individual causation." See, e.g., In Re Hanford Nuclear Reservation Litigation, 292 F.3d 1124, 1133-35 (9th Cir. 2002).

³⁸ In other parts of his declaration, Dr. Mark refers to exposures being "a significant contributing cause of the diffuse malignant mesothelioma." CP 4565. It is that portion of his opinion that defendants particularly challenge. See, e.g., Leslie Br., p. 27, n. 10, citing Lindstrom v. A-C Product Liability Trust, 424 F. 3d 488 (6th Cir. 2005). This Court, however, need not rely on Dr. Mark's opinion quoted above in this footnote, since his opinions quoted in the text are both very similar to the opinions referred to in Lockwood, Mavroudis, and the out of state cases referred to infra and, standing alone, support reversal of the summary judgment in this case.

B. Frye Does Not Apply to Dr. Mark’s Opinions, Which Are Not Novel.

Defendants have failed to identify what method employed by Dr. Mark is novel or untested, and instead attacked the substance of his opinion. In fact, all of his methods have been commonly used for decades, if not longer, as in the case of Dr. Mark’s use of the principles of epidemiology. In State v. Ortiz, 119 Wn.2d 294, 311, 831 P.2d 1060 (1992), the Supreme Court held that “testimony which does not involve new methods of proof or new scientific principles from which conclusions are drawn need not be subjected to the Frye test,” see State v. Roberts, 142 Wn.2d 471, 520, 14 P.3d 719 (2009) (same). At RP 154, the trial court relied on Bruns v. Paccar, Inc., 77 Wn. App. 201, 210, 890 P.2d 469 (1995), where this Court held that there was no need to conduct a Frye analysis when the expert employs established scientific methods rather than novel ones.³⁹ Even defendants agree that Dr. Mark’s opinion “may be characterized as medical causation testimony that is not ‘novel’.” Buffalo Pumps Br., p. 30, n. 12,

A number of out of state opinions have also held that Frye hearings for issues similar to those raised by defendants are not necessary. The

³⁹ Numerous other Washington decisions have reached the same conclusion. City of Bellevue v. Lightfoot, 75 Wn. App. 214 (1994) (holding that Frye is applicable to police radar; the court stated, “the principles involved in traffic radar evidence are not novel or experimental.”), State v. Vermillion, 112 Wn. App. 844, 866, 51 P.3d 188 (2002).

court in Weigman v. A C & S, Inc., 24 A.D. 3d 375, 376, 806 N.Y.S. 2d 531 (2005) held that:

Defendants-appellants' claim that a *Frye* hearing should have been held is without merit. The link between asbestos and disease it is well documented, and the parties merely differed as to whether the asbestos contained in this particular product could be released in respirable form so as to cause disease. Since the parties argued over causation, no novel scientific technique or application of science was at issue, and a *Frye* hearing was not warranted.⁴⁰

C. Appellate Courts Throughout The Country Support Plaintiffs' Position That Dr. Mark's Testimony Is Not Novel And Is Generally Accepted.

Dr. Mark's testimony quoted above is not novel. To the contrary, it is very similar to medical testimony provided by numerous doctors and accepted by numerous courts for more than 35 years. While citing four trial court rulings applying Frye to asbestos causation, defendants studiously ignore appellate precedent on this issue. That is because appellate authority overwhelmingly rejects their position.

Plaintiffs previously quoted the language in Lockwood 24 years ago about the "cumulative effect" of asbestos in causing disease. This Court in Mavroudis discussed several approaches to the "substantial

⁴⁰ See also Gayle v. Port Authority of New York & New Jersey, 775 N.Y.S.2d 2 (N.Y. App. Div. 2004) ("Defendant's factual disagreement with plaintiffs medical causation theory did not warrant a hearing under Frye, since no scientific technique or novel application of science was at issue.").

factor" test in mesothelioma cases in Washington, and utilized

Dr. Hammar's testimony that:

[S]cientific information indicated that all of Mr. Mavroudis's exposure to asbestos at Puget Sound Naval Station from 1957 to 1963 probably played a role in causing the mesothelioma ...".

Mavroudis, 86 Wn. App. at 32-33. As Buffalo acknowledged above, Dr.

Mark's evidence on causation issues is similar to the testimony Dr.

Hammar gave in Mavroudis.

Numerous appellate courts in Texas, Louisiana, Alabama, Oregon, The District of Columbia, California and Pennsylvania over the past 37 years have also accepted the theory that asbestos diseases, including mesothelioma, are caused by the cumulative effects of the person's total asbestos exposure. In Borel v. Fibreboard, 493 F.2d 1076 (5th Cir. 1973), an asbestosis and mesothelioma case, the Fifth Circuit held that "[i]t was . . . established that the effect of exposure to asbestos dust is cumulative, that is, each exposure may result in an additional and separate injury." 493 F.2d at 1094.⁴¹ The Oregon Court of Appeals relied on Dr. Andrew

⁴¹ In Keene Corp. v. Belford, 881 S.W.2d 608, 610 (Tex. App. – Corpus Christi 1994, no writ), the Court held that where the plaintiff's medical expert concluded that "each and every exposure to asbestos products contributed cumulatively to the plaintiff's asbestos-related disease and that no specific source could be identified as the cause of his injuries," there was sufficient evidence in the record to establish that the plaintiff was exposed to asbestos-containing products manufactured by the defendants. See also Sheffield v. OCF, 595 So.2d 443, 456 (Alabama Supreme Court 1992) ("Exposure to asbestos for as little as one day can significantly contribute to, cause, and/or aggravate asbestos-related lung diseases. The injurious effect of ingesting asbestos fibers into the lungs is cumulative.").

Churg, a well known expert who testifies for both plaintiffs and defendants in asbestos litigation, for the same evidence:

Churg testified that a single exposure to asbestos fibers can cause mesothelioma, with each subsequent exposure exponentially increasing the risk of the disease. Thus, Churg concluded that all of plaintiffs exposure to asbestos fibers over the years "contributed to some degree" to his mesothelioma.

Purcell v. Asbestos Corp., Ltd., 959 P.2d 89, 93 (Or. App. 1998)

(emphasis added.).

In McAskill v. American Marine, 9 S.3d 264 (La. Ct of Appeals 2009), the Court of Appeals held:

[W]e acknowledged certain medical principles regarding the asbestos cases. First, brief exposures to asbestos have caused **mesothelioma** in persons decades later. Second, every non-trivial exposure to asbestos contributes to and constitutes a cause of **mesothelioma**. *Hennegan, supra*, p. 8-17, at 103-107.

In Jones v. John Crane, Inc., 132 Cal. App. 4th 990, 999 (2005), the California Court of Appeals relied on similar testimony:

Dr. Barry Horn testified that Jones had substantial occupational exposure to asbestos while in the Navy and that every exposure, including asbestos releases from defendant's packing and gasket products, contributed to the risk of developing lung cancer. The testimony of the experts provided substantial evidence that Jones's lung cancer was caused by cumulative exposure, with each of many separate exposures having constituted substantial factors contributing to his risk of injury.

In Alliegro v. AC&S, Inc., 691 A.2d 102, 104 (1997), the D.C.

Court of Appeals relied on the following medical testimony in reversing the trial court's dismissal:

Each and every dose contributes to the risk of developing the disease and also contributes to the risk of progressing once you have the disease. So it's impossible to pick out one particular exposure and say that's the culprit. Each and every exposure contributes to it and that's been shown in a number of different studies that there's this dose response relationship. The more you get exposed, the higher your risk of developing the disease is and the more you get exposed, the higher your risk of progressing with that disease.⁴²

In sum, numerous appellate courts throughout the United States recognize and accept as reliable and sound the opinion – based in biological and epidemiological science – that the dose-response relationship applies to asbestos disease and that all exposures to asbestos cumulatively contribute to cause mesothelioma.

⁴² In Smalls v. Pittsburg Corning, 843 A.2d 410, 414 (Pa. Sup. 2004), the appellate division rejected an attack on similar testimony:

Next, Appellant asserts that the trial court erred in allowing Dr. Richard Katz, Appellees' expert, to testify as follows: "Each and every breath of asbestos fibers is [a] significant and substantial contributing factor to the asbestos-related disease that Mr. Smalls has." N.T. Trial, 12/4/01, at 32. Appellant argues that the opinion was inadmissible because it had no basis in fact nor general acceptance in the scientific community. We disagree.

D. The Opinion That All Asbestos Exposure Contributes To Cause A Person's Mesothelioma Follows From The Generally Accepted Principle That Mesothelioma Is A "Dose-Response Disease".

The scientific community generally holds that asbestos diseases, including mesothelioma, are "dose-response diseases," and that there is no known threshold of asbestos exposure below which mesothelioma cannot occur.⁴³ This conclusion has been widely held in the scientific community since before the 1980's. For example, in a 1985 review entitled, "*Asbestos, effects on health of exposure to asbestos*," Richard Doll and Julian Peto, two very well known professors of epidemiology stated:

As with lung cancer (and with other cancers due to other causes) increasing exposure increases the risk of developing the disease, but does not affect the length of the induction period.

Similarly, Dr. Irving Selikoff, the most well known asbestos researcher in the United States, stated:

Less asbestos, less disease. More asbestos, more disease.
This central fact provides guidance for what is to be done.

* * * *

[E]ach opportunity for asbestos exposure should be controlled not only because of its own hazard, but because it would be adding to the risk from other sources. . . . The

⁴³ Defendants acknowledge:

There is no dispute in the relevant scientific communities that mesothelioma, like other asbestos-related diseases, is a dose-responsive disease. That means that the risk of developing the disease rises as an individual's exposure to asbestos fibers increases over time and in severity.

IMO Br., p. 41, n. 17 (emphasis added).

dose response relationship for asbestos appears to be linear. This predicts disease with low exposures. The model has been shown to be correct. (emphasis added)

Irving J. Selikoff, Twenty Lessons from Asbestos: A Bitter Harvest of Scientific Information, Journal of Environmental Health 47:140-144 (1984) (Reprinted from EPA Journal).⁴⁴ As recently as May, 2006, the World Health Organization reiterated its conclusion that “there is no safe threshold level of exposure.” World Health Organization, publication dated September 2006.

E. Even Low Dose Exposure to Asbestos Increases the Risk of Developing Mesothelioma And The Risk Rises With Increased Exposure.

It is well established that mesothelioma has been diagnosed in individuals with brief, low, or indirect exposures to asbestos. See S.N. Chang, L.E. White, W.D. Scott, Assessing Asbestos Exposure Potential in Nonindustrial Settings, J. Community Health, 12(2): 176-184 (1987). See Gunnar Hillerdal, Mesothelioma: Cases Associated With Non-Occupational And Low Dose Exposures, Occup. Environ. Med. 1999, 56: 505-513.⁴⁵ A large case control study by Iwatsubo et al ⁴⁶ found that

⁴⁴ Dr. Finkelstein's study of asbestos workers in a cement plant reached a similar conclusion: “the relation [between exposure and the development of mesothelioma] is compatible with a linear function *through the origin*.” Finkelstein, M.M., Mortality among Long-Term Employees of an Ontario Asbestos-Cement Factory, British Journal of Industrial Medicine, 40:138-144 (1983). All of these articles are attached as an Appendix to this Reply Brief.

⁴⁵ See also Luigi Giarelli, Claudio Bianchi, Giorgio Grandi, Malignant Mesothelioma of the Pleura in Trieste, Italy. Am. J. Industrial Med. 22:521-530 at 526 (1992) (“[V]ery

the exposure group with total estimated exposures from .5 to .99 f/ml years, was four times as likely to develop mesothelioma than the control group. The authors concluded that there was "a clear dose-response between the cumulative exposure to asbestos and pleural mesothelioma . . . A significant excess of mesothelioma was observed for levels of cumulative exposure that were probably far below the limits adopted in many industrial countries during the 1980s." Iwatsubo, at 141. Likewise, Rodelsperger⁴⁷ also concluded that there was a distinct dose-response relationship even at levels of cumulative exposure below 1 fiber year, with exposures from .15 to 1.5 fiber years showing a significantly increased risk of mesothelioma. These results were confirmed by a further case-control study that looked at lung tissue fiber concentrations. Rodelsperger, at 273.

Much of this literature was the subject of testimony in a Frye hearing conducted before Judge Sharon Armstrong in November 2006 in the case of Lott v. Bondex International, Case No. 05-2-06955-4 SEA. Dr. Brodtkin and Dr. Hammar testified in that hearing and the court denied

short periods spent in a workplace polluted by asbestos are sufficient to induce a malignant mesothelioma after many decades.").

⁴⁶ Iwatsubo et al, Pleural Mesothelioma: Dose Response Relation at Low Levels of Asbestos Exposure in a French Population-based Case Control Study, Am. J. of Epi. 148: 133-142 (1998).

⁴⁷ Rodelsperger, et al., Asbestos and Man-Made Vitreous Fibers as Risk Factors for Diffuse Malignant Mesothelioma: Results from a German Hospital-Based Case-Control Study, Am. J. Industrial Medicine, 39:262-275, at 272 (2001).

defendants' effort to strike the expert testimony. A copy of that order, as well as the testimony in that hearing, is attached to this brief as part of Appendix A. This testimony further supports the position that if Frye were applicable to Dr. Mark's opinions, his opinions satisfy the Frye requirements.

VI. HUE SUPPORTS AN ALTERNATIVE BASIS FOR FINDING PROXIMATE CAUSE IN THIS CASE

All parties in the trial court extensively discussed Mavroudis on the issue of proximate cause. No one reading the "causation" section of Mavroudis (86 Wn. App. 27-33) could fail to understand the relevance to that discussion of Hue, which was cited ten times and extensively discussed in those seven pages. For example, at page 30, this Court held:

By citing *Lockwood* in conjunction with *Martin v. Abbott Laboratories*, the case eliminating the need to show individual causal responsibility in DES cases, the *Hue* court certainly implied that asbestos-injury plaintiffs need not prove or apportion individual causal responsibility but need only show that the defendant's asbestos products were among those in the plaintiff's work environment when the injurious exposure occurred.

This language forecloses defendant Buffalo's argument that Hue is not "analogous to asbestos cases." Buffalo Br., p. 37. Nor is Buffalo correct in its argument that Hue is not applicable because the trial court here (unlike the trial court in Hue), may not have utilized Dr. Mark's opinion that "all of the asbestos exposure [sustained by plaintiff] that

occurred prior to the malignancy together contributed to cause his diffuse malignant mesothelioma. Id. at p. 38. This Court reviews the evidence “*de novo*,” so it does not make sense to argue that similarity of Dr. Mark’s opinion and the evidence in Hue should be determined by how the trial court in this case evaluated the evidence.

Buffalo and Warren argue, citing RAP 2.5, agree that “Plaintiff Failed To Preserve Error Regarding The Application Of The Hue v. Farmboy Spray.” Buffalo Br., p. 37, n.19; Warren Br., pp. 25-27. Leslie, however, did not make this argument. That is probably because Leslie knew that plaintiffs specifically cited Hue in connection with Leslie’s causation argument at CP 5234:

The medical causation testimony offered by plaintiffs in the case at bar is consistent with *Mavroudis v. Pittsburgh Corning Corp.*, 86 Wn. App. 22, 935 P.2d 1684 (1997), *Lockwood v. A C & S*, 109 Wn.2d 235, 744 P.2d 605 (1987), and *Hue v. Farmboy Spray Co.*, 127 Wn.2d 67, 896 P.2d 682 (1995).

Given that all remaining defendants incorporated Leslie’s arguments, it only makes sense that the cases raised in opposition to Leslie’s arguments would also apply to those “incorporating defendants.” Moreover, as discussed above, both plaintiffs and defendants repeatedly cited to Mavroudis, which clearly brought up the Hue case and analysis.

Leslie also seeks to distinguish Hue by arguing that in Hue it:

[D]id not matter which part of the cloud may have caused the plaintiffs' alleged damages (or what percentage of the cloud such product constituted) since DuPont provided all of it. . . . *Mavroudis* merely explained that, in the multi-supplier asbestos case before it, the plaintiff would have prevailed even if the *Hue* standard had been applied because there was evidence that the plaintiff's exposure to Kaylo was sufficient in and of itself to have caused the disease at issue

Leslie Br., p. 32-33. That argument blatantly misreads both Hue and Mavroudis. It misreads Hue because, in addition to suing DuPont, the plaintiffs in Hue sued 27 separate wheat ranchers who ordered their ranches to be sprayed. 127 Wn.2d at 70. It therefore mattered a lot to each of those 27 defendants whether their individual application had caused damage. The ranchers who were each responsible for a relatively small portion of the pesticide are directly analogous to these defendants who purchased asbestos packing and gaskets from a manufacturer and were also responsible for a relatively small percentage of Mr. Morgan's asbestos exposure.

Leslie also misreads Mavroudis' analysis of Hue, which was that Hue established an easier standard than the jury instruction considered in Mavroudis. That is because, unlike the instruction, Hue did not require proof that the individual defendant's share of the harmful agent would have been sufficient in and of itself to cause them harm. 86 Wn. App. at

29-30. This Court's point in Mavroudis was that because the instruction in Mavroudis was stricter than what was required by Hue, it was thus within Hue's broad reach.⁴⁸

Defendants' goal is to create a situation in which when many companies distribute cancer causing materials that combine to give a person cancer, then none of them would be liable. This is explicit in Aurora's Br. at page 20, arguing that:

In this case, Farrow identified nine different valve manufacturers and 15 different pump manufacturers during his depositions. (CP 1435, 4206-07) He also identified manufacturers of numerous other asbestos-containing products. (CP 4218-23, 4229, 32) Under these circumstances, Morgan's limited exposure to pumps made by Aurora does not rise to the level of a "substantial factor." (emphasis added)

While good for Aurora and other distributors of cancer causing materials, that position would be disastrous for people contracting cancer from those materials. Moreover, Lockwood, Hue, and Mavroudis, reject that argument.

VII. DEFENDANTS ARE NOT ENTITLED TO SUMMARY JUDGMENT ON THE GOVERNMENT-CONTRACTOR DEFENSE

Weir admits that it "moved for summary judgment on the basis of the government-contractor defense recognized by the U.S. Supreme Court

⁴⁸ Defendants ignore that, as explained by this Court, the Hue formulation was the formulation recommended by PROSSER AND KEETON'S ON TORTS § 41 in Fifth Edition. 86 Wn. App. at 30. Thus, Hue was also well supported by scholarly analysis.

in Boyle v. United Technologies Corp., 487 U.S. 500 (1988).” Weir Br., p. 34. That motion was denied. RP 156. Weir also admits that, “Boyle, like this case, presented the question of whether a contractor providing military equipment to the federal government could be held liable under state law for injury caused by a product design defect.” Id. at 35 (emphasis added).

A. Neither Weir Nor Any Other Defendant Argues In This Court A Contract Specification Defense Based On Failure To Warn.

As discussed above, Weir’s argument only deals with design defects. While cases following Boyle have applied that defense to warnings, they do not utilize the test enunciated by Boyle for design defect, but utilize different factors. Joint Eastern and Southern District New York Asbestos Litigation, 897 F.2d 626, 630 (2d Cir. 1990). Dorse v. Eagle-Picher Industries, Inc., 716 F. Supp. 589 (S.D. Fla. 1989), *aff’d*, 898 F.2d 1487 (11th Cir. 1990). In Timberline Air v. Bell Helicopter, 125 Wn.2d 305, 324-330, 884 P.2d 920 (1994), the Washington Supreme Court explained that the issues are generally different in a government specification defense based on warnings than in a government specification defense based on design defect. Defendants do not argue or even cite those cases on these factors. Indeed at pages 13-14 of its brief, Buffalo admits that the military specification defense was only raised with

regard to design defect. See also RP 56, 78. Thus, there is no basis to dismiss plaintiffs' warning claims based upon the government-contractor defense. See RAP 9.12.

B. Summary Judgment Was Not Warranted, Even Relating To Design Specifications.

As the Second Circuit explained in In re Joint Eastern and Southern District New York Asbestos Litigation, 897 F.2d at 632:

[S]tripped to its essentials, the military contractor's defense under *Boyle* is to claim, "The Government made me do it." *Boyle* displaces state law only when the Government, making a discretionary, safety-related military procurement decision contrary to the requirements of state law, incorporates this decision into a military contractor's contractual obligations, thereby limiting the contractor's ability to accommodate safety in a different fashion." (Emphasis added.)

It is therefore important in evaluating the Boyle test to know whether any government's contract "incorporates this decision into a military contractor's contractual obligations." Plaintiffs pointed out in the trial court that defendants had not supplied any such contracts. See, e.g., RP 57. In denying the motion, the trial court at RP 136 noted that "we don't have the contracts" and that:

[I]t is contested factually, particularly, it seems to me as to what are reasonably precise specifications. And whether or not the equipment conformed to these specifications.

The record supports the trial court's conclusion that there were disputed issues of fact. While presenting no contracts, defendants,

including Buffalo, presented some evidence that the government required then to follow military specifications requiring the use of asbestos in gaskets and packing. However, there was substantial contrary evidence, including testimony from Buffalo's corporate representative that Buffalo eliminated the use of asbestos in gaskets and packing in Navy pumps without Navy approval:

- A. Gaskets and packing. And the Navy side, again, we had to get the approval. We finally didn't – couldn't wait for the approval anymore, so it was our decision to change to the non-asbestos types. The timing is a little different on the two of them. (Emphasis added)

CP 5175. Given that testimony, there is substantial evidence the “the Government [didn't] make me do it,” and defendants never provided the contracts to settle that dispute.⁴⁹

There was also disputed evidence concerning whether the specifications allowed defendants to choose between asbestos and non-asbestos components for its product. For example, Weir corporate representative Samuel Shield, testified at CP 6192:

⁴⁹ See also Weir's representative's testimony at CP 6191:

Q. Does Atwood & Morrill have any documentary evidence at all – any documents, correspondence or anything – from the United States Navy, indicating that the United States Navy required the use of asbestos in valves it purchased from Atwood & Morrill?

A. No. None that I know of.

Q. Navy specifications – let me ask you this question. If a Navy specification allowed for the use of asbestos or non-asbestos components, Atwood & Merrill could make an election and still be within the parameters of the specification, correct.

A. Yes. But I've never seen that. (Emphasis added.)

Other defendants, however, submitted contradictory evidence in the form of the specifications themselves. For example, Buffalo submitted a military specification for pumps that required that packing be “in accordance with drawing B-153”:

3.3.19 Stuffing boxes and packing –

* * * *

3.3.19.2 Packing shall be in accordance with Drawing B-153. All packing shall be of a brand approved by the bureau or agency concerned.

Drawing B-153 (CP 3302) actually shows that for many purposes, the specification permitted either asbestos or non-asbestos packing.⁵⁰

Plaintiffs also explained in the trial court why the evidence concerning Aurora Pumps made summary judgment inapplicable on this defense::

Asbestos “was the common material used in all of industry.”⁵ (Franklin Depo., April 28, 2009, p. 72, Exhibit B.) Prior to 1984, non-asbestos packing was used by Aurora “only in special applications. There was very little packing that was non-asbestos at that time.” (*Id.*, p. 73.) In fact, no other material other than asbestos was used as packing in the 1960 timeframe for Aurora pumps installed

⁵⁰ Plaintiffs attach as Appendix B to this reply an enlargement of Drawing B-153 because the original is almost impossible to read.

aboard naval vessels. (Franklin Depo., July 8, 2008, p. 81, Exhibit D.) When packing needed replacement, Aurora specified in its Bulletin that the customer needed to use “long fibre asbestos.” Aurora’s Bulletin also specified that its outlined procedures “must be rigidly followed.” (*Id.*, p. 63-64 and Exhibit 5003, p. 3 Exhibit D to the Barrow Deposition.)

CP 6244-6245.

VIII. DEFENDANTS ARE NOT ENTITLED TO SUMMARY JUDGMENT BASED ON SUPERSEDING CAUSE

In Washington, there is a non-delegable duty to warn a user, even if the user’s employer is aware of the product’s danger. For example, in Braxton v. Rotec Indus., 30 Wn. App. 221, 226, 633 P.2d 897 (1981), this Court explained that a manufacturer has a separate duty to warn an employee even if the employer knows the danger: Braxton is consistent with Hoglund v. Raymark Indus., 50 Wn. App. at 370-72. Hoglund is directly on point with the present case because it also involved a defendant’s claim that the Navy’s failure to warn about the risks of asbestos exposure at PSNS should have been a superseding cause. This Court at pages 371-372, rejected defendant’s position, stating:

... To remove liability from the original tortfeasor, the intervening negligence of another must be so extraordinary or unexpected that it falls outside the realm of reasonably foreseeable events; unless this threshold is met, there is not superseding cause. *Smith v. Acme Paving Co.*, 16 Wn. App. 389, 558 P.2d 811 (1976). The actions of the government through its management of PSNS were not unexpected or extraordinary, since the procedures for using asbestos

products at PSNS were similar or identical to those followed elsewhere. ...

At most, the failure of the government to warn *Hoglund* of the danger of asbestos exposure was a concurring cause of his injury and, as such, did not remove Raymark from liability for the injury. (Emphasis added.)

Leslie's Brief at page 49 cites one page from Campbell v. ITE Imperial Corp, 107 Wn.2d 807, 733 P. 2d 969 (1987), but its interpretation of Campbell is contrary both to the case itself and to the way Campbell has been interpreted by the Washington Court of Appeals in Anderson v. Dreis & Krump Mfg. Corp., 48 Wn. App. 432, 739 P.2d 1177 (1987). First, Leslie ignores large portions of Campbell, including 107 Wn.2d at 814, where the Supreme Court held that:

The manufacturer bears responsibility for affixing an adequate warning to its product, *see Teagle v. Fisher & Porter Co.*, 89 Wn.2d 149, 155, 570 P. 2d 438 (1977), and this duty generally is not delegable. *Minert v. Harsco Corp.*, 26 Wn. App. 867, 874, 614 P. 2d 686 (1980). Thus, it would be anomalous to hold that an employer's failure to warn constituted a superseding cause. . . . Such a rule might improperly shift the duty of warning to product purchasers. Although such a purchaser might be held jointly liable for breach of its duty to warn, its negligence generally should not relieve the manufacturer of liability for failure to warn. Regardless, we believe the PUD's negligence in failing to warn was reasonably foreseeable. (Emphasis added)

Second, in Anderson, 48 Wn. App. at 442-444, the Court relied on Campbell, but interpreted Campbell consistently with plaintiffs' position:

In this context our Supreme Court has held that generally an intervening act is not a superseding cause where the intervening act (1) does not bring about a different type of harm than otherwise would have resulted from the defendant's conduct; and (2) does not operate independently of the situation created by the defendant's conduct. *Campbell*, at 813-14; *Herberg v. Swartz*, 89 Wn.2d 916, 927-28, 578 P.2d 17 (1978); *Restatement (Second) of Torts* §§ 442-445 (1965). The above principles are equally applicable to negligence and strict products liability theories. *Campbell*, at 814.

Id. at 444 (emphasis added; footnotes omitted).

The Washington Supreme Court confirmed Anderson's (and plaintiffs') view of Washington law relating to superseding cause in Crowe v. Gaston, 134 Wn.2d at 519-520:

Only intervening acts which are not reasonably foreseeable are deemed superseding causes.' *Cramer v. Department of Highways*, 73 Wn. App. 516, 520, 870 P.2d 999 (1994) (quoting *Anderson v. Dreis & Krump Mfg. Corp.*, 48 Wn. App. 432, 442, 739 P.2d 1177 (1987)).⁵¹

(Emphasis added.) Defendants, however, do not present evidence to prove either that (a) the Navy's conduct brought about a different type of harm than otherwise would have resulted from their failure to warn; or (b) the Navy's conduct was wholly unforeseeable to defendant. Yet, both of those must be shown by defendants, who have the burden of proof on this

⁵¹ See also McCoy v. American Suzuki Motor Corp., 136 Wn.2d 350, 961 P.2d 952 (1998) (the defendant's actions are the cause in fact of plaintiff's injuries if the defendant's wrongdoing produced the injuries complained of and any intervening cause was reasonably foreseeable. *Maltman*, 84 Wn.2d at 982-83; *Schooley*, 134 Wn.2d at 482); Johnson v. State, 77 Wn. App. 934, 942, 894 P.2d 1366 (1995); Riojas v. Grant County PUD, 117 Wn. App. 694, 72 P.3d 1093 (2003).

affirmative defense, in order for the Navy's conduct to be a superseding cause. There is thus, at a minimum, materially conflicting evidence.

Turning first to foreseeability, there is abundant evidence that the Navy's conduct was not unforeseeable to defendants, who themselves did not warn their employees of the risk of asbestos from gaskets and packing.

See, e.g., CP 5216, 6246. As explained in In re Brooklyn Navy Yard Asbestos Litigation, 971 F.2d 831, 838-39 (2d Cir. 1992):

An intervening act breaks the causal nexus only if it is "extraordinary under the circumstances, not foreseeable in the normal course of events." . . . The Navy's conduct in failing to protect its workers from the hazards of asbestos exposure, while reprehensible, was anything but unforeseeable.

Turning next to the necessity that the intervening acts "bring about a different type of harm than otherwise would have resulted from the defendant's conduct,"⁵² defendants can make no such showing with respect to failure to warn. The harm caused by defendants' failure to warn was that Mr. Morgan was unaware of the risks of asbestos from their products. That is exactly the same harm caused by any failure by the Navy to warn Mr. Morgan. As quoted above:

At most, the Government's failure to warn Heglund of the danger of asbestos exposure was a concurring cause of his injury, and, as such, did not remove Raymark from liability for his injury.

⁵² Anderson, 48 Wn. App. at 444.

Hoglund, 50 Wn. App. at 372. See also Greenleaf v. Puget Sound Bridge & Dredging Co., 58 Wn.2d 647, 364 P.2d 796 (1961); Van Buskirk v. Carey Canadian Mines, Ltd., 760 F.2d 481, 493-497 (3d Cir. 1985).

IX. DEFENDANTS ARE NOT ENTITLED TO SUMMARY JUDGMENT BASED ON THE SOPHISTICATED USER DEFENSE⁵³

A. Strict Liability.

In states which (unlike Washington) have adopted the “sophisticated user defense”, it “is considered an exception to the manufacturer’s general ‘duty to warn’.” Johnson v. American Standard, Inc., 43 Cal. 4th 56, 64, 179 P.3d 905, 910 (2008). As its name implies, the “sophisticated user defense” looks to the sophistication of the “user” of the product as that term is defined under the relevant law. In Johnson, the Court analyzed the evidence of the knowledge of HVAC technicians – one of whom was the plaintiff. The sophisticated user defense could only be relevant to this case if this Court were to conclude, contrary to controlling Washington law, that the Navy, rather than Mr. Morgan, was the relevant user or that a manufacturer did not have a duty to warn the ultimate user.

Plaintiffs raised a strict liability claim in their complaint. CP 10. Buffalo acknowledges at page 9 of its brief that plaintiffs made claims under “strict product liability under Section 402A of the Restatement

⁵³ The only defendants who briefed these issues in this Court are Buffalo (Brief, pp. 46-48) and Leslie (Brief, p. 49, n. 19).

(Second) of Torts.” Washington adopted strict liability under that section in Ulmer v. Ford Motor Co., 75 Wn.2d 522, 452 P.2d 729 (1969).

Washington strict liability law focuses on the “ultimate user” which is the term used in Restatement (2d) of Torts, §402A.

Washington law holds that a user includes the person (such as an employee), who actually uses the product. For example, in Jackson v. Standard Oil Co., 8 Wn. App. 83, 100, 505 P.2d 139 (1972), this Court relied on a comment to Restatement § 402A when holding:

“User” includes . . . those who are utilizing it for the purpose of doing work upon it, as in the case of an employee of the ultimate buyer who is making repairs upon the automobile which he has purchased.

(Emphasis added.) Similarly, in Lunsford v. Saberhagen, 125 Wn. App. 784, 793, 106 P.3d 808 (2005), this Court held that the trial erred in finding, as a matter of law, that the spouse of a worker, who was exposed to asbestos via her husband’s work, “was not a user or consumer of Saberhagen’s products.” Washington law also specifically provides that it is not relevant that a danger is known to an employer; the relevant issue is whether it was known to the employee. Braxton v. Rotec Indus., 30 Wn. App. at 226. See Minert, 26 Wn. App. at 874-75; Campbell, 107 Wn.2d at 814. This means that, contrary to defendants’ position, warning an

employer is not sufficient for strict liability purposes even if the employer is “sophisticated”.

The Washington cases defendants rely on are Reed v. Pennwalt Corp., 22 Wn. App. 718, 722, 591 P.2d 478 (1979) and the Court of Appeals decision in Little v. PPG, 19 Wn. App. at, 825. Buffalo Br, p. 45. Both cases base their analysis on Restatement (Second) of Torts § 388, which explicitly relates to negligence rather than strict liability.⁵⁴

Defendants fail to point out, however, that the Washington Supreme Court in Little v. PPG Industries, 92 Wn.2d at 121, reversed the Court of Appeals analysis applying § 388 to strict liability. The Supreme Court held:

Because of the language in comment j, and because the Restatement treats the duty to warn in another section, 388, and that section spells out the duty in terms of negligence, it has been suggested that section 388 should be read into section 402A by implication.

We think, however, that the objective of the rule of strict liability with respect to dangerous products is defeated if a plaintiff is required to prove that the defendant was negligent, or the latter is allowed to defend upon the ground that he was free of negligence. It is the adequacy of the warning which is given, or the necessity of such a warning, which must command the jury’s attention, not the defendant’s conduct. (emphasis added)

⁵⁴ Akin v. Ashland Chemical, 156 F.3d 1030, 1037 (10th Cir. 1998) and Strong v. E.I. DuPont de Nemors Co., Inc., 607 F.2d 682, 686-87 (8th Cir. 1981), the Federal cases cited by Buffalo at page 47 of its brief also rely on § 388.

Thus, neither the Court of Appeals decisions in Reed nor Little have been good law in Washington on this issue, in the context of strict liability, since 1979.⁵⁵

B. Negligence.

Plaintiffs also raise a negligence claim in their complaint and § 388 of the Restatement is applicable to negligence under Washington law. See Baughn v. Honda Motor Co., 107 Wn.2d 127, 727 P.2d 655 (1986).

However, summary judgment is not proper even for the negligence claim under the facts presented here. The facts of record in Johnson stand in sharp contrast to the facts of record here.⁵⁶ Johnson held that the focus of the defense is whether “the danger in question was so generally known within the trade or profession that a manufacturer should not have been expected to provide a warning specific to the group to which plaintiff belonged” 179 P.3d at 915. Under that “focus,” the facts here will not

⁵⁵ It is more understandable that the Delaware trial judge in In re Asbestos Litigation, 542 F.2d 1205, 1209-10 (Del.Superior Ct. 1986) was not aware that the Washington Supreme Court had rejected the use of § 388 in strict liability cases than that defendants’ Washington counsel would be unaware of the Supreme Court decision in Little. Moreover, other states, in the asbestos injury context, have rejected the sophisticated user doctrine in strict liability cases. Menna v. Johns-Manville Corp., 585 F.Supp. 1178, 1185 (D. N.J. 1984), *aff’d*, 772 F.2d 895 (3d Cir. 1985) (Pennsylvania law); Russo v. Abex Corp., 670 F.Supp. 206 (E. D. Mich. 1987) (Michigan law).

⁵⁶ In Johnson, the dangers of the product which caused injury -- R-22 -- was repeatedly listed on Material Safety Data Sheets that Johnson received in 1997 when he first started working with that product, and Johnson’s employers were required to train their employees about such dangers. 179 P.3d at 907. In the present case, there is no evidence that Mr. Morgan or others in his trade were aware of the hazards of asbestos and even defendants submitted evidence that the Navy was unaware of the hazards of asbestos-containing gaskets and packing in December 1968. CP 4132.

justify summary judgment because there is no evidence that the dangers of asbestos packing and gaskets were generally known within Mr. Morgan's trade of pipefitter.

The Second Circuit, in a factually very analogous setting involving asbestos injury at the Brooklyn Naval Shipyard rejected defendants' arguments relating both to the sophisticated user and superseding cause even under § 388 of the Restatement (Second) of Torts. In In Re Brooklyn Navy Yard Asbestos Litigation, 971 F.2d at 838-839, the Court stated:

Given that the record supports neither a finding that defendants actually relied on the Navy to warn its workers, nor a finding that any such reliance would have been justifiable, the presence of the Navy as an alleged "sophisticated intermediary" or "knowledgeable user" does not call into question the jury's finding of defendants' duty to warn. See Restatement (Second) of Torts § 388, cmt. n (1965). (Emphasis added.)

Buffalo cites no evidence that it relied on the Navy to warn workers such as Mr. Morgan or that the Navy's conduct was unforeseeable. This Second Circuit opinion strongly supports plaintiffs' position that, at a minimum, there are disputed issues of material fact regarding the applicability of the sophisticated user doctrine, even under negligence law, as well as the applicability of superseding clause. Even In Re Related Asbestos Cases, 543 F.Supp. 1142, 1151 (N.D.Cal. 1982), the federal case

relied on in Johnson, the court recognized that a plaintiff would be permitted:

[T]o negate the defense by showing that the sophisticated employer's misuse of the product was foreseeable, and so did not absolve the defendants of liability for failure of the duty to warn.

Other appellate cases on this issue in the asbestos context include Oman v. Johns-Manville Corp., 764 F.2d 224 (4th Cir. 1985) (en banc); Willis v. Raymark Industries, 905 F.2d 793 (4th Cir. 1999); Eagle-Picher v. Balbos, 326 Md. 179, 604 A.2d 445 (1992). According to Oman "Virginia recognizes the sophisticated user defense." 764 F.2d at 233. The plaintiffs in Oman were exposed to asbestos while working at the Newport News Shipbuilding facility. The Fourth Circuit, sitting en banc held that the trial court didn't err in refusing to charge the jury on the sophisticated user defense. Oman, 764 F.2d at 233. The court's analysis of § 388 in the shipyard asbestos context is equally applicable to the present case:

In this case the product, because it contained asbestos fibers, was very dangerous. The burden on the manufacturers in placing a warning on the product was not great. The employer was unaware of the danger until 1964. Finally, once the employer became aware of the potential danger it failed to convey its knowledge to its employees. We cannot say that the district court erred in refusing to give the charge requested by the manufacturers under the set of facts involved in this case.

604 A.2d at 465.⁵⁷

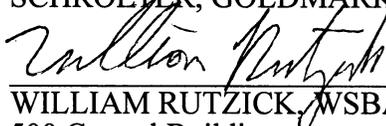
As discussed above, since these defendants never warned their own employees of the risks of asbestos, it was entirely foreseeable that Mr. Morgan's employer would do the same.

X. CONCLUSION

For the foregoing reasons, and the reasons set forth in plaintiffs' opening brief, the order dismissing plaintiffs' claims against defendants should be reversed and this matter remanded for trial.

RESPECTFULLY SUBMITTED this 1st day of ~~May~~ ^{June}, 2010.

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⁵⁷ Willis followed the reasoning in Oman. In Balbos, Maryland's highest court held:

To be entitled to a sophisticated user instruction, suppliers, at a minimum, must have introduced evidence that they warned the intermediary of the danger . . . or that they knew a warning was unnecessary because the intermediary was already well aware of the danger.

A-1

Twenty Lessons from Asbestos

A Bitter Harvest of Scientific Information

Irving J. Selikoff, M.D.

Reprinted from the EPA JOURNAL, May 1984.

It seems that we sometimes learn most from our worst mistakes. This certainly was the case in one of the greatest public health disasters in modern times—cigarette smoking. When the marked increase in cigarette use began after World War II, there were few predictions of what was to occur in the 1960s, 1970s and 1980s.

More recently, nature has been similarly unforgiving with regard to asbestos, perhaps because we were reluctant to heed the warnings that we were given. It was found in 1924, for example, that exposure to asbestos could result in fatal disease. In that year, the British Medical Journal published a report by W.E. Cooke of a young woman who had worked with asbestos and who had died with extensively scarred lungs. In 1927, again in the British Medical Journal, he gave the disease the name it still bears, Pulmonary Asbestosis. By 1930, additional British studies demonstrated that such scarring was very common among workers exposed to asbestos and these observations were soon confirmed in our country by Fulton, Dressen, Lanza and their colleagues as well as by other scientists. By the mid-1930s, it was well established that asbestos inhalation could frequently cause disease and that such disease might be fatal. Scientific research since then has added much information but, in a sense, this largely defined the different ways that asbestos could kill. Thus, in 1935, Lynch and Smith in the United States and Gloyne in Great Britain, noted the association of lung cancer and asbestos work, and during the 1940s and 1950s,

cases of pleural and peritoneal mesothelioma were seen in asbestos-exposed workers. This association was clarified and firmly established in the first half of the 1960s by Wagner, Selikoff, Churg, Newhouse and others. Additional neoplasms (malignant growths)—again, further ways of dying—were subsequently found related.

We are now in the midst of wide-spread asbestos disease resulting from exposures during the past 60 years. So far, W.J. Nicholson has calculated that there have been more than 100,000 deaths of asbestos-associated disease and that we may look forward to more than 350,000 additional such deaths before the effects of past exposures run their course. These projections are concerned with cancer deaths from occupational sources. There will be additional excess cancer deaths from non-occupational exposures, as well as deaths from asbestosis, but it has not yet been possible to make appropriate quantitative predictions. Further, the predictions are predicated on the assumption that, after 1980, asbestos exposure will have ceased. Initial experiences suggest that this was a dubious assumption, and that the tragic toll of death and disease will extend longer than we thought. Moreover, the 9,000 or so excess cancer deaths from occupational sources now seen each year are accompanied by many times that number of workers with asbestosis of greater or lesser severity, with greater or lesser disability, but insufficient to directly cause death.

Inevitably, the observation of so much serious disease has led to increased understanding of the circumstances in which it has occurred, (as scientists sought to evaluate those factors) both for prevention of disease in the future and to provide help to those for whom prevention is now too late. There has also been the hope that what we have

learned from the asbestos tragedy will provide principles that may help to prevent similar disasters in the future.

Twenty Lessons

We have been taught much by the asbestos experience. This could be analyzed differently by the industrial hygienist, the regulator, corporate risk manager, clinician, industry executive, union official, pathologist, insurance company executive, lawyer, physiologist, economist, molecular biologist, and others. But perhaps the most pertinent lessons of all have been those gleaned from a public health point of view, from the perspective of how to prevent preventable disease. Twenty have been selected as being central to EPA responsibilities and concerns.

1. Latency: Although tissues and cells begin to react to the presence of inhaled asbestos fibers on a microscopic level within hours and days, clinical effects are not seen for years or decades. Even with the extensive exposure that was frequently found in asbestos factories in the past, it was commonplace to find no X-ray or pulmonary function change until five, ten, or more years had passed. These clinical probes are insensitive for demonstrating early changes. In one study of 1,117 asbestos insulation workers, regularly employed in the construction industry under circumstances in which significant exposure was the rule, more than half of those with less than 20 years from onset of exposure still had normal X-rays. After that point, most X-rays were abnormal. We should not expect to see early evidence of asbestotic change.

The same constraint is the rule for asbestos-associated cancer and for fatal asbestosis, as well. In a prospective study of 17,800 asbestos insulation

Workers, 1967-1976, relatively few asbestosis-associated deaths were seen in less than 20 years from onset of their work exposure. Indeed, most deaths occurred 30, 40 or more years after exposure had occurred.

The disease and deaths now being experienced are the results of exposures in the 1940s and 1950s, with the 1960s beginning to make their contribution, the legacy of our mistakes in the past. Current exposures will not show their effects until the year 2010 and subsequently.

2. Irreversible errors: Once exposure has occurred (with one exception so far, see below) the die seems cast. We know of no way to remove or neutralize fibers in the lung or in other tissues (to which some migrate). Whether this is because of the residual fiber tissue burden or because of cellular and molecular changes is not known. From the point of view of prevention of future disease, control of human exposure, wherever and whenever it is occurring, is an emergency. Sometimes this is not appreciated. Somehow when the disease effect is 30 years off, there is little sense of urgency. This is wrong. There might be less complacency about friable asbestos in schools and public buildings if this were better appreciated.

3. Dose-disease response: Less asbestos, less disease; more asbestos, more disease. This central fact provides guidance for what is to be done. We may not be able to control every last fiber in the environment, but we can take some comfort in knowing that as our engineering and regulatory measures become more and more effective, there will be less and less disease. However, the "dose" of asbestos is cumulative with newly inhaled fibers added to the burden already present. Therefore, each opportunity for asbestos exposure should be controlled not only because of its own hazard, but because it would be adding to the risk from other sources. This is a good example of the correctness of the definition of dose as "intensity \times time."

With many agents, it is very difficult to ascertain "dose" associated with disease being seen, since the exposures responsible for such disease occurred decades before, when measurements were not made. Seidman and his colleagues have recently reviewed a unique set of circumstances demonstrating the dose-disease response nature of asbestosis disease. They traced the long-term

mortality experience of a large group of asbestos factory workers employed during World War II. They were all exposed to the same fiber, making the same products, using the same machinery, in the same plant. They differed, however, in one respect. Because of wartime conditions, some worked for a day, a week, a month, several months. Others worked from the time the plant opened in 1941 to when it closed in 1954. Since the intensity for the groups involved was the same, dose was proportional to duration of exposure. Lung cancer incidence for the various groups increased with increasing dose.

4. Disease with brief exposure: There have been numerous reports of relatively brief exposure and the subsequent occurrence of disease. However, many reflected individual experiences and for diseases such as lung cancer, they did not "prove" an association with short exposure.

The risk of brief exposure became better established with the study of mesothelioma, a neoplasm which has few known causes in humans other than asbestos. When mesothelioma is found, prior asbestos exposure is looked for and usually found. When asbestos exposure occurs, there is significant risk of subsequent mesothelioma. The extraordinary relationship between asbestos exposure and mesothelioma was perhaps best considered by Cochrane and Webster. They interviewed 107 patients in whom the diagnosis of mesothelioma had recently been established by biopsy. In 106, potential prior exposure to asbestos was elicited. The experiences of Seidman et al. (see above) have provided the necessary population-based data to confirm the keen clinical observations previously made.

The mechanism by which brief exposure subsequently results in disease is not known. It may be related to the retention of fibers in tissues but it may not. The same phenomenon is seen in bladder cancer following exposure to beta-naphthylamine or benzidine or in angiosarcoma of the liver after vinyl chloride exposure where there is no evidence for retention of the chemical carcinogens.

5. Disease with low-level exposure: The dose-response relationship for asbestos appears to be linear. This predicts disease with low exposures. The model has been shown to be correct.

In 1965, Newhouse reported mesothelioma among individuals whose only known exposure had occurred as a result of residence in households of asbestos workers, or by virtue of living within a half-mile of an asbestos plant in London. Such family contact and neighborhood exposure mesothelioma has been widely confirmed and its importance documented. Of course, it can be argued that such exposure is not "low," particularly since it results in a significant amount of disease (in one current study, lung cancer risk appears to be about doubled and mesothelioma to be responsible for approximately 1% of deaths occurring 20 or more years following the initiation of household contact exposure).

What will happen at the lowest levels of exposure is still not known. There are other uncertainties. Brief exposure, if fairly intense, produces disease. Long-term exposure, at relatively low levels (household) produces disease. It is not known whether brief exposure to low levels will produce detectable disease. Complicating such analyses is the cumulative nature of even low-level exposure. The problem is not unique to asbestos; it is also the case with PCBs, dioxins, etc. This again points to the necessity for control of all sources.

6. Multiple factor interaction: It has long been suspected that much human disease from exogenous sources is multifactorial in nature. Asbestos taught us that this is indeed so. When the experiences of the 17,800 asbestos insulation workers, with smoking habits known and observed prospectively, were compared with those of 73,736 like men in the American Cancer Society's prospective study of cigarette smoking, a remarkable multiplicative effect was seen. Men who did not smoke and did not work with asbestos suffered 11 deaths per 100,000 man-years. For asbestos workers who did not smoke, it was five times as much, 58. On the other hand, individuals who smoked but did not work with asbestos had a death rate of 122 per 100,000 man-years, and men who had both exposures, asbestos and cigarette smoking, had 601. There is evidence that the same cigarette smoking-asbestos interaction may explain the increased risk of cancer of the esophagus, oropharynx and buccal cavity, and larynx. There is no such interaction, however, for mesothelioma, cancer of the stomach, colon-rectum or kidney—both

okers and non-smokers suffer equally.

Conclusions important for prevention may be drawn. First, all individuals known to have been exposed to asbestos should never start smoking, or, if they are smoking, should stop immediately. This is particularly important since data indicate that there can be reversal of risk once smoking ceases. Asbestos insulation workers who stop smoking after 5-10 years, have about one-third to one-half the risk of lung cancer of their mates who continue to smoke. While cancer, once it occurs, is not reversible, cancer risk may be. A corollary conclusion, however, is inherent in the above observations. Since smoking cessation will not affect risk of mesothelioma or the other neoplasms not associated with smoking, it will be equally necessary to control asbestos exposures. Both measures are needed.

7. Product use: For every worker employed in the manufacture of asbestos products, there may be 500 who would use them or be exposed indirectly during such use. It is therefore unfortunate that at the outset of our asbestos experience, we thought of "asbestos workers"—men and women employed in mining, milling or factory work. The first phase of asbestos exposure and accompanying disease was associated with *product manufacture*. Later, during the last 40 years or so, there was increasing attention to disease associated with product use in the construction industry, shipyards, powerhouses, chemical plants and refineries, brake maintenance and brake repair, etc. We are now entering a third phase—in which asbestos exposure will be associated with *environmental exposures*, during repair, renovation, removal, and maintenance of the asbestos put in place during Phase Two. We have learned the difficult lesson of not thinking of asbestos workers, but asbestos-exposed workers.

8. Industrial origin of environmental disease: The factory gate and the factory fence are porous. Almost all asbestos exposure is industrial in origin, although some fibers derive from erosion of natural outcroppings, and water may be contaminated as it filters through asbestos rock formations. Such environmental contamination is very limited, however, particularly in terms of disease.

9. Multiple effects/multiple agents: Asbestos can produce a variety of illnesses, ranging from pulmonary and pleural fibrosis to lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, cancer of the oropharynx and buccal cavity, laryngeal cancer, and kidney cancer. Other effects, too, are now being seen, including immunomodification and serological changes. The other side of the coin, important from a diagnostic point of view, is that virtually all of these diseases and modifications can be caused by other agents, as well. Even mesothelioma, so highly attributable to asbestos, can be found to have other causes. Already, erionite has been seen to produce pleural and peritoneal mesothelioma among residents of Cappadocia, Turkey, and there is considerable concern that other materials, particularly man-made fibers, may eventually be associated with mesothelioma risk.

10. Environmental persistence: It has been said that asbestos has "a half-life of infinity." This is remembered ruefully as one considers the 30,000,000 tons of asbestos put in place from 1900 to 1980, in our ships, buildings, schools, chemical plants, refineries, powerhouses, factories, etc. Approximately 700,000 tons of insulation materials were installed in the same period; much remains.

11. Complexity of initiation and promotion: There has been much scientific interest in recent years concerning the concept that carcinogenic agents may either initiate the cancer process or, once initiated by other agents, promote its development. Asbestos seems to do both, according to circumstances. Thus, for lung cancer, the data suggest that it acts as a promoter, multiplying the background risk at each attained age. A 50-year-old individual has a much greater background risk of lung cancer than, let us say, one who is 20. Asbestos, in each, multiplies that risk. It therefore does not achieve very much to restrict hiring to older workers, in the hope that latency would give them a very long life before lung cancer might strike. Two latencies have to be considered—background exposure and asbestos. This would apply, for example, to teachers in asbestos-laden schools. Their risk depends upon their age as well as their prior asbestos exposure. A 55-year-old teacher with

only 10 years in such a school nevertheless has important risk.

On the other hand, since there is little background risk of mesothelioma, asbestos acts as an initiator with risk increasing with age by approximately a power of four. Again in school circumstances, this points to the importance of prevention of exposure of children, with long lives ahead of them.

12. Complexity of societal consequences: It has long been a truism that, from an ecological and environmental point of view, everything is related to everything else. With asbestos, this dictum applies to other circumstances, as well. Current litigation has been marked by bankruptcy of major industrial firms, thousands of lawyers face each other in courts clogged by suits seeking help and redress, insurance companies are concerned with potentially monumental costs. It has been variously estimated that asbestos disease payments to victims will range between 40 and 150 billion dollars. In addition, Professor William G. Johnson of Syracuse has calculated that social costs of asbestos disease due to previous exposure will total more than three hundred billion dollars. Industrial practices are changing, with the advent of substitute materials, many of untested toxicity. Doubt has even been cast on the effectiveness and applicability of the workers compensation system.

We are also beginning to see another legal tangle, perhaps of equal or greater complexity, with legal battles shaping up over who is to pay for the expense associated with abatement of asbestos in schools and public buildings.

13. Early utilization of industrial hygiene engineering: Failure to respond early to information concerning the disease potential of asbestos carried with it the omission of measures needed to control exposure. Asbestos became entwined in industrial procedures with hazards intact. When, decades later, there was increasing concern with disease potential, it was doubly difficult to change uses and procedures integral with the entire fabric of industrial production. Moreover, since the industrial engineering measures that were needed were being telescoped into a relatively short period of time rather than having been accomplished over many years, these costs had to be borne at a time when the product itself was being questioned and sales were decreasing.

Disadvantages of fragmentary regulatory approaches: There has been less than complete interaction and interdigitation of knowledge, experience, research, regulatory actions. Dressen of the U.S. Public Health Service undertook a rather elegant study of asbestos disease potential in the early '30s (published in 1938). I expect that it was hardly known to the National Cancer Institute's Advisory Council when, in 1951, it rejected a proposal by Leroy U. Gardner, then a dean of experimental dust disease pathologists, to study cancer potential of asbestos in animals (he had early hints of such findings in his pneumoconiosis experiments).

There has been less than complete integration of the interests and studies of the EPA, NIOSH, NIEHS, CPSC, NCI. Fortunately, mechanisms exist for interdigitation.

15. Science is necessary but not sufficient: When, in the latter half of the 19th century, it began to be found that serious human disease could be caused by exogenous agents (infectious) a revolution in scientific thinking began: there was now not only description, but causation. (It is instructive to appreciate how recent this has been; 1982 was only the one hundredth anniversary of the discovery of the tubercle bacillus by Koch.) It was soon found that the identification of causes could be followed by their control. Pasteurization of milk, as well as sewer systems and clean water supplies were put in place. In the first half of the 20th century, we again applauded those who discovered still other causes of disease, often metabolic, endocrine, or nutritional.

The same approbation has not inevitably met those studies which have identified some of the new exogenous causes of disease. The tobacco industry has given no testimonial dinners to the researchers who have shown that this year we might expect more than 100,000 deaths from lung cancer due to cigarette smoking (plus additional excess deaths from cardiovascular disease and emphysema). As we consider 8-naphthalymine and benzidine, 4-aminobiphenyl, nickel smelting, arsenic, vinyl chloride, lead, cadmium, chromium, etc., we are reminded that, in the 1890s, there were no trade associations for the protection of the cholera vibrio or the tubercle bacillus, no firms producing salmonella, no public relations groups operating on

behalf of the pneumococcus, the diphtheria or the staphylococcus.

It has become clear that, just as in the 1890s, scientific research is necessary for the identification of causes of disease. But the simple gathering of data is only one part of the process. Utilization of the information is also required. Regulatory measures are needed, often of considerable complexity.

16. Indoor air pollution: It took some little time before it became clear which agency was going to consider itself responsible for indoor air pollution with asbestos. The complexity of the problems being found makes such bureaucratic reluctance understandable. Nevertheless, in view of the very large number of people involved, this has become increasingly important. Perhaps the late acceptance of responsibility, as well as the late identification by scientists of the potential importance, help to explain the paucity of exposure data now at hand.

17. Recruitment of constituencies: An important asbestos lesson, perhaps related to what has been said before about science being necessary but not sufficient, has been the increasing understanding that application of knowledge can be speeded up when those who are directly affected have the information that intimately concerns them. OSHA operates best, perhaps, when both labor and industry are aware of the facts that form the background for OSHA regulations. EPA's requirement that parents and teachers be told of asbestos findings in schools is of this genre. Control of asbestos exposure depends at least as much upon understanding at the shop floor, as upon intricate regulations ensconced in the *Federal Register*. If we don't have understanding of what has to be done on the part of supervisory personnel and workers, there will never be enough inspectors to insure safety. With understanding, we will need few.

All this translates into an important educational function for EPA!

How Many Angels on the Head of a Threshold?

18. Disease: There are learned and often esoteric discussions of how much disease might be expected at very low levels of exposure. Calculations are made and projections offered. It will be very difficult to verify or contradict

these. Epidemiologically, very large populations will be required, carefully defined as to biases and variables. Since few cases of disease are expected at such levels, it is unlikely that the vast resources necessary for these studies will ever be made available. Animal experiments at very low levels will always have the disadvantage of insecurity with regard to extrapolation to humans.

The discussions, while interesting and important from a regulatory point of view, nevertheless have an air of unreality at this moment, with workers still being exposed to permissible levels of more than 20 million fibers per day; these estimates refer to longer fibers and do not take into account the very much larger number of shorter ones which accompany them but are not counted. Concern about very low levels seems somewhat out of touch with reality while some schools have levels of 100 to 1,000 nanograms and while maintenance and repair work on asbestos materials is often undertaken without precautions or supervision.

19. Limitations of epidemiology: These are widely acknowledged—evidence is based upon human disease that has already occurred, available methods are insensitive in detecting other than very gross and marked effects, studies are not suitable for smaller populations, there is frequent lack of concomitant exposure data, etc. Further, with the inevitable biases and variability inherent in human population studies, residual uncertainties persist and sometimes the best that can be achieved is the acknowledgment of "associations" rather than definitive causation.

Yet for asbestos disease, epidemiology has served us well and we have had only limited assistance so far from animal studies. It is to be hoped that in coming years, with other agents, we will no longer have to depend so heavily on epidemiological studies of human experience.

20. The concept of "industry" identity: There is probably no such thing as a monolithic industry, each sector being identical with all others. Some industry units are knowledgeable, others not. Some are concerned and truly responsible, others couldn't care less. Who, then, speaks for "industry"? My own experience with asbestos problems indicates that trade associations do not

always speak for the most knowledgeable and the most involved industry units. This can be an important disadvantage.

Editor's Note: A reference list was not published in the *EPA JOURNAL*. Contact Dr. Selikoff for studies and publications referred to in the text. This reprinted article was not subjected to the Journal's editorial review, and is intended as a starting point for assessing the asbestos situation in the U.S. today. Dr. Selikoff is the nationally recognized leader in asbestos health effects research.

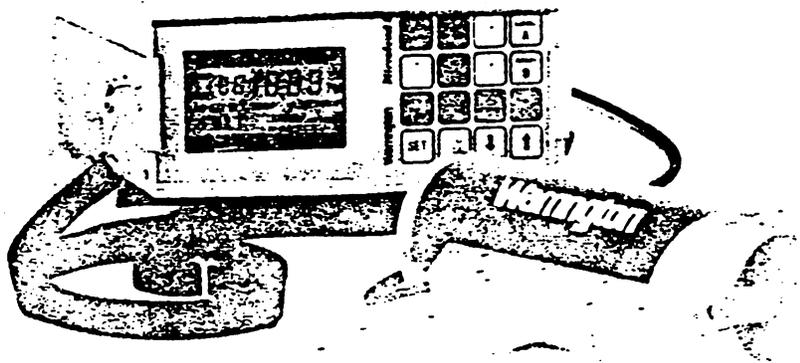
Research Council Offers Post-doctoral Studies

The National Research Council plans to award 250 new full time research associateships in 1985 to Ph.D. scientists and engineers of unusual promise and ability to conduct research at locations throughout the United States. Projects are at the researcher's choosing but must be compatible with the research interests of the supporting laboratory. Most of the programs are open to both U.S. and non-U.S. nationals and to both recent Ph.D. degree holders and senior investigators. The awards will be made on a competitive basis for research in chemistry, engineering and mathematics, and in the earth, environmental, physical, space and life sciences.

Awards are made for one or two years; however, senior applicants who have held the doctorate at least five years may request shorter tenures. Stipends for the 1985 program year will begin at \$25,350 for recent Ph.D.s and will be determined individually for senior associates. A stipend supplement up to \$5,000 may be available to regular (not senior) awardees holding recognized doctoral degrees in disciplines for which the number of degrees conferred by U.S. graduate schools is significantly below current demand.

Applications must be postmarked no later than January 15, 1985. Information on specific research opportunities and federal laboratories, and application materials may be obtained from Associateship Programs, Office of Scientific and Engineering Personnel, JH 608-D3, National Research Council, 2101 Constitution Ave. NW, Washington, DC 20418. Phone (202) 334-2760.

PRODUCT NEWS



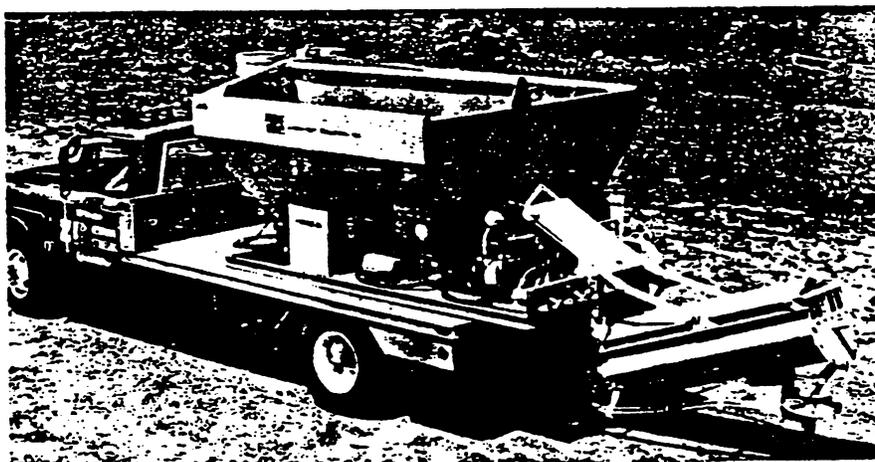
PN128401 ▲

The Warrington Inc. MicroLead I is a micro-computer based x-ray fluorescence spectrum analyzer with memory and report printing capabilities for monitoring lead in paint. It features a multi-colored liquid crystal display designed for effective visual interpretation. It has 8 to 10 year useful-life rechargeable batteries and self-diagnostics. The instrument measures toxic levels of lead to within 0.1 mg/cm².

For information on these products, use Reader Service Coupon, Page 171.

Zimmerman Industries, Inc. is offering a new Hot Sand Spreader for sanding icy roadways. It is a self-contained unit with its own auxiliary power plant that can be mounted on a conventional dump or flat bed truck. It carries approximately 160 cu ft of sand or other fine aggregate and immediately before spreading heats it with LP gas to approximately 380° F. The hot sand melts into the ice and as it refreezes a layered sandpaper effect is developed; thus continuous traction is possible as the ice wears down.

PN128402 ▼



A-2



**World Health
Organization**

Elimination of asbestos- related diseases

World Health Assembly Resolution 58.22 from 2005 on cancer prevention and control urged Member States to pay special attention to cancers for which avoidable exposure is a factor, particularly exposure to chemicals at the workplace and the environment. Asbestos is one of the most important occupational carcinogens causing about half of the deaths from occupational cancer (1;2). Furthermore, the Thirteenth Session of the Joint ILO/WHO Committee on Occupational Health in 2003 recommended that special attention should be paid to the elimination of asbestos-related diseases (3).

The term "asbestos" designates a group of naturally occurring fibrous serpentine or amphibole minerals with current or historical commercial usefulness due to their extraordinary tensile strength, poor heat conduction, and relative resistance to chemical attack. The principal varieties of asbestos are chrysotile, a serpentine material, and crocidolite, amosite, anthophyllite, tremolite and actinolite, which are amphiboles (4).

Exposure to asbestos causes a range of diseases, such as lung cancer, mesothelioma, and asbestosis (fibrosis of the lungs), as well as pleural plaques, thickening and effusions (5;6). There is also evidence that it causes laryngeal and possibly some other cancers (7).

Exposures to asbestos and its impact on public health are substantial

Exposure to asbestos occurs through inhalation of fibres primarily from contaminated air in the working environment, as well as from ambient air in the vicinity of point sources, or indoor air in housing and buildings containing friable asbestos materials. The highest levels of exposure occur during repackaging of asbestos containers, mixing with other raw materials and dry cutting of asbestos-containing products with abrasive tools. Exposure can also occur during installation and use of asbestos-containing products and maintenance of vehicles. Friable chrysotile and/or amphibole-containing materials are still in place in many buildings and continue to give rise to exposure to both chrysotile and amphiboles during maintenance, alteration, removal and demolition (5).

Currently about 125 million people in the world are exposed to asbestos at the workplace (1). According to global estimates at least 90,000 people die each year from asbestos-related lung cancer, mesothelioma and asbestosis resulting from occupational exposures (1;2;8). In addition, it is believed that several thousands of deaths can be attributed to other asbestos-related diseases as well as to non-occupational exposures to asbestos. The burden of asbestos-related diseases is still rising, even in countries that have banned the use of asbestos in the early 1990s. Because of the long latency periods attached to the diseases in question, stopping the use of asbestos now will only result in a decrease in the number of asbestos-related deaths after a number of decades.

All types of asbestos cause cancer in humans

Asbestos (actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite) has been classified by the International Agency for Research on Cancer as being carcinogenic to humans (9). Exposure to

chrysotile, amosite and anthophyllite asbestos and to mixtures containing crocidolite results in an increased risk of lung cancer (9). Mesotheliomas have been observed after occupational exposure to crocidolite, amosite, tremolite and chrysotile, as well as among the general population living in the neighbourhood of asbestos factories and mines and in people living with asbestos workers (9).

The incidence of asbestos-related diseases is related to fibre type, fibre size, fibre dose and to industrial processing of the asbestos (6). No threshold has been identified for the carcinogenic risk of chrysotile (5). Cigarette smoking increases the risk of lung cancer from asbestos exposure (5;10).

Chrysotile is still widely used

Asbestos has been used in thousands of products for a vast number of applications, such as roofing shingles, water supply lines, fire blankets, plastic fillers, and medical packing, as well as clutches and brake linings, gaskets and pads for automobiles. As a result of increasing health concerns, the use of asbestos has declined in many countries. The use of crocidolite and products containing this fibre as well as spraying of all forms of asbestos have been prohibited under the ILO Convention No. 162 from 1986 Concerning Safety in the Use of Asbestos. However, chrysotile asbestos is still widely used, with approximately 90% being employed in asbestos-cement building materials, the largest users of which are developing countries (11). Other remaining uses of chrysotile are friction materials (7%), textiles and other applications (11).

To date, more than 40 countries, including all member states of the European Union, have banned the use of all forms of asbestos, including chrysotile. Other countries have introduced less stringent restrictions. However, some countries have maintained or even increased their production or use of chrysotile in recent years (12). World production of asbestos in the period 2000-2005 has been relatively stable, at between 2,050,000 and 2,400,000 metric tonnes per annum (13;14).

WHO recommendations on prevention of asbestos-related diseases

Bearing in mind that there is no evidence for a threshold for the carcinogenic effect of asbestos and that increased cancer risks have been observed in populations exposed to very low levels (5;9), the most efficient way to eliminate asbestos-related diseases is to stop using all types of asbestos. Continued use of asbestos cement in the construction industry is a particular concern, because the workforce is large, it is difficult to control exposure, and in-place materials have the potential to deteriorate and pose a risk to those carrying out alterations, maintenance and demolition (5). In its various applications, asbestos can be replaced by some fibre materials (15) and by other products which pose less or no risk to health.

Materials containing asbestos should be encapsulated and, in general, it is not recommended to carry out work that is likely to disturb asbestos fibres. If necessary, such work should be carried out only under strict preventive measures to avoid exposure to asbestos, such as encapsulation, wet processes, local exhaust ventilation with filtration, and regular cleaning. It also requires the use of personal protective equipment - special respirators, safety goggles, protective gloves and clothing - and the provision of special facilities for their decontamination (16).

WHO is committed to work with countries towards elimination of asbestos-related diseases in the following strategic directions:

- by recognizing that the most efficient way to eliminate asbestos-related diseases is to stop the use of all types of asbestos;

- to provide information about solutions for replacing asbestos with safer substitutes and developing economic and technological mechanisms to stimulate its replacement;
- to take measures to prevent exposure to asbestos in place and during asbestos removal (abatement);
- to improve early diagnosis, treatment, social and medical rehabilitation of asbestos-related diseases and to establish registries of people with past and/or current exposures to asbestos.

WHO strongly recommends planning for and implementation of these measures as part of a comprehensive national approach for elimination of asbestos-related diseases. Such an approach should also include: developing national profiles; awareness raising; capacity building; an institutional framework; and a national plan of action for elimination of asbestos-related diseases.

WHO will collaborate with ILO on the implementation of the Resolution on Asbestos, adopted by the Ninety-fifth Session of the International Labour Conference (17) and will work other intergovernmental organizations and civil society towards elimination of asbestos-related diseases worldwide.

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Exposure
Levels

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Mortality Experience of Amosite Asbestos Factory Workers: Dose-Response Relationships 5 to 40 Years After Onset of Short-Term Work Exposure

Herbert Seidman, MBA, Irving J. Selikoff, MD, and Steven K. Gelb, MS

A cohort of 820 men in a Paterson, New Jersey, amosite asbestos factory which began work during 1941-1945 was observed from 5 to 40 years after start of work. Most of the cohort had limited duration of work experience (days, weeks, months), though some men worked for several years until the factory closed in 1954.

With white males of New Jersey as the control population, Standardized Mortality Ratios (SMRs) of 500 are evident for the cohort for lung cancer and for noninfectious pulmonary diseases (including asbestosis), while being almost 300 for total cancer and about 170 for all causes of death. A statistically significant SMR of almost 200 is seen for colon-rectum cancer. Mesothelioma incidence initially shows a strong relationship with advancing time since onset of exposure and then tails off.

The main concern of the study is with dose-response patterns. Response is measured by the mortality for relevant causes of death, while the direct asbestos dosage was measured in two ways. One way was the length of time worked in the factory and the other was the individual's accumulated fiber exposure, calculated by multiplying the aforementioned length of time worked by the estimated fiber exposures associated with the particular job that the worker had in the factory. Whichever measure of dosage is used, it was found that, in general, the lower the dose, the longer it took for adverse mortality to become evident and, also, the smaller the magnitude of that adverse mortality.

Key words: amosite asbestos, occupational exposure, fiber exposures, lung cancer, gastrointestinal cancer, mesothelioma, noninfectious pulmonary diseases

INTRODUCTION

There is considerable interest in dose-response relationships involving exposure to carcinogenic agents. However, a major difficulty in establishing these relationships

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is that there usually is a lengthy latent or induction period between the exposure and the subsequent overt emergence of cancer.

Most carcinogenic agents leave an imprint for the cancer but then are excreted or metabolized so as not to be discernible when the cancer becomes evident years later. With asbestos, including amosite asbestos [Selikoff et al, 1972], large amounts of the material are retained in the tissues and fibers are readily identifiable at autopsy or biopsy using extraction and electron microscopy techniques [Langer et al, 1973].

It is plausible that the presence of the residual retained asbestos constitutes continuing exposure, which may be termed *in situ* or residence exposure. Cancer is not the only concern of such exposure. Asbestosis, known principally as a fibrosing disease, may also be lethal after many years. The direct dose as well as the time in residence are then both of great significance.

We have previously reported on the mortality experience of a group of Paterson, New Jersey, amosite asbestos factory workers from the onset of work during the years 1941-1945 through 35 years thereafter [Seidman et al, 1979]. Some of these men had a very limited duration of direct asbestos exposure.

It was found that work exposure to amosite asbestos for as short a period as one month resulted in a clear excess risk of cancer.

With longer periods of exposure (ie, two months, three months, six months, and so on), the cancer risk became greater.

With very brief direct exposure, cancer risk was to be found increased only after a latent period of 25 years. On the other hand, longer employment resulted in excess risk of cancer being found after shorter postexposure observation periods.

This report is an expansion of the previous study. In addition to an extension of the follow-up period, findings are given in terms of the jobs of the workers and estimates of the dose of fiber exposure (dose = concentration \times time) accumulated by the workers during their work at the factory.

We have had the opportunity to extend the observation period through December 31, 1982, and thereby the analysis was extended to 40 years after onset of work. At each updating, we thoroughly review the information available for each man and present our results according to the best assessments we can make at that time. This usually results in some very small changes as compared with previous reports.

MATERIAL

Just before the entry of the United States into World War II, an amosite asbestos factory was established in Paterson, New Jersey, to supply the U.S. Navy with asbestos insulation for the pipes, boilers, and turbines of its ships. From June 1941, when the factory began operations, through December 1945, 933 men were recruited to work in this plant, which continued in operation until November 1954. Though nonwhites were employed in the later years of the plant's operation, the initial group was almost entirely white. Wartime conditions had a marked influence on the composition of this work force. Younger and fitter men having been siphoned off by the Armed Services, the men employed tended to be older than is usual for those entering a new line of work. There were very few "career" men (only 21 had worked with asbestos previously); in contrast to other groups of asbestos workers that have been studied, composed largely of those who continued to work in the industry once they

started, a large proportion of this group drifted off to different employment, and still others left to enter the Armed Services as the need for men increased.

This resulted in a unique experience: men with very limited duration of intense work exposure to amosite asbestos, followed by long observation. To focus on this exposure we have considered follow-up observation of a man terminated as soon as he had subsequent asbestos work experience other than the work in this company.

There were no direct observations of fiber counts in this factory. It is known that there was very deficient ventilation as detailed by review of conditions with workers and management and examination of ventilation engineering plans. However, fiber counts were made in more recent years in two plants of the same company. These facilities made the same products as the Paterson factory with the same fibers and the same production processes.

STATISTICAL ANALYSES

We have conducted the present analyses in terms of Standardized Mortality Ratios (SMRs). Thus, we have computed the ratios of observed deaths to expected deaths 5 to 40 years after onset of work, passing over the first five years after onset of work. The expected deaths were computed by categorizing the man-years of observation in the study group by five-year age group for five-year calendar year periods and multiplying such man-years by death rates of the general white male population of New Jersey in appropriate age groups and calendar-year periods. Whether or not the SMRs were statistically significantly different from 100 in a two-sided test was evaluated at the $p = .05$, $p = .01$, and $p = .001$ levels under the Poisson distributions with Program 13 in Rothman et al [1979].

We also have computed death rates with the observed and expected deaths in conjunction with the man-years at risk. We then employed life-table procedures [Reed and Merrell, 1939] to compute probabilities of dying in various intervals of time from these death rates.

The coding for causes of death in this study is that in use in the United States from 1949 on, based on the sixth through ninth revisions of the International Classification of Diseases and Causes of Death in World Health Organization [1948, 1957, 1977] and the National Center for Health Statistics [1968].

The observed deaths were coded in two ways. First, according to death certificate information only, but then also according to "best evidence" established from additional information obtained about the decedent from autopsy, surgical specimens, X-ray films, and clinical findings [Hammond et al, 1979; Selikoff et al, 1979].

The problem of which coding is preferable for particular purposes is discussed at length in Hammond et al [1979] and Selikoff et al [1979]. Since this analysis considers not only differences in mortality between the study group and the general population control group, but also concentrates on the patterns of differences among the various categories of workers, the cause established by best evidence has been utilized for the most part in this report.

The category termed "all asbestos diseases" has been taken to encompass asbestosis and other noninfectious pulmonary diseases (including chronic obstructive pulmonary disease and emphysema), lung cancer, mesotheliomas, cancers of the esophagus, stomach and colon-rectum, larynx, buccal cavity, pharynx, and kidney in

accordance with Seidman et al [1979], Hammond et al [1979], and Selikoff et al [1979].

"All asbestos diseases" has coherence to us only in terms of best evidence available and only such coding is used for this category. However, some results according to coding of the death certificate information only are detailed for other cause of death categories.

Omitting the first five years after onset from our analyses had a number of advantages. It reduced the possibility of the "healthy worker effect" in mortality selection and permitted an unequivocal classification of the men into length-of-time-worked categories. As is usual, the suitability of the general population of an area to portray what the mortality risks of a specific group of workers would have been without their special exposure, is subject to question. As compared with the general population, which includes many persons with sedentary occupations, factory workers might be expected to have lower rates of coronary death, for example, presumably owing to occupational exertion and/or selection. These might well be balanced by higher death rates from other social and life-style differences. With respect to cancer rates, it is known that New Jersey rates are among the highest in the United States [Mason and McKay, 1973].

Of the 933 men recruited to work in this factory from June 1941 through December 1945, 113 men were omitted from further analysis for not attaining the five-year point after start of employment: 21 had prior asbestos work, 14 more took up asbestos work elsewhere before the five-year point, 40 had died, and 38 were lost to follow-up shortly after terminating employment. Table I shows the status of the 820 men who remained for study at the five-year point after start of work and at each subsequent five-year point until either the 40-year point or the termination of observation, December 31, 1982. By that time we had determined that there were 6 men who were kept in the study until they began asbestos work elsewhere, 5 men who were lost to follow-up, and 593 men who had died. Only 216 men were still alive at risk in the Study Group, 95 had completed 40 years of follow-up, and 121 were still alive in the 38th to 40th years of follow-up on December 31, 1982.

RESULTS

Table II shows the total observed and expected deaths and SMRs from 5 to 40 years after onset of work for various causes of death. SMRs of 500 are evident for lung cancer and for noninfectious pulmonary disease, while that for total cancer is almost 300 and for all causes of death is as high as 167. A statistically significant SMR of almost 200 is seen for colon-rectum cancer.

Table III shows the same information (BE) for each five-year period for several of the causes. Expected deaths are not available for mesothelioma and asbestosis, which are very uncommon in the general population. Instead, death rates per million man-years (not adjusted for age) are shown for these causes. Mesothelioma, which usually shows a strong relationship with advancing time since onset of exposure, here shows an anticipated rise in death rates for the 20-24-, 25-29-, and 30-34-year periods but tails off in the 35-39 year period, perhaps partly due to previous heavy selective mortality from other asbestos associated diseases.

For the men who worked various lengths of time from less than one month to 2-14 years (when the factory closed), Tables IV-XI show the cumulative mortality

TABLE I. Status of All 820 Men at Various Elapsed Times 5 to 40 Years After Onset of Work in an Amosite Asbestos Factory, 1941-1945

	No. of elapsed years since onset of work						
	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Number of men at risk at start of period	820	763	687	583	478	364	274
Mean year of age per man at start of period	41.9	46.0	49.8	52.9	55.9	59.2	62.3
Number of men age 40 or more at risk at start of period	417	470	499	497	478	364	274
Number of deaths during period	52	72	103	105	113	90	58
Number of "withdrawals alive" during period	5	4	1	0	1	0	121
Started other asbestos work	3	3	0	0	0	0	0
Lost to follow-up	2	1	1	0	1	0	0
Had not attained 40 years of follow-up by December 31, 1982	0	0	0	0	0	0	121

TABLE II. Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Cause of Death*

All causes	Expected	Obs (BE)	SMR	Obs (DC)	SMR
	355.87	593	167 ^c	593	167 ^c
Cancer, all sites	74.19	213	287 ^c	197	266 ^c
Lung cancer	20.51	111	541 ^c	102	497 ^c
Pleural mesothelioma	—	8	—	1	—
Peritoneal mesothelioma	—	9	—	1	—
Mesothelioma not specified above	—	0	—	4	—
Larynx, buccal, pharynx cancer	3.65	7	192	—	—
Esophagus cancer	2.06	1	—	1	—
Stomach cancer	5.78	11	190	9	156
Colon-rectum cancer	11.90	22	185 ^a	22	185 ^a
Kidney cancer	1.70	3	—	3	—
Bladder cancer	3.13	3	—	3	—
Pancreas cancer	3.92	5	128	9	230 ^a
Other and unspecified cancer	21.54	33	153 ^a	38	176 ^b
Noninfectious pulmonary diseases	9.40	46	489 ^c	50	532 ^c
Asbestosis	—	31	—	15	—
Cardiovascular diseases	208.52	232	111	250	120 ^b
Other and unspecified causes	63.76	102	160 ^c	97	152 ^c
Subtotal, all "asbestos" diseases	55.00	218	396 ^c	—	—
Cancer included in subtotal	45.60	172	377 ^c	—	—

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only. See text for definition of all "asbestos" diseases.

^ap < .05.

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TABLE III. Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Cause of Death*

Man-years of observation Underlying cause of death (BE)	Elapsed No. of years since onset of work						
	5-9	10-14	15-19	20-24	25-29	30-34	35-39
All causes	3,952	3,628	3,198	2,656	2,094	1,576	1,086
Obs	52	72	103	105	113	90	58
Exp	45.45	54.42	61.25	59.51	56.17	45.35	33.72
SMR	114	132 ^a	168 ^c	176 ^c	201 ^c	198 ^c	172 ^c
Cancer, all sites	9	22	33	32	43	42	32
Obs	8.56	11.01	12.09	11.83	11.47	10.47	8.75
Exp	105	200 ^b	273 ^c	271 ^c	375 ^c	401 ^c	366 ^c
Lung cancer	2	13	20	17	22	21	16
Obs	1.76	2.54	3.06	3.31	3.50	3.39	2.96
Exp	—	512 ^c	654 ^c	514 ^c	629 ^c	619 ^c	541 ^c
SMR	0	0	0	1	3	4	0
Pleural mesothelioma	0	0	0	372	1,574	2,539	0
Obs	0	0	0	0	0	0	0
Exp	0	0	0	1	2	4	2
SMR	0	0	0	372	1,049	2,539	1,842
Rate/10 ⁶ MY	0	0	0	0	0	0	0
Peritoneal mesothelioma	0	0	0	0	0	0	0
Obs	0	0	0	0	0	0	0
Exp	0	0	0	0	0	0	0
SMR	0	0	0	0	0	0	0
Rate/10 ⁶ MY	0	0	0	0	0	0	0

TABLE IV. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Length of Time Worked: All Causes of Death*

Length of time worked	No. of men at 5-year point	Elapsed No. of years since onset of work									
		5-9	5-14	5-19	5-24	5-29	5-34	5-39			
Total	Obs	52	124	227	332	445	535	593			
	Exp	45.45	99.87	161.12	220.63	276.80	322.15	355.87			
	SMR	114	124 ^b	141 ^c	150 ^c	161 ^c	166 ^c	167 ^c			
< 1 Month	Obs	0	1	1	6	13	20	32			
	Exp	2.37	5.83	10.91	18.02	26.40	34.18	39.82			
	SMR	—	17 ^a	9 ^c	33 ^b	49 ^b	59 ^b	80			
1 Month	Obs	4	10	23	32	42	51	55			
	Exp	4.41	10.24	17.52	24.61	30.60	36.25	41.33			
	SMR	—	98	131	130	137	141 ^a	133 ^a			
2 Months	Obs	6	13	22	34	45	52	54			
	Exp	5.69	12.93	21.56	29.29	34.44	38.98	41.61			
	SMR	105	101	102	116	131	133	130			
3-5 Months	Obs	11	29	51	78	95	107	118			
	Exp	9.84	20.76	32.74	42.41	51.90	59.62	64.88			
	SMR	112	140	156 ^b	184 ^c	183 ^c	179 ^c	182 ^c			
6-11 Months	Obs	8	12	33	45	57	73	79			
	Exp	5.07	11.82	19.15	25.54	31.88	37.59	41.99			
	SMR	159	102	172 ^b	176 ^c	179 ^c	194 ^c	188 ^c			
1 Year	Obs	3	15	22	36	58	74	87			
	Exp	4.81	10.58	17.03	24.75	32.62	38.71	44.13			
	SMR	—	142	129	145 ^a	178 ^c	191 ^c	197 ^c			
2+ Years	Obs	20	44	75	101	135	158	168			
	Exp	13.26	27.70	42.20	56.00	68.94	76.79	82.11			
	SMR	151	159 ^b	178 ^c	180 ^c	196 ^c	206 ^c	205 ^c			

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates.

^ap < .05.

^bp < .01.

^cp < .001.

TABLE VI. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Length of Time Worked: Lung Cancer

Length of time worked	No. of men at 5-year point	Elapsed No. of years since onset of work										Observed (DC) 5-39	
		Observed (BE)											
		5-9	5-14	5-19	5-24	5-29	5-34	5-39					
Total	820	Obs 2	Obs 15	Obs 35	Obs 52	Obs 74	Obs 95	Obs 111	Obs 102	Obs 102	Obs 111	Obs 102	Obs 102
		Exp 1.76	Exp 4.30	Exp 7.36	Exp 10.67	Exp 14.17	Exp 17.56	Exp 20.51	Exp 20.51	Exp 20.51	Exp 20.51	Exp 20.51	Exp 20.51
		SMR —	SMR 342 ^c	SMR 470 ^c	SMR 483 ^c	SMR 519 ^c	SMR 538 ^c	SMR 541 ^c	SMR 495 ^c				
< 1 Month	61	Obs 0	Obs 0	Obs 0	Obs 1	Obs 2	Obs 4	Obs 6	Obs 5	Obs 6	Obs 6	Obs 5	Obs 5
		Exp 0.10	Exp 0.27	Exp 0.53	Exp 0.90	Exp 1.38	Exp 1.92	Exp 2.38	Exp 2.38	Exp 2.38	Exp 2.38	Exp 2.38	Exp 2.38
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
1 Month	89	Obs 0	Obs 1	Obs 4	Obs 4	Obs 5	Obs 7	Obs 7	Obs 6	Obs 7	Obs 7	Obs 6	Obs 6
		Exp 0.18	Exp 0.46	Exp 0.82	Exp 1.21	Exp 1.62	Exp 2.08	Exp 2.49	Exp 2.49	Exp 2.49	Exp 2.49	Exp 2.49	Exp 2.49
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
2 Months	79	Obs 0	Obs 0	Obs 1	Obs 3	Obs 6	Obs 8						
		Exp 0.23	Exp 0.57	Exp 0.96	Exp 1.33	Exp 1.61	Exp 1.89	Exp 2.16	Exp 2.16	Exp 2.16	Exp 2.16	Exp 2.16	Exp 2.16
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
3-5 Months	155	Obs 0	Obs 0	Obs 2	Obs 5	Obs 7	Obs 10	Obs 13	Obs 13	Obs 13	Obs 13	Obs 13	Obs 13
		Exp 0.41	Exp 0.94	Exp 1.56	Exp 2.15	Exp 2.76	Exp 3.33	Exp 3.83	Exp 3.83	Exp 3.83	Exp 3.83	Exp 3.83	Exp 3.83
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
6-11 Months	120	Obs 0	Obs 1	Obs 4	Obs 7	Obs 8	Obs 11	Obs 13	Obs 14	Obs 14	Obs 14	Obs 14	Obs 14
		Exp 0.20	Exp 0.49	Exp 0.84	Exp 1.22	Exp 1.76	Exp 2.16	Exp 2.61	Exp 2.61	Exp 2.61	Exp 2.61	Exp 2.61	Exp 2.61
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
1 Year	121	Obs 0	Obs 4	Obs 5	Obs 8	Obs 12	Obs 16	Obs 21	Obs 19	Obs 19	Obs 19	Obs 19	Obs 19
		Exp 0.19	Exp 0.46	Exp 0.80	Exp 1.24	Exp 1.73	Exp 2.23	Exp 2.73	Exp 2.73	Exp 2.73	Exp 2.73	Exp 2.73	Exp 2.73
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —
2+ Years	195	Obs 2	Obs 9	Obs 19	Obs 24	Obs 34	Obs 39	Obs 43	Obs 37	Obs 37	Obs 37	Obs 37	Obs 37
		Exp 0.52	Exp 1.19	Exp 1.92	Exp 2.68	Exp 3.45	Exp 3.99	Exp 4.38	Exp 4.38	Exp 4.38	Exp 4.38	Exp 4.38	Exp 4.38
		SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —	SMR —

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05.

^bp < .01.

^cp < .001.

2+ Years	195	9	19	24	34	39	43	37
Obs	195	7	12	17	22	28	34	32
Exp	0.52	1.19	1.92	2.68	3.45	3.99	4.38	4.38
SMR	—	738 ^c	974 ^c	886 ^c	977 ^c	970 ^c	983 ^c	840 ^c

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

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^bp < .01.

^cp < .001.

TABLE VII. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Anisotropic Asbestos Factory, 1941-1945, by Length of Time Worked: Gastrointestinal Cancer*

Length of time worked	No. of men at 5-year point	Elapsed No. of years since onset of work										Observed (DC) 5-39	
		Observed (BE)											
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	5-39	5-39	5-39		
Total	820	2	7	12	17	22	28	34	32	34	34	32	32
Obs	820	2	7	12	17	22	28	34	32	34	34	32	32
Exp	2.74	6.08	9.56	12.64	15.44	17.83	19.71	19.71	19.71	19.71	19.71	19.71	19.71
SMR	—	115	126	134	142	157 ^a	173 ^b	162 ^a	162 ^a	173 ^b	173 ^b	162 ^a	162 ^a
< 1 Month	61	0	0	0	1	1	2	4	4	4	4	4	4
Obs	61	0	0	0	1	1	2	4	4	4	4	4	4
Exp	0.13	0.33	0.62	0.99	1.40	1.81	2.12	2.12	2.12	2.12	2.12	2.12	2.12
SMR	—	—	—	—	—	—	—	—	—	—	—	—	—
1 Month	89	0	0	2	2	2	2	3	2	3	2	2	2
Obs	89	0	0	2	2	2	2	3	2	3	2	2	2
Exp	0.25	0.59	0.99	1.36	1.66	1.97	2.24	2.24	2.24	2.24	2.24	2.24	2.24
SMR	—	—	—	—	—	—	—	—	—	—	—	—	—
2 Months	79	1	0	0	0	2	2	2	2	2	2	2	2
Obs	79	1	0	0	0	2	2	2	2	2	2	2	2
Exp	0.36	0.82	1.31	1.70	1.94	2.15	2.29	2.29	2.29	2.29	2.29	2.29	2.29
SMR	—	—	—	—	—	—	—	—	—	—	—	—	—
3-5 Months	155	0	2	4	6	8	10	11	11	11	11	11	11
Obs	155	0	2	4	6	8	10	11	11	11	11	11	11
Exp	0.60	1.29	1.99	2.50	2.97	3.37	3.68	3.68	3.68	3.68	3.68	3.68	3.68
SMR	—	—	—	240	269 ^a	297 ^b	299 ^b	299 ^b					
6-11 Months	120	0	0	0	0	0	0	0	0	0	0	0	0
Obs	120	0	0	0	0	0	0	0	0	0	0	0	0
Exp	0.29	0.69	1.10	1.42	1.75	2.07	2.32	2.32	2.32	2.32	2.32	2.32	2.32
SMR	—	—	—	—	—	—	—	—	—	—	—	—	—
1 Year	121	0	1	1	2	3	5	7	7	7	7	7	7
Obs	121	0	1	1	2	3	5	7	7	7	7	7	7
Exp	0.27	0.62	0.97	1.36	1.74	2.07	2.38	2.38	2.38	2.38	2.38	2.38	2.38
SMR	—	—	—	—	—	—	—	—	—	—	—	—	—
2+ Years	195	1	3	4	5	6	7	7	6	7	7	6	6
Obs	195	1	3	4	5	6	7	7	6	7	7	6	6
Exp	0.81	1.71	2.56	3.30	3.95	4.37	4.65	4.65	4.65	4.65	4.65	4.65	4.65
SMR	—	—	—	152	152	160	151	129	129	151	129	129	129

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05.

^bp < .01.

^cp < .001.

TABLE VIII. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Length of Time Worked: Noninfectious Pulmonary Diseases (Observed Number of Asbestosis Deaths Shown in Parentheses)*

Length of time worked	No. of men at 5-year point	Elapsed No. of years since onset of work										Observed (DC)	
		Observed (BE)											
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	5-39	5-39			
Total	Obs	5 (3)	8 (4)	18 (12)	28 (19)	36 (26)	42 (30)	46 (31)	50 (15)				
	Exp	0.63	1.60	3.04	4.62	6.31	7.89	9.40	9.40				
	SMR	763	488	584	601	567	530	490	530				
<1 Month	Obs	0	0	0	0	0	1	1	1	1	1	1	1
	Exp	0.03	0.09	0.21	0.39	0.64	0.92	1.19	1.19				
	SMR	-	-	-	-	-	-	-	-				
1 Month	Obs	0	0	0	0	1	1	1	2				
	Exp	0.06	0.17	0.34	0.53	0.71	0.92	1.17	1.17				
	SMR	-	-	-	-	-	-	-	-				
2 Months	Obs	0	0	0	1 (1)	1	1	2 (1)	3				
	Exp	0.08	0.21	0.41	0.61	0.76	0.90	1.02	1.02				
	SMR	-	-	-	-	-	-	-	-				
3-5 Months	Obs	0	2	3	4	4	4	4	4				
	Exp	0.14	0.34	0.63	0.90	1.20	1.47	1.71	1.71				
	SMR	-	-	-	-	-	-	-	-				
6-11 Months	Obs	0 (9)	0	3 (2)	4 (2)	4 (2)	5 (3)	5 (3)	5				
	Exp	0.07	0.19	0.35	0.52	0.70	0.89	1.08	1.08				
	SMR	-	-	- ^a	- ^b	- ^a	561 ^b	465 ^a	465 ^a				
1 Year	Obs	0	0	0	0	1 (1)	3 (2)	4 (3)	4				
	Exp	0.07	0.17	0.32	0.52	0.74	0.95	1.19	1.19				
	SMR	-	-	-	-	-	-	-	-				
2+ Years	Obs	5 (3)	6 (4)	12 (10)	19 (16)	25 (22)	27 (24)	29 (24)	31 (15)				
	Exp	0.18	0.43	0.77	1.14	1.54	1.82	2.06	2.06				
	SMR	2,778 ^c	1,393 ^c	1,558 ^c	1,667 ^c	1,623 ^c	1,484 ^c	1,408 ^c	1,505 ^c				

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05.

^bp < .01.

^cp < .001.

2+ Years	195	Obs	5 (3)	6 (4)	12 (10)	19 (16)	25 (22)	27 (24)	29 (24)	31 (15)
		Exp	0.18	0.43	0.77	1.14	1.54	1.82	2.06	2.06
		SMR	2.77 ^a	1.39 ^b	1.55 ^c	1.66 ^d	1.62 ^e	1.484 ^e	1.408 ^e	1.505 ^e

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.
^ap < .05.
^bp < .01.
^cp < .001.

TABLE IX. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Length of Time Worked: All Asbestos Diseases*

Length of time worked	No. of men at 5-year point	Elapsed No. of years since onset of work:									
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	Observed (BE)		
Total	820	9	30	67	102	147	189	218			
	Obs	5.84	13.53	22.42	31.26	40.04	48.11	55.00			
	Exp	154	222 ^a	299 ^b	326 ^c	367 ^c	393 ^c	396 ^c			
< 1 Month	61	0	0	0	2	3	7	11			
	Obs	0.29	0.76	1.51	2.52	3.78	5.13	6.26			
	Exp	SMR					136	176			
1 Month	89	0	1	6	6	9	11	12			
	Obs	0.56	1.38	2.41	3.45	4.43	5.50	6.51			
	Exp	SMR		2.49	174	203	200	184			
2 Months	79	1	1	2	6	10	13	15			
	Obs	0.74	1.78	2.98	4.03	4.76	5.45	6.06			
	Exp	SMR			149	210 ^a	239 ^b	248 ^b			
3-5 Months	155	0	4	10	16	21	26	31			
	Obs	1.29	2.88	4.67	6.19	7.71	9.07	10.20			
	Exp	SMR			214 ^a	258 ^b	272 ^c	304 ^c			
6-11 Months	120	0	1	8	12	16	21	24			
	Obs	0.63	1.54	2.56	3.52	4.59	5.69	6.67			
	Exp	SMR			313 ^a	341 ^c	349 ^c	360 ^c			
1 Year	121	0	5	6	12	19	29	37			
	Obs	0.60	1.40	2.35	3.50	4.71	5.85	6.98			
	Exp	SMR		357 ^a	255	343 ^c	403 ^c	496 ^c			
2+ Years	195	8	18	35	48	69	82	88			
	Obs	1.75	3.79	5.93	8.01	10.00	11.36	12.32			
	Exp	SMR	457 ^b	475 ^c	590 ^c	599 ^c	690 ^c	714 ^c			

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available.
^ap < .05.
^bp < .01.
^cp < .001.

TABLE X. All Causes: Standardized Mortality Ratios for Cumulative Deaths From 5 to 40 Elapsed Years Since Onset of Work by Length of Time Worked

Length of time worked	Elapsed No. of years since onset of work						
	5-9	5-14	5-19	5-24	5-29	5-34	5-39
< 1 Month	0	17	9	33	49	59	80
1 Month	91	98	131	130	137	141	133
2 Months	105	101	102	116	131	133	130
3-5 Months	112	140	156	184	183	179	182
6-11 Months	159	102	172	176	179	194	188
1 Year	62	142	129	145	178	191	197
2+ Years	151	159	178	180	196	206	205

TABLE XI. Lung Cancer: Standardized Mortality Ratios for Cumulative Deaths From 5 to 40 Elapsed Years Since Onset of Work by Length of Time Worked

Length of time worked	Elapsed No. of years since onset of work:						
	Observed (BE) ^a						
	5-9	5-14	5-19	5-24	5-29	5-34	5-39
< 1 Month	0	0	0	79	145	208	252
1 Month	0	217	488	331	308	337	281
2 Months	0	0	104	226	373	423	371
3-5 Months	0	0	128	233	254	300	339
6-11 Months	0	204	476	574	479	509	498
1 Year	0	870	625	645	694	717	770
2+ Years	385	738	974	886	977	970	983

^aBE. coding of cause according to best evidence available.

results at five-year intervals to 40 years since onset of work, respectively, for all causes of death, all cancers, lung cancers, gastrointestinal cancers, noninfectious pulmonary disease (including asbestosis), and "all asbestos diseases." The data are shown on a cumulative basis to illustrate that, in general, the heavier the dose as measured by the length of time worked, the shorter the time in which an adverse effect is observable. Thus, for cancer of the lung in Table VI, marked excesses are evident within 15 years for the longer-term workers. For those who worked shorter periods of time it may take 25 years or more. Also in Table VI it is clear that the heavier the dose, the greater the response tends to be in terms of higher SMRs. Some of these findings may also be seen in Figures 1-6 and Tables X-XIII.

During World War II, between 300 to 400 workers were employed at any one time at the Union Asbestos and Rubber Company factory in Paterson, New Jersey. During peak production, three shifts were worked. There was a great deal of turnover, some men being drafted into the Armed forces and others moving on in short order to other employment. Postwar, the workforce was down to about 100 until the plant closed in 1954.

Amosite asbestos was used virtually exclusively. No crocidolite was used and very little chrysotile. The amosite arrived as a crushed stone from Africa and was

Deaths From 5 to 40

Length of work	5-34	5-39
1929	59	80
1937	141	133
1931	133	130
1933	179	182
1939	194	188
1938	191	197
1936	206	205

Deaths From 5 to 40

Length of work:	5-34	5-39
1929	208	252
1937	337	281
1931	423	371
1933	300	339
1939	509	498
1938	717	770
1936	970	983

... respectively, for all cancers, noninfectious diseases." The data are heavier the dose as in which an adverse marked excesses are who worked shorter VI it is clear that the higher SMRs. Some XIII. employed at any one aterson, New Jersey. great deal of turnover, ing on in short order ut 100 until the plant

idolite was used and rom Africa and was

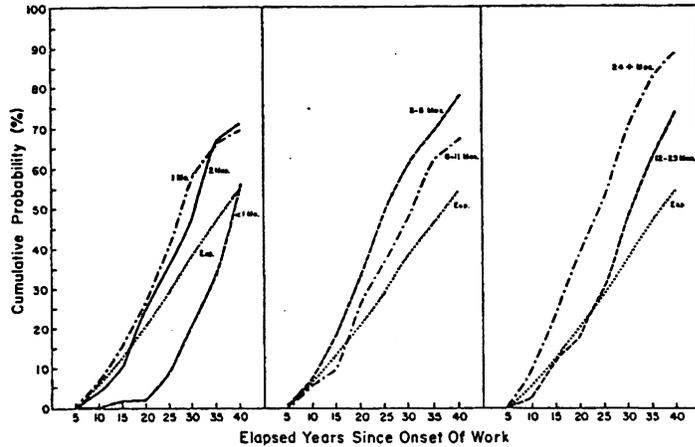


Fig. 1. Cumulative observed and expected probabilities of dying from all causes by length of time worked from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945.

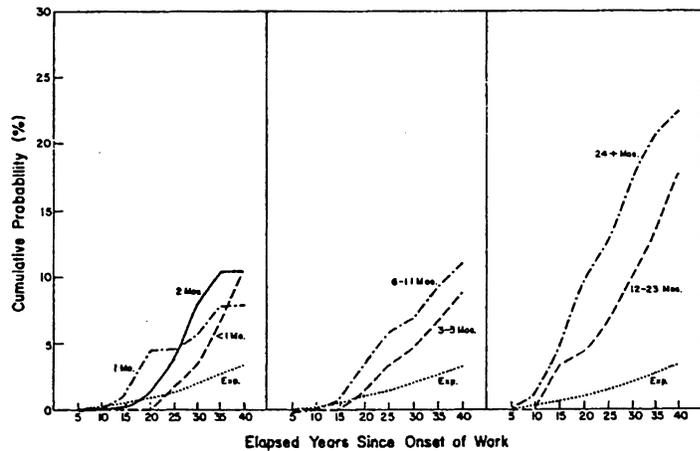


Fig. 2. Cumulative observed and expected probabilities of dying from lung cancer by length of time worked from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945. Observed lung cancer deaths shown are those classified according to best evidence available.

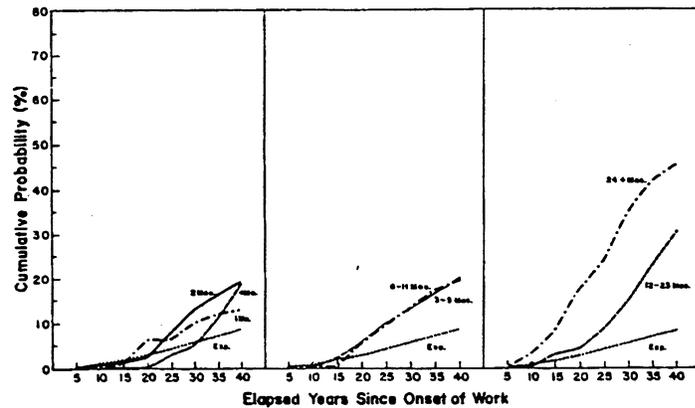


Fig. 3. Cumulative observed and expected probabilities of dying from all "asbestos" diseases by length of time worked from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945. See text for definition of all "asbestos" diseases.

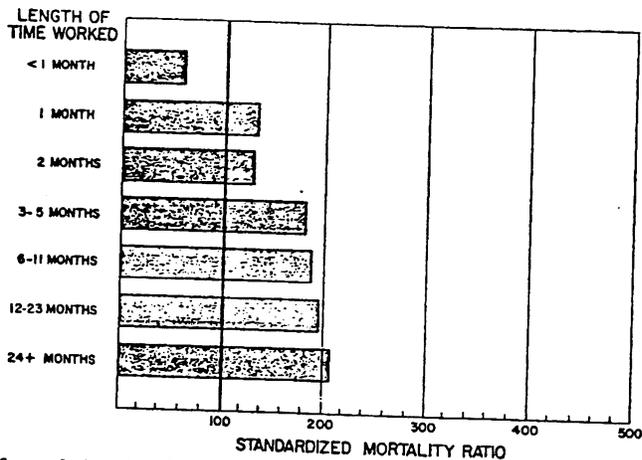


Fig. 4. Ratio of cumulative observed to expected probabilities of dying from all causes from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to length of time worked.

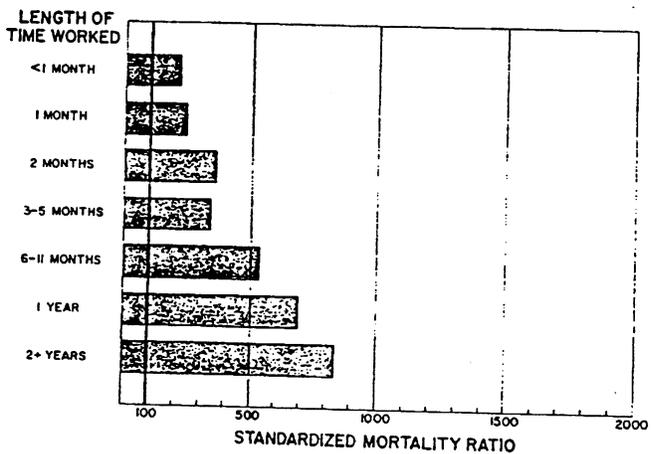


Fig. 5. Ratio of cumulative observed to expected probabilities of dying from lung cancer from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to length of time worked.

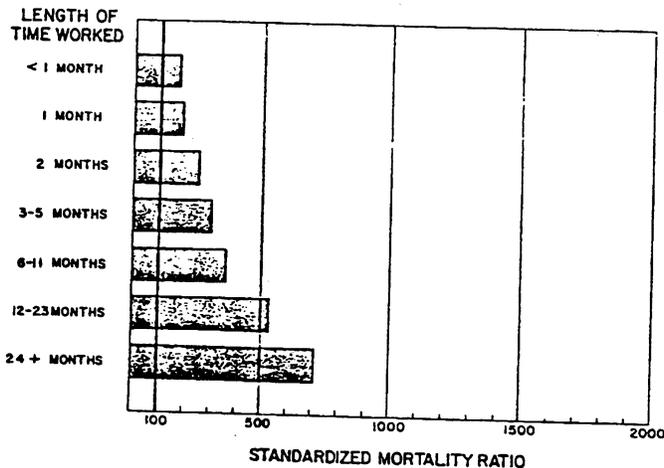


Fig. 6. Ratio of cumulative observed to expected probabilities from all "asbestos" diseases from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to length of time worked.

TABLE XII. All Asbestos Diseases: Standardized Mortality Ratios for Cumulative Deaths From 5 to 40 Elapsed Years Since Onset of Work by Length of Time Worked

Length of time worked	Elapsed No. of years since onset of work:						
	Observed (BE) ^a						
	5-9	5-14	5-19	5-24	5-29	5-34	5-39
< 1 Month	0	0	0	79	79	136	176
1 Month	0	72	249	174	203	200	184
2 Months	135	56	67	149	210	239	248
3-5 Months	0	139	214	258	272	287	304
6-11 Months	0	65	312	341	348	369	360
1 Year	0	357	255	343	403	496	530
2+ Years	457	475	590	599	690	721	714

^aBE, coding of cause according to best evidence available.

then broken down at the factory in pulverizers. The fine material was mixed with sodium silicate to form pipe coverings, and amosite fibers were also used for sheets, "mattresses," blocks, and spun around cotton cord into asbestos rope. Waste stone was collected and carted away. Thus, there was a rather complete operation including mill, textile work, pipe covering, and block making.

We do not have direct fiber count measurements or exposures in this plant; fiber counting was not used during the years of operation of the facility. Though it is quite obvious that the plant as a whole was quite dusty, certain areas and jobs were considerably dustier than others. For example, when surviving former workers were examined during the 1950s and 1960s (Selikoff, unpublished data), all reports were that the worst area was the disintegrator room with the pulverizers, and that dumping bags, feeding hoppers, or filling bins involved almost as much exposure. On the other hand, there was much less dust in the office or in the shipping area, although just walking through the plant resulted in some exposure.

We do, however, have fiber count measurements made by the U.S. Public Health Service* in 1967, 1970, and 1971 in the Tyler, Texas, and Port Allegheny, Pennsylvania, plants of the same company where the same products were made with the same machinery, amosite fiber, and production processes. General conditions may have been somewhat better in these plants, but at least prior to the installation of superior dust extraction equipment in the late 1960s in the Port Allegheny plant, they could hardly have been greatly so. We were fortunate to have these fiber counts as rough guides and to be able to call upon the expertise of Dr. William J. Nicholson to help us assign plausible estimates of the exposures likely to have been associated with particular jobs in the Paterson plant. These estimates may be somewhat on the high side to the extent that industrial hygienists tend to over-sample the dustier areas of factories. It is important to realize that such overestimation as there may be in the fiber counts we have assigned will also serve to overstate the dose responsible for the various disease responses observed associated with asbestos exposure at the Paterson plant.

Table XIII shows the counts of fibers 5 μm or longer per cc that we assigned to each job and the number of men who worked at the various particular jobs. The median value, considering the number of workers holding the various jobs, was 50

*We are grateful to Richard Lemen and his colleagues at the National Institute for Occupational Safety and Health, Cincinnati, Ohio, for making these available to us.



all causes from 5 through 5. according to length of



m lung cancer from 5 941-1945. according to



"stos" diseases from 5 41-1945. according to

TABLE XIII. Estimated Exposure to Fibers $>5\mu\text{m}$ in Length per cc for Jobs in an Amosite Asbestos Factory and Number of Workers With Onset of Work 1941-1945 by Length of Time Worked: 820 Study Group Men

Job	Estimated No. of fibers in length $>5\mu\text{m}$ per cc	All 820 men		384 men who worked <6 mo		241 men who worked 6-23 mo		195 men who worked 24+ mo	
		No.	% Total	No.	% Total	No.	% Total	No.	% Total
Total		820	100.0	384	100.0	241	100.0	195	100.0
Disintegrator operator (felt, pipe covering)	120	8	1.0	3	0.8	3	1.2	2	1.0
Pulverizer (felt, pipe covering)	110	19	2.3	7	1.8	9	3.7	3	1.5
Abestos bag dumper, filler of bins, mixer, hopper feeder	100	17	2.1	15	3.9	2	0.8	0	0.0
Carding operator (felt)	90	3	0.4	1	0.3	1	0.4	1	0.5
Loom operator, fixer, weaver (felt)	60	34	4.1	8	2.1	10	4.1	16	8.2
Rovings machine operator (felt)	60	28	3.4	8	2.1	7	2.9	13	6.7
Block production	60	4	0.5	1	0.3	0	0.0	3	1.5
Builder, roller, fitter (pipe covering)	55	62	7.6	23	6.0	28	11.7	11	5.6
Felt or pipe covering dept. n.o.s.	55	37	4.5	15	3.9	15	6.2	7	3.6
Mattress or blanket wrapper, maker, sewer (felt)	50	19	2.3	7	1.8	5	2.1	7	3.6
Supervisor, production	50	3	0.4	0	0.0	2	0.8	1	0.5
Machine operator, n.o.s.	50	32	3.9	17	4.5	13	5.4	2	1.0
Sweeper	50	2	0.2	1	0.3	0	0.0	1	0.3

50	19	2.3	7	1.8	5	2.1	7	3.6
50	3	0.4	0	0.0	2	0.8	1	0.5
50	32	3.9	17	4.5	13	5.4	2	1.0
50	2	0.2	1	0.3	0	0.0	1	0.3

50	160	19.3	121	31.2	27	11.2	12	6.4
50	47	5.7	30	7.8	17	7.1	0	0.0
40	29	3.5	18	4.7	5	2.1	6	3.1
40	10	1.2	1	0.3	2	0.8	7	3.6
40	35	4.3	14	3.6	10	4.1	11	5.6
40	5	0.6	0	0.0	1	0.4	4	2.1
40	14	1.7	6	1.6	5	2.1	3	1.5
30	5	0.6	0	0.0	2	0.8	3	1.5
25	6	0.7	4	1.0	0	0.0	2	1.0
25	22	2.7	10	2.6	7	2.9	5	2.6
25	11	1.3	5	1.3	4	1.7	2	1.0
15	4	0.5	1	0.3	1	0.4	2	1.0
15	6	0.7	4	1.0	1	0.4	1	0.5
15	9	1.1	3	0.8	4	1.7	2	1.0
15	10	1.2	2	0.5	4	1.7	4	2.1
15	73	8.9	39	10.2	21	8.7	13	6.7
15	10	1.2	1	0.3	4	1.7	5	2.6
5	9	1.1	3	0.8	3	1.2	3	1.5
"	87	10.6	16	4.2	28	11.7	43	22.2

Multiple jobs
 aFiber counts for men who worked at multiple jobs is the average of the estimated counts for their individual jobs. The range of these averages was 15-95 f/cc and the median value was 50.

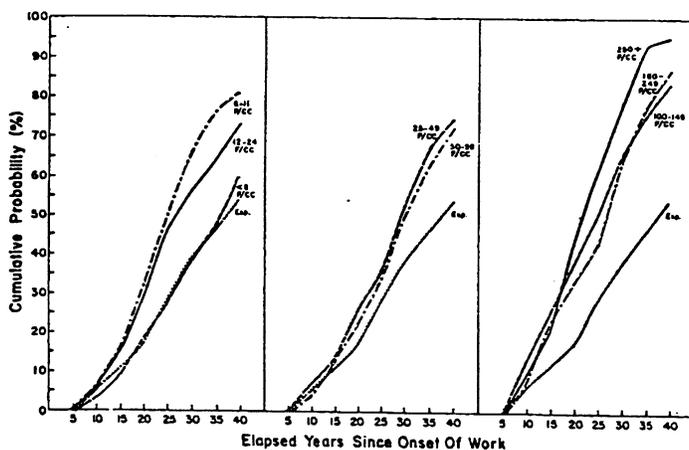


Fig. 7. Cumulative observed and expected probabilities of dying from all causes by estimated fiber exposure from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945.

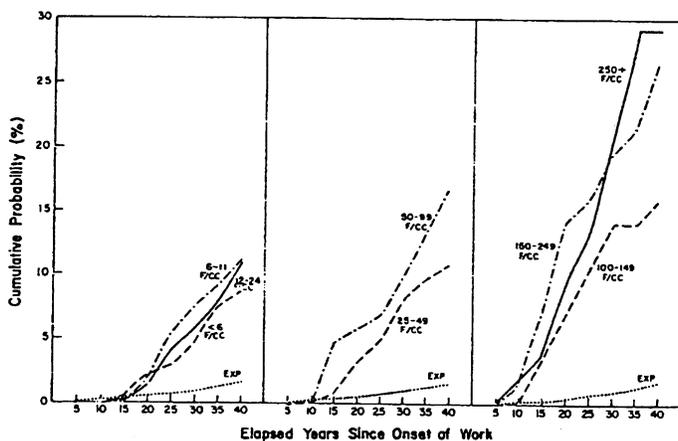


Fig. 8. Cumulative observed and expected probabilities of dying from lung cancer by estimated fiber exposure from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945. Observed lung cancer deaths shown are those classified according to best evidence available.

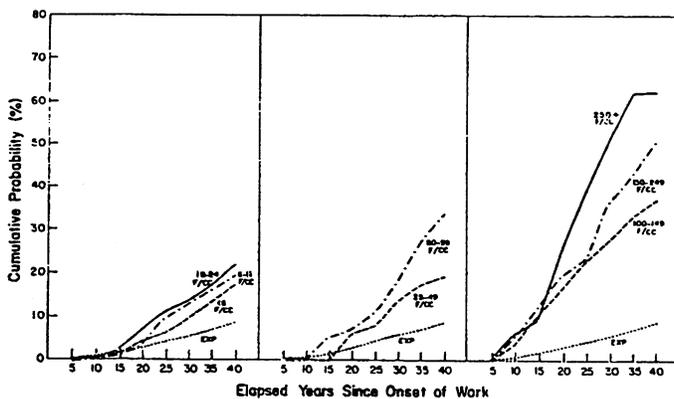


Fig. 9. Cumulative observed and expected probabilities of dying from all "asbestos" diseases by estimated fiber exposure from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945. See text for definition of all "asbestos" diseases.

fibers/cc, a higher value than we had anticipated beforehand. Also shown in Table XIII are the distributions of the number of men in various jobs according to the length of time they had worked. Probably most of the men experienced an apprenticeship period in which they did some of the dirtier work in their department for a short period before settling into a longer range routine. Thus, the shorter-term worker may well have received a higher dose per unit time than his longer-term counterpart.

We have estimated the total work exposures as fiber-years per cc by multiplying the fiber counts for the various jobs by the time worked.

Tables XIV-XIX are a set of tables for estimated fiber exposure groups that are analogous to the series of Tables IV-IX for length of time worked groups. There are some variations but the general patterns that emerge are much the same. Figures 7-12 and Table XX-XXII show some of the probability of death and SMR findings for the fiber exposure groups for all causes of death, lung cancer, and "all asbestos diseases" for 5 to 40 years after onset of exposure. A very dramatic focus on the dose-response relationship for asbestos exposure and lung cancers is presented in Figure 13, a picture strikingly like that found among chrysolite asbestos textile workers by Dement et al [1983]. Within the limits of the available data of this study, a linear zero threshold dose-response seems implausible. In practical terms, this speaks against a threshold for cancer risk with occupational exposure to asbestos.

Table XXIII shows the distribution of workers for groups by cross-tabulating length of time worked with estimated fiber exposures. As would be expected, certain fiber-year/cc categories are dominated by certain length of time worked groups and vice versa.

Table XXIV presents lung cancer mortality for 5 to 40 years after onset for the cross tabulations of length of time worked groups and fiber exposure categories. It would seem that within given fiber exposure categories, there is a very slight tendency toward higher ratios of observed to expected deaths for those with longer compared with shorter times worked. In other words, whatever difference there is, it is in the direction of higher SMRs with longer length of work at jobs with lower fiber counts rather than shorter length of work at jobs with higher fiber counts.

CONCLUSIONS

1. Heretofore, using the length of time worked in an amosite asbestos factory as a measure of the direct dosage of asbestos, we found that, in general, the lower the dose, the longer it took for adverse mortality experience to become evident and also the smaller the magnitude of that adverse mortality.

2. With the new additional data on estimated fiber exposure at hand, it can be seen that much the same dose-response patterns are evident between asbestos exposure and mortality whether one uses length of time worked or estimated fiber exposure as the measure of dosage.

3. This has very important implications for the control of cancer. If it is not possible to completely avoid exposure to asbestos (or other carcinogenic agents), at least reducing the exposure might both delay the occurrence of adverse effects and lower the frequency of their occurrence.

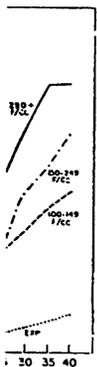
4. As previously stated, in addition to the direct exposure, the exposure "in residence" resulting from the asbestos retained in tissues is of major importance. This tissue (including cellular) exposure continues long after the direct exposure may have stopped. Despite the continued loss to further observation of the presumably more



causes by estimated fiber exposure groups in an amosite asbestos factory, 1941-1949



cancer by estimated fiber exposure groups in an amosite asbestos factory, 1941-1949; evidence available



"asbestos" diseases by length of time worked in an amosite asbestos factory

TABLE XIV. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: All Causes*

Fiber-years per cc	No. of men	Elapsed No. of years since onset of work									
		5-9	5-14	5-19	5-24	5-29	5-34	5-39			
Total	Obs	52	124	227	332	445	535	593			
	Exp	45.43	99.84	161.09	220.60	276.77	322.12	355.87			
	SMR	114	124 ^a	141 ^c	151 ^c	161 ^c	166 ^c	167 ^c			
<6.0	Obs	6	16	32	49	67	83	101			
	Exp	8.04	18.78	32.48	47.73	63.34	78.47	90.21			
	SMR	75	85	99	103	106	106	112			
6.0-11.9	Obs	7	18	36	55	71	82	86			
	Exp	7.92	18.03	29.45	39.28	46.00	51.17	53.90			
	SMR	88	100	122	140 ^b	154 ^c	160 ^c	160 ^c			
12.0-24.9	Obs	9	23	42	65	78	90	100			
	Exp	8.53	18.06	29.00	37.88	46.32	53.23	58.14			
	SMR	106	127	145 ^b	172 ^c	168 ^c	169 ^c	172 ^c			
25.0-49.9	Obs	9	15	32	43	64	82	89			
	Exp	5.39	11.83	19.01	26.34	34.40	40.10	44.79			
	SMR	167	127	168 ^b	163 ^b	186 ^c	204 ^c	199 ^c			
50.0-99.9	Obs	4	13	21	35	51	64	73			
	Exp	5.47	11.94	18.78	25.37	32.08	37.17	41.94			
	SMR	73	109	112	138	159 ^b	172 ^c	174 ^c			
100.0-149.9	Obs	8	15	22	29	37	43	47			
	Exp	4.32	7.96	11.52	15.58	19.82	23.47	25.92			
	SMR	185	188 ^b	191 ^b	186 ^b	187 ^c	183 ^c	181 ^c			
150.0-249.9	Obs	4	13	19	24	36	43	48			
	Exp	3.21	6.82	10.59	15.11	19.43	22.05	24.10			
	SMR	-	191 ^a	179 ^a	159 ^a	184 ^b	195 ^c	199 ^c			
250.0+	Obs	5	11	23	32	41	48	49			
	Exp	2.55	6.42	10.26	13.32	15.39	16.47	16.86			
	SMR	196	171	224 ^c	240 ^c	266 ^c	291 ^c	291 ^c			

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates.

^ap < .05.

^bp < .01.

^cp < .001.

TABLE XV. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos

250.0+	53	191 ^a	179 ^a	159 ^a	184 ^a	195 ^a	199 ^a
Obs	5	11	23	32	41	48	49
Exp	2.55	6.42	10.26	13.32	15.39	16.47	16.86
SMR	196	171	224 ^c	240 ^c	266 ^c	291 ^c	291 ^c

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates.

^ap < .05.
^bp < .01.
^cp < .001.

TABLE XV. Cumulative Observed and Expected Deaths From 5 to 99 Elapsed Years Since Onset of Work in an Anisite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: All Cancers*

Fiber-years per cc	No. of men	Elapsed No. of years since onset of work											Observed (DC) 5-39			
		Observed (BE)														
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	5-39	5-39	5-39	5-39				
Total	820	9	31	64	96	139	181	213	213	197	197	197	197	197	197	197
Obs	820	9	31	64	96	139	181	213	213	197	197	197	197	197	197	197
Exp	8.56	19.57	31.66	43.49	54.96	65.43	74.19	74.19	74.19	74.19	74.19	74.19	74.19	74.19	74.19	74.19
SMR	105	158 ^a	202 ^a	221 ^c	253 ^c	277 ^c	287 ^c	287 ^c	287 ^c	266 ^c	266 ^c	266 ^c	266 ^c	266 ^c	266 ^c	266 ^c
<6.0	177	2	3	8	11	16	22	29	29	27	27	27	27	27	27	27
Obs	177	2	3	8	11	16	22	29	29	27	27	27	27	27	27	27
Exp	1.50	3.67	6.34	9.29	12.39	15.82	18.77	18.77	18.77	18.77	18.77	18.77	18.77	18.77	18.77	18.77
SMR	—	—	126	118	129	139	155 ^a	155 ^a	155 ^a	144	144	144	144	144	144	144
6.0-11.9	109	1	1	6	13	17	21	24	24	23	23	23	23	23	23	23
Obs	109	1	1	6	13	17	21	24	24	23	23	23	23	23	23	23
Exp	1.52	3.59	5.81	7.70	9.05	10.18	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95
SMR	—	—	103	169	188 ^a	206 ^b	219 ^b	219 ^b	219 ^b	210 ^b	210 ^b	210 ^b	210 ^b	210 ^b	210 ^b	210 ^b
12.0-24.9	139	0	3	9	17	21	28	35	35	33	33	33	33	33	33	33
Obs	139	0	3	9	17	21	28	35	35	33	33	33	33	33	33	33
Exp	1.63	3.58	5.75	7.55	9.24	10.86	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25
SMR	—	—	157	225 ^b	227 ^b	258 ^c	286 ^c	286 ^c	286 ^c	269 ^c	269 ^c	269 ^c	269 ^c	269 ^c	269 ^c	269 ^c
25.0-49.9	123	1	2	7	9	19	24	26	26	25	25	25	25	25	25	25
Obs	123	1	2	7	9	19	24	26	26	25	25	25	25	25	25	25
Exp	0.98	2.24	3.66	5.19	6.96	8.37	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64	9.64
SMR	—	—	191	173	273 ^c	287 ^c	270 ^c	270 ^c	270 ^c	259 ^c	259 ^c	259 ^c	259 ^c	259 ^c	259 ^c	259 ^c
50.0-99.9	104	0	5	7	12	21	31	38	38	37	37	37	37	37	37	37
Obs	104	0	5	7	12	21	31	38	38	37	37	37	37	37	37	37
Exp	1.01	2.27	3.61	4.94	6.33	7.53	8.73	8.73	8.73	8.73	8.73	8.73	8.73	8.73	8.73	8.73
SMR	—	220	194	243 ^a	332 ^c	412 ^c	435 ^c	435 ^c	435 ^c	424 ^c	424 ^c	424 ^c	424 ^c	424 ^c	424 ^c	424 ^c
100.0-149.9	57	2	7	9	11	13	15	18	18	17	17	17	17	17	17	17
Obs	57	2	7	9	11	13	15	18	18	17	17	17	17	17	17	17
Exp	0.82	1.57	2.30	3.12	3.98	4.80	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40	5.40
SMR	—	446 ^b	391 ^b	353 ^c	327 ^c	313 ^c	333 ^c	333 ^c	333 ^c	315 ^c	315 ^c	315 ^c	315 ^c	315 ^c	315 ^c	315 ^c
150.0-249.9	58	2	6	10	11	15	19	22	22	18	18	18	18	18	18	18
Obs	58	2	6	10	11	15	19	22	22	18	18	18	18	18	18	18
Exp	0.61	1.35	2.11	2.99	3.85	4.45	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93
SMR	—	444 ^b	474 ^c	368 ^c	390 ^c	427 ^c	446 ^c	446 ^c	446 ^c	365 ^c	365 ^c	365 ^c	365 ^c	365 ^c	365 ^c	365 ^c
250.0+	53	1	4	8	12	17	21	21	21	17	17	17	17	17	17	17
Obs	53	1	4	8	12	17	21	21	21	17	17	17	17	17	17	17
Exp	0.49	1.30	2.09	2.72	3.17	3.42	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53
SMR	—	—	383 ^b	441 ^c	536 ^c	614 ^c	595 ^c	595 ^c	595 ^c	482 ^c	482 ^c	482 ^c	482 ^c	482 ^c	482 ^c	482 ^c

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05.
^bp < .01.
^cp < .001.

TABLE XVI. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: Lung Cancer*

Fiber-years per cc	No. of men	Elapsed No. of years since onset of work										Observed (DC) 5-39	
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	5-39	5-39	5-39		
Total	Obs	2	15	35	52	74	95	111	102				
	Exp	1.76	4.30	7.36	10.67	14.17	17.56	20.51	20.51				
	SMR	—	3.49 ^c	476 ^c	487 ^c	522 ^c	541 ^c	541 ^c	497 ^c				
<6.0	Obs	0	1	4	5	8	13	15	14				
	Exp	0.31	0.82	1.50	2.30	3.23	4.32	5.31	5.31				
	SMR	—	—	—	217	248 ^b	301 ^b	282 ^c	264 ^b				
6.0-11.9	Obs	0	0	2	6	8	10	12	12				
	Exp	0.32	0.80	1.35	1.86	2.26	2.61	2.89	2.89				
	SMR	—	—	—	323 ^a	354 ^b	383 ^c	415 ^c	415 ^c				
12.0-24.9	Obs	0	0	2	6	8	11	15	15				
	Exp	0.33	0.78	1.32	1.83	2.34	2.88	3.39	3.39				
	SMR	—	—	—	328 ^a	342 ^b	382 ^c	442 ^c	442 ^c				
25.0-49.9	Obs	0	1	4	6	10	12	13	12				
	Exp	0.19	0.47	0.84	1.30	1.87	2.36	2.78	2.78				
	SMR	—	—	—	462 ^b	535 ^c	508 ^c	468 ^c	432 ^c				
50.0-99.9	Obs	0	5	6	7	10	14	17	17				
	Exp	0.19	0.46	0.80	1.18	1.60	1.99	2.38	2.38				
	SMR	—	1.087 ^c	750 ^c	593 ^c	625 ^c	704 ^c	714 ^c	714 ^c				
100.0-149.9	Obs	0	2	4	6	8	8	9	9				
	Exp	0.17	0.35	0.54	0.78	1.04	1.30	1.49	1.49				
	SMR	—	—	—	769 ^c	769 ^c	615 ^c	604 ^c	604 ^c				
150.0-249.9	Obs	1	4	8	9	11	12	15	12				
	Exp	0.14	0.31	0.50	0.73	0.98	1.17	1.32	1.32				
	SMR	—	—	1,600 ^c	1,233 ^c	1,122 ^c	1,026 ^c	1,136 ^c	909 ^c				
250.0+	Obs	1	2	5	7	11	15	15	11				
	Exp	0.11	0.30	0.50	0.68	0.82	0.90	0.94	0.94				
	SMR	—	—	1,000 ^c	1,029 ^c	1,342 ^c	1,667 ^c	1,596 ^c	1,170 ^c				

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05.

^bp < .01.

^cp < .001.

TABLE XVII. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: Gastrointestinal Cancer*

TABLE XVIII. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: Noninfectious Pulmonary Diseases (Observed Number of Asbestosis Deaths Shown in Parentheses)*

Fiber-years per cc	No. of men	Elapsed No. of years since onset of work										Observed (DC)	
		5-9	5-14	5-19	5-24	5-29	5-34	5-39	5-39				
Total	Obs	5 (3)	8 (4)	18 (12)	28 (19)	36 (25)	42 (30)	46 (31)	50 (31)				
	Exp	0.63	1.60	3.04	4.62	6.31	7.89	9.40	9.40				
	SMR	794 ^b	500 ^c	592 ^c	606 ^c	571 ^c	532 ^c	489 ^c	532 ^c				
<6.0	Obs	0	0	1	1	2	3 (0)	4	4				
	Exp	0.11	0.30	0.62	1.01	1.46	1.99	2.54	2.54				
	SMR	—	—	—	—	—	—	—	—				
6.0-11.9	Obs	0	1	1	3 (1)	3 (1)	3 (1)	3 (1)	5				
	Exp	0.11	0.30	0.57	0.84	1.05	1.23	1.35	1.35				
	SMR	—	—	—	—	—	—	—	370 ^a				
12.0-24.9	Obs	0	1	2 (1)	3 (1)	3 (1)	3 (1)	3 (1)	3				
	Exp	0.12	0.29	0.55	0.79	1.03	1.26	1.47	1.47				
	SMR	—	—	—	—	—	—	—	—				
25.0-49.9	Obs	0	0	2 (1)	2 (1)	3 (2)	2 (1)	3 (2)	3				
	Exp	0.07	0.18	0.34	0.53	0.78	0.98	1.20	1.20				
	SMR	—	—	—	—	—	—	—	—				

25.0-49.9 123 0 0 2 (1) 2 (1) 3 (2) 2 (1) 3 (2) 3
 Exp 0.07 0.18 0.34 0.53 0.78 1.20 1.20
 SMR — — — — — — — — —

50.0-99.9	104	Obs	0	0	10	1 (1)	2 (2)	3 (2)	3
		Exp	0.07	0.18	0.52	0.72	0.89	1.08	1.08
		SMR	—	—	—	—	—	—	—
100.0-149.9	57	Obs	2	3 (2)	5 (4)	6 (4)	7 (5)	8 (5)	11 (1)
		Exp	0.06	0.12	0.32	0.45	0.59	0.71	0.71
		SMR	— ^b	— ^a	1.563 ^c	1.333 ^c	1.186 ^c	1.127 ^c	1.549 ^c
150.0-249.9	58	Obs	1 (1)	2 (2)	3 (3)	6 (6)	7 (7)	8 (7)	6 (4)
		Exp	0.05	0.11	0.32	0.46	0.56	0.64	0.64
		SMR	—	— ^a	— ^a	1.304 ^c	1.250 ^c	1.250 ^c	938 ^c
250.0+	53	Obs	2 (2)	2 (2)	11 (9)	13 (11)	14 (12)	14 (13)	15 (10)
		Exp	0.03	0.10	0.27	0.33	0.37	0.41	0.41
		SMR	— ^b	— ^a	4.074 ^c	3.939 ^c	3.784 ^c	3.415 ^c	3.659 ^c

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available; DC, coding of cause according to death certificate information only.

^ap < .05

^bp < .01

^cp < .001

TABLE XIX. Cumulative Observed and Expected Deaths From 5 to 40 Elapsed Years Since Onset of Work in an Amosite Asbestos Factory, 1941-1945, by Estimated Fiber Exposure: All Asbestos Diseases*

Fiber-years per cc	No. of men		Elapsed No. of years since onset of work: Observed (OE)									
			5-9	5-14	5-19	5-24	5-29	5-34	5-39			
Total	820	Obs	9	30	67	102	147	189	218			
		Exp	5.84	13.53	22.42	31.26	40.04	48.11	55.00			
		SMR	154	222 ^c	299 ^c	326 ^c	367 ^c	393 ^c	396 ^c			
<6.0	177	Obs	1	2	8	11	17	24	30			
		Exp	1.02	2.53	4.50	6.67	9.03	11.67	14.01			
		SMR	—	—	178	165	188 ^a	206 ^b	214 ^c			
6.0-11.9	109	Obs	0	1	3	10	14	17	20			
		Exp	1.05	2.51	4.15	5.57	6.60	7.47	8.08			
		SMR	—	—	—	180	212 ^a	228 ^b	248 ^b			
12.0-24.9	139	Obs	0	3	9	15	18	24	30			
		Exp	1.13	2.49	4.09	5.44	6.72	7.96	9.04			
		SMR	—	—	220 ^a	276 ^b	268 ^c	302 ^c	332 ^c			
25.0-49.9	123	Obs	0	1	7	9	16	21	23			
		Exp	0.65	1.52	2.54	3.69	5.05	6.16	7.17			
		SMR	—	—	276 ^a	244 ^a	317 ^c	341 ^c	321 ^c			

Age Group	SMR	Obs	Exp	SMR	Obs	Exp	SMR	Obs	Exp	SMR	Obs	Exp	SMR	Obs	Exp	SMR	
25.0-49.9	Obs	0	1	220 ^a	276 ^b	268 ^c	1.50	302 ^c	9.04	332 ^c	23	7.17	321 ^c	34	28	5.46	
	Exp	0.65	1.52	2.54	3.69	5.05	6.16	341 ^c	302 ^c	21	6.16	341 ^c	32	28	5.46	6.39	
	SMR	—	—	276 ^b	244 ^a	317 ^c	341 ^c										
	SMR	—	—	276 ^b	244 ^a	317 ^c	341 ^c										
50.0-99.9	Obs	0	5	7	11	19	1.53	327 ^a	314 ^a	419 ^c	513 ^c	532 ^c					
	Exp	0.66	1.53	2.51	3.50	4.54	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46	
	SMR	—	—	279 ^a	314 ^a	419 ^c	513 ^c	532 ^c									
	SMR	—	—	279 ^a	314 ^a	419 ^c	513 ^c	532 ^c									
100.0-149.9	Obs	2	6	9	13	16	1.05	571 ^b	586 ^c	557 ^c	541 ^c	524 ^c					
	Exp	0.53	1.05	1.59	2.22	2.87	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	
	SMR	—	—	566 ^c	586 ^c	557 ^c	541 ^c	524 ^c									
	SMR	—	—	566 ^c	586 ^c	557 ^c	541 ^c	524 ^c									
150.0-249.9	Obs	3	7	11	13	20	0.95	737 ^c	599 ^c	709 ^c	732 ^c	765 ^c					
	Exp	0.44	0.95	1.51	2.17	2.82	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	3.28	
	SMR	—	—	728 ^c	599 ^c	709 ^c	732 ^c	765 ^c									
	SMR	—	—	728 ^c	599 ^c	709 ^c	732 ^c	765 ^c									
250.0+	Obs	3	5	13	20	27	0.95	850 ^c	995 ^c	1,149 ^c	1,255 ^c	1,208 ^c					
	Exp	0.38	0.95	1.53	2.01	2.35	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	
	SMR	—	—	850 ^c	995 ^c	1,149 ^c	1,255 ^c	1,208 ^c									
	SMR	—	—	850 ^c	995 ^c	1,149 ^c	1,255 ^c	1,208 ^c									

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rate. BE, coding of cause according to best evidence available. See text for definition of all "asbestos" diseases.

^ap < .05.

^bp < .01.

^cp < .001.

TABLE XX. All Causes: Standardized Mortality Ratios for Cumulative Deaths From 5 to 40 Elapsed Years Since Onset of Work by Estimated Fiber Exposure

Fiber-years per cc	Elapsed No. of years since onset of work						
	5 - 9	5 - 14	5 - 19	5 - 24	5 - 29	5 - 34	5 - 39
<6.0	75	85	99	103	106	106	112
6.0 - 11.9	88	100	122	140	154	160	160
12.0 - 24.9	106	127	145	172	168	169	172
25.0 - 49.9	167	127	168	163	186	204	199
50.0 - 99.9	73	109	112	138	159	172	174
100.0 - 149.9	185	188	191	186	187	183	181
150.0 - 249.9	125	191	179	159	184	195	199
250.0+	196	171	224	240	266	291	291

TABLE XXI. Lung Cancer: Standardized Mortality Ratios for Cumulative Deaths from 5 to 40 Elapsed Years Since Onset of Work by Estimated Fiber Exposure

Fiber-years per cc	Elapsed No. of years since onset of work: Observed (BE) ^a						
	5-9	5-14	5-19	5-24	5-29	5-34	5-39
<6.0	0	122	267	217	248	301	282
6.0 - 11.9	0	0	148	323	354	383	415
12.0 - 24.9	0	0	152	328	342	382	442
25.0 - 49.9	0	213	476	462	535	508	468
50.0 - 99.9	0	1,087	750	593	625	704	714
100.0 - 149.9	0	571	741	769	769	615	604
150.0 - 249.9	714	1,290	1,600	1,233	1,122	1,026	1,136
250.0+	909	667	1,000	1,029	1,342	1,667	1,596

^aBE, coding of cause according to best evidence available.

TABLE XXII. All Asbestos Diseases: Standardized Mortality Ratios for Cumulative Deaths From 5 to 40 Elapsed years since onset of work by estimated fiber exposure

Fiber-years per cc	Elapsed No. of Years Since Onset of Work: Observed (BE) ^a						
	5-9	5-14	5-19	5-24	5-29	5-34	5-39
<6.0	98	79	178	165	188	206	214
6.0 - 11.9	0	40	72	180	212	228	248
12.0 - 24.9	0	120	220	276	268	302	332
25.0 - 49.9	0	66	276	244	317	341	321
50.0 - 99.9	0	327	279	314	419	513	532
100.0 - 149.9	377	571	566	586	557	541	524
150.0 - 249.9	682	737	728	599	709	732	765
250.0+	888	526	850	995	1,149	1,255	1,208

^aBE, coding of cause according to best evidence available. See text for definition of all "asbestos" diseases.

Deaths From 5 to 40 Elapsed Years

Years of work	5 - 29	5 - 34	5 - 39
0	106	112	112
1	160	160	160
3	169	172	172
5	204	199	199
7	172	174	174
10	183	181	181
15	195	199	199
20	291	291	291

Observed Deaths from 5 to 40

Observed (BE) ^a	5 - 34	5 - 39
0	301	282
1	383	415
2	382	442
3	508	468
4	704	714
5	615	604
6	1,026	1,136
7	1,667	1,596

Cumulative Deaths From

Observed (BE) ^a	5-34	5-39
0	206	214
1	228	248
2	302	332
3	341	321
4	513	532
5	541	524
6	732	765
7	1,255	1,208

Definition of all "asbestos"

TABLE XXIII. Distribution of Workers in an Amosite Asbestos Factory, With Onset of Work 1941-1945, by Length of Time Worked and by Estimated Fiber Exposures

Fiber-years per cc	Total No. of men (%) ^a	< 1 mo		1 mo		2 mo		3-5 mo		6-11 mo		12-23 mo		24+ mo	
		No. of men (%)													
Total	820 (100.0)	61 (100.0)	89 (100.0)	79 (100.0)	155 (100.0)	120 (100.0)	121 (100.0)	195 (100.0)	0 (0.0)	2 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
< 6.0	177 (21.5)	61 (100.0)	74 (83.1)	17 (21.5)	23 (14.8)	0 (0.0)	2 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
6.0-11.9	109 (13.3)	0 (0.0)	12 (13.5)	55 (69.6)	23 (14.8)	18 (15.0)	1 (0.8)	0 (0.0)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
12.0-24.9	138 (16.9)	0 (0.0)	3 (3.4)	7 (8.9)	94 (60.7)	20 (16.7)	13 (10.7)	2 (1.0)	13 (10.7)	2 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
25.0-49.9	123 (15.0)	0 (0.0)	0 (0.0)	0 (0.0)	15 (9.7)	73 (60.8)	20 (16.5)	15 (12.2)	20 (16.5)	15 (12.2)	15 (12.2)	15 (12.2)	15 (12.2)	15 (12.2)	15 (12.2)
50.0-99.9	104 (12.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
100-149.9	57 (7.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
180.0-249.9	58 (7.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
250.0+	53 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Range	0.1-1,170.0	0.1-4.0	0.4-13.2	0.9-17.0	3.8-36.3	7.5-82.5	5.0-200.4	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0	12.5-1,170.0
Median	21.0	1.1	4.0	8.5	12.5	26.8	58.5	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0

^a% of total is indicated by number in parentheses.

3-5 Months												
Obs	13	1	1	10	1	0	0	0	0	0	0	0
Exp	3.81	0.49	0.50	2.21	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SMR	341 ^c	—	—	452 ^c	—	—	—	—	—	—	—	—
6-11 Months												
Obs	13	0	3	4	5	1	0	0	0	0	0	0
Exp	2.60	0.00	0.46	0.47	1.43	0.24	0.00	0.00	0.00	0.00	0.00	0.00
SMR	500 ^c	—	— ^a	— ^b	350 ^b	—	—	—	—	—	—	—
1 Year												
Obs	21	0	1	1	4	14	0	0	1	1	0	0
Exp	2.72	0.02	0.04	0.32	0.31	1.62	0.34	0.34	0.08	0.08	0.00	0.00
SMR	772 ^c	—	—	—	— ^b	864 ^c	—	—	—	—	—	—
2+ Years												
Obs	43	0	0	0	3	2	9	14	14	14	15	15
Exp	4.38	0.00	0.00	0.08	0.43	0.52	1.14	1.14	1.24	1.24	0.94	0.94
SMR	982 ^c	—	—	—	— ^a	—	789 ^c	789 ^c	1,129 ^c	1,129 ^c	1,596 ^c	1,596 ^c

*SMR not shown if both observed and expected deaths are less than 5. Expected deaths based on New Jersey white male quinquennial age and calendar year period specific death rates. BE, coding of cause according to best evidence available.

^ap < .05.

^bp < .01.

^cp < .001.

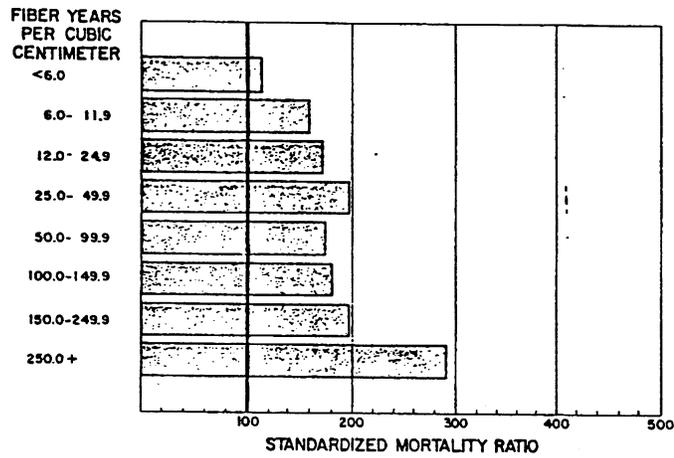


Fig. 10. Ratio of cumulative observed to expected probabilities of dying from all causes from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to estimated fiber exposure.

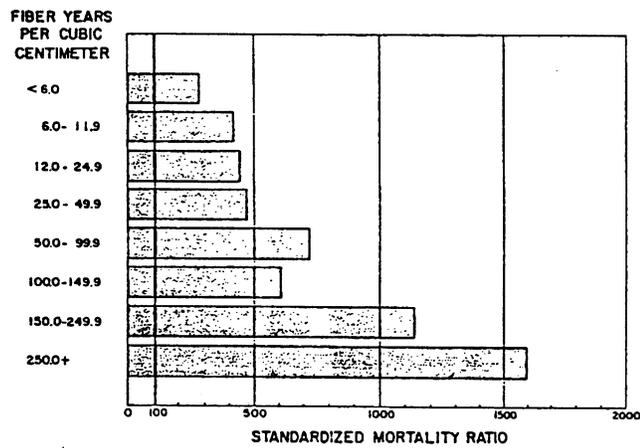


Fig. 11. Ratio of cumulative observed to expected probabilities of dying from lung cancer from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to estimated fiber exposure.

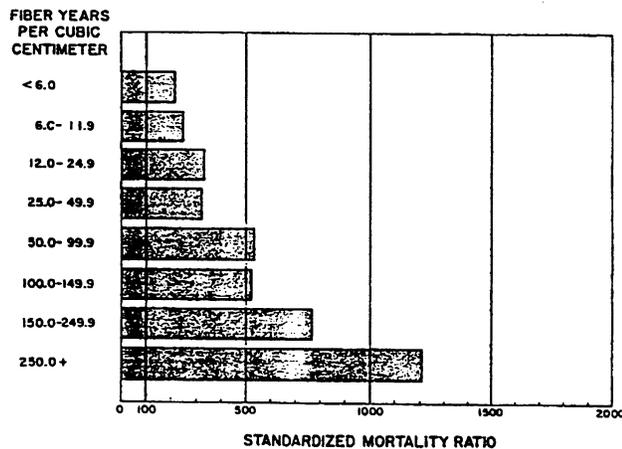


Fig. 12. Ratio of cumulative observed to expected probabilities of dying from all "asbestos" diseases from 5 through 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, according to estimated fiber exposure. See text for definition of all "asbestos diseases".

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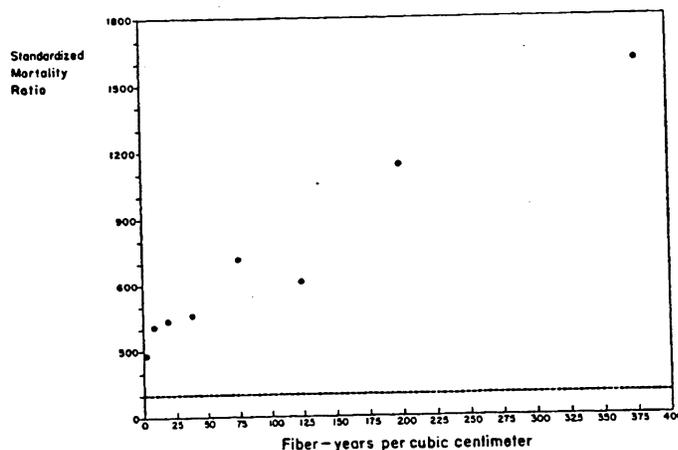


Fig. 13. Fiber-years per cubic centimeter for lung cancer from 5 to 40 elapsed years since onset of work in an amosite asbestos factory, 1941-1945, by fiber year per cubic centimeter estimated fiber exposure.

“susceptible” men through death, in general, as time goes on, the longer the time after onset of work, the more pronounced the excesses in mortality.

5. Especially with lighter (and/or shorter) direct exposure, prolonged follow-up is necessary to evaluate the effects on health.

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ORIGINAL CONTRIBUTIONS

Pleural Mesothelioma: Dose-Response Relation at Low Levels of Asbestos Exposure in a French Population-based Case-Control Study

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A hospital-based case-control study of the association between past occupational exposure to asbestos and pleural mesothelioma was carried out in five regions of France. Between 1987 and 1993, 405 cases and 387 controls were interviewed. The job histories of these subjects were evaluated by a group of experts for exposure to asbestos fibers according to probability, intensity, and frequency. A cumulative exposure index was calculated as the product of these three parameters and the duration of the exposed job, summed over the entire working life. Among men, the odds ratio increased with the probability of exposure and was 1.2 (95% confidence interval (CI) 0.8-1.9) for possible exposure and 3.6 (95% CI 2.4-5.3) for definite exposure. A dose-response relation was observed with the cumulative exposure index: The odds ratio increased from 1.2 (95% CI 0.8-1.8) for the lowest exposure category to 8.7 (95% CI 4.1-18.5) for the highest. Among women, the odds ratio for possible or definite exposure was 18.8 (95% CI 4.1-86.2). We found a clear dose-response relation between cumulative asbestos exposure and pleural mesothelioma in a population-based case-control study with retrospective assessment of exposure. A significant excess of mesothelioma was observed for levels of cumulative exposure that were probably far below the limits adopted in most industrial countries during the 1980s. *Am J Epidemiol* 1998;148:133-42.

asbestos; case-control studies; mesothelioma; occupational exposure

Mesothelioma is a rare cancer that is mainly due to occupational or nonoccupational asbestos exposure. The background level is assumed to be as low as 1-2 per million inhabitants (1). During recent decades, however, its prevalence has been increasing in the general populations of most industrialized countries (2, 3).

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Abbreviations: CEI, cumulative exposure index; CI, confidence interval; ISCO, International Standard Classification of Occupations (1968 edition); ISIC, International Standard Industrial Classification of All Economic Activities; OR, odds ratio.

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In the cohorts of workers occupationally exposed to asbestos that have been followed since the 1960s, the risk of mesothelioma has increased with the level or duration of exposure or both (4-14). The absence of accurate measurements for low exposure levels limits the reliability of any current quantitative assessments of the risk they carry. Furthermore, since only a few subjects in these cohorts were exposed to low levels of asbestos, there is not enough statistical power to show any significant association with mesothelioma.

Case-control studies among the general population and its variety of occupational categories exposed to different asbestos levels are more likely to include subjects whose exposure was low. Despite recent developments in retrospective assessment of exposure (15, 16), the quantitative assessment of low levels remains difficult, since measurements of dust concentration during the relevant periods are not often available.

Previous studies of mesothelioma (4-14) have examined exposure parameters, including cumulative exposure and such time-related variables as time since or age at first exposure. Other exposure parameters, in particular, the time-related pattern of exposure, might be useful. Although the current asbestos exposure pro-

file involves mostly intermittent exposure, the data now available do not allow any conclusion about whether asbestos inhalation at intermittent peaks contributes to the risk of mesothelioma.

The aims of this study were to examine the dose-response relation by using several types of exposure parameters and to study the role of time-related exposure patterns (intermittent compared with continuous) in a large case-control study conducted in France since 1987.

MATERIALS AND METHODS

This report is based on data collected in a hospital-based case-control study of pleural malignant mesothelioma (hereafter referred to as mesothelioma). This study is ongoing, and the present analysis is limited to data collected between January 1, 1987, and December 31, 1993. Five administrative regions of France are currently participating: The study began in the Paris metropolitan area in 1987 and was extended in 1989 to the region of Provence-Alpes-Côte-d'Azur and to Corsica and, in 1992, to Lorraine and Auvergne. The respiratory disease, chest surgery, and oncology departments of all public hospitals and the main private clinics were informed of the study and invited to participate.

Mesothelioma patients in this study met the following criteria: 1) consultation, at any stage of the disease, in a participating hospital; 2) histologically confirmed diagnosis; 3) resident in a participating region at diagnosis; and 4) alive at the time of interview.

The diagnosis of mesothelioma was confirmed by the French Mesothelioma Panel (17, 18). The panel excluded 46 (10 percent) of the subjects initially considered eligible (for whom, after pathology review, the principal diagnosis was adenocarcinoma). In 125 subjects (31 percent of the remaining 405 cases), however, the panel could not reach a conclusion because the histologic sample was insufficient or because the slides had not been sent to the panel. The likelihood of diagnosis was then determined by reviewing clinical data (clinical history, radiologic data), laboratory test reports, and the histologic conclusions of the local pathologists. Hospital controls were individually matched for sex, age (± 5 years), place of residence (administrative department), and racial or ethnic origin (black, white, North African, Asian, or other) and were selected in the departments of internal medicine, ophthalmology, and surgery. Patients with a medical history of malignant tumors or asbestos-related diseases (i.e., asbestosis and lung cancer) were excluded as controls. To the extent possible, controls were chosen in the same hospital as their matching cases.

Data collection

An experienced interviewer questioned patients during their hospitalization. In a few cases, the subject was interviewed at home. A standardized questionnaire was used to collect information on work history: work periods, including the starting and ending dates of each job that lasted at least 6 months; the company's economic branch of activity; and a description of the tasks performed by the subject. This information allowed us to classify the subject's job according to the International Standard Classification of Occupations (ISCO) code for occupations (19) and the International Standard Industrial Classification of All Economic Activities (ISIC) code (20) for industrial activities. For each job period, the subjects were asked five specific questions about direct (handled) and indirect (working in the immediate vicinity of colleagues who handled) asbestos exposure.

Exposure assessment

A panel of five experts in industrial hygiene evaluated occupational exposure to asbestos, as follows: 1) all job periods of all subjects (cases and controls) were sorted by economic branch of activity (ISIC codes) and occupation (ISCO codes); 2) the job periods were selected for review according to the likelihood of exposure of the job titles, classified by ISIC and ISCO codes; 3) the job periods for which subjects reported exposure were selected; and 4) occupational exposure to asbestos was evaluated for all job periods selected in either step 2 or step 3, in sequential order of both the ISIC and ISCO codes. Each job period for each subject was thus evaluated independently. This procedure was chosen to minimize errors in the exposure assessment due to knowledge of the subjects' lifetime exposure.

The experts were blinded to the case-control status of each job period, and decisions were made by consensus. The experts had access to all information from the questionnaire, such as job history, tasks performed, and self-report of direct or indirect exposure to asbestos.

This evaluation of each job allowed each job period to be classified according to the probability, intensity, and frequency of exposure. Categories of intensity and frequency were established by the experts before the evaluation began by using the following semiquantitative scale: probability of exposure: not exposed, possible, definite; frequency: sporadic (less than 5 percent of work time); irregular (5–50 percent of work time); continuous (more than 50 percent of work time); intensity: low (less than 1 fiber/ml); medium (1–2 fibers/ml); high (2–10 fibers/ml); very high (>10 fibers/ml).

We attributed weighting factors to each exposure category to calculate an exposure index: probability:

null = 0, possible = 0.5, definite = 1; frequency: sporadic = 0.025, irregular = 0.25, continuous = 0.75; intensity: low = 0.1 fiber/ml, medium = 1 fiber/ml, high = 10 fibers/ml, very high = 100 fibers/ml.

Because the latency period of the disease is so long, we did not analyze asbestos exposure during the 20 years before the mesothelioma diagnosis (1, 21, 22).

We used the following exposure parameters for each subject.

Highest probability, intensity, and frequency. Each subject's highest probability of exposure was determined by the highest probability of any job period during lifetime work history. Highest intensity and frequency were determined in the same way.

Duration of exposed jobs. Duration of exposed jobs (years) is defined as the total duration of job periods involving possible or definite exposure.

Cumulative exposure index (CEI). CEI is the lifetime sum of the products of probability, frequency, intensity, and duration for each job period. Because no measurements of airborne asbestos levels were available, all estimations of exposure parameters were based on the experts' subjectivity, that is, semiquantification, to which we subsequently assigned weighting factors. This index of cumulative exposure was expressed in terms of fibers/ml-years inside quotation marks ("f/ml-years").

Pattern of exposure in time. We examined the relative risks associated with the pattern of exposure by distinguishing subjects who had undergone only intermittent exposure from those whose exposure was considered continuous. Subjects' exposure was classified as intermittent if it was sporadic or irregular and if they had never worked at a job with continuous exposure. The continuous category was reserved for subjects who had been employed in at least one job with continuous exposure.

In addition to these composite variables, age at first exposure and time since first exposure were also examined.

Statistical analysis

We calculated the odds ratio by using logistic regression and the unconditional maximum likelihood method, with the aid of BMDP software (23). This technique allowed us to include the cases who had no controls. The analysis took the matching variables into account. The relation between asbestos exposure and mesothelioma was examined separately for men and women.

Quantitative parameters were categorized by percentile points. To allow us to consider the effect of some previously used cutoff points, we used additional categories for studying cumulative exposure (5 and 10 "f/ml-years").

The effect of the time-related exposure pattern (that is, intermittent vs. continuous) was analyzed after taking into account cumulative exposure.

RESULTS

The study included 405 cases and 387 controls (table 1). The largest group of cases (69.9 percent) came from the Paris metropolitan area. Cases and controls did not differ significantly by sex (82 percent and 81 percent men, respectively) or age at interview (63.5 and 63.9 years, respectively). Since almost the entire sample was white (96.8 percent of cases and 97.7 percent of controls), we did not adjust for race or ethnic origin. The socioeconomic category of the subject was determined by the last occupation held before the interview and coded using the major groups of the ISCO (table 2). Cases and controls differed significantly, with more blue-collar workers among the cases. Thus, for all comparisons, the odds ratios were adjusted for socioeconomic category.

Table 3 presents the main occupations and industries that entailed asbestos exposure among the 3,498 job periods for men. We consider in this table only activities and professions that contained at least 50 job periods and for which at least 25 percent of the job

TABLE 1. Main characteristics of cases and controls by study area, French Mesothelioma Case-Control Study, 1987-1993

Study area and years of study	Cases					Controls				
	No.	% of males	Age (years)			No.	% of males	Age (years)		
			Mean	(SD)*	Range			Mean	(SD)	Range
Paris metropolitan area (1987-1993)	283	78	62.9	(10.8)	25-88	279	78	63.4	(11.2)	29-93
Provence-Alpes-Côte-d'Azur (1989-1993)	82	92	64.5	(8.9)	44-85	73	89	65.2	(9.4)	43-84
Corsica (1989-1993)	8	75	67.5	(7.0)	60-81	7	86	64.7	(4.9)	56-71
Lorraine (1992-1993)	28	89	64.8	(12.2)	32-85	25	89	65.8	(10.7)	47-87
Auvergne (1992-1993)	4	88	68.0	(4.1)	63-73	3	75	66.0	(4.0)	62-70
Total	405	82	63.5	(10.5)	25-88	387	81	63.9	(10.7)	29-93

* SD, standard deviation.

TABLE 2. Distribution of mesothelioma cases and controls according to socioeconomic category,* French Mesothelioma Case-Control Study, 1987-1993

	ISCO code (major groups)	Men				Women			
		Cases		Controls		Cases		Controls	
		No.	%	No.	%	No.	%	No.	%
Professional, technical, and related workers	0/1	47	14.3	45	14.5	7	9.6	15	20.3
Administrative and managerial workers	2	22	6.7	17	5.5	1	1.4	0	0
Clerical and related workers	3	35	10.6	40	12.9	28	38.4	25	33.7
Sales workers	4	30	9.1	24	7.7	5	6.9	3	4.1
Service workers	5	14	4.3	32	10.3	13	17.8	20	27.0
Agricultural, animal husbandry, and forestry workers; fishermen; and hunters	6	2	0.6	8	2.6	0		3	4.1
Production and related workers, transport equipment operators, and laborers	7/8/9	179	54.4	145	46.6	19	26.0	8	10.8
No occupational activity		1		1		2		1	

* Socioeconomic category corresponding to the International Standard Classification of Occupations (ISCO) code of the last job held by the subject before interview.

periods were evaluated as possibly or definitely exposed. In the industries and occupations in which we had anticipated asbestos exposure, the proportions of exposure were high. For example, exposure was likely to have occurred in 264 of the 487 (54 percent) men's job periods in the construction industry and in 55 of the 70 (79 percent) men's job periods in the shipbuilding industry. In some occupations, exposure was frequent, e.g., 82 percent among motor vehicle mechanics and 85 percent among plumbers and pipe fitters. The proportion of exposed job periods in the categories of other industrial activities and occupations was low (16 and 19 percent, respectively).

Table 4 indicates the distribution of job periods of male cases and controls according to starting date and exposure intensity for possibly and definitely exposed job periods. Very few job periods were considered as very highly exposed, and those were found mainly among cases (18 job periods in cases vs. four among controls). These were observed after 1950 when the industrial use of asbestos had developed.

Table 5 reports the distribution of male cases and controls according to various exposure parameters. The exposure measures in this table have not been adjusted for the other exposure parameters. Mesothelioma risk increased with exposure probability, intensity, and frequency. The odds ratio for possible exposure was 1.2 (not significant), and for definite exposure, it was 3.6. Risk increased with frequency of exposure, but subjects with sporadic exposure were not at greater risk of mesothelioma than were controls. Risk also increased with the total duration of exposed jobs: The odds ratio for subjects exposed for at least 20 years was 5.4.

The odds ratio for the relation between pleural mesothelioma and asbestos exposure parameters did not increase with time since first exposure, nor was any consistent trend observed with age at first exposure.

As determined by the experts' evaluations and the weighting factors, the cumulative exposure of our population was rather low. Twenty-three percent of the cases and 35 percent of the controls had been exposed to less than 0.5 "f/ml-years." A gradient was observed with the CEI; the odds ratio rose from 1.2 for the subjects with less than 0.5 "f/ml-years" to 8.7 for the category with more than 10 "f/ml-years."

Among women, a significant risk of mesothelioma was observed among those possibly and definitely exposed to asbestos, considered together (odds ratio (OR) = 18.8, 95 percent confidence interval (CI) 4.1-86.2). Because of the small number of women exposed to asbestos, especially among controls (25 cases and two controls, for 33 and 3 percent of their respective categories), we did not analyze the dose-response relation among women any further.

The results about the time-related pattern of exposure reveal a significantly elevated odds ratio among workers whose exposure to asbestos was intermittent (OR = 1.8, 95 percent CI 1.3-2.6). The odds ratio was much greater, however, for continuous exposure (OR = 5.7, 95 percent CI 3.4-9.7). The median CEI within each category considered, i.e., <0.5, 0.5-0.99, 1-9.99, and ≥ 10 "f/ml-years," was similar among intermittent and continuous exposure cases, except in the highest class of CEI (≥ 10 "f/ml-years") (0.1, 0.65, 3.5, and 38.7 "f/ml-years" for the intermittent exposure groups and 0.075, 0.65, 3.1, and 71.3 "f/ml-years" for the continuous groups, respectively). We attempted

TABLE 3. Selected principal industrial activities and occupations entailing asbestos exposure among men, French Mesothelioma Case-Control Study, 1987-1993*

Title	No. of job periods	Proportion of exposed job periods† (%)
Industrial activities (4-digit ISIC‡ code)		
5000 Construction	487	54
3843 Manufacture of motor vehicles	113	27
7111 Railway transport	76	30
3841 Shipbuilding and repairing	70	79
3813 Manufacture of structural metal products	65	49
3511 Manufacture of basic industrial chemicals, except fertilizers	52	54
9513 Repair of motor vehicles and motorcycles	62	71
3823 Manufacture of metal and wood working machinery	58	26
3829 Manufacture of machinery and equipment, except electrical not elsewhere classified	54	30
3845 Manufacture of aircraft	51	31
3710 Iron and steel basic industries	51	61
Other industries and industries not specified (n = 7)	2,359	16
Occupations (3-digit ISCO‡ code)		
9-99 Laborers not elsewhere classified	152	26
8-41 Machinery fitters and machine assemblers	110	38
8-55 Electrical wiremen	107	54
8-49 Machinery fitters, machine assemblers, and precision instrument makers (except electrical) not elsewhere classified	99	57
8-73 Sheet-metal workers	85	49
9-54 Carpenters, joiners, and parquet workers	75	37
8-71 Plumbers and pipe fitters	73	85
9-51 Bricklayers, stonemasons, and tile setters	69	58
8-43 Motor vehicle mechanics	67	82
3-91 Stock clerks	58	28
Other professions	2,603	19
Total job periods	3,498	27

* In these tables, only activities and professions that contained at least 50 job periods and for which at least 25 percent of the job periods were evaluated as possibly or definitely exposed were considered.

† Possible or definite exposure to asbestos without taking into account the 20-year latency period.

‡ ISIC, International Standard Industrial Classification of all Economic Activities; ISCO, International Standard Classification of Occupations.

to separate the possible effect of the exposure delivery pattern from that of cumulative exposure by a stratified analysis. The odds ratios increased with the CEI among subjects with intermittent and with continuous exposures (table 5). The amplitude of the odds ratio differed, however, between these categories. When we examined the odds ratios for subjects within each of our CEI categories, they were almost twice as high for subjects with continuous exposure as for those intermittently exposed, except for the CEI category of 0.5-1 "f/ml-years."

DISCUSSION

This study, one of the larger population-based case-control studies published (24-37) sheds light on several important aspects of mesothelioma and asbestos.

As far as we know, our study is the first conducted in a general population that uses a semiquantitative

assessment of exposure to examine the dose-response relation between asbestos exposure and mesothelioma.

The mesothelioma cases of this study were identified in hospitals that had agreed to participate in the case-control survey. Cases seen in other hospitals and those who were not followed within a hospital structure were not included. There is no reason to suppose, however, that the type of health care facility depended on the level of asbestos exposure. We ought to point out another source of selection bias. Mesothelioma diagnosis remains difficult. The patient who has a known history of asbestos exposure is more likely to be diagnosed with mesothelioma than a patient with similar symptoms but no known history of asbestos exposure. This bias could have heightened the dose-response relation between asbestos exposure and mesothelioma. There are probably few cases erroneously diagnosed as mesothelioma, since the French Me-

TABLE 4. Distribution of job periods among men, according to the intensity of exposure* and decade of beginning, French Mesothelioma Case-Control Study, 1987-1993

Probability of exposure	Distribution job periods												Total	
	Before 1930		1930-1939		1940-1949		1950-1959		1960-1969		1970 and after			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cases														
Not exposed	83	77.6	172	75.1	332	66.9	280	62.8	202	61.2	215	69.8	1,284	67.0
Low	10	9.4	25	10.9	65	13.1	55	12.3	54	16.4	38	12.3	247	12.9
Medium	12	11.2	26	11.4	74	14.9	64	14.4	50	15.2	29	9.4	255	13.3
High	2	1.9	6	2.6	23	4.6	40	9.0	20	6.1	21	6.8	112	5.9
Very high	0		0		2	0.4	7	1.6	4	1.2	5	1.6	18	0.9
Total	107	100	229	100	496	100	446	100	330	100	308	100	1,916†	100
Controls														
Not exposed	65	82.3	192	84.2	341	80.6	282	80.8	218	79.3	183	83.9	1,281	81.5
Low	2	2.5	21	9.2	46	10.9	33	9.5	29	10.8	17	7.8	148	9.4
Medium	7	8.9	13	5.7	31	7.3	27	7.7	26	9.5	15	6.9	119	7.6
High	4	5.1	2	0.9	4	1.0	6	1.7	1	0.4	3	1.4	20	1.3
Very high	1	1.2	0		1	0.2	1	0.3	1	0.4	0		4	0.3
Total	79	100	228	100	423	100	349	100	275	100	218	100	1,572‡	100

* Intensity for possible or definite exposure to asbestos without taking into account the 20-year latency period.

† Job periods for which the year of beginning is missing = 6.

‡ Job periods for which the year of beginning is missing = 4.

sothelioma Panel excluded, after pathology review, 10 percent of subjects initially considered eligible and confirmed the diagnosis for 62 percent of the cases on the basis of pathology reports. We accepted the remaining 28 percent after reviewing available histologic data and hospital records.

The use of hospital controls could have entailed some bias. In particular, cases and controls differed in socioeconomic status, with the latter group containing fewer blue-collar workers. This difference could have arisen from a selection bias and might reflect the controls' failure to represent adequately the population from which the cases were drawn, or it might be due to a particularly high rate of pleural mesothelioma among blue-collar workers because of their high prevalence of asbestos exposure. In the latter case, taking socioeconomic status into account could have led to overadjustment of the relation between asbestos exposure and pleural mesothelioma. The crude odds ratios, however, were of same order of magnitude as the adjusted values.

The validity of the information about asbestos exposure depends on how well we have avoided three types of errors: difference in the quality of interview data according to disease status (recall bias or interviewer bias), errors by the experts in classifying the subjects into defined categories, and errors related to the accuracy of the weighting factors subsequently assigned to each category. As recently stated in an International Agency for Research on Cancer meeting on retrospective assessment of occupational exposure in epidemiology (38), the validity of expert judgment, which relies on both the knowledge and the experience of industrial hygienists, has rarely been evaluated.

Indeed, when no objective method of measuring exposure is available, their judgment is most often considered the gold standard.

Our study assessed frequency and intensity of exposure by using ordinal categories with specific boundaries. This procedure should have minimized the misclassification of subjects between extreme exposure categories. The experts themselves, however, reported sometimes encountering difficulties in distinguishing between sporadic and irregular exposure and between low and moderate exposure.

Moreover, they suggested that the quality of their assessment for the periods under consideration (20 or more years ago) might not be as good as for more recent years because of the lack of published data for these periods. These errors could have led to the nondifferential misclassification of subjects into exposure categories and the possible underestimation of the odds ratios (39).

To avoid the exposure suspicion bias, the experts were blinded to case-control status when they evaluated exposure. Recall bias could have influenced the quality of the answer to the questionnaire and, subsequently, the expert judgment. To test this potential bias, we compared the experts' assessment with results from an asbestos job exposure matrix (40). We found no difference between cases and controls (data not shown), suggesting that it was unlikely that a substantial recall bias had affected the experts' judgment. The interviewers, however, were aware of case-control status and thus might have conducted the interviews of the case subjects more thoroughly than those of controls. Since the experts considered all of the information available, they might have been able to evaluate

TABLE 5. Odds ratios for relations between pleural mesothelioma and asbestos exposure parameters among men, French Mesothelioma Case-Control Study, 1987-1993, with a latency period of 20 years

Asbestos exposure parameters	No. of cases	No. of controls	OR*	95% CI†
Highest probability of exposure				
Not exposed	95	154	1.0	
Possible	51	71	1.2	0.8-1.9
Definite	184	87	3.6	2.4-5.3
Highest intensity of exposure				
Low	55	74	1.2	0.8-1.9
Medium	106	66	2.8	1.8-4.3
High	74	18	7.1	3.9-12.9
Highest frequency of exposure				
Sporadic	56	86	1.0	0.7-1.6
Irregular	94	46	3.3	2.1-5.1
Continuous	85	26	5.7	3.4-9.7
Duration of exposed job (years)				
1-7	63	64	1.7	1.1-2.6
8-19	74	60	2.0	1.3-3.1
≥20	98	34	5.4	3.2-8.9
Time since first exposure (years)				
20-37	77	53	2.3	1.4-3.6
38-48	83	47	2.8	1.8-4.5
≥49	75	58	2.2	1.4-3.6
Age at first exposure (years)				
<16	66	55	1.9	1.2-3.1
16-22	96	52	3.0	1.9-4.6
≥23	73	51	2.3	1.5-3.7
Cumulative exposure (f/ml-year‡)				
0.001-0.49	77	109	1.2	0.8-1.8
0.5-0.99	29	12	4.2	2.0-8.8
1-9.9	80	27	5.2	3.1-8.8
≥10	49	10	8.7	4.1-18.5
Cumulative exposure (f/ml-year)				
Temporal exposure pattern§				
Intermittent				
<0.5	66	98	1.1	0.8-1.7
0.5-0.99	19	8	4.0	1.7-9.7
1-9.99	48	21	4.0	2.2-7.2
≥10	17	5	5.9	2.1-16.7
Continuous				
<0.5	11	11	1.9	0.8-4.8
0.5-0.99	10	4	4.6	1.4-15.4
1-9.99	32	6	9.2	3.7-23.1
≥10	32	5	11.3	4.1-30.7

* Odds ratios (ORs) adjusted for age and socioeconomic category.

† CI, confidence interval.

‡ Cumulative exposure index was based on subjective assessment, that is, semiquantification of exposure by the experts and selected weighting factors assigned to each category of exposure, with no objective measurement of airborne asbestos levels. Thus, the exposure unit, f/ml-years, is expressed in quotation marks.

§ Subjects' exposure was classified as intermittent if it was sporadic or irregular and if they had never worked at a job with continuous exposure. The continuous category was reserved for subjects who had been employed in at least one job with continuous exposure.

exposure more precisely for the cases than for the controls. The frequency of the exposure category "possible," used when the experts could not reach a definite conclusion, was higher among controls than among cases, so that this type of error cannot be excluded. We thus undertook a supplementary analysis to examine, at least in part, the effect of this bias. First, we considered all of the jobs in the possible category as nonexposed. The pattern of dose-response relation was very similar to that observed: no significant risk for subjects in the category of less than 0.5 "f/ml-years" and an odds ratio of 7.8 (95 percent CI 3.8–16.2) for those in the category of more than 10 "f/ml-years." Classifying all of the possibly exposed subjects as definitely exposed did not change the dose-response relation pattern very much either (OR = 1.0, 95 percent CI 0.7–1.6 for the lowest category and OR = 7.7, 95 percent CI 3.8–15.7 for the highest).

The validity of the dose-specific risks in our study also depends greatly on the values of the weighting factors selected for each exposure category. For this purpose, we attempted to retain the intervals used by the experts. Although this procedure is assumed to provide more precise exposure evaluation than would a relative ranking of subjects by an ordinal scale without specified boundaries, some misclassification of subjects according to dose-specific exposure probably occurred. Indeed, all jobs classified in the same exposure category were assigned the same weighting value without consideration of the variability of exposure within the category. Such nondifferential misclassification of the subjects usually attenuates the relation between exposure and disease and flattens the dose-response curve (39). We should note that the intervals used by the experts for the categories of intensity were rather dissymmetric—narrow for medium exposure and large for very high exposure. There were few job periods with very high exposure, however, so that errors due to the variability in this category should have had little effect on the dose-response relation observed.

We observed a dose-response relation with cumulative exposure. Because, as stated, the exposure assessment for the earliest periods might have been underestimated and because of the imprecision of intensity weighting factors, we tested two models using two other series of coefficients for weighting intensity of exposure: 1) second model: 0.5, 1.5, 6, and 550 fibers/ml, for low, medium, high, and very high exposures, respectively (midpoints of boundaries), and 2) third model: 0.5, 5, 50, and 500 fibers/ml for low, medium, high, and very high exposures, respectively. These models showed a dose-response relation with the CEI similar to that in the first model, but they did not show

as clear a dose-response trend as the first model. In the second model, the odds ratio was 1.0 (95 percent CI 0.7–1.6) for the lowest dose and 6.4 (95 percent CI 3.4–12.2) for the highest. The corresponding odds ratios for the third model are 0.9 (95 percent CI 0.5–1.4) for the lowest and 7.1 (95 percent CI 4.2–11.9) for the highest.

The pattern of the dose-response curve could have depended on the length of latency period selected. We have used a 20-year latency period, as suggested by McDonald and McDonald (1, 21), who concluded that latency is seldom less than 20 years and usually 30–40 years. We also examined the effects of 10- and 30-year latency periods. The results obtained with the former were very similar to those we found with the 20-year latency period. A 30-year latency period resulted in a lower odds ratio and a less clear dose-response relation, suggesting that exposure misclassification occurred using such a long latency period.

Because no objective measurement was available to test the validity of the experts' evaluation, we express the cumulative exposure using units of f/ml-years in quotation marks. Even in cohort studies, however, precise measurement of exposure is difficult (2, 41).

In this study, we used several surrogate parameters for dose to examine dose-response relation, as suggested by Blair and Stewart (42) and Suarez-Almazor et al. (43). We considered separately the intensity, frequency, and duration of exposure, and each was significantly related to mesothelioma. The relative risk increased along with each parameter. In addition, when each of these parameters was adjusted for the others, the relative risk of each, although lower, remained significant. These results suggest that each exposure parameter contributed to some extent to the occurrence of mesothelioma, although the dose-response relation seemed to be described best by the CEI.

The existence of a causal association between asbestos exposure and mesothelioma was first demonstrated in 1960 (44). Both cohort (6–9, 11–14, 45) and case-control (32, 34–37, 46, 47) studies focusing on mesothelioma and examining surrogate parameters for dose have reported a dose-response relation.

However, because of the rarity of mesothelioma, even among asbestos workers, little quantitative information is available from which the dose-response relation can be precisely estimated (1, 41, 48).

Peto et al. (49), using mathematical models, observed that the risk of mesothelioma in one occupationally exposed cohort (North American insulators) was best described by a model in which the risk increases with the third or fourth power of time since first exposure. They also concluded that their data were compatible with a linear dose-response relation

between the level of asbestos exposure and the risk of mesothelioma. Our data for the higher categories of CEI also support this conclusion. The pattern of a dose-response relation is more doubtful at low doses because the uncertainties of exposure evaluation are highest for low doses.

Some indication of the effect of exposure that is low level by the brevity of its duration comes from industrial cohort studies. Very few cases of mesothelioma have been observed among those whose exposure was very brief: There were no cases of mesothelioma among members of the cohort of Australian Blue Asbestos workers who were exposed for less than 3 months (47), none among the North American insulators whose exposure lasted less than 15 months (4), and only one, rather than the 25 expected, among Rochdale textile workers exposed for less than 10 years (8). These cohorts do not, however, provide data that allow us to examine the effect of low-intensity exposure.

Ilgren and Browne (50) considered whether a threshold exposure might exist and concluded that mesothelioma was unlikely in persons exposed for less than 5 f/ml-years. Our results indicate, however, that mesothelioma cases occurred below a cumulative exposure of 5 f/ml-years and perhaps below 0.5 f/ml-years.

Very few studies have focused on the time-related pattern of exposure as a factor in mesothelioma. Schenker et al. (51) examined the risk of mesothelioma among railroad workers, distinguishing between "intermittent" and "regular" asbestos exposure on the basis of job categories. No significant risk was observed for those whose exposure was intermittent, but those in the regular exposure category were at high risk.

Our study examined the temporal exposure pattern according to the frequency of exposure and the CEI. We observed a dose-response relation with cumulative exposure for both intermittent and continuous patterns of exposure. Much more attention to the role of these temporal patterns is needed, adjusting for cumulative exposure. Our results suggested that intermittent exposure does not entail as high a risk of mesothelioma as does continuous exposure. Assessment of this apparent excess risk of continuous compared with intermittent exposure, however, should bear in mind the likelihood that more subjects with intermittent exposure are misclassified.

We could not examine mesothelioma risk according to fiber types because our study design (i.e., case-control study in a general population) did not allow us to identify those subjects whose exposure was only to chrysotile fibers.

The odds ratio between exposure to asbestos and mesothelioma was much higher for the women in our study than for the men. No evidence of individual, sex-related susceptibility to mesothelioma has been found (52). One explanation for this might be the different distributions of asbestos-related occupations between men and women. Since asbestos-related occupations were rarely held by women, any exposure that did occur may have been very well characterized, leading, in turn, to fewer misclassification errors than for males, particularly among controls.

We found a clear dose-response relation between cumulative exposure to asbestos and pleural mesothelioma in a population-based case-control study with retrospective assessment of exposure. A significant excess of mesothelioma was observed for levels of cumulative exposure that were probably far below the limits adopted in many industrial countries during the 1980s.

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1 THE HONORABLE SHARON ARMSTRONG

2 FILED

3 KING COUNTY, WASHINGTON

4 NOV - 6 2006

5 SUPERIOR COURT CLERK
6 BY KIRSTIN GRANT
7 DEPUTY

8 IN THE SUPERIOR COURT OF THE STATE OF WASHINGTON
9 IN AND FOR THE COUNTY OF KING

9 SANDRA LOTT, as Personal Representative
10 of the Estate of TIMOTHY LOTT, deceased,

11 Plaintiff,

12 v.

13 SABERHAGEN HOLDINGS, INC., et al.,

14 Defendants.

No.: 05-2-06955-4 SEA

DEFENDANTS BONDEX
INTERNATIONAL, INC., RPM, INC. AND
RPM INTERNATIONAL, INC.'S "FRYE"
HEARING BRIEF

15 I. INTRODUCTION

16 Plaintiff has designated pathologist John Maddox, M.D. as her expert on medical
17 causation. Defendants Bondex International, Inc., RPM, Inc., and RPM International, Inc.
18 ("Bondex") expect that Dr. Maddox will provide the same causation testimony at trial that he
19 did at deposition. That testimony is that every single exposure to every asbestos-containing
20 product Timothy Lott encountered during his lifetime, including Bondex joint compound,
21 was a substantial contributing factor - i.e., a proximate cause - of Mr. Lott's mesothelioma.
22 Such testimony not only fails to satisfy the *Frye* test for admissibility, it contradicts common
23 sense. The testimony is inadmissible and must be excluded.

24 The exact same ultimate opinion testimony on causation that Bondex anticipates that
25 Dr. Maddox will offer on this case has been found to fail the *Frye* test of admissibility and
26

1 has been excluded in other cases. Earlier this year, the Superior Court for Allegheny County
2 Pennsylvania, (Pittsburgh) conducted a consolidated Frye hearing in several selected
3 asbestos exposure cases (lead case: *Vogelsberger v. Owens-Illinois*). Judge Robert Coville
4 prepared a detailed opinion that explained why an ultimate causation opinion, which is
5 identical to the one at issue in this motion, failed to satisfy the *Frye* test for admissibility and
6 should be excluded. Bondex has already provided the court and plaintiff's counsel with a
7 copy of Judge Colville's opinion. And, Judge Erlich has recently excluded the same
8 testimony from Dr. Hammar in the *Anderson* case.

9 II. RELIEF REQUESTED

10 Bondex requests an order that Dr. Maddox's ultimate opinion testimony on causation
11 is inadmissible and must be excluded.

12 III. STATEMENT OF FACTS

13 Plaintiff has listed Dr. John Maddox as an expert witness she intends to call at the
14 trial of this action. Dr. Maddox is a physician and board certified pathologist who practices
15 in Virginia. Dr. Maddox regularly provides deposition and trial testimony in asbestos
16 exposure litigation around the country, primarily testifying on behalf of plaintiffs. At his
17 deposition, Dr. Maddox testified that any exposure to asbestos that was below a
18 "background" level was not causative for mesothelioma. Maddox Depo. (Washington), pp.
19 65:24-66:3, 99:15-22. In a separate asbestos exposure lawsuit filed in Texas, Dr. Maddox
20 testified that there was no safe level of exposure to asbestos. Maddox Depo. (Texas)
21 attached to the Leta Gorman Declaration, Ex. 1, p. 19:3-12. Based on this testimony,
22 Bondex believes that Dr. Maddox will offer in this case the same ultimate causation opinion:
23 each and every exposure Timothy Lott had to any asbestos-containing product, including
24 those manufactured by Bondex, was a substantial contributing factor in causing Mr. Lott's
25 mesothelioma. See Maddox Depo., *Shirley Colvin v. AC&S, Inc., et al.*, Gorman Decl., Ex.
26 2, p. 74:5-9.

1 **II. STATEMENT OF ISSUES**

2 Is Dr. Maddox's proposed opinion testimony regarding ultimate causation
3 inadmissible because it is not based upon established scientific methodology?

4 **III. EVIDENCE RELIED UPON**

5 Bondex relies upon the Declaration of Leta Gorman in Support of Motion to Exclude
6 Dr. Maddox's Testimony, and attached Exhibits.

7 **IV. AUTHORITY**

8 The Washington Supreme Court reaffirmed in *State v. Copeland*, 130 Wn. 2d 244,
9 261, 922 P.2d 1304, 1315 (1996) that the admissibility of scientific evidence in Washington
10 is governed by the "Frye" test, based upon *Frye v. United States*, 293 F. 1013 (D.C. Cir.
11 1923). The primary goal of a *Frye* analysis under ER 702 is "to determine whether the
12 [scientific opinion] evidence offered is based on established scientific *methodology*." *State*
13 *v. Gore*, 143 Wn. 2d 288, 302, 21 P.3d 262, 270 (2001) (emphasis added). "There must be
14 both general acceptance in the relevant scientific community of the theory and of the
15 technique used to implement the theory." *Id.*, 143 Wn. 2d at 302, 21 P.3d at 271. That is, in
16 determining whether scientific opinion evidence should be admitted, the trial court must
17 determine: (1) whether the underlying theory is generally accepted in the scientific
18 community and (2) whether there are techniques, experiments, or studies utilizing that theory
19 that are capable of producing reliable results and are generally accepted in the scientific
20 community. *Grant v. Boccia*, 133 Wn. App. 176, 179, 137 P.3d 20, 22 (2006) (citing *State v.*
21 *Riker*, 123 Wn. 2d 351, 359, 869 P.2d 43, 47-48 (1994)).

22 Here, the question to be addressed is: Is Dr. Maddox's ultimate causation opinion
23 (viz., that each and every exposure to asbestos-containing products – including specific
24 products manufactured or distributed by Bondex – was a substantial contributing factor in
25 causing Mr. Lott's mesothelioma) based upon methodologies utilizing scientific principles
26 that are logically applied in a manner that can be tested and empirically verified? The clear

1 answer to this question is “no.” Therefore, the Court should preclude Dr. Maddox from
2 offering his ultimate causation opinion at trial.

3 **A. Dr. Maddox’s ultimate causation opinion cannot satisfy the *Frye* test for**
4 **admissibility.**

5 1. **The same testimony bt Dr. Hammar has been excluded by Judge Erlich.**

6 *Webster’s Collegiate Dictionary* (10th ed. 1998) defines a “hypothesis” as “a tentative
7 assumption made in order to draw out and test its logical or empirical consequences[.]”

8 Further, “HYPOTHESIS implies insufficient evidence to provide more than a tentative
9 explanation.”

10 By its very definition, a hypothesis is not a generally accepted scientific theory. To
11 become a generally accepted scientific theory, a hypothesis must be proven or verified by
12 controlled experiments. Tentative assumptions unquestionably do not amount to generally
13 accepted scientific methodology.

14 Dr. Maddox’s causation opinion is shared by Dr. Sammuel Hammar. But Dr.
15 Hammar attempted to offer this testimony in the *Anderson* asbestos trial this week, and Judge
16 Erlich concluded that the testimony was not allowable.

17 Because Dr. Hammar’s testimony based on the same hypothesis was excluded as an
18 unproven hypothesis without scientific support, the same opinion by Dr. Maddox clearly
19 cannot satisfy the *Frye* test and must be excluded.

20 2. **Dr. Maddox contradicts his ultimate opinion that all asbestos exposures**
are a “cause” by conceding that “background” exposure is not a “cause.”

21 Asbestos is ubiquitous – it occurs naturally in the ground and is naturally released into
22 the air. Asbestos is also released into the air from a multitude of asbestos-containing
23 products that have been used in everyday life over the past century. Accordingly, it is
24 generally accepted in the scientific community that everyone is exposed to asbestos and that
25 everyone has asbestos fibers in his or her lungs. This exposure to which everyone is
26 subjected is called “background” or “ambient” exposure.

1 No expert, including Dr. Maddox, believes background levels of asbestos exposure
2 can increase the risk of developing an asbestos-related disease, including mesothelioma. In
3 fact, Dr. Maddox has consistently testified in the past that background levels of asbestos
4 exposure – which vary significantly from place to place – are not a contributing cause of
5 asbestos-related disease, including mesothelioma. At a deposition in another case, Dr.
6 Maddox testified:

7 Q Do you consider a lifetime dose of background
8 exposures to asbestos significant?

9 A. If a person only has a background or environmental
10 level, that is not sufficient for me to ascribe causation of those
11 fibres to the development of that person's mesothelioma. I
12 would still relate that to the idiopathic group. *Kwasnik v.*
13 *AC&S, et al*, Gorman Decl., Ex. 3, p. 180:4-10.

14 It is logically inconsistent and contradictory for Dr. Maddox to concede on the one
15 hand that background levels of asbestos exposure – whatever they may be – cannot be a
16 contributing cause of mesothelioma while insisting on the other hand that each and every
17 exposure to asbestos-containing products – whatever the exposure level might be – is a
18 substantial contributing factor in causing mesothelioma. Inherently flawed, Dr. Maddox's
19 ultimate causation opinion is unreliable and must be excluded.

20 3. Dr. Maddox also contradicts his ultimate opinion that all asbestos
21 exposures are a "cause" by conceding that an exposure below
22 "background" is not a "cause."

23 Dr. Maddox believes and has testified that, if any particular exposures during a
24 person's lifetime can be identified as being at or below "background," those exposures
25 cannot be considered to be a substantial factor in causing mesothelioma. *Kwasnik v. AC&S,*
26 *et al*, Gorman Decl., Ex. 3, p. 180:4-10.

Again, just as it is logically inconsistent and contradictory for Dr. Maddox to concede
that background levels of asbestos exposure cannot be a contributing cause of mesothelioma
while claiming that each and every exposure to asbestos-containing products is a substantial

1 contributing factor, it is likewise inconsistent and contradictory for Dr. Maddox to concede
2 that no exposures below background will cause mesothelioma and yet opine that *any*
3 exposure will cause mesothelioma. This contradiction was highlighted in the following
4 deposition testimony:

5 Q. Background -- background levels of asbestos are, in fact,
6 considered an exposure?

7 A. Well, I'm afraid so, yes. I mean, you're not -- you're not
8 born with asbestos as part of your body.

9 Q. So it's clear then, to the Jury, as they've just heard your
10 testimony, that not each and every exposure to asbestos
11 contributes to a peritoneal mesothelioma, isn't it?

12 A. Each and every exposure above background contributes.

13 Q. Well, Dr. Maddox, how can we tell the Jury exactly
14 where and how far above background an exposure needs to be to
15 be a contributing factor?

16 A. In other words, where does one draw the line in the
17 sand? Well, in my opinion, one should draw the line in the sand
18 at anything above background or environmental exposure.
19 *Kwasnik v. AC&S, et al*, Gorman Decl., Ex. 3, p. 181:8-25.

20 Because his opinion is internally inconsistent, Dr. Maddox's ultimate causation
21 opinion is unreliable and must be excluded.

22 4. Dr. Maddox's hypothesis that all asbestos exposures -- including low dose
23 exposures -- cause mesothelioma also defies common sense.

24 Consistent with the generally accepted view in the scientific community, Dr. Maddox
25 believes that all asbestos-related diseases are, at high levels of exposure, subject to a dose-
26 response curve. That is, at high dose exposures, greater amounts of inhaled asbestos fibers
correlate to a greater risk of developing an asbestos-related disease. But Dr. Maddox readily
concedes that dose-response data, acquired through generally accepted scientific
methodology, simply does not exist for low dose exposures. *Kwasnik v. AC&S, et al*,
Gorman Decl., Ex. 3, p. 182:1-15.

1 Logically, Dr. Maddox's ultimate causation opinion that every single exposure to
2 every asbestos-containing product Mr. Lott encountered during his lifetime is a substantial
3 contributing factor in causing Mr. Lott's mesothelioma would have to mean that exposure
4 dosage is irrelevant. Low dosage exposure would have to be every bit as harmful, and
5 equally causative of disease, as higher dosage exposure. In the absence of scientific data
6 showing that low dosage asbestos exposure is harmful, however, the logic fails.

7 The logical fallacy of basing a hypothesis on a downward extrapolation from dose-
8 response data rather than on actual data obtained through generally accepted scientific
9 methodology is plainly illustrated by common experience. Excessive amounts of water can
10 be lethal whereas lower levels of water intake are healthful. Likewise, excessive doses of
11 medicines can be lethal while moderate doses promote health. The mere fact that greater
12 amounts of exposure to a substance are harmful clearly does not mandate the conclusion that
13 smaller amounts of exposure to the same substance are also harmful.

14 Accordingly, Dr. Maddox's ultimate causation opinion that each and every exposure
15 to every asbestos-containing product Mr. Lott encountered during his lifetime, regardless of
16 the exposure dosage, is a cause of Mr. Lott's mesothelioma, based on extrapolation
17 unsupported by scientific data, must be deemed inadmissible and excluded.

18 **B. Plaintiff should not be permitted to offer opinion evidence devoid of scientific**
19 **merit for the purpose of escaping the deficiencies in her proof.**

20 In order to prevail on her product liability claim against Bondex, plaintiff must prove
21 that a product manufactured or distributed by Bondex caused Mr. Lott's mesothelioma.
22 *Lockwood v. AC&S, Inc.*, 109 Wn. 2d 235, 242-49, 744 P.2d 605 (1987). The court in
23 *Lockwood* ruled that "[t]rial courts should consider a number of factors when determining if
24 there is sufficient evidence for a jury to find that causation has been established." *Id.* at 248.

25 Those factors are:

- 26 (1) plaintiff's proximity to the asbestos product when the exposure occurred and the expanse of the work site where asbestos fibers were released; (2) the extent of time the plaintiff

1 was exposed to the product; (3) the types of asbestos products to
2 which plaintiff was exposed, the ways in which plaintiff was
3 exposed, and the ways in which the products were handled and
used; and (4) evidence of the medical causation of the worker's
disease. *Id.* at 248-49.

4 In this case, plaintiff does not have any direct evidence to satisfy any of the first three

5 *Lockwood* factors:

- 6 • no evidence of the types, size, composition, age, or
7 condition of asbestos-containing products manufactured
8 or distributed by Bondex which were actually
9 encountered by Mr. Lott;
- 10 • insufficient evidence of Mr. Lott's proximity to the
11 product;
- 12 • insufficient evidence of the ways the product was
13 handled or manipulated;
- 14 • no evidence that the handling or manipulation of the
15 product released asbestos fibers into the air;
- 16 • no evidence of the quantity of asbestos fibers released
17 into the air or the expanse of the area where the release
18 occurred; and
- 19 • no evidence of asbestos exposure dose experienced by
20 Mr. Lott (*i.e.*, airborne concentration of asbestos fibers
21 and the frequency and duration of Mr. Lott's inhalation
22 of the fibers).

23 The only hope plaintiff has of obtaining a verdict against Bondex is to obscure the
24 lack of product exposure evidence by confusing the jury with Dr. Maddox's unproven
25 ultimate causation opinion – that any exposure, no matter how fleeting or small, establishes
26 causation. If the jury is permitted to hear Dr. Maddox give his opinion that any encounter
Mr. Lott may have had with a Bondex product constitutes a cause in fact of Mr. Lott's
mesothelioma, the jury will be impermissibly invited to return a verdict against Bondex
based not upon valid, generally accepted scientific methodology, but upon speculation and
conjecture.

1 **C. The above reasons are why Judge Colville has excluded Dr. Maddox's causation**
2 **testimony.**

3 As Judge Colville points out, Dr. Maddox's opinion that Mr. Lott's exposure to
4 Bondex products was a proximate cause of his mesothelioma is and must be grounded in his
5 opinion that exposure to every single asbestos product is a proximate cause of a subsequently
6 diagnosed asbestos disease. (Colville Opinion, p. 2) Judge Colville based his decision on
7 the fact that Dr. Maddox's "every exposure" opinion is not based on "methodologies
8 utilizing discrete and scientific principles logically applied in a manner that can be
9 affirmatively articulated, reference, reviewed, and tested, and empirically verified," but
10 rather on Dr. Maddox's "best estimate," "gut instinct" or "educated guess." (Colville
11 Opinion, p. 4)

12 Judge Colville noted that case reports, which Dr. Maddox relies upon as support from
13 his opinion, are not reliable support for the opinion because the "only report associations –
14 not causal correlations." (Colville Opinion, p. 9)

15 He also noted that Dr. Maddox relied on a dose response bell curve, but cannot
16 articulate how he concludes a dose response curve is applicable to a specific plaintiff such as
17 Mr. Lott, because he does not rely on any actual quality or quantity of exposure to Mr. Lott,
18 (Colville Opinion, pp. 11-12), and that generally accepted dose response curves for low dose
19 exposures simply do not exist. (Colville Opinion, p. 13) Dr. Maddox is therefore forced to
20 "extrapolate down" from the premise that exposure to higher doses causes disease to the
21 conclusion that exposure to small amounts of asbestos can cause disease. Judge Colville
22 convincingly debunks that theory as unsupportable. And, Dr. Maddox cannot quantify Mr.
23 Lott's exposures, so he cannot establish what his dose is in any event. He does not even
24 attempt to delineate a threshold exposure or potential range for threshold exposure. (Colville
25 Opinion, p. 25) He must fall back on his opinion that since it is an occupational exposure, it
26 is a proximate cause of Mr. Lott's disease. (Colville Opinion, pp. 14, 16-17)

1 This is certainly a low-dose case. In his deposition, Dr. Dyson, Bondex's industrial
2 hygienist, testified that, in his opinion, Mr. Lott had an "ultra-low exposure" to asbestos from
3 all joint compounds. Gorman Decl., Ex. 4, p. 49:3-8. As Mr. Lott testified yesterday, he
4 cannot specifically recall working with or around a Bondex joint compound; he recalls
5 seeing it in the maintenance shed and assumes that if it was there, they must have used it.
6 Even assuming he used a Bondex joint compound equally with the 7 other joint compounds
7 he identified, it is an ultra-low exposure divided by 7.

8 Judge Colville also pointed to the lack of biological evidence supporting Dr.
9 Maddox's opinion. The same is true in this case, as there are no biological findings upon
10 which Dr. Maddox relies to support his causation opinion – it is simply that Mr. Lott was
11 exposed to a Bondex product. (Colville Opinion, p. 24-25) he also concludes that Dr.
12 Maddox does not answer how he can distinguish Mr. Lott's mesothelioma from the
13 percentage of idiopathic mesotheliomas which exist – this is especially true for peritoneal
14 mesothelioma, which Dr. Brody called "more mysterious" as to the cause – there is a
15 significantly higher percentage of idiopathic peritoneal mesotheliomas than pleural ones.
16 (Colville Opinion, p. 23-24)

17 Judge Colville concludes that there "is no medical authority or generally accepted
18 methodology that would support the conclusion that low-dose exposures cause asbestos-
19 disease generally, let alone the rather extraordinary assertions by Dr[.] Maddox...that 'each
20 and every exposure' contributed to Mr. Lott's disease. Judge Colville concluded that Dr.
21 Maddox's methodology is fundamentally flawed and not generally accepted by the relevant
22 scientific community. (Colville Opinion, p. 27)

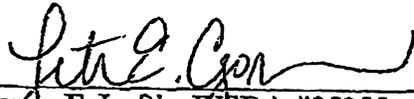
23 V. CONCLUSION

24 Dr. Maddox's opinion regarding ultimate causation is, by his own admission, a
25 hypothesis unsupported by scientific evidence. Moreover, his testimony contradicts his own
26 hypothesis. His opinion that any exposure to asbestos is sufficient to cause mesothelioma is

1 inadmissible under the *Frye* standard, and Bondex requests that the Court order it to be
2 excluded.

3 DATED November 3, 2006.

4 BULLIVANT HOUSER BAILEY PC

5
6 By 
7 Jearge F. Loftis, WSBA #35355
8 Leta E. Gorman, WSBA #24337

9 Attorneys for Defendant Bondex International,
10 Inc., RPM, Inc. and RPM International, Inc.

IN THE SUPERIOR COURT OF THE STATE OF WASHINGTON
IN AND FOR THE COUNTY OF KING

SANDRA LOTT, as Personal Representative
of the Estate of TIMOTHY LOTT, deceased,

No.: 05-2-06955-4 SEA

Plaintiff,

DECLARATION OF SERVICE

v.

SABERHAGEN HOLDINGS, INC., et al.,

Defendants.

I, the undersigned, declare and state as follows:

1. I am employed by the law firm of Bullivant Houser Bailey PC, 888 SW 5th Ave., Ste. 300, Portland, Oregon 97204. I am and at all times herein was a citizen of the United States, and am over the age of 18 years.

2. On November 3, 2006 I caused to be served true and correct copies of the foregoing **DEFENDANTS BONDEX INTERNATIONAL, INC., RPM, INC. AND RPM INTERNATIONAL, INC.'S "FRYE" HEARING BRIEF**; and the concurrently filed **DECLARATION OF LETA E. GORMAN** and the **ORDER [PROPOSED] DENYING MOTION TO SHORTEN TIME** on the following counsel of record by the method indicated:

///

///

1 Via e-mail

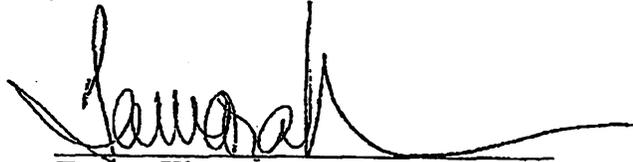
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19 **Attorneys for Plaintiff Sandra Lott, PR of the Estate of Timothy Lott**

20 I declare under penalty of perjury under the laws of the State of Washington that the
21 foregoing is true and correct.

22 DATED at Portland, Oregon this 3rd day of November 2006.

23 
24 Tamara King

25 10306127.1

A-6

THE HONORABLE SHARON ARMSTRONG

FILED

KING COUNTY, WASHINGTON

NOV - 6 2006

SUPERIOR COURT CLERK

BY **KIRSTIN GRANT**
DEPUTY

SUPERIOR COURT OF WASHINGTON FOR KING COUNTY

SANDRA LOTT, Individually and as Personal
Representative of the Estate of TIMOTHY
LOTT,

Plaintiff,

v.

SABERHAGEN HOLDINGS, INC.; et al.,

Defendants.

No. 05-2-06955-4 SEA

ORDER DENYING BONDEX'S
MOTION TO EXCLUDE PORTIONS
OF DR. MADDOX'S TESTIMONY
PURSUANT TO *FRYE*

~~PROPOSED~~

THIS MATTER comes before the Court on Bondex's Motion to Exclude Portions of Dr. Maddox's Testimony Pursuant to *Frye*. In adjudicating this Motion, the Court has considered the following pleadings submitted by the parties and testimony from the following witnesses:

- (1) Bondex International and RPM Inc.'s Frye Hearing Brief;
- (2) Declaration of Leta Gorman in Support of Motion to Exclude Dr. Maddox's Testimony and attached Exhibits;
- (3) Plaintiff's Response to Bondex's Motion to Exclude Portions of Dr. Maddox's Testimony Pursuant to *Frye*;
- (4) Declaration of Glenn S. Draper in Opposition to Bondex's Motion to Exclude Dr. Maddox's Testimony and attached Exhibits;

ORDER DENYING BONDEX'S MOTION TO EXCLUDE DR>
MADDOX PURSUANT TO *FRYE*- 1

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ORIGINAL

EXHIBIT NO. D

- 1 (5) ^{G-10} ~~Testimony of Dr. John Maddox at the Frye hearing;~~ 
- 2 (6) Testimony of Dr. Samuel Hammar at the Frye hearing;
- 3 (7) Testimony of Dr. Carl Brodtkin at the Frye hearing;
- 4 (8) Testimony of Dr. Arnold Brody given at trial in this matter.

5 BASED ON THE FOREGOING, IT IS HEREBY ORDERED that Bondex's Motion to
6 Exclude Portions of Dr. Maddox's Testimony Pursuant to Frye is DENIED.

7
8 DONE IN OPEN COURT this 6th day of November, 2006.

9
10 
11 THE HONORABLE SHARON ARMSTRONG
King County Superior Court Judge

12 Presented by:

13 BERGMAN & FROCKT

14 _____
15 Matthew P. Bergman, WSBA 20894
16 David S. Frockt, WSBA 28568
17 Ari Y. Brown, WSBA #29570
18 Counsel for Plaintiff
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20
21
22
23

A-7

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SUPERIOR COURT OF WASHINGTON FOR KING COUNTY

SANDRA LOTT, Individually and as)
Personal Representative of the Estate)
Of TIMOTHY LOTT,)
)
Plaintiff,)
)
vs.) No.)
) 05-2-06955-4 SEA)
)
BONDEX INTERNATIONAL,)
)
Defendant.)

FRYE HEARING
(Transcribed from Audio Recording)
November 6, 2006
Seattle, Washington

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1

Frye Hearing (Lott)
November 6, 2006

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1 BE IT REMEMBERED that on Monday,
2 November 6, 2006, before The Honorable Sharon Armstrong, the
3 following proceedings were had, to wit:

4
5 <<<<<< >>>>>>

6
7 THE COURT: Good morning. Please raise
8 your right hand.

9
10 CARL ANDREW BRODKIN, MD, MPH, having been first duly
11 sworn, testified as
12 follows:

13
14 THE COURT: Please be seated and pull up
15 a microphone.

16
17 DIRECT EXAMINATION

18 BY MR. FROST:

19 Q Could you state your name for the record, please?

20 A Carl Andrew Brodtkin.

21 Q And, Dr. Brodtkin, as you've heard, we're going to stipulate
22 to the admission of your curriculum vitae. But very
23 briefly, one of your professional interests is the
24 relationship between asbestos and disease?

25 A Yes. I've been a physician in occupational medicine who has

1 treated and evaluated a number of patients over the
2 years with occupational asbestos exposure and related
3 disease.

4 Q And have you had an opportunity to review Bondex's
5 motion to exclude certain testimony from Dr. Maddox in
6 this case?

7 A I have been provided and discussed issues regarding
8 cumulative exposure to asbestos and whether that issue
9 should be considered in excluding testimony, yes.

10 Q Okay. And do you have an opinion, sir, about the
11 relationship between cumulative exposure to asbestos
12 and the development of mesothelioma?

13 A Yes, I do. This is an issue I have given some thought
14 over the years, yes.

15 Q Okay. What is that opinion, sir?

16 A I believe the body of scientific literature has well
17 established that mesothelioma is a dose response
18 disease. With increasing dose, there is increasing
19 risk for development of mesothelioma in individuals.

20 The dose at which this occurs, I believe the
21 literature has shown, is substantially above
22 background levels, ambient levels, which are quite low
23 in the environment and really represent very
24 identifiable over exposures to asbestos that result in
25 cumulative exposure.

1 Certainly the literature has shown that this
2 linear relationship can occur at low doses of asbestos
3 exposure, but increases as -- the risk increases as
4 the dose increases.

5 Q So if I can summarize, your opinion is that every
6 identifiable occupational or environmental exposure to
7 asbestos, does that contribute to the risk of
8 development of mesothelioma?

9 A Well, I would be very clear in saying not every
10 exposure to asbestos fibers contributes to risk for
11 developing mesothelioma. The body has protected
12 mechanisms of clearing particulates, including
13 asbestos fibers, and certainly minimal exposures, many
14 ambient exposures, would not result in a significant
15 biological dose.

16 However, identifiable exposures where high
17 asbestos fiber levels exist in the air and are
18 available for inhalation would certainly result in
19 increased risk for mesothelioma, and those should be
20 identifiable exposures

21 Q Have you had an opportunity to review the deposition
22 testimony of Mr. Timothy Lott?

23 A Yes, I have.

24 Q And in reviewing that testimony, did you see any
25 identifiable asbestos exposure?

1 A I did. In my review of Mr. Lott's testimony, he
2 reviewed his occupational history between 1973 and
3 1976, and while working at the Jewel Lake Villa
4 Apartments regularly participated in application,
5 sanding and sweeping of joint compounds related to
6 patching of drywalls and repair of apartments in
7 preparation for residents.

8 Q So and is it your testimony today, sir, that that
9 exposure to asbestos contributed to the development of
10 Mr. Lott's mesothelioma?

11 A Well, these are identifiable exposures that would
12 contribute. Joint compound is a substance that has
13 been well studied. Fiber levels associated with
14 sanding, mixing, sweeping have been well characterized
15 in studies from the 1970's and result in significant
16 fiber cc levels and certainly would be identifiable
17 levels that would contribute to mesothelioma risk.

18 Q Sir, your opinion that identifiable exposures to
19 asbestos contribute to the risk of development of
20 mesothelioma, can you tell us what that is based on,
21 sir?

22 A The scientific methodology for determining a cause and
23 effect relationship, and in Mr. Lott's case this deals
24 with chrysotile exposure causing mesothelioma, has
25 been characterized and summarized in a group of

1 criteria known as the Bradford Hill criteria. This
2 was put forward by Dr. Hill in the mid 1960's, and I
3 think is the most recognized and commonly used
4 criteria used by the medical community to assess
5 causation and whether an exposure such as chrysotile
6 would be associated with mesothelioma.

7 Q And the Bradford Hill methodology, is that one that is
8 generally accepted among the scientific community for
9 the determination of cause and effect of
10 asbestos-related disease?

11 A I would say that it's widely and uniformly accepted.
12 It's something that I was taught when I was getting my
13 master's in public health degree and is something that
14 I have used frequently over the years, and I think
15 other physicians in my field and other fields
16 evaluating exposures would routinely use, yes.

17 Q I wonder if you could just take us very quickly
18 through the Bradford Hill criteria?

19 A Yes. There are nine criteria, and in discussing it,
20 this would certainly relate to chrysotile exposure and
21 cumulative exposure and mesothelioma. That's the
22 issue at hand.

23 The Bradford Hill criteria stipulate nine
24 criteria. The first one is what is known as strength
25 of association, and this relates to epidemiologic

1 studies, studies of disease in human populations, in
2 this case mesothelioma in human populations, and
3 ranging from low exposures, for instance, in a study
4 by Welch in a recent publication in the International
5 Journal in 2005, to high exposures that Yano described
6 in American Journal of Industrial Medicine in 2001.
7 We consistently see in this literature a very high
8 magnitude of risk associated with chrysotile exposure
9 for both peritoneal mesothelioma and for pleural
10 mesothelioma.

11 And as well as the epidemiologic studies, lung
12 burden studies, such as Roger's study in the early
13 1990's, show that as chrysotile fibers increase in the
14 lung, the risk for mesothelioma increases dramatically
15 16 fold.

16 So whether one looks at epidemiology or lung
17 burden studies, one consistently sees a strong
18 strength of association. And that's very important
19 medically because strength of association is how you
20 assess attributable risk, whether a disease can be
21 attributed more than 50 percent to an exposure.

22 And often these relative risks are as high as five
23 or greater, which would certainly correlate with an
24 attributable risk greater than 50 percent.

25 The second criteria --

1 Q Hold on just one second. The two methodologies that
2 you mentioned in support of the first criteria were
3 epidemiological studies and also lung fiber burden
4 analysis?

5 A Yes.

6 Q Are both of those methodologies widely used and
7 generally accepted in the medical and scientific
8 communities?

9 A Yes.

10 Q Their uses aren't limited to just asbestos, is it?

11 A No, these would be generally accepted methodologies.

12 Q How about the second criteria?

13 A The second criteria would be temporal association.
14 The exposure to the punitive agent, chrysotile, should
15 precede the disease mesothelioma by an appropriate
16 period of time, which we term the latency period.

17 And in mesothelioma, this has been well studied.
18 Groups that I've been involved in have looked at this
19 and published it in a journal of the National Cancer
20 Institute. And, basically, one sees a latency of
21 certainly over 10 years and often decades between
22 exposure and development of mesothelioma.

23 So I think the literature supports the case of an
24 individual exposed in the mid 1970's developing
25 mesothelioma in 2003 would fit fell within that

1 latency period

2 Q The third criteria?

3 A The third criteria is one that we call biologic
4 gradient or dose response. If there truly is
5 causation, one typically sees a dose response, the
6 greater the dose, the greater the response. And I
7 think that has been well characterized for all
8 asbestos fibers in mesothelioma, and it has certainly
9 been characterized for chrysotile exposure.

10 Studies that have looked at this have really
11 defined levels of exposure, cumulative levels of
12 exposure, where individuals become at risk and
13 actually develop mesothelioma. And I think some
14 important studies would include the study by Iwatsubo
15 in American Journal of Epidemiology in 1997 where at a
16 dose of .5 to .99 fiber cc years, a low exposure, but
17 a very identifiable exposure, there's about a four
18 fold increased risk in mesothelioma.

19 And then other studies in the German Registry by
20 Rodelsperger in American Journal of Industrial
21 Medicine in 2001 very consistently show that at .15
22 fiber cc years, you see about an eight fold increased
23 risk in mesothelioma. And certainly the risk
24 increases as the dose increases, but these are the
25 doses where one starts to see increasing risk and I

1 think firmly establishes a dose response.

2 And briefly the other studies that I look at are
3 studies that look at time, how long workers have
4 worked with asbestos-containing materials. And in a
5 number of the important studies of asbestos cement
6 workers new New Orleans that Hughes and Weill
7 published and other studies, they find that workers
8 that have worked less than one year have developed
9 both pleural and peritoneal mesotheliomas at high
10 risk.

11 So while certainly workers with high durations of
12 exposure of many years are at greater risk, the
13 workers with less than a year of exposure certainly do
14 develop this condition in chrysotile environments.

15 Q The next Bradford Hill criteria?

16 A The next criteria would be one of consistency. In the
17 epidemiologic literature, one should see a consistency
18 of the magnitude of risk. And this is really well
19 demonstrated in chrysotile exposure. If you look at
20 Quebec miners and millers, if you look at textile
21 workers in the Carolinas, if you look at asbestos
22 cement workers in New Orleans or if you look
23 internationally to South Africa or France or Germany,
24 studies consistently show a dose response of
25 increasing exposure, including chrysotile and

1 development of mesothelioma.

2 Now, I think this has best been described by
3 Leslie Stayner in the American Journal of Public
4 Health in 1996 who did a nice review of this and
5 concluded that chrysotile is indeed a potent
6 carcinogen that causes mesothelioma.

7 And although one may see differences in potency
8 among the fibers, and certainly you do, all fiber
9 types are carcinogenic.

10 Q And I think we're on No. 5?

11 A I've lost count, but I can keep going.

12 Q Okay.

13 A In addition to consistency, one wants to see
14 biological evidence or biologic plausibility that an
15 exposure such as chrysotile can cause mesothelioma,
16 and that really relates to the mechanism of disease.
17 And while medical science is always refining and
18 learning about the mechanism of disease, for an
19 exposure like asbestos, this has really been very well
20 described and was reviewed in the New England Journal
21 of Medicine, one of the leading medical journals, last
22 year by Robinson.

23 And the mechanisms include both tumor initiation
24 through damage of the genetic material in the lining
25 of the pleura or the peritoneum by asbestos fibers, by

1 a variety of mechanisms, changes in the pattern of
2 division of the mitotic division of cells that
3 encourage development of cancers, and inflammatory
4 responses, direct physical injury to the lining of the
5 lung or peritoneum by asbestos fibers.

6 And these all provide a cogent mechanism for
7 development of mesothelioma that I think has been well
8 established.

9 Q How would you describe the science that you just
10 talked about? Is that molecular biology?

11 A That is what I would describe generally as basic
12 science and cellular biology. Quajaron (sic.) who has
13 studied this significantly and published in
14 Environmental Health Perspectives in the late 1990's
15 basically looked at cellular models and looked at
16 mesothelioma at the cellular level and molecular
17 level.

18 Q And the methods used by cellular biologists, are they
19 generally accepted in the field of science in
20 medicine?

21 A Yes, they are an important complement to epidemiologic
22 literature which looks at human experience and
23 basically looks at it, if you will, from another
24 perspective.

25 Q The next Bradford Hill criteria?

1 A In addition to mechanisms and biologic plausibility,
2 one wants to see specificity. A specific exposure
3 should cause a specific effect. In this case, we have
4 asbestos fibers and chrysotile fibers, and we have
5 mesothelioma. I think there has been rarely a disease
6 described where such a strong specificity exists for
7 an exposure such as asbestos as preeminently causing a
8 specific disease. So obviously mesothelioma would
9 well meet the specificity criteria.

10 Q And the next criteria?

11 A The next criteria would really be experimental models.
12 Does the punitive exposure reproduce disease in an
13 experimental model? If you expose as animal to
14 chrysotile, will that animal develop mesothelioma?

15 And an example of this would be the study done by
16 Davis in the early 90's in British Journal of
17 Experimental Pathology where various fibers,
18 chrysotile, amosite, crocidolite, were injected into
19 the peritoneal mesothelial lining of rats. And all
20 fiber types cause mesothelioma. In this animal model,
21 actually chrysotile was the most potent of those three
22 fibers in causing mesothelioma. But this would be an
23 example where direct experimentation with animals
24 reproduces what happens with humans and is strong
25 evidence of the causal association.

1 Q The use of animal studies, is that a principal that is
2 generally accepted and widely used throughout the
3 science and medicine, not just in the asbestos field?

4 A Yes, I would say it is a complement to epidemiologic
5 studies. It allows for control of the environment in
6 a way usually that can't be achieved in human
7 populations.

8 Q And the next Bradford Hill criteria?

9 A There are two remaining Bradford Hill criteria that I
10 generally link or lump together, and Bradford Hill
11 caused these analogy and coherence. And basically
12 what that means is that a similar group of exposures
13 should cause the same disease. And obviously asbestos
14 fibers would be a strong example of this, where
15 various fiber types, though not identical, have
16 similar properties, have overlapping properties, if
17 you will. And certainly the various fiber types,
18 amosite, crocidolite, chrysotile, while may have a
19 variable potency, certainly cause a similar effect in
20 mesothelioma.

21 And the sort of flip side of that is coherence.
22 Is there a compelling reason why one similar exposure
23 shouldn't cause the disease that other similar
24 exposures cause? And I would say in this case, no,
25 that chrysotile from a biologic or medical perspective

1 would be anticipated to cause similar disease as
2 amphibolic fibers.

3 So those are the nine criteria. And I think in
4 the case of asbestos in general and chrysotile
5 specifically, the criteria are well met in terms of
6 cumulative exposure and development of mesothelioma.

7 Q During your testimony today, I think you mentioned
8 epidemiology, you've mentioned lung fiber burden
9 analysis, you've mentioned cellular biology, and you
10 have mentioned animal studies. Are all of those tools
11 generally used and widely accepted throughout the
12 scientific community?

13 A Yes.

14 Q And it's fair to say that certain other experts may
15 look at the information derived from those tools and
16 reach a different conclusion than you have reached?

17 A I think part of the scientific process is discussion
18 and debate about studies. And certainly in the
19 epidemiologic literature, no study is exactly
20 reproduced in another study. And this is an important
21 basis for debate and discussion, and certainly there
22 are disagreements among experts.

23 Q But there's no disagreement that those tools that
24 you've talked about are generally accepted and widely
25 used throughout science?

1 A I don't believe there would be any significant
2 degree -- disagreement that the Bradford Hill criteria
3 are not an appropriate way to look at the scientific
4 evidence in terms of evidence of causation.

5 MR. FROST: Thank you. I don't have
6 any additional questions.

7 MR. OSBURN: Thank you, Your honor.
8

9 CROSS-EXAMINATION

10 BY MR. OSBURN:

11 Q Dr. Brodtkin, what was Mr. Lott's dose of joint -- of
12 chrysotile asbestos from joint compound over his life?

13 A In my review of Mr. Lott's deposition, he described
14 fairly regular use of joint compound between 1973 and
15 1976 when working after school with his father. The
16 specific types of activities would include mixing. He
17 used some pre mix, but also a dry mix joint compound.
18 He applied it during his patching work. He performed
19 sanding procedures and performed clean-up procedures.

20 In addition to that direct exposure, he assisted
21 his father and describes holding drywall at very close
22 proximity to manipulation of joint compounds. So I
23 think there would be a direct and bystander exposure.

24 Certainly joint compound during the mid 1970's
25 when Mr. Lott worked in the apartments is known as an

1 asbestos-containing material generally had a 4 to 12
2 percent asbestos content.

3 Q Maybe you missed my question. How often did he do it
4 and what was the exposure to chrysotile? What are the
5 numbers?

6 A My knowledge of his exposure relates to his
7 deposition. He testified that he worked on apartments
8 during the winter months approximately two to three
9 times weekly, regularly performed manipulations of
10 joint compounds. So those would represent his
11 exposures.

12 In terms of the fiber cc levels, obviously he did
13 not have a dosimeter on, but in terms of the
14 activities he was doing, for instance, mixing in
15 various studies has been shown to result in up to 30
16 fiber per cc exposure.

17 Sanding can result in at least a mean of 5 fiber
18 per cc with maximum 19 to 20 fiber cc exposure.
19 Clean-up activities similarly can result in high fiber
20 cc levels. So those would be the types of exposure
21 that Mr. Lott would experience during that three-year
22 period.

23 Q But you can't quantify his exposure to joint compound,
24 can you?

25 A My knowledge --

1 Q Quantify it?

2 A My knowledge is from his description of the
3 deposition. I'm not aware that specific levels were
4 measured during his work.

5 Q And you can't quantify Mr. Lott's exposure to, say,
6 Bondex joint compound, which is what this trial is
7 about, right?

8 A In the deposition, Mr. Lott described working with
9 several joint compounds, among them Bondex.

10 Q And you can't quantify his exposure to Bondex?

11 A No. Certainly Mr. Lott did not discuss that in his
12 deposition.

13 Q You mentioned the Yano study. That is a high
14 exposure, is it not?

15 A The Yano study would be a high exposure study, yes.
16 Generally about five to seven fiber cc in that cohort
17 setting.

18 Q Was any fiber burden analysis done in this case?

19 A I'm not aware in my review of the materials that any
20 fiber burden analysis was performed.

21 Q Was there any radiological evidence of asbestosis in
22 Mr. Lott?

23 A In my review of Dr. Maddox' report and Dr. Maddox'
24 deposition, there was no clear evidence of pleural or
25 parenchymal fibrosis.

1 Q Was there -- there was no radiological evidence of
2 pleural plaques in Mr. Lott, was there?

3 A I don't believe so. There was unilateral
4 calcification, but the description of it was a
5 development of a calcification fairly acutely, which
6 can happen with mesothelioma. I don't believe it was
7 observed on the first imaging study, which I think
8 would weigh against that being a plaque.

9 Q There isn't any biological or radiological evidence
10 that Mr. Lott's exposure to chrysotile asbestos caused
11 his mesothelioma?

12 A Well, there's strong biological evidence obviously of
13 mesothelioma. Dr. Maddox' pathologic description
14 describes both histology and immunohistochemistry,
15 which were very specific for mesothelioma. There is
16 nothing intrinsic to the pathology of mesothelioma
17 that says it's an asbestos-related mesothelioma.

18 One has to look at various criteria, which can
19 include biologic effects such as plaques and fibrosis,
20 but in most cases involves review of occupational
21 history because at least 60 percent of cases of
22 mesothelioma do not have pleural plaques or evidence
23 of parenchymal fibrosis at the time of presentation.

24 Q So in this case there is only Mr. Lott's history.
25 There's no radiological evidence? There's no

1 biological evidence? Correct?

2 A There is the evidence of mesothelioma and there is the
3 occupational history in my opinion.

4 Q And you can't quantify the occupational history; is
5 that correct?

6 A One has to look really qualitatively at the types of
7 exposure and then look at the science in terms of what
8 that exposure represents.

9 And I think in the case of joint compounds, this
10 is one of the more well-studied exposures where
11 activities such as mixing, sanding, sweeping, have
12 been well quantified in a number of studies
13 consistently in terms of fiber cc levels.

14 Q You are obviously familiar with Dr. Richard Lemen?

15 A Yes.

16 Q Dr. Lemen came up with a criteria when he worked with
17 OSHA for exposure to essentially a threshold level of
18 chrysotile asbestos which caused mesothelioma,
19 correct?

20 A Well, Dr. Lemen has contributed widely to the
21 literature. He has published in numerous areas.

22 Q And one of his conclusions in one of his writings was
23 that he required a 0.1 fiber cc year exposure to
24 attribute mesothelioma to chrysotile asbestos,
25 correct?

1 A I'm not specifically aware of that. In terms of .1
2 fiber per cc, my understanding of that level really
3 relates to Dr. Stayner and Dr. Lemen's work in terms
4 of asbestos-exposed workers in the Carolinas.

5 And basically at that level, .1 fiber per cc,
6 which ultimately became the permissible exposure
7 limit, over a 40-year working career, you would have a
8 four fiber cc year exposure. And at those dose, they
9 saw two cases per thousand of asbestosis and more
10 cases of lung cancer. They didn't characterize
11 mesothelioma as such, even though peritoneal and
12 pleural mesotheliomas were found in that cohort.

13 But I'm not aware of any threshold. In fact, in
14 that study and others published by Stayner, they are
15 very clear in saying there is not a threshold level at
16 which suddenly no risk is encountered with asbestos
17 exposure.

18 Q Actually I'm not asking about Dr. Lemen. You probably
19 haven't read his testimony in the Pell versus Amitek
20 case, have you, Brazoria County?

21 A I have not.

22 Q Okay. Dr. Lemen was asked, "Do you believe there it
23 been demonstrated that exposure to chrysotile causes
24 peritoneal mesothelioma?" And Dr. Lemen reports that
25 there is very little evidence on chrysotile and

1 peritoneal mesothelioma. He has not seen any
2 epidemiological studies. And he finally says, "I
3 would say there are no epidemiological studies that
4 have been able to demonstrate chrysotile in its
5 greatest form or any other form have caused peritoneal
6 mesothelioma."

7 And we're talking about peritoneal mesothelioma in
8 Mr. Lott's case, aren't we?

9 MR. FROST: Your honor, if he's
10 going to use depositions, we would request copies of
11 those because --

12 THE COURT: That's appropriate.

13 MR. FROST: -- Dr. Lemen has given
14 hundreds of depositions.

15 THE COURT: You will need to provide
16 copies.

17 MR. OSBURN: Certainly. That will
18 be Exhibit 624.

19 THE COURT: Is that a new exhibit?

20 MR. OSBURN: It is a new exhibit.
21 It is for cross-examination only.

22 THE WITNESS: My response to that
23 would be, first of all, to agree that there are, you
24 know, ongoing efforts at studying asbestos-related
25 facts. And certainly the issue of chrysotile exposure

1 and peritoneal mesothelioma, I would agree with
2 Dr. Lemen that, you know, specific epidemiologic
3 studies have not been designed to look only at that
4 question.

5 But I would note that the general issue of
6 mesothelioma and chrysotile has been looked at, and a
7 number of studies such as Yano observed with pure
8 chrysotile exposure both pleural mesothelioma and
9 peritoneal mesothelioma.

10 And a number of the studies looking at
11 mesothelioma such as Suzuki in Annals of New York
12 Academy of Science, 2002, had more than a dozen cases
13 of peritoneal mesothelioma where chrysotile was the
14 dominant mesothelial fiber burden. And in 24 percent
15 of cases in that study, the only identifiable fiber in
16 the lung and the pleura was chrysotile.

17 And I think based on that, it would be an
18 erroneous conclusion to say that chrysotile does not
19 cause peritoneal mesothelioma. I think it's a fair
20 statement to say that specific studies designed to
21 look only at that question have yet to be carried out.
22 I would agree with that.

23 Q And you would agree that 0.1 fiber cc years, after a
24 year of working, which is either 265 or 262 days, I
25 can't remember?

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Page 25

1 A Well, I don't know which it is. It may be more or
2 less depending on the worker. But --

3 Q Roughly that over eight hours a day, correct?

4 A Yes. I would represent full-time employment at the
5 permissible exposure limit for a year, .1 fiber cc
6 year.

7 Q That's well over 2,000 hours exposure?

8 A I haven't calculated the hours, but that is the metric
9 for assessing .1 fiber per cc.

10 Q And the rat studies where chrysotile and other
11 products were injected into the peritoneal cavity,
12 that would directly pass the body's defense
13 mechanisms, which are otherwise quite excellent for
14 all fibers, aren't they?

15 A Well, the experimental studies are really in the
16 nature of two types: One in direct injection, which I
17 described in the Davis study, which certainly would
18 bypass defenses, the other are inhalation studies,
19 such as Dr. Coffin did in Inhalation Toxicology in
20 1992. Those are high level of exposures. They are
21 direct inhalation studies strongly associated with
22 chrysotile-induced mesothelioma.

23 MR. OSBURN: Thank you, Doctor.

24 Nothing further.

25 ///

Frye Hearing (Lott)
November 6, 2006

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REDIRECT EXAMINATION

1
2 BY MR. FROST:

3 Q Dr. Brodtkin, are you familiar with Dr. Lemen's
4 article, Chrysotile Asbestos As a Cause of
5 Mesothelioma?

6 A Yes, I believe I am.

7 Q I wonder if you could just read for the court this
8 highlighted section on Page 237?

9 A I'm just reading from the highlight here. "However,
10 even when potency on a dose by dose basis is
11 considered, the fact remains that chrysotile is
12 capable of causing mesothelioma and that no safe dose
13 has been identified below which a risk of developing
14 mesothelioma no longer exists."

15 Q Thank you. Now, Mr. Osburn asked you about what kind
16 of exposures would be necessary to create a .1 fiber
17 cc year of cumulative exposure. And I think his
18 description was it would take 2,000 hours of work at a
19 .1 fiber cc environment to create that exposure?

20 A Well, he mentioned 2,000 hours. Basically, a year in
21 an eight-hour work shift, five days per week, would
22 result in at permissible exposure limits, .1 fiber per
23 cc.

24 I do want to emphasize that OSHA in publishing
25 that recommends that exposures be as far below that as

1 possible, but that would be at that limit.

2 Q That's not a safe level of exposure, is it?

3 A It is not a safe level of exposure. In fact, it's
4 clearly stated and Stayner notes in his article in
5 Occupational and Environmental Medicine in 1997 that
6 at that level one can anticipate two cases of
7 asbestosis per thousand and even more cases of
8 malignancy.

9 Q So if it took 2,000 hours at .1 fiber cc of exposure,
10 then 200 hours at 1 fiber cc of exposure would create
11 that same .1 fiber cc year?

12 A Yes. The cumulative exposure metric involves two
13 parameters, intensity and duration. So a shorter
14 duration of exposure at higher intensity certainly can
15 result in the same cumulative exposure as a lower
16 intensity exposure over a longer duration.

17 Q By the same token, it would only take 20 hours at 10
18 fiber cc's to develop a .1 fiber cc year total?

19 A Yes. Basically as intensity increases, the duration
20 would increase -- decrease linearly that would be
21 required to produce the same cumulative exposure.

22 Q And the studies that you relied on show that drywall
23 activities, mixing, sanding, sweeping, often create
24 exposures in excess of 10 fiber cc's?

25 A Frequently. Sanding procedures up to 20 fiber per cc,

1 mixing, particularly dry mixing, up to 40 fiber per
2 cc, even pre mix when you sand it and sweep it will
3 have very significant fiber cc levels.

4 MR. FROST: Nothing additional.
5 Thank you.

6 MR. OSBURN: Very quickly, Your
7 Honor.

8
9 RECROSS-EXAMINATION

10 BY MR. OSBURN:

11 Q But you don't have any idea in any manner how Mr. Lott
12 used Bondex --

13 A My only knowledge is from Mr. Lott's deposition, and
14 he described his use of joint compound generically.
15 He noted he was exposed to a number of different joint
16 compounds, but didn't describe his work with a
17 particular joint compound brand in contra distinction
18 to another.

19 Q Did you read his testimony where he testified that he
20 could not recall working specifically with Bondex
21 joint compound?

22 A I certainly read Mr. Lott's testimony. I can't
23 remember every word of it, and I would trust what it
24 said. But my recollection is that he used a number of
25 different joint compounds, and he did not provide any

1 testimony of specific activity with a particular brand
2 of joint compound. I certainly don't recall that.

3 MR. OSBURN: That would be fine.
4 Thank you, Doctor.

5 MR. FROST: Nothing additional.

6 THE COURT: Thank you, Dr. Brodkin.

7 THE WITNESS: Thank you, Your Honor.

8 MR. FROST: Plaintiffs call
9 Dr. Samuel Hammar.

10
11 SAMUEL P. HAMMAR, MD, FCCP, having been first duly
12 sworn, testified as
13 follows:

14
15 DIRECT EXAMINATION

16 BY MR. FROST:

17 Q Will you please state your full name and your address
18 and zip code for the record?

19 A Yes, Samuel P. Hammar, Diagnostic Specialties
20 Laboratory, 700 Lebo, L-E-B-O, Boulevard, Bremerton,
21 Washington, 98310.

22 MR. FROST: And, Your Honor, we're
23 going to use a Powerpoint with Dr. Hammar. We had the
24 slides marked as Plaintiff's Exhibit No. 364 for use
25 in this.

1 THE COURT: All right.

2 Q (By Mr. Frost) Now, Dr. Hammar, you understand that
3 we're going to use your CV and supplement the record
4 with your qualifications, but is it fair to say you
5 have written extensively and studied extensively the
6 field of asbestos medicine?

7 A Yes.

8 Q Now, you understand the issue in this case is
9 cumulative exposures and how they relate to causation
10 in mesothelioma cases, correct?

11 A Yes.

12 Q Would you explain to the judge what your opinions are
13 and what those -- what the basis of your opinions are
14 concerning cumulative exposures as they relate to
15 causation of mesothelioma?

16 A I think as already partially stated by Dr. Brodkin is
17 that asbestos related diseases are all dose response
18 related, which means that the more that one is exposed
19 to asbestos, the greater the risk is of an individual
20 developing one of the asbestos-related diseases.

21 And if you look at it from an incidence point of
22 view, the greater the exposure, the greater the
23 incidence is of the disease. And it's thought that
24 all bystander and occupational exposures to asbestos
25 have the ability to contribute to cause the injury

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1 that eventually leads to one of these diseases.

2 Q And, Dr. Hammar, have you had an opportunity to review
3 the deposition of Mr. Lott in this case?

4 A I have, yes.

5 Q And I'm trying to not go over the same areas that we
6 went over with the previous doctor, but in regards to
7 Mr. Lott's explanation of his exposures, would those
8 have been causally related to his mesothelioma?

9 A Yes.

10 Q Now, I want to talk to you a little bit about whether
11 there is a safe level of exposure to asbestos and what
12 the literature says in regards to that.

13 And so the first thing I want to direct your
14 attention to is the statement by Dr. Selikoff that
15 there is no safe level of asbestos. Is that a true
16 and accurate statement? Is that a generally held view
17 in the medical community?

18 A I think it's definitely an opinion that is held in the
19 medical community, specifically with respect to
20 occupational bystander exposure to asbestos.

21 Q Now, in regards to whether there is a threshold at a
22 minimal lower limit, could you explain how, and I have
23 got the quote from the Hillerdal paper where it talks
24 about there's no proof of a threshold value that is a
25 minimal lower limit below which asbestos fibers cannot

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1 cause the tumor. And that's related to the
2 mesothelioma.

3 Could you explain what that means?

4 A Sure. That paper by Dr. Hillerdal had to do with a
5 report of several examples of mesothelioma occurring
6 in people that had nonoccupational exposure to
7 asbestos and lower level dose exposure.

8 And Dr. Hillerdal's opinion was really there isn't
9 any specific background incidence of mesothelioma in
10 the United States or in the world with respect to
11 asbestos causation of mesothelioma. The number that
12 is usually cited is one case per million people per
13 year, which is an incredibly low level of exposure.

14 What this is is just evidence that you can see
15 cases of mesothelioma in people who have incredibly
16 low levels of exposure. And based on that, there
17 really isn't a threshold that you can state that if a
18 person was exposed to a concentration of asbestos
19 below this amount, then they would not get
20 mesothelioma.

21 Q Now, I want to move on to NIOSH. NIOSH has discussed
22 this, whether there's a safe level or not, and NIOSH
23 has indicated in 1980 that excessive cancer risks have
24 been demonstrated in all fiber concentrations and
25 studied to date. The evaluation of all available

1 human data provides no evidence for a threshold or for
2 a safe level of asbestos exposure.

3 Is that a similar finding as the Hillerdal?

4 A That is, yes.

5 Q And as we sit here today, is that still NIOSH's
6 opinion as far as you know?

7 A Yes.

8 Q Now, Dr. Roggli, who has been brought up before, has
9 written a medical textbook on pathology and
10 asbestos-related diseases, correct?

11 A He has, yes.

12 Q And is that textbook, is that generally accepted as --
13 although there may be things in it that folks disagree
14 with, is that generally accepted in the scientific
15 community as a peer-reviewed and scientific book that
16 is relied upon by doctors?

17 A It's a learned treatise, sure. Dr. Roggli is an
18 absolute expert in asbestos-related diseases. That
19 book now is in the second edition.

20 Q Now, in the 1992 edition, Dr. Roggli talked about this
21 linear dose response relationship. And he indicated
22 that there is a linear dose response relationship
23 between the amount of asbestos to which an individual
24 is exposed and the risk of developing mesothelioma.
25 In addition, the threshold level of exposure below

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1 which mesothelioma will not occur has not yet been
2 identified.

3 Is that still a correct statement as we sit here
4 today?

5 A I believe it is, yes.

6 Q And is that generally accepted in the scientific
7 community as a statement in regards to the threshold
8 level of exposure in regards to mesothelioma?

9 A Yes.

10 Q Now, besides Dr. Roggli, the Consumer Products Safety
11 Commission has also looked at the scientific
12 literature in regards to whether there's a threshold
13 below which asbestos diseases occur.

14 Are you familiar with the Consumer Products Safety
15 Commission?

16 A Sure.

17 Q And you are familiar with their ban on patching
18 compounds, including joint compounds?

19 A Yes.

20 Q The consumer product -- and is that something that is
21 something you generally looked at and relied upon in
22 the past and are aware of in the scientific
23 literature?

24 A Yes.

25 Q Now, Dr. Hammar, the Consumer Products Safety

1 Commission indicated that the commission noted that in
2 the scientific literature, there is general agreement
3 that there is no known threshold level below which
4 exposure to respirable free-form asbestos would be
5 considered safe. Is that still true today and
6 scientifically valid?

7 A Yes.

8 Q And I believe we already talked about NIOSH and their
9 statement.

10 Now, do you know who Dr. Battifora is?

11 A Sure.

12 Q Who is Dr. Battifora?

13 A Dr. Battifora is a well-known pulmonary pathologist.
14 He was the author of the third series of fascicles on
15 tumors of the serosal membranes, which are basically
16 mesotheliomas and other tumors that look like
17 mesotheliomas. And he and Dr. McCaughey, and
18 Dr. McCaughey was a pathologist in Canada who wrote
19 that fascicle.

20 Q And the fascicle is a pamphlet put out by the Armed
21 Forces Institute of Pathology?

22 A It is. It's about 100 pages long about, I would say
23 close to a half-inch thick. There's one -- a newer
24 one after this one that just was published recently,
25 but this was the third edition or the third series

1 fascicle.

2 Q And in regards to the fascicle, was that generally
3 relied upon by scientists and medical doctors?

4 A I think so, yes.

5 Q And was that a statement of the general consensus in
6 the scientific community?

7 A Yes.

8 Q And in the third series of the fascicle of the Armed
9 Forces Institute of Pathology, Dr. Battifora
10 indicated, "The incidence of diffuse malignant
11 mesothelioma rises with increasing intensity and
12 duration of exposure to asbestos. The dose specific
13 risk data is a linear relationship."

14 Do you agree with that?

15 A I do, yes.

16 Q Could you explain that a little bit to the court?

17 A Sure. What it means is basically is that if you were
18 to plot the incidence of mesothelioma on, say, the X
19 axis and the concentration of asbestos a person was
20 exposed to on the Y axis, you would get this line that
21 would go like that. (Indicating.)

22 Eventually it does level out. It doesn't increase
23 forever, but it's linear for much of the data that has
24 been studied.

25 Q And is that linear relationship, is that something

1 that is generally agreed upon in the scientific
2 literature?

3 A That's what almost all of the articles use when they
4 do any type of studies in trying to assess low levels
5 of exposure or even high levels of exposure. So the
6 answer is yes.

7 Q And why is it important in dealing with low levels of
8 exposure, that linear relationship?

9 A Well, it's important because if you don't know what
10 the low level incidence is of a disease like
11 mesothelioma, you wouldn't know exactly how to protect
12 people from or what concentration of asbestos should
13 people be allowed to be exposed to.

14 Q Now, the American Journal of Industrial Medicine, is
15 that a peer-reviewed publication?

16 A It is, yes.

17 Q And in the year 2001, Rodelsperger published an
18 article called Asbestos in Manmade Vitreous Fibers As
19 Risk Factors For Diffuse Malignant Mesothelioma,
20 Results From a German Hospital-Based Case Control
21 Study.

22 And in that article, they came to the conclusion
23 that our results confirm the previously recorded
24 observation of the distinct dose response relationship
25 even at levels of cumulative exposure below one fiber

1 year.

2 Is that something that you agree with?

3 A I agree with that, yes. I have that article with me
4 today.

5 Q And could you explain to the judge how that relates to
6 your basis of your opinions in this case as to the
7 causation of the mesothelioma in Mr. Lott?

8 A Well, it's additional evidence that mesothelioma can
9 occur in people that are exposed to low concentrations
10 of asbestos.

11 Q Now, the same -- the same article also indicates that
12 they did a further case control analysis based on lung
13 tissue fiber concentrations in addition to the
14 interviews, and they yield similar OR's. Are you
15 familiar with the, in that particular study, the use
16 of lung tissue fiber concentrations in order to
17 supplement the interviews of the subjects?

18 A That's described in that article, yes.

19 Q And why is that important?

20 A Well, what that is looking at is actually the
21 concentration of asbestos you have in the lung tissue
22 which would directly relate to a person's exposure. I
23 guess the only thing that might be better than that
24 would be what the concentration was of asbestos,
25 either the pleura if it was a pleural mesothelioma, or

1 in the peritoneum, if it was a peritoneal
2 mesothelioma.

3 Q Now, in regards to a mesothelioma, in order to
4 attribute a mesothelioma to asbestos, do you need
5 pleural plaques?

6 A No.

7 Q Do you need findings of fibrosis or asbestosis?

8 A No.

9 Q Now, in regards to your opinions as to whether you
10 need pleural plaques, asbestosis or other fibrosis in
11 order to attribute a mesothelioma to asbestos
12 exposure, are those generally accepted in the
13 scientific community?

14 A Absolutely. They are published by the Helsinki
15 Consensus Report Journal, Scandinavian Work and
16 Environmental Health in 1997.

17 Q And those have been throughout the literature, those
18 same type of statements in regards to pleural plaques
19 and mesothelioma and asbestosis?

20 A Yes.

21 Q Is there really any disagreement in regards to that?

22 A I don't think there's any disagreement, no. If you
23 look at plaques, it's kind of an interesting thing
24 about how many you see radiographically versus autopsy
25 versus standard chest radiographs. There's quite a

1 bit of difference based on what technique you use with
2 respect to how many you see.

3 And that's also true for asbestosis in that when
4 Dr. Dodson and I published our paper in 1997 on fiber
5 types of 55 cases of mesothelioma, it turned out
6 clinically there were only three cases of asbestosis.
7 But when we looked pathologically, it turned out there
8 were 29 cases of asbestosis, most of which were
9 CAP-NIOSH Grade 1 asbestosis, which is the least
10 severe form of asbestosis.

11 Q Now, even based on those findings, did you still come
12 to the conclusion that you do not need asbestosis or
13 finding of pleural plaques in order to attribute a
14 mesothelioma to asbestos exposure?

15 A That is correct because, again, clinically, I think as
16 Dr. Brodkin stated, in that most people with
17 mesothelioma, you don't see asbestosis.

18 Q Now, the next article we have is the -- I know I'm
19 going to butcher the name -- Iwatsubo. It's called
20 Pleural Mesothelioma: Dose-Response Relation at Low
21 Levels of Asbestos Exposure in a French
22 Population-based Case-Control Study. Are you familiar
23 with that article?

24 A I am. I have that one with me also.

25 Q And is that a peer-reviewed publication?

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1 A It is, yes.

2 Q And is that something that is generally accepted and
3 used by folks in the medical community?

4 A Yes.

5 Q Now, in Iwatsubo, it talks about a significant excess
6 of mesothelioma was observed for levels of cumulative
7 exposure that were probably far below the limits
8 adopted in most industrial countries during the
9 1980's. What are they talking about there?

10 A They are talking about the fact that mesothelioma can
11 occur at very low levels of concentration of exposure,
12 and that they occur at concentrations greater than
13 what the permissible exposure levels that various
14 countries have initiated for asbestos to try to
15 control the diseases that asbestos cause.

16 Q And is that something you've also seen in your
17 practice?

18 A Sure. It's sometimes hard to evaluate exactly how
19 much a person was exposed based on some of the
20 information you get. But I don't think there's any
21 doubt that there are cases of low level exposure to
22 asbestos that cause mesothelioma.

23 Q And is that based on review of the scientific
24 literature and is there statements in the scientific
25 literature regarding low dose exposures causing

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1 mesothelioma?

2 A Sure.

3 Q And then again in Iwatsubo it talks about the dose
4 response relationship with cumulative exposures for
5 both intermittent and continuous patterns of exposure.
6 Why is that important?

7 A Again, the more you are exposed to, the more likely
8 you are to get a disease.

9 Q Now, I want to talk a little bit about short or
10 indirect exposures, and we've just hit on that very
11 briefly.

12 A Uh-huh.

13 Q In the Greenberg and Davies study, which is the
14 mesothelioma register from '67 to '68 published in
15 1974, it talks about the duration of exposure was more
16 widely spread ranging from three weeks to over 50
17 years. 12 percent of the cases had been exposed for
18 under five years. A man with only three weeks of
19 exposure died over a half century later.

20 Why is that important when you are considering the
21 issue of causation of mesothelioma in cumulative
22 exposure

23 A Well, I guess what is really important is that you are
24 trying to protect everybody that might ever be exposed
25 to asbestos. And if you know there are examples of

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1 people that develop mesothelioma at very low levels of
2 exposure, you would have to try to protect those
3 people also.

4 And the only way you could do that is to make sure
5 that they were either never exposed to asbestos or
6 exposed to an exceedingly small concentration.

7 Q And then I have the next slide, which is also from the
8 Greenberg and Davies, and it talks about hobby
9 exposure where it indicated that there were folks who
10 had a history of exposure to asbestos with their hobby
11 work, including a case of nonoccupational asbestos
12 exposure in a mesothelioma victim exposed for one day
13 sawing asbestos cement sheets to construct two sheds.
14 Are you aware of that study?

15 A I am, yes.

16 Q And how does that relate, and when you talk about the
17 dose response relationship and mesothelioma?

18 A Well, again, it's an example of cases of mesothelioma
19 developing in people that had what appeared to be
20 relatively low exposures. It could turn out that in
21 that case the exposure actually might be higher than
22 you think based on the fact that he was sawing cement
23 board.

24 But, again, it's an example of a short time of
25 exposure resulting in the development of mesothelioma.

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1 Q And I'm not sure if previously we talked about peek
2 exposures, but what are peek exposures?

3 A Most people who are exposed to asbestos don't --
4 aren't exposed to a concentration of asbestos that
5 stays the same over their entire working day or entire
6 working life. And you can have people that, say, at
7 one point in time of their working day might be
8 exposed to very low levels and no asbestos, but at
9 other times be exposed to incredibly high
10 concentrations of asbestos.

11 And when you calculate the fiber cc years of
12 exposure, you have to take that information into
13 account.

14 Q Now, I put up the article from Anderson, et al, which
15 is Mesothelioma Among Employees With Likely Contact
16 With In-Place Asbestos-Containing Building Materials.
17 These are basically the teacher studies. Are you
18 aware of those?

19 A I am, yes.

20 Q And it indicates that 75 percent of the school
21 teachers, the only identifiable potential source of
22 asbestos exposure was derived from in-place asbestos-
23 containing materials in schools. One teacher had
24 spent the season in the merchant marine aboard an iron
25 ore hauling ship and two had worked in the residential

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1 construction industry.

2 How does that indicate that, again, the low levels
3 of exposure that can be causally related to
4 mesothelioma?

5 A Again, it's just an example of how things happen. I
6 mean, in the Third Wave Book, which was a symposium of
7 information published from a conference held in Ottawa
8 in 1998, there's some more examples of teachers
9 developing mesothelioma. And it's accepted an type of
10 person who can get it, presumably from asbestos in
11 place that became friable where they were exposed to
12 it that way or maybe from some other way in the school
13 where they say they were sweeping up asbestos from
14 asbestos-containing thermal insulation on pipes, for
15 example.

16 Q Now, in the Iwatsubo article, it indicated that
17 background levels are assumed to be as low as one to
18 two per million in habitus, and we are talking about
19 the rate of mesothelioma.

20 Do you agree with that?

21 A Well, that's what the number that is usually given,
22 it's usually one or between one to two cases per
23 million people per year.

24 But Dr. Hillerdal in his article published in
25 1999, he didn't think there was any actual background

1 level of mesothelioma in the population who had not
2 been exposed to asbestos.

3 Q Now, the Iwatsubo article also talks about based on
4 their review of the mesothelioma cases, about
5 cumulative exposures, and it indicates their results
6 indicated that mesothelioma cases occurred below a
7 cumulative exposure of five fibers per milliliter
8 years and perhaps below .5 fibers per milliliter
9 years.

10 Could you explain how those relate to your
11 opinions in this case?

12 A Again, those would be examples of low exposures.
13 Again, the fiber cc years, the way to calculate that
14 is you try to determine the average concentration of
15 asbestos a person was exposed to during their
16 eight-hour day work, and you would try to determine
17 that for the 252 days a year that they worked, and
18 then you would determine what that concentration was
19 over that time period.

20 So, for example, five fiber ML years could
21 potentially be exposed to five fibers per cc of air
22 eight hours a day, 252 days a week -- I mean 252 days
23 a year for one year or it could be something like
24 exposed to, say, one fiber per cc of air eight hours a
25 day for a week and then exposed to maybe 20 the next

1 week and on and on, you could get various combinations
2 that could result. That is a relatively low
3 concentration. And the 0.5 fiber cc's is 10 times
4 less than that. So that's even a much lower
5 concentration of asbestos that resulted in
6 mesothelioma.

7 Q And how does that relate when we're talking about the
8 linear and dose response?

9 A Well, it just shows that asbestos-induced mesothelioma
10 occurs at a very low level of concentration.

11 Q And is it generally accepted in the scientific
12 community?

13 A Sure.

14 Q Now, the US Department of Health and Human Services
15 has also indicated in regards to -- you are familiar
16 with the US Department of Health and Human Services
17 statements on asbestos?

18 A I have seen those before, yes.

19 Q And they have indicated that on their report to
20 commerce on workers' home contamination study, that
21 mesothelioma has occurred following short-term
22 asbestos fibers of only a few weeks and can result
23 from very low levels of exposure. Is that
24 scientifically based?

25 A It is, yes.

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1 Q And is that based upon all those articles and things
2 that we talked about so far?

3 A Yes.

4 Q And, in fact, there have been cases of individuals who
5 work at the home and not directly with asbestos where
6 they also get mesothelioma, correct?

7 A Unfortunately, yes.

8 Q And that's what the next slide is in regards to
9 household exposure. And you agree that that's
10 generally accepted in the scientific community that
11 individuals who aren't directly occupationally exposed
12 but could be exposed through secondary sources, that
13 those folks also could causally get mesothelioma?

14 A Right. They could have either what is called
15 household exposure or domestic bystander exposure or
16 what is called neighborhood exposure.

17 And in the abstract that Dr. Roggli and I
18 submitted in 1997 on 103 cases of mesothelioma in
19 women, the most frequent way the women were exposed
20 was from that bystander household or neighborhood
21 exposure.

22 Q And the last area I want to go over with you,
23 Dr. Hammar, is this area concerning each exposure
24 shortens the latency period for mesothelioma.

25 And could you explain to the court what we mean by

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1 each exposure shortens the latency period for
2 mesothelioma?

3 A Well, the latency period by definition with respect to
4 an asbestos-related disease is the time when a person
5 was first exposed to asbestos to the time they were
6 either diagnosed with the disease or the time that
7 they developed symptoms for the disease.

8 And for example in mesothelioma, the shortest
9 latency that is recognized by Helsinki is 10 years.
10 The longest is over 60 years. The shortest that I
11 have seen in my own practice as a pathologist, I saw
12 one case of a person who had a 10-year latency. But
13 most of the people have had latencies between,
14 basically, about 20 to 60 years.

15 But what it is shown is that if you look at the
16 mechanism by which mesothelioma or any other type of
17 cancer induced by a carcinogen is based on, it's a
18 mechanism by which there is continued injury over a
19 period of time in which cells are changed, and
20 eventually these cells will exhibit changes in a lot
21 of the genes that -- or many of the genes that control
22 cell growth, many of the genes that control cell
23 death, the genes that control DNA repair and many of
24 the cell cycle functions.

25 And it's thought that the more of these changes

1 that you have, the more likely one of the cells that
2 has been injured by asbestos or another carcinogen,
3 for example, would become malignant.

4 So the higher the dose is of exposure, you would
5 think that these cellular changes would occur more
6 rapidly and would shorten the latency period for
7 mesothelioma. And that's generally been accepted,
8 although, I would say this in my own experience,
9 there's always going to be exceptions to that rule.

10 Q And is that one of the reasons then in regards to
11 asbestos exposures each and every exposure is causally
12 related to a mesothelioma?

13 A Well, I think that's it. The idea, basically, is that
14 each and every exposure a person has in an
15 occupational or a bystander setting has the ability to
16 contribute to cause that injury. And the way that
17 happens with mesothelioma, for example, is that you
18 inhale air that contains asbestos fibers into your
19 lungs, and a certain concentration of that asbestos is
20 translocated from the lung where it was first
21 deposited to other parts of the body.

22 And with respect to mesothelioma, that would be
23 the pleura that lines the chest cavity in the lung.
24 And in the case of the peritoneal mesothelioma, it
25 would be the peritoneum that covers the organs and

1 lines the abdominal cavity.

2 And the basic idea is that the more asbestos you
3 get to that part of the body, the more likely you are
4 to have this cellular injury that in some individuals
5 will result in the development of a mesothelioma.

6 Q And is this idea of translocation of the asbestos
7 fibers to both pleura and the peritoneum, is that
8 generally accepted in the scientific community?

9 A Well, it's more than generally accepted. It's proven
10 I think at this point in time. In the year 2000,
11 Dr. Dodson and I wrote an article in Chest titled
12 Asbestos in Extrapulmonary Sites, Omentum and
13 Mesentery, which we showed that all types of asbestos
14 that you found in the lung could be found in the
15 abdominal fat tissue and mesentery fat tissue where
16 peritoneal mesotheliomas develop.

17 In 2001, Dr. Suzuki and Dr. Yuen published an
18 article showing that asbestos was translocated to the
19 pleura and that the dominant type of asbestos you
20 found in the pleura was actually short fiber
21 chrysotile, but you did find amphiboles as well.

22 And then there was another article that is not
23 recently -- is not thought of very frequently, but one
24 I think is very important, and that was an article by
25 Hiller, et al, published in 1996, where they were

1 actually looking at ovarian tissue in women and showed
2 that they could find a significant concentration of
3 asbestos, chrysotile asbestos, some amphibole
4 asbestos, in this ovarian tissue, some of the women
5 being -- having bystander exposure to husbands,
6 fathers, who were exposed to asbestos and in some
7 women having no known bystander exposure to asbestos.

8 So there's another example of asbestos being
9 translocated to a target organ where, in this case,
10 peritoneal mesotheliomas develop.

11 Q And is that why in dealing with causation, you have to
12 look at each of the exposures to asbestos to try to
13 determine whether it's causally related?

14 A Yeah. And I think what you know is that in all of the
15 exposures I think a person has to asbestos in an
16 occupational or bystander setting, there is a certain
17 concentration of that asbestos that's going to get
18 into the lung tissue.

19 There's no doubt that a significant amount of it
20 is cleared prior to getting into the lung tissue by
21 the defense mechanisms, which would include a lot of
22 different things, but a certain amount of it does or
23 is deposited in the lung.

24 And once deposited in the lung, then that asbestos
25 has the ability to be translocated to other parts of

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1 the body like the pleura and the peritoneum where it
2 can cause mesothelioma.

3 Q And very briefly, Doctor, I don't think we talked
4 about the Bianchi article, Latency Periods in
5 Asbestos-Related Mesothelioma of the Pleura, European
6 Journal of Cancer Prevention from 1997. It indicated
7 that, and we're talking about each exposure shortens
8 the latency period for mesothelioma, that the data for
9 the most heavily exposed people, as well as those as
10 the groups with the lowest exposure, are exactly the
11 same as would be expected. An inverse correlation
12 exists between an intensity of exposure to asbestos
13 and the duration of the latency period.

14 And that's again talking about how the -- as the
15 exposure lessens, the latency period gets longer?

16 A Right, low levels are associated with long latencies,
17 high levels of exposure are associated with short
18 latencies.

19 Q I also think Dr. Churg has indicated in his book that
20 as exposure level decreases, the latency period
21 increases; is that correct?

22 A That is correct, yes.

23 Q Is there any disagreement in the scientific literature
24 on that issue?

25 A I don't think there's any necessarily disagreement. I

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1 think, again, with what you can see those is
2 variation, and I think that's what you have to be open
3 to the idea that that's not necessarily going to
4 happen in every case.

5 But I think that what is stated right there is
6 generally what is accepted in the scientific
7 literature.

8 Q Now, Doctor, just so the record is clear, all the
9 opinions that you have given today are within a
10 reasonable degree of medical probability?

11 A Yes.

12 Q And in regards to all the articles that I have shown
13 you on the Powerpoint, these are all articles that you
14 have reviewed and are generally accepted in the
15 scientific community or in the peer-reviewed
16 literature?

17 A Right, articles that I have reviewed or statements
18 that are present in, like, government documents that I
19 have reviewed.

20 Q And are all these the types of materials that you have
21 relied upon in coming to your conclusions in this
22 case?

23 A Yes.

24 MR. FROST: That's all we have, your
25 honor.

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1 THE COURT: Mr. Osburn, any
2 questions?

3 MR. OSBURN: I will try and be
4 brief, Your Honor.

5
6 CROSS-EXAMINATION

7 BY MR. OSBURN:

8 Q Dr. Hammar, are you aware that Judge Colville in
9 Allegheny county reviewed a couple of your transcripts
10 in his decision on a Frye Hearing on the same reason
11 we're here this morning?

12 A No.

13 Q The transcript from the Eisen -- I believe you
14 testified in the Eisenreich (sic.) case in 1999?

15 A Yes.

16 Q And in the Kulig case on June 5th, 2003?

17 A I remember those names. I don't think I could have
18 told you the dates.

19 Q Doctor, you've testified many times that exposure
20 below 0.1 fiber cc years is not sufficient to cause a
21 mesothelioma; is that true?

22 A I have stated that statistically there's no evidence
23 until just recently that I thought showed that. That
24 was based on Dr. Nicholson's determination published
25 in the 1986 Federal Register which stated that at .1

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1 fiber cc years of exposures, there was seven cases of
2 mesothelioma per 100,000 people. There was no
3 statement of anything lower than that. And that was
4 the number given at that point in time.

5 Q And you've testified that on Nicholson's model, which
6 is 0.1 fiber per cc, which is eight hours a day for a
7 working year, which is 252 days, and that's the
8 exposure he's talking about?

9 A Yes.

10 Q And you testified in the McPhee trial that you were
11 never going to be able to collect a group of people
12 with that low of exposure and, say, compare them with
13 people that had no exposure. It's just not possible
14 to do. So what they do is extrapolate from higher
15 numbers to lower numbers, and higher numbers means the
16 higher dose to a lower dose, does it not?

17 A That's basically what they do. That's correct.

18 Q You have testified, I believe, in the Whitehead case
19 that you cannot quantify a threshold for peritoneal
20 mesothelioma, correct?

21 A I would say that even today. I don't know if anybody
22 knows what the threshold for peritoneal mesothelioma
23 is. I know when Dr. Roggli and I, again, wrote our
24 abstract in 1997, what we found was that there was
25 really a significant variation in the concentration of

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1 individuals' lung tissue for asbestos in people who
2 had peritoneal mesothelioma.

3 And I strongly feel that today there's always
4 going to be a range of what you find in concentration
5 of asbestos in lung tissue, pleural tissue, peritoneal
6 tissue where people have mesotheliomas. It's never
7 going to be an absolute number

8 Q You testified that you can't use case reports alone to
9 establish causation (Inaudible) or further study
10 rather to assign (Inaudible), right?

11 A I have stated that. But, you know, it's kind of
12 interesting that there was just a recent article about
13 that where it talked about two incidents in which case
14 reports were used for causation. And the one is
15 really pertinent to mesothelioma, and that was the
16 report by Dr. Wagner, Sleggs and Marchand in the
17 British Journal of Industrial Medicine in 1960 where
18 they reported 33 cases of mesothelioma in the
19 Northwestern Cape Province of South Africa. And it
20 was that article that basically led the world to
21 conclude that mesothelioma was caused by asbestos.

22 The other case report that did a similar thing was
23 five cases of angiosarcoma that occurred in workers
24 who were exposed to vinyl chloride. And it's thought
25 that that case report, again, drew the world's

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1 attention to the idea that vinyl chloride was a cause
2 of angiosarcomas in liver.

3 Q Right. And they draw the world's attention to things
4 by saying here's something we really can't -- we're
5 not sure about, we can't draw conclusions from, so
6 we're going to go ahead and study them, and we are
7 going to go ahead and do a biological study and then
8 we're going to find out?

9 A Well --

10 Q If you just have an isolated case, you can't draw a
11 conclusion from that. That was your testimony in the
12 Whitehead case on December 8th, 2005.

13 A Well, that might well have been. But I would say at
14 the same time is that if you were to ask anybody in
15 mesothelioma medicine, I will put it that way, when
16 they thought that mesothelioma was caused by asbestos,
17 I would suspect the majority would say when the
18 article by Wagner, Sleggs and Marchand was published.

19 If you actually look at the real date, it probably
20 was Merewether's studies from 1940 where he used the
21 word tumors of the pleura, which were probably
22 mesotheliomas. And he did do an epidemiologic study,
23 but unfortunately he didn't use -- did not use the
24 word mesothelioma.

25 Q You mentioned the Iwatsubo study from 1998, correct?

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1 A Pardon me?

2 Q You mentioned the Iwatsubo study --

3 A Yes.

4 Q -- on the French population. The Iwatsubo study,
5 right, does not (Inaudible) "Furthermore, since only a
6 few subjects in these cohorts were exposed to low
7 levels of asbestos, there is not enough statistical
8 power to show any significant association with
9 mesothelioma"?

10 A That is a correct statement in that article, yes.

11 Q And you can't quantify Mr. Lott's exposure to
12 asbestos?

13 A I can't, no.

14 Q Let's talk about the Helsinki criteria, one of which
15 refers to diagnosis, one of which is actually
16 attribution of causation, one of which is biological
17 evidence which is not available in Mr. Lott's case?

18 A That is correct.

19 Q The second which is radiological evidence, which is
20 also not available in Mr. Lott's case?

21 A That is correct.

22 Q The third is occupational history, but Helsinki says
23 you need a significant occupational exposure, doesn't
24 it, Dr. Hammar?

25 A No, it doesn't say that. What the Helsinki Consensus

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1 Report says, it's on Page 313, and the exact title of
2 the article is Consensus report: Asbestos, Asbestosis
3 and Cancer: The Helsinki Criteria For Diagnosis and
4 Attribution, Scandinavian Journal of Work and
5 Environmental Health, 1997, Volume 23, Pages 311-316.

6 And on Page 313, it says -- it starts out by
7 saying -- talking about lung fiber content, and then
8 it says, "Should be sufficient to relate a case of
9 pleural mesothelioma to asbestos exposure on a
10 probability basis. In the absence of such markers,"
11 and it's talking about plaques and asbestosis, "a
12 history of significant occupational, domestic or
13 environmental exposure to asbestos will suffice for
14 attribution."

15 And then it states that -- in the bullet points
16 it states that, the second once, mesothelioma can
17 occur in cases with low asbestos exposure. However,
18 very low background environmental exposures carry only
19 an extremely low risk.

20 And then it states that an occupational history of
21 brief or low-level exposure should be considered
22 sufficient for mesothelioma to be designated as
23 occupationally related.

24 So it seems to me that that's saying that if you
25 don't have the markers like fiber concentrations,

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1 asbestos body concentrations, plaques or asbestosis,
2 you can attribute causation by a history of exposure,
3 and even a very low level of exposure will suffice.

4 Q In the -- you were shown a couple of slides. One was
5 from Rodelsperger?

6 A Yes, mm-hm.

7 Q And it talks about levels of cumulative exposure below
8 one fiber year, and that's one fiber cc year, correct?

9 A Yes, mm-hm.

10 Q Doctor, what -- in the Anderson case, the judge
11 excluded your testimony on causation or at least
12 limited it?

13 A No.

14 Q He didn't?

15 A Pardon me?

16 Q He didn't limit your testimony on causation?

17 A On Anderson? Oh, yes, yeah.

18 Q And how did he limit it?

19 A Pardon me?

20 Q How did he limit it?

21 A He said that we could not talk about anything -- a
22 concentration of asbestos I think it was below .1
23 fiber cc years. And there was another limitation that
24 I can't remember. But it was -- it was limiting. Oh,
25 I know. The other one is that we couldn't talk about

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1 all of the exposures that we thought that Mr. Anderson
2 had to asbestos-containing materials from the
3 Caterpillar engine.

4 Q As being causative of mesothelioma?

5 A Yes, mm-hm.

6 Q And didn't he prevent you from giving a range of
7 exposures being causative of mesothelioma without
8 giving a lower threshold, correct?

9 A He did. I will never understand it.

10 MR. OSBURN: Thank you, Doctor.
11 Nothing further.

12 THE WITNESS: Okay.

13
14 REDIRECT EXAMINATION

15 BY MR. FROST:

16 Q Dr. Hammar, is there any scientific basis for that
17 limitation in your testimony?

18 A Well, there certainly wasn't to me. And I will tell
19 you, as a pathologist, I didn't understand it at all,
20 and I still don't, and I never will. And it seemed to
21 me very unfair.

22 Q And, Dr. Hammar, in regards to your testimony, you
23 have testified throughout the country, correct?

24 A I have, yes.

25 Q Has your testimony ever been limited before?

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1 A No.

2 Q Now, Dr. Hammar, you also testified in an in re
3 asbestos litigation, what I'm going to call a very
4 large friction motion, that dealt with all these same
5 issues in the state of Delaware, correct?

6 A I did.

7 Q And in that, there's also an opinion in that case that
8 has Dr. Samuel Hammar, and it discusses your
9 testimony, and it discusses other witnesses including
10 Dr. Dodson, correct?

11 A Yes.

12 Q And in that case, in that friction case, which
13 involved the same issues, that judge in Delaware
14 overruled the motion, correct?

15 A That is correct.

16 Q And also in Texas, we have an MDL procedure for the
17 entire state. You are aware of that, that there's one
18 judge that decides all pretrial matters?

19 A Dr. Davidson -- Judge Davidson. Excuse me.

20 Q He might think he's a doctor.

21 MR. FROST: Can that be stricken
22 from the record, Judge?

23 THE COURT: Nothing gets stricken
24 from our record.

25 Q (By Mr. Frost) And Judge Davidson has dealt with

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1 these exact same issues. Dr. Hammar, you testified
2 for a number of days, and I think many experts
3 testified in front of Judge Davidson on this exact
4 same issue, correct?

5 A That is correct, yes.

6 Q And in that particular case, in the Texas MDL that
7 involves every asbestos case filed in the state of
8 Texas, you were not excluded, nor was your testimony
9 limited?

10 A That is correct.

11 MR. FROST: That's all we have.

12 THE COURT: Dr. Hammar, I have a
13 question.

14 THE WITNESS: Okay.

15 THE COURT: You were talking about
16 the Nicholson study, and you agreed that you had
17 previously testified that exposure to less than .1
18 fiber cc year isn't sufficient to cause mesothelioma,
19 and then there was an implication that, however, maybe
20 more recently your opinion has changed.

21 Did I just read that in or is that correct?

22 THE WITNESS: That's absolutely
23 correct, Judge.

24 THE COURT: Okay. Could you explain
25 that?

1 THE WITNESS: Well, there have been
2 more articles published and one that I had overlooked
3 that talked about lower levels of asbestos.

4 For example, the Hodgson Darnton article that was
5 published in the American Journal of Occupational
6 Hygiene in 2000 in Table 11, they show concentrations
7 of asbestos.

8 MR. FROST: And, Your Honor, that
9 has previously been marked as Plaintiff's Exhibit 334.

10 THE WITNESS: In Table 11 of that
11 article, they show concentrations of asbestos -- I'm
12 trying to get the exact article -- I mean the exact
13 table. (Peruses document.)

14 But, basically, they show levels as low as .001
15 fiber cc's of asbestos, and this is amphibole
16 asbestos, as causing mesothelioma, extremely low
17 concentrations.

18 And then in the Iwatsubo article, I think their
19 concentration went down to 0.01 fiber cc years, which,
20 again, is lower than Dr. Nicholson's level of .1 fiber
21 cc years.

22 THE COURT: And that was chrysotile?

23 THE WITNESS: In -- in the case of
24 chrysotile in the Hodgson and Darnton article -- and
25 maybe -- let me see if I can find that, and I can read

1 it to you exactly. (Peruses documents.)

2 They stated for one fiber cc years that there
3 were, for crocidolite, they stated estimate 650 deaths
4 per 100,000 exposed, and this is for mesothelioma,
5 highest arguable estimate 1,500, lowest 250. For
6 amosite, it was 90 deaths per 100,000, highest
7 arguable estimate 300, lowest 15 for chrysotile, best
8 estimate five deaths per 100,000 exposed, highest
9 arguable, 20, lowest one.

10 And then they get down to .1 fiber cc years for
11 crocidolite. It was 100 per 100,000 exposed. For
12 amosite, it was 15. And then they said for chrysotile
13 risk, probably insignificant, highest arguable
14 estimate, four deaths per 100,000 exposed.

15 But even at that level, though, if you look at the
16 real background of one case per million people, and if
17 you have four deaths per 100,000 people, that's 40
18 times what you would expect to find in the background,
19 which is an incredible high risk.

20 THE COURT: And the Iwatsubo study,
21 was that chrysotile as well --

22 THE WITNESS: Let me see if I can --

23 THE COURT: -- that .01 fiber?

24 THE WITNESS: Let's see. (Peruses
25 documents.) I don't have that with me. Does anybody

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1 have the Iwatsubo article?

2 MR. FROST: I do, Your Honor. Where
3 it is is a different story.

4 THE WITNESS: I thought that I had
5 that with me, but I guess I didn't.

6 MR. OSBURN: I have a copy here. It
7 was one of the submissions by Dr. Maddox in Judge
8 Colville's case.

9 THE COURT: Would you mind handing
10 the article to Dr. Hammar just for a minute?

11 MR. OSBURN: Here you are.

12 THE WITNESS: Thank you.
13 Unfortunately, this doesn't -- this is not the whole
14 article.

15 THE COURT: Oh, it's just the
16 abstract.

17 THE WITNESS: It had the table.

18 MR. OSBURN: It's just the abstract.

19 THE WITNESS: It had the table
20 there. I'm sorry.

21 THE COURT: Okay. But in any event,
22 what was the concentration again in the Iwatsubo?

23 THE WITNESS: It got down to 0 --
24 0.01 fiber cc years.

25 THE COURT: Okay.

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1 THE WITNESS: Then at the
2 International Mesothelioma Interest Group which I
3 participated in about two weeks ago in Chicago, there
4 was an abstract presented again at a low level of
5 0.07, which they reported cases of mesothelioma
6 occurring in that low of concentration.

7 And I can furnish the people, the court, I can
8 furnish that to you, Judge, with the abstract.

9 THE COURT: Okay. Thank you very
10 much. Anything further?

11 MR. OSBURN: Just briefly, Your
12 Honor.

13
14 RE-CROSS-EXAMINATION

15 BY MR. OSBURN:

16 Q The Hodgson and Darnton article was published in 2000?

17 A Yes, mm-hm.

18 Q And Iwatsubo was published in 2002?

19 A Right.

20 Q You testified in the McPhee trial on March 3rd, 2006,
21 right?

22 A Yes.

23 Q You were asked, "You would not attribute -- if a
24 person had an exposure of less than .1 fiber per cc
25 year, you would not attribute that person's disease of

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1 mesothelioma to asbestos?" And your answer, "I would
2 say statistically I couldn't do it based on what has
3 been published." Right?

4 A Right. And that was an error that I made of not being
5 aware of those exact concentrations that were present
6 in the Hodgson and Darnton article and the Iwatsubo
7 article. That was my lack of not keeping totally up
8 to date.

9 MR. OSBURN: That's all I have.

10 THE COURT: Thank you, sir. And if
11 you have that abstract, you should probably return
12 that, the yellow sheet.

13 THE WITNESS: I gave that back.

14 MR. OSBURN: I have that, Your
15 Honor.

16 THE COURT: Okay. Good. Thank you.
17 Thank you very much.

18 MR. FROST: Your Honor, I think
19 honestly anything else would be probably cumulative.

20 THE COURT: Let me tell you what I'm
21 really interested in. I would like, and I'm assuming
22 Dr. Maddox may be doing this, I would like somebody to
23 do some math, give a range of possible fiber year
24 exposures for Mr. Lott and tie it into this testimony.

25 I mean, I've been sitting here trying to do the

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1 math myself, but I don't know if I'm right.

2 MR. FROST: Your Honor, the problem
3 with that is that's not generally accepted --

4 THE COURT: I'm asking you, it would
5 help me make my decision.

6 MR. FROST: I understand. I'm
7 just --

8 THE COURT: I'm just asking you to
9 do that. So if there's someone who can do that, that
10 would help me.

11 MR. FROST: Your Honor, can we have
12 a few minutes?

13 THE COURT: Sure.

14 (Recess.)

15
16 THE COURT: Please be seated.

17 MR. FROST: Your Honor, we have
18 talked extensively with Dr. Maddox, and one of the --
19 that's not really his expertise, the numbers. That's
20 more of an occupational medicine type issue. That's
21 why we brought the occupational medicine person
22 earlier. He's unable to come back down right now.

23 But, meanwhile, we took the testimony that he gave
24 and kind of put the pen to paper ourselves. And Glenn
25 is willing to explain to the court kind of where --

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1 what conclusions we drew on that.

2 THE COURT: That's fine.

3 MR. FROST: Although, to be honest
4 with the court, I don't think that you need to go
5 there.

6 THE COURT: I know that that's your
7 position. Thank you.

8 So let's do argument then, Mr. Draper?

9 MR. DRAPER: Okay. So Mr. Lott's
10 testimony was that he worked during the school year
11 three or four hours a week and that drywall work was
12 one of the major activities that he did, but it
13 certainly wasn't the only activity that he did.

14 During the summer, he worked 40 hours a week.
15 Most of that work was outdoors, landscaping, but he
16 still did occasional drywall work during the summer as
17 well. And then in addition to the work that he did
18 directly, he also had some bystander exposure to the
19 drywall work.

20 So what I assumed was that Mr. Lott did two hours
21 of drywall or back -- background exposure to drywall
22 two hours a week for three years, which I think is
23 well supported by his testimony. So two hours a week
24 times 52 would be 110 hours a year. Three years would
25 be 330 hours.

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1 So now we need to figure out what exposures he
2 received during those 330 hours. And, you know, we
3 have looked at the studies with Dr. Brodtkin, and they
4 found exposures anywhere from 10 fiber cc's all the
5 way up to 46 fiber cc's during the sweeping of a joint
6 compound. I just took the lower number. I assumed
7 during that 330 hours, he's exposed to 10 -- asbestos
8 levels of 10 fiber cc's.

9 So you just do the math. That gives you a total
10 of 3,300 fiber cc hours. Basically, 330 hours at 10
11 fiber cc's is the same thing as 3,300 hours at one
12 fiber cc. A fiber cc year I just assumed to be 2,000
13 hours. So divide 3,300 by 2,000, and what you get is
14 1.65 fiber cc years.

15 This is just kind of a back-of-the-envelope sketch
16 obviously. The way you can see is an order of
17 magnitude above the .1 figure that we were talking
18 about as a possible threshold. So even if we're off
19 by a factor of 10 with this calculation, we're still
20 well above what the defendants have argued is a
21 threshold for causation of mesothelioma.

22 THE COURT: Okay. And is there any
23 other argument you want to make on this issue? I
24 mean, I have read both of the briefs.

25 MR. FROST: Your Honor, I think you

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1 are well aware of the issue. I don't see a great need
2 for additional argument.

3 THE COURT: Okay.

4 MR. FROST: Unless the court does.

5 THE COURT: No. Thank you.

6 Mr. Osburn?

7 MR. OSBURN: Your Honor, just
8 briefly. I will respond to this as sort of the rough
9 calculations that Mr. Draper did in a moment. Neither
10 Dr. Brodtkin, nor Dr. Hammar, nor Dr. Maddox, because
11 he says so in his deposition, can quantify Mr. Lott's
12 exposure to joint compound. And they certainly can't
13 quantify Mr. Lott's exposure to Bondex joint compound,
14 which is one of the (Inaudible) that he mentioned.
15 With Bondex, he said that he never -- he doesn't
16 remember working with it, and he can't say that he was
17 working around it. He simply saw a can (Inaudible).
18 So that's the kind of exposure that we're talking
19 about.

20 Exhibit 293 are Mr. Lott's social security records
21 which show how much he worked at the Jewel Lake Villa
22 Apartments. And he worked for a number of apartments,
23 but the Jewel Lake Villa is the one he testified
24 that's where he did the joint compound work. The
25 other ones it was all (Inaudible).

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1 And we haven't gone over the figures, and Ms.
2 Loftis has been working on those, so she can address
3 that.

4 MS. LOFTIS: So what I did, Your
5 Honor, was I went through the social security records
6 to see how much money he made during the relevant time
7 period. And in 1973, he made during the entire year
8 \$152, \$44 of which was made during the summer months
9 when he testified he predominantly did landscaping
10 work.

11 But even if you calculate the entire amount of
12 work that he did in 1973, he said he was paid \$6 an
13 hour for interior work, \$10 an hour for exterior work.

14 At \$6 an hour to \$10 an hour, the amount that he
15 was paid equates to 15 to 25 hours during the entire
16 1973. And that 15 to 25 hours he told us in his
17 deposition was equally spent among all of the tasks
18 that he did for his father, which include flooring,
19 electrical work, helping the plumber, painting and
20 then landscaping.

21 In 1974, he worked more hours certainly. The
22 total amount of hours, and again using the same
23 calculation, taking the total amount that he's paid
24 and using a range of \$6 an hour to \$10 an hour is 134
25 hours, so 224 hours. In 1975, he didn't work at all.

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1 So there's no work in 1975.

2 And I will hand it back to Mr. Osburn to talk
3 about the significance of these numbers.

4 MR. OSBURN: The corresponding theme
5 between Dr. Brodkin and Dr. Hammar's testimony is that
6 they cannot come up with a study that says that low
7 dose exposures to chrysotile causes mesothelioma, at
8 least the 0.1 articulated by Dr. Nicholson and
9 ascribed to by Dr. Hammar. They don't know what
10 Mr. Lott's dose was.

11 So in this case, they cannot testify that his
12 exposure to joint was compound was then to the one
13 tenth or one eighth of that to Bondex caused what was
14 a substantial contributing factor to his disease.
15 They simply cannot do it. There's no fiber burden
16 analysis, so we can't tell if there were deposition of
17 asbestos fibers in the lungs, and there's no
18 radiographic evidence there was exposure to asbestos.
19 All you have is this occupational history.

20 I didn't hear any support for low dose from
21 Dr. Brodkin, just chrysotile causation in general,
22 nothing on low dose exposures. All he was doing was
23 what Dr. Hammar really had to do and what Judge
24 Colville found and what Dr. Maddox is doing is taking
25 a high dose, studies that say there are high doses

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1 that cause mesothelioma, and extrapolating down.
2 That's exactly what Judge Colville said you can't do.

3 Dr. Hammar likes to point to certain cases that
4 sort of explain but don't result in epidemiological
5 studies, which is what you have to rely on for
6 causation. He simply says you need a significant
7 occupational exposure.

8 No one has testified or will testify in this case
9 that this was a significant occupational exposure.
10 All they have are generalized statements and case
11 examples of chrysotile causes mesothelioma, asbestos
12 causes mesothelioma. No actual support for their case
13 in this case with Mr. Lott. So low exposures to
14 spouses and children, they carefully didn't mention
15 chrysotile because those were not chrysotile
16 exposures. Those are amphibole exposures from the
17 shipyards to insulation.

18 So what we have in this case is exactly -- it's
19 actually even an even tougher case for the plaintiffs'
20 experts than Judge Colville faced because we have
21 peritoneal mesothelioma for which there are no studies
22 that show that chrysotile is associated with it or at
23 least low doses or as Dr. (Inaudible) states in his
24 testimony ultra low doses, which we have in this case.

25 So we would move the court to strike Dr. Hammar's

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1 testimony generally on the fact -- or his testimony
2 that all exposures to disease in this case and -- or
3 failure to demonstrate in this case a causal link
4 between Mr. Lott's exposure and a threshold level of
5 exposure required for peritoneal mesothelioma.

6 THE COURT: Thank you. Mr. Frost,
7 do you have the Hodgson Darnton -- Dartson?

8 MR. FROST: Your Honor, I don't
9 believe I have a full copy. There is one additional
10 article, Your Honor, that I would like to --

11 THE COURT: Actually, I'm really
12 interested in that article. Does it say what the base
13 measurement was? Dr. Hammar referred to Table 11,
14 which indicated a certain number of cases per "X" of
15 population, and I can't remember what the base number
16 was, what the denominator was. Was it 1,000?

17 MR. FROST: It is 1,000.

18 THE COURT: Is it 1,000 or was it
19 more than that?

20 MR. FROST: Your Honor, at .1 fibers
21 per milliliter years, it says the highest estimate is
22 four deaths per 100,000 --

23 THE COURT: 100,000.

24 MR. FROST: -- for chrysotile, for
25 chrysotile. Now, for the others it has -- and that's

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1 the article --

2 THE COURT: Let me just ask this
3 question: What is the translation of milliliter into
4 cubic centimeter?

5 MR. DRAPER: I think they are
6 approximately equal.

7 MR. FROST: Well --

8 THE COURT: I didn't have any
9 expressed testimony on that.

10 MR. FROST: There's a differing of
11 opinions as to whether you can do that.

12 THE COURT: Is one generally bigger
13 than the other?

14 MR. FROST: I'm not an industrial
15 hygienist, Judge, so I don't know for sure. I just
16 know there is a dispute in the literature whether you
17 can transpose back and forth.

18 Dr. Maddox says a milliliter is a cc, so they
19 should be exactly the same.

20 THE COURT: Okay. Good.

21 MR. FROST: I'm glad somebody knows.

22 THE COURT: I am ready to give the
23 decision unless you want to make more arguments?

24 MR. FROST: Well, Your Honor, I have
25 one additional paper that talks about low dose

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1 exposure to peritoneal mesothelioma that I think --
2 and Dr. Maddox was going to testify about this.

3 MR. DRAPER: I think Dr. Brodkin
4 referred to it as well.

5 THE COURT: Which one is it?

6 MR. FROST: It's asbestos And
7 Peritoneal Mesothelioma Among College Educated Men.
8 It's Plaintiff's Exhibit No. 357.

9 THE COURT: Who is the author?

10 MR. FROST: It's Welch and
11 Sugarbaker.

12 THE COURT: He talked about it.

13 MR. FROST: Okay. And, Your Honor,
14 here is the article. And it deals, Your Honor,
15 specifically with low dose exposure, peritoneal meso's
16 and also deals with individuals that work with brakes,
17 which are chrysotile. And there's no doubt that every
18 single individual that has dealt with brake mechanics
19 and brake linings, that those are all
20 chrysotile-containing products, and there are eight
21 peritoneal mesotheliomas in that group.

22 THE COURT: Is there case studies
23 or --

24 MR. FROST: It is a case study.
25 And, Your Honor, that's the only thing in regards to

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1 the statement from the defense that somehow we need
2 epi studies on every single thing, that is just not
3 the law. And that's a 2005 article, Your Honor.
4 That's one of the latest writings in regards to
5 peritoneal mesothelioma and low dose.

6 (Pause in proceedings.)
7

8 THE COURT: And I'm trying to figure
9 out the amount of exposure here.

10 MR. FROST: And, Your Honor, that's
11 why you have to look at the methodology and what they
12 were looking at in that particular study because
13 that's the important part when we're dealing with Frye
14 issues is whether the methodology that folks are using
15 are generally accepted in the scientific community.

16 And all these arguments about what is on your SSPO
17 are great for the jury or for summary judgment, but
18 not for whether the basis of scientific opinions are
19 based on the Hill criteria and based on valid
20 scientific method.

21 That particular cohort, what they did was they
22 looked at individuals who were college educated, and
23 they determined that because they were college
24 educated, much like Mr. Lott, their exposures to
25 asbestos were earlier and very slight, but they still

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1 developed peritoneal mesothelioma later.

2 THE COURT: Okay. Thank you. Well,
3 I have read the briefing, and I, of course, read the
4 opinion of the Allegheny County judge. I think it is
5 well established that mesothelioma occurs at 0.1 fiber
6 cc years, and Dr. Hammar seems to think there's
7 evidence that it occurs at below that.

8 I think there is a plausible calculation that
9 Mr. Lott was exposed to that amount or more. And I
10 understand the defense calculation, but I'm not sure
11 that that is dispositive as to the number of hours he
12 actually worked or was exposed, and I'm relying
13 instead on his deposition testimony as to what he did.
14 I think a reasonable jury could accept that as the
15 basis for his number of hours exposed.

16 Assuming that to be true, there's certainly
17 sufficient scientific evidence to prevent Dr. Maddox
18 to testify that this type of exposure, and even if,
19 you know, the Bondex exposure presented some fraction
20 of the total, that Bondex's product could have been a
21 substantial contributing factor to his development of
22 mesothelioma.

23 I certainly do respect Judge Erlick. I just think
24 I come out differently on the issue.

25 The other thing that is of some significance to me

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1 is that we have a Court of Appeals decision in
2 Muprutis (sic.) and while this precise issue wasn't
3 presented to that court, they have accepted the type
4 of testimony that Dr. Maddox and Dr. Hammar give to
5 the effect that every exposure contributes, that it is
6 a dose response disease and that the cumulative effect
7 is what ultimately causes his illness.

8 I think that may be a different legal frame work
9 than what we saw in Pennsylvania. So I am denying the
10 motion to exclude Dr. Maddox. Dr. Maddox will be
11 permitted to testify. And I'm not imposing any
12 restrictions on the testimony in the manner that Judge
13 Erlick did.

14 Do you all need a break or can we bring in our
15 jurors? They've been very patient.

16 MR. FROST: If we could just have a
17 short break --

18 THE COURT: Let's have a five-minute
19 break. They've waited for two hours and 15 minutes,
20 so we need to --

21 MR. FROST: And I apologize for the
22 length of the hearing, Your Honor. I just wanted --

23 THE COURT: That's all right. We
24 now have a complete record I think. And I'm giving
25 you back this one.

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1 MR. FROST: Thank you, Your Honor.
2 I'm trying to be better with the exhibits this time.

3 THE COURT: Okay.

4 MR. FROST: I'm trying.

5 THE COURT: Good. Thank you.

6 (Proceedings concluded.)

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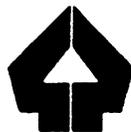
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A-8

Asbestos

Effects on health of exposure
to asbestos



Richard Doll and Julian Peto

microscope in all the common histological forms (squamous carcinoma, small or oat-cell carcinoma, and adenocarcinoma).† Asbestos, moreover, seems to exert its effect synergistically with tobacco smoke, increasing the incidence rate among people of given age by the same proportion in smokers and non-smokers alike. Whether the two agents act to multiply each other's effect exactly is uncertain; but the interaction is so strong and so nearly multiplicative that, on present knowledge, we must assume that the chance that the lung cancer in a particular man or woman who has been exposed to asbestos is attributable in part to that exposure, is unaffected by his or her past smoking habits. This is convenient from a legal viewpoint, as it means that evidence about tobacco use is not needed and it may be extremely fortunate from the point of view of practical prevention; for the relationship presumably extends, to some extent at least, to ex-smokers as well. If so, analogy with the effects of stopping smoking in the general population would suggest that an individual, who has previously been exposed to asbestos and who currently smokes, can materially reduce the likelihood that the previous asbestos exposure will ultimately cause a lung cancer, simply by stopping smoking. In other words, cessation of smoking is likely to confer an even greater avoidance of risk of lung cancer in people with a history of heavy asbestos exposure than in the population at large.

Lung cancer attributable to asbestos, like carcinomas attributable to other known causes, does not generally occur until several years after the initial exposure. The first few cases in an exposed population may appear as soon as five to nine years after first exposure, but the excess risk of developing the disease continues to increase for a further 20 years and possibly for longer. Thus, no single "latent period" can be said to exist and the belief that it does has, on occasion, led to some seriously misleading predictions.

As with other environmentally induced cancers, the mean period from first exposure to the appearance of the disease is unrelated to the intensity of exposure, except in so far as heavy exposures shorten the expectation of life and consequently the time during which cancers can occur. We cannot, therefore, aim to reduce exposure to such an extent that the individual will inevitably die of something else before the disease

† In some series asbestos-associated cancers have included an unusually high proportion of adenocarcinomas which are not normally found to be common in smokers (Kannerstein and Churg, 1972). This, however, may be due to the inclusion of a high proportion of cases examined at autopsy, when adenocarcinomas in the periphery of the lung are included, whereas they are frequently missed in series based on biopsies.

is able to appear. Unless, unexpectedly, there turns out to be some threshold dose below which asbestos does not act as a carcinogen, all we can hope to do is to reduce the attributable risk* at each interval after first exposure to such a level that the balance of the risk and benefit associated with its use is socially acceptable.

Mesothelioma

Mesotheliomas of the pleura or peritoneum are normally so rare, other than after occupational or other unusual exposure to asbestos, that any case that occurs after well attested and substantial asbestos exposure is commonly accepted as due to that exposure, subject only to the qualification that the time since the exposure occurred must be long enough to permit the disease to have been produced. This qualification is important as the delay between first exposure and effect is longer for mesotheliomas than for most other cancers; it is seldom less than 15 years, and possibly never less than 10 years. Any period less than 15 years must, therefore, throw doubt on the relationship of the disease to the exposure in question. As with lung cancer (and with other cancers due to other causes) increasing exposure increases the risk of developing the disease, but does not affect the length of the induction period. Periods of 30, 40, or even 50 years are common, and according to Peto *et al* (1982), who sought a model that would fit several of the largest sets of data, the risk continues to increase indefinitely with the time since exposure first occurred.

The relationship of mesothelioma to asbestos differs in several ways from the relationship for lung cancer. The hazard appears to be more strongly dependent on the type of asbestos and to be largely or wholly unaffected by smoking. As a result of these and other differences the ratio of the numbers of mesotheliomas and lung cancers produced by any given exposure to asbestos varies at least 10-fold from about 1-10 to 1-1 (see Chapters 4 and 6).

Other cancers

The evidence relating other types of cancer to asbestos is less clear and is discussed in detail in Chapter 3.

* We shall have occasion to refer to risk in this report many times. Unqualified, it means the chance that a particular event will occur in a given period. Qualified as attributable, it means the risk caused by a particular hazard, usually exposure to asbestos. The life-long risk is the chance that the event will occur before death can be expected from other causes. Relative risk is the ratio of the number of events observed in a special population to the number expected from the experience of some standard population with which it is compared; when used in this sense the period of time is understood to be the period of observation, unless otherwise defined.

A-9

Asbestos and Man-Made Vitreous Fibers as Risk Factors for Diffuse Malignant Mesothelioma: Results From a German Hospital-Based Case-Control Study

Klaus Rödelsperger, DSc,¹ Karl-Heinz Jöckel, PhD,² Hermann Pohlabein, MSc,³ Wolfgang Römer, MA,¹ and Hans-Joachim Weitowitz, MD¹

Background This study examines the role of occupational factors in the development of diffuse malignant mesothelioma with special emphasis on the dose-response relationship for asbestos and on the exposure to man-made vitreous fibers (MMVFs).

Methods One hundred and twenty-five male cases, diagnosed by a panel of pathologists, were personally interviewed concerning their occupational and smoking history. The same number of population controls (matched for sex, age and region of residence) underwent similar interviews by trained interviewers. Odds ratios (OR) were calculated for an expert-based exposure index using conditional logistic regression.

Results Exposure to asbestos shows the expected sharp gradient with an OR of about 45 for a cumulative exposure > 1.5 fiber years (arithmetic mean 16 fiber years). A significant OR was calculated even for the lowest exposure category "> 0-≤ 0.15 fiber years". Although the mean cumulative exposure to MMVF is roughly 10% of the exposure to asbestos, an increased OR is observed in an ever/never evaluation. This observation is heavily hampered by methodical problems. A corresponding case-control study was performed using a lung tissue fiber analysis in addition to interviews. Both interviews and the lung tissue analysis yielded similar OR levels between the reference and the maximum exposure intervals.

Conclusions Despite a possible influence as a result of selection and information bias, our results confirm the previously reported observation of a distinct dose-response relationship even at levels of cumulative exposure below 1 fiber year. Moreover, the study confirms that asbestos is a relevant confounder for MMVF. A causal relationship between exposure to MMVF and mesothelioma could neither be detected nor excluded, as in other studies. *Am. J. Ind. Med.* 39:262-275, 2001. © 2001 Wiley-Liss, Inc.

KEY WORDS: mesothelioma; case-control; asbestos; MMVFs; occupational history; lung tissue

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INTRODUCTION

Diffuse malignant mesothelioma (DMM) is predominantly caused by asbestos fibers [HEI-AR, 1991; Mark and Yokoi, 1991; Rösler et al., 1994; Spirtas et al., 1994; Gun, 1995]. In the past, its incidence in the general population was low, but it has been increasing for decades in industrialized countries and it may take another 20 years before its peak is passed [Peto et al., 1999]. In addition to asbestos exposure at the workplace, contact in the household and environmental exposure to asbestos are established causes of DMM [Hain and Dalquen, 1974; Vianna and Polan, 1978; Großgarten and Weitowitz, 1993; Rödel-sperger et al., 1996; Schneider et al., 1996; Magnani et al., 1997; Rees et al., 1999]. It has been demonstrated that the time since initial exposure and the type of asbestos are important for the quantification of the risk [Doll and Peto, 1985]. A risk estimate based on accurate workplace measurements is not yet available. Nevertheless, it has recently been demonstrated that an increase of risk may occur even below a cumulative exposure of a few fiber years (fibers/mL \times years) [Iwatsubo et al., 1998]. However, a reliable dose-response relationship between the concentration of long amphibole fibers and the risk of mesothelioma has been consistently established by several research groups on the basis of lung tissue fiber analysis, while no relationship was observed for chrysotile fibers [Rödel-sperger et al., 1999]. This is true even though the amphibole fibers in the lung tissue do not seem to be a good indicator of the fiber content of the pleura, where chrysotile fibers are predominantly observed [Smith and Wright, 1996].

Animal experiments show that other kinds of fibers, with a minimal length above 5 μ m, may also induce mesothelioma after direct application [Pott, 1991]. They confirm the hypothesis that fibers, which are sufficiently long, thin, and durable, are carcinogenic [DFG, 1997]. Besides asbestos sufficient evidence for this hypothesis in humans has only been obtained for erionite [IARC, 1988; DFG, 1997]. In inhalation experiments in rats only erionite fibers caused mesothelioma whereas asbestos and ceramic fibers, but not other man-made vitreous fibers (MMVF), provoked lung cancer. However, even for asbestos this effect was observed only at very high fiber concentrations, which are not feasible for MMVF, since they are much longer and thicker than asbestos fibers and would, therefore, require a much higher mass concentration. This model is, therefore, considered too insensitive for predicting carcinogenic effects in humans [Pott and Roller, 1993; Infante et al., 1994, 1996; Rödel-sperger and Weitowitz, 1995]. The question of the carcinogenicity of MMVF is of utmost public health relevance. Epidemiological observations have revealed an increased lung cancer mortality in producers of glass, stone, and slag wool, but the causal relationship to MMVF remained unclear [Infante et al., 1994, 1996; DeVuyst

et al., 1995; DFG, 1997]. The concentration of MMVF is higher for processing than for production [IARC, 1988; WHO, 1988; Corn et al., 1992]. However, epidemiologic investigations in craftsmen processing these fibers are difficult since they also process asbestos.

The original aim of this study was to investigate not only asbestos, but also MMVF and other inorganic fibers as causal factors of the DMM [Weitowitz et al., 1993; Rödel-sperger, 1996; Rödel-sperger et al., 1998, 1999]. Since it was necessary to carry out a lung tissue fiber analysis, in addition to recording occupational histories, patients undergoing surgical resection for a diagnosis other than mesothelioma were selected as controls in the participating hospitals. Most of them suffered from lung cancer. In addition, a suitable group of population controls was recruited for the cases from the area of Hamburg. The results obtained for pairs of cases and population controls from the area of Hamburg are reported in this paper. It was from the first results of this study that there was a strong association between exposure to asbestos and to MMVF. Hence, it was first necessary to make a thorough examination of the influence of asbestos. Meanwhile, in connection with the study of Iwatsubo et al., [1998], a critical commentary on the use and the methodological problems of population-based mesothelioma case-control studies has emphasized the importance of direct risk estimation in a low-dose population [Siemietycki and Boffetta, 1998]. Accordingly, we have examined the relationship between exposure to asbestos and the risk of mesothelioma and compared this with the relationship which was obtained from lung tissue fiber analysis [Rödel-sperger et al., 1999].

MATERIAL AND METHODS

Subjects

The 415 incident patients with suspected diagnosis of diffuse malignant mesothelioma (DMM), recruited between January 1, 1988 and December 31, 1991 from clinics in Hamburg, Heidelberg, Essen, Munich, and Berlin, included 324 cases (275 male, 49 female) with a definite diagnosis confirmed by a panel of pathologists.

The present study was restricted to cases from Hamburg, which were individually matched to population controls. They had to be of German nationality, willing and able to give a personal interview and to provide written informed consent. Of 137 male and 37 female cases (almost all patients of DMM being treated in two specialized hospitals in Hamburg during the recruitment period) it was possible to include 125 male cases in the final analyses after matching with controls (according to region of residence, sex, year of birth \pm 5 years). Females were not included on account of the small sample available. Population controls

TABLE I. Characteristics of Male Cases and Controls from Hamburg

No.	Cases 125	Controls 125
Age (years)		
Median	62.0	64.0
Mean	62.6	64.2
SD	9.4	10.0
No. of jobs		
Median	6.0	6.0
Mean	6.0	5.6
Ever smoked	99 (79.2%)	107 (85.6%)

were randomly drawn from the mandatory registries of suitable administrative units [Woitowitz et al., 1993]. The response rate was 63%. One case/control pair had a year-of-birth difference >5 years. However, this did not influence the results presented in this paper. Some basic characteristics of cases and controls are shown in Table I.

Data Collection

In the first step, a structured questionnaire was used by trained interviewers to obtain information on job history

and, in a second step, to obtain further specific information on occupational exposure to asbestos, MMVF, and other mineral fibers. Additionally, smoking, residential exposure, medical history, leisure-time activities and basic demographic characteristics were registered. Interviewers participated in several intensive training seminars during the recruitment phase. In a subset of variables from the questionnaire—(e.g., the duration of the interview and the number of job periods) the data were entered immediately in order to monitor and reduce possible interviewer effects.

Quantification of Occupational Exposure to Asbestos and MMVF

The description which in the first step was obtained for every job held (duration of at least 12 months) was supplemented with information from the second step (without limit of duration) and an expert industrial hygienist used these data to assess the cumulative dose of exposure to Asbestos and to man-made vitreous fibers.

Expert judgment was obtained blind with respect to the case-control status. Fiber concentration was quantified by assignment to one, two or even three of five exposure categories (Table II).

The geometric mean of the experts' estimate of the maximal and minimal value of fibers/ml per working shift

TABLE II. Definition of the Categories of the Asbestos Fiber Concentration and the Reproducibility of the Estimates of Two Experts

Categories of fiber concentration: definition by concentration intervals

Category	Fiber concentration fibers/ml				
	None	Low	Middle	High	Very high
Minimal value	0	0.005	0.025	0.25	2.0
Maximal value	0	0.025	0.25	2.0	10.0
Expert 1	Expert 2				total
	none	low	middle	high	
Estimation of the minimal concentration value^a					
None	191	10	4	—	205
Low	10	18	6	3	37
Middle	1	2	7	2	12
High	1	2	8	—	11
Total	203	32	25	5	265
Estimation of the maximal concentration value^a					
None	191	—	9	5	205
Low	3	1	—	3	7
Middle	6	2	7	4	19
High	3	1	6	24	34
Total	203	4	22	36	265

^aNumber of job periods per exposure category. If the experts were not able to assign the exposure to a certain category, they were allowed to combine two or more of them. In this case the minimal value resulted from the lowest and the maximal value from the highest category. Agreement is 82% for minimal and 84% for maximal concentration value.

was multiplied by the number of the working shifts with exposure. Integrating over the life span of each individual yielded the cumulative exposure to fibers (fiber years). For job periods with exposure to both asbestos fibers and MMVF the duration of exposure was only recorded once for both fiber species together. Because of the large differences between the minimal and maximal value of the concentration estimate and of the category of the frequency of working shifts with exposure, the arithmetic mean concentration, averaged over all job periods and correspondingly the cumulative exposure in fiber years, is taken as five times the geometric mean value (compare Table III and the section "Error of the Expert Estimate of the exposure to asbestos").

The quantitation is based on our own experience in measurement [Woitowitz and Rödelsperger, 1983; Arhelger et al., 1984; Rödelsperger et al., 1980, 1986, 1991], the international literature for asbestos [Woitowitz et al., 1983] and for man-made fibers [Walton and Coppock, 1987; IARC, 1988; WHO, 1988]. A second industrial hygienist reevaluated 265 job periods of 50 patients in order to check the reproducibility of the concentration estimates. The agreement for both rates is described in Table II.

The experts agreed in assigning the category "none" for 191 job periods (72%). For 48 periods (18%) asbestos exposure was scored by both while 26 times (10%) this was scored by only one of them. In all, the experts scored asbestos exposure for 74 job periods. When these are evaluated separately only 34% of the minimal values and 43% of the maximal values are classified in the same exposure category, while 15% of the minimal and 36% of the maximal values differ for more than one category. The

weighted κ values are 0.61 (95% CI 0.53–0.70) and 0.68 (95% CI 0.59–0.78) for the minimal and maximal concentration values, respectively, (SAS-procedure proc freq). If distinction is only made between exposed and unexposed people, both values increase to 0.72 (95% CI 0.62–0.82). For each expert the number of overestimates was nearly equal to the number of underestimates. Finally, the following parameters were selected for each person:

- Time since first exposure (years) defined as years since the beginning of the first job period with exposure to asbestos.
- Duration of an asbestos exposure (years) defined as duration of all job periods with exposure to asbestos.
- Highest intensity of asbestos exposure (f/ml) estimated during any period of the working life.
- Cumulative exposure to asbestos and MMVFs (f/ml × years) defined as fiber dose. For asbestos the cumulative exposure was calculated until the date of the interview and to time points 10 and 20 years previously.

Statistical Analysis

Odds ratio (OR) and 95% confidence intervals (95% CI) were calculated by conditional logistic regression using the SAS procedure PHREG [SAS institute, 1992]. Occupational risks were analyzed separately for job categories and industries, and for the parameters of exposure.

Job titles and industries were coded according to standard classifications [Statistisches Bundesamt, 1975, 1979]. The analysis of job histories was based on these

TABLE III. Frequency of the Geometric Mean Fiber Concentrations per Working Shift with an Exposure to Asbestos, Estimated for 454 Single Job Periods with an Exposure to Asbestos. Possible Concentrations are Obtained from Table II by Taking the Geometric Mean Values for Various Combinations of Lower and Upper Limits of the Concentration Ranges

Job periods				Cases		Controls	
				n	%	n	%
All periods				746		697	
Periods with exposure to asbestos							
No.	GM f/ml	Range f/ml		324	100	130	100
1	0.0112	0.005	0.025	108	33.3	51	39.2
2	0.0354	0.005	0.25	99	30.6	47	36.2
3	0.0791	0.025	0.25	25	7.7	8	6.2
4	0.1	0.005	2	12	3.7	4	3.1
5	0.2236	0.025	2	41	12.7	13	10.0
6	0.5	0.025	10	16	4.9	0	0.0
7	0.7071	0.25	2	1	0.3	0	0.0
8	1.581	0.25	10	22	6.8	7	5.4
9	4.472	2	10	0	0.0	0	0.0

codes which were grouped into 32 job categories and 21 branches of industry [Jöckel et al., 1994, 1998]. An ever vs. never exposure concept was used, in addition to information on the longest-held job, which had been commenced at least 20 years before the onset of disease; on evaluation this yielded comparable results.

In order to adjust for the established impact of asbestos on mesothelioma risk, 4–5 categories of the different parameters of exposure were set up and included into the logistic regression as additional dummy variables. Five categories of cumulative exposure were used for MMVFs in a similar manner. An ever/never evaluation was also performed.

RESULTS

Job History

The mean duration of lifetime employment was 42 years for cases and 43 years for controls. Asbestos exposure was registered for 454 of a total of 1,443 single job periods of cases and controls. Table III gives the geometric mean value (GM) and the corresponding range of fiber concentration per shift for the five categories of exposure defined in Table II and their combinations together with the number of job periods assigned to these categories. The percentage of the job periods with asbestos exposure amounts to 43.4% for cases compared to 18.3% for controls. The frequency distribution of job periods with asbestos exposure is similar for cases and for controls.

Table IV gives the percentage of job periods with asbestos exposure, the duration of exposure and the

TABLE IV. Job Periods Starting During Different Periods of Calendar Time

Time period	Cases		Controls	
Number of job periods and % with asbestos exposure				
Before 1950	343	39.7%	340	14.1%
1950–1970	352	50.3%	281	24.6%
1970–	51	21.6%	76	17.1%
Mean duration of exposure (years)				
Before 1950	6.02		6.14	
1950–1970	10.94		10.04	
1970–	5.85		7.29	
Mean fiber concentration (fibers/ml)				
Before 1950	0.75		0.97	
1950–1970	1.08		0.51	
1970–	0.90		0.33	

Characterisation of job periods according to the percentage with an asbestos exposure, the mean duration of exposure and the estimate of the (arithmetic) mean of the fiber concentration, which is averaged among all shifts with an exposure.

arithmetic mean fiber concentration calculated as five times the GM value. After 1950 the frequency of exposure and fiber concentration, but not the mean duration of exposure, are higher for the cases than for the controls.

Tables V and VI show the number of cases and controls together with the odds ratios (ORs) for 22 of the 32 predefined occupations and for 20 of the 21 predefined industries, where at least five cases or five controls were exposed. Again the percentages of job periods with asbestos exposure and the estimate of the arithmetic mean fiber concentrations during these periods are also presented.

Significantly increased ORs and the highest numbers of mesothelioma cases were observed for the occupation of mechanics, fitters, and plumbers ($n = 62$), and in the industry of engine and vehicle building ($n = 82$).

Asbestos Exposure

We considered years since first exposure, years of duration of exposure, highest intensity of exposure estimated during any period of the working life, and cumulative asbestos exposure as parameters of an occupational asbestos exposure (Table VII). None of these parameters has been adjusted for the effects of the others. Comparing exposed persons to not-exposed ones yields a significantly increased OR for any of the categories of any of these parameters. For each of the parameters, with the exception of time since first exposure, the OR even increases among exposed persons, when the lower intervals of exposure are compared to the higher ones. A steep risk gradient up to $OR = 47$ is observed for the highest intensity of exposure, for years of exposure, and for the cumulative dose estimate. This result does not alter very much by introducing cut-off points 10 or 20 years before the end of observation for the calculation of the cumulative exposure.

Exposure to MMVFs

Table VIII reveals that elevated risks have been found for three intervals of cumulative exposure to MMVFs, although their concentration range is lower, by a factor of 10, than the corresponding range for asbestos exposure (see Table VII). Adjustment for asbestos exposure, however, causes a distinct reduction of the OR and the results are no longer significant. Instead of analyzing on the basis of a dose estimation, an ever/never evaluation may be performed by comparing the first exposure group (0 fiber years = never) to the three upper groups altogether (= ever). In this case the OR remains significant even after adjustment for asbestos.

Additionally, in Table IX exposure estimates and ORs are compared for four different groups of persons with and without exposure to asbestos or MMVFs. A significantly increased OR is registered for cases and

TABLE V. Number of Cases and Controls and Odds Ratio from an Ever/Never Evaluation of 22 of 32 Occupations Where At Least Five Cases or Five Controls were Exposed. Within Each of the Occupations the Job Periods are Characterized by the Percentage of Jobs with an Asbestos Exposure and by the Arithmetic Mean of the Fiber Concentration

Key ^a	Occupation ^a	Cases No.	Controls No.	OR ^b	Jobs periods of cases and controls		
					All periods		Only periods with an asbestos exposure
					% of all n periods	Fiber concentration GM × 5 l/ml	
11,41-43	Farmer	17	25	0.60	92	0	0.00
21-32,	Forestry worker, fisherman,						
44,52	Animal husbandry worker	4	6	0.67	15	13.3	0.10
12,51	Gardener, vineyard worker	2	5	0.40	16	0	0.00
71-91	Miner	6	8	0.75	21	0	0.00
141-150	Chemical processor and related worker	13	11	1.18	48	60.4	1.39
181-184, 501-504	Joiner, wood processing worker	9	8	1.12	79	21.5	0.34
191-252	Metal production and processing worker	26	14	2.09*	81	45.7	0.80
261-306	Mechanician, fitter, plumber	62	21	2.82*	359	72.1	0.79
311-315	Electrician	15	5	3.00*	88	37.5	0.41
391-433	Food production and processing worker	3	5	0.60	47	0	0.00
441-453	Carpenter, bricklayer, roofer	8	10	0.78	96	34.4	0.69
461-472	Road construction worker, pipe layer, well digger, Unskilled construction worker	17	17	1.00	96	15.6	0.73
481-492	Tile setter, plasterer, paviour, upholsterer	11	3	3.67*	30	63.3	2.94
531	Unskilled worker not elsewhere classified	5	8	0.57	19	31.6	0.14
541-549	Stationary engine and heavy equipment operator	19	7	3.40*	41	65.9	0.70
601-635	Technician engineer	19	9	2.25	89	46.1	0.28
681-706	Sales assurance agent	11	26	0.38*	80	3.8	0.06
711-744	Transportation & store worker	48	39	1.32	227	22.9	0.20
751-784	Administrative & organization clerk	34	49	0.57*	201	4.0	0.07
791-805	Protective service worker	59	71	0.56	240	7.5	0.09
861-893	Teacher, scientist, social worker	4	7	0.57	41	14.6	0.10
901-937	Housekeeper, cleaner, hairdresser, bartender	5	7	0.71	28	14.3	0.62

^a A priori defined occupational groups, see [Jöckel et al., 1994, 1998], code according to standard classification of industries [Statistisches Bundesamt, 1975, 1979].

^b Odds ratio matched for age and region of residence.

^c Cases, population controls and control patients.

* $p < 5\%$, two-sided.

controls, which were exclusively exposed to MMVFs, if they are compared to those exposed to neither MMVFs nor asbestos.

DISCUSSION

Retrospective exposure assessment is one of the main problems arising from case-control studies [Finkelstein, 1995; Siemiatycki, 1996, 1997; Benke et al., 1997]. Exposure estimates are often based on job exposure matrices (JEM) where estimates describing probability, frequency, and intensity of exposure are not related to specific persons

but to specific combinations of occupations and industries. Different types of exposures are often estimated side by side [Siemiatycki, 1996; Benke et al., 1997; Cocco, 1999]. The mesothelioma case-control study of Iwatsubo et al., [1998] for example, is based on this concept. In our study, however, the frequency and the upper and lower limits of intensity of exposure to asbestos and MMVFs were estimated semi-quantitatively for the single job periods of individual persons. Other types of fiber-containing materials, such as talc or attapulgite, were considered at least qualitatively. Besides asbestos, MMVF was by far the most frequent cause source of exposure to fibers and it was only for MMVF that

TABLE VI. Number of Cases and Controls and Odds Ratio from an Ever/Never-Evaluation of 20 of 21 Industries Where at least Five Cases or Five Controls were Exposed. Within Each of the Industries the Job Periods are Characterized by the Percentage of Jobs with an Asbestos Exposure and by the Arithmetic Mean of the Fiber Concentration

Key ^a	Industries ^a	Cases No.	Controls No.	OR ^b	Jobs periods of cases and controls		
					All periods	only periods with an asbestos exposure	
					% of all n periods	fiber concentration GM × 5 f/ml	
011-077	Fishing, forestry, farming and horticulture	20	31	0.58	124	1.61	0.10
100-118	Energy and mining	20	11	1.82	61	34.4	1.89
200-205	Chemical and oil industry	13	16	0.79	65	30.8	0.18
210-216	Rubber and plastics	9	7	1.33	36	83.3	1.62
221-227	Stone and glass	15	9	2.00	36	55.6	2.73
230-239	Metal production	20	9	3.20*	72	52.8	0.30
240-249	Engine and vehicle building	82	45	3.18*	351	65.5	1.01
250-259	Electrical and sheet metal	15	10	1.71	61	14.8	0.23
260-269	Paper, wood, and print	11	17	0.57	97	5.2	0.13
270-279	Leather and textile	6	7	0.86	19	10.5	0.65
281-299	Food and tobacco	16	14	1.17	77	2.6	0.06
300-308	Construction	36	36	1.00	232	25.9	0.43
310-316	Installation	27	9	4.00*	92	57.6	0.29
401-439	Trade	11	17	0.63	115	7.0	0.11
511-517	Transportation	36	29	1.33	152	32.9	0.18
551-555	Stock-keeping and shipment	14	12	1.18	74	32.4	0.26
600-657	Financial service and insurance	4	9	0.38	33	3.0	0.18
731-745, 98	Cleaning service, barbershop, house-keeping, waste disposal	4	8	0.50	25	16.0	0.59
751-799, 94, 96	Education, sport, health	11	20	0.53	75	12.0	0.20
811-990	Public service and non-profit organizations	73	80	0.74	352	9.9	0.11

^a A priori defined industries, see [Jöckel et al., 1994, 1998], code according to standard classification of industries [Statistisches Bundesamt, 1975, 1979].

^b Odds ratio matched for age and region of residence.

^c cases, population controls and control patients.

* $p < 5\%$, two-sided.

an increased risk was estimated (Tables VIII, IX). However, exposure to MMVFs is heavily confounded with exposure to asbestos; therefore this result has to be discussed very carefully. First, a critical examination of the study design has to be performed [Siemiatycki and Boffetta, 1998] and in addition, comparisons may be made with results which have previously been obtained for a second series of hospital controls using the same method, and with results of lung tissue fiber analysis [Woitowitz et al., 1993; Rödelsperger, 1996; Rödelsperger et al., 1999].

Selection Bias

It has been argued that the diagnosis of mesothelioma may be made more probable if asbestos exposure is evident

[Siemiatycki and Boffetta, 1998]. This diagnostic bias would increase the risk estimate for asbestos. In our study a panel of pathologists was installed to exclude diagnostic errors. Each diagnosis obtained by the pathologist of a participating hospital had to be confirmed by a member of this panel. The whole panel was then included in the decision for 24% of the diagnoses, where the decisions were discrepant. A total of 15% of the cases considered was discarded (5% in agreement between the two pathologists and 10% by a panel decision).

Selection bias for the selection of population controls is minimized by the matching procedure. In contrast, many of the hospital controls of our previous study suffered from lung cancer [Woitowitz et al., 1993], which is well known to be caused by asbestos.

TABLE VII. Odds Ratios for the Relationship between Mesothelioma and Asbestos Exposure Together with the Number of Cases and Controls According to Different Parameters of the Asbestos Exposure

	125 Cases	125 Controls	Odds ratio ^a	95%-CI
Time since first exposure (years)				
not exposed	11	67	1	
≤30	12	4	22.5	4.3-119
>30-40	40	22	18.9	5.3-67.3
>40	62	32	19.6	5.7-67.2
Duration of exposure (years)				
not exposed	11	67	1	
>0-10	24	21	10.4	2.9-37.1
>10-20	22	14	16.5	4.1-65.6
>20-30	19	8	27.7	5.8-132
>30	49	15	43.7	10.8-177
Highest intensity of exposure^b				
not exposed	11	67	1	
low	14	12	9.2	2.3-35.9
medium	37	25	17.9	5.0-64.4
high	63	21	46.3	12.1-178
Cumulative exposure up to end of observation (fiber years)				
not exposed	11	67	1	
>0-0.15	14	12	7.9	2.1-30.0
>0.15-1.5	38	25	21.9	5.7-83.8
>1.5-15	46	16	47.1	11.5-193
>15	16	5	45.4	8.1-257
Cumulative exposure up to 10 years before end of observation				
not exposed	11	67	1	
>0-0.15	15	13	7.9	2.1-29.5
>0.15-1.5	39	24	24.0	6.2-93.0
>1.5-15	45	16	51.8	12.4-216
>15	15	5	42.6	7.3-249
Cumulative exposure up to 20 years before end of observation				
not exposed	14	68	1	
>0-0.15	15	13	9.2	2.4-35.0
>0.15-1.5	44	24	20.5	5.8-72.6
>1.5-15	40	16	32.2	8.5-122
>15	12	4	43.8	7.1-269

^aOdds ratio matched for age and region of residence.^b"Low" (<0.1 fibers/ml), "High" (>1 fiber/ml) or "medium" (otherwise) according to five times the geometric mean fiber concentration given in Table III.

Information Bias

Information bias may be caused by the different situation of the interview for mesothelioma patients compared to that for the healthy reference population [Siemiatycki and Boffetta, 1998]. In the total for our population controls it is likely that there will be a great deal of information bias increasing the risk estimate while selection bias ought to be

low. This may lead to an overestimate. In contrast, the interview situation should be comparable both for the cases and for the hospital controls of the previous study, who have been treated by pulmonary resection. Hence, information bias, which may increase the risk estimate, should be low, while selection bias, which is expected to decrease the risk, should be high. The overall result might be to underestimate the risk. In order to reduce this type of bias, biographical

TABLE VIII. Odds Ratios and Number of Cases and Controls in Males and Exposure to MMVF

Geometric mean × 5 (fiber years)	Cases	Controls	Odds ratio ^a	95%-CI	Odds ratio ^b	95%-CI
never = 0	70	111	1.00	—	1.00	—
>0–0.015	10	6	2.96	0.92–9.57	0.78	0.16–3.77
>0.015–0.15	11	4	4.19*	1.17–15.00	3.11	0.56–17.2
>0.15–1.5	20	1	26.28*	3.39–203.75	7.95	0.88–72.3
>1.5	14	3	6.50*	1.47–28.80	5.43	0.72–41.0
ever >0	55	14	6.12*	2.90–12.93	3.08*	1.17–8.07

^aOdds ratio matched for age and region of residence.

^bOdds ratio adjusted for asbestos fiber years by means of four indicator variables, as defined in Table III.

*p < 5%, two-sided.

history of all job periods was obtained in a first step, then a check list of asbestos and other fibrous products, including brand names, working processes and photos, was presented in a second step, but only minor additions were obtained.

Exposure Assessment Bias

An underestimate of the higher past exposure levels may be caused by information bias or even by change in the methods of fiber counting [Doll and Peto, 1985; Siemiatycki and Boffetta, 1998]. A magnification of the dose–response relationship may result. On the other hand, random errors as a result of misclassification of exposure usually bias the risk toward null value (no association) [Armstrong, 1998].

In Table IV, where exposure estimates of exposure to asbestos for different time periods are presented, the percentage of jobs with asbestos exposure, the mean duration of exposure, and fiber concentration for cases is higher between 1950 and 1970 than in the time periods before and afterwards. This pattern, apart from the fiber concentra-

tion, is similar for population controls. A similar pattern in time was observed in the French mesothelioma case–control study [Iwatsubo et al., 1998]. In this study the highest rate of job periods with asbestos exposure also was observed between 1950 and 1970, but the percentage of about 38% in cases and 20% in controls lies below the German results. In contrast, the prevalence of exposure is higher in France from 1970. This observation might be explained by the restrictions in the use of asbestos, which were introduced in Germany at the end of the 1970s.

In our study quantitative estimates may be subject to error by using only one common duration of exposure in job periods where asbestos and MMVFs were used side by side. For job periods with exposure to asbestos the percentage for an additional exposure to MMVFs was only 22% in cases and 9% in controls. In periods with an exposure to MMVFs the percentage of an additional asbestos exposure was 85% in cases and 67% in controls. Hence, an overestimate must be expected, particularly for the cumulative exposure to MMVFs.

TABLE IX. Exposure to Asbestos and MMVF in Males. Estimate of MMVF and Asbestos Fiber Dose, Numbers of Cases and Controls and Odds Ratio

Exposure	Mean fiber years	125 Cases	125 Controls	Odds ratio ^a	95%-CI
MMVF –	0	9	65	1.00	—
Asbestos –	0				
MMVF+	0.6	2	2	15.1*	1.05–218
Asbestos –	0				
MMVF –	0	61	46	19.8*	4.7–83
Asbestos +	7.1				
MMVF +	2.4	53	12	61.3*	12.9–292
Asbestos +	16.2				

^aOdds ratio matched for age and region of residence.

*p < 5%, two-sided

Error of the Expert Estimate of the Exposure to Asbestos

According to Table III the factor between the GM value of fiber concentration per shift and the upper and lower limits, respectively, of the exposure category which corresponds to this GM value may vary between 2.2 (No.9), and 20 (No.4) with weighted mean values of 6.4 for cases and 5.5 for controls. This expert estimate of the range of uncertainty largely describes the random error for single job periods. The mean bias for the exposure estimates of all job periods should lie below these factors. A similar but lower uncertainty results from classifying the number of working shifts with exposure to asbestos into only three categories where the highest category, e.g., even everyday exposure which is registered as "more than once per week," only contributes half of the working days of a year.

For a single job period the cumulative exposure to asbestos is obtained by the years of duration of exposure normally multiplied with the arithmetic mean values (AM) of fiber concentration per shift and the rate of working shifts with the exposure. Here AM amounts to half the sum of the lower and the upper limit of the expert estimate and therefore, an upper limit much higher than the lower limit would yield an AM which is roughly half the upper limit. A better description of the range of uncertainty is obtained using the GM, but GM values are systematically lower than AM values. The AM of fiber concentration is estimated five times the GM in order to compensate this bias, which results from the uncertainties of the estimate of the fiber concentration (factor 3) and of the frequency of asbestos exposure (factor 1.5). The weighed average of the AM values for all jobs with exposure to asbestos is 0.93 f/ml for the cases while it is 0.66 f/ml for the controls (Table III).

Consistency Between Exposure and Risk Estimates

OR significantly increases (Table VII) for each of the three parameters of cumulative exposure even within the first exposure interval $> 0 - \leq 0.15$ fiber years. Exceptional behavior is observed for the time after first exposure. Here the OR remains constant, although a steep relationship should exist for this parameter. However, this discrepancy may be explained from study design: Controls were matched to cases with respect to the year of birth. There is a good correlation between cases and controls for the age and the time of first exposure.

In Tables V and VI, the percentage of job periods with asbestos exposure and the concentration estimate as parameters of exposure are compared to the OR. The correlation is better with the percentage of job periods with an asbestos exposure ($R=0.810$ for occupations and $R=0.769$ for industries, both $P < 0.001$) than with mean fiber concentra-

tion ($R=0.765$, $P < 0.001$ and $R=0.524$, $P=0.018$). The most distinct discrepancy appears between the installation and the stone and glass industries. For the former, the highest OR of 4 (statistically significant) is associated with a small average concentration of 0.29 f/ml. For the latter, an OR of 2 (not significant) is associated with the highest concentration estimate of 2.7 f/ml.

In the "installation industry" a total of 56 job periods of 27 cases and 21 job periods of nine controls was observed. They worked as tin smith or plumber (12 cases and 2 controls), carried out heating installation (5 cases and 3 controls), air conditioning installation (2 cases and 1 control) or worked as electrician (4 cases and 2 controls) or, interior designer or painter (4 cases and 1 control). In this industry working procedures were distributed homogeneously among cases and controls and, therefore, estimates of asbestos exposure were similar for both of them. The low exposure estimates are reliable since exposure mainly resulted from pipe insulation with asbestos, asbestos cement, welding protection, and sealing.

In the "glass and stone" industries a total of only 27 job periods of 15 cases and nine controls was observed. Nine cases but only one control ($P=0.02$) worked as insulators and definitely used asbestos in most periods; three times this was spray asbestos. One further case had mined asbestos in the Urals as a prisoner of war and two others had worked in the asbestos industry. The latter is also true for one control but he mainly worked inside the office as a designer. One of the remaining three cases was a boilerman in a glass factory. The other two worked as locksmiths in the cement industry. In contrast, the seven remaining controls worked in quarries ($n=4$) and in concrete production ($n=3$). The work periods of cases and controls are very obviously different in the "glass and stone" industry. While the high exposure estimate is convincingly justified by the work place descriptions of the cases, the OR is reduced by a large number of controls with places of work where a much lower degree of asbestos exposure should be expected.

Comparison with Lung Tissue Fiber Analysis

The fiber burden of the pulmonary tissue has been analyzed for a total of 66 cases (60 male and 6 female) and 66 hospital controls (primarily lung cancer cases) of the original study, among them 27 cases and 39 controls are from Hamburg as reported elsewhere [Rödelsperger, 1996; Rödelsperger et al., 1999]. The dose estimates for these cases on the average (AM) are 1.7 times higher, than for the cases from the present study. A subsample of 20 male cases was included in both studies, among them was the one with the highest exposure estimate of 167 fiber years.

For the patients of the lung tissue study, cumulative asbestos exposure, as derived from the interview, correlates with the concentration of asbestos fibers longer than 5 μm in

the lung tissue for amphibole ($R = 0.44$, $P < 0.001$), but not for chrysotile fibers [Rödelsperger, 1996]. Regression analysis reveals that a fiber dose of one fiber year roughly corresponds to a concentration of 80,000 amphibole fibers longer than 5 μm per gram dry lung tissue (g dry). This relationship is in good agreement with other estimates [Consensus Report, 1997].

A clear dose-response relationship could be observed between the concentration of these long amphibole fibers and the risk of mesothelioma [Rödelsperger and Woitowitz, 1995; Rödelsperger et al., 1999]. An OR of almost 100 was obtained from the almost linear relationship, when 10 of 66 cases (15%) in the reference interval $< 50,000$ fibers/g dry were compared to 29 of 66 cases (44%) in the uppermost interval $\geq 500,000$ fibers/g dry.

Correspondingly, from the present study (Table VII) an OR of about 45 is observed, if the 11 cases (9%) of the reference interval (0 fiber years) are compared to the 62 cases (50%) of the two uppermost intervals ≥ 1.5 fiber years.

Within these uppermost exposure intervals the average dose estimate combined for cases and controls amounts to 25 fiber years for the lung burden study and to 16 fiber years for the interview study. Obviously, the results of both studies are very similar. This is true, though the OR of the lung burden study should be reduced in comparison to the present study because of the choice of hospital controls instead of population controls. On the other hand, the diminution of the OR by random error may be much stronger for the interview study.

Comparison With Other Case-Control Studies

In this study some 91% of the cases compared to 54% of the controls were occupationally exposed to asbestos (Table VII). Since only male individuals from Hamburg were included, the results are not representative for the German population as a whole. For example, higher exposure to asbestos can be expected in Hamburg due to shipyards and asbestos-processing industries [Hain and Dalquen, 1974]. The rates correspond to the upper limits of the ranges of 12–95% for mesothelioma cases and 2–48% for controls, which have been reported from international mesothelioma case-control studies [Brochard et al., 1993].

Iwatsubo et al. [1998] observed a pattern very similar to the results of Table VII for the different parameters of exposure, but in the uppermost intervals OR generally only reached 5 to 9 compared to about 45 in the German study. Again the OR remained almost constant for the time since first exposure. Its value is 2.2–2.8 in the French and 18.9–22.5 in the German study. The percentage of cases exposed is much higher for the German study (91% compared to 71%). In contrast, the rate of exposure among the German

population controls is somewhat lower than for the French hospital controls (46% compared to 51%).

The ORs observed in our study fully support the well-established epidemiologic evidence for the carcinogenicity of asbestos with respect to mesothelioma. However, due to the low number of pairs with exposed controls and non-exposed cases, the absolute magnitude of the OR should be regarded with caution: the maximum OR decreased from about 100 in the original study [Woitowitz et al., 1993] to 45 in the present paper when the definition for “not exposed to asbestos” slightly was altered from “ < 0.015 fiber years” to “0 fiber years” according to Iwatsubo et al., [1998]. According to Table VII the latter reference category contained 11 cases and 67 controls, among them eight pairs. The three remaining cases formed pairs with exposed controls.

Furthermore, if our results obtained for 125 population controls are compared to the results obtained for 125 additionally available hospital controls consisting primarily of lung cancer patients [Woitowitz et al., 1993], the maximum OR decreases from 100 to about 10. If, however, the matching is broken and a *stratified unconditional logistic regression* is applied the maximum OR decreases to 17 for the population controls while it remains almost constant for the hospital controls (OR = 9.4 in the maximum). A clear dose-response relationship is obtained even for these hospital controls and even for an exposure “ > 0.15 – 1.5 fiber years” there is a significantly increased OR of 3.2 (95% CI: 1.7–6.1).

Asbestos Fibers and MMVFs

The estimate of the exposure to MMVFs is only about 10% of the exposure estimated for asbestos (Table IX) and, in addition, the effect of MMVF is greatly affected by this exposure. By adjusting for asbestos, a significantly increased OR only remains in the ever/never evaluation, which does not depend on the dose estimate (Table VIII). Considering the two cases and two controls, who were only exposed to MMVF but not to asbestos yield a significantly increased OR of 15.1 (Table IX). Despite the difference in fiber years the risk estimate is very similar for those exposed to asbestos alone. Therefore, MMVF even might be more hazardous than asbestos. However, this conclusion is severely hampered by the problems of estimation of exposure, which influence both the adjustment for asbestos exposure and the definition of non-exposed. In addition, the type of asbestos—chrysotile or amphibole—is unknown in spite of its well-known importance [Rödelsperger et al., 1999]. Further difficulties arise from the small sample size in cells with differing exposure with respect to either agent. Accordingly in the original report [Woitowitz et al. 1993], restriction to cases and controls without exposure to asbestos did not yield an increased OR since—as was discussed in the last section—the definition of the reference category was “ < 0.015 fiber years” instead of “0 fiber

years." Therefore, in agreement with other studies, there is insufficient evidence to establish a causal relationship between the exposure to MMVF and mesothelioma. Nevertheless, even those studies, which do not show significantly increased incidence of mesothelioma, cannot exclude the possibility MMVF being carcinogenic with sufficient precision [Doll, 1987; Simonato et al., 1987; Marsh et al., 1990; Marsh et al., 1996; Boffetta et al., 1997].

In agreement with other studies [McDonald et al., 1990], our lung burden study did not reveal increased concentrations of MMVF, even after heavy exposure to glass or rock wool [Rödelsperger, 1996; Rödelsperger et al., 1998]. Yet, as for chrysotile, it cannot be excluded that these fibers may have caused a tumor, even if they are not present in lung tissue, when it is diagnosed [Baker, 1991; Weitowitz et al., 1991].

CONCLUSIONS

For all measures of asbestos exposure the OR increases significantly up to about 45 in the uppermost intervals. Even within the first exposure interval "> 0-≤ 0.15 fiber years" the OR significantly increases. This relationship may be influenced by information bias, exposure assessment bias, and the random error. Nevertheless, a stratified analysis, where matching is broken, and a further series of hospital controls yields a lower but still substantial OR.

The OR estimate shows a plausible relationship to the estimate of fiber concentration and to the percentages of jobs with asbestos exposure for different occupations and industries. The highest numbers of mesothelioma together with a significantly increased OR are found in "mechanics, fitters and plumbers" and for the "engine- and vehicle-building" industry. Discrepancies appear between the "glass and stone", and the "installation" industry since OR is reduced for the latter despite a much higher concentration estimate. This may be explained by a substantial difference in the type of exposure of cases and controls in this industry.

Although exposure to MMVF is much lower than the exposure to asbestos, an increased OR is observed in an ever/never evaluation. It even remains significant, if confounding by asbestos is considered by adjustment or if evaluation is restricted to cases and controls without any exposure to asbestos. However, when considering the problems of dose estimation and the sample size, a causal relationship can neither be proven nor excluded.

A further case-control analysis, based on lung tissue fiber concentrations in addition to the interview, yields similar ORs, if reference intervals and uppermost exposure intervals contain similar percentages of all cases. These results confirm the distinct dose-response relationship of the interview study even at a cumulative exposure below 1 fiber year. They clearly support the outcome of the French mesothelioma case-control study.

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