The rapid development of the drywall construction trade in the United States is described. It is estimated that some 75,000 U.S. construction workers are currently employed in this trade. The use of a variety of spackle and taping compounds is shown to be associated with significant asbestos exposure; air samples taken in the breathing zone of drywall tapers during sanding of taping compounds show fiber concentrations exceeding, by several times, the maximum level permitted by United States Government regulations. These findings are given together with the result of a clinical field survey of drywall construction workers demonstrating that asbestos disease may be an important health hazard in this trade.

Drywall construction and asbestos exposure

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introduction

The introduction of new industrial processes widens the range of possible occupational health hazards. During the past two decades, drywall construction has achieved an important place in the United States construction industry. In such construction, taping of joints is required, i.e. applying and finishing spackle material at wallboard joints. Spackling and drywall taping compounds consist of extremely fine-grained white powders or pre-mixed pastes. Analyses of samples of spackling, patching and jointing compounds have shown that plaster of Paris is frequently a major constituent but that quartz, talc, micas, clays and ground limestone may occur in many formulations. More significantly perhaps, it has been shown that some compounds contain asbestos minerals, added as reinforcing agents. Either chrysotile or amphibole asbestos, or both, have been found in 13 out of 15 industrial products; analysis of spackle compounds, which are used in home repair work, has demonstrated that they also frequently contain from 5 to 12% by weight of asbestos minerals, as well as quartz.[1]

history and terminology

The history of the drywall industry in the United States began at the end of World War II. Returning servicemen and their families needed living places rapidly and inexpensively. Drywall construction would very soon replace lathing and plastering. While the plasterer had to perform his work alone, the drywall tapers were able to synchronize their work with that of carpenters, electricians, plumbers and other building trades, greatly reducing construction time. Low cost housing went into mass production in 1947-1948; wallboard sections were soon manufactured to fit standard room dimensions, enabling a worker to construct living quarters within a few hours. Drywall construction was also considered superior because of its adaptation to soundproofing and fire codes. The tapers were to be called "drywal workers" as opposed to plasterers or "wet wall workers." Initially part of the International Brotherhood of Painters and Allied Trades local unions, workers engaged in this new trade tended to be separately defined in the 1960's and local union groups of drywall tapers and painters were constituted with currently a total of some 3,500 members. Furthermore, it is estimated that some 75,000 other construction workers were currently employed in this trade in the United States, but are not in defined local unions of tapers. (In addition, carpenters, electricians, and plumbers may work in the vicinity of ongoing drywall construction.)

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Figure 1 — Pole sanding of drywall taping compounds. Several applications of taping compounds may be required to make a smooth join between gypsum wall boards, requiring extensive sanding.

work procedures

Work performed by tapers may be associated with significant asbestos exposure. Tapers spend approximately 5-10% of their working time sanding dried spackle and thus may experience intermittent asbestos exposure. Significant exposure may also occur among painters who occasionally apply or sand spackle and taping compounds.

mixing

Prior to applying the spackle material at the wall board joints, the compound is prepared in the following way: Half of a 25 lb. bag of drywall taping compound is poured into a 5 gallon bucket containing about 2 gallons of water. The mixture is stirred until it has obtained a desired degree of consistency, whereupon the remainder of the dry mix is added. The mixture is again stirred. This operation takes approximately 60-90 seconds. Until pre-mix material came into use in approximately 1975, the mixing was done several times a day.

sanding

After the taping compound has been applied at the wallboard joint and has dried, the surface is sanded. Two different sanding techniques have been used:

pole sanding

This is the most common method at present. The apparatus used consists of a 5-foot pole with a steel plate to which a piece of sandpaper is attached (Figure 1).

hand sanding

This technique is preferred to pole sanding by some tapers, since it allows better visual and manual control. Hand sanding is also required in those situations in which the space relationships prevent the taper from using pole sanding.

analysis of materials

Analysis of taping compounds and spackle materials indicate that a number of biologically active minerals are to be found. The compounds that have been analyzed by x-ray powder diffraction, optical and electron microscopy include both dry and paste types. Of 15 industrial drywall taping and spackling compounds, 13 contained asbestos (Table I). In addition, three compounds contained two different types of asbestos, namely chrysotile and tremolite. Quartz, and other silicates were also present in some other compounds. The results of these analyses showed that most of the taping compounds used in the United States construction industry contained asbestos in the order of 4-5%. One compound contained 10-15% chrysotile and 8-12% tremolite.

personal air sampling during drywall taping

A series of dust counts showed that asbestos fiber concentration may be considerable. Table II shows fiber concentrations experienced during pole and hand sanding of drywall taping compounds. Air samples taken in the breathing zone of the drywall tapers during sanding of wall board taping showed that fiber concentrations often exceeded, by several times, the maximum level permitted by United States government

TABLE I
Mineral Content of Fifteen Industrial Drywall Taping and Spackling Compounds

Mineral Phase	Sample Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Chrysotile	6-8%	5-10%		6-8%	5-10%	5-12%	5-10%	5-10%	5-10%	5-10%		5-8%	10-15%		8-12%
Tremolite	4-7%											4-7%	8-12%	2-3%	
Talc		‡	+									‡	‡	‡	+
Quartz	+	‡	+	‡	‡	‡					‡			‡	
Mica	‡	‡		+	‡	‡	‡	‡	‡	‡		‡	‡	‡	‡
Kaolinite		+			+	‡	+	+	+	+		+		+	
Calcite	+						‡		+	‡	‡	‡	‡	‡	+
Dolomite	‡						‡	‡		‡	+				
Plaster of Paris (bassanite)		‡	‡	‡	‡	‡			‡						

Major constituents are indicated by ‡; minor constituents by +; weight percentages of asbestos minerals (chrysotile and tremolite) were determined by step-scanning x-ray diffraction.

regulations. Measurements were made utilizing the standard techniques of the National Institute of Occupational Safety and Health (NIOSH) for asbestos sampling and analysis.

During pole sanding, 7 out of 10 samples exceeded the then existing threshold limit value (TLV) of 5 fibers/cm^3 longer than 5 μm. (The TLV has since been reduced to 2 fibers/cm^3, longer than 5 μm). Hand sanding generated fiber concentrations close to or in excess of the TLV. It may be emphasized that the asbestos fiber concentrations generated by sanding were similar to those measured in the work environment of asbestos insulation workers. Mixing of drywall taping compounds, a procedure which is currently not frequently used, generated fiber counts 7-10X the threshold limit values. Moreover, the data in Table II show that, at various distances from the actual taping operations, detectable fiber concentrations are present in adjacent rooms during the various procedures. Other building trades would thus also be exposed. It should be emphasized that the fiber concentrations measured by standard procedures using optical microscopy reflect only a small proportion of the number of fibers actually present since they fail to detail fibers shorter than 5 μm in length and 0.5 μm in width. However, electron microscopic analyses of these air samples showed a large number of these smaller fibers too fine to be seen by optical microscopy (Figure 2). The disease-inducing potential of such fibers may be significant.

prevalence of asbestos disease among taping workers

A clinical field survey of 114 taping workers, employed in the New York Metropolitan area, was conducted. Examination included a careful life-time occupational history with recording of all previous occupations on a specially designed questionnaire. Interview also included passed medical history, smoking history and review of chest symptoms, such as chronic bronchitis, dyspnea and cyanosis. Chronic bronchitis was recorded as present if the individual gave a history of phlegm production for more than three months per year during a period of two years or longer. Each individual had a comprehensive physical examination with

TABLE II
Asbestos Fiber Levels During Use of Taping Compounds Containing Asbestos Minerals

Operations	Number of samples	Mean fiber concentration (fibers/cm³)	Range of fiber concentrations (fibers/cm³)
Pole sanding (3-5 ft.)	10	10.0	1.2-19.3
Background (8 ft.) same room	3	8.6	3.5-19.8
Background (25 ft.) adjacent room	2	4.8	0.7- 8.8
Hand sanding (3-5 ft.)	11	5.3	1.3-16.9
Background (8 ft.) same room	2	2.3	2.1- 2.5
Background (15 ft.) adjacent room	2	4.3	1.5- 7.1
Dry mixing (3-5 ft.)	2	47.2	35.4-59.0
Background (10-20 ft.) same room	3	5.8	0.5-13.1
Background (16-35 ft.) adjacent room	2	2.6	2.1- 3.1
Sweeping floor (10-50 ft.) 15 minutes after sweeping	1	41.4	
35 minutes after sweeping	1	26.4	

special emphasis on examination of the chest. Standard 14" × 17" chest roentgenograms were taken; both PA and oblique projections were taken; interpretation of chest films was done by a panel of 5 experienced readers, and a consensus reading was thereafter obtained.

Readings were classified according to the ILO U/C International Classification of Radiographs of Pneumoconioses, and a reading was considered abnormal if fine or moderately thin irregular opacities were present (s or t $\geq$ 1/0) and/or pleural thickening was present ($\geq$ a-1).

The age distribution of the examined workers is shown in Table III. Only 17 (15%) were less than 30 years of age, while 75 workers (66%) were between 30 and 49 years. Many young workers had been in the taping trade for several years; Table IV illustrates the distribution of duration since onset of taping. The majority of the workers had a long history in the trade; for 67 individuals (59%), 15 years or more had passed since the onset of occupational exposure to taping compounds, while 19 workers (17%) had begun exposure 10 years prior to the examination or later.

TABLE III
Age Distribution of 114 Drywall Tapers

Age	Number	Percent
< 30	17	14.9
30 - 39	31	27.2
40 - 49	44	38.6
50 - 59	15	13.2
60 +	7	6.1
Total	114	100.0

TABLE IV
Duration Since Onset of Exposure of 114 Drywall Tapers

Years since onset of exposure	Number	Percent
0 - 9	19	16.7
10 - 14	28	24.6
15 - 19	31	27.1
20 - 24	26	22.8
25 -	10	8.8
Total	114	100.0

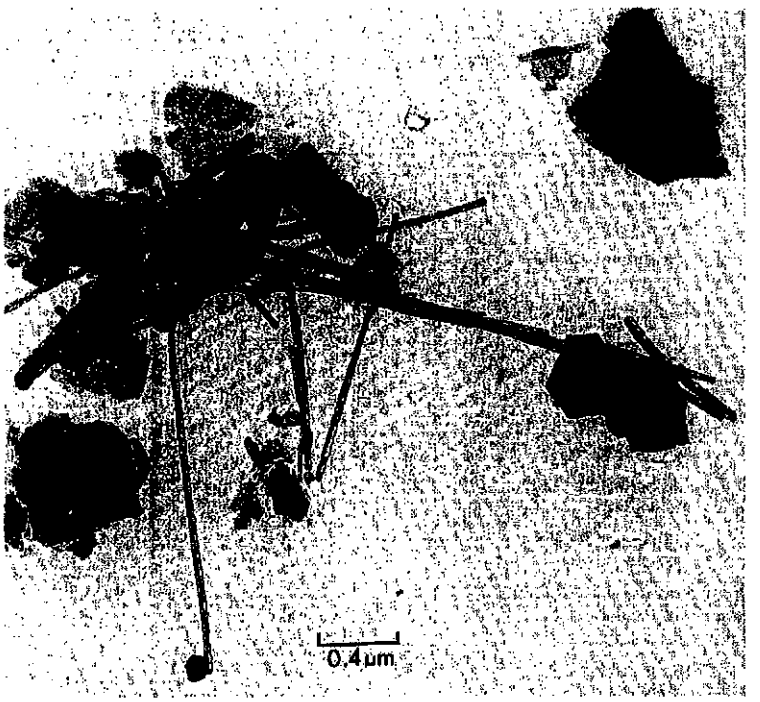

Figure 2 — Electron photomicrograph of air sample taken during sanding of taping compound. Numerous chrysotile fibers are visible, most of which are shorter than 1 micrometer. They would not be visible by optical microscopy. Granular particles are micas, clays and plaster of Paris.

There were 79 smokers (69%), 13 non-smokers (11%) and 22 ex-smokers (19%) among the examined workers. Chronic bronchitis was reported by 25 individuals (22%), all of whom were heavy smokers. 10 workers (9%) gave a history of dyspnea on exertion, 9 of whom were heavy smokers; one was an ex-smoker. Chest examination revealed dry rales in 10 individuals (9%), 7 of whom were smokers and 3 of whom were ex-smokers. 6 of these, however, had a positive chest x-ray for parenchymal disease; none had any visible pleural abnormality.

Rhonchi were found in 15 workers (13%), 14 of whom were smokers. 5 of these showed parenchymal disease on x-ray, while 2 had pleural thickening.

The roentgenographic abnormalities among the examined workers are shown in Tables V and VI. The prevalence of abnormal chest films increased with longer duration since onset of exposure; among those with 10 years from onset of exposure or less, 26% had positive roentgenographic signs (≥ S, 1/0); this prevalence increased to a high of 51% among

TABLE V
Roentgenorgraphic Abnormalities (Parenchymal) Among 110 Drywall Tapers

Years since onset of exposure	Total number examined	Abnormal x-ray (>S, 1/0)	
		Number	Percent
0 - 9	19	5	26.3
10 - 19	56	22	39.3
20 +	35	18	51.4
Total	110	45	

TABLE VI
Pleural X-ray Abnormalities Among 109 Drywall Tapers

Duration (years)	Total number examined	Number of abnormalities	% abnormal of group
0 - 9	34	0	0.0
10 - 19	50	4	8.0
20 -	35	5	14.3
Total	109	9	8.3

tapers with 20 years or longer since onset of exposure.

Pleural thickening was found in 9 (8%) of the examine workers, 5 of whom had concomitant parenchymal abnormalities. All individuals with pleural thickening had a history of long duration since onset of taping; the mean duration since onset was 19.1 years (range 13-22), (Table VII).

discussion

The identification of asbestos in drywall spackling and taping compounds and the considerable prevalence of asbestosis among those who use these materials have added a new occupational health perspective to industrial drywall construction, a trade that is of growing importance in the United States and throughout the world. In fact, the prevalence of asbestosis in this population of drywall tapers is similar to that found by others among asbestos insulation workers.[2] In these studies, evidence of pulmonary asbestosis was present in 542 of 1,117 examined workers, i.e. in 48.5% (having radiological change as sole criteria); this is to be compared with the present study, which demonstrated a prevalence of 40.9%. It is of considerable importance to emphasize the inadequacy inherent in the standard NIOSH procedure for determining asbestos exposures which uses optical microscopy alone. Electron microscopic examination of air samples shows a large number f fibers too fine to be seen by optical microscopy, but which nevertheless may cause disease. Analysis of the lung of a taping worker who suffered from lung cancer, showed very large numbers of fibers, all too small and fine to be seen with the optical microscope. This has been reported elsewhere.[3]

conclusion

We have found that taping workers in drywall construction have risk of exposure to asbestos. Our findings suggest that asbestos disease, as a result, is an important hazard in this trade. It is therefore important and urgent that appropriate measures be taken in order to prevent further asbestos exposure. The availability of asbestos-free taping compounds would be an important step toward this objective. Despite this, however, asbestos-related disease will inevitably be seen in taping workers in the future since asbestos-free materials were not widely introduced into the trade until very recently, and the result of past exposure will be with us for some decades in the future. The question of appropriate long-term surveillance is important and unresolved.

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