

Issues on Asbestos Analytical Method for Asbestos-Containing Materials in Japan

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Ordinance on Prevention of Hazard due to Asbestos

2006 JIS A 1481

Determination of asbestos in building material products

2008 JIS A 1481 revision

JIS A 1481

Determination of asbestos in building material products

A. Qualitative analysis

1. Preparation of sample

Removal matrix by Ashing and preparation of powdered sample (through a 425-500um sieve)

2. Qualitative analysis

XRD (X-ray diffraction method)

3. Qualitative analysis

DS-PCM (dispersion staining phase contrast microscope method)

B. Qualitative analysis

1. Qualitative analysis by a X-ray diffraction method

ISO/DIS 22262-1

Sampling and qualitative determination of asbestos in commercial bulk materials.

A. Qualitative analysis

1. Preparation of sample

Removal matrix by ashing, acid treatment, flotation or gravimetric procedures.

2. Stereomicroscope examination

Detect small fiber bundles and select samples for PLM examination

3. PLM examination

Identify samples by PLM (morphology, colour and pleochroism, birefringence, extinction characteristics, sign of elongation and refractive indices).

| | Japan JIS A 1481 | U.S. EPA/600/R-93/116 | U.K. HSG248 | ISO ISO/DIS 22262-1 |
|----------------------------------|--|---|--|---|
| Analytical methods (instruments) | XRD, DS-PCM, (Extinction angle method by PLM) | Stereomicroscope, PLM, Gravimetry, XRD, Analytical electron microscope | Stereomicroscope, PLM, additionally SEM and TEM | |
| Definition of asbestos | Fibrous silicate minerals belonging to serpentine group (chrysotile) and amphibole group (amosite, crocidolite, tremolite, actinolite, and anthophyllite) among the minerals, which constitute rock. (P.1) | A commercial term applied to the asbestiform varieties of six different minerals. The asbestos types are chrysotile (asbestiform serpentine), amosite (asbestiform grunerite), crocidolite (asbestiform riebeckite), and asbestiform anthophyllite, asbestiform tremolite, and asbestiform actinolite...(Appendix A-1) | Any of minerals chrysotile, crocidolite, amosite, fibrous anthophyllite, fibrous actinolite or fibrous toremolite. (P.81) However, the asbestos regulations only apply to the asbestos form of the minerals. (P.89) | A term applied to a group of silicate minerals belonging to the serpentine and amphibole groups which have crystallized in the asbestiform habit, causing them to be easily separated into long, thin, flexible, strong fibers when crushed or processed. (P.3) |
| Morphological definition | Fibrous particles: Particles that are three or more in aspect ratio (length/width). (P.2) | Asbestiform: A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility. Morphology: In the light microscope, the asbestiform habit is generally recognized by the following characteristics: (a) The presence of fibre aspect ratios in the range of 20:1 to 100:1 or higher for fibres longer than 5 μ m; (b) The capability of longitudinal splitting into very thin fibrils, generally less than 0.5 μ m in width. In addition, observation of any of the following characteristics for the fibre type under consideration provides additional confirmation that the fibres are asbestiform: - Parallel fibres occurring in bundles; - Fibre bundles displaying splayed ends; - Fibres in the form of thin needles; - Matted masses of individual fibres, and/ or; - Fibres showing curvature. (ISO: P.19) | | |

XRD: X-ray diffraction method, DS-PCM: Dispersion staining phase contrast microscope, PLM: Polarized light microscope
SEM: Scanning electron microscope, TEM: Transmission electron microscope

Table.1 Comparison of asbestos analysis method in bulk materials between Japan, U.S, U.K. and ISO

Differences between JIS and ISO

| | Methods | Definition of asbestos | Morphological definition |
|----------------|--------------------------|--|--|
| JIS | XRD and DS-PCM | Fibrous silicate minerals belonging to serpentine group (chrysotile) and amphibole group | 3 or more in aspect ratio |
| ISO,EPA,HSE... | Stereomicroscope and PLM | A group of silicate minerals belonging to the serpentine and amphibole groups which have crystallized in the asbestiform habit | The presence of fibre aspect ratios in the range of 20:1 to 100:1 or higher for fibres longer than 5 μm ... |

Table.1 Comparison of asbestos analysis method in bulk materials between JIS and ISO

What is “asbestiform”?

or

What is the source of “aspect ratio 3”?

The term of “asbestiform” has been used since the beginning of 20th century.

Highly developed fibrous: asbestiform

The fibrous structure may be due to an abnormal development of the cleavage...

Stephen Taber, The origin of veins of the asbestiform minerals, National academy sciences 1916, 2, 659

The counting rule of asbestos was established at the ARC: Asbestosis Research Council 4th meeting on 30 September 1958.

Dust counting rule would be reported for asbestos fibres only in the size range 5-100um, a fibre being defined as a particle whose length was at least three times greater than its width.

W. H. Walton, The nature, hazards and assessment of occupational exposure to airborne asbestos, Ann. Occup. Hyg. 1986, 25, 117.

But the counting rule of asbestos did not have clear scientific reason.

...the definition of of a fiber being arbitrarily taken as a particle whose length was at least three times its diameter .

S. Holmes, Development in dust sampling and counting techniques in the asbestos industry, Ann. NY. Acad. Sci. 1965, 132, 288.

However the counting rule had little scientific basis, it became popular worldwide. It was applied into the first regulation of asbestos by NIOSH and OSHA in 1972. But...

...the choice of a 3:1 aspect ratio as the definition of a fiber is an unfortunate one.

A. G. Wylie, Fiber length and aspect ratio of some selected asbestos samples, Ann. NY. Acad. Sci. 1979, 330, 605.

One of the most unfortunate of such decision was related to asbestos .

T. Zoltai, Asbestiform and acicular mineral fragments, Ann. NY. Acad. Sci. 1979, 330, 621.

The morphological definition of asbestos should be ASBESTIFORM.

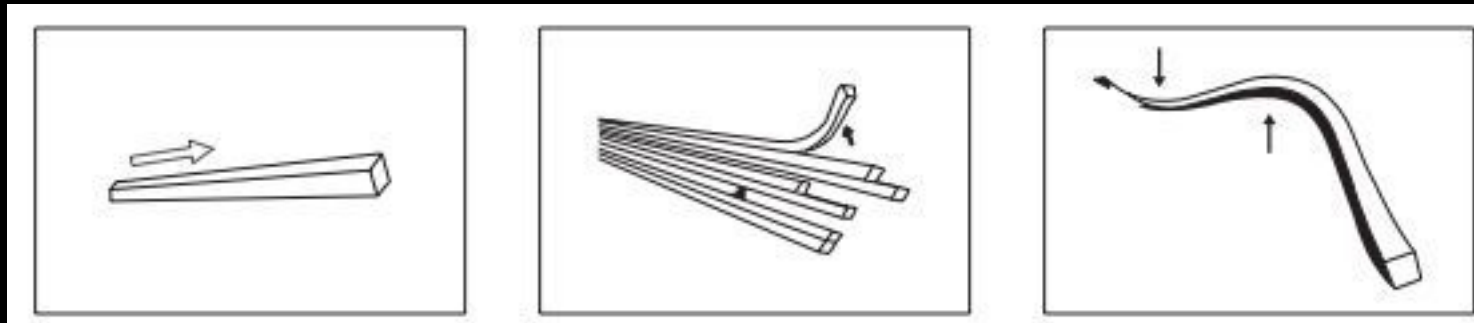
Asbestos : ...serpentine and amphibole mineral groups, which have crystallized in the asbestiform habit...

Asbestiform: ...the following characteristics when viewed by light microscopy:

- 1. Aspect ratio 20-100, >5um.*
- 2. <0.5um in width.*
- 3. 2 or more of the following attributes:*
 - a) Parallel fibers occurring in bundles;*
 - b) Fibers displaying splayed ends;*
 - c) Matted masses of individual fibers; and*
 - d) Fibers showing curvature*

“Post-Hearing Comments in the Matter of Proposed Revisions to the Asbestos Standard, “Code of Federal Regulations Title 29. 1984.

Asbestiform

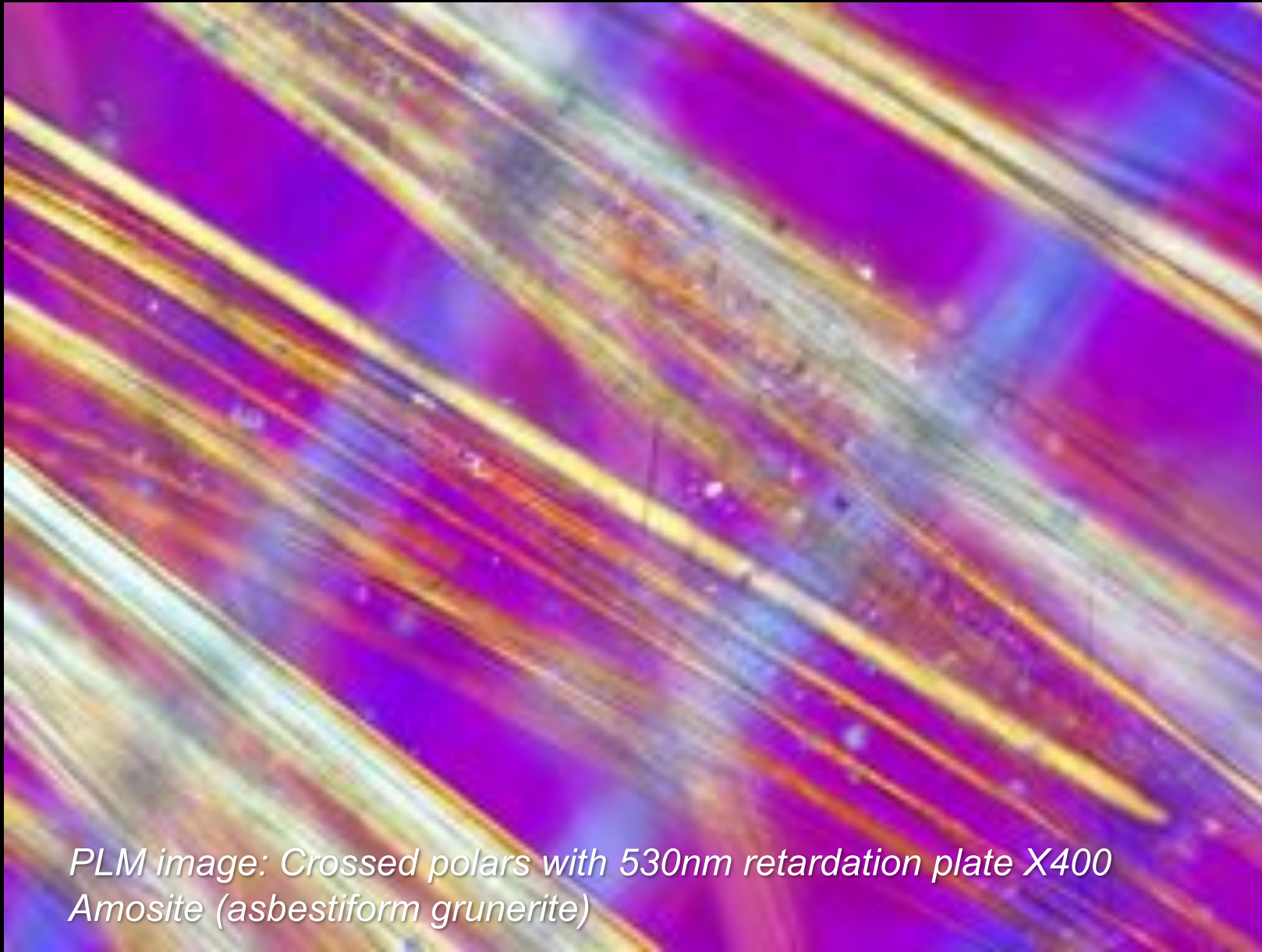


Non-Asbestiform (cleavage fragments)



Fig.1 Asbestiform and nonasbestiform graphics by John W. Kelse (1989)

a) Parallel fibers occurring in bundles



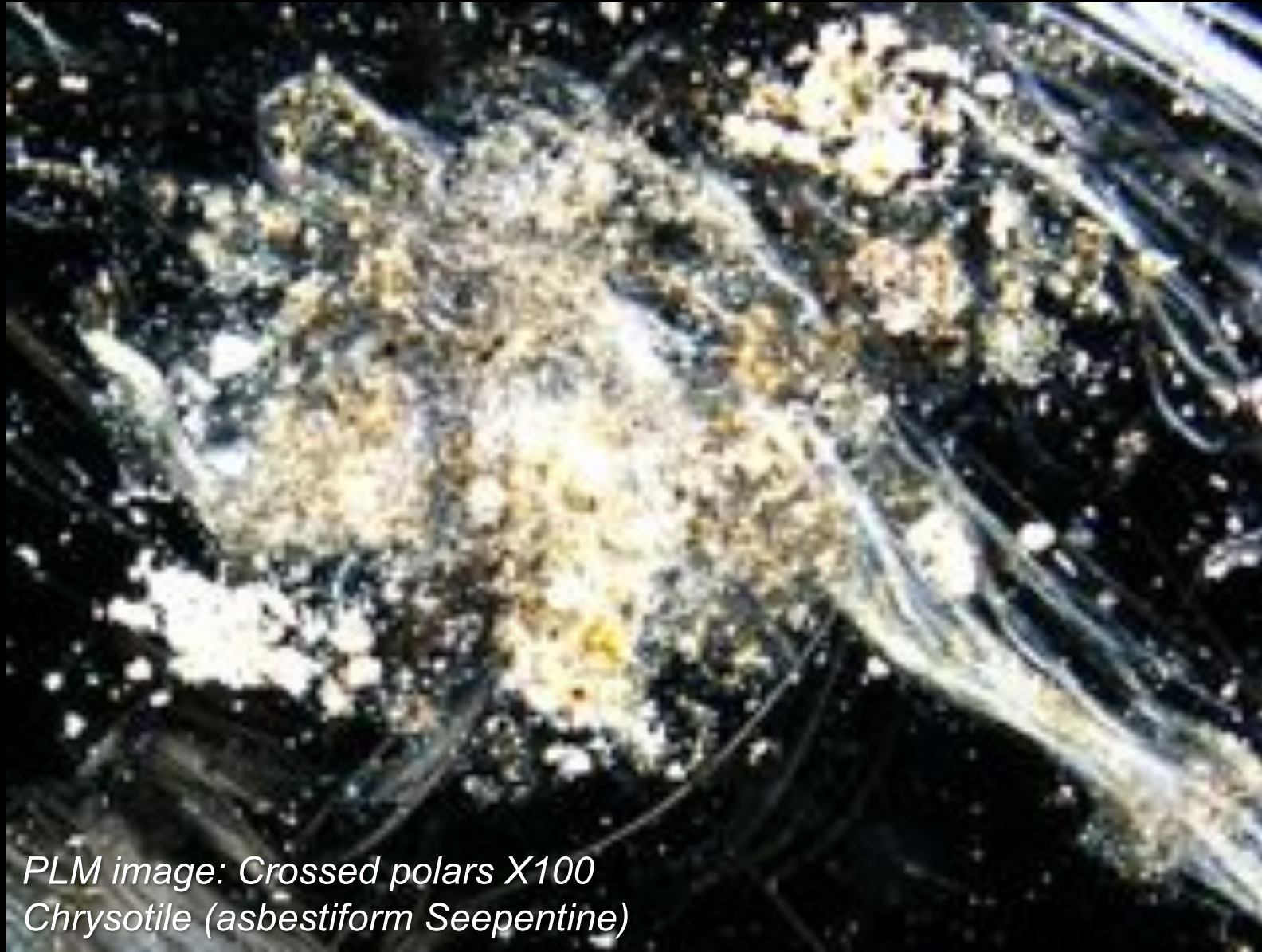
*PLM image: Crossed polars with 530nm retardation plate X400
Amosite (asbestiform grunerite)*

b) Fibers displaying splayed ends



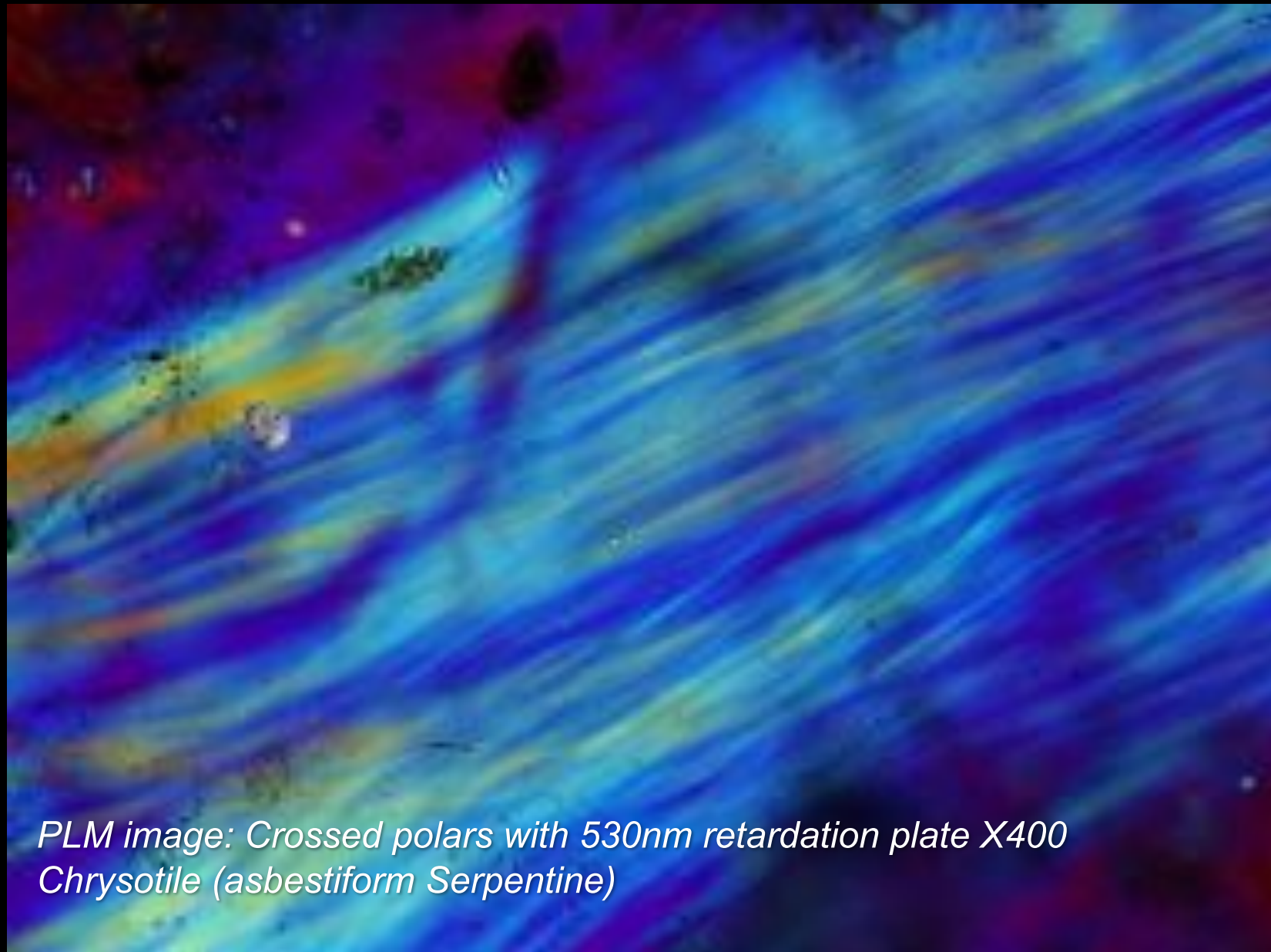
*PLM image: Crossed polars X400
Asbestiform tremolite*

c) Matted masses of individual fibers



*PLM image: Crossed polars X100
Chrysotile (asbestiform Serpentine)*

d) Fibers showing curvature



*PLM image: Crossed polars with 530nm retardation plate X400
Chrysotile (asbestiform Serpentine)*

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Table.1 Comparison of asbestos analysis method in bulk materials between JIS and ISO



Photo 1: Stereomicroscope image (X20)

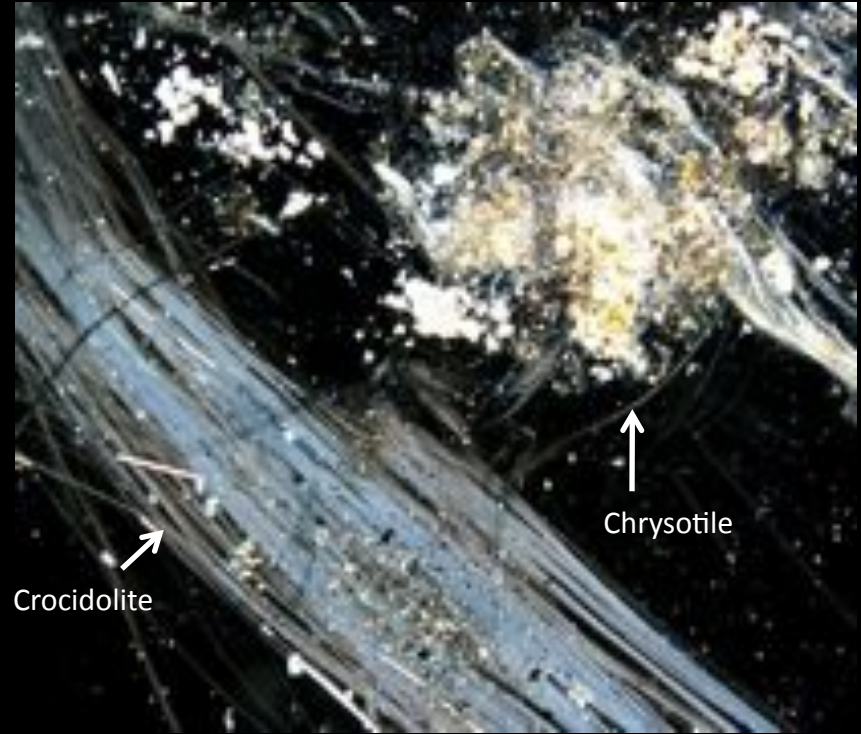


Photo 2: PLM image (crossed polars, X100)

Fig.2 Microscope images of an asbestos containing slate board from the ISO/DIS 22262-1







| | Stereomicroscope image X20 | PLM image (crossed polarized) X100 | PLM image (crossed polarized) X400 |
|-------------|---|--|---|
| Tremolite A |  <p>A-1</p> |  <p>A-2</p> |  <p>A-3</p> |
| Tremolite B |  <p>B-1</p> |  <p>B-2</p> |  <p>B-3</p> |

Fig.3: Microscope images of two kinds of tremolite

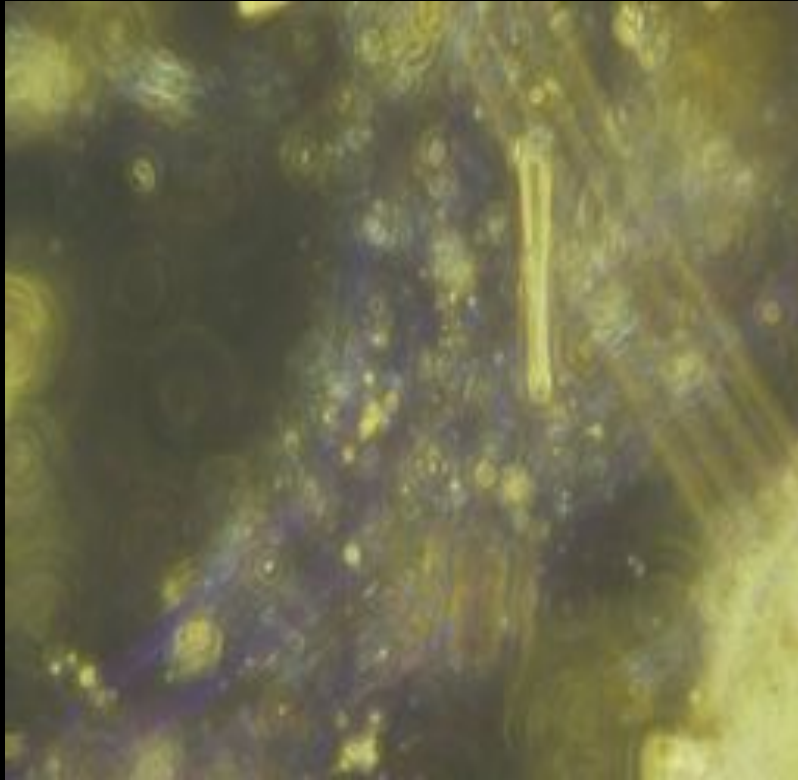


Photo 1 : DS-PCM image (X400)



Photo 2 : PLM image (X400, crossed polarized)

Fig.4 Microscope images of chrysotile fibers in spray rock-wool comparing between DS-PCM and PLM on the same field of view

The result of analysis by JIS A 1481 (DS-PCM and XRD)

Adhesive determination for both samples from Dr. Eric Chaffin 2006.10.6

| Sample No. | Date sample No. | Adhesive | Determined by FTIR (1) | | Determined by XRD (2) | | JIS A 1481 Comparison |
|------------|-----------------|----------|------------------------|--------------|-----------------------|--------------|-----------------------|
| | | | Adhesive | Non-Adhesive | Adhesive | Non-Adhesive | |
| 1 | 1001 | Adhesive | | | | | Adhesive |
| 2 | 1002 | Adhesive | | | | | Adhesive |
| 3 | 1003 | Adhesive | | | | | Adhesive |
| 4 | 1004 | Adhesive | | | | | Adhesive |
| 5 | 1005 | Adhesive | | | | | Adhesive |
| 6 | 1006 | Adhesive | | | | | Adhesive |
| 7 | 1007 | Adhesive | | | | | Adhesive |
| 8 | 1008 | Adhesive | | | | | Adhesive |
| 9 | 1009 | Adhesive | | | | | Adhesive |
| 10 | 1010 | Adhesive | | | | | Adhesive |
| 11 | 1011 | Adhesive | | | | | Adhesive |
| 12 | 1012 | Adhesive | | | | | Adhesive |
| 13 | 1013 | Adhesive | | | | | Adhesive |
| 14 | 1014 | Adhesive | | | | | Adhesive |
| 15 | 1015 | Adhesive | | | | | Adhesive |
| 16 | 1016 | Adhesive | | | | | Adhesive |
| 17 | 1017 | Adhesive | | | | | Adhesive |
| 18 | 1018 | Adhesive | | | | | Adhesive |
| 19 | 1019 | Adhesive | | | | | Adhesive |
| 20 | 1020 | Adhesive | | | | | Adhesive |
| 21 | 1021 | Adhesive | | | | | Adhesive |
| 22 | 1022 | Adhesive | | | | | Adhesive |
| 23 | 1023 | Adhesive | | | | | Adhesive |
| 24 | 1024 | Adhesive | | | | | Adhesive |
| 25 | 1025 | Adhesive | | | | | Adhesive |
| 26 | 1026 | Adhesive | | | | | Adhesive |
| 27 | 1027 | Adhesive | | | | | Adhesive |
| 28 | 1028 | Adhesive | | | | | Adhesive |
| 29 | 1029 | Adhesive | | | | | Adhesive |
| 30 | 1030 | Adhesive | | | | | Adhesive |
| 31 | 1031 | Adhesive | | | | | Adhesive |
| 32 | 1032 | Adhesive | | | | | Adhesive |
| 33 | 1033 | Adhesive | | | | | Adhesive |
| 34 | 1034 | Adhesive | | | | | Adhesive |
| 35 | 1035 | Adhesive | | | | | Adhesive |
| 36 | 1036 | Adhesive | | | | | Adhesive |
| 37 | 1037 | Adhesive | | | | | Adhesive |
| 38 | 1038 | Adhesive | | | | | Adhesive |
| 39 | 1039 | Adhesive | | | | | Adhesive |
| 40 | 1040 | Adhesive | | | | | Adhesive |
| 41 | 1041 | Adhesive | | | | | Adhesive |
| 42 | 1042 | Adhesive | | | | | Adhesive |
| 43 | 1043 | Adhesive | | | | | Adhesive |
| 44 | 1044 | Adhesive | | | | | Adhesive |
| 45 | 1045 | Adhesive | | | | | Adhesive |
| 46 | 1046 | Adhesive | | | | | Adhesive |
| 47 | 1047 | Adhesive | | | | | Adhesive |
| 48 | 1048 | Adhesive | | | | | Adhesive |
| 49 | 1049 | Adhesive | | | | | Adhesive |
| 50 | 1050 | Adhesive | | | | | Adhesive |
| 51 | 1051 | Adhesive | | | | | Adhesive |
| 52 | 1052 | Adhesive | | | | | Adhesive |
| 53 | 1053 | Adhesive | | | | | Adhesive |
| 54 | 1054 | Adhesive | | | | | Adhesive |
| 55 | 1055 | Adhesive | | | | | Adhesive |
| 56 | 1056 | Adhesive | | | | | Adhesive |
| 57 | 1057 | Adhesive | | | | | Adhesive |
| 58 | 1058 | Adhesive | | | | | Adhesive |
| 59 | 1059 | Adhesive | | | | | Adhesive |
| 60 | 1060 | Adhesive | | | | | Adhesive |
| 61 | 1061 | Adhesive | | | | | Adhesive |
| 62 | 1062 | Adhesive | | | | | Adhesive |
| 63 | 1063 | Adhesive | | | | | Adhesive |
| 64 | 1064 | Adhesive | | | | | Adhesive |
| 65 | 1065 | Adhesive | | | | | Adhesive |
| 66 | 1066 | Adhesive | | | | | Adhesive |
| 67 | 1067 | Adhesive | | | | | Adhesive |
| 68 | 1068 | Adhesive | | | | | Adhesive |
| 69 | 1069 | Adhesive | | | | | Adhesive |
| 70 | 1070 | Adhesive | | | | | Adhesive |
| 71 | 1071 | Adhesive | | | | | Adhesive |
| 72 | 1072 | Adhesive | | | | | Adhesive |
| 73 | 1073 | Adhesive | | | | | Adhesive |
| 74 | 1074 | Adhesive | | | | | Adhesive |
| 75 | 1075 | Adhesive | | | | | Adhesive |
| 76 | 1076 | Adhesive | | | | | Adhesive |
| 77 | 1077 | Adhesive | | | | | Adhesive |
| 78 | 1078 | Adhesive | | | | | Adhesive |
| 79 | 1079 | Adhesive | | | | | Adhesive |
| 80 | 1080 | Adhesive | | | | | Adhesive |
| 81 | 1081 | Adhesive | | | | | Adhesive |
| 82 | 1082 | Adhesive | | | | | Adhesive |
| 83 | 1083 | Adhesive | | | | | Adhesive |
| 84 | 1084 | Adhesive | | | | | Adhesive |
| 85 | 1085 | Adhesive | | | | | Adhesive |
| 86 | 1086 | Adhesive | | | | | Adhesive |
| 87 | 1087 | Adhesive | | | | | Adhesive |
| 88 | 1088 | Adhesive | | | | | Adhesive |
| 89 | 1089 | Adhesive | | | | | Adhesive |
| 90 | 1090 | Adhesive | | | | | Adhesive |
| 91 | 1091 | Adhesive | | | | | Adhesive |
| 92 | 1092 | Adhesive | | | | | Adhesive |
| 93 | 1093 | Adhesive | | | | | Adhesive |
| 94 | 1094 | Adhesive | | | | | Adhesive |
| 95 | 1095 | Adhesive | | | | | Adhesive |
| 96 | 1096 | Adhesive | | | | | Adhesive |
| 97 | 1097 | Adhesive | | | | | Adhesive |
| 98 | 1098 | Adhesive | | | | | Adhesive |
| 99 | 1099 | Adhesive | | | | | Adhesive |
| 100 | 1100 | Adhesive | | | | | Adhesive |

False Negative 6/21: 28.6%

Conclusion

1. JIS A 1481 adopts different definition and different method from ISO/DIS22262-1
2. The JIS method confuses fiber counting rule with the morphological definition of asbestos.
3. The confusion may cause “false positive” and also “false negative”.