

## Continuous Filament Glass Fibre and Human Health

### CHARACTERISTICS OF CONTINUOUS FILAMENT GLASS FIBRE

#### *Introduction*

Glass fibre has been commercially manufactured and marketed for more than 60 years. During this time, it has become one of the world's most useful and beneficial man-made materials.

While it has numerous uses and applications, glass fibre is generally produced in two basic forms: wool-type fibres, referred to most commonly as glass wool or glass fibre insulation, and continuous filament glass fibres, produced in long, continuous strands or filaments.

#### *Continuous Filament Glass Fibre Products and Applications*

Continuous filament glass fibre is produced and supplied in a variety of forms: roving, chopped strand, yarn, mat, fabric, tissue, etc. The main end-use is the reinforcement of thermosetting and thermoplastic resins. These composites are used in a wide variety of applications.

The main markets for composite materials are the automotive and transport sectors, the electrical/electronics industry and the building industry. Other markets include pipes and tanks, agricultural equipment, industrial machinery, wind-turbine blades and the sports, leisure and marine sectors. The second most important end-use is the manufacture of textiles that are used in similar markets to composites though clearly for different applications. The main market for glass textiles in the electronics industry is in the production of printed wiring boards.

#### *Man-Made (Synthetic) Vitreous Fibres (MMVF / SVF)*

Glass fibre is categorised within a group of man-made materials historically referred to as man-made mineral fibres (MMMF). However, a more appropriate name is man-made vitreous fibres (MMVFs) or synthetic vitreous fibres (SVFs), reflecting the glassy, non-crystalline nature of the material. Glass fibres are made from molten sand and other inorganic materials under highly controlled conditions.

#### *Composition of Continuous Filament Glass fibre*

The predominant glass composition for continuous filament glass fibre is known as E-glass. It accounts for almost all the world's production of these glass fibres. E-glass is a member of the family calcium-aluminium-silicate glasses.

Boron oxide is generally a major additive of E-glass, and the alkali oxides of sodium and potassium are maintained at low levels to give acceptable electrical properties. In recent years, alternative E-glass formulations, without boron oxide addition, have been developed and used in most applications, except for printed wiring boards or aerospace applications.

For some applications requiring specific properties, e.g. high mechanical strength, higher temperature resistance, improved resistance to corrosion, resistance to alkali in cement, high dielectric properties, other glass families like C, D, R, AR and S are also produced as continuous filament glass fibres.

### *Manufacturing continuous filament glass fibre*

Glass fibres are a high technology product. Continuous filament glass fibre is produced by a continuous drawing process through the calibrated holes of bushings at constant speed, thus leading to a very narrow variation in filament diameter.

In any given product, the diameter of the fibres does not differ much from the mean or nominal diameter. Standard deviation of the diameter in continuous filament products is typically less than 10% of the nominal diameter. The nominal diameter of continuous filament glass fibre products manufactured by APFE Member companies ranges from 5 to 25 microns (depending on the product) with the majority of the products being 9 microns or larger in diameter.

Another characteristic of the manufacturing process is that it gives a parallel orientation to the continuous filaments constituting the fibre bundles.

Further processing of continuous filament products does not generate any change in diameter, nor in the parallel orientation of filament bundles.

## HEALTH AND SAFETY ASPECTS OF CONTINUOUS FILAMENT GLASS FIBRE

### *Inhalation*

Airborne continuous filament can be inhaled. However, the potential for inhaled glass fibre to cause any health hazard depends on its "respirability", i.e. its potential to enter the lower regions of the lung. Indeed, the essential feature of a health and safety assessment for the product is to determine whether it is possible for the product to cause lung disease through respiration.

Fibres with diameters greater than 3 microns, which is the case for continuous filament glass fibre, do not reach the lower respiratory tract and, therefore have no possibility of causing serious pulmonary disease.

According to the WHO definition, respirable fibres have a diameter (d) smaller than 3 microns, a length (l) larger than 5 microns and a l/d- ratio larger than or equal to 3.

Continuous filament glass fibres do not possess cleavage planes which would allow them to split length-wise into fibres with smaller diameters, rather they break across the fibre, resulting in fibres which are of the same diameter as the original fibre with a shorter length and a small amount of dust.

Recent microscopic examination of dust from highly chopped and pulverised glass demonstrated the presence of small amounts of respirable dust particles. Among these respirable particles, some were fibre-like in terms of l/d ratio (so-called "shards"). To the eye however, it can be clearly seen that they are not regular shaped fibres but irregular shaped particles with fibre-like dimensions. To the best of our knowledge, the exposure levels of these fibre-like dust particles measured in the APFE member companies' manufacturing plants are of the order of magnitude between 50 to 1000 below existing applicable limits.

### *Irritation*

On the other hand, glass fibres indeed can cause a purely mechanical irritation (itching) of the skin and eyes. This is definitely not an allergic reaction.

This has been confirmed by the 23rd amendment (Directive 97/69) of the Directive 67/548 on the labelling of dangerous substances, which applies to man-made mineral fibre. Only glass wool or rock wool in certain circumstances and refractory fibres are concerned by this labelling. Continuous filament glass fibres are not.

When sufficient amounts of continuous filament glass fibres are released into the air during manufacture and handling, some workers may experience temporary upper respiratory tract irritation. Like skin irritation, upper respiratory irritation is a mechanical reaction to the fibres. It is not an allergic reaction and the irritation generally does not persist. Such exposures to high concentrations of airborne fibres may result in temporary coughing and/or sneezing. These effects will subside after the worker is removed from exposure, and should have no further impact on his or her health or well being.

By respecting the manufacturers' safety data sheets and handling instructions, users can readily avoid these mechanical effects.

As a general rule, the mechanical irritation caused by glass fibres disappears when the person is no longer exposed to the product.

### *Human Epidemiology Studies*

An important method for assessing the effects of a substance on humans is through epidemiological studies. Such studies typically examine large groups of people who have been exposed to the substance being studied.

Two major studies involving 21500 workers in the USA and Europe, conducted respectively by the University of Pittsburgh (School of Public Health) and the International Agency for Research on Cancer (IARC), showed no increase in lung cancer or non-malignant respiratory disease among persons working in glass fibre production. A smaller study was conducted among workers in a continuous filament glass fibre manufacturing facility in Canada with the same results.

Three epidemiological studies have been published recently on cohorts of people working in MMMF factories. The first one in Europe by Boffetta (1997) on different types of MMMF concluded for two plants in Northern Ireland and Italy that there was no significant increase of different types of cancer compared to reference cohorts. The two other studies by Chiazzo were specifically made in one plant producing continuous filament glass fibre in the USA. Chiazzo (1997) concluded that there was no evidence of excess of cancer in the populations working in this plant for a long time (more than 15 years). References are mentioned below.

### *Animal Studies*

In 2000 the Institute of Occupational Medicine (IOM) in Edinburgh Scotland published the results of a long-term animal inhalation study on respirable micro-fibres in the scientific journal *Inhalation Toxicology*. In the IOM study, the micro-fibres utilized were respirable with a mean diameter of 0.5 microns. The laboratory animals were exposed to an extremely high concentration (1022 respirable fibres per cubic centimetre of air (f/cc) for five hours per day, seven days a week for 52 weeks) of these special application E-glass micro-fibres (not produced by APFE members). Exposure to the respirable micro-fibres at a very high exposure concentration resulted in the development of fibrosis, lung and pulmonary tumors. The level of airborne respirable fibres used in the study was 100,000 times higher than fibre levels typically measured in our continuous filament manufacturing operations.

### *Classification and Regulatory Aspects*

In recent years, several major reviews have been undertaken by various expert international organizations on the health and safety aspects of glass fibres. The first of these was conducted by the International Agency for Research on Cancer (IARC) in 1987. The purpose of the IARC review was to determine whether these fibres are carcinogenic to humans. At that time, IARC concluded that continuous filament glass fibres are not classifiable as to their carcinogenicity to humans (IARC classification Group 3). In October 2001, after a comprehensive review of more recent human epidemiology and animal toxicity data, IARC concluded that the classification of continuous filament glass fibres in Group 3 is appropriate, confirming that there is currently no evidence for the carcinogenicity of continuous filament glass fibres to humans (IARC Monograph Man-Made Vitreous Fibres Vol. 81, 2002).

*IARC groups man-made vitreous fibres (MMVF) into categories based on raw materials, production process and end use. IARC noted, in its 2001 reclassification of MMVFs, that an additional category had been added to group those durable glass fibres produced by flame attenuation for special applications. IARC retained the Group 2B classification for what IARC termed "Special Purpose Fibres." IARC gave as examples of these SPF: E and 475 respirable glass fibres. IARC retained the Group 3 classification for continuous filament fibres, regardless of chemical composition. Continuous filament fibres differ from Special Purpose Fibres in their method of manufacture and end use. They may also have different composition. Thus, continuous filament E-glass fibres should not be confused with SPF E-glass fibres and are still classified as Group 3.*

Environment Canada also completed a review of the scientific data for glass fibres. The purpose of the review was to assess both the hazards of glass fibres and the risk to humans and the environment presented by those fibres. It concluded for continuous filament glass fibres:

"Based principally on the likelihood that few respirable fibres are generated in the production and use of continuous filament and that concentrations in the general environment should be extremely small, it has been concluded that continuous glass filament is not entering the environment in quantities or under conditions that may constitute a danger in Canada to human life or health".

The American Conference of Governmental Industrial Hygienists (ACGIH) has classified continuous filament glass fibres as not classifiable as human carcinogen. The ACGIH has established a TLV (Threshold Limit Value or recommended exposure limit) for glass fibre of 1 fibre per cubic centimetre of air for respirable fibres and 5 mg per cubic meter of air for inhalable glass fibre dust. These levels were established to prevent mechanical irritation of the upper airways. IARC, NTP (US National Toxicology Program) and OSHA (US Occupational Safety and Health Administration) do not list continuous filament glass fibres as a carcinogen.

Inorganic chemicals in dust form, which hold as (suspected) carcinogens, are classified as Class III under the German TA-Luft regulation. The TLV mass concentration in air for these is 5 mg/m<sup>3</sup>. In the German MAK values list the criteria for carcinogenicity for fibres are listed. These can be found under Chapter III 'Carcinogenic Industrial Chemicals' Paragraph 'Fibredust' (Faserstaub). The above criteria for carcinogenicity are as follows: length/diameter ratio larger than 3, length larger than 5 µm, diameter smaller than 3 µm.

Continuous filament glass fibre as produced by APFE member companies does not conform to these criteria. All APFE produced continuous filament glass fibre types have a diameter larger than 3 µm and hence are **not** to be considered as (suspected) carcinogens under the definitions of the German MAK values list. The so-called KI-index which reflects a risk assessment of respirable fibres based on their composition, does **not** apply to continuous filament glass fibre as produced by the APFE member companies.

Continuous filament glass fibres are not considered as a dangerous substance following the rules of the European Directive 67/548/EC for labelling of dangerous substances and its subsequent amendments. This has been confirmed by the 23<sup>rd</sup> amendment (Directive 97/69/EC) on Man-made Mineral Fibre where continuous filament glass fibres are not to be labelled either for toxicity, carcinogenicity or irritation. Labelling is only applicable to glass or rock wool in certain circumstances and refractory fibres.

#### *Industry Recommended Work Practices*

While continuous filament glass fibres are safe to manufacture and handle, a number of general work practices should nevertheless be followed by those who are involved with these operations. Besides preventive measures aiming to reduce the possibilities of generating dust or broken filaments, a series of protective measures in areas of high exposure are recommended: gloves, long sleeves, long legged trousers, respiratory masks especially for workers involved in cutting operations, cleaning or discharging of containers. It is furthermore recommended to measure as appropriate the number of fibres in the air to prevent high exposure levels to fibre or dust, in order to ensure compliance with existing exposure limits.

Years of airborne fibre sampling at APFE manufacturing facilities confirm that very low concentrations of respirable fibres may be present, but the concentrations are well below current recommended exposure limits. APFE will continue to conduct exposure monitoring to ensure proper work practices, engineering controls and personal protective equipment (PPE) are in place to eliminate or minimise exposure risk.

APFE product information will continue to be reviewed and updated as needed based upon the evaluation of work by different laboratories studying these subjects and the ongoing analysis of our products.

## SUMMARY

*Continuous filament glass fibres produced by APFE member companies have diameters greater than 3 microns. These fibres therefore have diameters above the respirable range of 3 microns or less, thus minimising the potential for any chronic pulmonary effects associated with exposure to these fibres. Customers can confirm the diameter of the fibre that they purchase from their supplier. The irritation possibly caused by these fibres is a simple mechanical one, which can be minimised by good industrial hygiene practices.*

*Manufacturers and their customers should continue to use recognised safety and health practices to ensure safe use of our products. Work practices and procedures should be in place to minimise dust generation. Local exhaust ventilation should be used if necessary to minimise and/or keep airborne dust levels at or below recommended limits. A government approved dust respirator should be used if airborne concentrations exceed regulatory and recommended limits, if irritation occurs or if the workers choose to do so for personal comfort. Exposure assessments should be conducted, as appropriate, to ensure exposures are within recommended limits.*

**References on Epidemiological Studies**

**Paolo Boffeta and al**

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