PLAINTIFF'S EXHIBIT

CAP-507

AIA NORTH AMERICA
ASBESTOS INFORMATION ASSOCIATION
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January 25, 1983

Memorandum For: W. Aldridge, Turners ~~Building~~ Products
W. H. Beasley, CAPCO
Frank Betts, Atlas Building Materials
John H. Lonnquist, Johns-Manville Corporation
Kurt Schwarz, Suprudar Manufacturing Corporation
Gerald N. vonDohlen, International Bldg. Products

Subject: Forwarding of Booklet Entitled "Asbestos-Cement: The Facts"

The enclosed booklet entitled "Asbestos-Cement: The Facts" has been received from the Asbestos International Association and is forwarded for information and use as may be deemed appropriate.

As you know, this Association and the Asbestos Cement Pipe Producers Association have published related materials as identified below:

Shop Fabrication of Asbestos Sheet Products (AIA/NA)

Field Fabriciation of Asbestos Cement Sheet (AIA/NA)

Recommended Work Practices for A/C Pipe (AACPP)

Working With Asbestos Cement (AIA/NA)

An order form is enclosed should you desire quantity numbers of the above booklets.

B. J. Pigg
Executive Director

Enclosure

cc: Joseph C. Jackson
AACPP

ASBESTOS INTERNATIONAL ASSOCIATION
68 GLOUCESTER PLACE, LONDON W1H 3HL

MEMORANDUM

TO: Member Associations — Ref: AIA/7/1/3/PROD

FROM: Director General — 7 January 1983

ASBESTOS-CEMENT : THE FACTS

The enclosed booklet "Asbestos-Cement : The Facts" is forwarded for your use.

It was compiled by members of the Building and Construction Advisory Panel (BCAP) under the Chairmanship of Mr. Yves Alexandre, but it is not an AIA publication in view of its commercial content.

The booklet is intended to be used as a source of information to help Member Associations should they wish to issue something similar on a national basis.

If you wish to use the format of this booklet unchanged as a basis for your own publication, then please put the name of your Association on the cover and where necessary in the text* put in the figures which apply to your Country or Association.

N Stack

Sir Neville Stack
Director General

cc Governing Council Members } without enclosure
Executive Committee Members }

BCAP Members (with enclosure)

* Pages 4, 10, 11, 12, 13 & 19

ASBESTOS-CEMENT : THE FACTS

December 1982

ASBESTOS-CEMENT : THE FACTS

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ASBESTOS-CEMENT : THE FACTS

INTRODUCTION

1. A 'WEALTH' OF FACTUAL INFORMATION

The various sections assembled in this document:

'Asbestos-Cement : The Facts"

constitute an up-to-date and objective data base which, judiciously employed, will help:

1.1 To emphasise the inherent qualities of asbestos-cement products in their technical and/or economic performance in the markets they supply - either intrinsic qualities or by comparison with competing products;

1.2 To put environmental factors into proper perspective while explaining how production procedures and the correct use of asbestos-cement products allows us to take advantage of the products' qualities without running any health risks.

2. WHAT DO WE MEAN BY 'JUDICIOUSLY EMPLOYED'?

2.1 THE SPECIFIC USE OF TECHNICAL FACTS

It is not the intention to defend asbestos-cement products by denigrating competitors, but rather to supply objective criteria to those responsible for choosing to use or not to use asbestos-cement products.

Comparisons between the inherent qualities of asbestos-cement products and alternative products must thus be used without value judgments, but simply to highlight, by juxtaposition. the advantages of asbestos-cement products.

In order to obtain maximum benefit from the use of this information a technical sales programme directed towards specifiers as a whole should be undertaken concomitant, in so far as possible, with an information campaign focused on contractors, the distribution network and the final consumer of asbestos-cement products.

The main categories of 'decision makers/specifiers' are as follows (a non-exhaustive list):

1. National Standardisation Organisations;

2. Public Administrations using Asbestos-Cement Products:
   - Health - hospitals
   - Education - schools

- Construction - public housing
- Armed Forces - military buildings
- Departments of Roads & Bridges - pipes
- Local Authorities

3. Professional Organisations & Corporate Federations:
   - Industrial buildings
   - Private homes
   - Agricultural co-operatives
   - Engineering or consulting groups

4. The liberal professions tied to the building industry:
   - Architects
   - Surveyors
   - Control Specialists

5. Journals specialising in the building industry and related secondary activities.

2.2 PARTICIPATION IN LEGISLATIVE ACTION ON THE ASBESTOS AND HEALTH QUESTION

It is important that any action taken by members of the industry is done so in a spirit and attitude of responsibility and frankness - this should hold true whatever the country:

1. responsibility: to recognise all the problems which may arise and to show a determination to solve them;

2. open-mindedness: never to refuse to enter into a constructive dialogue; such dialogue could create a 'natural partnership.

Over and above this 'general attitude' the specific situations which arise in each country must decide the communications policy and time-table for addressing the problem. It is essential to begin with a proper assessment of the existing situation.

A thumbnail sketch of the participants

At its simplest there is on the one hand industry and on the other public opinion and in between there is Government which arbitrates.

The whole asbestos industry and not one isolated manufacturer should speak with a unified and coherent voice.

As far as public opinion is concerned, to try and make a distinction ~~between~~ for asbestos-cement products has no value: it is asbestos itself which public opinion questions - whatever its form of use may be.

That is why it is necessary to have one industrial organisation world-wide and not to limit the organisation to a particular asbestos industry.

Public opinion is influenced primarily by the scientific and medical communities - by definition these are impartial, credible and wise - they are considered a priori to possess 'the truth'.

Next in importance come the trade unions and the labour force.

The media, as the voice of the people, tend to exaggerate problems and thus create interest and discussion which, in turn, crystallises public opinion.

These various forces, through the pressure they exert on authority, contribute to the defining of legislation and its progression.

One must not forget that the speed with which problems are broadcast internationally makes a purely national policy in a purely national context a mere Utopia.

3. THE ASBESTOS INDUSTRY MUST DEFINE ITS OWN COHERENT PLAN OF ACTION:

3.1 AT THE INDUSTRIAL LEVEL: to meet or exceed existing regulations (plants and environment) or adhere to a voluntary code of regulations (based on Europe for example) - this involves discussions with regulatory authorities;

3.2 AT THE COMMUNICATIONS LEVEL: actively to search for objective dialogue with the 'participants' listed above.

4. It would also be in our interest to seek to co-ordinate industry's actions by discussing the specific situation of each partner in the industry and sharing information on the progress of research and of different actions undertaken. Specifiers, distributors and users should be kept suitably informed.

5. Industry must, whenever possible, take the initiative. This will enable it to address the problems (or to orient the treatment of the problems) at a reasonable and controlled rate while maintaining its image of responsibility and objectivity. The image must correspond to reality and contribute to the Industry's credibility. The industry must be viewed as manufacturers who responsibly control the risks linked to asbestos in order to continue to offer the community high performance and economical products.

FACTS ABOUT ASBESTOS-CEMENT PRODUCTS

1. THE ASBESTOS-CEMENT INDUSTRY

1.1 HISTORY

The basic technology was developed at the end of the 19th centrury by Ludwig HATSCHECK.

Many of the asbestos-cement products used today were developed at the very beginning of the industry's history.

1.2 GENERAL INFORMATION

World wide, 30 million tons are manufactured annually, in 500 plants, and the activity of the asbestos-cement industry is growing.

In our country:

.... (A) * (number) of plants spread all over the country managed by
.... (B) * (number) of companies produced
.... (X) * (thousand tons) of asbestos-cement products in 1980 for
.... (Y) * (million $) net sales.

.....(C) * (thousand persons) are employed in these plants and the asbestos-cement industry is among the largest manufacturers of building materials in our country.

Asbestos-cement products provide shelter, clear drinking water, irrigation water, sewage and waste disposal for the population under economical conditions.

The asbestos-cement industry is well suited for the developing countries. An asbestos-cement industry would enable them to satisfy their own needs for building materials and pipes:

- unsophisticated technology;
- low cost of plant;
- low expenditure of foreign currency for raw materials;
- low energy consumption;
- easy to use, economically and technically competitive products;

* Use National statistics in these cases and similarly on subsequent pages where ".... (X)" is shown.

- 25,000 people die every day from lack of water (FAO) and 50,000 more die every day from inadequate water.

With technical adaptability better than any other natural or man-made fibre, asbestos is unmatched for the reinforcement of high performance products like asbestos-cement materials.

It possesses all these qualities:

- tensile strength (40-200 daN/mm^2)
- resistance to high and low temperature;
- fire resistance;
- chemical resistance, particularly to cement alkalinity;
- dielectrical resistance;
- fineness of the fibres;
- optimal compatibility with cement as binder;
- resistance to bacteria, fungi, ...
- weather proof, ...

Cement: Portland cement locally produced is suitable for use in the asbestos-cement industry. This gives asbestos-cement an advantage over the steel, cast-iron and aluminium industries which require the import of iron ore or bauxite.

2. ASBESTOS CEMENT MANUFACTURING

2.1 RAW MATERIALS

Asbestos

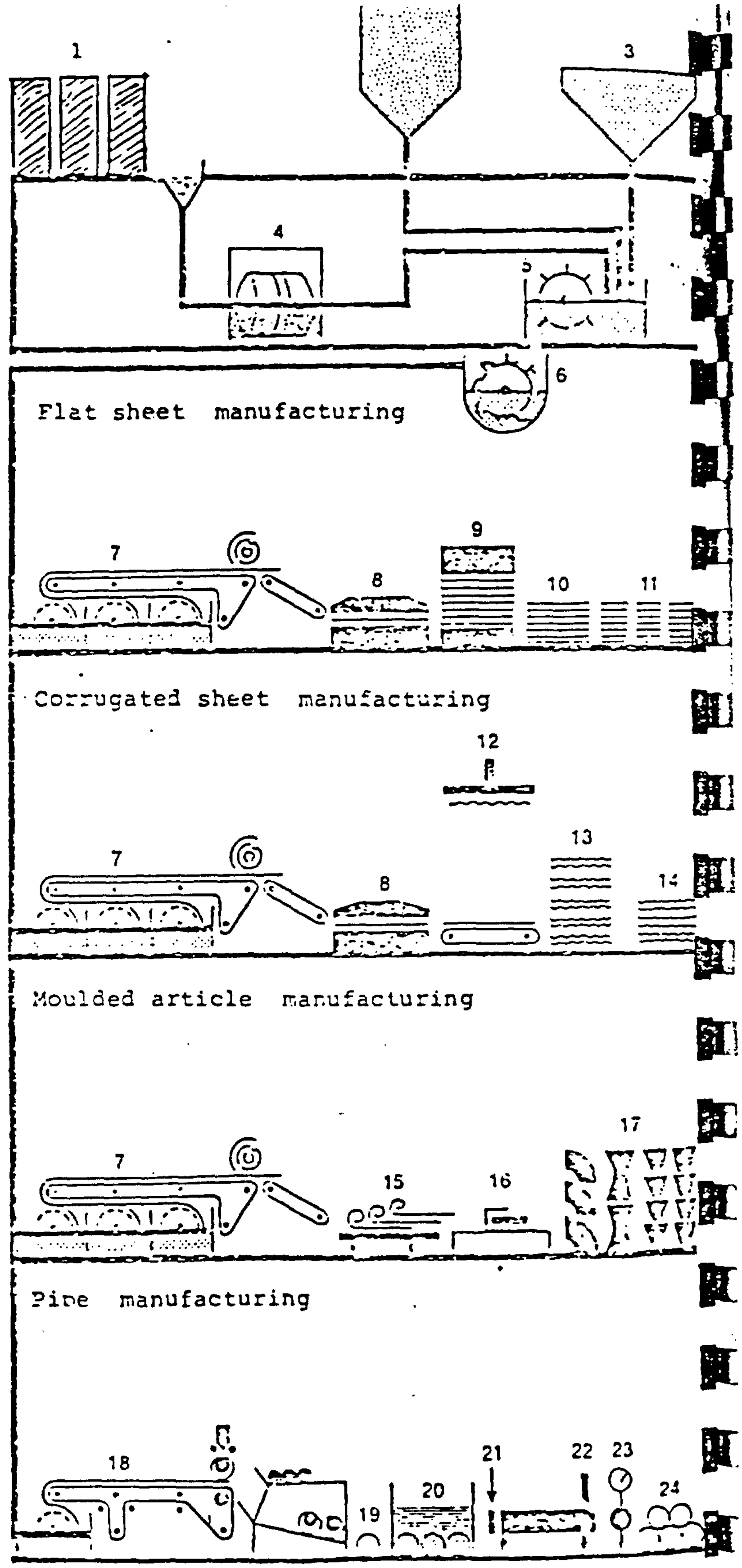
Asbestos is a naturally occurring mineral fibre commercially available in most parts of the world. Supply is fairly diversified. Thus there is no strategic dependency on a single supplier.

Asbestos Production (US Bureau of Mines) - (Estimate)

Country	1978	1979	1980
USSR	2,435	2,470	2,150
Canada	1,422	1,501	1,291
South Africa	257	249	270
Zimbabwe	225	250	251
China	-	250	250
Italy	135	130	145
Brazil	-	120	140
USA	-	93	80
Australia	-	70	80
Various	680	145	161
TOTAL (x 1,000 metric tons)	5,154	5,278	4,818

MANUFACTURING PROCESS

1. Asbestos
2. Cement
3. Water
4. Asbestos is fiberized by milling
5. Asbestos + cement + water mixture
6. Intermediate storage tank
7. Endless felt picks up the thin layer of materials and rolls it up on an iron cylinder
8. Length and width cutting
9. Sheets can be compressed
10. Flat sheets stock
11. Slates stock
12. Corrugation of flat green sheet
13. AC sheets desposed on metal forms
14. Corrugated sheets stock
15. Flat green sheets for moulding
16. Moulding
17. Moulded articles stock
18. For pipe manufacturing the AC layer is rolled up on an iron mandrel
19. Iron mandrel is removed after setting of cement
20. Pipes are cured in water
21. – 22. Cutting and machining the pipes end for coupling
23. Testing – Internal pressure
24. Pipes stock



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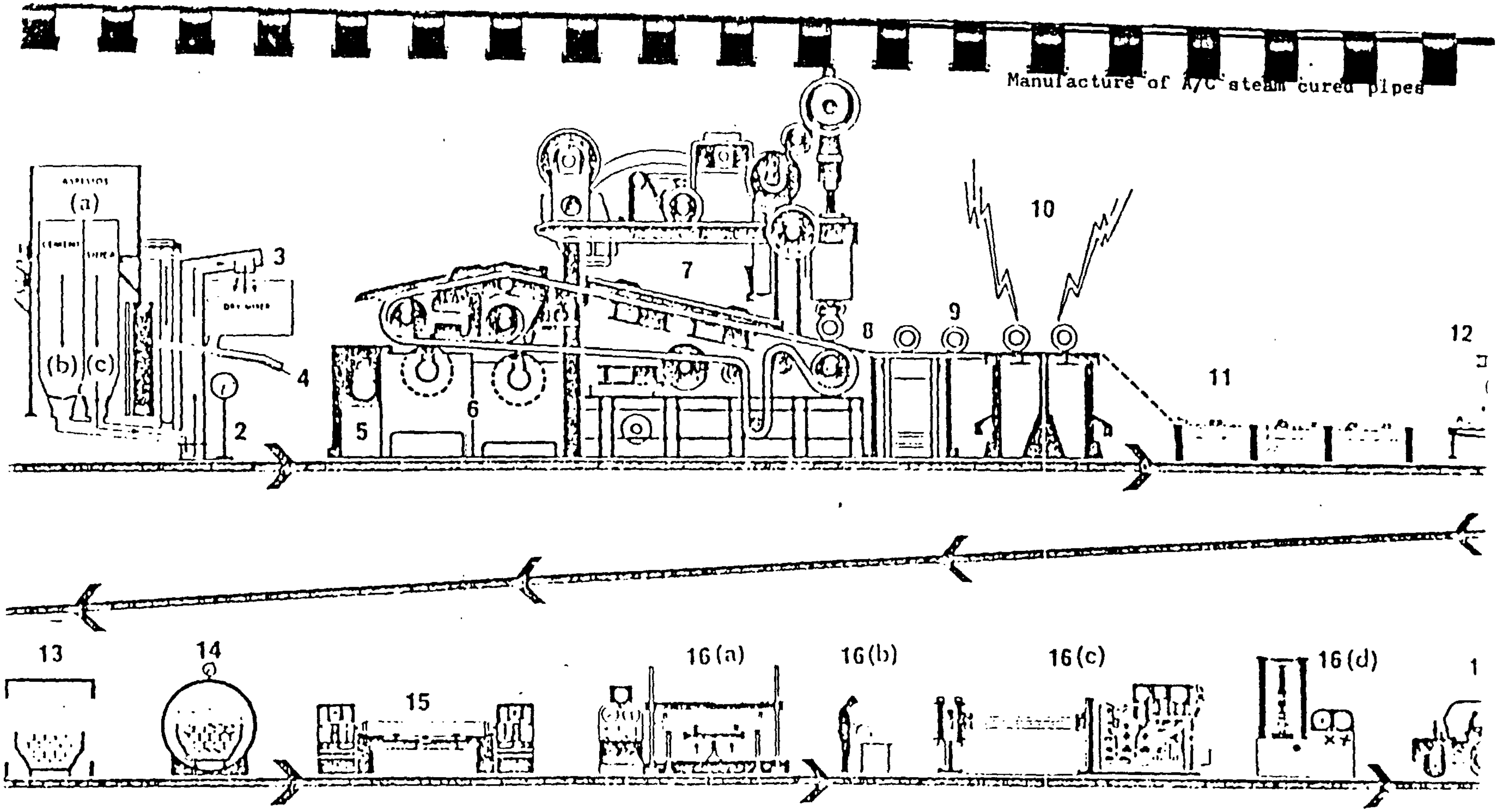


oduction line bins — raw
iterials enter the line as follows:
asbestos — from the willow where the fiber is separated into individual strands and thoroughly mixed
cement — directly from receiving hoppers
Silica — from grinding mill
ectronic Scales — for precise eighing, accurate control for uniform results

3. Dry Mixer — blends raw materials thoroughly
4. Conveying Trough — water carries stock to wet mix vat
5. Wet Mix Vat — thorough dispersion of reinforcing fibers
6. Screen Cylinder Mold — picks up slurry and deposits on moving felt
7. Vacuum Box — excess water removed
8. Felt deposits stock on Mandrel — wall thickness built up under pressure to proper size
9. Mandrel (with pipe) — removed from machine, next mandrel positioned
10. Electrolytic Loosner — free pipe from mandrel, prevents distortion
11. Slow-down Conveyor — provides pre-cure time, initial set
12. Mandrels — removed and pipe stencilled for identification
13. Air Cure Room — strict control of time, temperature and humidity
14. Autoclaves — high pressure steam curing imparts maximum strength and excellent chemical stability
15. Lathes — turn and machine ends exact dimensions
16. Testing Equipment — checks for adherence to rigid specifications
a flexure testing machine
b inspection
c hydrostatic tester
d crush tester (calculator,)
17 Materials Handling Equipment transfers pipe to shipping area

Asbestos-cement mixture contains (10-15%) of asbestos fibres, mainly Chrysotile (white) and for some products a small amount of Crocidolite (blue) or Amosite (brown).

2.2 THE MANUFACTURING PROCESS (see diagrams of basic processes)

Asbestos fibre and cement are thoroughly mixed together with water in the refining apparatus. The homogeneous mixture is kept in a tank which continuously feeds the production lines.

The mixture is de-watered in the vats equipped with rolled cylindrical screens. The thin layer of material is picked up by an endless belt and rolled up on an iron cylinder, in the form of a multi-layered, compressed material.

Once the desired thickness is obtained, the asbestos-cement accumulated on the cylinder is cut and layed out as a flat green sheet.

This sheet is deposited on a metal form (flat, corrugated or in various shapes for moulding) during the first setting of the cement.

For pipe manufacturing, the asbestos-cement cylinder remains uncut around a central metal mandrel.

Finished products are stocked for three to four weeks before delivery to allow the cement to harden.

Other manufacturing processes have been developed particularly to produce moulded products (by injection) or boards and panels (by extrusion).

3. ASBESTOS-CEMENT PRODUCTS CHARACTERISTICS

3.1 PHYSICAL PROPERTIES

Density

Density varies between 1, 4 and 2.0 g/cm^3 according to the production process and the use of the asbestos-cement material: the lower the density, the higher the water absorption capacity: from 30% to 13%.

These sheets are used as ceiling boards and roofing in very moist atmospheres, eg breweries, textile plants, agricultural buildings for animal breeding - where they act as a humidity regulator without creating condensation and droplets as with other products (metal sheets) which may, in addition be destroyed in such an atmosphere.

The higher the density, the higher the mechanical strength and surface hardness: asbestos-cement products resist abrasion by snow, ice and sand storm in roofing and by sandy sewage in sewer pipes.

Impermeability

Asbestos-cement sheets are impermeable to water and satisfy test requirements defined in ISO recommendations: under water pressure, there is no penetration of moisture to the sheet's underside.

Dimensional stability

Moisture movement $= K^h = 2.10^{-4}$
$= 2$ mm/m/10% Δh

Δh = variation of water content

Temperature movement $= k^t = 10^{-5}$
$= 1$ mm/m/100°C Δt

Δt = variation of temperature

Thermal conductivity is related to the density and can vary from 0.30 to 0.65 W/m°C.

(Flow of heat per m^2 through 1 m of material necessary to obtain 1°C temperature difference between the two sides of sheet).

Asbestos-cement products are not specific thermal insulators compared to light and thick panels (glass fibres, plastic foam) but with the same thickness, steel sheets transmit more than 100 times as much heat and aluminium sheets more than 500 times as much heat as asbestos-cement sheets.

Asbestos-cement pipes are used for water mains up to 70°C (permanent).

Asbestos-cement products are incombustible and do not spread flames. They can support temperatures up to 250°C.

Special insulation boards are fire resistant up to 1,000°C. Asbestos-cement does not burn nor develop smoke during a building fire.

Asbestos-cement products are frost resistant. They are used for roofing and piping in extremely cold climates.

Accoustic insulation

Low, between 4 and 20 db in the intermediate range. Nevertheless, asbestos-cement roofing deadens rain noise better than other materials, particularly metal sheets which, in addition, flap and create noise when the wind blows.

Electrical insulation

Asbestos-cement does not react in electrolytic conditions and does not require special protection against corrosion like metal sheets and steel or cast-iron pipes when buried in the earth.

3.2 MECHANICAL STRENGTH

Flexural strength

Minimum breaking loads under flexure are defined by ISO standards as follows (see Annex 2 - "The International Standardisation of Asbestos Cement Products"):

15 N/mm2 - flat sheets
16 N/mm2 - corrugated sheets
20 N/mm2 - slates
20 N/mm2 - sewer pipes
20 N/mm2 - pressure pipes.

Asbestos-cement roofing materials will support uniformly distributed loads, and alternating loads resulting from wind pressure; point loading should be avoided, and footbridges or crawling boards are essential for all roof traffic.

Tensile strength

For pressure pipe, the tensile strength by internal pressure must be over 22 N/mm^2.

Asbestos-cement pipes are defined (strength and thickness) to support permanent internal hydraulic pressure and short high pressure such as water hammer.

When buried they support external loads, crushing and bending produced by earth load and traffic.

Couplings provide pliability to the ducts during earthquakes and earth slides and keep total watertightness under load and movements (see Annex 3 - Behaviour of Asbestos-Cement Pipes during Earthquakes).

3.3 WEATHER RESISTANCE - DURABILITY

The mechanical strength and stability of asbestos-cement materials improve with ageing.

They are frost resistant and can withstand freeze-thaw cycles. They do not deteriorate under ultraviolet light, sun and weathering Chemical agents whose pH is lower than 5.5 may attack the cement in asbestos-cement products.

Asbestos-cement pipe is used without protection for drinking water or sewer mains when pH $> 5.8/6.0$ and alkalinity $CaCO^3 >$ 70/30 mg/1 $CaCO^3$. For pure and acid water or acid soils, they can be protected by coatings (epoxy, bitumen, ...,) (see Section 8 - "The Behaviour of Asbestos-Cement Pipes in Corrosive Media").

Asbestos-cement roofing and siding materials withstand common marine, industrial or urban atmospheric attack, which can affect metal sheets and reduce the effectiveness of the roof itself.

Asbestos-cement sheets and slates are available in through-coloured materials and/or surface coated to provide improved appearance.

Asbestos-cement materials are rot proof, vermin proof and are not affected by termite or insect attack.

The good weathering characteristics of asbestos-cement products help keep maintenance costs low.

3.4 ADAPTED TO USAGE

Asbestos-cement products are easy to use on site:

Weight, length and width allow for easy handling.

Modular systems, a wide range of available sizes, supported by a choice of fittings and accessories, and in different finishes and colours make them suitable materials for good design in buildings.

They can be cut, drilled and shaped to meet on-site requirements.

Asbestos-cement pipes and couplings provide watertight joints and avoid seepage and pollution. The smooth bore reduces friction with little loss of pressure head. They have very good resistance to encrustation and tuberculation.

Handling and use of asbestos cement materials in which the asbestos fibres are encapsulated in the cement binder are basically dust free. The adaptability of the products and the availability of standard fittings minimise the need for site work.

When cutting, machining or finishing work is required, the use of recommended tools and sound work practices are recommended to reduce the risk of exposure to asbestos to insignificant levels.

Refer to the following publications (see Annex 4):

- AIA - RCP 2 : 'Asbestos-Cement Products'
- AIA - Insert to RCP 2 : 'Catalogue of Tools for Working with Asbestos-Cement Products on Site'.

4. ASBESTOS-CEMENT PRODUCTS : USES AND MARKETS

Asbestos-cement products are widely used in building construction and considered as traditional and standardised materials.

4.1 ROOFING FOR PRIVATE HOMES

Asbestos-cement slates

- Represent .... (A)% of the total small roofing elements and .... (B)% of all slates (natural and asbestos-cement slates).

- Asbestos-cement slates (production 1980) ...... (X) tonnes
  ...... (Y) m2

- Price comparison (slate 40 x 24):

- asbestos-cement slates	(material)	...... (A) $/m^2$
	(installed)	...... (B) $/m^2$
- natural slates	(material)	...... (C) $/m^2$
	(installed)	...... (D) $/m^2$

- Asbestos-cement advantages:

  - standardised: does not need sorting;
  - easier and more rapid installation;
  - complete line of accessories and fittings;
  - economical;
  - less and easier maintenance.

  (Slates are also used for siding.)

Special shaped asbestos-cement sheets supporting clay tiles

- Developing an asbestos-cement product for supporting 'canal' type clay tiles. 'Canal' type clay tiles represent 50% of all clay tile roofing.

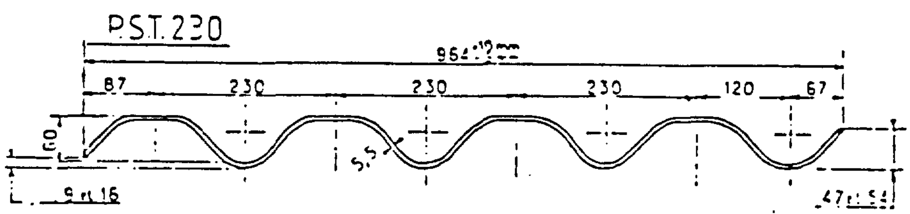
- Special asbestos-cement sheet (production 1980): ...... (X) tonnes
  ...... (Y) m2

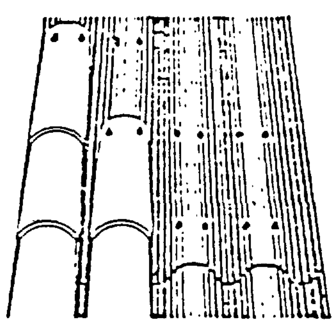
- Price comparison:

- asbestos-cement sheets + clay tiles	(installed)	...... (A) $/m^2$
- traditional clay tiles	(installed)	...... (B) $/m^2$

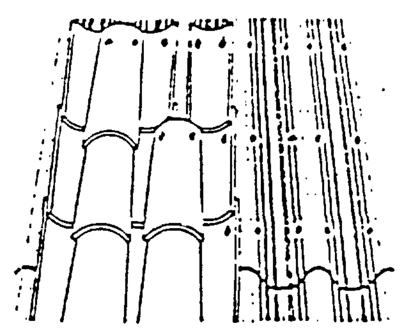
- Asbestos-cement advantages:

  - traditional appearance of the roof;
  - watertightness;
  - well adapted to gentle slopes;
  - easier installation;
  - less and easier maintenance;
  - economical solution.





Tile fixed in one layer



Tiles fixed in two layers

4.2 ROOFING FOR AGRICULTURAL, INDUSTRIAL & COMMERCIAL ... BUILDING

Asbestos-cement corrugated sheet (roofing and siding)

- It is the most widely used roofing material:

  ...... (A)% agricultural roofing;
  ...... (B)% industrial roofing;
  ...... (C)% commercial roofing.

Competitive products

- steel sheets for roofing;
- aluminium sheets for siding.

- Asbestos-cement corrugated sheet (production 1980): ...... (X) tonnes ...... (Y) m^2

- Price comparison:

- asbestos-cement grey corrugated sheets	(material)	...... (A) $\$/m^2$
	(installed)	...... (B) $\$/m^2$
- steel corrugated sheets	(material)	...... (C) $\$/m^2$
	(installed	..... (D) $\$/m^2$

- Asbestos-cement corrugated sheet advantages:

  - no corrosion - durability, appearance;
  - fire resistant;
  - less rain and wind noise;
  - absorbs condensation or droplets;
  - complete range of accessories and fittings;
  - easy installation;
  - easy maintenance;
  - lower price.

- Disadvantage:

  - weak impact strength - especially for siding.

4.3 WALLS, PARTITIONS, CEILING CLADDING (inside or out)

Can be built with asbestos-cement flat sheets, shaped, corrugated sheets or extruded panels. The appearance and quality of these products may be improved by various finishes or painting. The wide variety of types and styles of asbestos-cement sheet enable this material to be used for many applications. We must compare the characteristics and prices of installed asbestos-cement products with competitive products: wood, plaster boards ... masonry ...

- General asbestos-cement flat sheet advantages:

  - durability (moisture);
  - stability;
  - weather resistant;
  - colouring durability in specific products;
  - price (must be analysed);
  - fire protection with low density insulation boards.

- Disadvantage:

  - weak impact strength.

4.4 PIPE

Asbestos-cement pipe is used for the transportation of almost all fluids:

- inside buildings: water, waste water, air, polluted air;
- outside: drinking, water, sewage, drainage, irrigation, ... and for drilling and thrust boring.

Plumbing and ducts

- Market shares:

  - asbestos-cement ...... (A)%
  - PVC ...... (B)%

- Price comparison (material $/m)

Ø mm	60	100	150	200
Asbestos-cement				
PVC				

Sewer pipe

- Main sewer (market shares need comparison by range of diameters - %)

Ø mm	100	200	300	400	500	600
Asbestos-cement						
PVC						
Stoneware						
Concrete						
Other material						
Other material						

- Price comparison (material - for same class - $/m)

Ø mm	100	200	300	400	500	600
Asbestos-cement						
PVC						
Stoneware						
Concrete						
Other material						
Other material						

Pressure Pipe

- Water supply (market share needs comparison by range of diameters - %)

Ø mm	100	200	300	400	500	600
Asbestos-cement						
PVC						
Ductile iron						
Other material						
Other material						

- Price comparison (material - for same class - $/m)

Ø mm	100	200	300	400	500	600
Asbestos-cement						
PVC						
Ductile iron						
Other material						
Other material						

Comparative advantages of asbestos-cement pipe versus competitive piping material:

- asbestos-cement / PVC :

  asbestos-cement:
  - durability;
  - resistance to cyclical fatigue;
  - no degradation by ultra-violet;
  - no restriction on applications;
  - in very hot and cold climates;
  - long term proven performance.

PVC:
- light weight;
- ease of installation;
- corrosion resistance;
- impact resistant;
- low price.

- asbestos-cement /ductile iron :

  asbestos-cement:
  - light weight compared to ductile iron;
  - ease of installation;
  - corrosion resistance;
  - durability;
  - joint flexibility (earthquakes);
  - low price.

  ductile iron:
  - impact resistant.

- asbestos-cement / concrete and stoneware :

  asbestos-cement:
  - ease of installation (weight, length, coupling);
  - ease of maintenance and carrying;
  - watertightness (external - internal);
  - joint flexibility.

  stoneware:
  - corrosion resistant.

  concrete:
  - low price.

4.5 MISCELLANEOUS USES OF ASBESTOS-CEMENT PRODUCTS

- For flat sheets:

  - shuttering, shelving, ...
  - electric insulators, ...
  - cooling towers.

- For moulded materials:

  - flower boxes;
  - all kinds of acessories for roofing, siding and piping in asbestos-cement materials.

ASBESTOS CEMENT PRODUCTS - HEALTH AND SAFETY

SYNOPSIS - (SEE ALSO ANNEX 1)

The greatest single use of asbestos fibre is in asbestos-cement products, but there is much less reference to health questions in relation to these products than in relation, for example, to insulation materials, asbestos spray, etc

This no doubt results from the fact that asbestos-cement products are made by a wet process and that, in the finished articles, the asbestos fibres are firmly embedded in cement. For these reasons, the health and safety record of the asbestos-cement industry is a good one and it is indeed possible that the present controversy would never have arisen if use of asbestos fibres in the past had been confined to asbestos-cement and similar products where the manufacturing operation may be safely controlled and in which the fibres are firmly locked into the structure of the product.

Control of asbestos fibres during manufacture of asbestos-cement products does not present the insulation engineer with great difficulty and such records of health problems as exist stem from uncontrolled handling of the raw material before its introduction to the wet process. Such conditions have been eliminated in modern plants which employ automated and enclosed units for opening the bags, preparing the fibre and adding it to the water.

However safe the manufacturing process may be, the use and installation of the material on building sites and elsewhere must clearly be questioned since supervision and control may be more difficult than under factory conditions. At the same time, it is true to say that, however indifferent work people may have been in the past to possible health hazards from asbestos, it is very difficult to find records of adverse health effects of more than a minimal nature among site workers. With modern techniques - which are referred to in detail elsewhere in this publication - any hazards to them under such conditions must approach zero

Numerous measurements of dust levels have been taken both inside and in the vicinity of buildings containing asbestos-cement products. The levels of asbestos fibre dust found in the air have been so low as often to be hardly measurable. As a result, the UK "Simpson Committee"* and other independent bodies have concluded that the presence of such products is unlikely to have produced any noticeable increase in risk to the general public.

The possible effect of small quantities of asbestos fibre in drinking water supplied through asbestos-cement pipes has also been extensively investigated A number of researchers have fed considerable quantities of asbestos to rats and other animals without an adverse effect. Many studies have also been made of the medical history of populations who have been supplied with

* The Advisory Committee on Asbestos (ACA) Chairman: Mr W Simpson

drinking water through asbestos-cement pipes for many decades. Only in one instance* - where the statistical analysis has been questioned - does there appear to be measurable difference between the health of those using such water and those who have used water supplied by other means.

The question of demolition of buildings containing asbestos-cement products also needs tó be considered. Demolition can be a very dusty business but it should be remembered that such dust clouds are short lived and that asbestos-cement building products normally contain only about 12% of asbestos fibre. Recent measurements in Austria have demonstrated that under normal conditions of demolition high concentrations of asbestos fibre are not found in the air. It is necessary, however, that those regularly engaged on demolition work that may involve asbestos-cement products, should be aware that asbestos fibre dust can present a hazard and that precautions must be taken to avoid exposure to dust when appreciable quantities of asbestos-cement are present in structures to be demolished.

Refer to the following publication (see Annex 4):

- AIA-RCP8 : "Repair and Removal of Asbestos Insulation".

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* The Kanarek Study (reference no 17 at Annex 1) has again been questioned by scientists in a recent EPA workshop which evaluated all the researches EPA had funded into ingested asbestos costing millions of dollars over a period of many years. (EPA Summary Workshop on Ingested Asbestos; Cincinnati, Ohio; 14/15 October 1982)

THE ENERGY CONTENT OF ASBESTOS-CEMENT PRODUCTS

In papers submitted to AIA by industry, we noted varying results for the energy content of asbestos-cement products. Ideally we should calculate these results for each country taking account of national data and conditions:

- cement - dry or wet process;

- asbestos-cement production:
  - steam curing;
  - heat curing
  - air curing;
  - productivity.

- stoneware pipes:
  - old or new plants.

- ......, etc

However, we propose, as a first step the following energy ratios comparing asbestos-cement products to competitive materials - for the same use (without consideration of the energy continuously consumed for the 'CATHODIC Protection' of iron pipes).

Energy Ratios of Different Materials

SHEETS (m^2 laid)	
Asbestos-cement sheets	1
Aluminium sheets	4 to 5
Stelvetite	7 to 8
PRESSURE PIPES ø 200	
Asbestos-cement pipes	1
PVC pipes	4 to 6
Cast iron pipes	5 to 8
NON-PRESSURE PIPES ø 200	
Asbestos-cement pipes	1
PVC pipes	3 to 4
Stoneware pipes	4 to 5
Concrete pipes	1

generally steam cured

KWH/t.	FINLAND	IRELAND	SOUTH AFRICA	GREECE	U.K.	ACPPA *	J.M. *	
MATERIEL								
Asbestos			1 872	1 706	1 706	750		
ment			1 760	1 050	1 180	2 205		
lica-waste				100		110		
P.V.C.				17 945		25 291		
uminium				15 000	26 210			
ron + P.V.C.					8 647			
uctile iron						4 807		
ay						110		
Concrete						441		
ESSING								
A.C. sheets			588	42	65,5			
. sheets				8 340	291			
Iron + PVC sheets					6 662			
C. pipes			215	257		1 142		
C pipes				800		595		
Cast iron pipes						4 697		
oneware pipes						3 925		
Concrete pipes						706		
RIAL (total)								
A.C. sheets	1 820		2 208	928	1 018			
. sheets				23 340	26 501			
on + PVC sheets					15 309			
C. pipes	2 260	1 158	1 875	1 211		2 427	2 513	
V.C. pipes				18 745		25 886	20 659	
Cast iron pipes						9 504	9 240	
neware pipes				3 126		4 035		
ncrete pipes						1 147		
GY RATIO								
Sheets (m2 laid)								
C. sheets				1	1			
. sheets				4,4	4,2			
Iron + PVC sheets				,	7,5			
essure Pipes Ø 200								
A.C. pipes				1		1	1	
V.C. pipes				5,7		4,1	4,0	
st iron pipes						8,4	5,7	
Non pressure pipes Ø 200								
A.C. pipes				1		1		
P.V.C. pipes				8,6		2,9		
neware pipes				4,5		4,2		

SUBSTITUTES FOR ASBESTOS AND ASBESTOS-CEMENT PRODUCTS

1. SUBSTITUTES FOR ASBESTOS

There is no one fibre or mineral which can be used as a replacement for asbestos, particularly for manufacturing asbestos-cement products. A substitute material must provide the following qualities:

- High elasticity modulus and tensile strength;
- Large fibre surface area;
- Good adhesion between cement and fibre surface;
- Resistance to ageing and deterioration of the fibre within the cement matrix.

The search for substitutes for asbestos has been going on for many years. However substitutes must meet the following minimum criteria:

- The health risk using them should be less than with asbestos. We should not change a controlled risk for an unknown one.
- They should allow production of technically equivalent materials.
- They should be economically acceptable.

1.1 COST OF SUBSTITUTES (European Industry Sources)

Material	$/kg	Price Ratio
Asbestos	0.55	1
Fibre glass	1.4	2 - 3
Alkali resistant fibre glass	2.7 - 5.0	5 - 9
Steel fibres	1.7 - 12.5	3 - 23
Carbon fibres	25.0 - 50.0	45 - 90
Ceramic fibres	2.0 - 6.0	4 - 10
Polypropylene fibres	1.2	2

1.2 SUBSTITUTES FOR ASBESTOS-CEMENT PRODUCTS

There is no reason for such substitution:

- There is no more health risk for the asbestos-cement worker than in other industries: quarries (for slates and tiles); mines and metallurgy plants (for steel and ductile iron); chemical industries (for plastics).

- The use of asbestos can be and is controlled today.

- The use of asbestos-cement products does not bring any significant environmental pollution.

- In our country the asbestos-cement industry provides ...... (X) thousands of direct employment.

- Asbestos-cement products provide the following economic advantages:

  - low energy content;
  - low expenditure of foreign currency for raw materials;
  - low purchase price;
  - low maintenance cost;
  - durability.

- Asbestos-cement products are well adapted for building and construction and are easy to use on site with the following advantages:

  - standardised and traditional;
  - standard fittings available;
  - adapted to local architecture;
  - weatherproof water and soil resistant.

- The asbestos-cement production process is not a sophisticated one and can be used for large building and construction projects throughout the world, eg: houses (roofing and cladding), pipes (water distribution, sewage, drainage, irrigation).

Section 5

THE ASBESTOS-CEMENT INDUSTRY AND THE ENVIRONMENT

Every human activity, including that of industry, can affect the environment if it does not control the emission of pollutants and the production of waste.

Asbestos fibre is transported from the mine to the factory in a manner that stringently controls the possible release of asbestos. Impermeable bags are used, usually in pallets and in closed containers. This avoids dust emission during transit (lorries, boats, trains, etc).

Asbestos-cement products can be manufactured in the plant using engineering controls without any significant influence on the environment. This is because air emissions can be controlled by using efficient filtration devices where any asbestos or asbestos-cement dust is produced.

For example the French regulations set the following standards:

- < 0.1 mg/Nm^3 for asbestos dust
- < 0.5 mg/Nm^3 for asbestos-cement dust.

The asbestos-cement process uses a high volume of water, but it works in an almost closed flow circuit. The quantity of waste water discharged is low and it also has a low asbestos content. Its quality after treatment therefore does not significantly affect the environment.

For example the French regulations set the following standards:

- Quantity = 0.2 - 0.7 m^3 T asbestos-cement produced
- Quality = 5.5 $<$ pH $<$ 8.5
  temperature $<$ 30°C
  suspended matter $<$ 30 mg/litre
  BOD 5 $<$ 40 mg/litre
  COD $<$ 120 mg/litre
  Cr VI $<$ 0.1 mg/litre
  Hydrocarbons $<$ 5 mg/litre

Manufacturing waste is recycled as far as possible and the non-recycled part deposited in licensed tips:

- Asbestos and asbestos-cement dust are damped and put in appropriate closed containers.

- Sludge from water treatment is dried to avoid dispersion during transport unless special sludge-tankers are used.

- Bags which have contained asbestos fibre are placed in appropriate closed containers for recycling or disposal by burying.

The waste which must be put in a licensed tip is progressively covered with an adequate layer of earth under controlled conditions to comply with regulations. Refer to the following: AIA-RCP 3 - 'Asbestos Waste Materials'.

Section 6

THE INTERNATIONAL STANDARDISATION OF ASBESTOS CEMENT PRODUCTS

SYNOPSIS - (SEE ALSO ANNEX 2)

Product standardisation is now generally acknowledged to be one of the most important phases of industrial production and application.

The International Standardisation Organisation (ISO) is the international institute whose purpose is to promote the preparation, co-ordination and circulation of the Technical Standards referred to in the specifications governing commercial exchanges between countries.

The ISO standards are also the reference points for setting up national standards.

In so far as asbestos-cement products are concerned, there is a specialised Technical Committee (ISO/TC 77) within the ISO whose title is 'Products in Fibre Reinforced Cement'. The Swiss standardisation association (SNV) is responsible for the secretariat.

There are at present seventy-one countries represented on the ISO/TC 77 Committee, thirty-three of them with the right to vote, the others being observers.

The ISO/TC 77 Technical Committee is one of the most active in the ISO and does its work through Study Groups and Task Forces. At the time of writing, three Study Groups and three Task Forces have been set up and carry out activities in connection with asbestos-cement products.

Of all the products used in civil engineering (construction of buildings and hydraulic structures), asbestos-cement products have the largest number of ISO standards.

At the time of writing there are eleven ISO standards already published, seven ISO standards being published and seven draft ISO standards in process of preparation.

Some of these standards concern the use of asbestos-cement products and are an extremely valuable and much appreciated aid to design engineers and to users.

One of the draft standards is of special importance. This concerns instructions to be observed during work-site operations in order to protect both the health of workers on the site and the local environment. This is considered to be a highly modern 'ecological' standard which demonstrates the sense of responsibility of the asbestos cement industry.

ASBESTOS CEMENT PIPES

"Water Means Life

> "Open a kitchen tap of clean gushing water: it represents a fantasy for half of humanity. For one person in two in the world the first priority, of clean water in abundance, is simply not there."

Extract from UNICEF, United Nations Children's Fund Publication, June 1982.

Asbestos-cement pipes have been in widespread use within Europe, America, the USSR and Japan, as well as many other water authorities throughout the world, for well over fifty years. Asbestos-cement pipes are used extensively for water supply and distribution as well as for sewage pumping and disposal in both rural and urban environments involving many different conditions and terrains.

It is true to say that manufacturers do not just make asbestos cement pipes; they are in the business of supplying pipelines to meet the specification and criteria of the design engineer, who in turn seeks to meet the needs of the people.

The basic problems in the carrying of liquids are well-known and can be summarised as:

1. Volume of liquid to be carried.
2. Throughput of liquid.
3. Distance to be carried.
4. Terrain to be crossed (mountain, desert, valley, etc).
5. Soil conditions to be considered.
6. Friction and head of pressure.

The next considerations are concerned with:

a. Durability - length of operational life.

b. Long term strength.

c. Immunity to electro-chemical corrosion.

d. Resistance to internal encrustation.

e. Resistance to tuberculation.

f. Carrying capacity not diminished with time.

g. Minimum maintenance needed.

h. Availability of material and comparatively low cost.

In most developed countries it is normal to use trunk mains less than 900 millimeteres in diameter but in developing third world countries, facing the problems of vast areas and distance with a wider range of different soil conditions, larger diameter pipes have been found to achieve the performance characteristics at an economical cost.

The use of crocidolite in large-diameter asbestos-cement pipes adds to the structural integrity of the product but the critical key factors are better drainage leading to easier manufacture at less cost, and improved chemical resistance to withstand aggressive soils or water, and erosion, etc. Large diameter asbestos-cement pipes are not only used for water and sewage conveyance but are also used for thrust boring, pipe jacking, multi-cable and service ducting (tunnels) and man-holes.

Broadly speaking, asbestos-cement pipes offer a user six main benefits. These are:

1. Long operational life.

2. Long-term strength.

3. Immunity to corrosion.

4. Minimum maintenance.

5. Light weight compared with most other pipes.

6. Watertight joints for inside and outside pressures.

As you would expect, the highest importance is attached to the quality of manufacture and the testing of the finished product. Both require the very best in capital equipment and resources. Equally, both must be supported by well-established production skills and experience of the sort which have been traditionally associated with the manufacture of this type of product since the late 1920s.

The manufacturing process itself involves a controlled mix of approximately 85% ordinary Portland cement and 15% asbestos-reinforcing fibres. Both materials are inherently stable and have a natural bonding affinity for each other. The characteristics of Portland cement, particularly in relation to its use in concrete, are well established. It is universally accepted that the material has few natural occurring enemies. As a general rule, when it is used in conjunction with either concrete or asbestos fibre, the extent to which it is susceptible to attack varies inversely with the degree of consolidation.

The manufacturing process results in a pipe made of a composite material which is homogenous, highly compact, tough and easily machineable, allowing an extremely smooth finish to bores. Pipe ends are subsequently machined, with internal and external coatings being applied as a standard option for those applications where particularly aggressive ground conditions may be expected.

Irrespective of coating, however, all finished products are subjected to stringent dimensional checks, quality control and inspection procedures. These include the hydrostatic testing of every pipe to twice its maximum rated constant operating pressure. Those of large diameter are subjected to similar testing to two-thirds more than their maximum rated constant operating pressure.

These basic principles of manufacture have been progressively developed and refined over many years. So too have associated jointing methods for use in the field. The latest of these is the flexible joint by which pipes may be connected directly in a trench using levers and protective wooden blocks. For larger diameters, pre-socketing of pipes at the side of a trench using a mounting mechanism is normally advisable.

Joints are made by first cutting thickened pipes into short collars. These are then machined to give the correct internal profile, including the two grooves into which rubber sealing rings are locked after jointing. The close tolerances to which bores of joints and spigots of pipes are manufactured contribute, of course, towards the accepted high performance of the pipes. For this reason, manufacturers of asbestos-cement pipes attach the highest importance to giving users as much assistance as possible by providing detailed but easily understood jointing instructions.

For water distribution systems in particular, there may often be a need to connect pipes of differing materials. In these cases, asbestos-cement pipes may be connected without difficulty to iron or PVC pipelines either by flanged adaptors or by stepped 'Viking Johnson' couplings. In some applications, it may be necessary to drill and tap pipes under pressure to receive ferrules for, say, house-service connections. Once more, these pose no particular problems for easily machineable asbestos-cement pipes for which ferrules of the plain shank or threaded type are readily available.

An important consideration for pipeline design of course is that concerning the magnitude of pressure head dissipated in overcoming friction, whether the main is under gravity or pumped flow. It is evident from the roughness value, $K_s = 0.025$ mm recommended for asbestos-cement pressure pipes in the 'Colebrook-White' equation that bores of this type of pipe have an extremely smooth finish. As a result, practical experience of pipes in service over many years has shown that they are not subject to tuberculation. Similarly, it has also been shown that carrying capacity is not significantly reduced with the passage of time.

Beam strength is not a problem with small diameter pipes, assuming that they have been properly bedded, laid and jointed. 200 mm diameter pressure pipes, for example, have a section modulus approximately twice that of the 150 mm size, and the modulus continues to increase rapidly with further corresponding increase in pipe diameter. Within the range 300-750 mm, therefore, beam strength no longer becomes a key factor in design, Of much greater importance is a proven strength which can adequately withstand the effects of internal pressure - including surge pressure - and external loading acting in combination.

In meeting these considerations, asbestos-cement pipelines for water supply and distribution requirements have been shown to be fully capable of withstanding heavy traffic loading conditions over many years. Moreover, as we have seen, since asbestos-cement itself is a rigid material, the pipes are not susceptible to fatigue. On the contrary, they are perfectly capable of coping with some of the rather more dramatic stresses of nature. Recent official reports by Greek water supply authorities, for example, have shown that pipes of this type which form a significant part of the underground water supply and sewerage networks of Athens and surrounding areas, have fully maintained their strength and jointing integrity during a recent series of earthquakes. Following detailed inspections of all networks, no incidence of pipe damage has been recorded (see Section 9).

Potential Health Hazard?

The concerns about asbestos ingested in drinking water emanate from the observance of disease in occupational workers; principally asbestos miners and millers and insulation and factory workers. These worker groups were exposed to heavy and prolonged concentrations of airborne asbestos fibres, a large portion of which were cleared from the lungs and swallowed. The argument that the exposure of asbestos workers is directly relevant to the ingestion of asbestos in drinking water is a specious one.

In the estimation of risk from asbestos ingestion, the best source of information would be human ingestion studies; the next best would be animal ingestion studies; and the third best would be human or animal studies where the asbestos enters the body by some route other than ingestion. In this last case, ie secondary route of entry, any cause-and-effect relationship inferred would be tenuous. So, it is extremely important that all of the available information be considered.

The Safe Drinking Water Committee of the US National Academy of Sciences (NAS) expressed its views on the problem of extrapolating from inhalation to ingestion, stating:

> "The fact that exposure to air heavily polluted with asbestos mineral fibres often leads to the diseases mentioned above does not necessarily indicate that drinking water contaminated with an equally large number of such fibres may lead to the same diseases or perhaps some other diseases."

NAS is not alone. Similar conclusions have been drawn by independent scientists and an American Water works Association Research Foundation Select Committee which considered the question of the health hazard of asbestos in drinking water.

THE BEHAVIOUR OF ASBESTOS-CEMENT PIPES IN CORROSIVE MEDIA

An important argument for the application of asbestos cement pipes to the conveying both of potable water and of sewage is their high resistance to most corrosive media encountered in the normal environment.

The durability of asbestos-cement pipes is a function of their reaction with the surrounding medium and the characteristics of the fluid conveyed.

Any corrosive process is either a chemical or an electro-chemical reaction taking place between the material concerned and the substances in the medium surrounding the pipe. In all cases in which electro-chemical corrosion may be expected, the main condition for its appearance is high electrical conductivity of the pipe materials. Asbestos-cement is not a good electrical conductor so that an electro-chemical reaction will not take place. This is a big advantage compared with steel and cast iron pipes where a cathodic protection must be provided. Asbestos-cement pipes may be attacked chemically either by the fluid being carried from the inside or by a wet soil from the outside, respectively called internal or external corrosion.

Corrosion of asbestos-cement pipes whenever it occurs may often be noticed by a softening penetration into the pipe's surface up to, and only up to, a certain depth. This softening of the affected surface is the result of an attack on the calcium compounds in the cement matrix which leaches them out and leaves layers of interwoven fibres. If this occurs, the products of the chemical reaction may be either soluble or insoluble. The soluble products will be dissolved and washed out leaving a soft net of asbestos fibres; the insoluble product remaining will fill the tiny voids in the structure. Asbestos fibres are absolutely inert and cannot be attacked and corroded by substances which are normally encountered in ground water, sewage and potable water.

It is because of this that the corrosion resistance of asbestos-cement pipes basically depends on the chemical resistance of the cement matrix in the material. When the reaction products are insoluble the corrosion process is non-linear which means that the progress of the chemical attack is not one steadily increasing with time but one which usually occurs at a decreasing rate. With advancing corrosion of the cement matrix, the closely interwoven asbestos fibre nets will gradually become thicker, thus creating a dense sieve which will protect the deeper layers of the material and slow down further deterioration. This means that as a result of corrosion penetrating into the wall, provided that the corrosion products are insoluble, a self-protecting layer is formed which slows down further corrosion and, in certain circumstances, will stop the process completely. This phenomonon of self-protection which was observed in field and laboratory tests, is an important characteristic of asbestos-cement material.

One might ask the question: which chemical agents are liable to attack asbestos-cement pipes? The answer to this question is not so easy. Due to the fact that the material consists of about 85% of cement stone, it contains large proportions of calcium bound with aluminates, carbonates, silicates and hydroxides and also some magnesium compounds. All these are of a typical alkaline character and therefore in general vulnerable to acidic materials which may be regarded as corrosive whereas alkalis do not attack asbestos-cement in normal conditions.

Concluding, we can say that asbestos-cement, because of its dense structure and its very low water-cement factor (WC = 0.28), performs much better than other cement materials (concrete!). With ageing the calcium compounds will be gradually carbonised giving an insoluble calcium carbonate which cannot be attacked.

Care should be taken with corrosive media with low pH 6-5.8 sulphates and aggressive carbon dioxide (CO_2). In these cases a coating should be provided or, as sulphate attack may be expected, a sulphate-resistant cement should be applied in the manufacture of the pipes.

Indication	Without protection	External protection	Internal protection			
Type of lining	-	Coaltar	Bitumen	Coaltar	Epoxy-tar	Epoxy
pH	$\geqslant 6$	$\geqslant 4,5$	$\geqslant 4,5$	$\geqslant 4,5$	$\geqslant 3,5^{(*)}$	$> 3,5^{(*)}$
Titration acidity - ml Na OH N/10 per 100 g of soil	< 20	< 30	-	-	-	-
Hardness of the water - dF. French degrees (1 dF = 10 mg/l CaCO3)	> 5	no limit	no limit	no limit	no limit	no limit
Aggressive CO_2 - mg/l CO_2	(**)	< 30	< 30	< 30	no limit	no limit
SO_4 mg/l relatively Cl mg/l	Cl / SO_4 0 < 500 3000 < 800 5000 < 1430	no limit	no limit	no limit	no limit	no limit
NH_4 mg/l	< 80	no limit	no limit	no limit	no limit	no limit
MgO mg/l relatively SO_4 mg/l	SO_4 / MgO 0 < 2000 200 < 700	no limit	no limit	no limit	no limit	no limit
Alkaline solution %	$< 10\%$	no limit	no limit	no limit	no limit	no limit
Vegetable oils and fats mg/l	< 300	no limit	300	no limit	no limit	no limit
Light alcohols and non polar solvents - Esters-Wax-Fat s - Benzol - Toluol	no resistance	no resistance to esters	no resistance to esters no resistance	no resistance to esters no resistance	no resistance to ersters no resistance of lining	no resistance to esters no resistance of lining
Heavy alcohols and polar solvents - Glycol-Glycerine-Acetone - Phénol mg/l - Sugar In case of fermentation with production of CO_2 - Acetic acid - lactic acid ...	no resistance < 70 no attack no resistance	no resistance $\leqslant 1000$ no limit risk depends on pH	no resistance $\leqslant 1000$ no limit risk depends on pH	no resistance $\leqslant 1000$ no limit risk depends on pH	no resistance $\leqslant 10.000$ no limit risk depends on pH	no resistance $\leqslant 10.000$ no limit risk.depends on pH

(*) - No risk for lower pH value during short time
(**) - Due to the complexity of soft water equilibrium the chemist of the AC producer should be consu

(*) [illegible]

THE BEHAVIOUR OF ASBESTOS CEMENT PIPES DURING EARTHQUAKES

SYNOPSIS - (See also ANNEX 3)

There is considerable evidence over many years and from a number of places to demonstrate the excellent performance of asbestos-cement pipes during earthquakes. These examples include the Senegallia earthquake (Italy, 1962), Los Angeles (USA, 1971), Ancona (Italy, 1972-1974), Frioul (Italy, 1976), Thessaloniki (Greece, 1978) and Attica (Greece, 1981).

To account for this performance, experts have studied the effects of an earth tremor and have categorised three separate types of movement.

Firstly there is a 'shaking' action during which there is no actual movement of the earth mass but simple oscillations occur of an undulatory type.

Then there is a 'fault displacement' action the effect of which is to cause masses of earth to move against one another.

Lastly there is a third type of action due to 'ground failure' which causes specific areas to subside.

No type of pipe can withstand the effect of either of these last two earth movements.

Only pipes defined as 'elastically discontinuous' can withstand the first type of action, which is the most frequent one, ie 'shaking'. However, in order to construct an 'elastically discontinuous' pipeline it is not necessary to use a pipe with elastic properties. On the contrary, it has been shown that pipe elasticity is a disadvantage because bending the pipe produces slippage of the joint if the latter is of the elastic type; or else if the joint is welded or bonded it creates severe longitudinal tension with the possibility of breaking the joint.

To produce an 'elastically discontinuous' pipe it is essential to use elastic and discontinuous joints which enable the whole pipeline to behave in the same way as a chain.

The closer the intervals of the elastic joints along the pipeline, the better its behaviour will be. It has been found that the ideal practical length of pipe is a maximum of five metres.

The explanation of the excellent behaviour of asbestos-cement pipes during earthquakes lies in the type of joint used, which is a sleeve with two rubber packings. It has been found that two rubber packings give the joint a degree of elasticity which is double that of a single rubber packing, which is the type found in iron, reinforced cement, sandstone and PVC pipes.

The tolerances for axial movements in a joint with two rubber packings are greater than those in a joint with only a single packing. Moreover, the joints contain elastic spacers which prevent the two ends of the tubes from striking one another and thus being damaged.

The standard length of asbestos-cement pipes is four or five meters depending on diameter; and these lengths completely meet all known technical and economic requirements. Nevertheless, the method of manufacturing asbestos-cement pipes, as opposed to other materials, can easily be adapted to produce shorter sections (generally half the standard length); thus the particularly difficult requirements can be satisfied which are found in unfirm or sandy ground, or that subject to earthquakes.

ASBESTOS AND HEALTH

Asbestos is one of many substances that can, with excessive exposure, cause disease in humans. However, most of these materials including asbestos and asbestos-containing materials can be used safely without any increased health risk either to workers manufacturing or handling the products or to the general public.

1. AIRBORNE ASBESTOS DUST (Inhalation)

1.1 DURING MANUFACTURING

Excessive exposure to and prolonged or heavy inhalation of airborne asbestos dust can lead to ASBESTOSIS, a scarring of the lung tissue which impairs breathing and to an increased risk of LUNG CANCER, the risk being exacerbated by smoking cigarettes. To a much lesser degree, asbestos dust may cause MESOTHELIOMA, a rare cancer of the lining of the chest or abdomen. There are conflicting reports of increased risk to gastro-intestinal cancer following excessive exposure to airborne asbestos dust (1,2).

All identified occurrences of these diseases attributed to asbestos, have involved exposures in, or related to, occupational settings. These occupational diseases normally show up after a period of fifteen to forty or more years after the first exposure. The cases presently occurring are the unfortunate result of working conditions that were very different from those encountered today. Dust levels at that time were 100 or even 1,000 times higher than at present and little was known about the potential health problem.

In many countries, a maximum acceptable concentration of 2 f/ml (L $>$ 5 μm - O $<$ 3 μm) over a normal working period has been adopted by the regulatory agencies. Refer to the following publications (see Annex 4):

AIA - RCP1 - "The Control of Asbestos Dust"
AIA - RTM1 - "Reference Method for the Determination of Airborne Asbestos Fibre Concentrations at Workplaces by Light Microscopy"

1.2 DURING ON-SITE OPERATIONS

The handling and use of asbestos-cement products - in which the asbestos fibres are encapsulated in the cement binder - are basically dust-free operations. The adaptability of asbestos-cement products and the availability of standard fittings greatly minimise the need for field operations.

Even in the most confined working space dust levels are barely measurable. A survey conducted by the Port of Tyne Authority in England measured dust levels in the hold of a ship loading asbestos-cement pipes. The highest dust measurement was 0.01 f/ml - one fiftieth of the general accepted standard (3).

When cutting, machining or finishing are necessary, fibre levels will be below present standards and the risk of working with asbestos-cement materials is virtually non-existent when the recommended work practices in the following publications are followed (see Annex 4):

AIA - RCP2 - "Asbestos Cement Products"
AIA - Insert to RCP2 - "Catalogue of Tools for Working with Asbestos-Cement Products on Site"

1.3 IN THE GENERAL ATMOSPHERE

In the total dust present in the atmosphere, asbestos fibres have been detected by electron microscopy. A recent research programe initiated by the Austrian asbestos-cement industry, supported by the Federal Austrian Ministry of Health and Environmental Protection was carried out by the Institute for Environmental Protection and Clean Air (Leoben, Austria) during the period 1978-80 (4). This study assessed that the asbestos fibre concentrations in a village with asbestos-cement roofing were of the same order of magnitude as in another village without asbestos-cement roofing. The average asbestos fibre concentrations found from weathering asbestos-cement products were below 0.1 f/l within the detection limit of the applied measuring technique (SEM) and lower by a factor of 10^{-4} than the TLV considered as safe in the workplace.

Such low asbestos fibre concentrations do not present an increased health risk for the general population, according to medical experts.

"Report of the Advisory Committee on asbestos cancers to the Director of the IARC" 1972 (5).

"Is there evidence of an increased risk of lung carcinoma at low levels of exposure to asbestos, such as have been encountered by the general population in urban areas?

"The evidence of an exposure-response relationship based in part on past dust measurements and in part on the type of job within the industry suggests that an excess lung carcinoma risk is not detectable when the occupational exposure has been low. These low occupational exposures have almost certainly been much greater than that to the public from general air pollution."

"Is there evidence of an increased risk of mesothelial cancers at low levels of exposure to asbestos, such as have been encountered by the general population in urban areas?

"There is evidence of an association of mesothelial tumours with air pollution in the neighbourhood of crocidolite mines and of factories using mixtures of asbestos fibre types. The evidence relates to conditions many years ago. There is evidence of no excess risk of mesotheliomas from asbestos air pollution which has existed in the neighbourhood of chrysotile and amosite mines. There are reported differences in the incidence of mesothelioma between urban and rural areas, the causes of which have not been established. There is no evidence of a risk to the general public at present."

"Is there evidence of a risk of lung fibrosis from low levels of exposure to asbestos such as have been encountered by the general population in urban areas?

"There is at present no evidence of lung damage by asbestos to the general public The amount of asbestos in the lungs of members of the general public is very small compared to those occupationally exposed. It is greatest where asbestos is mined or worked, and lowest in rural areas."

"'Public health risk of exposure to Asbestos'. Report of a Working Group of experts prepared for the Commission of the European Communities (1976) (6)."

In the general conclusion:

"There is no established evidence that true ambient exposure through air, water, drugs, beverage or food, as prevalent in western European countries at this moment carries such a definite health risk. However, there exist too many uncertainties to deny such a risk, though if the risk was substantial it is likely it would have been detected by now."

2. <u>ASBESTOS FIBRES IN FOOD AND BEVERAGES</u> (Ingestion)

In contrast to inhalation, a clear 'cause and effect' relationship between ingested asbestos and gastro-intestinal cancer does not exist.

The prevalence of asbestos in soil results in its presence in most lake, river and well waters and in many distribution systems regardless of the piping material utilised.

Tapping asbestos-cement pipe to provide house connections also can contribute asbestos to drinking water. We recommend when tapping asbestos-cement pipe while under pressure, that equipment with a positive purge be used. This ejects 99% of the asbestos-cement chips and downstream flushing takes care of the rest.

Field measurements confirm laboratory results that asbestos-cement pipe does not contribute significant or in many cases even measureable amounts of asbestos to drinking water conveyed through it, certainly far less than was found in many natural source waters.

One must keep in mind there is neither a quantifiable nor a predictive relationship between any corrosion index and levels of asbestos released from asbestos-cement pipe into drinking water.

- North-east Illinois - an analysis of fifteen public water systems containing asbestos-cement pipes of various ages, length and diameters: "No significant release of asbestos from asbestos-cement pipe."

- California - an analysis of water from a distribution system with nearly 1,000 miles of asbestos-cement pipes: "Asbestos levels below detectable limits."

- Texas, Ohio and Connecticut - EPA studies of asbestos-cement pipe systems. Fibre level "not statisticaly significant" or "below detectable limits".

In animal experiments, mice, rats, hamsters and baboons have been watered, force-fed or have freely consumed as much as 6% asbestos in their food intake without evidence of tumour production (8,9).

During recent years:

- The Health Research Institute at Fairleigh-Dickinson University reported: "No malignant tumours related to treatment in hamsters maintained on drinking water containing thirteen billion asbestos fibres per litre."

- Summary minutes of the National Toxicology Board of Scientific Counsellors peer review of the carcinogenesis bioassay of asbestos fed to Syrian golden hamsters. The conclusions state: "Under the conditions of the bioassay, the ingestion of short range and intermediate range chrysotile asbestos was not carcinogenic in male and female Syrian golden hamsters."

  Similar conclusions were drawn with respect to amosite.

Substantial epidemiological evidence exists that the ingestion of asbestos in drinking water does not cause cancer. Studies of populations exposed to asbestos in drinking water supplies have been conducted in Connecticut (10,11), Duluth (12,13), Canada (14,15) and Pacific Northwest (16) where millions and in some cases billions of asbestos fibres per litre are present in the drinking water. These studies have been conducted for at least ten years, some using date bases extending for up to thirty-five to forty years, well beyond the latency period for cancer. All such studies have failed to show a carcinogenic risk from ingesting asbestos in drinking water.

- Eunice E SIGURDSON, principal investigator of an epidemiological study conducted by the Minnesota Department of Health reported: "In our opinion there are currently no observed etiologic or causal associations between exposure to amphiboles (asbestos) fibres in the Duluth drinking water supply and the development of cancer." (1981)

These results are similar to those reported in earlier studies by:

- MASSON et al (1974) (12)

- LEVY-SIGURDSON et al (1976) (13)

- The Health Protection Branch Department of National Health and Welfare (Ottowa) examined a number of municipalities across Canada for statistical links between asbestos in drinking water and cancer mortality rates (TOFT, WIGLE et al, 1981) (15).

  Their main conclusion is: "The mortality rates for persons living in two localities in which asbestos is present at high concentration in water samples from the distribution system were analysed. Although there are serious limitations to this type of study, no consistent increase of cancer mortality rates for any cancer rate was demonstrated. This finding is consistent with a previous, but more limited, epidemiology study carried out in Quebec." (WIGLE) (14).

- The only epidemiological study to suggest a positive statistical correlation between asbestos ingestion and gastrointestinal cancer was presented by KANAREK, CONFORTI et al (17). The California Department of Health has stated that the study does not establish "any causal link" between asbestos in drinking water and cancer (18), and the study is not considered "definitive" by EPA (19). The study's authors also have recognised the limited predictive value of the study, stating in their report that studies such as this can only suggest associations and cannot pinpoint definite causation.

  A peer review of the San Francisco study concluded that, beyond the lack of control of ethnicity, occupational exposure to asbestos, dietary or smoking habits, alcohol consumption or exposure to other potential carcinogens in water, the study did not adjust for population density (people who live in more crowded areas when the population density is higher consistently manifest higher cancer rates). This serious experimental flaw led independant epidemiologists to conclude that the findings of this study simply are not valid (21,22, 23)*.

(* See also footnote to Section 2)

Experts' conclusions:

- Report of the Advisory Committee on Asbestos Cancer to the Director of the IARC (1972) (5): "Is there evidence of an increased risk of cancer resulting from asbestos fibres present in water. beverages, food or in the fluids used for the administration of drugs? Such evidence as there is does not indicate any risk."

- National Cancer Institute (1976): "NCI scientists ... have found no unusual cancer mortality patterns so far among persons residing where drinking water is contaminated by asbestos ... " (20).

  'Public Health Risk of Exposure to Asbestos' Report of a Working Group of experts prepared for the Commission of the European Communities (1976) (6).

In the general conclusion:

- "There is no established evidence that true ambient exposure through air, water, drugs, beverage or food, as prevalent in western European countries, at this moment carries such a definite health risk. However there exist too many uncertainties to deny such a risk, though if the risk was substantial it is likely it would have been detected by now."

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(21) Letter from Dr Higgins to the American Journal of Epidemiology, 1981: Volume 114 (1) 16.1.162.

(22) Letter from Dr K Browne to the American Journal of Epidemiology, 1982: Volume 115 (1).

(23) Letter from Dr K Browne and Dr R Murray to the LANCET; 22 August 1981.

Annex 2

INTERNATIONAL STANDARDISATION OF ASBESTOS-CEMENT PRODUCTS

1. STANDARDISATION IN THE MANUFACTURING PROCESS

Product standardisation is now generally acknowledged to be one of the most important phases of industrial production.

Industrial technology made stupendous progress in the twentieth century and it is no longer conceivable that there are products whose technical characteristics are not defined standards.

At the beginning of the twentieth century, and also after the First World War, the standardisation process of a product mainly concerned dimensional standardisation in order to ensure the assembling and the interchangeability of parts.

However, with industrial progress and the development of new industrial technologies applicable to a given product, the standardisation procedure was extended and now governs not only dimensional characteristics but also regulations applicable to the physical and mechanical properties of the product.

Another step forward took place after the Second World War when the standardisation process started to play a role in the utilisation field by defining the rules to be observed for the use and end goal, and this in the widest sense. In other words, the drawing up of the project in which the standard product will be employed, its installation, its control during functioning, and through this, the functioning itself.

2. STANDARDISATION IN INTERNATIONAL RELATIONS

The most advanced industrialised countries were faced with the need to have technical standards and, to satisfy this requirement, created their own standardisation authorities which were officially recognised by their respective governments.

Other countries adopted the standards enforced in countries with which they had the most important and frequent commercial relations. However, with the breaking down of commercial frontiers, this special relationship decreased which gave birth to the need for international standardisation.

3. ISO - INTERNATIONAL STANDARDISATION ORGANISATION

ISO is an international institute whose goal is to encourage the development, co-ordination and dispatching of unified industrial standards at the international level. These standards may be used as a reference for the drawing up of national standards and also to define technical conditions when impartiality and freedom of choice of commercial conditions between various countries make it necessary to avoid the use of national standards.

ISO standards, therefore, have an ever-growing importance and are seen as setting the seal of quality on industrial products.

4. ASBESTOS-CEMENT PRODUCTS AND ISO STANDARDS

Naturally, asbestos-cement products have had to meet ISO standards as these products have been widely used throughout the world during the last fourteen years and as it is impossible to replace them completely by other products in their civil engineering, industrial and hydraulic (1) applications.

A special ISO technical committee deals with asbestos-cement products. This is the ISO/TC 77, called PRODUCTS IN FIBRE REINFORCED CEMENT. The Secretariat of this Committee is provided by the Swiss Standardisation Association (SNV) whose head office is at RAPPERSWIL (2).

(1) C Pirani: "Amianto-cemento; un prodotto di base per opere edili ed idrauliche e servizio dell'uomo." 4° Conferenza Internazionale sull' amianto; Torino, 26-30 maggio, 1980.

(2) ISO/TC 77, Holweg 3, CH 8640 Rapperswil. Telephone: (55) 273357.

Seventy-one countries participate in the workings of the ISO/TC 77 Committee (countries recorded at the end of 1981). These countries are listed in Table A (Annex).

The ISO/TC 77 Technical Committee also liaises with other specialised international authorities. The list of these authorities at the end of 1981 is given in Table B (Annex).

4.1 HOW AN ISO STANDARD IS CREATED FOR ASBESTOS-CEMENT PRODUCTS

To create a standard, ISO procedure requires that after the request is formulated by a member country and examined, a study group (SG) is set up whose task is to examine the request and to give the main lines to be followed during the standard drafting, if there are no objections. The process starts with a draft proposal (DP) which is drawn up by a working group (WG). If the initial study of the standard by a study group is not deemed necessary, the draft proposal is drawn up directly by the working group.

Decisions are taken by majority by the Full Assembly of the ISO/TC 77 Committee on the discussions concerning the previously described procedure. The Committee generally meets every two years.

The Full Assembly seat is selected by the General Secretary of ISO taking into account the offers received from the various countries involved in order to rotate the seat from country to country and to ensure full and complete impartiality.

4.2 THE ISO STUDY GROUPS AND WORKING GROUPS FOR ASBESTOS-CEMENT PRODUCTS

The working groups and study groups comprise a set number of specialists/experts on the subject of the document being drafted.

At the present time three study groups and ten working groups have been made up and are studying all asbestos-cement products. Table C gives the list of these groups and also the logo of the national standardisation authority which provides the secretariat for each group.

Table C - Study Groups and Working Groups for Asbestos Cement Products in the ISO/TC Committee (Annex - Table C)

Fifteen meetings took place in 1981 (five study group meetings and ten working group meetings), at various locations. This shows the busy schedule of the ISO/TC 77 Technical Committee as regards asbestos-cement products. In fact, this is one of the most active committees of all the ISO committees.

4.3 ISO STANDARDS OF ASBESTOS-CEMENT PRODUCTS ARE A GUARANTEE OF QUALITY

Of all products used in civil engineering works (hydraulic constructions and construction of buildings), asbestos-cement products are among those covered by the largest range of ISO standards.

These standards have a very important role as regards function and quality selection and prevent lower quality products from being marketed.

Tables D, E and F below list the standards which have already been published, the standards which will be published in the near future and those being prepared.

- Table D : ISO standard already published.
- Table E : Draft standards being approved or to be published in the near future.

- Table F : Projects of standards being drafted (DP) and revision projects for existing standards (DR).

Tables D, E and F show that all widely used asbestos-cement products are covered by an international ISO standard.

Certain products are also standardised as regards use. This concerns pipes for buried pipelines for which there are not only ISO standards concerning technical specifications (ISO 160, ISO 881, ISO 4488) but also standards for laying (ISO 4482), acceptance tests on-site (ISO 4483), stability calculations (ISO 2785) and hydraulic calculations for project drafting (DIS 7336).

4.4 ASBESTOS-CEMENT TAKES ECOLOGICAL PROBLEMS INTO ACCOUNT

DIS 7337 standard is very important and is called: 'Guide for On-Site Work Practices for Asbestos Reinforced Cement Products.'

This is an ecological standard which sets down the regulations to be observed during site work in order to protect the health of workers installing this type of product as well as the environmental ecological environment. This is, therefore, a very up-to-date standard. The asbestos-cement industry is aware that in these days industrial activity can no longer be disassociated from problems linked to ecology and through this standard wanted to set an example and prove quality.

Tables A-F attached.

TABLE A

COUNTRIES PARTICIPATING IN ISO/TC 77

P	O	Countries	P	O	Countries
		Albania (BSA)			Korean People's Democratic Republic (CSK)
		Algeria (INAPI)			Libya (LYSSO)
x		Australia (SAA)		x	Malaysia (SIRIM)
x		Austria (ON)	x		Mexico (DGN)
		Bangladesh (BDSI)			Mongolia (MSC)
x		Belgium (IBN)	x		Morocco (SNIMA)
x		Brazil (ABNT)	x		Netherlands (NNI)
	x	Bulgaria (DKC)	x		New Zealand (SANZ)
x		Canada (Scc)			Nigeria (NSO)
	x	Chili (INN)		x	Norway (NSF)
x		China (CAS)		x	Pakistan (PSI)
x		Colombia (ICONTEC)			Peru (ITINTEC)
	x	Cuba (NC)			Philippines (PS)
		Cyprus (CYS)	x		Poland (PKNiM)
x		Czechoslovakia (CSN)	x		Portugal (DGO)
x		Denmark (DS)	x		Rep of South Africa (SABS)
		Dominican Rep (DIGENOR)	x		Rumania (IRS)
	x	Egypt (EOS)		x	Saudi Arabia (SASO)
	x	Ethiopia (ESI)		x	Singapore (SISIR)
x		Finland (SFS)	x		Spain (IRANOR)
x		France (AFNOR)		x	Sri Lanka (BCS)
x		German Federated Rep (DIN)			Sudan (SSD)
		Ghana (GSB)			Sweden (SIS)
x		Greece (ELOT)	x		Switzerland (SNV)
	x	Hungary (MSZH)			Syria (SASMO)
x		India (ISI)			Tanzania (TBS)
	x	Indonesia (YDNI)	x		Thailand (TISI)
		Iraq (IOS)			Trinidad & Tobago (TTBS)
x		Ireland (IIRS)		x	Turkey (TSE)
x		Israel (SII)	x		United Kingdom (BSI)
x		Italy (UNI)	x		USA (ANSI)
		Ivory Coast (BIN)	x		USSR (GOST)
		Jamaica (JBS)	x		Venezuela (COVENIN)
	x	Japan (JISC)			Vietnam (TCVN)
	x	Kenya (KEBS)	x		Yugoslavia (JZS)
	x	Korean Republic (KES)			

(x) P (participant) countries and O (observer) countries.

TABLE B

SPECIALISED INTERNATIONAL ORGANISATIONS CONCERNED WITH ISO/TC 77

Initials	Short Title of International Organisation
CCE	Commission of the European Communities "The Removal of Restrictive Trade Practices - Construction Materials"
CERTICO	Certification Committee
ECE	UN Economic Commission for Europe "Committee for Habitation, Construction and Planning"
CEMBUREAU	European Cement Association
CCD	Council for Customs Co-operation
CMEA	Council for Mutual Economic Help
RILEM	International Meeting of Testing and Research Laboratories Concerned with Materials and Building.

TABLE C

WORKING GROUPS IN ISO/TC 77

Number	Title	Secretariat responsible*
12	Pressure pipes and sewage pipes	SNV
15	Asbestos-cement ventilation ducts	DIN
20	Building and sanitary pipes and fittings	DIN
21	Corrugated sheets for roofing and cladding and asymmetrical section corrugated sheets and a 'Work Practice Guide'	AFNOR
22	Asbestos cement slates for roofing and cladding	IBN
23	Sheets for insulation and fire protection	BSI
24	Methods of on-site work with fibre-cement products	SNV
25	Test methods of asbestos fibres	BSI
26	Recommended requirements for internal quality control	SNV
27	Flat sheets in cement reinforced by cellulose or wood fibres	DIN
GE	Certification mark of asbestos cement products	NNI
GE	Cement products reinforced with non-asbestos fibres	BSI
GE	Faults in flat asbestos-cement products	AFNOR
GE	Dimensional variations of all asbestos-cement products	AFNOR

* For the country see the corresponding logo at Table A.

TABLE D

ISO STANDARDS ALREADY PUBLISHED

Initials	Date	Title
ISO 160	01.03.80	"Asbestos-cement pressure pipes and joints"
ISO 881	15.02.80	"Asbestos-cement pipes, joints and fittings for sewerage and drainage"
ISO 4488	15.10.80	"Asbestos-cement pipes and joints for thrust-boring and pipe jacking"
ISO 4482	01.09.79	"Asbestos-cement pipelines - Guide for laying"
ISO 4483	01.07.79	"Asbestos-cement pipelines - Field pressure testing"
ISO 880	01.06.81	"Asbestos-cement siding shingles"
ISO 396-I	15.08.80	"Part 1: Asbestos-cement flat sheets"
ISO 396-II	15.08.80	"Part 2: Silica-asbestos-cement flat sheets"
ISO 396-III	15.08.80	"Part 3: Cellulose-asbestos-cement flat sheets"
ISO 2785	15.10.80	"Guide to the selection of Asbestos-cement pipes subject to external loads with or without internal pressure"
ISO 390	01.08.77	Asbestos-cement products - Sampling and inspection"

TABLE E

DRAFT STANDARDS BEING APPROVED OR TO BE PUBLISHED IN THE NEAR FUTURE

Initials	Title
DIS 391	"Building and sanitary pipes in asbestos-cement"
DIS 393	"Asbestos-cement corrugated sheets and fittings for roofing and cladding"
DIS 394-I	"Asymmetrical section corrugated sheets and fittings for roofing and cladding"
DIS 395-II	"Asbestos-cement slates"
DIS 7336	"Guide for the hydraulic calculation of asbestos-cement pipelines"
DIS 7337	"Guide for on-site work practices for asbestos reinforced cement products"
DIS 1896	"Non-combustible fibre-reinforced boards of calcium silicate or cement for insulation and fire protection"

TABLE F

PROJECTS OF STANDARDS BEING DRAFTED (DP)

REVISION PROJECTS FOR EXISTING STANDARDS (DR)

Initials	Title
DP 394-II	"Asbestos-cement trapezoidal section sheets and fittings for roofing and cladding"
DP 393-II	"Short Asbestos-cement corrugated and asymmetrical section sheets and fittings for roofing"
DP 393-III	"Asbestos-cement-cellulose corrugated sheets for roofing and cladding"
DP 119	"Guide for the use of Asbestos-cement corrugated sheets and fittings for roofing"
DP 392	"Asbestos-cement pipe fittings for building and sanitary purposes"
DP 4486	"Asbestos-cement ventilation ducts and fittings - Dimensions and characteristics"
-	"Recommended requirements for internal quality control"
DR 2785	"Guide to the selection of asbestos-cement pipes subject to external loads with or without internal pressure"
DP 7338	"Methods of test for asbestos fibres"

BEHAVIOUR OF ASBESTOS-CEMENT PIPELINES DURING EARTHQUAKES

Approximately 50,000 earth tremors occur in the world every year. Most of the time they are not felt by the population but are only recorded and measured by seismometers and seismographs. However, approximately 100 earth tremors per year occur with a force likely to cause damage at their epicentre or in neighbouring areas (1,5).

Generally the effects of an earthquake are analysed and special standards concerning construction, dams, bridges, supporting walls, etc are drawn up. However, underground conduits for drinking water supply, the removal of waste water, distribution of gas, etc, are of very little interest to technicians. This is a serious drawback as water shortage considerably aggravates the difficulties which a population faces when earthquakes occur. These problems include protection of the population (fire fighting) general living conditions, or the servicing of the waste water network (the interruption of which may lead to pollution risks and endanger hygiene). Lastly, the dangers which may be caused by the failure of gas conduits are self-evident.

In order to assess how an earthquake can affect different undergound pipelines and consequently the measures to be taken to protect them, we must consider the three effects of an earth tremor (2, 5, 6).

Firstly there is a 'shaking' movement which moves the ground in ripples of varying amplitude and intensity. During this type of movement there is no displacement of earth mass and the damage caused depends on the velocity and duration of the tremors. Then there is an action termed 'fault displacement' during which large masses or blocks of earth move one over the other. These movements may occur vertically or horizontally, or even obliquely. Lastly, there is a third type of action caused by ground failure during which specific areas subside. It is easy to see that the last two types of action are very similar, at least as regards their effect on underground pipelines which cannot withstand such a drastic effect. However, in rare circumstances conduits can be specially designed to withstand even these effects.

However, on probabilities it is the 'shaking' action which we should consider since it always occurs during an earthquake and affects very extensive areas.

To afford protection against this type of ground tremor it is not necessary to use flexible piping in underground pipelines, but rather to construct '<u>flexible</u> and <u>discontinuous pipelines</u>'.

Although at first sight the longitudinal flexibility of a pipe may appear as an excellent feature, it is in practice a negative attribute. The pipe curve, which increases with length, causes the joint seals to open, if they are of the elastic type; or else in the case of welded or bonded joints, the curve creates high longitudinal tension possibly causing pipe failure.

To construct a 'flexibly discontinuous pipeline' it is necessary to use discontinuous and flexible joints thus enabling piping which is being shaken by an earthquake to behave like a chain and to transmit the stress to the joints themselves. When the elastic joints are mounted at close intervals in the conduit the behaviour of the conduit improves considerably. From this has arisen the suggestion of using pipes not exceeding five metres in length.

Rigidity of the joints was revealed as being a very harmful factor during earthquakes. For example, in gasline piping during the San Fernando earthquake (USA 1971), a much higher proportion of joints sealed with cement were damaged compared to those sealed with lead or with a rubber seal (1,5) Conversely, for steel piping the welded joints during the 1966 earthquake in the Frioul area, in Italy, provided a continuous path allowing the vibrations and the energy creating them to be transmitted along the entire pipeline up to the connection points where special controlling machinery was damaged.

Another lesson from the Frioul earthquake was that the rigidity of the joints in the reinforced cement pipeline did not allow the system to move with the earth tremor. This led to failure at practically all joints which in turn caused serious transversal damage to individual pipes at the bearing points (2). In addition the heavy weight of the pipes themselves must have had a negative influence on their performance.

The explanation of why the asbestos-cement pipelines behaved in such a satisfactory meanner during earthquakes is that their sleeve joints are sealed by means of two rubber packings. With this type of joint 'flexible discontinuity' is obtained, which protects the pipeline by enabling it to follow the earth tremor wave.

The superiority of flexible joints compared to the non-flexible is shown by comparing the respective damage caused to asbestos-cement and cast-iron pipelines during the earthquake which occurred in the Los Angeles area on 9th February 1971.

The facts are that in the Newhall/Saugus area, the water pipeline network consisting of more than 300 kilometers of asbestos-cement piping had only fifty failures: in the San Fernando area, located at approximately the same distance from the epicentre and with a similar geological formation the water pipelines constructed of cast iron pipes were practically all put out of service (3).

Even where flexible joints are mounted it is important that these joints have a double flexibility, ie two rubber seals, one for each of the two pipes to be connected. This is the assembly procedure for asbestos-cement pipelines. However, only one seal is used for joints in cast iron pipelines, reinforced pipelines and fire-clay or PVC concrete pipelines.

This aspect was evident at the Managua earthquake (the capital of Nicaragua) in 1972. In this earthquake, on approximately 330 ilometers of asbestos-cement pipeline there were 393 points with dama whereas on approximately 89 kilometers of cast iron pipeline there were 107 points of damage. An average was therefore 1.2 damaged areas per kilometer for both types of material whcih demonstrates clearly that the higher mechanical resistance of the cast iron piping brought no advantage (1,4,5).

The survey carried out at Managua revealed two elements which influence the behaviour of flexible seals. These are: the axial movement and the distance between the ends of two adjacent pipes. As regards the first point, it was considered that for joints with rubber seals, permissible axial movements without the pipes separating were less than what is possible with a coupling fitted with two rubber joints. As regards the second point the Managua study revealed that numerous points of damage on the asbestos-cement conduits occurred because the ends of the pipings interconnected inside the couplings (1,5). In modern couplings for asbestos-cement pipes this possibility is eliminated because the joints are provided with separating elements which stop the ends of the pipes from damaging one another.

As regards the problem of the joint uncoupling, the unit length of the pipes plays an important role. It is obvious that with very long pipes there are less joints and consequently the 'flexible discontinuity' is reduced. The available lengths for axial movement are also reduced. Asbestos-cement pipes have an advantage from this point of view as their standard commercial length is between four and five meters, depending on the diameter. This length is an acceptable compromise between the various technical and economic requirements. It is necessary to note an important point. Unlike other processes, making asbestos-cement pipes allows shorter units to be produced These are generally half the standard length, which thus make it possible to deal with particularly difficult situations where the ground is highly unstable or subject to frequent earthquakes.

The considerations stated here therefore supply a technical explanation of the superior behaviour of asbestos-cement pipelines during earthquakes and the preference which was given to this material for replacing pipelines manufactured from other materials which were damaged, or for the construction of extensions (3) to existing networks.

Favourable reports concerning this superior behaviour are numerous and cover many sites constructed over a wide period of time since 1930. Senigallia (7), Irpinia 1962 (8), Los Angeles 1971 (3), Ancona 1972-74 (9), Friuli 1976 (2,10), Thessaloniki 1978 (11,12), Attica 1981 (13,14).

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6. E Orsi e G Agnoletto, "Alcune indicazioni per l'approvvigionamento idrico nelle zone sismiche" (L'Installatore Italiano - Anno 30 - 6 giugno 1979, pag 791 e seguenti).

7. Comune de Senigallia - Terremoto del 30 ottobre 1930 - Attestato del 18 dicembre 1930.

8. Consorzio Idrico Inter Provinciale dell'Alto Calore di Avellino - Terremoto del 1962; Attestato del 8 aprile 1963.

9. Azienda Municipalizzata Servizi di Ancona - Terremoto del 1972 e 1974; Attestato del 30 luglio 1976.

10. Anonimo, "Un réseau d'eau fait ses preuves - L'alimentation en eau de Frioul - Vénétie Giulia après le séisme" (AC-CANALISATION No. 06)

11. Thessaloniki Water Supply Company - Certificate of 15 July 1978.

12. Hellenic Republic - Prefecture of Thessaloniki - Certificate of 4 August 1978.

13. Hellenic Republic - Prefecture of Attica - Certificate of 11 May 1981.

14. "Water and Sewerage Company of the Capital" (Athens) - Certificate of 7 April 1981.

PUBLICATIONS BY THE ASBESTOS INTERNATIONAL ASSOCIATION

Recommended Control Procedures:

- RCP1 The Control of Asbestos Dust
- RCP2 Asbestos Cement Products
- Insert - Catalogue of tools for working with asbestos-cement products on site
- RCP3 Asbestos Waste Materials
- RCP4 Absestos Fibres, Packaging, Handling and Transportation
- RCP5 Asbestos Fibres, Bag Opening
- RCP6 Asbestos Textile Products - Manufacture
- RCP7 Asbestos Textile Products - Fabrication and Use
- RCP8 Repair and Removal of Asbestos Insulation
- RCP9 Protection Equipment for Use in the Manufacture and Use of Asbestos Products
- RCP10 Asbestos-Containing Friction Materials. Application and Servicing.*

Recommended Technical Methods:

- RTM1 Reference Method for the Determination of Airborne Asbestos Fibre Concentrations at Workplaces by Light Microscopy (Membrane Filter Method)
- RTM2 Reference Method for the Determination of Airborne Asbestos Fibres by Scanning Electron Microscopy.*

* Not yet printed.