PC-1453

(3) Notes to Industry No.11.)

(2) Lead in Paint)

1. Paint - Analysis
2 Lead - Toxicity (1) (

Paint
RESEARCH
ASSOCIATION)

Components of Paint

A modern [illegible] paint, as purchased from the local DIY supplier or supermarket is made from three major components:

Solvent
Binder
Pigment

The solvent is a volatile liquid the purpose of which is to reduce the viscosity of the liquid paint sufficiently to assist application by brush or roller

The binder is a polymeric resin, a plastic type material which serves to form a thin coherent film when the solvent evaporates.

The pigment is a finely powdered opaque material which is insoluble in the solvent and whose functions include colouring the paint and improving its hiding power. Strictly speaking pigments have a refractive index greater than about 1·7. Powdered materials with lower refractive indices, when incorporated into paints, are known as extenders.

In addition to these three major components almost all paints contain small amounts of additional materials (known as additives) which perform certain specific functions not fulfilled by the major ingredients. One of the most important additives in decorative paints are the driers. These are metal compounds without which the drying time of a conventional white spirit based decorative paint would be measured in days rather than in hours.

Formulations of Paint

Two main types of decorative paints are available today: those based on the solvent white spirit and those based on water. In a white spirit based paint the binder is dissolved in the solvent. When the paint is applied, the white spirit evaporates to leave a sticky dispersion of pigment in binder which, over a period of several hours, reacts with oxygen in the atmosphere to form a dry film. It is this reaction with oxygen which is speeded up by the metal driers.

The water-borne paints differ in that the binder is not dissolved in the water but is dispersed in the form of an emulsion. When these "emulsion paints" are applied, the water evaporates and the small particles of binder coalesce to form a coherent dry film. There is no reaction with atmospheric oxygen and hence no need for the presence of driers.

Any lead in a decorative paint will originate primarily from the pigments and additives and those concerned with the toxic hazard of lead must take into account the fact that paint formulations have changed markedly over the years. In older buildings it is quite possible that the original paint was never completely removed but was simply overcoated.

Pre 1930 paint films are liable to contain substantial amounts of white lead, a basic carbonate of lead approximating to

$$2PbCO_3 \cdot Pb(OH)_2$$

Basic sulphate white lead:

$$PbO \cdot x\,PbSO_4 \text{ (x is between 2 and 5)}$$

was also used but in much smaller amounts

Coloured lead pigments included

Chrome yellow	($PbCrO_4 - PbSO_4$)
Red lead	($Pb_3O_4 + PbO$)
Chrome green	(Chrome yellow + iron blue)
Brunswick green	(Chrome yellow + iron blue + barytes).

These pigments were used with a linseed oil binder thinned with turpentine for application to wood or metal. Water-based coatings intended for use on interior walls and ceilings were also manufactured. The simplest of these was whitewash, a dispersion of lime in water to which a little tallow might be added as a binder. Alternatively whiting was dispersed in an aqueous solution of glue or casein to form distempers. Lead is unlikely to be found in white ceiling coatings of this period but will probably be present in coloured wall paints.

It should be remembered that lead is not the only toxic element likely to be found in paints; arsenic based pigments were also used in paints made before the turn of the century.

Between the wars the higher cost of lead-based pigments tended to limit their use to high quality paints. In fact it was a matter of pride to decorators to advertise that they used "only genuine white lead paints". Many people remember the long-lasting properties of paints in the 'twenties and 'thirties and tend to associate them entirely with the use of lead pigments. In truth they should also take into account factors such as the much higher quality of timber then available and also the higher standard of craftsmanship of carpenters and painters.

Old and Modern

When compared with modern paints, the pre-war white lead based coatings has several disadvantages (discounting cost and toxicity). They only gave, at best, a semi-gloss finish and one which, unless applied by a skilled craftsman, was very prone to show brushmarks. The drying time was much longer and the paints also tended to darken due to reaction of the pigment with atmospheric pollutants.

However, the association in people's minds between lead paints and quality still lingers. Until recently the GLC specified the use of lead primers and it is not uncommon for leases to contain a clause stating that the property should be repainted periodically using a lead based paint.

During the Thirties low quality grades of titanium dioxide pigments began to be used and their properties were enhanced by the use of antimony oxide pigments. Good quality antimony oxide is virtually insoluble, and therefore non-toxic, but it is possible that some of these paints may contain detectable amounts of soluble antimony and possibly arsenic as an impurity.

The lead content of water-borne coatings applied during this period is unlikely to differ significantly from that of pre 1930 paints although the higher cost of lead pigments and the increasing availability of synthetic substitutes both tended to favour a lower lead content for coloured wall paints.

After 1945 the availability of high quality grades of the white pigment titanium dioxide, coupled with the escalating price of lead, tended to limit the use of lead pigments to wood and metal primers. Synthetic resins in white spirit based air-drying formulations were used, invariably in conjunction with lead driers, but the lead content of these would not account for more than 1 per cent of the total dry film.

Galvanised steel window frames, manufactured from the Fifties onwards, were often coated with primers based on calcium plumbate $2\,CaO - PbO_2$.

These high-lead primers can present a special hazard because they tend to flake off on ageing.

Untreated steel windowframes might well be coated with another high lead primer based on red lead.

Lead Content Control

With increasing awareness of the hazards of lead it was considered that more stringent controls should be placed on the lead content of paints available to the general public. Accordingly, in 1963, an agreement was reached between the Ministry of Health and the Paintmakers Association of Great Britain by which the manufacturers undertook that they would label any paint containing more than one per cent of lead in the dry film or containing any known toxic compounds of other metals. This label states:

Caution
Do not apply on toys, furniture or interior surfaces which might be chewed by children.

In practice, the effect of this voluntary agreement is that almost all decorative paints are now formulated so as not to require the cautionary labelling. The lead content of modern decorative paints now tends to be less than 0.6 per cent and some ranges contain less than 0.1 per cent.

According to the Lawther report it is estimated that lead paints now make up less than three per cent of total sales in the UK. Most of this is used in the construction and shipbuilding industries. As long ago as 1972 the Paintmakers Association of Great Britain issued a recommendation to its members to discontinue the production or sale of proprietary lead based primers for wood and, according to the Lawther report (Para. 69), these are no longer being manufactured. This statement is erroneous: the primers are not usually sold by DIY shops or supermarkets but are obtainable from builders merchants.

Regulations

Until recently the only general legal restrictions on lead paints in the UK were the Lead Paint Regulations 1927. These required lead paints to be labelled as such and imposed restrictions on their use i.e. for interior spraying or dry rubbing down.

For the purpose of these regulations a lead paint was defined as one in which the pigment yielded more than five per cent of *soluble* lead compounds when extracted under specified conditions with hydrochloric acid.

These regulations have recently been superseded by the Control of Lead at Work Regulations 1980, and the Health and Safety Commission have issued a Code of Practice which gives guidance on the interpretation of these regulations and also considers protective measures, air and biological monitoring and analysis.

The lead content of paints used on children's toys was restricted by the Toys (Safety) Regulations 1974 to 0.25 per cent (2500 ppm) measured as *total* lead in the dry paint film. As expected the restrictions on lead in paints on pencils etc. are more stringent and

the Pencils and Graphic Instruments (Safety) Regulations 1974 limit the amount of lead to 0.025 per cent (250 ppm). However, this is defined as the *soluble* lead content of the dry film, i.e. lead which is extractable under specified conditions using hydrochloric acid.

Thus current UK regulations define the lead content of paints both in terms of total and of soluble lead and there are arguments for and against both methods of definition. From the point of view of the analyst, total lead is preferable since this value is unambiguous and can be determined precisely and reproducibly by different laboratories. However, medical authorities will argue that the amount of soluble lead is the really important parameter. This poses the problem of how to define soluble since the quantity of soluble lead which can be extracted from a dried paint depends upon the composition of the solvent, the size of the paint particles, the temperature and duration of the extraction stage, the method of dispersing the particles in the solvent and the way in which the insoluble material is separated from the solution. Unless an analytical method defines all these parameters it is very unlikely that it will give good interlaboratory replication.

Lawther Report

The Lawther report defines sources of lead peculiar to a local environment or specific product as "adventitious" and regards lead paints as the most important single cause of lead poisoning in children. However, it must be emphasised that this is due to the ingestion of old lead paintwork in the home. The low lead content of modern decorative paints means that it is virtually impossible for a child to ingest sufficient dry paint to cause harm.

Children are particularly at risk because of their habit of mouthing, sucking or chewing non-edible objects. The ingestion of substances not normally regarded as foodstuffs is defined as "pica" and its occurrence in children has been the subject of extensive medical research over the past few decades. Pica in children has been correlated with ethnic origin, iron deficiency, disturbed mother-child relationships, a tendency towards addiction and a low mental age. However, all research of this type is complicated by the need for a more precise definition of pica. It is a very rare child that has never placed a toy or other item in its mouth and almost all children gain relief from the pain and discomfort of teething by sucking or biting on a convenient object. If these objects are painted it is probable that the child will ingest some of the paint.

Some idea of the magnitude of the risk can be gained by considering the amount of lead in a paint film which is 76 micrometres thick.

A white lead linseed oil top coat of the type used before the last war could contain over 60 per cent lead in the dry film. The amount of lead present in an old paint film of this type would be of the order of 150 μg per square millimetre.

A modern white lead wood primer applied at the same dry film thickness would give a lead concentration of about 100 μg per square millimetre whilst a modern decorative gloss paint (0.5 per cent lead in the dry film) would give a concentration of 0.5 μg per square millimetre.

A good toys paint (0.01 per cent lead in the dry film) would give a concentration of about 0.01 per cent μg per square millimetre.

It has been shown that the ***habitual*** ingestion of 1000 μg of lead by a child has resulted in severe clinical lead poisoning in 3—4 months. The area of the four paint systems which would have to be ingested regularly is as follows:

76 micrometre paint film	*Area containing 1000 μg of lead (mm^2)*	*Objects of approximately similar area*
White lead-linseed oil topcoat.	7	The cross-sectional area of the lead in a pencil.
Modern white lead wood primer.	10	The cross-sectional area of the lead in a pencil.
Modern decorative gloss.	2,000	The largest face of a match-box.
Good toys paint.	100,000	½ page of *Daily Telegraph*.

Since even the most determined child would be unable to ingest 2,000 square millimetres of paint *on a regular basis*, modern decorative paints cannot be regarded as a significant hazard.

However, there is a very real hazard to children who chew surfaces coated with old lead paints or modern lead primers.

The Lawther report makes a number of recommendations relating to the hazard of lead in paint. In para. 70, concern is expressed that high lead paints might be used in places accessible to children and that the warning label may not be totally effective. The report recommends that the hazard should be completely eliminated but does not suggest exactly how this might be done. Short of banning the manufacture and use of all lead paints it is difficult to see how this hazard can be eliminated. Lead pigments are indispensable in the manufacture of anticorrosive primers for industry and there will always be the risk that they will be used on surfaces accessible to children.

In para. 75, the report recommends that the Toys and the Pencils and Graphic Instruments Regulations should be enforced, especially with regard to imported goods. This is a very valid recommendation and it has been our experience at the Paint RA that imported toys, particularly those originating from the Far East, often contain quantities of lead and other toxic elements which are far in excess of the permitted levels.

Solutions

In para 211 (i) the report recommends setting up a programme of work for the detection of lead in paint coatings accessible to young children. Such information would be valuable in quantifying the hazard at specific locations but, inevitably, it will raise questions of what is the best way of dealing with interior surfaces of a building which are found to be heavily contaminated with lead paint. This topic has been the subject of research in the United States and it appears that there are three main solutions to the problem.

The use of barrier materials.
Paint removal.
Replacement of components.

The barrier material method involves covering the painted surfaces to render them inaccessible. Walls can be covered with wall board, hardboard, plywood or vinyl fabric. Alternatively a thick layer of a cementitious, aggregate or textured paint can be used. Such methods can be useful for covering painted walls but are generally impracticable for dealing with painted interior woodwork.

Total removal of the lead paint is, in theory at least, the ideal solution but in practice this can present problems. Under no circumstances should dry sanding or abrasion be used since this will release lead paint dust into the atmosphere and result in widespread contamination of the building. In any case the dry rubbing down of interior lead paints is specifically prohibited by the Lead Paint Regulation 1927.

The paint can be removed with a chemical stripper but this can be a tedious method and thick layers of paint may require repeated applications of stripper. There are hazards associated with the use of paint strippers: they are corrosive materials which give off toxic fumes and the toxicity hazard is greatly increased by smoking. Stripping operations should be carried out in a well ventilated atmosphere by workers who are wearing adequate skin and eye protection.

An alternative method of removal is to use some suitable heat source such as a blowlamp, a gas torch or an electric heat gun. Special care must be taken not to heat the paint to a level where it catches fire otherwise lead fumes will be liberated into the atmosphere.

This is definitely a task for skilled operatives working under qualified supervision.

Obviously any paint removed by stripping or by thermal means must be collected and disposed of safely.

The complete removal and replacement of doors, windows, their frames and other interior woodwork is an accepted technique of lead paint abatement although it is used mainly in cases where the components are of such an age or condition that replacement is justified. If this method is employed, care should be taken to collect up any paint flakes which may become detached during the removal process.

The industry has done much over the last decade to minimise the hazards to young children from lead sources in paint films. Work is still going on to find a "lead free" system which is economical and does not present any other risks.

Until such time as this goal is achieved the best form of protection available is the warning label, a point which the EEC experts have acknowledged by following the UK industry's voluntary agreement with HM Government and proposing the adoption of it in the future labelling legislation.

This article is based on a paper published in 'Environmental Health' in October 1980. We are grateful to the editor of this journal for permission to reproduce it as a Note to Industry.