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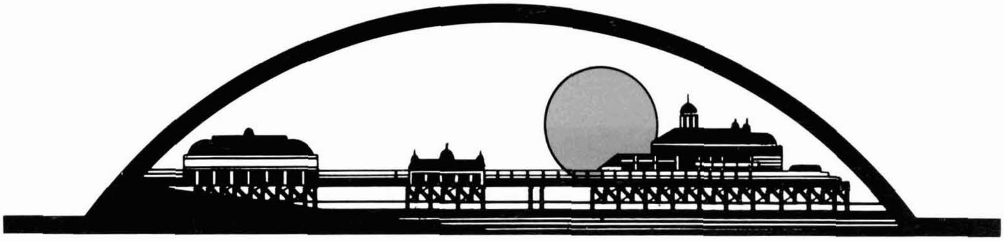
JOCCA

LABELLING FOR SUPPLY AND CONVEYANCE

Also in this issue:

- UV Curing for Offset Printing Inks and Varnishes
- The Application of Colour Physics to Printing Inks
- The CMC Colour Difference Formula
- Hazardous Raw Materials used in the Paint and Ink Industries

Journal of Oil and Colour Chemists' Association,
Priory House, 967 Harrow Road, Wembley, Middlesex, HA0 2SF, England.



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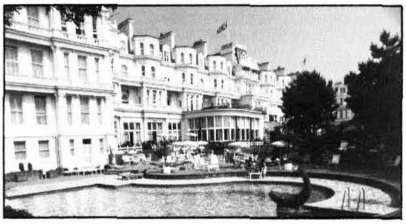

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The Honorary Research and Development Officer now invites offers of papers for presentation at this Conference. Anyone wishing to submit a paper for consideration should notify his intention as soon as possible to: The Director and Secretary, Oil and Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF, UK. (Tel: 01-908 1086. Telex: 922670).

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Contents **Vol. 69 No. 11** **November 1986**

Transactions and Communications

Aspects of labelling and related legislation for supply and conveyance 280
by D. Cornelius

Ultra-violet curing for offset printing inks and varnishes 288
by C. G. Roffey

The application of colour physics to printing inks 297
by J. H. Nobbs

Relative tolerances in CMC colour-difference formula for paint samples 302
by O. Adebayo and B. Rigg

Hazardous raw materials used in the paint and ink industries 310
by I. Scott

Company Visits 314

OCCA Meetings 314

News 318

INDEX TO ADVERTISERS

B
British Rema 313

C
Ciba-Geigy 290,292
CIRP Engineering .... Inside back cover

D
Datapaq Ltd ii

H
Hüls AG 284

J
Joshua Greaves & Sons Ltd 287

L
Lankro Chemicals Ltd 294

M
Minolta (UK) Ltd 306

N
NL Chemicals Inc .... Back cover

O
OBS Machines Ltd ii

S
Sachtleben Chemie GmbH .... Centre fold
Sheen Instruments Ltd 296
Spectrum International Ltd 301
Sub-Tropical Testing Service Inc iii

W
Wacker-Chemie GmbH .... Bound insert

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Aspects of labelling and related legislation for supply and conveyance*

C. Cornelius†

Cray Valley Products Ltd, Farnborough, Kent BR6 7EA, UK

Summary

In this paper the labelling aspects and related legislation for supply and conveyance are considered. The recently implemented Packaging and Labelling Regulations SI 1984 and the Health and Safety at Work Act 1974 are discussed.

Introduction

Although the final date for implementation of the classification Packaging and Labelling Regulations SI 1984 No 1244 was 1 January 1986, there is clear evidence there are certain areas of this Statutory Instrument which staff responsible for labelling and associated health and safety data have difficulty in coming to terms with. This is not surprising when most of the regulations are written in an over complicated way an example of which is given below:

"In any other case, the particulars required by paragraph (2)(a), (b)(i), (iii), (iv) and (v) of Regulation 8 and paragraph (2)(b)(ii) and (iii) and (c) of Regulation 9, except that the particulars required by Regulation 9(2)(c) may be shown on a separate statement accompanying the package if that statement also shows the particulars required by Regulation 9(2)(a) and (b)(i) and the classification". (SI 1984 No 1244)

Therefore, it is the intention of this paper to try to clarify some of these 'grey' areas and at the same time to illustrate how past, current, and proposed legislative requirements link together, and why it is a dangerous practise to isolate and familiarise oneself with just one piece of legislation or part legislation

Historical data

The data for discussion relates to legislation already adopted or proposed by our own Government, the United Nations, and the European Community. (Some of this data is listed in Appendix 1. However, this is not intended as a definitive list, but rather to illustrate just how much information one is expected to digest and comprehend).

In the UK there are various laws—some like the Poisons Act—dating from the Middle Ages governing the transport and safe handling of chemicals, but these laws are of a haphazard nature. The UN organisation consolidated some of these requirements and introduced the now well-known 9 classes or categories.

The intention (which has been successful) was to bring a degree of uniformity among the many countries of the world, and most maritime, air, and road TRANSPORT (CONVEYANCE) legislation is based on the UN recommendations.

- Class 1 Explosives
- Class 2 Gases
- Class 3 (In)flammable liquids
- Class 4 (In)flammable solids (et al)
- Class 5 Oxidising agents
- Class 6 Toxic
- Class 7 Radioactive
- Class 8 Corrosive
- Class 9 Miscellaneous

Many of the European Directives (issued prolifically over the past decade) have extended TRANSPORT requirements to provide information for the USER (SUPPLY imformation) the original intention here being to have a uniform set of common sense rules which would make trade easier between the common market countries!!! (Subsequent to the introduction of the Directives in Europe, adoption of all or parts of European Community Directives are being consolidated into National requirements by countries outside the European Community e.g. Australia, Sweden, Norway, South Africa, etc.)

The difference between Transport and Supply labelling must be observed but the derogations given by the Directives are in favour of the international transport rules.

Aspects of CONVEYANCE/TRANSPORT requirements

- Transportation Regulations begin from the moment the goods are placed *on* the vehicle until the are removed *from* the vehicle.
- There are few exemptions from SI 1244, and these exemptions are applicable where legislative provision already applies e.g. medicines, cosmetics, bulk tanker supply, or where precedent has already been set by international rules.
- The *internationally* agreed classification appears in column 6 of Part 1A. Unlisted products should be compared with the characteristic hazardous properties listed in Schedule 2^1, and if the product does display any such properties classsification for conveyance by road is necessary.

Aspects of SUPPLY

SUPPLY information includes, in the course of, or for use at work. It covers importation and transfers between sites in the same ownership (but not on the same site). Supply (within the meaning of the Consumer Safety Act 1978) is literally anyone who supplies i.e. manufactures, importers or other suppliers along the distribution chain making transfers.

The criteria for SUPPLY classification is given in SI 1984 1244 and is designed to ensure that the Supplier warns the

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*Presented at the OCCA London Section Symposium, "Health and Saftey in the Coatings and User Industries", Royal Institution, 10 April 1986.

†Currently Headlines, 17 High Street, Aylesford, Kent ME20 7AX, UK.

Table 1

SUPPLY classification SI 1984 1244

Health Hazards	**Symbol**	**Physical Hazards**	**Symbol**
Very Toxic	(T) Skull and Crossbones	Extremely Flammable	(F) flame
Toxic	(T) Skull and Crossbones	Highly Flammable	(F) flame
Harmful	(Xn) St Andrews Cross	Flammable	word only no symbol required
Corrosive	(C) Hand showing damaging affect of acid	Oxidising Explosive	flame from circle exploding bomb
Irritant	(Xi) St Andrews Cross		

Table 2

Current requirements for both transport and supply labelling

TRANSPORT (CONVEYANCE)	USER (SUPPLY)
1. For experts 2. Immediate problem 3. Emergency action	1. For non-experts 2. Long short term effects 3. Preventative advice.
Labelling information required	
a) Appropriate diamond and hazard symbols	a) Unique Name of Substance or Preparation (plus general description of product if relevant)
b) Indication of Substance or Preparation e.g. Resin/Paint-Ink	b) Any chemical over the amount requiring legislatively to be disclosed
c) Name and address of manufacturer or supplier	c) Name and address of manufacturer or supplier
d) U.N. Number (S.I. Number)	d) Hazard indication e.g. symbol and general nature of risk
	e) Risk phrases ('R')
	f) Safety phrases ('S')

user of two aspects of danger i.e. physical hazards and health hazards (the now familiar black symbols on an orange background) as outlined in Table 1.

These symbols are complemented by relevant Risk and Safety Phrases. In the UK, the various European Directives classifying and labelling dangerous substances, solvents, paints, varnishes, printing inks, adhesives and pesticides has been consolidated into Statutory Instrument 1984 No 1244. SI 1984 1244 gives "Information Approved for the Classification Packaging and Labelling of Dangerous Substances for Supply and Conveyance by Road". The current basic requirements for both TRANSPORT and SUPPLY labelling is given in Table 2.

Further aspects of SUPPLY AND CONVEYANCE labelling

Whilst SI 1244 is a vital tool in classsifying materials there are several points worth further consideration.

1. SI 1244—has no jurisdiction outside the United Kingdom, and therefore no relevance to goods in transit in other European countries (This of course is of great importance to a company like Cray Valley where 45% of the resins are exported).
2. Relevant European Directives, National legislation, and international conveyance requirements apply to material transported across EEC boundaries.
3. The harmful (Xn) and Irritant (Xi) symbols are not yet recognised by CONVEYANCING/TRANSPORT laws (or related accepted codes of practise) and are currently relevant only to SUPPLY data.
4. The definition and connotation of "dangerous substance" is significantly different between the accepted term in the UK and Europe. The European Directives make a clear distiction between 'substances' and 'preparation' but in the UK the Health and Safety Executive use the two words interchangeably.
5. Labelling must be supported by comprehensive Health and Safety information. The label is just an edited version of the total Health and Safety data 'package'.
6. All the European Community Directives have been developed separately. Therefore, there are bound to be anomalies.
7. Not all substances are listed in the Approved List. Dangerous Substances are not restricted to those *in* the Approved List, but include all those materials having comparable properties. These require 'self-classification'.

Self-classification seems to be the area in which most people have problems, and so because time today is limited

Table 3

Substance category specification by LD_{50}/LC_{50}

Category	LD_{50} absorbed orally in rat mg/kg	LD_{50} absorbed percutaneously in rat or rabbit	LC_{50} absorbed by inhalation in rat mg/litre (4hrs)
Very toxic	25	50	0.5
Toxic	25 to 200	50 to 400	0.5 to 2
Harmful	200 to 2000	400 to 2000	2 to 20

and we are unable to discuss each problem progressively in depth, I think it would be appropriate at this stage to look at some of the criteria for self-classification:

For some unlisted materials "classification without tears" is relatively easy e.g. a 25% acid concentration of Acid Butyl Phosphate. The major hazard is the 25% phosphoric acid which I have classified as Corrosive for SUPPLY. To classify this I have used the criteria given in Schedule 1 Part 2: "If facts show that for the purpose of classification it is inadvisable to use LD_{50} or LC_{50} values as a principle basis because the substance produces other effects, the substance shall be classified according to the magnitude of these effects".

Additionally ACOP give further guidance:

Part I of Schedule I allows classification on the basis of data obtained from a number of different sources, for example from:

1. Previous test data,
2. information obtained from testing which might have been necessary to comply with Section 6 of the HSW Act,
3. information obtained from reference works or the literature and
4. information derived from practical experience,
5. information required in relation to conveyance rules, in particular the international rules and here Acid Butyl Phosphate is classified as a Class 8 Corrosive Liquid.

There should already be available sufficient information which can be used, in conjunction with the criteria and with reference when appropriate to COP 9[2] or 10[3], to determine whether any substance has the characteristic properties specified in Schedule 1 of the Regulations.

For new substances the problem is more difficult and it becomes necessary to look at Part 2 of Schedule 1 SI 1984: No 1244 in more detail, and at the guidelines for self-classification which are quite specific. Apart from the materials which fit into (the guideline given above) it is always necessary to know or have tests carried out by an Authoritative body to determine LD_{50} or LC_{50} figures, e.g. to determine whether a substance is "very toxic" "toxic" or "harmful" in relation to a dangerous substance NOT classified in accordance with:

SCHEDULE 3 (Classification provisions for preparations intended to be used as pesticides).
SCHEDULE 4 (Classification provisions for certain preparations intended to be used exclusively in solvents).
SCHEDULE 5 (Classification provisions for preparations intended to be used exclusively as, or exclusively for use in paints, varnishes, printing inks, adhesives and similar products).

Table 3 given above should be used.

So, leaving aside another problem area i.e. whether or not the LD_{50} tests on rats and rabbits have significant relevance to man (or in my case woman!) it may be more useful to look at the self-classification approach by taking a specific example:

If we take a high boiling aromatic solvent with a percutaneous LD_{50} (rat) of 2,000 mg/kg and apply the criteria for self-classification in Schedule 1 Part 2 (SI 1984 No 1244) then the solvent would clearly fall within the criteria given and will require a harmful (Xn) label with appropriate Risk and Safety phrases. The relevant Approved Code of Practise[4] again gives specific data, and indicates which Risk phrase to use i.e.

R21 Harmful in contact with skin
(– acute toxicity results:
LD_{50} dermal, rat or rabbit : 400 to 2,000 mg/kg)

However, the product for self-classification may not fall within the parameters given above, and it may be necessary to determine whether or not it is an irritant (Xi). The procedure to follow once again is given in specific terms but here reference should be made to ACOP 10 "Methods for the determination of Toxicity" (the tests required to determine LD_{50} or LC_{50} figures for toxicity will be carried out by Research laboratories authorised to perform the tests on animals necessary to comply current lawful requirements.). This piece of data is the equivalent to annex V of the Sixth Amnedment Directive, and is based on test guidelines published by the Organisation for Economic Co-Operation and Development, to ensure information given in approved codes of practise for product Health and Safety by Regulatory Authorities has uniformity in the major industrialised countries. Unless the substance for self-classification has LD_{50} and/or LC_{50} figures already determined or has the irritancy test carried out or is a substance on which there is existing data and significant experience of usage, then the substance cannot be self-classified and therefore cannot be marketed in the European Community until the necessary tests are carried out.

Further aspects of the CONVEYANCE LABEL (SI 1984 No 1244)

Regulation 9 requires an appropriate label to be clearly displayed on packages containing substances dangerous for conveyance. Regulation 10 allows a number of labelling options:

When the substance is classified as dangerous both for supply and conveyance, the supply label with the addition of the Substance Identification Number (or UN No) if it can be clearly seen, will satisfy conveyance requirements in the following cases:

1. where the package consists of a single receptacle containing less than 250 litres,
2. where the package consists of one or more receptacles in outer packagings containing in aggregate less than 250 litres,
3. where the package consists of two or more smaller receptacles (labelled for supply + SIN) mounted on a pallet in such a way that the labels on the smaller packages can be clearly seen, no additional labelling is required.

Manufacturers may wish to consider using this type of label as their standard supply label so that an additional conveyance label is not required in the above cases. (However, personally I do not think it wise to mix supply and transport data particularly if the goods are for export).

Where the supply label plus the substance Identification No is not sufficient, four types of conveyance label are recommended to cover the following situations-

Circumstance A
This type of Conveyance Label can be used in the following cases:

1. Where the individual receptacles are enclosed in packagings so that the supply label cannot be seen,
2. where packages contain two or more receptacles containing substances of the same hazard classification for conveyance,
3. where each receptacle in the package is 25 litres or less. (Irrespective of aggregated quantity).

Circumstance B
Where the supply label cannot be seen and for where two or more receptacles contain materials of the same hazard classification but at least one receptacle is greater than 25 litres then additional information must be provided on the label showing the nature of the dangers that can arise and the emergency action to be taken.

Alternatively, provided that an accompanying separate written statement showing the nature of the dangers that can arise, and the emergency action that should be taken, from the products in each receptacle greater than 25 litres, must be in the possession of the driver of the vehicle used to convey the package.

(The choice regarding Circumstance B is the suppliers. In the past an accompanying written statement has been thought unwise by some companies because they have not wanted to place responsibility with the driver. However, with the "Conveyance By Road in Packages" Regulations becoming effective later this year giving the driver specified responsibilities, company procedures regarding the transportation of goods may need revision.)

Circumstance C
Where the supply label cannot be seen, and where each receptacle in the package is 25 litres or less. But the packages contain two or more substances which are characterised by having different dangerous properties for conveyance, then the "Mixed hazards" hazard warning sign and a description indicating the nature of the substance must be used. (No Substance Identification (UN No) is required).

Circumstance D
Where the supply label cannot be seen and packages contain two or more substances which have different hazards for conveyance and at least one receptacle is greater than 25 litres then the "Mixed Hazard" hazard warning sign must be used, and additional information provided on the label showing the nature of the dangers that can arise, and emergency action to be taken, for the product in each receptacle greater than 25 litres. (No Substance Identification number is required).

(The Paintmakers Association will provide comprehensive data with illustrated examples of all the labelling options given above(5)).

Aspects of the Health and Safety at Work Act 1974

SECTION 6 and proposed amendments to Section 6

The 1974 Health and Safety at Work Act is all embracing with most of the new or proposed legislation a reiteration or clarification of existing Regulations. Therefore, despite consderable criticism and apprehension from the chemical industry, it is unlikely the proposed changes to the Act will be substantially revised.

Duties under the Act are expressed in general rather than specific terms and are applicable both to employees and employers. They are "designed to encourage employers and employees to take a wide ranging view of their roles and responsibilities"[6]. The proposed amendments are considered necessary because the Factory Inspectorate currently has difficulty in bringing prosecutions, and has virtually no experience of bringing cases to court under Section 6. In some areas the "general duties" have been supplemented by specific requirements and it is the intention of the Health and Safety Executive that these specific requirements (usually in the form of a Statutory Instrument) will continue to be introduced. SI 1984 No 1244 (although the UK equivalent to European Directives) is already encompassed by the *unamended* Health and Safety at work Act viz "In connection with the use of a substance at work adequate information about the results must be available in connection with the substance, and conditions necessary to ensure the material will be safe and without risks when properly used"[6].

Currently in order to comply with Section 6 it is not necessary to ensure the full information package is sent with every consignment, providing steps have been taken to ensure information is available to the user. However, the Amended Regulations (due for implementation this year) state full information shall be provided by the supplier "*at the time of supply*" (i.e. with every consignment or sample) and to "provide revised information to any persons to whom the unrevised information has been provided". The onus of responsibility here being on the supplier to give comprehensive information and to keep a record of where the data is sent. (Further complications are likely to arise if/or more likely WHEN the proposed Product Liability

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Regulations[7] and proposed Access to Health and Safety Information by Members of the Public[8], Laws are Adopted.

Proposed Amendments to Section 6 also intend to have:

1. more extensive controls on imported goods so they are liable to the same stringent Regulations as domestic ones, and
2. enforcement by Inspectors at the source of supply to prevent unsafe material from reaching the user, with the power to issue a prohibition notice preventing the material from being sold until the contravention of Section 6 has been remedied.

Two recent supplier prosecutions[10] (brought under the UNAMENDED Act) for failure to give adequate warning associated with their products, illustrate that the Health and Safety Executive are already revising their strategies, and will take the proposed amendments to Section 6 seriously. These successful prosecutions have given the Authorities confidence.

Section 6 of the HSA Work Act stipulates it is the duty of the supplier to ensure further relevant information is given to the user if sufficient data cannot be given on the label. More significantly the HS Exec. are now suggesting that it may be necessary to refer to the availability of this additional information ON THE LABEL[10]. The Health and Safety Executive do not consider phrases such as "when properly used" or "adequate information" to be a problem, but rather "enshrined in case law" and comparable to the approach taken in the Federal Republic of Germany. (i.e. 'General" safety law is couched in terms of "proper use").

Occupational Exposure Limits (OEL)[11]

Occupational Exposure Limits are published annually by the Health and Safety Executive and are once again encompassed by the 1974 Health and Safety AW Act. "These limits form part of the criteria which are used by the Health and Safety Executive (HSE) in assessing compliance with the H & S AW Act 1974 (HSW Act) and other relevant statutory provisions".

It is important to ensure the CURRENT publication is to hand, and not one which is out of date. The data is dynamic i.e. exposure limits on many of the products have been changed, and on others notification of impending change has been given.

CONVEYANCE BY ROAD IN PACKAGES:

"Dangerous Substances (Conveyance by road in Packages) Regulations 1985" is scheduled for implementation this year. It complements the "Classification Packaging and Labelling of Dangerous Substances Regulations 1984 SI No 1244", and is an extension of Dangerous Substances (Conveyance by Road in Tankers and Tank Containers) Regulations 1981 SI 1059 to cover transport by road in packages.

The new Regulations normally covering 500 kilos and above of dangerous substances (preparations), are materials in UN Packing groups 1 and 2 (given in the Approved list SI 1984 No 1244) or to any comparable substance which because of its physical or chemical properties would create a similar risk to Health and Safety[12].

Responsibility for Health and Safety of the Packages during Conveyance will be SHARED between manufacturer or supplier AND the vehicle driver. These requirements have considerable implications for both small and large companies and some of these implications are highlighted below:

Regulation 6: Information relating to dangerous substances

Operators must not convey dangerous substances unless they have obtained all information necessary for compliance with the Regulations and to be aware of risks which may be created to the Health and Safety of any person. The suppliers of this information must ensure it is both accurate and sufficient.

Regulation 7: Information in writing to be available during conveyance

Operators must ensure that vehicle drivers receive adequate written information on the identity, nature of danger, and action to be taken, covering materials transported.

Drivers must ensure that information in writing is kept on the vehicle at all times while the relevant product is being conveyed. Drivers must also ensure that any written information regarding materials *not* being conveyed are either removed from the vehicle or kept in a closed container clearly marked to show it does not relate to the load being carried.

The written information will either be consolidated into specific and comprehensive label data as specified in the CPL Regulations or by providing TREMCARDS or similar documents.

Regulation 8: Instruction and Training of Drivers

Drivers to receive training to ensure they are aware of their duties under the new Regulations and aware of the dangers and action to be taken. Four of five training schools in the UK are now operational and a certificate of Attendance (not competence) is given.

Regulation 9: Loading/Unloading and Storage

All persons involved must take steps to ensure the above procedure does not create Health and Safety risks.

Regulation 10: Fire or Explosion

All persons involved must take steps to prevent the occurrence of fire or explosion.

Regulation 12: Marking of Vehicles

Vehicles carrying 500kg or more of dangerous substances must carry specified markings governed by the quantities and nature of the loads.

Operators must ensure that the vehicles are marked and both operators and drivers ensure that the correct markings are displayed at all times during the conveyance of dangerous substances, and that the markings are kept clean and free from obstructions. The marksings are expected to be front and back diamonds and HAZCHEM codes. In other words an extension of SI 1059 "Conveyance by road in tankers and tank containers".

Regulation 13: Vehicle Supervision

Drivers are responsible for ensuring that, before they leave the vehicle, all reasonable precautions are taken to prevent interference with or theft of the load. In the cases of specifically identified substances drivers must ensure that vehicles are parked in a safe place and supervised at all times by a competent person over 18 years of age.

Regulation 14: Notification of Incidents

To notify the enforcing Authority within 7 days of any:

- fire
- spillage

The formal responsibility for enforcement of the Regulations will rest with HSE Inspectors and Department of Transport Traffic Examiners (The Department of Transport consider closing a major road for one hour while assessing unlabelled containers can cost CA. £20,000)

Conclusions

The ever increasing new legislation affecting labelling, and the gradual enforcement of existing Regulations make the suppliers' task of coming to terms with lawful labelling requirements extremely difficult.

Additionally, if the European Community proposals on Product Liability (85/374/EEC) and Preparations (85/C211/03) are Adopted without major amendments, much of the work carried out by the Chemical Industry to meet existing requirements will be obsolete!!!

References

1. SI 1984 No 1244 Schedule 2—The classification of, and hazard warning signs for substances dangerous for conveyance.
2. ACOP 9—Methods for the determination of physico-chemical properties.
3. ACOP 10—Methods for the determination of toxicity.
4. ACOP CPL of Substances Dangerous for supply and/or Conveyance by Road.
5. Labelling guidelines. Paintmakers Association.
6. A Guide to the Health and Safety at Work Act 1974. (HS(R)6).
7. Product liability legislation (85/374/EEC).
8. Access to Health and Safety Information by members of the public (Discussion Doc. HSC).
9. Proposed changes to Section 6 of the Health and Safety at Work Act 1974 (HSC).
10. HSIB 115 9/7/1985.
11. Guidance NOTE EH40/85 Occupational Exposure Limits 1985.
12. There are certain exemptions under these Regulations e.g. for explosives or radioactive substances or where other legislation already exists.

Appendix 1

1. Substances

67/548/EEC) Classification, Packaging & Labelling of
69/81/EEC) Dangerous SUBSTANCES.
70/189/EEC)
71/144-EEC) Published in the U.K. as
73/146-EEC) Statutory Instrument 1978 No. 209
75/409/EEC) (+Extension 1983 No. 17) revoked by
76/907/EEC) Statutory Instrument No. 1244*.

79/370/EEC 2nd Adaptation to Technical Progress. Published in the U.K. as Statutory Instrument 1981 No. 792 revoked by Statutory Instrument 1984 No. 1244*.

79/831/EEC 6th Amendment (Responsible for new Substances and for the introduction of ECOIN). Published in the U.K. as Statutory Instrument 1982 No. 1496 (partially adopted) Subsequently covered comprehensively by Statutory Instrument 1984 No. 1244*.

81/957/EEC 3rd Adaptation to Technical Progress.

82/232-EEC 4th Adaptation to Technical Progress. Published in the U.K. as Statutory Instrument 1983 No. 17 revoked by
83/467/EEC 6th Adaptation to Technical Progress now adopted by: Statutory Instrument 1984 No. 1244*

2. Solvents

73/173/EEC) Classification, Packging and Labelling of
80/781/EEC) Dangerous PREPARATIONS
(SOLVENTS).
81/957/EEC) Adopted as SI 17
82/232/EEC) revoked by
82/473/EEC) Statutory Instrument 1984 No. 1244*.

3. Paints, Varnishes (etc)

77/728/EEC) Classification, Packaging and Labelling of
81/916/EEC) PAINTS, VARNISHES, PRINTING
INKS, ADHESIVES
83/265/EEC) and similar products adopted by
) Statutory Instrument 1984 No. 1244*.W

4. Pesticides

78/631/EEC) Classsification, Packaging and Labelling of
81/187/EEC) DANGEROUS PREPARATIONS
(PESTICIDES)
84/291/EEC)

81/867/EEC) Amending Directive
84/291/EEC) Amending Directive
) Directives adopted by statutory Instrument
W1984 No. 1244*

5. Waste

78/319/EEC) Toxic and dangerous WASTE
MATERIALS adopted in part by 1980 SI
1709 now covered by Statutory Instrument
1984 No. 1244*.

6. Other

**Statutory Instrument 1984 No. 1244 is supported by essential documents viz*

(I) Authorised and Approved List.

Information approved for the Classification, Packaging and Labelling of Dangerous Substances for Supply and Conveyance by Road. (HSE Publication 15.5.84.).

(II) Approved Code of Practice.
Packaging of Dangerous Substances for Conveyance by Road. Classification, Packaging and Labelling of Dangerous Substances Regulations 1984 (HSE Publication 1984).

(III) Approved Code of Practice.
Classification and Labelling of Substances Dangerous for Supply and/or Conveyance by Road. Notification of New Substances Regulations 1982. Classification, Packaging and Labelling of Dangerous Substances Regulations 1984 (HSE Publication 1984).

(IV) Proposed Revision No. 1 to the Approved List. (Information Approved for the Classification, Packaging and Labelling of Dangerous Substances) and consequent amendments to the Classsification, Packaging and Labelling of Dangerous Substances Regulations 1984.

Statutory Instrument SI 1982 No. 1496—Testing of New Substances Regulations (Effective 26.11.82).

ACOP10 SI 1982 No. 1496—Approved Code of Practice Methods for the Determination of Toxicity.

ACOP9 SI 1982 No. 1496—Methods for the Determination of Physico-Chemical Properties.

ACOP8 SI 1982 No. 1496—Methods for the Determination of Ecotoxicity.

Health and Safety at Work Act 1974. Proposed Changes to Section 6 of the Health and Safety at Work Act 1974. Consultative Document (HSE Publication 1984).

Guidelines for the Classification, Packaging and Labelling of Resin Products. (British Resin Manufacturers Association Publication—May 1983).

Dangerous Chemical Substances and Proposals Concerning their Labelling. (Council of Europe—Strasburg 1978).

Guidance Note EH40—Health and Safety Executive. Occupational Exposure Limits 1985.

Control of Substances Hazardous to Health—Draft Regulations and Draft Approved Codes of Practice (HSE Publication 1984).

European "equivalent":
80/1107/EEC Protection of Workers from the risks related to exposure to chemicals. Physical and biological agents at work.

Proposal for Dangerous Substances (Conveyance by Road in Packages etc)

Regulations 198—(Implementation during 1986).

Appendix 2

Useful Addresses	Comment
CPL Regulations Health & Safety Executive, St. Hughes House, Stanley Precinct, Bootle, Merseyside L20 3QY.	Currently offering an 'information package' on Classification Packaging and Labelling of Dangerous Substance Regulations 1984.
Health & Safety Executive, Hazardous Substances Division, Branch C1, 25 Chapel Street, London NW1 5DT.	Lobby to make ammendments to proposed legislation e.g. Control of Substances Hazardous to Health.
British Resin Manufacturers Association, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS.	Advice on resins.
Paintmakers Association, Alembic House, 93 Albert Embankment, London SE1 7TY.	Advice on paints. Offer an excellent labelling system for categorising paints.
Society of British Printing Ink Manufacturers Association, PIRA House, Randalls Road, Leatherhead, Surrey KT22 7RU.	Advice on printing inks.
Chemical Industries Association, Alembic House, 93 Albert Embankment, London SE1 7TY.	Advice on all chemicals.
George Hayward, 'Maenan' Harold Wood, Romford, Essex RM3 0NP.	Consultant on all health and safety problems.
Arthur Hancock, Pentre, Dinas Cross, Newport, Pembrokeshire SA42 0YA.	Consultant on matters relating to packaging.

Ultra-violet curing for offset printing inks and varnishes

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Summary

An introduction to UV curing is presented. This is confined in this current treatise to offset and letterpress printing inks and varnishes, although the principles remain similar for other areas. A brief resumé of the history of UV curing is described. This is followed by outlines of elementary formulation principles, mechanism of action and the predominant lamp source employed. Typical application within the offset printing area, such as sheet and web fed are surveyed. These are for various substrates including, paper and board, metal decorating and plastics. Finally, a summary is given of the major advantages and disadvantages of UV curing.

1. History of UV curing

The ancient Egyptians were known to treat their linen cloths with a light sensitive mixture. It was a combination of Lavender oil and Syrian asphalt, which was dried by sunlight. This was then used for wrapping mummies[1]. In the 19th Century, Syrian asphalt was also used for the preparation of lithographic printing plates until replaced by the more convenient gelatin/dichromate.

The ancients also had long been aware of the action of light upon substances, altering their nature. Some examples were the chlorophyll of vegetation turning green on exposure and the fading of coloured fabrics as well as the ripening of fruit.

Schultz in 1727 stumbled upon the fact that certain silver salts, in particular the halides, are radically changed by the action of light. This led to our modern day photographic technology involving such photoresponsive compounds.

There were attempts in the 1940's to formulate UV curing materials based upon natural drying oils such as tung and oiticica used in conjunction with halogenated hydrocarbons[2]. These were not very successful as the ozone from the lamps was thought to be responsible for the curing[3].

Pioneer work was essentially involved with the then available resins that were photopolymerizable. Primarily these were unsaturated polyesters of maleic origin and diallyl phthalate resins. 1946 was the year in which a patent was first granted for UV curing printing inks.

Prior to the 1960's acrylic acid esters of mono alcohols such as ethyl and n-butyl acrylate predominated along with specific functionalised acrylic esters such as hydroxy ethyl acrylate. These acrylic esters were however commercially insignificant compared to their analogues the methacrylic esters, for example methyl methacrylate. Later, in the 1960's UV curing printing ink acrylate chemistry was essentially that of the introduction of 'PETA' (pentaerythritol triacrylate), 'TMPTA' (trimethylol propane triacrylate), and "HDDA" (1,6 hexanediol diacrylate), as multifunctional acrylic esters[4].

In the early 1960's, unsaturated polyesters or drying oils in combination with available vinyl type monomers such as styrene were used[5].

Klose[6] in 1968 found that a combination of short wave length UV and ozone cured a range of conventional coatings. In the 1970's acrylate systems predominated and is expanding[7]. Non-acrylate systems also exist such as thiolenes, N-vinyl pyrrolidone, vinyl acetate etc. Cationic curing UV systems are of topical interest as they eliminate the need for acrylate chemistry.

In modern times, there are two major reasons for the current rapid advance of UV curing technology[8]. These are:

1. Energy and matter conservation.
2. Environmental pollution control.

Both of these received an impetus from the US where the shortage of natural gas in certain states led to the search for alternative energy sources and the Los Angeles Pollution Act of 1966, which resulted from the concern of volatile hydrocarbon solvents being released into the atmosphere.

2. What is UV curing?

To understand this term, an examination of what is normally meant by the word "curing" as applied to surface coatings such as printing inks must first be considered.

The "curing" of a surface coating means its conversion from the liquid state to the solid state. In essence this is the chemical drying (i.e. by chemical bond formation) of the material whereby crosslinking or polymerization occurs throughout the film. This is in contrast to simple hardening of films, which is physical drying whereby solvent is removed from a polymer solution. In this case the polymer molecules are present initially in the original liquid product. Photopolymerization or UV curing however creates polymers from monomers or low molecular weight oligomers initially present.

Traditionally, one of the more common methods of achieving a chemical phase change has been by thermal means. There are many methods of thermal drying which often include hybrids between physical and chemical processes.

A new technology has now emerged whereby this "curing" may be achieved by using light energy instead of heat.

The UV curing of inks and varnishes is effected by electrically derived UV light energy as the driving force to produce instantaneously dried inks. In common with all ink drying, this conversion involves a phase change. In this case a mobile liquid is converted in a fraction of a second (@ 0.02 sec) to a hard rigid solid network, the phases having different solubility parameters. UV curing, in contrast to other drying mechanisms such as IR, promotes an

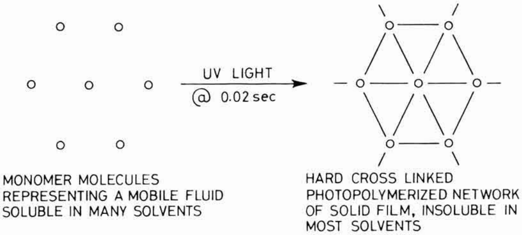


Figure 1. Schematic representation of UV ink curing

immediate chemical change. This process which may be regarded as synthesizing a plastic on a given substrate by the action of light is depicted in Figure 1.

Energy is conserved as the area of application of the UV Light is specific to the varnish or ink involved, not to the substrate as occurs with some other methods of drying.

UV inks and varnishes are composed of 100% reactive materials and contain no evaporative volatile solvents as compared to conventional materials. Their mechanism of drying depends upon some of their chemical constituents being sensitive to UV light of certain wavelengths.

3. Formulation

The composition of offset lithographic or letterpress UV ink for example is basically as follows:

Material	*Function*
Pigment	Provides colour and opacity or transparency as required
Pre-Polymer/Monomer	Film forming materials giving physical and chemical properties
Photo-Initiator	Light sensitive chemical which starts the polymerisation reaction off
Inhibitor	Pot life stabilizer
Reactive Diluent	Rheology control (Tack and viscosity)
Additives	Fillers, slip agents, flow promoters etc.

A typical conventional (i.e. metal decorating) offset ink could be based on:

Material	*Function*
Pigment	Colour
Heat sensitive Resin/driers	Film forming materials
Solvents	Evaporate on stoving
Additives	Fillers, slip agents, flow promoters etc.

The comparison shows that for conventional inks, a great deal of volatile solvent is exhausted to the atmosphere during the stoving cycle. With UV inks all the components react to form the film. There is therefore little or no atmospheric pollution with these inks. Matter is therefore conserved in the UV curing process as no volatiles are lost.

Some comments will be made for the raw materials used for composing a UV ink.

3.1 Pigment

As UV curing inks do not lose material on drying, the final film to be equivalent to conventional material on colour strength needs initially to be formulated at a higher pigmented level. This does mean that gloss may suffer in thin film.

Pigment selection has to be made with care as the processing coatings often present on them can affect the cure rate and pot stability of UV inks. The photo-initiator response can also be affected, if the pigment competes with it for the incident light quanta. This explains the slower curing of black inks in a four-colour process set. Carbon black is conjugated, polycyclic and has a large surface area and therefore absorbs radiation strongly in the UV area of the electro-magnetic spectrum. It may also because of this unsaturation act as a scavenging trap for free radicals.

'Squash' can be troublesome with carbon black inks in letterpress UV formulations, as through cure in the thicker film area is difficult.

In general the colour cure sequence is yellow>magenta>cyan>black, although magenta is often the fastest, depending upon the pigment selection etc.

For non-pigmented systems such as overprint varnishes, cure is much easier. Selection of photo-initiators does however have to be made with care to prevent yellowing after cure.

3.2 Resins

Conventional letterpress and lithographic inks can be formulated from resins of many types including:

1. Resin esters
2. Phenolic resins and variants
3. Hydrocarbon resins
4. Maleic resins
5. Alkyd resins
6. Polyurethanes
7. Rosin derivatives
8. Styrene/Maleic copolymers
9. Chlorinated rubbers
10. Coumarone resins

Some tend to be saturated organic compounds (though not necessarily so) in nature.

UV inks contain as the vehicle, pre-polymers and monomers as the cross-linking film formers. A pre-polymer is an unsaturated organic compound generally partly polymerised and therefore with a low activation energy to obtain complete polymerisation. This activation energy is supplied from UV light via the photo-initiator or photo-sensitizer used.

The rheology of these materials varies from the liquid state to that of the solid hard resin type and they confer in the inks, pigment wetting, tack, vicosity, rub resistance, gloss and many other required physical and chemical properties.

This kind of binder is often of the following types:

Radiation Curing

Irgacure-Photoinitiators

cure faster than it takes
to read “Radiation Curing” – clean and
energy saving!

®IRGACURE
from

CIBA–GEIGY

1. Unsaturated polyester/acrylated polyester
2. Acrylated epoxy resins
3. Acrylated urethanes (both aliphatic and aromatic)
4. Acrylated silicone resins
5. Thiol-ene systems
6. Acrylated polyethers
7. N-vinylurethanes
8. Acrylated melamines
9. Acrylated oils
10. Acrylated polyesters

and many others depending on the required film properties such as flexibility, cure-speed, rub resistance, gloss etc. As can be see above, acrylated materials tend to currently predominate.

The monomer can be an unsaturated lower molecular weight form of liquid pre-polymer, generally an acrylic type having different functionalities (i.e. monoacrylate, diacrylate, etc) and depending on type confers the physical and chemical properties mentioned for pre-polymers in the final film. They can also act as reactive diluents for rheology control. Rheology control is an extremely important parameter to master as the science of the study of the flow and deformation of matter. In the case of printing inks, it needs to be correct in terms of viscosity and tack. This will ensure good flow, lack of picking on paper and board and reduce misting or flying.

3.3 Photo-initiator

The photo-initiator is of paramount importance in these systems. It is selective to light of specific wavelengths and during selection for formulation, is matched in absorption characterisitcs to the peak wavelengths present in the lamp source. It is, however, the final wet ink absorption characteristics that are the most important, as this will be modified by the resins and additives present which may also absorb UV radiation.

A distinction should be made between the terms 'photo-initiator' and 'photo-sensitizer' often used interchangeably. A 'photo-initiator' absorbs the incident light directly and splits up or fragments to form free radicals. These then attack the monomers (generally by hydrogen atom abstraction), to initiate the photo-polymerisation reaction. In contrast, a 'photo-sensitizer' absorbs the incident light but does not fragment itself, but 'transfers' the energy it has obtained to another compound (which may be the monomer), which will then procure initiation of the polymerization reaction.

Some common types of photo-initiators fall into the classes of:

1. Aromatic ketones and synergistic amines
2. Alkyl benzoin ethers
3. Cationic curing quaternary ammonium salts
4. Thioxanthones
5. Benzil ketals
6. Acylphosphine oxides
7. Ketoxime esters

4. Mechanism

The mechanism of UV curing can simplistically be represented by the formulae in Table 1.
R—is the photo-initiator and MH denotes the monomer or pre-polymer reacting by hydrogen abstraction. The species denoted with ⋆ represent highly reactive free radicals.

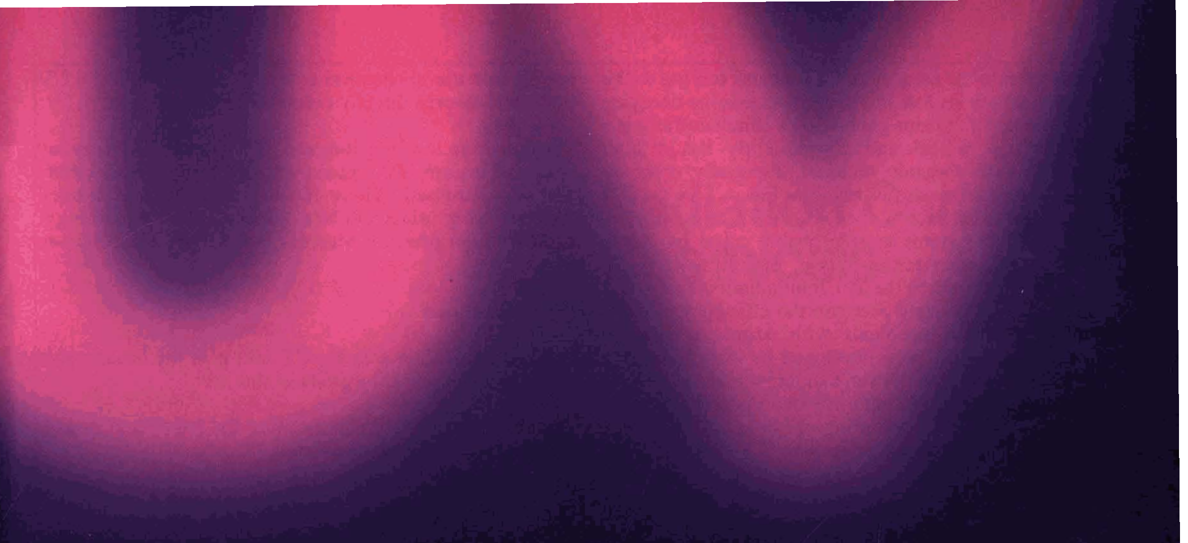
5. Lamp sources

Many radiation sources have been explored for UV curing but current commercial interest centres around the high intensity medium pressure type[9]. These lamps operate about 1 bar and 200 watts per linear inch. The principle peak wavelengths lie in narrow bands (to which the photo-initiator is matched as closely as possible). These are: 184.9nm, 253.7nm, 265.4nm, 303nm, 313nm, and 365nm. The 184.9nm band is absorbed by oxygen. This converts oxygen to ozone and is a hazardous gas. An extractor is

Table 1

UV curing mechanism

		UV LIGHT	
PHOTO-INITIATION (the absorption of light to form free radicals)	R − R (photo-initiator)	⟶	$R^* + R^*$ (free radicals)
	$R^* + MH$ (monomer)	⟶	$M^* + RH$
PROPAGATION (chain reaction to form polymeric species)	$M^* + M_1H$	⟶	$M(M_1H)^*$
	$M(M_1H)^* + M_2H$	⟶	$M(M_1H)\ (M_2H)^*$
	$M(M_1H)\ (M_2H)^* + M_3H$	⟶	$M(M_1H)\ (M_2H)\ (M_3H)^*$ etc
	OR IN GENERAL $M^* + n(MH)$	⟶	$M(MH)_n^*$
TERMINATION (end of chain reaction)	$M_{197}^* + M_{64}^*$	⟶	M_{261}
	$M_{32}^* + M_{41}^*$	⟶	M_{73} etc
	OR IN GENERAL $M_x^* + M_y^*$	⟶	$M_{(x+y)}$


UV

incorporated into the lamp system to exhaust this gas to the atmosphere where its half life is short, the ozone decaying to harmless oxygen. Ozone gas has to be eliminated as it is a molecular free radical and consequently has a high reactivity towards organic material, especially common polymers present such as rubber.

Early UV ink systems most probably cured by ozone causing the polymerisation rather than incident UV radiation. Ozone absorbs the 253.7nm radiation and would be expected to effectively decrease the efficiency of cure. To overcome these problems with ozone, non-ozone producing lamps have been developed by incorporating a special silica in the material surrounding the electrodes. A typical spectrum of a high intensity medium pressure lamp is presented in Table 2 operating at about 200 watts per linear inch (80 watts per linear cm).

Table 2

High intensity medium pressure mercury arc spectrum

Region of spectrum	Wavelength (nanometres)	Radiation (W.cm^{1})	
Infra-red	1367	0.35	A
	1129	0.94	
	1014	3.27	
Visible	578/9	5.51	B
	546	6.06	
	436	4.80	
	405	2.40	
Ultraviolet	365/6	4.76	C
	334	0.55	
	313	2.17	
	303	1.26	
	297	0.79	
	289	0.28	
	280	0.55	
	275	0.16	
	270	0.28	
	265	0.59	
	257	0.83	D
	254	0.47	
	248	0.51	
	240	0.47	
Total infra-red	=	4.56	
Total visible	=	18.77	
Total ultraviolet	=	13.67	
Total rating of lamp	=	78.74	
UV emission efficiency	=	17.4%	

Infra-red and visible energy are respectively found in the groups 'A' and 'B'. These are not directly used in the UV curing process. Photo-initiator and photo-sensitizers are matched for use in band 'C', according to the Grotthus-Draper Law of Photo-Chemistry, where they convert light energy into useful chemical energy. The vehicle in the UV ink often absorbs directly radiation in the 'D' area.

Apart from low, medium and high pressure mercury arc lamps which are UV sources with electrodes many others are being utilised. These include microwave generated spectra from electrodeless lamps, laser technology, capillary high pressure Mercury lamps and pulsed Xenon lamps.

6. Applications

A large application area for UV inks is in the lithographic field. Some important aspects of this are:

1. Sheet fed lithographic printing for paper and board, plastics and metal decorating
2. Web offset for paper and foils

6.1 Sheet-fed lithographic printing

Folding cartons are a large growing area[10], where many advantages from UV curing are prevalent. For example, the elimination of offset spray powders has been achieved by UV and, as a consequence, lead to increased production and better quality. The sheets are dried instantly and are abrasion-resistant on delivery. Set-off is therefore not a problem. Set-off is a problem which occurs when a not fully dried print is stacked and the printed matter transfers to the underside of the sheet above. In more serious conditions 'blocking' can occur where layers stick together. Handling for additional processing such as immediate die-cutting is therefore made easy. In-line die-cutting is possible. UV dried prints have, in general, good scuff, scratch and chemical and solvent resistance. Also UV inks are stable on the press and in the duct as they are non-volatile and are not subject to oxidation by the atmosphere. This is in contrast to their conventional counterparts which 'skin'. The inks can, therefore, be left 'open' on the press overnight or a weekend if required with no skinning problems. The need for tedious and expensive wash-ups is, therefore, reduced. UV curing permits the ability to dry between stations on a press. This wet on dry trapping or inter-colour drying can increase print accuracy and eliminate problems such as doubling or ghosting. Inks do not need to be tack graded for inter-colour drying.

An often encountered problem in conventional ink sheet-fed printing is 'dry-back', where the dried ink colour is not the same as it was when freshly applied. This is often due to paper and board variables. These are costly in the folding carton areas. UV curing helps to eliminate this problem and consequently results in reducing paper waste.

Also most of the advantages depicted above such as ink stability, wet on dry trapping and instant drying are likely to lead to more efficient press design.

Less odour level is now frequently encountered with UV formulation, due to raw material suppliers keeping the 'free' acrylic acid content in their acrylate monomers and pre-polymers to a minimum, although in some areas such as metal decorating, a small amount of acrylic acid may promote adhesion.

The water balance is very important in lithographic offset printing. Compared to conventional sheet fed inks UV curing inks tend to take up less water on the press. They do

generally however, pick up water much more quickly and also release it faster.

6.2 Web offset printing[11]

Apart from those previously mentioned, there are many other advantages of the UV process for web offset printing. After burners are eliminated and hence no emission occurs of hydrocarbons to the atmosphere. Gaseous oxides from the combustion of natural gas are also eliminated as the energy source from UV curing is electrical in nature.

The wet on dry trapping principle would also in this case be expected to eliminate dot-doubling associated with wet on wet trapping. The Gravure printing process has for a long time had this advantage at the expense of offset printing and UV helps to tip the balance towards lithography.

The resistance of the UV ink film to skin oils, which is of significant importance for magazine covers and other publications that have excessive handling, is of great interest for the publication printer.

Web temperature reduction owing to the use of UV radiation curing is also important, as blistering and the need for chill roller employment are eliminated. The possibility of using thinner, lower cost, paper stocks also is a consequence of the reduced web temperature.

6.3 Metal Decorating[12-17]

Flat Sheet Metal Offset Lithographic Printing and Dry Offset Application

UV has enjoyed growth in the metal decorating field. Interpass UV permits the flat sheet metal printer to go through the production line at one pass instead of the multipass system traditionally used. For conventional inks, metal decorators often print two colours first, thermally cure (generally at 300-350°F for about 12 minutes) and rack, then print two more colours, a wet varnish and again thermally cure. This is costly and slow and the advantages of a one-pass system are clearly seen as is the elimination of the enormous cost of installing energy consuming, long thermal ovens.

Hybrid systems are currently being used employing two colours of UV ink, two colours conventional ink, plus a conventional wet varnish. Complete UV systems without thermal energy are now emerging, although adhesion sometimes leaves much to be desired without the short 'thermal bump' being included.

The general film properties of UV cured metal inks are often much better than conventional systems. Metal decorating UV is not only applicable in flat-sheet but is also viable in two-piece can decorating, where the advantages of space and reduced oven maintenance are of paramount importance.

Interdeck UV curing on multicolour tin-printing lines is salient. Unlike paper and board printing where up to six colours can be printed in a single pass, owing to the substrate usually possessing some absorbency, sheet metal printing has been limited to two or three impressions per pass followed by stoving and then printing of any further colours. UV curing has enabled four colours to be printed in one pass, the first two inks being set by radiation and then overprinted with conventional oxidation drying inks prior to varnishing and stoving.

The inks are generally only 'set' (surface cured) sufficiently to enable them to be overprinted and finally cured and hardened in the wicket ovens. The quantity of UV radiation and the formulation of the inks have to be adjusted to ensure the print has sufficient adhesion to plain metal so that it is not picked off by the following printing blanket. At the same time, however, it must develop sufficient interfilm adhesion with the overlying conventional inks and varnish.

For total UV lines where the ovens are replaced by a UV drier at the end of the line rather than interdeck which is much cheaper, the line will occupy much less space and require less energy. The print will have to be cured sufficiently to avoid scratching and more particularly, "set off", when the sheets are stacked in the unloader. More radiation (larger number of lamps) is likely to be required than for interdeck setting, as for example thicker films will need to be cured (i.e. several colours printed down wet on top of each other).

6.4 Plastics

These may be printed by two offset processes, such as lithography or dry offset (letterset). Dry offset UV curing is used especially in the USA for printing preformed plastic containers and closures (such as tapered pots, cups, tubes, lids etc). UV is of specific relevance, when tapered pots and lids are nested as this tends to satisfy food safety regulations, as any contamination on the inside (for foodstuffs) is extremely undesirable.

Adhesion has been a major hurdle to overcome with plastics, as being a surface oxidation problem has led to pre-printing treatments such as flame treatment of the polyolefines both for UV and conventional inks being needed.

Inks of the conventional type require thermal energy to cure which distort the shape of the plastic container. Many glycol based printing inks do not ultimately give adequate resistance to many of the materials being packaged, i.e. anti-freeze solution and oils for motor vehicles. UV curable inks can help to overcome these problems, as in the former case, distortion does not occur due to 'coldcure' of UV. In the latter case, the hard dense cross linked film after UV curing often prevents 'solvent and moisture' penetration.

7. Advantages and disadvantages

To summarise, the major advantages of UV curing for offset printing inks and coatings[18-19] include:

1. Solvent free formulations, eliminating afterburners, oven and other emission control devices, both energy and raw material saving
2. Removes dependence on natural gas
3. UV lamps and equipment take little space, being readily adaptable into existing production sequences
4. Production lines and throughput can be accelerated
5. No set-off spoilage or subsequent marks on folding and cutting etc
6. Wet on dry trapping (interdeck curing) is obtainable

7. Improves film properties such as good chemical and rub resistant films
8. Increases press stability (ability of ink to be left open on press), no volatile components to cause tack and viscosity changes on the press
9. Eliminates wax/starch spray (paper and board) powder and the practice of shaking stacks
10. Instant drying
11. In-line cutting, creasing and decorating, saving space and lead times
12. Elimination of thermal distortion (plastics)
13. Improved product resistance
14. Better colour reproduction
15. Higher flash point materials used therefore safer from a flammability point of view
16. Accomodates foil and poly lined boards
17. Low odour and taint for food packaging
18. Elimination of dry back due to vehicle drainage giving reliable colour immediately

Mileage is reputed to be equal or about the 15% level greater than conventional inks and the elimination of dry back should enlarge the effective mileage.

There are, of course, as with all systems some disadvantages such as:

1. UV equipment costs are high to install
2. UV materials are costly
3. the improvement of chemical resistance with a UV cured film makes de-inking very difficult

Certain highly pigments systems that are very opaque are difficult to dry with UV. Metallic pigmented inks can present problems as they will tend to reflect the UV light and resist cure. If surface cure is obtained, this can retard or prohibit 'leafing' occurring.

Re-reeling newsprint and label printing is a progressive area for UV curing. Clear UV overprint varnishes, in particular dry-offset, lithographic and roller coated lacquers have become popular. This is because of the attraction of the handling speed, the extra gloss, rub resistance and economy compared to lamination.

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The application of colour physics to printing inks*

The best laid plans of mice an' men gang aft a gley.

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Abstract

This article discusses our progressive understanding of numerical colour specification dealing first with tristimulus values, then CIE L*a*b* colour space and finally optimised colour difference equations.

Introduction

The overall title for the symposium is "Recent Changes and Future Trends". From a personal viewpoint, the most notable change over the last few years is the increasing interest of the industry in colour physics and colour computation.

I would like to remind those tempted to leave the consideration of colour physics to others, of the view expressed 86 years ago by Paterson[1]:

> "Theoretical knowledge alone cannot make a successful colour mixer, but it certainly proves of great value in explaining the true causes of failure and directing the conditions that lead to success"

Human colour perception

The numerical representation of colour perception is the basis of colour physics. Colour perception is one of those rare subjects in which we literally carry the experimental apparatus around in our heads. It is a sense that is being quantified, just as smell, touch and hearing are senses. Thus colour perception has been a subject of study by psychologists, medical scientists, artists and designers as well as physical scientists.

Four things need to be considered before numerical colour specification is possible. The nature of the illumination, the size of the object, the conditions of observation and the observer. Under a particular set of conditions, the additive laws describing the mixing of coloured light apply. These laws essentially say that any colour can be reproduced by combining the light from a maximum of three appropriately chosen sources. This forms the basis of numerical colour specification, if the amount of light needed from each source to match a colour is known, then the colour is specified. The additive mixture of light from a single set of three real sources can only reproduce a limited gamut of colours. To overcome this problem, the CIE system of colour specification uses a single set of three imaginary light sources. They are chosen in such a way as to simplify the numerical specification of colour. They are imaginary in the sense that they do not physically exist, however there is a set of simple relations between the amounts of the imaginary sources and those of three real sources needed to match the same colour.

In 1931 the CIE set out a scheme of colour specification that established:

1. The nature of the illumination by defining a set of standard illuminants. The illuminants are specified by their spectral energy distribution, i.e. the relative power per unit wavelength range at a series of wavelengths throughout the visible spectrum. Three illuminants were defined:
Illuminant A represents light from a gas filled coiled filament tungsten lamp.
Illuminant B represents direct sunlight.
Illuminant C represents average daylight.
It was later found that B and C do not adequately represent sunlight or daylight, particularly in the ultraviolet region. A new illuminant was defined.
Illuminant D_{65} a better representation of average daylight.
Illuminants D_{65} and A should be sufficient for general use in colorimetry.
2. The conditions under which the samples were to be observed were also defined.
3. The nature of the background.
4. *2° standard observer.* The visual response of the standard observer. The observer defined in 1931 is known as the 2° standard observer. The angle describes the semi-angle of the cone of light from the sample that enters the eye. The standard observer is defined by a set of tables containing the response of the eye at a series of wavelengths within the visible spectrum. Subsequent to its definition, a number of reports were received indicating that the values did not adequately represent an average observer with normal vision, particularly in the spectral region 380 to 460nm. A new standard observer has been defined.
10° standard observer. This observer is recommended for use when large colour fields are being observed.

Under these conditions a colour can be expressed numerically by the tristimulus values X, Y and Z. These values represent the amount of each imaginary source needed in an additive mixture to match the colour of the given sample. X represents an imaginary red source, Y an imaginary green source and Z an imaginary blue source. Specification of colour in terms of the tristimulus values alone has a number of practical limitations:

1. It is difficult to interpret the hue, lightness and depth of a colour from its X, Y and Z values.
2. The tristimulus values do not represent co-ordinates in a three dimensional colour space.
3. A numerical value for the perceived difference in colour between two similar samples is not represented by the difference in their tristimulus values.

It is clear that while it is possible to define a colour by specifying the values of X, Y and Z, the standard illuminant, the illumination and viewing geometry and the standard observer, such a specification is by no means ideal. More practical systems based on the concept of a uniform colour space have been developed.

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Uniform colour space

A uniform color space is a representation of colour perception in terms of points in a three-dimensional space. The distance between any two points in the space can be taken as a measure of the visual difference between the colours of two samples represented by those points. Many attempts have been made to derive equations that transform the tristimulus values into three parameters that represent coordinates in a uniform colour space. The most practical are those based on the Munsell system of colour specification. This system was constructed by placing physical samples into a perceptually uniform arrangement. There is a vertical axis representing the achromatic colours from black to white. The chromatic colours are arranged in the hue plane which lies perpendicular to the vertical axis. In 1976 the CIE recommended the CIE L* a* b* system, its arrangement is shown in Figure 1. The system is intended to be a uniform colour space with the following properties:

1. A rectangular, three-dimensional colour space (L*, a*, b*) in which all surface colours can be represented.
2. The distance between the points representing the colours of two samples is proportional to the visual colour difference between them.
3. The axes are scaled so that a just perceptible colour difference is represented by unit distance.
4. L*, a*, and b* values can be easily interpreted in terms of the hue, lightness and depth of a colour.

CIE L* a* b* Colour Space

L* is the vertical axis and represents lightness, 0 being a perfect black and 100 a perfect white sample.
a* an axis in the plane normal to L* which represents the redness/greeness quality of the colour. Positive values denote redness and negative values denote greeness.
b* an axis normal to both L* and a* which represents the yellowness/blueness quality of the colour. Positive values denote yellowness and negative values denote blueness.

The coordinates of the points representing the colour of a sample can also be expressed in terms of the cylindrical coordinates, lightness (L*), chroma (C*) and hue (h).

$$C^* = (a^{*2} + b^{*2})^{1/2}$$

$$h = \tan^{-1}(b^*/a^*)$$

The conversion of tristimulus values to CIE L* a* b* is performed by the following equations.

$$L^* = 116.V_Y - 16$$

$$a^* = 500.\ (V_X - V_Y)$$

$$b^* = 200.\ (V_Y - V_Z)$$

Where:

$$V_Y = (Y/Y_o)^{1/3}, \text{ for } (Y/Y_o) > 0.008856$$

Otherwise:

$$V_Y = 7.787\ (Y/Y_o) + (16/116)$$

Similarly for V_X and V_Z.

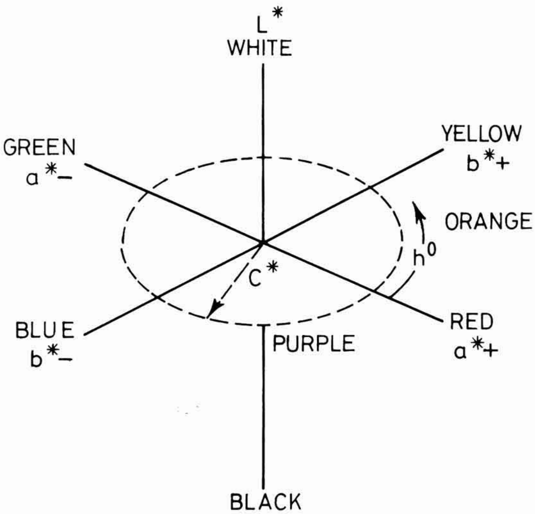

Figure 1. The CIE L*a*b* colour space

The subscript (o) denotes the tristimulus value for a 100% reflecting sample under the chosen illuminant.

The CIE L* a* b* system is by no means perfect, but it is an internationally agreed system and is becoming the system of preference for surface colour specification. It still should be noted that a full instrumental colour specification includes not only the L* a* b* values but also the illuminant, the standard observer and the conditions of illumination and observation.

It is worth being reminded that instrumental methods measure the colour in isolation. In most practical applications the colour is viewed in association with neighbouring colours. These affect our perception of the colour under consideration. One effect, that of "simultaneous contrast" is relatively easy to demonstrate. The apparent lightness of a neutral grey sample depends on the background against which it is viewed. For example, it will appear lighter viewed against a dark blue background than against a bright yellow background. The background conditions can be arranged so that the neutral grey sample even appears to take on a distinct hue.

Since the establishment of CIE L* a* b*, it has been found to have a number of failings. The most important of which is that it is not a truly uniform colour space. It has also become clear that the psychological primary colours do not lie exactly along the a* and b* axes as originally intended. The psychological primaries are the four colours red, yellow, green and blue. They are psychologically pure when each one is seen not to contain any of the colour attributes of the other three. For example the red is judged to be neither yellowish or blueish, the yellow is judged to be neither greenish or reddish, and so on for green and blue. (see Table 1).

Non-uniformity of CIE L* a* b* space and the assessment of colour difference

CIE L* a* b* space was intended to be uniform in the sense that the straight line distance between two points was a measure of the perceived difference in the colour of the

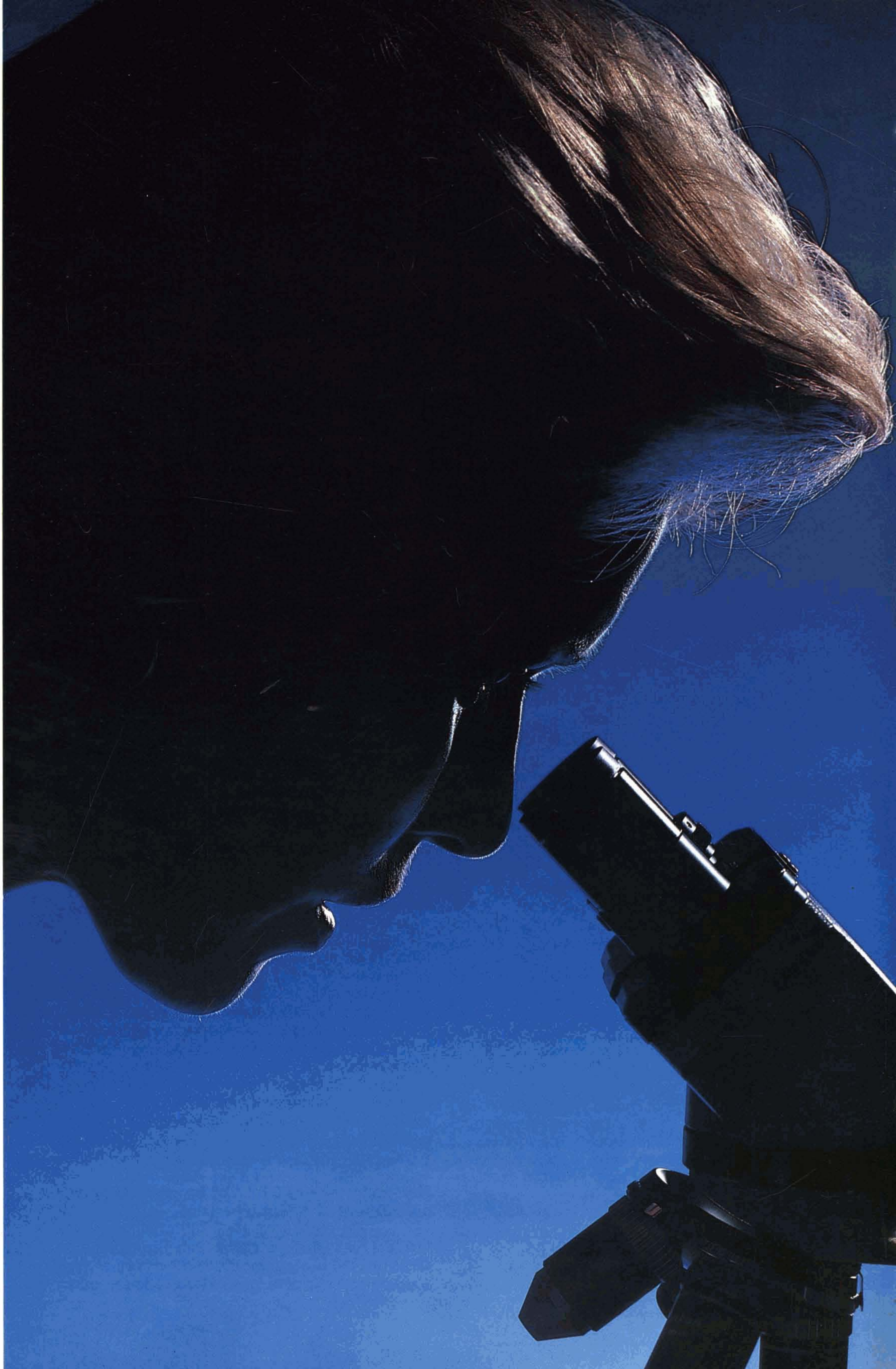

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Table 1

The primary colours

Primary Colour	Hue Angle Ideal	(Degrees) Actual
Red	0	27
Yellow	90	95
Green	180	163
Blue	270	261

samples represented by those points. It soon became clear that this was not the case. In CIE L* a* b* space the colour difference between a standard and a trial sample is expressed numerically by ΔE.

$$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

Where

$$\Delta L^* = L^*_T - L^*_S$$

$$\Delta a^* = a^*_T - a^*_S$$

$$\Delta b^* = b^*_T - b^*_S$$

Where the subscripts T and S denote trial and standard samples respectively. Such an equation allows the possibility of instrumental pass/fail decisions based on a limiting value of ΔE. Trial samples whose ΔE value exceeds the limit are judged not to match the standard (fail). Those whose ΔE is less than or equal to the limit are judged to match (pass). It is often helpful when interpreting a numerical colour difference, to split it into contributions from differences in lightness (ΔL^*), chroma (ΔC^*) and hue (ΔH^*).

$$\Delta E = (\Delta L^{*2} + \Delta C^{*2} + \Delta H^{*2})^{1/2}$$

$$\Delta C^* = C^*_T - C^*_S$$

and ΔH^* is given by:

$$\Delta H^* = (\Delta E^2 - \Delta L^{*2} - \Delta C^{*2})^{1/2}$$

The accuracy of pass/fail judgements made using a colour difference equation is best assessed by comparing them with those made by human colourists. The way in which this may be done has been described by McLaren[2]. The method can be illustrated by considering the Davidson and Friede[3] data. A series of 287 trial samples clustered around 19 standard colours was assessed under controlled viewing conditions by 8 colourists. The correct answer as to whether a trial matched the standard or not was taken as the majority decision of the colourists. It was found on average that a single colourist disagreed with 17.1% of the majority decisions. This can be interpreted as saying that on average a single colourist will make an incorrect pass/fail decision for 17 out of 100 assessments. When a numerical assessment based on the CIE L* a* b* colour difference equation is made on the same set of samples, an incorrect pass/fail decision is made 19 times out of 100 assessments[4–6]. The numerical method produces more incorrect decisions than a single visual assessment. Closer study of the Davidson and Friede results and other sets of data show that there is a systematic variation of the limiting acceptable value of $\triangle E$ with the lightness, chroma and hue of the standard. A number of scientists have produced optimised colour difference equations which are designed to allow for this variation. These are colour difference equations and do not represent actual distances in an associated colour space.

One of the most recent and most successful is the CMC (l,c) equation[4]. CMC stands for the Colour Measurement Committee of the Society of Dyers and Colourists, the term (l,c) represents two constants whose value depend on the type of assessment being made. The colour difference $\triangle E_{CMC}$ is still expressed in terms of differences in lightness ($\triangle L^*$), chroma ($\triangle C^*$) and hue ($\triangle H^*$) between the trial and the standard, however their contribution is dependent on the L* C* h values of the standard. The equation is:

$$\triangle E_{CMC} = [\,(\triangle L^*/lS_L)^2 + (\triangle C^*/cS_C)^2 + (\triangle H^*/S_H)^2]^{1/2}$$

The weighting function S_L is a function of L* only, S_C is a function of C* only and S_H is a function of both C* and hue angle h. There values are given by:

$$S_L = 0.040975L^*/(1+0.01765L^*)$$

Unless $L^*<16$ when $S_L = 0.511$

$$S_C = [0.0638\,C^*/(1+0.0131\,C^*)] + 0.638$$

$$S_H = S_C(Tf + 1 - f)$$

$$f = \{(C^*)^4/[(C^*)^4 + 1900]\}^{1/2}$$

$$T = 0.36 + |\,0.4\cos(h+35)|$$

Unless h is between 164° and 345° when

$$T = 0.56 + |0.2\cos(h+168)|$$

In all the above equations L*, C* and h refer to the standard of a pair of samples. The recommended values of (l,c) to use are (2,1) if the assessment is being made in terms of a commercially acceptable colour difference and (1,1), if made in terms of a perceptible colour difference.

When a numerical assessment based on the CMC (2,1) colour difference equation is made on the Davidson and Friede set of samples, an incorrect pass/fail decision is made 11 times out of 100 assessments [4–6]. The numerical method produces significantly fewer incorrect decisions than a single visual assessment. A similar standard of assessment is achieved when the M & S equation available on ICS colour measurement systems is used.

Conclusions

It is clear from this very brief discussion that numerical colour specification has progressed from trisimulus values, which although scientifically correct are of limited direct practical use, to CIE L* a* b* and optimised colour difference equations. I feel one of the most important steps in the future is for the industry to decide upon a preferred or standard method of colour specification and colour difference assessment. Thus specifications established by the final customer can be easily and reliably communicated along the manufacturing chain.

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Relative tolerances in the CMC colour-difference formula for paint samples

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Summary

Previous work has shown that the CMC(l:c) formula is superior to the CIE L*a*b* formula. Different l values were required for results based on acceptability judgements on textiles and perceptibility judgements on paint samples. Parallel experiments have been carried out using gloss paint, matt paint and textile samples. The results for the three substrates were quite similar, the l value required for gloss paint samples being slightly higher than those required for the other two substrates. It appears that the different l values found earlier were due to a difference between acceptability and perceptibility judgements rather than the difference between the substrates. An l value of 2 is probably the best value to use for tolerance work involving paint samples.

OCCA CONFERENCE 1987 see opp. p.i

Introduction

Many different colour-difference formulae have been published. In 1976 the CIE recommended two formulae[1], one of which, the CIE L*a*b* formula, is mor usually used for object colours such as painted surfaces. There is considerable evidence that for small colour differences such as those involved in colour tolerance work, CIE L*a*b* space is far from uniform, i.e. equal distances in the colour space (and hence equal ΔE values) do not correspond to the same perceived difference. Since 1976 several attempts at producing an improved colour difference formula have been made. McDonald[2, 3] modified the ANLAB formula (which is very similar to the CIE L*a*b* formula) to produce the JPC79 formula which agreed better with published data and has been applied successfully in industrial shade passing[4, 5]. The JPC79 formula was itself modified by members of the Society of the Dyers and Colourists Colour Measurement Committee, basically to overcome certain problems which might have arisen for very dark and near neutral samples[6]. The new formula, designated CMC (l:c) was extensively tested using the available experimental data involving over 3000 pairs of samples from 10 separate studies and was found to perform substantially better than the CIE L*a*b* formula and slightly better than the JPC79 formula. More recent work[7, 8] has confirmed the superiority of the CMC formula.

One important feature of the CMC formula[6] is that it allows for the possibility of different lightness or chroma weightings being required for different circumstances (e.g. for perceptibility data rather than acceptability judgements, or for acceptability judgements on different substrates such as paints, textiles or leather). The formula is given in Equation 1.

$$\Delta E = \left[\left(\frac{\Delta L^*}{lS_l} \right)^2 + \left(\frac{\Delta C^*}{cS_c} \right)^2 + \left(\frac{\Delta H^*}{S_H} \right)^2 \right]^{1/2} \qquad (1)$$

where $S_L = 0.040975L_1^*/(1 + 0.01765L_1^*)$

unless $L_1^* < 16$ when $S_L = 0.511$
$S_c = 0.0638C_1^*/(1 + 0.0131C_1^*) + 0.638$
$S_H = S_c\,(Tf+1-f)$
$f = \{(C_1^*)^4/[(C_1^*)^4 + 1900]\}^{1/2}$
$T = 0.36 + |0.4 \cos(h_1+35)|$
unless h_1 is between 164° and 345° when
$T = 0.56 + |0.2 \cos(h_1+168)|$

L_1^*, C_1^* and h_1 refer to the standard of a pair of samples, these values and ΔL^*, ΔC^* and ΔH^* being calculated from the CIE L*a*b* formula, and l and c are the relative tolerances required for a particular application. The formula was constructed so that for perceptibilty data, l = c = 1 and the formula for such data would be denoted by CMC(1:1).

When the formula was tested using acceptability data, it was found[6] that, overall, the best results were obtained using CMC(2:1) i.e. with l = 2, c = 1. This implies that in acceptability experiments, lightness differences are less significant than equally perceptible chroma or hue differences. An alternative explanation could be that the different l values arise from the different substrates used since the acceptability results analysed were all based on work with textiles samples, whereas the perceptibility results were almost all based on paint samples.

The present work was undertaken with the object of determining which of these explanations is correct; are different l values required for paint samples as opposed to textile samples, or, are different l values required for acceptability as opposed to perceptibility judgements? In more practical terms, if the CMC(l:c) formula is to be used for tolerance work involving painted surfaces, what values of l and c should be used?

Design of the experiment

The basic approach adopted was to conduct parallel experiments using gloss paint, matt paint and dyed wool samples so that the results for the different substrates would be directly comparable; in the calculations referred to previously, all comparisons were indirect in that the acceptability and perceptibility experiments were carried out quite independently and therefore involved different colour centres and different groups of observers.

For each colour centre a set of samples was prepared on each of the three substrates. Each set included at least one pair of samples showing essentially a difference in lightness only (i.e. the differences in hue and chroma were negligible) and a further two pairs showing essentially differences in hue and chroma respectively. All the samples in any one set corresponded to approximately the same colour. The colour differences were assessed by the same group of observers, using three different methods of assessments, two different ratio methods and a grey scale method. Five such sets of samples were prepared for each of the three substrates.

Experimental

Preparation of samples

The L*a* and b* coordinates of the colour centres used are given in Table 1 together with an indication of the colour and the set name used for the same colour centres in previous work[9]. Recipe prediction programs were used to prepare sets of samples close to each colour centre. The samples for any one centre were all prepared using the same dyes or paints to avoid any possible metamerism. From the samples for any one centre, pairs were chosen according to the following criteria. All the samples chosen were to be reasonably close to the appropriate colour centre. (Almost all the samples used were within 5 CIE L*a*b* units of the colour centre). For any one pair, the difference was to be essentially a lightness difference, a hue difference, or a chroma difference. For any one centre, at least one pair showing each type of difference was to be selected. The differences were to be clearly visible, about 2 to 5 CIE L*a*b* units. Although it was relatively easy to produce samples fairly close to the required centres, it was much more difficult to produce pairs satisfying all the criteria, and in some cases more than 20 samples were prepared before satisfactory pairs could be obtained.

Table 1

*1976 CIE L*a*b* values for the colour centres studied*

Set	Setname	Colour	L*	a*	b*
1	BFD RCK 4	Yellow-green	60.5	-8.1	17.1
2	BFD RCK 16	Orange	62.4	23.1	18.4
3	BFD RCK 17	Pink	64.7	15.8	4.4
4	BFD KPC 27	Light-blue	63.5	-11.4	-8.9
5	BFD AAK 38	Purple	41.7	3.3	-17.9

The paint samples were prepared using mixtures of commercial gloss or matt paints. The mixtures were carefully applied to stiff card using sufficient coats to ensure that a completely opaque layer had been applied, and finally cut to 7.5 cm squares. The textile samples were produced by dyeing plain wool serge with acid dyes. The samples were mounted (four layers) on stiff white card, each sample again being 7.5 cm square.

Colour measurements

All measurements were made using a Macbeth MS2000 abridged spectrophotometer, with the specular component excluded. In every case four measurements were made at directions separated by 90° intervals. Tristimulus values and the corresponding L*a*b* C* and h* values were calculated for illuminant D65 and the 1964 supplementary standard observer. Measurements were made before, during and after the visual assessments, the mean values being used in subsequent calculations. The small differences between the measurements made at different times showed that the measurement repeatability was good, and that the samples did not change appreciably during the experiments.

Visual assessments

All visual assessments were carried out in a Veri-vide viewing cabinet, the interior of which was finished with grey emulsion paint with x, y, Y values of 0.299, 0.322 and 14.7 respectively under illuminant D65. A five-foot Artifical Daylight tube was used to simulate D65. The colour differences were assessed by a panel of 20 observers using ratio assessments[9] and a grey scale method[10]. For the ratio assessments the observer was presented with two pairs of samples, told that one of the pairs was to be taken as the standard pair, and asked to assess the other colour difference as a ratio of the colour difference for the standard pair. In the "ratio all sets" (RAS) method, pairs from all five sets were compared with each other. In the "ratio within sets" (RW) method, only pairs within one set were compared directly.

Previous work[9] has shown that there is an apparent bias on the part of observers carrying out ratio assessments in that the ratios given are usually closer to one than expected. This was tested by preparing small series of samples such that in any one series the samples were all similar in colour, and the samples lay on a straight line in colour space. For such series, the visual differences should be directly proportional to the measured differences. The results of such experiments have shown that the true visual differences (ΔV) can be related to the mean of the observed ratios (ΔV^*) by

$$\Delta V = (\Delta V^*)^{\alpha} \qquad (2)$$

where the value of α varies with the particlar group of observers used. In the present work α was found to be 1.629, a value similar to those found previously[9] (1.62 to 1.89). For each pair of samples, the ΔV^* values were corrected using Equation 2.

For the grey scale assessments each pair of samples was assessed against a grey scale. The grey scales used were similar to the one used in fastness testing for assessing change of colour[11], except that the grey scales samples were of the same size and material as the samples being assessed. Thus, for example, the gloss paint pairs were assessed using a grey scale made using gloss paint samples. The Y tristimulus value of the standard for the grey sacle should be 12±1. The nominal differences from standard of the other grey scale samples are given in Table 2 together with the actual values for the scales produced for each surface. The actual values for all three scales were all within accepted limits. The ΔL^* values were always within 0.1 of the ΔE values showing that the Δa^* and Δb^* values were negligible.

For the grey scale assessments, the samples were arranged as shown in Figure 1 except that the sample pair and the grey scale pair were interchanged in a random manner during the assessments. Similarly the samples in a pair were interchanged (left and right) and the pairs were presented in a different random order for each observer. The observer was asked to pick a sample from the grey scale, put it alongside the standard grey scale sample (STD) and to compare the difference with that for the sample pair. Different grey scale samples were tried until the one giving a difference (from STD) closest in magnitude to that for the sample pair was found. The observers were encouraged to give intermediate grades if possible, e.g. 2.8 if the difference between the sample pair was slightly larger than that between STD and grey scale sample 3.

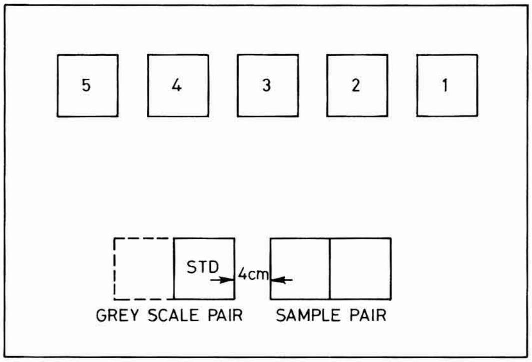

Figure 1. Arrangement of samples for grey-scale assessments.

The grey scale samples lay in a straight line in colour space, and hence the ΔE values should be directly proportional to the differences seen, irrespective of whether CIE L*a*b* space is uniform overall. For each of the grey scales a graph was plotted of ΔE against "grade" using the values in Table 2. Then for any grade obtained using the grey scale, a value designated ΔV and proportional to the differences seen, could be read off the ΔE scale of the appropriate graph.

As indicated earlier, for the visual assessments the sample pairs were presented to the observers in a random order. However not all the samples were available at any one time and the assessments were carried out in a series of stages. Thus all the gloss paint pairs for sets 1-5 were assessed together using the "ratio all sets" (RAS) method. The same pairs were later assessed using the grey scale method. This procedure was also adopted with the matt paint samples and then the textile samples. Finally, the "ratio within sets" (RW) method was used.

Table 2

*Nominal and actual ΔE (CIE L*a*b*) values for the grey scale samples*

Grade	Nominal ΔE	Tolerance	Actual ΔE values		
			gloss	matt	textile
5	0.0	0.2	0.1	0.1	0.1
4	1.7	0.3	1.7	1.5	1.7
3	3.4	0.4	3.7	3.5	3.7
2	6.8	0.6	7.0	6.8	7.0
1	13.6	1.0	13.8	14.1	12.7

Results

The results for the gloss paint samples will be used as an example throughout, but details of all the other results are obtainable from the authors. The 1976 CIE L*a*b* values of the five sets of gloss paint samples used in the experiments are given in Table 3. The ΔL^*, ΔC^* and ΔH^* values for the chosen pairs are given in Table 4. For each pair the differences in two of the attributes were intended to be negligible and it can be seen that this aim was achieved reasonably well. For example, for Pair 1-7 (Set 1) the ratio of ΔL^* to the total colour difference ΔE is 0.99.

"Ratio all sets" (RAS) results

Three different sets of visual assessments were carried out. In the RAS experiments, each of the 19 pairs was compared with each of the other 18 pairs, the relative magnitudes being expressed as a ratio. The 342 possible comparisons were divided equally (as far as possible) between the 20 observers. The detailed visual results for Sets 1 and 2 are given in Table 5. The values tabulated are the ratios given by the observers when comparing the pair listed at the head of a column with the pair listed at the beginning of a row, with the latter pair being taken to be the standard. Thus when comparing Pair 1-3 (Set 1) with Pair 1-7 (Set 1) the former difference was considered to be 0.9 times the latter difference. Similarly, when comparing Pair 1-3 (Set 1) with Pair 1-8 (Set 3), the former difference was considered to be 1.5 times the latter difference. The values in any one column are a measure of the size of the visual difference of the pair indicated at the top of the column. The difference for Pair 2-4 (Set 2) was somewhat larger than most of the other differences and hence most of the ratios were above one. On the other hand for Pair 1-3 (Set 1) the visual difference was one of the smallest, and the ratios were generally less than one. Torgerson[12] has shown that in such an experiment, the mean of the ratios in any one column gives the best estimate of the size of the difference for the pair indicated at the head of the column. The mean ratio for each pair was therefore calculated and the result given as ΔV^* at the foot of each column. These values were corrected for observer bias using Equation 2, and the results given as ΔV for each pair. The ΔV (RAS) values for all the gloss paint pairs are given in Table 4.

The ΔE CMC(1:1) values for each pair were calculated from the measurements given in Table 3. If there was no experimental error and the CMC(1:1) formula was correct, the ratio of $\Delta E/\Delta V$ for each pair should be constant. These ratios are given in Table 6, the results for pairs showing essentially lightness differences, chroma differences and hue differences being tabulated separately. It can be seen that the $\Delta E/\Delta V$ ratios for the lightness differences are consistently higher than those for chroma and hue differences. This implies that the ΔE(CMC(1:1)) values are too high for lightness differences, i.e. the weighting factor l in equation 1 needs to be increased. This point will be discussed in more detail after considering the results from the other two methods of visual assessments.

Grey scale results

For the grey scale method each of the 19 pairs was compared with the grey scale as described earlier. The detailed visual results for the gloss paint samples for Sets 1 and 2 are given in Table 7 as examples. Each pair of samples was assessed (in a different random order) by the 20 observers. The observers expressed their results as grey scale numbers in the usual way, expect that any intermediate value was allowed. Thus for Pair 1-7 (Set 1, RCK 4) the first observer judged the difference to be equivalent to 2.2 on the grey scale (i.e. slightly smaller than the grey scale difference 2) while the third observer judged the difference to be equivalent to 2.9 on the grey scale (i.e. slightly larger than the grey scale difference 3). The mean of the grey scale assessments for each pair is given as "Mean Grade" and these were converted to ΔV values (which should be directly proportional to the differences seen) as described earlier. Again the CMC(1:1) $\Delta E/\Delta V$ ratios should all be equal. The ratios for the lightness, chroma and hue difference pairs were calculated separately and the mean values were 0.95, 0.68 and 0.68 (Table 8), again suggesting that the ΔE values were too high for the lightness differences. (The fact that the $\Delta E/\Delta V$ ratios in Table 6 are much higher than those in Table 8 is of no significance, since the ΔV values from the ratio assessments are on an arbitrary scale).

Calculation of l and c values

The mean $\Delta E/\Delta V$ ratios can be used quite simply to derive

Table 3

*1976 CIE L*a*b* values for all the gloss paint samples selected for investigation*

Set	Set name	Sample number	L*	a*	b*
1	BFD RCK 4	1	60.6	-6.3	18.6
		3	60.6	-6.7	20.9
		4	60.4	-8.2	18.1
		7	63.2	-6.5	18.9
		8	60.7	-6.1	18.5
2	BFD RCK 16	1	62.1	22.5	18.0
		2	62.2	22.6	18.0
		3	62.4	26.0	20.5
		4	62.5	20.9	20.8
		5	66.4	22.9	17.0
3	BFD RCK 17	1	64.6	15.7	5.3
		3	64.6	18.5	6.4
		6	64.2	16.7	3.4
		8	67.3	16.1	5.8
		10	64.5	15.6	5.0
		11	64.5	14.4	2.4
		13	64.1	16.4	3.1
4	BFD KPC 27	1	63.3	-10.2	-9.4
		2	63.6	-14.0	-12.4
		5	63.1	-11.9	-14.2
		6	66.0	-10.0	-9.0
		8	68.1	-9.8	-8.9
		9	63.3	-10.1	-9.5
		10	63.7	-13.9	-12.2
5	BFD AAK 38	1	40.4	3.1	-16.8
		2	40.5	3.7	-20.2
		4	41.9	1.3	-18.3
		6	42.4	3.9	-18.6
		8	44.2	2.7	-16.5

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Table 4

ΔL, ΔC*, ΔH* and ΔV values for the gloss paint pairs*

Set	Pair	ΔL*	ΔC*	ΔH*	RAS ΔV	GS ΔV
1	1-7	2.6	0.3	0.0	0.66	2.42
	1-3	-0.1	2.3	0.4	0.66	1.96
	4-8	0.3	0.4	2.1	0.82	2.78
	1-4	0.2	0.2	2.0	0.95	3.14
2	2-5	4.2	0.4	0.9	1.01	3.36
	2-3	0.2	4.2	0.2	1.21	5.98
	1-3	0.3	4.2	0.2	1.15	4.28
	2-4	0.3	0.5	3.3	1.46	6.19
3	1-8	2.7	0.5	0.4	0.68	2.07
	3-10	0.1	-3.1	0.4	0.67	2.44
	11-13	0.4	2.1	0.3	0.57	2.10
	1-6	0.3	0.5	2.1	0.86	2.36
4	1-8	4.9	-0.6	0.1	1.15	5.09
	1-6	2.7	-0.4	0.2	0.98	3.06
	9-10	0.3	4.6	0.5	1.30	5.31
	2-5	0.5	-0.2	2.7	1.27	3.26
5	1-8	3.9	-0.3	0.3	1.14	3.44
	1-2	0.1	3.5	0.0	0.93	2.38
	4-6	0.6	0.7	2.5	1.50	4.74

Table 5

Visual results for the "Ratio all sets" (RAS) method for gloss paint pairs

		Set 1				Set 2			
	Sample pair	1-7	1-3	4-8	1-4	2-5	2-3	2-4	1-3
	standard pair								
Set 1	1-7	—	0.9	1.4	1.2	1.2	1.2	1.5	0.75
	1-3	0.2	—	1.5	0.9	1.0	0.5	1.2	0.5
	4-8	0.7	0.9	—	1.0	1.0	1.5	2.0	1.0
	1-4	1.4	1.0	0.9	—	1.7	0.5	2.0	1.0
Set 2	2-5	0.7	0.95	1.4	1.4	—	1.3	0.8	0.7
	2-3	1.6	0.8	0.5	0.5	0.25	—	0.5	2.0
	2-4	1.0	0.6	0.5	1.4	1.3	0.4	—	0.8
	1-3	1.0	1.2	1.5	0.7	0.8	1.1	1.3	—
Set 3	1-8	0.7	1.5	0.9	1.0	1.1	2.5	0.2	1.2
	3-10	1.0	0.85	1.1	0.8	0.8	1.4	2.5	1.1
	1-6	1.0	0.8	1.1	1.0	0.9	1.5	2.0	1.5
	11-13	0.75	1.0	0.9	1.1	1.0	1.4	1.5	2.5
Set 4	1-8	0.7	0.3	0.2	1.0	0.6	1.3	1.0	1.0
	9-10	0.7	0.4	0.7	1.5	1.4	1.3	1.5	1.0
	2-5	0.2	0.75	1.2	1.5	2.3	1.5	2.0	1.8
	1-6	1.5	1.1	1.0	1.1	1.1	1.3	1.5	0.8
Set 5	1-8	1.0	0.9	0.8	0.8	0.8	1.5	1.5	1.5
	1-2	0.6	0.5	1.2	0.9	1.6	1.0	2.0	1.0
	4-6	1.0	0.4	0.75	0.5	1.0	0.9	0.9	1.0
	ΔV*	0.77	0.77	0.88	0.97	1.01	1.13	1.26	1.09
	ΔV	0.66	0.66	0.82	0.95	1.01	1.21	1.46	1.15

Table 6

Ratio of measured colour difference, ΔE (CMC(1:1)), to visual differences, ΔV (RAS), for gloss paint sets 1-5

	Lightness differences			Chroma differences			Hue differences		
Set	ΔE	ΔV	ΔE/ΔV	ΔE	ΔV	ΔE/ΔV	ΔE	ΔV	ΔE/ΔV
1	2.16	0.66	3.27	1.43	0.65	2.20	1.84	0.82	2.24
							1.76	0.95	1.85
2	3.64	1.01	3.60	2.13	1.21	1.76	3.47	1.46	2.38
				2.18	1.15	1.90			
3	2.24	0.68	3.29	1.95	0.67	2.95	2.36	0.86	2.74
				1.51	0.57	2.65			
4	3.99	1.15	3.47	3.40	1.30	2.62	2.38	1.27	1.87
	2.23	0.98	2.28						
5	4.00	1.14	3.51	2.31	0.93	2.48	2.79	1.50	1.86
Mean			3.24			2.36			2.16

Table 7

Visual results using grey scale (GS) method for gloss paint samples (20 observers)

	Set 1 (RCK 4)				Set 2 (RCK 16)			
Sample pair	1-7	1-3	4-8	1-4	2-5	2-3	2-4	1-3
Observer								
1	2.2	3.5	3.4	3.5	1.5	1.5	2.0	1.8
2	3.1	3.4	3.1	3.1	3.2	2.3	2.4	2.8
3	2.9	3.2	4.5	3.8	2.8	1.8	1.8	4.5
4	3.9	4.8	4.0	2.5	2.7	2.2	1.7	1.9
5	2.8	3.8	2.7	2.6	3.8	1.6	2.5	2.4
6	4.6	3.2	1.4	2.4	2.8	1.2	1.4	1.4
7	2.8	4.0	2.9	2.4	2.8	2.5	2.5	2.8
8	3.8	4.0	3.9	3.4	3.8	2.4	2.7	2.9
9	3.9	4.2	4.2	3.5	3.5	3.2	2.8	3.8
10	4.1	4.0	3.8	3.5	3.5	2.2	2.5	2.8
11	3.8	4.0	3.6	3.9	3.5	3.4	2.8	3.2
12	3.6	3.5	2.9	2.2	2.9	2.4	1.7	2.0
13	2.9	3.8	3.2	3.5	3.7	2.6	3.1	2.8
14	3.8	3.8	2.5	2.7	2.2	2.2	2.0	2.2
15	3.3	3.5	2.75	3.25	2.75	2.0	2.25	2.9
16	3.9	3.4	3.5	3.8	2.4	2.6	1.9	3.1
17	3.0	3.2	3.4	3.4	3.5	2.3	1.9	2.6
18	3.5	3.4	3.2	4.1	3.3	2.6	2.2	3.5
19	4.1	3.8	3.7	2.2	3.3	2.2	2.1	2.5
20	3.2	3.5	3.1	3.0	3.1	2.0	2.0	2.6
Mean grade	3.46	3.70	3.29	3.14	3.05	2.26	2.21	2.73
ΔV	2.42	1.96	2.78	3.14	3.36	5.98	6.19	4.28

the appropriate l and c values to use in the CMC(l:c) formula as follows. From the mean values for the RAS results in Table 6, the ΔE values for the lightness differences need to be reduced by a factor of 3.24/2.16 to make the mean ΔE/ΔV ratio for the lightness differences the same as that for the hue differences. This can be achieved by taking l = 3.24/2.16 = 1.50. Similarly the ratio for the chroma differences needs to be reduced by a factor of 2.36/2.16 and this can be achieved by taking c= 2.36/2.16 = 1.09. Treating the GS results (Table 8) in the same way gives l = 0.95/0.68 = 1.40 and c = 0.68/0.68 = 1.00.

Table 8

Ratio of measured difference, ΔE (CMC(1:1)), to visual difference ΔV (GS assessments) for gloss paint sets 1-5

	Lightness differences			Chroma differences			Hue differences		
Set	ΔE	ΔV	ΔE/ΔV	ΔE	ΔV	ΔE/ΔV	ΔE	ΔV	ΔE/ΔV
1	2.16	2.42	0.89	1.43	1.96	0.73	1.84	2.78	0.66
							1.76	3.14	0.56
2	3.64	3.36	1.08	2.13	5.98	0.36	3.47	6.19	0.56
				2.18	4.28	0.51			
3	2.24	2.07	1.08	1.95	2.44	0.80	2.36	2.36	1.00
				1.51	2.01	0.75			
4	3.99	5.09	0.78	3.40	5.31	0.64	2.38	3.26	0.73
	2.23	3.06	0.73						
5	4.00	3.44	1.16	2.31	2.38	0.97	2.79	4.74	0.59
Mean			0.95			0.68			0.68

An alternative method for obtaining the l and c values best fitting the experimental results was also used. The ΔE values for all the pairs of samples should be linearly related to the corresponding ΔV values. The pair of l and c values giving the best agreement between ΔE and ΔV values is required. In previous similar work [13, 14] this has been achieved by trying different pairs of constants until the pair giving for example, the maximum correlation coefficient has been found. In the present work, three different measures of fit were used[6] and the mean of the best l and c values determined. For the gloss paint samples the RAS results treated in this way gave l = 1.49, c = 1.00 while the grey scale results gave l = 1.25, c = 1.11. Both values agreed fairly well with those obtained earlier from the mean ΔE/ΔV ratios. The same procedure was used with the experimental results for the matt paint samples for Sets 1-5 and the textile samples for Sets 1-5. The results are summarised in Tables 9 and 10. In general the results from the two calculation methods agreed very well and the mean values (also given in Tables 9 and 10) are used in the subsequent discussion.

"Ratio within sets" (RW) results

In the ratio comparisons experiments, the observers sometimes had to compare pairs of samples of quite different colours, for example an orange pair from Set 2 with a purple pair from Set 5. It was considered desirable to check the l and c values obtained above by carrying out experiments in which only samples from within one set were compared. Thus, for example, a lightness difference and a chroma difference from the same set were compared directly, the observers expressing the results as ratios.

The detailed experimental results for the RW method for the gloss paint samples for Set 1 are given in Table 11. For each pair the type of difference is indicated (ΔL*, ΔC* or ΔH*). Although the actual comparisons were closely related to the objectives of the work in that for example a lightness difference was directly compared with a hue difference, treatment of the results is complicated by the fact that the ΔV values were not on a common scale. Thus there is no relationship between the ΔV values for set 1 (RCK 4) with those for Set 2 (RCK 16) etc, and therefore the methods used earlier for the RAS results and GS results could not be used. The method actually used was as follows.

Table 9

Best l values from ratio all sets and grey scale results

		calculation method		
Substrate	Visual method	from ΔE/ΔV	from "best fit"	mean
Gloss	RAS	1.50	1.49	1.50
	GS	1.40	1.25	1.33
Matt	RAS	0.90	1.00	0.95
	GS	1.20	1.25	1.23
Textile	RAS	0.86	0.97	0.92
	GS	1.35	1.39	1.37

Table 10

Best c values from ratio and grey scale results

		calculation method		
Substrate	Visual method	from ΔE/ΔV	from "best fit"	mean
Gloss	RAS	1.09	1.00	1.05
	GS	1.00	1.11	1.06
Matt	RAS	0.64	0.75	0.70
	GS	0.94	1.00	0.97
Textile	RAS	0.78	0.83	0.81
	GS	1.01	1.00	1.01

Table 11

Visual results from 'Ratio within sets' (RW) method for gloss paint samples for set 1 (RCK 4), 20 observers

Standard pair	1-7 (ΔL*)	1-7 (ΔL*)	1-7 (ΔL*)	1-3 (ΔC*)	1-3 (ΔC*)	4-8 (ΔH*)
Sample pair	1-3 (ΔC*)	4-8 (ΔH*)	1-4 (ΔH*)	4-8 (ΔH*)	1-4 (ΔH*)	1-4 (ΔH*)
Observer						
1	1.1	1.15	0.9	0.95	0.85	0.95
2	1.2	1.2	1.15	1.1	1.15	1.0
3	0.6	0.8	0.7	1.2	1.1	1.0
4	0.6	1.3	0.9	1.0	0.75	0.9
5	0.7	1.3	0.75	1.15	1.1	1.0
6	0.5	1.5	0.8	1.2	1.3	0.9
7	0.8	1.3	1.1	2.2	1.3	1.1
8	0.7	0.65	0.9	1.2	1.1	1.0
9	0.8	1.2	1.0	1.1	1.05	1.0
10	1.3	1.5	0.7	1.0	1.5	1.0
11	0.8	1.0	1.2	1.0	0.9	0.8
12	1.1	1.0	1.1	1.0	1.0	1.0
13	1.5	1.2	0.7	1.5	0.8	0.7
14	1.1	1.1	1.0	1.1	1.0	1.0
15	1.0	0.9	1.0	1.0	1.1	1.0
16	1.3	0.9	0.95	1.1	1.05	1.0
17	1.3	1.0	1.0	1.0	0.9	0.8
18	0.8	0.8	0.7	1.0	1.0	1.0
19	1.1	1.6	0.9	1.2	1.1	1.2
20	0.9	1.1	1.1	1.2	1.0	1.0
ΔV*	0.92	1.1	0.91	1.14	1.04	0.96
ΔV	0.87	1.16	0.86	1.23	1.06	0.94

Table 12

Final l values from the three visual methods

	RAS	GS	RW	Mean
Gloss	1.50	1.33	1.22	1.35
Matt	0.98	1.28	1.01	1.09
Textile	0.87	1.31	1.11	1.10

Final c values from the three visual methods

	RAS	GS	RW	Mean
Gloss	1.05	1.06	0.90	1.00
Matt	0.68	0.96	0.74	0.79
Textile	0.80	1.00	0.82	0.87

Consider one comparison of a lightness difference with a hue difference, with the hue difference being taken as the standard. Then ideally,

$$\frac{\Delta E \text{ for lightness difference}}{\Delta E \text{ for hue difference}} \text{ should} = \text{the visual ratio } \Delta V$$

i.e if

$$\frac{\Delta E \text{ for lightness difference}}{(\Delta E \text{ for hue difference}) \, .\Delta V} = k,$$

k should equal one.

The values of k for comparisons of lightness and hue difference, for all five sets of gloss paint samples were calculated. The mean value of k was 1.22. Thus the ΔE values for the lightness differences were too high, and could be corrected by using $l = 1.22$. The results for comparisons of lightness and chroma differences were treated in the same way to give the appropriate c value. The mean l and c values obtained in this way for all three substrates are given in Table 12 together with the corresponding values obtained from the RAS and GS results.

Conclusions

In general the values from all three visual methods agreed moderately well and finally the mean values were calculated; these are also given in Table 12. When comparing the results for the different substrates, it should be noted that the results are from matched experiments. The same group of observers assessed similar sets of samples using the same methods of assessment and hence intercomparisons between the results for the different substrates should be more reliable than when using results from experiments in which factors in addition to the substrates are quite different.

According to Clarke et al[6] an l value of 2 in the CMC(l:c) formula was required for acceptability data using textile samples as opposed to 1 for perceptibility data obtained using mainly paint samples. The question posed earlier was whether the higher l value was due to the use of acceptability judgements or to the use of textile substrates. On balance, the l values for the textile substrate in the present work are even lower than those for the paint substrates. The results provide no evidence whatsoever that a higher l value is required for textiles and the conclusion must be that the higher l value found by Clarke et al must have been associated with acceptability judgements. The difference between the l values required for acceptability as opposed to perceptibility judgements (corresponding to a factor of 2) seems surprisingly large, particularly in view of the close similarity found for results of chromaticity differences assessed by perceptibility and acceptability methods and the fact that c values appear to vary only slightly. However the l values found to be required for gloss paint samples in the present work is even higher than that required for textile samples. Hence for acceptability judgements on paint samples it would seem to be best to use an l value of 2. The mean c values in Table 12 are all fairly close to one and hence we recommend that CMC (2:1) should be used for all tolerance work involving paint samples.

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SURFEX
88

Preliminary Notice

The next Association Exhibition will be held at the Harrogate Conference and Exhibition Centre, Yorkshire, England, 15-16 June 1988. Further details will be published in JOCCA in due course.

Hazardous raw materials used in the paint and ink industries*

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Abstract

In this article hazardous raw materials used in the paint/ink industry are discussed. Specific raw materials are mentioned and precautions to be taken when using them are outlined.

Scope of the problem

A typical large paint manufacturer with resin making facilities may have an inventory of about 1,000-1,500 raw materials. Essentially this number will comprise of approximately:

350	Pigments
100	Solvents
300	Monomers, oils and resin chemicals
300	Additives
150	Bought-in intermediates

However, in addition most manufacturers make use of in-house manufactured intermediates which may add another 500-600 materials to be handled in the factory. These will be resins, pigmented colour bases and additive solutions.

It must not be forgotten that the finished product itself has to be processed and therefore must be considered when assessing the hazardous materials handled. A large paint manufacturer may have as many as 8,000-10,000 products on its range.

Nor must it be forgotten that those materials used in process operations but which do not form part of the product e.g. nitrogen, caustic soda, and Thermex.

In assessing the scope of the problem the quantities of the materials handled must be borne in mind. Often bulk handling facilitates the containment of hazardous materials in essentially closed systems. Nevertheless such systems need maintenance and may constitute a greater risk to the maintenance worker than the process operator. Typical examples here are molten phthalic anhydride and TDI 'toluene di-isocyante'.

Defining hazardous raw materials

Starting from the assumption that no chemical is safe unless it is handled properly it must be said that many materials used in paint and ink manufacture are inert and do not represent more than a nuisance hazard. Such materials included in this category are titanium dioxide and china clay, iron oxides and many organic pigments. Amongst the innocuous liquids handled are vegetable oils and glycerol. In number such materials may account for more than 60% of the total inventory and, in tonnage terms, will be significant. Such materials should be handled under what might be termed "good industrial hygiene practice" (see Appendix), where much depends on the operator's working methods in avoiding raising dusts, avoiding skin contact and the breathing of vapours.

To differentiate from those materials which can be handled safely following good industrial hygiene practice one should consider the hazardous materials to be those which consitute a health risk in either chronic or acute terms and for which special precautions must be taken.

In classifying hazardous materials and the risk to the work-force, the assessment requirements of COSHH will be critical. Only by this means can the basis of effective control be established and resources directed to dealing with the real problem areas.

Nature of the hazards

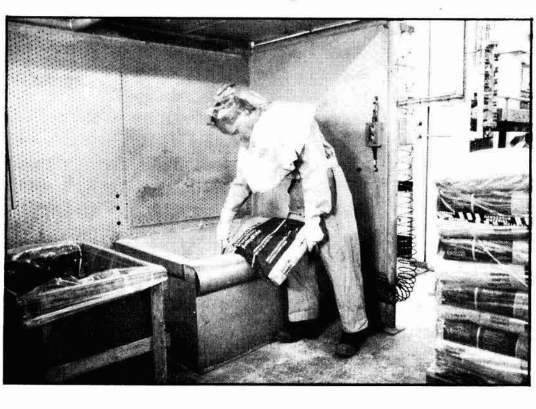
The risk to operators and maintenance workers relate essentially to:

1. the inhalation of harmful dusts and vapours which then give rise to acute or chronic effects.
2. skin contact leading to chronic skin complaints, sensitisation or harmful absorption into the body system. Some corrosive products handled can give rise to skin damage if not treated immediately.
3. contact with the eyes which may give rise to permanent damage.

In our industries the risk of ingestion should be very low providing that proper attention is given to good industrial hygiene practice, personal hygiene and the provision of facilities for eating, drinking, smoking and the changing and storing of protective clothing.

Fortunately few of the raw materials handled

Figure 1. An operator loading a resin kettle with TMA wearing air-fed hood protection and working in a laminar flow booth.



represents an acute health risk which could rapidly lead to death or serious injury. However, some do exist, e.g. phenol, caustic soda, and asphyxiating solvents and one should also include nitrogen.

So in the main our industries are dealing with the chronic effects of handling hazardous materials arising from repeated exposure over a long period of time. This and the fact that many materials handled are not considered particularly hazardous can make it difficult to ensure that the work-force always take the elementary precautions necessary to avoid exposure. This is an ongoing challenge for management supported by safety personnel, industrial hygienists and medical personnel.

Some specific raw materials and the precautions taken

1. Resin Manufacture

PHTHALIC ANHYDRIDE

Nature of the hazard

Irritant, skin and respiratory sensitiser. Fumes from molten PA are especially irritating to the lungs and eyes. With flake PA the inhalation of dust is the major risk. (OEL 1ppm; 6mg/m^3)

Precautions to be taken:

Molten PA

Isolation of the area when tanker unloading. Personal protection for those involved in off loading—chemical goggles, PVC gloves and rubber boots. Full respiratory protection equipment should be available nearby in case of spillage. If melters are used, operators should wear a combined dust and fume respirator and chemical goggles.

PA Flake

An efficient dust mask should be worn in addition to chemical goggles and PVC gloves or gauntlets.

TRIMELLITIC ANHYDRIDE

Nature of hazard

Highly irritating to the eyes and respiratory system. Dust may cause severe injury to the eyes. Frequent exposure can lead to respiratory sensitisation with asthmatic type symptoms. Sensitised individuals are especially liable to forms of anaemia on further exposure. (OEL 0.04mg/m^3)

Precautions to be taken (Figure 1):

Efficient local exhaust ventilation together with a high standard of respiratory and eye protection is required when handling TMA. Preferably an air-fed hood should be worn but if dusty conditions are likely to be encountered a full chemical suit should be worn.

PHENOL

Nature of hazard

Both liquid and vapour are highly irritating, corrosive and toxic. Both liquid and vapour are readily absorbed through the skin. Absorption of small amounts may lead to collapse and death. (OEL 5ppm; 19mg/m^3).

Figure 2. Shows a fully protected operator at the decontamination shower after supervising the unloading of a TDI bulk tanker.

Precautions to be taken

A full chemical suit should be worn by anyone handling a significant quantity of phenol. Containers of phenol should be fully sealed at all times when not in use.

ACRYLIC MONOMERS

The hazards associated with acrylic monomers vary considerably depending upon the monomers used. For instance, methyl methacrylate monomer is of low acute toxicity and only slightly irritating to the skin, eyes and respiratory system. However, hydroxy propyl acrylate is irritating and corrosive to all parts of the body and harmful amounts may be absorbed through the skin. Permanent eye injury can arise from spalshes in the eyes. In the latter case full eye and skin protection should be worn.

TOLUENE DIISOCYANATE

Nature of hazard

Highly irritating to the lungs and a powerful respiratory sensitiser causing asthmatic symptoms in sensitised individuals. Skin sensitisation can occur. (OEL 0.02mg/m^3, as NCO).

Precautions to be taken (Figure 2):

As harmful levels of vapour are given off at room temperature full personnel protection and efficient local extract ventilation are necessary when handling TDI. A fresh air-fed hood must be worn if there is the slightest risk of liquid leakage or exposure to vapour.

Small quantity additives

Nature of the hazards

In resin manufacture many additives are used as initiators, inhibitors, catalysts, cross-linking agents, bacteriocides etc. Some of the materials used are highly hazardous and need special precautions to be taken; chemically we are talking about:

Peroxides — may give rise to permanent eye damage

Amines — highly irritating to the respiratory system, eyes and skin. Maybe skin sensitisers

Organic acids — corrosive or highly irritating—to all parts of the body

Bacteriocides — irritants or skin sensitisers

Organic oxides — severly irritating, corrosive and respiratory and eye hazard

Inorganic acids and alkalis — corrosive to all parts of body, eye hazard

Precautions to be taken:

Many of these materials are used in relatively small quantities and have to be decanted from larger containers. Invariably they have to be handled by operators making small additions through man-holes or to mixing vessels. Whilst personal protective equipment is readily available, plant contamination can easily occur and the work-force not actually handling these materials can be at risk from contaminated hand rails, valves, hoppers and pipe work.

2. Paint and Ink Manufacture

PIGMENTS

Nature of the hazard

Few pigments represent a significant hazard but those needing special attention are:

Chromates

Lead containing pigments

Silicas and silicates (talc)

Cadmium pigments

The principal hazard arises from possible inhalation of dusts but zinc chromate has given rise to cases of dermatitis through skin contact. Lead containing pigments are subject to the Control of Lead at Work Regulations and a commonly used pigment is lead chromate where the chromate hazard as well as the lead has to be considered.

Precautions to be taken (Figure 3):

Proper handling of pigments and the empty bags is essential if exposure is to be kept to a minimum. Proper weigh-out facilities are required where part bags have to be handled. Even where dusty but low hazard pigments are handled it is a wise precaution to wear some form of dust mask.

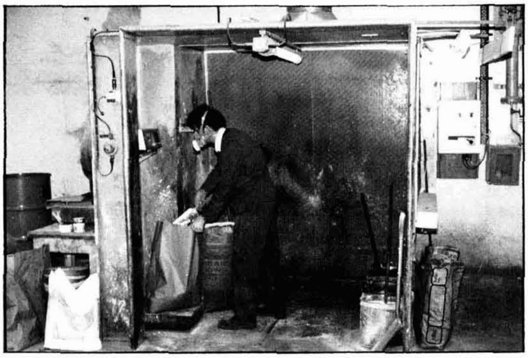


Figure 3. Operator weighing out small quantities working in a laminar flow booth and wearing a dust mask.

SOLVENTS

Nature of the hazard

Gone are the days when one considered some solvents to be "safe". We have seen only recently concerns raised about the ethylene glycol mono methyl and mono ethyl ethers and their acetates and white spirit. Whilst the inhalation of solvent vapour is the principal hazard many solvents are readily absorbed through the skin in toxic amounts. Repeated skin contact may give rise also to severe irritation.

Often we are having to deal with exposure to solvent mixtures—in some cases as many as eight different solvents will be present with differing toxic effects or very different occupational exposure levels.

Main risk areas

Wherever solvents are handled manually there is a risk of exposure but bad practices can greatly increase this risk. Operations such as making solvent additions to mixing vessels, unloading ball mills, operating triple roll mills or open top bead mills are known to lead to high levels of exposure. However, by far the highest risk of exposure occurs with the hand solvent cleaning of portable mixers and here operators require fresh air-fed hoods if high levels of exposure to vapours are to be avoided.

FINISHED PRODUCTS

The principal risk areas are associated with the filling operations and product testing. In filling, exposure to solvent vapours constitutes the highest risk particularly when fast evaporating solvents are used. Again cleaning operations give rise to high levels of exposure. When product testing, spray operators need to take special precautions particularly when testing isocyanate, lead and chromate containing products.

SUMMARY

Many of the raw materials and products handled by our industries are hazardous to a varying degree and increasingly the industry and its products are considered (and quoted) as being a health risk. We have only to look at the adverse publicity give to EG ethers, lead, formaldehyde, white spirit and polyurethanes to recognise this.

However, means do exist to minimise the exposure of workers in our industries but as much depends of the awareness, training and supervision of people to ensure that safe handling practices are followed as on the provision of special plant and protective equipment.

Appendix: Text of a Card handed out to every employee in a Paint Manufacturing Unit

Good Industrial Hygiene Practice

ALWAYS

- use barrier cream before starting work (but remember this on its own does not protect you from chemicals);
- read the safety instructions on the worksheet before starting a job;
- wear the correct overalls and safety shoes or boots;
- wear correct protective PVC/rubber gloves or gauntlets and check first they are in good condition;
- put on the correct eye protection (chemical goggles/face visor/safety glasses) for the job and always when handling liquids;
- wear your own dust mask (conforming to BS 2091) when handling dusty powders or disposing of empty pigment bags;
- ensure that the protective equipment being used is properly maintained and is not contaminated with chemicals;
- make sure that if local exhaust ventilation is provided, that it is switched on and working effectively;
- keep mixers and containers closed or lidded when not in use, to minimise the release of vapours;
- wash your rubber/PVC gloves in soap and water before taking them off;
- be careful not to contaminate your eyes or hands with chemicals when removing eye protection equipment (use the approved method);
- wash your hands with soap and water before visiting the toilet and wash your face as well before eating, drinking or smoking.

NEVER

- wash your hands or skin with solvents;
- take food, drink or tobacco into areas where chemicals are handled;
- risk exposing your eyes to liquid splashes, chemical mists or vapours;
- create dust clouds when handling powders or when folding, crushing and disposing of empty bags;
- enter designated noisy areas without wearing appropriate ear protection (muffs/plugs);
- use your mouth to blow or clear blockages in equipment or to suck liquids in small bore equipment such as pipettes;
- leave spillages of powder, solvents, oil, paint, resin etc. on the floor, steps or roadways;
- allow your soiled protective equipment to contaminate places (e.g. door handles, chairs, benches, handrails) which others may contact or touch;
- clean down dusty areas or your clothes with compressed air;
- leave your work to go to the canteen, or go home, wearing contaminated protective clothing.

REMEMBER: IF IN DOUBT ASK YOUR SUPERVISOR.

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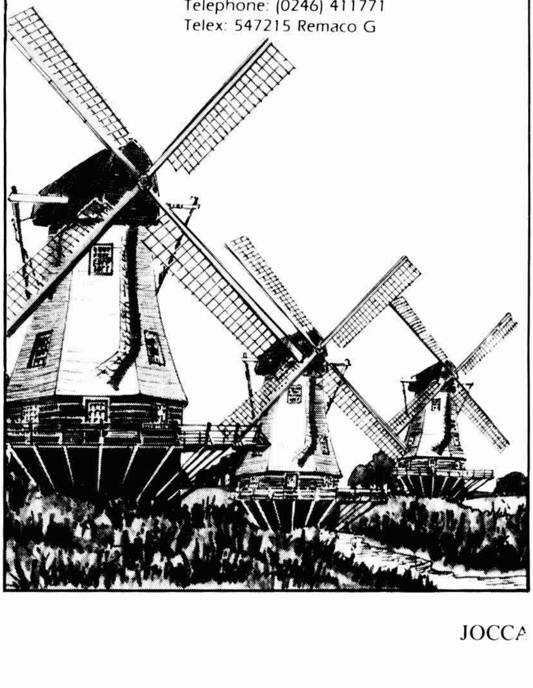
*OCCA London Section Symposium, "Health and Safety in the Coatings and User Industries", Royal Institution, 10 April 1986.



company visits

Glasurit Beck Ltd

New Technical Centre at Slinfold, West Sussex

Glasurit Beck's new Technical Centre at Slinfold near Horsham was opened by Sir Peter Hordern, MP for Horsham on 12 September 1986.

The purpose built centre replaces three separate, rather outdated and somewhat unattractive buildings and allows scope for future development.

The ground floor of the new building contains application and demonstration laboratories for the Company's building products and, next to it, an electrical testing laboratory which includes facilities for products to be tested to the Electricity Council's C81 standards for cable jointing materials.

Also on the ground floor is a surface coatings application laboratory for wood and foil lacquers used by the furniture industries. This laboratory is equipped to simulate coating methods under controlled conditions and includes infra-red and ultra-violet curing. Testing is also carried out to various industrial and national standards.

The first floor comprises of a number of separate laboratories, each devoted to a particular type of product.

The ink media laboratory develops and prepares inks on a laboratory scale and tests them for the usual important properties, such as rheology, printability, rub resistance, tack etc.

Two further laboratories are used for the development and testing of the many polyurethane resins manufactured on the site. These include gas leakage control compounds and resins for casting and encapsulating electrical components.

Wire enamels and impregnating resins for electrical motor manufacture and repair are produced on a laboratory scale and tested before manufacture in the adjoining factory.

There is another laboratory for measuring the mechanical properties of cured resins and for various analytical techniques, such as infra red spectroscopy and gel permeation chromatography.

All the laboratories are well appointed, conveniently arranged and very adequately equipped for their particular purposes.

Glasurit Beck's Head UK Office and resin manufacturing plant are located at Slinfold and also the headquarters of the Industrial and Building Products Division.

In 1984, Glasurit, a wholly owned member of the BASF Group acquired the Valentine Varnish and Lacquer Company, whose warehousing and manufacturing plant are located at West Drayton, where the Company's largest trading division—Automotive Refining is now based.

Powdered paints are manufactured at Newport, S. Wales. The industrial Paints Division produces paints for anodic and cathodic electrodeposition processes.

S. R. Finn

occa meetings

London Section

Chairman's Evening

The first meeting of the 1986/87 session was held on Wednesday, 10 September at British Petroleum plc, Britannic House, London EC2.

The evening's proceedings were opened with the very pleasurable ceremony of the presentation of the Commendation Award to Dr Leslie Valentine for his services to OCCA.

Robert Hamblin—Director and Secretary, read the Commendation, following which the presentation was made by Ken Arbuckle, London Section Chairman.

Some 40 members and guests were then treated to a most interesting and witty talk by Robert Hamblin on his "Reflections as the retiring Director and Secretary of OCCA". His reminiscences were outlined under various headings including "Membership", "The Journal", "Conference" etc, most of which contained some amusing or interesting anecdotes. Many probably hitherto unknown facts for most members relating to the Association were revealed, ranging back to 1951 when Robert Hamblin first took office.

Question Time was devoted more to comment by some of the longer serving members, for whom perhaps the turning back of the clock revived some forgotten memories. A vote of thanks was proposed by Mr Brian Gilliam—Association Treasurer, in which he made comment on the great contribution that Robert had made to the Association and how he will be sorely missed, which sentiment was echoed around the assembly.

Finally, a big vote of thanks to our hosts BP, who once again allowed us the privilege of using their very excellent facilities.

D. Bannington

OCCA Ties are now available from the Association's offices, with a single Association Insignia on either a blue or maroon background. The price is £4.25 each (including VAT) and orders **(prepayment only)** to Priory House.

London Section Presentation: Dr L. Valentine (middle) receiving his OCCA Commendation Award from Mr K. Arbuckle (left), London Section Chairman and Mr R. Hamblin (right), Director and Secretary.

The citation for the above award reads as follows: "At a Council Meeting held on 16 April 1986, it was unanimously agreed to confer upon Leslie Valentine BSc, PhD, FTSC, this Commendation Award in recognition of his support of the Association over many years. Not only has he presented many lectures to the Association's Conferences, Sections and—on behalf of the Association—to sister organisations abroad, but he has also made a substantial contribution to the success of Association Conferences by his outstanding Chairmanship of technical sessions. He has greatly encouraged members of his staff, both in-industry and at the Paint Research Station (of which he was Director 1960-67), to take an active part in the affairs of the Association. At all times his endeavours on behalf of the Association have enhanced the high regard in which it is held in the surface coatings industries". Signed: President, Hon. Secretary, Chairman (London Section), Director and Secretary.

Manchester Section

"Printing Inks for Packaging"—a major success

The Manchester Section held a two day symposium entitled 'Printing Inks for Packaging—Recent Changes, Future Trends', on 10-11 April, 1986, in the Chapman Building, University of Salford.

Seven papers were presented to an international audience of over 200 on the first day covering topics applicable to Liquid Inks and Flexible Packaging, whilst on the second day six papers were presented to 160 delegates on topics covering Paste and Screen Inks and the Non Impact Processes.

After an initial but easily rectified hiccup with a mistaken location of the lecture theatre the Section Vice Chairman, Fred Morpeth, Foscolor Ltd, opened the proceedings by introducing the session Chairman, Ray Pierce, BASF Inmont (Graphics). Mr Pierce went on to introduce each lecturer in turn before ably controlling the very active question periods which followed.

At the intervals for tea and coffee and during an excellent lunchtime buffet delegates were able to visit a Mini Exhibition with displays from 17 companies associated with printing inks and packaging.

On the first evening a symposium dinner was held in University House with an attendance of over 100 delegates, lecturers and officials.

After a sherry reception and a splendid meal which was thoroughly enjoyed by all present, Fred Morpeth with his typical Geordie humour introduced the top table in turn. The President, Frank Redman, then made a short speech before the majority of those attending retired to the bar to complete a convivial evening, discussing not only the success of this event but enquiring when the next symposium would take place, thus creating an aura of great friendship. Accommodation in the nearby Halls of Residence was available for those staying overnight.

Manchester Section Printing Inks for Packaging Symposium, 10-11 April, 1986, Chapman Building, University of Salford. Front row (left to right): R. J. Pierce, Dr J. Morgan, F. Redman, E. Stretton. Second row (left to right): Dr J. T. Guthrie, M. Nixon, F. Morpeth. Third row (left to right): F. Lewis, N. Seymour, P. Mullen, S. J. Parker. Back row (left to right): Dr J. H. Nobbs, M. S. Palmer, D. Pelling, C. Williams, G. Hutchinson.

The second day was again opened by Fred Morpeth who introduced Fred Lewis, Crown Wallcoverings Ltd, as session Chairman for that day. Mr Lewis proved to be a very capable chairman controlling the lecturers to very precise timing and encouraging a considerable number of questions to be asked.

Again time was available at the intervals to visit the exhibition; this extra attraction proving to be very worthwhile both for the delegates and the exhibitors themselves. Those present were: Allied Colloids, ICI Organics Division, Cobden Chadwick, Lawter International, Testprint BV, Ellis Jones, Tennant KVK, Colour Management for Printers/ICS, Kirstol, Foscolor, Fullbrook Systems, Kenroy Dispersions, Thomas Swan, Cray Valley Products, Lankro Chemicals, NL Chemicals, Cornelius Chemicals and OCCA.

At the close of the symposium a short speech was made by the Symposium Organiser, Michael Nixon. He emphasised that the success of the event and the fact that everything had run smoothly was a tremendous relief. Thanks were then given to the delegates for attending, the lecturers for their presentations, the session chairmen for the expert control shown, the exhibitors for the excellent displays, the University staff for their organisation and cooperation, all the OCCA officials for the assistance provided, his Company Winnetts Inks Ltd, for the time allowed and office facilities provided, finally thanks were extended to his wife for all the typing and his son for the sign writing which was in evidence around the campus. Without all of these there would have been no symposium.

Everybody was then wished Bon Voyage, whether they were travelling to Manchester, elsewhere in England, Scotland, Belgium, Germany or Italy it was hoped they would all arrive home safely.

The first of the papers appears in this issue and others will appear in consecutive issues. Where a paper from the symposium is not published in JOCCA then a summary of the paper will appear in the OCCA Meetings section of the Journal.

Printing inks for packaging—symposium summaries

Flexible packaging market in the UK

Mr Palmer of Maurice Palmer Associates Ltd of Chesterton highlighted his lecture by giving the characteristics of the UK packaging market as follows:

1. Market has good growth prospects in selected end-user and material sectors.
2. Highly competitive.
3. High import penetration.
4. No supplier brand identity.
5. High degree of material substitutions taking place.
6. Product and print quality play important roles in the purchasing decision.

The total market in 1984 was 166,010 tonnes with an expected growth rate of 1% from 1984-1988. On square meterage the growth rate will be high due to the down gauging of materials, conversion of paper to films, and cellophane to OPP.

He discussed the growth areas for flexible packaging and areas of decline and also the increase in substrate growth, these being OPP and pearlised OPP in particular. Cellophane, wax lamination and paper will decline.

Increase in the use of high barrier co-extruded films in the dairy and meat industries heralds an exciting new development.

Import penetration is estimated at 19% of total consumption, the main reason being one of price.

Price considerations are not considered as important as say print quality for the purchaser of flexible packaging. In a similar survey, price considerations are more important to converters. Converters surveyed also show that ink manufacturers are highly rated by the converters.

The flexible packaging market presents existing growth prospects compared to the rest of the packaging industry. The potential for ink suppliers is very strong with great emphasis on the attractiveness of the packaging.

The challenge of the new packaging film

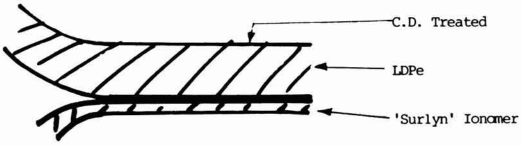
Mr. P. W. Stone of the Technical Support Department of BCL Shorko Films, reviewed the new packaging films, examined future trends and considered challenges posed to film manufacturers.

The new packaging films and derivatives of exisiting and established films are:

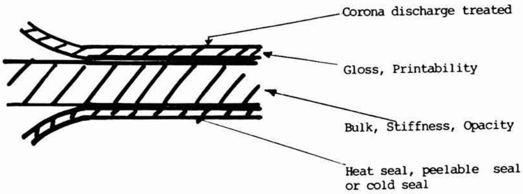
Polyethylene Coextrusions

Polymers are selected from about 20 basic types and are combined to give a single film. The film may be blown or cast to give a thickness of 38-40μ. The number of layers varies, in the UK two or three are typical, in the USA more complex structures are available.

2 layer structure (C.D. = Corona Discharge).



3 layer structure



Clarity is generally poor but is unimportant where total ink coverage occurs.

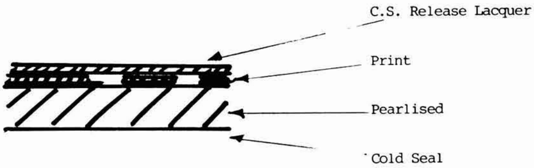
Wet and flatness gauge variation is still a problem against the superior web flatness of polyester and oriented polypropylene.

In addition, certain films have a 'memory' and prolonged storage can be a problem.

Oriented polypropylene

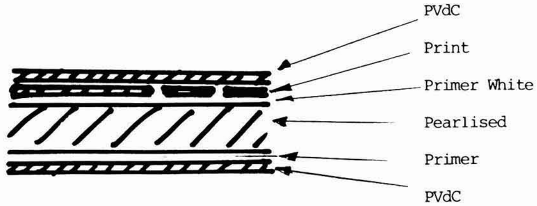
There has been a decline in Western Europe in the use of coated OPP base film and a rise in coextruded OPP. Decline is due to cost and the fact that any gas barrier is negated by the sealing integrity.

Typical structure for cold seal converted film is:



Uses are confectionary bars.

Problems associated with this type of film are discussed in the paper. With overall print coverage and two sides PVdc (PVdc = polyvinylidene chloride) coated for heat sealability.



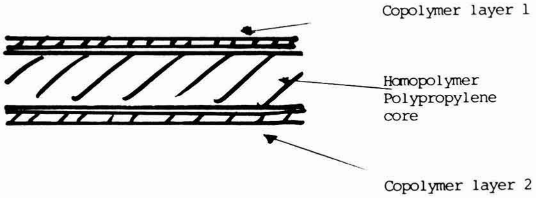
Typical uses are for high quality biscuit wrappers. For future speciality papers end uses are likely to come under attack. Labelling is also a likely target. Other types of cavitating agents will give rise to a whole new range of films.

Other challenges needing to be met are preferential slip additive movement, surface imperfections, print repeat. These films present few problems to the ink supplyer.

For the future, various polymers are being tried for gas barriers, some however require intermediate layers—five layer structures as opposed to three.

High speed coextruded OPP films

Structure:



These films have good 'hot tack' and the strength of the seals is very good. New additive systems leads to excellent clarity.

Metallised Co-extruded OPP

Difficulty has been to produce a suitable base for metallising since standard films are unsatisfactory i.e. poor metal adhesion. At present there is no sealant which gives a lap bunch seal to single web metallised film.

Coextruded metallised OPP is now popular for snacks, giving good moisture, good light barrier, delaying the on-set of rancidity.

Cellulose film

The cost, high density and poor flex against polypropylene led to its decline. A new process for its manufacture giving better cost effectiveness, tough film and thinner gauges will lead to its resurgence as a flexible package material.

Composition of liquid inks

Mr. T. Kendrew of Coates Brothers Inks Ltd discussed the composition of liquid inks.

Liquid inks are composed of pigment or dye, resin, plasticisers, solvent and additives.

The end user is only interested in the colour imparted by the pigment or dye. The rest of the formulation is only present as a means of satisfactorily transferring the colour through the press to the substrate, and then performing adequately in service.

Pigment/Dye

These are classified according to shade, hue and depth of colour. In terms of the 'colour circle', brighter pigments are found at the circumference and the closer the centre the darker the colour. Selection of pigments are now also governed by toxicology, resistance properties (both light and product), and also price.

Resins

This component is normally in two forms a carrier resin, which transports the pigment through the printing processes and protects the pigment on the substrate. Modifying resins are used to improve the adhesive to the substrate.

Resins are selected for the following properties: wetability, adhesion, solubility/flow, resistance and odour.

Typical resins used are: cellulose—ethyl, nitro, ester; hard resins—phenolic, maleic; acrylates/methacrylates; vinyl types; polyamides.

All these resins have been used and are being used in various liquid ink applications.

Other special resins are also used to produce one or two desired properties to the ink.

Plasticisers

Typical plasticisers used are the phthalates, citrates, adipates, phosphates and polyesters. Primary use is to impart flexibility.

occa meetings

Solvents

Many significant changes have taken place in the solvents used in liquid inks because of more toxicological awareness e.g. Glycol ethers are now no longer used and Toluene very rarely. Any solvent/solvent mixture used must have good dissolving power for the resin and good release at high press speeds.

Additives

The choice of additives are legion and are used to impart or improve specific properties to the ink.

W. Borrell

news

Exxon starts up world's largest hydrocarbon solvents plant

Exxon Chemical's Belgian affiliate has completed extensive additions to its Antwerp hydrocarbon solvents plant. The annual capacity has been increased from 360,000 tonnes to 550,000 tonnes making it the world's largest facility of these types of products. Exxon Chemical manufactures a wide range of solvents including its new ink grades marketed under its Varsol, Exxsol trademarks.

Nobel acquires Tecnomax

Casco Nobel of the Nobel Group of Sweden has acquired Tecnomax srl from the MaxFin Group of Milan, Italy for 19.6 billion Lira. Tecnomax manufactures paint for the mechanical engineering and wood industry.

Large ink factory opened by Coates

Coates Brothers Inks new £1.5m factory has opened at Ellenroad, Rochdale. This factory is the largest of its kind in Europe and produces more than 5,000 products for the printing industry. The Rochdale site factory makes use of many hundreds of raw materials and intermediates, and supplies a complete range of inks suitable for a wide variety of substrates. The lighting was carefully designed for matching and blending products with tight colour tolerances.

Coates new £1.5m ink factory

Second coating line for HMF

A second electrostatic powder coating plant has been installed at HMF, Hampshire Metal Finishers of Alton, Hampshire. The plant of a modular construction consists of a gas-fired tunnel with mono rail conveyor and two temperature controlled zones with blown ribbon type burners.

Laporte's Australian expansion

Laporte has acquired the Sydney based Davco Services (Pty) Ltd for A$4.2m. Davco specialises in the tile adhesives, grouts and concrete jointing materials. Davco products will complement those from Laporte acquisitions in other countries i.e. Ohio Sealants, Syracuse in the USA and Sovereign in the UK.

Aluminium powder distribution deal for Haeffner

H. Haeffner & Co of Chepstow has been appointed sole stockists and distributors throughout the UK and Ireland for the Metana range of aluminium powders and pastes manufactured by Johnson & Bloy Ltd.

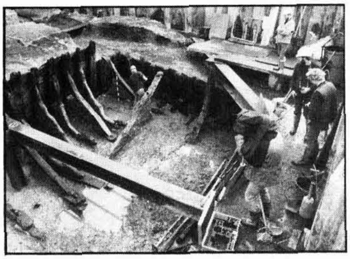
Essochem starts up speciality wax plant

Essochem has started up its 15,000 tonnes per annum synthetic wax plant at Antwerp. The process produces a wide range of Escomer speciality waxes which are used in printing inks and wax blends for coatings.

Polyethylene glycols saves London waterfront

A magnificent 13th century wooden quay from the Thames waterfront at Billingsgate recently went on display at the Museum of London's new exhibition "Capital Gains! Archaeology in London 1970-86". Measuring 5.5m long × 2m high and 3.5m deep, the timber quay was excavated at Billingsgate in 1982. It had been perfectly preserved in silt and consequently still bears the marks of its construction. After being recorded, the quay was dismantled and taken to the Museum for conservation.

This has been done by freeze-drying (Consortium Conservation of Dundee) a process which removes the moisture in the wood without causing cracking and warping. Polyethylene glycol (PG) a water-soluble wax was used to stabilise the wood. First low molecular weight PG was used to penetrate the solid heartwood and then a high molecular weight PG was used to consolidate the spongy wood, even the most difficult timbers were preserved.



Polyethylene glycols to the rescue

products

Spray can rust converter

Enviro-Chemie Eschenbach, Switzerland, has produced the first rust converter in a spray can. Called *Brunox* the converter contains an epoxy resin and can be overpainted with varnishes, spray paints or body fillers.

Reader Enquiry Service No. 30

NL Chemicals new rheological additive

NL Chemicals Inc of Brussels announce the introduction of *Bentone SD-3,* a new rheological additive for high performance coatings. It supplements NL Chemicals' product line of Bentone SD-1 and Bentone SD-2 additives. Bentone SD-3 rheological additive is a high efficiency organoclay based upon hectorite clay. It simplifies the formulation and manufacture of high performance paints of low to intermediate polarity. It does not need pregelling and requires no polar activator for full dispersion. The high efficiency of the Bentone SD-3 additive often allows a reduction of use-level in comparison with conventional rheological additives. Bentone SD-3 can be used in a wide range of aromatic solvents and blends of aliphatic and aromatic solvents.

Reader Enquiry Service No. 31

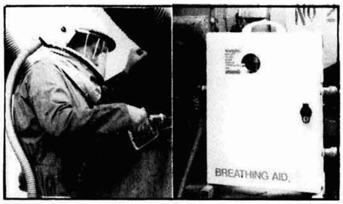
New breathing aid package for two-part paints

Thorite Ltd of Leeds has introduced a

news

complete breathing aid system for use in atmospheres contaminated by two-part paint spray. The system feeds clean breathing air to an operator, affording full respiratory protection. The package comprises a portable air filtration unit, air fed face mask, belt mounted flow regulator and 10m of connecting hose. The filtration unit, contained within a lockable steel cabinet, takes air from any industrial compressed air supply which is free from carbon monoxide and other toxic gases. Then, by four stages of filtration, the unit removes water, corrosive liquids, dirt, oil and oil odour to British Standard 4275: 1974.

Reader Enquiry Service No. 32

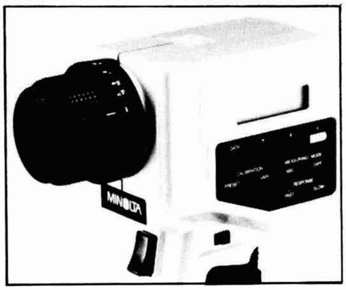


Thorite breathing aid for two-part paints

Spot colorimeter

Minolta of Milton Keynes has introduced the *Chroma Meter CS-100* non-contact tristimulus spot colorimeter for spot metering of a light source or surface colour. The single-lens reflex viewing system includes a centre circle which indicates what is being measured. A LCD display inside the viewfinder shows the luminance value and a LCD display on the side of the meter gives x and y chromaticity co-ordinates. Optical close-up lenses can be used for the metering of small objects. Applications include objects which should not be touched i.e. fresh paint.

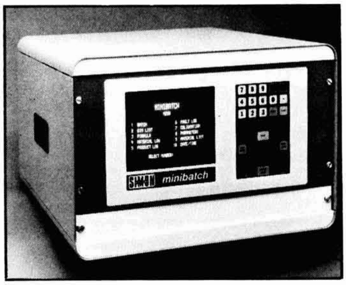
Reader Enquiry Service No. 33



Minolta CS-100

High accuracy pigment blending

Richard Simon & Sons of Nottingham, specialist weighing systems manufacturers has introduced a system for the blending of pigments to close tolerances called the *Minibatch*. The container used for collecting the pigments is placed on a platform scale that has a high accuracy digital weight display and filling is assessed by the new Minibatch MK II controller linked to a VDU. The Minibatch can store up to 50 formulations each with 32 ingredients.



Weighing in with Minibatch Mk II

Reader Enquiry Service No. 34

literature

Organotin antifouling paints

The Department of the Environment has published "Organotin in Antifouling Paints—Environmental Considerations". The report summarises action taken by the Government to regulate antifouling paints in freshwater, estuarial and marine environments. It also describes the follow-up studies that are in hand with the DOE to assess the effectiveness of these controls. From July 1987 new regulations will mean that all new antifouling agents will have to be registered under the Food and Environmental Protection Act 1985. Until these come into force the Paintmakers Association are co-operating in a voluntary notification scheme. The report is available from HMSO priced £5.80.

New guidance for cadmium workers

The HSE has published a revised Guidance Note, together with a free leaflet, for people working with cadmium or cadmium compounds. Cadmium and its compounds are present in a number of industrial raw materials and are used as pigments. The revised Guidance Note contains new information on the health surveillance of cadmium workers. The leaflet provides concise information for workers on hazards and precautions with these compounds. HSE Guidance Note EH 1 (Revised) "Cadmium: Health and Safety Precautions" is available from HMSO at £2.25 and HSE leaflet MS (A) 7 "Cadmium and You" is free from HSE.

Two new revised BSI publications

BS 5358: 1986 "Specification of solvent-borne priming paints for woodwork" and BS 5082: 1986 "Specification for water-borne priming paints for woodwork". For copies contact: BSI Sales Department, Linford Wood, Milton Keynes MK14 6LE.

meetings

Corrosion '86 Exhibition

UK Corrosion '86 will be held from 17 to 19 November at the Metropole Hotel, National Exhibition Centre, Birmingham. There will be three full days of conference proceedings and an exhibition featuring over 70 companies. For further information contact: Exeter House, 48 Holloway Head, Birmingham B1 1NQ.

Web-offset colour reproduction and printing conference

Pira and Intergraf (the International Confederation for Printing and Allied Industries) Conference on Web-offset Colour Reproduction and Printing will be held on 4-5 March 1987 at the Royal Lancaster Hotel, London. For further information contact: PIRA, Randalls Road, Leatherhead, Surrey KT22 7RU.

Colour '87

The International Exhibition of Colour Design and Colour Application, Colour '87, will be held in Cologne from 26-29 March 1987. For further information contact: Messe-und Ausstellungs-Ges.m.b.H.Köln, Messeplatz, Postfach 210760, D-5000 Köln 21, West Germany.

China Surface—Tech '87

The China Surface—Tech '87 International Surface Treatment Technology and Equipment will be held from 4-9 March 1987, at Guangzhou, Guangdong Province, China. For further information contact: Business & Industrial Trade Fairs Ltd, 4/F China Underwriters Centre, 88 Gloucester Road, Wanchai, Hong Kong. Telex: 64882.

people

Dr Karl Holoubek has been appointed a Member of the Board of Management of Hoechst AG and will be responsible for pigments, textile dyestuffs and intermediates, health and safety within the Hoechst works.

Edward P. Daly has been named Vice President of the Chemical Coatings Division of the O'Brien Corporation, South San Francisco, Calif., U.S.A.

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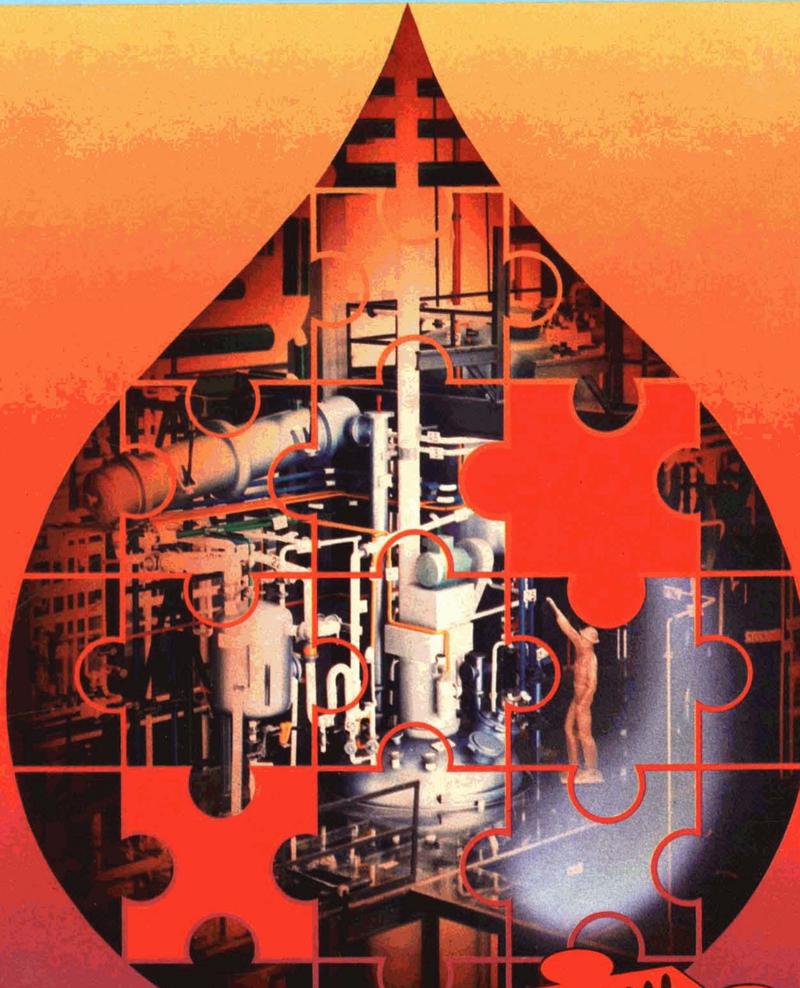

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