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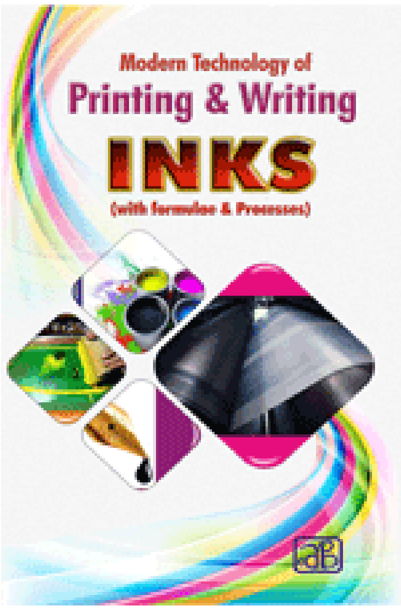
Modern Technology of Printing & Writing Inks (with Formulae & Processes) 2nd Revised Edition



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Ink is a liquid or paste that contains pigments or dyes and is used to colour a surface to produce an image, text, or design. Ink is used for drawing or writing with a pen, brush, or quill. Thicker inks, in paste form, are used extensively in letterpress and lithographic printing. Ink can be a complex medium, composed of solvents, pigments, dyes, resins, lubricants, solubilizers, surfactants, particulate matter, fluorescents, and other materials. The components of inks serve many purposes; the ink's carrier, colorants, and other additives affect the flow and thickness of the ink and its appearance when dry.
India is among the fast growing printing & writing ink markets globally spurred by the rapid expansion of the domestic print markets. Backed by a strong demand from key end user segments such as package printing, newsprint, publishing and other commercial printing, the printing ink market in India has registered strong growth over the years. The printing ink industry is fragmented with hundreds of manufacturers and a large number of players in the unorganised sector.
Printing ink sector in India witnessed a growth of around 7.5% per annum during the Past years. Printed packaging accounts for around 27% of the demand for printing inks in India followed by newspapers at 20%. Commercial printing/promotional and printed advertising together account for around 19% of the demand. Other key end user segments for printing inks include books and stationery. With the print sector forecast to grow at around 8% per annum, in coming years, printing ink segment is expected to grow strongly.
This handbook is designed for use by everyone engaged in the printing & writing ink industry and the associated industries. It provides all the information required by the ink technical for the day-to-day formulation of inks. It supplies the details of the manufacturing methods, including large-scale production, and gives guidance on achieving quality assessment and total quality management specifications. The book also describes properties and uses of the raw materials used in the formulation of printing & writing inks.
The major content of the book are the colour and colour matching, raw materials, printing inks, ink formulations, applications problems, writing inks, project profile, how to estimate, order & handle ink, testing of writing & miscellaneous inks, testing of printing inks, rollers, waterborne inkjet inks. The book contains addresses of raw material suppliers, plant & machinery suppliers with their Photographs.
This book will be a mile stone for the entrepreneurs, existing units, libraries etc.

Tags

Printing and Writing Inks with Formulae, Printing and Writing Inks with Processes, A Guide to Popular Printing Techniques, best small and cottage scale industries, formulations of printing inks, Gravure Printing industry, Growth in the Writing inks, How Ink Is Made, How Ink is manufactured, How printing ink manufactured in factory, how to manufacture ink, How to Start a Printing and writing inks Production Business, How to start a successful Printing and writing inks business, How to Start Printing and writing inks Industry in India, Ink and Printability Testing, Inking Rollers, Inking Rollers uses, Manufacture of Inks and varnishes, manufacturing of varnish, Modern Printing Process, Most Profitable Printing and writing inks manufacturing Business Ideas, new small scale ideas in inks manufacturing industry, Newspaper Printing Ink, Packaging Inks Market - Covering the Printing Inks, Coatings and Allied Industries, Printing and writing inks Based Small Scale Industries Projects, Printing and writing inks Business, Printing and writing inks manufacturing Industry in India, Printing and writing inks, manufacturing Projects, printing ink formulation, printing ink manual, Printing Ink Manufacturing, printing ink manufacturing process, Printing Ink Technology and Manufacture, Printing Inks & Applications, Printing Processes and Printing Inks, Printing processes: Offset, Flexo, Digital, Gravure, Profitable Small Scale inks Manufacturing, Robust Growth in the Indian Exports of Printing Inks, screen printing process, Setting up and opening your Printing and writing inks

Business, Setting up and opening your Printing Business, Setting up of Printing and writing inks manufacturing Units, Small scale Commercial Printing and writing inks production, Small Scale Printing and writing inks manufacturing Projects, Small Start-up Business Project, Start up India, Stand up India, Starting a Printing and writing inks manufacturing Business, Starting a Printing Business, Starting an Ink and Toner Cartridge Refilling Business, Starting an Offset Printing Press, Start-up Business Plan for Printing and writing inks, startup ideas, Startup Project, Startup Project for Printing and writing inks Business, startup project plan, Technology of Printing Inks: Raw materials and formulations, Testing Writing Inks, The manufacturing process of a news ink, varnish making process, Varnish manufacturing, varnish manufacturing process, Web Offset Machines, What Equipment Do I Need to Start a Printing Business?, Writing ink manufacturing process

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Sample Chapter:

INK FORMULATIONS

(A) LETTERPRESS INK

Letterpress inks will be formulated to be as versatile as possible, to run on a number of types of presses and substrates. Examples are given of a range of ink formulations suitable for the conditions stated, which can be modified to suit the other requirements of local conditions.

Platen ink for absorbent papers

Much of the work carried out on plated presses can involve absorbant papers and requires a quick turn around. An ink which penetrates the paper but remains open on the press is therefore advantageous and can be formulated on similar lines to a flat-bed newspaper ink, with higher viscosity and shorter flow :

Carbon Black (Ci Pigment Black 7)	19.0
Reflex Blue	2.0
70 poise mineral oil	55.0
0.5 poise mineral oil	9.0
15 poise bodied linseed oil	10.0
Asphaltum solution	5.0
	100.0

Cylinder press ink for uncoated papers

An ink formulated for a more general range of uncoated papers will require to have some drying properties. The incorporation of some resin giving the ink a degree of tack and flow, and the addition of slightly more blue toner can also be expected :

Carbon Black (CI Pigment Black 7)	18.0
Reflex Blue	4.0
Long oil alkyd	16.0
0.5 poise mineral oil	5.0
Varnish	55.5
10% Cobalt drier	0.5
Antioxidant	1.0
	100.0

a consists of a hydrocarbon resin or modified phenolic resin cooked into a blend of linseed and mineral oils.

Quick-set inks for coated paper

This type of ink will usually be based on a varnish formulated from resin, drying oil and distillates as described in the section dealing with resins. The choice of resin and ratio of resin/oil blend to distillates are determined by the quality of the substrate and the properties required from the final print.

The higher the absorbency of the substrated, the higher the viscosity of the resin/oil phase needs to be, in order that chalking of the print does not occur :

Calcium Carbonate	8.0
B Phthalocyanine Blue (CI Pigment Blue 15.3)	12.0
Gloss varnish	49.0
Setting varnish	16.0
Polyethylene wax paste	5.0
Anti-set-off paste	3.0
Cobalt/manganese drier	1.0
280-320°C distillate	6.0
	100.0

Letterpress ink drying by oxidation

An ink drying by oxidation for use on foil board or other impervious substrates would be formulated on the lines of :

Carbon Black (CI Pigment Black 7)	20.0
Reflex Blue	6.0
Long oil alkyd	30.0
Modified phenolic/tung oil varnish	30.0
Polyethylene wax paste	8.0
260-290 distillate	4.0
Cobalt/managanese drier	2.0
	100.0

The small percentage of distllate shown can be tolerated, but higher amounts would tend to be trapped in the ink film and make it easier to remove from the surface.

Water-reducible inks

For letterpress printing on corrugate boxes, a typical formula would be :

Water-reducible red

Blance Fixe (CI Pigment White 21)	10.0
Rutile Titanium White (CI Pigment white 6)	5.0
Lake Red C	14.0
Varnish	54.0

Diethylene glycol	8.0
Wax paste	5.0
Amine	4.0
	100.0

Varnish

High acid value	
Maleic resin	50.0
Glycol	40.0
Amine	10.0
	100.0

The printing involved will mainly consist of solids, type and linework and the print usually has a semi-matt appearance. On this type of substrate, two colours can usually be superimposed, wet-on-wet without tack grading, but on more solids boards, tack adjustments with mixtures of water and glycols with be required. A low viscosity ink aids distribution on the rollers and the transfer properties from the rubber stereo to the kraft paper.

Process inks

The use of the letterpress process is now hardly known in the UK for this purpose and BS 4160 : 1967 (European Reference CEI 12/66) has recently been made 'obsolescent' by the BSI. This standard specified the colour, colour strength, transparency, lightfastness and solvent resistance of the three primary colours - yellow, magenta and cyan. It also referred to a previous British Standard for letterpress process inks (BS 3020: 1959) for a suitable black ink.

Process magenta letterpress	
Calcium 4B toner (CI Pigment Red 57.2)	15.0
Polyethylene wax paste	3.0
Cooked quick-set vehiclea	32.5
Gloss quick-set vehicleb	28.0
Cobalt/manganese Drier	0.5
280-320Â°C distillate	20.0
Antioxidant	1.0
	100.0

aBased on modified phenolic resin, cooked into a long oil alkyd and linseed oil and let down in 280=320Â°C distillate.

bBased on modified phenolic resin, cooked into a long oil alkyd, let down with 280-320Â°C distillate and

aluminium gelled.
Similar formulations for the yellow and cyan would contain 15% Diarylide Yellow (CI Pigment Yellow 13) and 14% B Phthalocyanine Blue (CI Pigment Blue 15.3) respectively, to give the correct chromacity figures when printed in accordance with the standard, Because of the thicker ink films laid down, tack grading is essential < when printing two colours wet-on-wet.[/P]

Newspaper coloured inks

The titles and late news items are sometimes printed on very small units which have very limited rolling capacity. Due to the high operational speed of these units, considerable ink spray can be developed. Coloured inks are also widely used in provincial papers to give impact to advertising. These are usually printed on page wide units which present the formulator with similar problems to that of the seal or headliner colours. Occasionally, if the amount of coverage of colour warrants, a complete unit will be used, but more usually, half-deck, and the careful design of the page layout will provide the necessary colour.

A typical formulation would be :

Chlorinated Para Red (CI Pigment Red 4)	10.0
Extender pigment	10.0
Resin varnish	40.0
Mineral oils	25.0
Long oil length alkyd resin	10.0
Wetting agent Antioxidants, etc.	5.0
	100.0

aA hydrocarbon resin or low melting point phenolic resin dissolved in mineral oil.

The amount of pigment/extender is varied depending on the properties of colour strength, etc. That are required and the ratio of resins, solvents and oils adjusted to suit the individual units being used.

Rotary black inks for newspapers

The formulations used for printing newspapers have to meet the following targets which require good tolerance for troublefree running :

1.Low misting character;
2.Non-drying on press, but reasonable rub resistance on paper;
3.Easy deliver to the press;
4.Good transfer to the substrate;
5.Low linting character;
6.No adverse effect on stereos used;
7.Good penetration on newsprint but a minimum of strike through during the normal life of the paper.
8.Good de-inking properties;
9.Economical to use.

The colour strength is critical in formulating newspaper inks. If the ink is over-strength, reduced film weights are used, and this may give rise to poor coverage and uneven inking. Problems of linting and transfer may also occure if an insufficient volume of ink is being replaced on the forme and ink distribution roller chain. Conversely, with low-strength ink, problems of strike through, misting, flooding the stereo and marking off on path rollers occur, as high volumes of ink are transferred through the printing system to obtain the correct density.

The actual amounts of ink used per copy vary with the content of the edition and the absorption of the newsprint used. A guide to how much ink is used is : 1.7 g of rotary news ink per 1000 copies of a 32-page tabloid. (This is based on experience rather than a calculated formula). While the amount of ink used per copy is extremely small, the total amount of ink used by a newspaper publisher can be over 3000 tonnes per annum. The cost of the ink is therefore a significant factor in newspaper production costs, and can be a limiting factor which has to be taken into account by the formulator, restricting the use of certain raw materials.
A further economic factor to be taken into account is the need to include a proportion of reclaimed material in the newsprint paper manufacturing process. Before this happens, the printed paper must be deinked to maintain the final prightness of colour of the newsprint. The de-inking process consists of treating the paper with alkali to reduce the paper to fibre form allowing the ink to separate and float to reduce the paper to fibre form allowing the ink to separate and float to the surface from where it is removed. The paper slurry is then neutralized and included in the fresh paper-making cycle.
While this process is reasonable easy with conventional rotary letter-press inks, harder drying formulations can prove more difficult to separate.
The formulations in Table 5.2 show the type of variations in formulae used to obtain the correct properties for various presses, plates and papers. They must only be regarded as starting formulations to give the technologist guidance. Individual printers require inks with properties specific to their needs, and each type of manufacturing plant will produce inks of slightly differing properties using the same materials. The formulations have been chosen to give similar print performance under the various conditions used.
Formula A : General-purpose low mist black
This ink is capable of running at very high speed (50,000 cps) on a variety of presses and newsprints. It has a blend of mineral oils and flow acids which will give good density with other good print qualities of strike through, and non-marking on the turner bars of the press. The anti-spray additives are added to give the ink low mist and ink sling properties.
Formula B : Ink rail
A differing blend of mineral oils and flow aids to give excellent print qualities to an ink which is thinner and longer flowing than Formula A. This is necessary to allow the ink to freely circulate on the ink rail distribution system.
Formula C : Page-pak
This formulation has longer flow and is thinner than both the previous formulations because of the restrictions in the page-pak distributing systems.
Formula D : Keyless inking (indirect flexo)
The formulations of news inks for this type of ink metering system are similar to those for conventional units. The viscosity of the ink needs to be low enough to fill the cells of the etched roller and flow sufficient for the inks to be readily pumped. The level of pigmentation is dertermined by the depth and shape of the cells of the etched roller.
Formula E : Flat-bed rotary
The flat-bed rotary formulation included in Table 5.2 would normally by supplied in tins or buckets for use on the slower flat-bed and rotary presses. The relatively low ink usage and the position of the ducts is such that the ink is normally transferred to the duct manually using a palette knife. This type of ink is commonly referred to as 'knifeable'. The slow press speeds involved also required inks of a higher viscosity and shorter flow than previous formulations and the inclusion of anti-spray additives is not normally required. The amount of Carbon black in the formulation needs to be increased compared with high speed rotary presses in order to achieve similar print densities due to the different transfer properties of these inks.
Formula F

The formulation has been included to show that rub resistance of conventional news inks can be improved by the incorporation of an amount of varnish. This varnish usually consists of hard resin, typically hydrocarbon resin, mineral oil and distillate.

(B) LITHOGRAPHIC INKS

TYPICAL INKS AND VARNISHES

The details of litho ink and varnish formulation are dependent on the conditions under which the products are to be printed and the end-use requirements of the print. The major distinctions are between sheet-fed and web-fed printing and between the main classes of substrate, namely low-quality papers, high-quality papers, carbon boards and impervious substrate. Specific formulations are also usually employed for the small offset presses found in instant print shops and in-plant printing departments.

Inks and varnishes for sheet-fed paper printing

The quick set mechanism is the standard drying process employed in the sheet-fed offset printing of paper substrates. The formulating approach shown below is used to produce process colours, blacks, colour blending system inks and specially matched individual spot colours :

Organic pigmenta	18.0
Cooked quickset vehicleb	
Gloss quickset vehiclec	70.0e
Fast quickset vehicled PE wax paste	5.0
Anti-set-off paste	3.0
Cobalt/manganese driers	1.0
280-320Â°C distillate	3.0
	100.0

1. For example, CI Pigment Blue 15 : 3, for a process cyan.
2. Based on low solubility modified rosin ester cooked into linseed oil and let down in 280-320Â°C distillate.
3. Based on high solubility, low melting point modified rosin ester and long-oil alkyd, aluminium gelled.
4. Based on soluble modified rosin ester, used at high resin-to-oil ration.
5. The exact proportions of the various vehicles will depend on the desired balance of gloss, setting and machine performance.

Black inks of the highest density require the incorporation of specific wetting vehicles, generally based on low viscosity resins and alkyds to give high solids in the vehicle at moderate viscosity. This enables the vehicle to wet fully the substantial surface area associated with high loadings of fine particle size carbon blacks.

Good pigment wetting is essential for satisfactory in rheology, particularly flow and transference, to the promotion of gloss and a true black jetness.

Quickset overprint varnishes for sheet-fed lithographic application to paper substrates are based on rather different formulations to anything usually encountered in vehicles for inks. A typical varnish would consist of the following :

Maleic modified rosin ester (pale colour)	30.0

Tung oil	15.0
Long-oil alkyd	15.0
PE wax paste	7.5
Cobalt driers	2.5
260-290Â°C distillate	30.0
	100.0

The pale colour of the resin is necessary to minimise yellowing on top of non-ink-image are as and to avoid shade distortion of underlying colours. Tung oil is introduced to give a tough dry film for maximum rub and scuff resistance. As setting of overprint varnishes is often partially restricted by the ink films already present. Oxidation drying is speeded by the use of high drier contents, and solvent separation is encouraged by the use of more mobile and slightly more volatile, lower boiling range distillate fractions. These latter generally give acceptable roller stability since the throughput of varnish on the press is usually high due to the relatively high film weights and coverage which are commonly applied.

Specific ink formulating approaches are utilised where there are particular substrate requirements, such as with label papers, or particular pigment characteristics, as in metallic inks, or where there is a distinct variation in the characteristics of the printing process, e.g. small-offset.

Sheet-fed label inks

Plain paper labels for the can, jar and bottle industries are generally printed on large format sheet-fed machines with single sheet carrying many individual labels. The substrates used are normally low in base weight and coated on the front side only. Large sheet size, high ink coverage (in order to meet the visual impact demands placed on labels) and lightweight paper produce severe sheet curl problems unless specially formulated low tack inks are used. Adequate viscosity is preserved in such inks by the use of gelled vehicles and gelled reducer. A typical formulation would be :

Permanent Orange (CI Pigment Orange 13)	20.0
Cooked quickset vehiclea	60.0c
Gelled quickset vehicleb Long-oil alkyd	5.0
Long Oil alkyd Anti-set-off paste	3.0
Gelled reducer	3.0
Cobalt/manganese driers	2.0
PE wax paste	7.0
	100.0

1.Based on low solubility modified rosin ester cooked into linseed oil and let down in 280-320Â° distillate.
2.Based on soluble modified rosin ester. Aluminium chelate gelled.
3.The ratio of the two vehicles depends on the exact viscosity/tack relationship required.

Metallic inks

Gold and silver inks are based on bronze and aluminium linings respectively. These linings are powders of a specific physical from which consist of extremely small, flat particles. In order to achieve a satisfactory metallic luster at the low film weights printed by offset lithography, very high loadings of the finest particle size grades are utilised. Even then, optimum brilliance and luster can only result if the particles are able to 'leaf' in the ink vehicle, i.e. orientate themselves such that the flat surfaces are overlapping and parallel to the substrate surface. Care is required in formulating metallic litho inks in order to ensure that the vehicle both permits leafing and retains adequate tack and rheology characteristics when very high proportions of the metal linings are also major considerations because reactions can take place between the metal powder and ink vehicle components. A typical formulation of an offset litho gold suitable for sheet-fed printing on to paper and board would be :

Bronze lining pastea	50.0
Metallic quickset vehicleb	41.5
Cobalt driers	1.0
PE wax paste	7.5
	100.0

1. Approximately 85-90% bronze lining in low sulphur content distillate. (The latter is important to avoid tarnishing.
2. Based on soluble modified rosin ester resin and long-oil alkyd in low sulphur contents distillate. Stabiliser is incorporated into the vehicle for single-pack gold production.

Silver inks stilise a lower lining content than golds, due to the lower specific gravity and superior luster and opacity of aluminium linings. A typical level of incorporation would be 20%. Also, stabilizer is not usually required in single-pack silver inks since aluminium linings are inherently less reactive with oleoresinous vehicles that bronze powders.

In order to preserve the leaf line potential of the linings, all metallic inks must be manufactured by processes involving low shear only. Thus, slow mixing and blending are appropriate but high speed stirring and three roll milling are not.

Small-offset

The presses used in small-offset are designed for ease of operation, since they are often run be staff who are not fully trained litho printers, and for economic construction, in order to provide a low-cost facility for the duplication of type matter. Inking and dampening systems are frequently rather different from those employed on larger, sheet-fed presses and are often extensively integrated. The ink distribution system is restricted in rolling power. Additionally, a wide range of plates is used, extending down to very low cost grades which rely on a tough paper as the base support material. Such plates may have only limited distinction between image and non-image areas.

These factors impose a unique set of requirements on the physical and chemical characteristics of small-offset ins. Primarily, the inks must show good distribution and transference, controlled emulsification even on inteqrally damped presses with their associated founts (which may contain gloycols or glycerol), and high cohesion in order to prevent ink transfer to poorly protected non-image areas. The inks are usually required to remain non-skinning over extended periods because the presses are not routinely washed up, even at the end of the day of week, particularly where they are only utilized for printing black. This does not pose too many drying problems when the inks can be formulated to dry be penetration into uncoated paper stocks. Here rubber resin based inks can be used as well as inks based on oxidation drying vehicles with appropriately high additions of anti-oxidant. Where the role of small-offset presses is extended to include the printing of coated papers, oxidation drying systems with a very careful blance of driers and antioxidants must be utilized, usually to give extended non-skinning with relatively slow drying.

Typical formulations for oil-based and rubber-based small-offset blacks are as follows :

Carbon Black (CI Pigment Blaqck 7)	20.0
Reflex Blue (CI Pigment Blue 18)	2.0
Oxidation drying vehiclea	70.0
Anti-oxidant pasteb	2.0
Alkali-refined linseed oil	6.0
	100.0

1.Based on modified rosin ester in linseed oil.
2.Butylated hydroxy toluene inoleoresinour vehicle.

Carbon Blak (CI Pigment Blue 7)	20.0
Reflex Blue (CI Pigment Blue 18)	2.0
Microised talca	10.0
Cyclised rubber vehicleb	65.0
280-320Â°C distillate	3.0
	100.0

1.Incoroorated to control the severe flying tendency of cyclised rubber based system.
2.Cyclised rubber resin dissolved inrelatively high aromatic content distillate, at low resin solids.

Inks and varnishes for sheet-fed carbon board printing

A significant proportion of sheet-fed offset carton printing is now carried out using UV curing systems. This subsection will consider those formulations for board substrates which dry by the quickset mechanism. Although inks and varnishes produced for paper printing can be applied to board stocks, optimum performance to meet the stringent and unique demands of the folding carton packaging industry is usually achieved with specialized formulations. The major requirements are :

1. Hard drying with maximum scuff resistance in order to avoid markingon filling, distribution or retail of the packaged goods.
2. Very rapid setting to minimize set-problems and the needs for anti-set-off spray, aggravated by the substrate weight and its rapid development of pressure in the stack.
3. Minimum odour and minimum tendency to impart off-flavours (taint) when used for food and confectionery packaging.
4. Suitability of subsequent varnishing or lamination in relevant instance. (Note : It this requirements also applied to sheet-fed paper jobs, formulations similar to that outlined below can be used).

Maximum scuff resistance is achieved in inks typified by the following :

Naphthol Red (CI Pigment Red 2)a	20.0

Cooked quickset Vehicleb	50.0
Hard-drying vehiclec	20.0
Micronised PE wax	2.0
Micronised PTEF wax	1.0
280-320Â°C distillate	5.0
Cobalt/manganese driers	2.0
	100

1.Resistant red pigment for soap and detergent carton requirements.
2.Based on low solubility modified rosin ester cooked into linseed oil and let down in 280-320Â°C distillate.
3.Distillate-free oxidation drying vehicle based on modified rosin ester in tung and linseed oils. This type of ink is relatively slow setting particularly if the content of hard oxidation drying vehicle is further increased to meet particular rub resistance demands. Consequently, substantial use of a relatively coarse spray powder is normally necessary to avoid set-off. Where a less hard drying ink can be tolerated, substantial advantages in setting can be achieved by using a formuation as below, which is also appropriate as the basis for low odour and tain or varnishable requirements :

Rubine 4B (Ba salt) (CI Pigment Red 57 : 1)	20.0
Low odour quickset vehiclea	55.0
Hard drying quickset vehicleb	15.0
Micronised PE waxc	2.0
Micronised PTFE waxd	1.0
Low aromatics 280-320Â°C distillate	6.0
Cobalt/manganese driers	1.0
	100.0

1.Based on soluble modified rosin ester and soluble low odour modified hydrocarbon resin in long-oil soya modified alkyd and low aromatics distillate.
2.Oxidation drying vehicle. This eliminated where minimum odour characteristics are demanded.
3.PE wax content is reduced in inks for subsequent varnishing or lamination.
4.PTEF was is eliminated in inks for subsequent varnishing or lamination.

The key to success in this approach is very careful formulation of the low odour quickset vehicle. Resins must be chosen that have inherently low odour and good solubility in low aromatic distillates.

Overpring varnishes for sheet-fed lithographic application to food and confectionery packaging have to be formulated with due consideration for both these odour and taint factors and the colour and drying aspects described earlier.

Maleic modified rosin ester (pale colour)	30.0
Long-oil soya alkyd	25.0
PE wax paste	7.5
Cobalt driers	2.5
Low aromatics 260-290Â°C distillate	35.0
	100.0

Ink for sheet-fed impervious substrate printing

Offset lithography is heavily orientate towards the printing of paper and board substrates which posses a significant degree of absorbency. This enables penetration and setting to play major roles in drying and adhesion in most sheet-fed work. However, a range of foil and plastic stocks are printed lithographically either wit oxidation drying of UV curing formulation.

Oxidation drying inks for impervious substrates represent a difficult compromise between press stability and hard drying. They must be nonskinning in the duct and on rollers, plate and blanket, but free from set off and must give good key and adhesion to the substrate. In practice, stability times are trimed to the bare minimum in order to promote rapid, hard oxidation drying. Even so, anti-set-off spray powder and small stack heights are essential to avoid severe set-off and blocking. Bearing in mind the restrictions that apply to the chemistry of ligho vehicles as discussed in Section 6.1, it is not possible to achieve key to plastic substrates by incorporating resins of similar chemistry to the plastic in the binder vehicle of the ink. Key and adhesion have to be achieved through oxidation drying producting a hard, yet flexible, polymerized film. Because of this lack of formulating flexibility, litho inks cannot readily cope with the wide range of impervious substrates that are printed by gravure, screen and flexo.

A further complication arises in the areas of ink/water blance. Since the substrates are impervious they are unable to transport fount solution away from the impression areas of the press in the way that paper and board substrates can. This increases the likelihood over emulsification of the ink. As well as being a potential source of poor reproduction quality, such emulsification can also retard oxidation drying and provide another obstancle to satisfactory ink adhesion on print.

Despite all these potential pitfalls, correctly formulated oxidation drying inks in the hands of skilled litho printers regularly produce fully satisfactory work on foil boards and on plastic sheets. A typical formulation would be :

Phthalocyancine gree (OI Pigment Green 7)	20.0
Oxidation drying Vehiclea	70.0
Micronised PE wax	3.0
Micronised PTFE wax	1.0
Cobalt driers	3.0
Manganese dries	1.0
Alkali-refined linseed oil	2.0

	100.0

aBased on modified rosin ester containing high proportions of tung oil.

Inks for web-offset paper printing

The engineering advantage of handling a continuously running web rather than discreted sheets enables web-offset printing to cope with lower weight papers at significantly faster speeds than even the most productive sheet-fed press. This advantage can only be exploited with inks that are capable of printing and drying at high speeds. Thus, web-offset inks must be formulated to the correct chemistry and rheology for high speed, high shear lithographic printing and fast drying.

Coldset

A typical coldest formulation is illustrated by the following process cyan :

Phtalocyanine Blue (solvent stable) (CI Pigment Blue 15.3)	15.0
Hydrocarbon vehiclea	10.0
Process oilb	50.0
Montmorillonite clay-gelled process oil	20.0
280-320Â°C distillate	5.0
	100.0

1. Low cost hydrocarbon resin in process mineral oil and distillate used to assist pigment wetting.
2. Broad-cut liquid petroleum fraction, significantly less refined than the close-cut distillates used in quickset sheet-feed and heatset inks. Unlike distillates, process oils processes some pigment wetting capabilities.

Since coldest printing is used for relatively low quality, low cost publications, cost is a prime consideration in ink formulation, hence the use of hydrocarbon resin and process oil as the basic vehicle components. Where the dark colour can be tolerated in black inks, it is usual to utilize a cheap natural asphalt or bitument resin, such as gilsonite, in place of hydrocarbon resin to boost the pigment wetting capabilities of the process oil.

Heatset

Heatset inks are much more like quickset sheet-fed formulations. This can be seen from the following example :

Diarylamide Yellow (CI Pigment Yellow 12)	15.0
Fast heatset vehiclea Fast heatest gel vehicleb	75.0d
Slow heatset gel veiclec Micronised PE wax	2.0
Micronized PTFE wax	0.5
Low armatic 240-260Â°C distillate	7.5
	100.0

1. Based on a combination of modified rosin ester and modified hydrocarbon soluble resins at high resin : alkyd ratio in 240-260Â°C low aromatic distillate.

2.As (a) but gelled with aluminium chelate.
3.As (b) but on 260-290Â°C low aromatic distillate.
4.The exact proportion of the various vehicles will depend on the desired balances between tack and viscosity and between stability and heasetting.

Resins are chosen for good solubility in low aromatic distillate but must also allow rapid solvent release for optimum heatsetting. A highly efficient wax combination is required, the achieve good surface slip immediately upon solidification of the ink film. This ensures that the print is protected adequately as is passes over chill rollers en route to the in-line folders and cutters.

(C) GRAVURE INKS.

Publication inks

Once a major source of publications print, the last 10 years has been the decline of the gravure process in favour of web offset, certainly where runs below 500,000 copies are concerned.

Publication gravure inks are formulated to achieve the lowest possible cost; the main demands are on their press performance. Once printed their prime function is to provide text and illustrations, merely requiring adhesion to the substrate and a moderate degree of scuff resistance and lightfastness.

Typical formulations would be :

Conventianal :

Diarylide Yellow (CI Pigment Yellow 12)	6.0
Calcium carbonate	6.0
EHEC resin	2.0
Zinc/calcium resinate	37.0
Polyethylene wax	1.0
Resinous plasticiser	3.0
Aliphatic hydrocarbon solvent	20.0
Toluene	22.5
Xylene	2.5
	100.0

Low aromatic :

Rubine Red (CI Pigment Red 57)	7.5
Calcium carbonate	5.0
EHEC resin	2.0
Zinc/calcium resinate	37.0
Polyethylene wax	1.0
Resinous plasticiser	3.0
Aliphatic hydrocarbon solvent	39.0
n-propanol	2.0
Toluene	2.5
Xylene	1.0
	100.0

Inks for catalogue printing

The ink requirements for catalogue printing are somewhat different from those outlined above. The coated paper normally used in highly calendered with a rather more brittle surface than magazine papers. This means there is less ink penetration into the surface and a reduction in mechanical bonding.
In addition to high glose, inks are required to have tough flexible films with good rub resistance and printability. As there is little assistance from the substrate, rapid solvent release and hard film forming properties are essential to ensure adequate drying. Because of the nature of the paper, press speeds are usually lower than those used for magazine printing.
The solvent system is usually toluene or possible toluene/ester Typical formulation of catalogue ink would be :

Phthalocyanine Blue (CI Pigment Blue 15.3)	8.0
Chlorinated rubber	15.0
Phenolic modified resin	10.0
Resinous plasticiser	5.0
Polyethtylene wax	1.0
Toluene	51.0
Ethyl acetate	10.0
	100.0

Packaging inks for paper and board Lables
The use of labels in packaging is widespread and varied, normally the preprinted labels is attached to the product container to identify its contents. Unlike printed wrappers, labels do not have close contact with the product, which is normally packed in glass, plastic, metal or some other impervious material. This allow, within certain limitations, a fairly wide choice of solvent and resin combinations to be utilized for label printing inks. When printed labels are produced for returnable bottles, the ink film should be penetrable during the washing process, which utilizes a dilute of caustic soda, thus allowing easy removal of the label. Pigment selection will be dependent on colour requirements. A reasonable degree of lightfastness is obviously desirble and some labels may require product resistance. Where high levels of gloss in liquid inks should be utilized. Normally, ball milling or bead milling is the method of manufacture. Advantage can be taken of the low viscosity grades of chlorinated rubber to help promote gloss.
Typical fast-drying formula for labels :

Rubine 4B (CI Pigment Red 57)	5.0
Lake Red C (CI Pigment Red 53)	7.0
Chlorinated rubber	12.0
Phenolic resin	20.0
Resinous plasticiser	4.0
Dioctyl phthalante	3.5

Polyethylene wax	1.0
Toluene	27.0
Ethyl acetate	10.0
Aliphatic hydrocarbon	10.0

Some label printers have a preference for alcohol/ester-based inks choosing to avoid toluene for environmental reasons. This reduces the choice or resin systems considerable and normally means the use of nitrocellulose, maleic and ketone resins.

Non-curl properties and easy wash-off can be achieved by correct plasticisation and the choice of a suitable maleic resin. The main problem is to formulate suitable glossy inks that are sufficiently hard drying, especially when the label is not varnished. The use of specially developed, easily dispersed pigments give reasonable results. But as these pigments are limited range, it is often found to be expedient to use nitrocellulose chips as a means of equaling the gloss of the chlorinated rubber-based links.

Typical formula of a chip-based non-curl label ink :

50% Rubine 4B nitrocellulose chip	10.0
50% Lake Red C nitrocellulose chip	14.0
Maleic resin	10.0
Dioctyl phathalate	3.5
Wax dispersion	5.0
Ethyl acetate	40.0
Ethyl acetate	14.0
Selected glycol either	3.5
	100.0

A third option for labels are co-solvent polyamide based inks, where advantage is taken of their natural non-curl properties and potentially high gloss levels. There are some limitations to their use due to the high degree of resistance to weak alkalis, which prohibits them being used on wash off labels. Also ink film based on polyamide tend to weld when ram punched or quillotined, therefore they cannot be used on the edges of the labels.

Over recent years there has been a small but significant increase in the use of metallised paper for labels. There have been problems associated with ink adhesion on this substrate, vacuum depositing process has been completed has alleviated problem to great a extent. However, as the surface is basically non-absorbent, problems can occur with ink trapping as is the case with aluminium foil and certain films. In these circumstances it is useful to use a co-solvent polyamide backing ink, overprinted with nitrocellulose inks.

Typical co-solvent polyamide ink :

Phthalocyanine Blue (CI Pigment Blue 15.3)	10.0

Co-solvent polyamide	22.0
Nitrocellulose	3.0
Polyethylene wax	1.0
I sopropanol	12.0
Toluene	37.0
I sopropyl acetate	8.0
Ethanol	7.0
	100.0

Metallic label inks

Many labels require the use of metallic inks as part of the overall design. The various shades of bronze inks are particularly popular, usually they are the last colour to the printed in a multicolour design and often overprint one or more of the preceding inks.

Aluminum-based inks are used less frequently that bronze inks on labels. Primarilly they are used as background to give a metallic effect to overlying colours. Care is required in the selection of a suitable grade of aluminum if this is the case, to ensure interlayer adhesion. A typical formula for a bronze medium into which bronze powder would be added at 30-40% be weight is :

Chlorinated rubber (medium viscosity)	30.0
Dioctyl phthalate	10.0
Wax dispersion	7.0
Stabilizer	1.0
Toluene	52.0
	100.0
and a bronze ink :	40.0
Bronze powder (gravure ink lining)	20.0
Acrylic resin	5.0
Stabilizer wax dispersion	1.0
Toluene	27.0
I sopropyl acetate	7.0
	100.0

Paper wrapper inks

With paper wrappers being used predominatly for food, confectionery and toiletry packaging, the choice for raw materials in gravure inks is largely determined by their suitability for these end used. It is of paramount importance that the dried ink film is free from odour or potential tain that might be derived from retained solvent or odorous resins. Although inks are not intended to come into direct contact with foodstuffs, they should not cotain pigments or dyes which are likely to bleed into food constitutents, for example animal fats. Vegetable oils and in the case of chocolate product, cocoa fat. Migratory materials should be avoided where possible and harmful pigments, chemicals and additives should not be used.

A typical ink for a food wrapper would be :

Calcium Rubine 4B (CI Pigment Red 57.1)	10.0
Nitrocellulose	15.0
Maleic resin (low odour)	5.0
Wax dispersion	2.5
Dioctyl phthalate	5.0
Ethyl acetate	54.0
Ethyl acetate	5.0
Glycol ether	3.5
	100.0

Water-based overprint varnish, using specially selected low odour materials

Acrylic resin solution	28.0
Wax emulsion	12.0
Acrylic resin dispersion	40.0
Wax dispersion	5.0
Anti-foam	1.0
I sopropanol	8.0
Water	6.0
	100.0

Carton Inks

This is one of the areas in which gravure printing competes with offset litho and comparisons in print quality are often made. For this reason the lay characteristics of a carton cravure ink is of critical importance. Also many of the cartons for well known brands of chocolate confectionery and cigarettes, have considerable coverage of a colour with which their name is associate. Therefore particular attention is given to the print quality to ensure that it is somooth and unblemished.

Almost invariable, cartons are varnished and as with paper wrappers water-based overprint varnishes have become increasingly important. All cigarette cartons and many chocolate boxes and overwraped with transparent film which is heatsealed directly over the printed surface. Obviously this requires the inks to be heat resistant and the overprint varnish to have heatseal relase properties against the particular film employed.

In addition to heat resistance properties, the water-based overprint varnish should be formulated to give an acceptable gloss level and also be based on hard drying acrylic resins which have the ability to release water from the drying varnish film as rapidly as possible. In this respect the amine content should be critically evaluated and, if tolerable, ammonium hydroxide should be considered. Sometimes the best overall results can be reashed by a carefully balanced combination of two amines.

Heat-resistant carton ink :

Rubine 4B (CI Pigment Red 57.1)	10.0
Orange 5Y (CI Pigment Orange 5)	2.5
Titanium dioxide (PW 6)	7.5
Nitrocellulose	13.5
Maleic resin	5.0
Wax dispersion	5.0
Dioctyl phthalate	5.0
Ethanolyl	42.0
I sopropyl acetate	7.0
Glycol ether	2.5
	100.0

Heat seal resistant varnish:

Hard acrylic resin 15.0	
I sopropanol	20.0
Water	15.0
Amine or ammonium hydroxide	2.0
Wax emulsion	5.0
Acrylic emulsion	35.5
Wax dispersion	5.0
Release agent	1.5
Anti-foam	1.0
	100.0

When metallic links are required for carton printing the overall design has to be carefully considered. If the

areas of metallic print is small and if the ink has to overprint other colours, it is likely that the best printability will be achieved with a toluene-based acrylic resin type of ink described previously. If the ink is required to print directly on to the board then an ester-based acrylic metallic ink should perform satisfactorily.
Problems can occur when a large area of gold is required to overprint a nitrocellulose based colour and, be cause of the low odour requirements, a toluene system cannot be used. The best approach is to use a vinyl modi fied acrylic with a carefully balanced ester solvent system, suited to the machine speed and its drying capacity.
The choice of material for bronze inks is discussed in detail in the section dealing with metallic inks.

Metallic bronze gravure ink for cartons :

Bronze powder (Superfine lining)	40.0
Ester soluble vinyl resin	2.5
Acrylic resin	17.5
Wax dispersion	3.0
Stabiliser	1.0
Ethyl acetate	10.0
I sopropyl acetate	16.0
Glycol ether	10.0
	100.0

Foil inks

Aluminum foil is widely used in packaging both unsupported and as a laminate to paper and board. Having been used for a wide variety of packaging outlets over many years, sluminium foil is now being challenged by metallised papers and films, and former because of lower cost, the latter on product appeal.

Formulation for lightweight a aluminium foil :

50% pigmented nitrocellulose chip	25.0
Polyvinyl butyral	4.0
Dioctyl phthalate	4.0
Wax dispersion	3.0
Ethanol	54.0
I sopropyl acetate	10.0
	100.0

Foil board laminates

Printing foil board laminates was at one time almost exchlusively done by sheet-fed litho. The foil was usually coated with a cold tined nitrocellulose lacquer. After printing by offset the sheets were then varnished, often as a separate operation. A similar approach was followed when the gravure process was

originally adopted to print cigarette cartons on foil board laminate. Using a shieet-fed machine the gold lacquered foil/board was printed in one operation. Problems were encountered with printability and adhesion on the gold nitrocellulose base lacquer.
It is now more customary to print on foil/bord laminates which have been coated with shellac. Often the darker colours are printed directly on to the substrate with the light colour, usually a good, printed last also playing the part of an overprint varnish.
For example :

50% Yellow 83 nitrocellulose chip	3.0
50% Orange 5 nitrocellulose chip	2.0
Nitrocellulose	20.0
Modifying resin	10.0
Wax dispersion	5.0
Ethanol	46.5
I sopropyl acetate	10.0
Glycol ether	3.0
	100.0

Inks for polyethylene film
The vast majority of polyethylene film is converted by the flexographic process because of the similicity of the design or the length of run which makes the gravure process commercially unviable. However, derigns of a more complex nature still utilize the gravure method or alternatively the offset gravure process which can allow a blend of flexo and gravure printing stations.
Conventionally co-solvent polyamide resins have been used in gravure inks for polyethylene because of their excellent pigment wetting properties, good solvent release characteristics, good water resistance and not least they enable a high gloss print to be obtained. The trend to remove hydrocarbon solvents from packaging inks has meart a change to the use of alcohol-soluble polyamide resins. Unlike their co-solvent counterparts the alcohol-soluble grades have inferior solvent release and water resistance properties and modification with nitrocellulose is essential to provide inks of the desired quality.
For heat-resistant application polyamide resins cannot be employed and inks based on nitrocellulose modified with polyurethanes are used.
Inks based on co-solvent polyamide resin :

Phthalocyanine Blue (CI Pigment Blue 15.3)	12.0
Co-solvent polyamide resin	25.0
Antoxidant	0.5
I sopropanol	32.0
Toluene	14.0

Aliphatic hydrocarbon	12.0
Water	2.0
Amide wax	1.0
Polyethylene wax	1.5
	100.0

Inks based on alcohol-soluble polyamide resin :

Phthalocyanine Blue (PBI. 15.3)	12.0
Alcohol-soluble polyamide resin	13.0
Nitrocellulose	18.0
Dioctyl phthalate	2.0
Antioxidant	0.5
Ethanol	40.0
Ethyl acetate	7.5
n-proply acetate	5.0
Amide wax	1.0
Polyethylene wax	1.0
	100.0

Inks for treated polypropylene films

Treated polypropylene films have continued to find increasing use in gravure packaging outlets. The homopolymer film. (i.e. Opp) is still little used despite being the lowest cost since it is unsuitable for heat seal operations and the corona discharge treatment losses its effectiveness with time. Treated co-extruded polypropylene films are mainly used for heat resistant applications while the 'pearlised' grades have attained tremendous growth in cold seal outlets. The pearlescent effect in these films in produced by air entrapped in the film rather than by use of mica pigment. The insulating properties of these air bubbles makes heat sealing difficult within the dwell time on a packaging line.

For co-extruded films, inks based on nitrocellulose modified with polyurethanes and titanium acetyl-acetonate (TAA) are used for both surface and reverse printing as well as for lamination. Tianium acetylacetonate acts as the adhesion promoter to the treated side for the film but has a drawback in that it may also react with the pigment to give an unstable ink. The same system can also be employed for printing on the treated side of homipolymer polypropylenes though higher levels of the adhesion promoter may prove necessary with a consequent risk of ink instability and high residual odour.

White ink for treated side of co-extruded polypropylene :

Titanium dioxide (CI Pigment White 6)	30.0

Nitrocellulose resin	11.0
Dioctyl phthalate	3.0
Polyurethane	8.0
Polyethylene wax	1.0
Frucamide	1.0
Ethanol	27.0
Ethyl acetate	16.0
Titanium acetyl-acetonate (TAA)	3.0
	100.0

Since in cold seal work there is no heat resistance requirement, polyamide inks can be employed with polyamide varnishes to give base adhesion to the treated polypropylene film. For this reason micronised polyethylene or polypropylene waxes are used to give the correct coefficient of friction levels to suit the packaging requirements.

Coated polypropylene films

The PVC coated polypropylene films are heat sealable and have excellent gas and moisture barrier properties. Modification of the PVC latex with a methacrylate can broaden the sealing range of the films.

Yellow ink for printing on coated polypropylene film :

Diarylide Yellow (CI Pigment Yellow 12)	8.0
Alcohol soluble propionate	10.0
Acrylic resin	6.0
Ethanol	45.0
Ethyl acetate	30.0
Polyethylene wax	1.0
	100.0

Cellulose films

Due to the high energy costs involved in the manufacture of cellulose films they are continuing do decline in use in contrast to the increasing popularity of the polypropylene based products. For convenience the films can be divided into three categories :

(1)Single side coated films, using either a PVdC or nitrocellulose coating. The uncoated side (designated PT) must be printed and then laminated to another film to protect it from moisture. Inks are relatively simple, being based on plasticised nitrocellulose but high in ester solvents to prevent excessive retention of alcohol-based solvents.

Green ink for revere printing on PT film lamination

A

Diarylide Yellow (CI Pigment Yellow 13)	7.0
Phthalocyanine Blue (CI Pigment Blue 15.3)	2.5
Nitrocellulose (high nitrogen grade)	14.0
Dioctyl phthalate	5.5
Polyethylene wax	1.0
Ethyl acetate	70.0
	100.0

(2)Two side coated nitrocellulose films are available varying in the content of wax and plasticiser in the coating to alter the properties of the film. While plasticised nitrocellulose inks offer excellent adhesion to these films great care must be exercised in the resin to plasticiser ratio to prevent blocking. The high wax content in the film coating also causes ink to pinhole and the surface tension of the ink must be adjusted, usually by the addition of a phenolic resin.

White ink for surface printing on N/C coated films :

Titanium dioxide (CI Pigment White 6)	30.0
Nitrocellulose	12.0
Dioctyl phthalate	7.0
Polyethylent resin	1.0
Polyethylent wax	1.0
Ethanol	30.0
Ethyl acetate	19.0
	100.0

(3)Two side PVdC coated cellulose films form the third grouping with the PVdC being applied via an aqueous emulsion or solvent based varnish. Ink systems are similar to those described for PVdC coated polypropylene films though since the coatings have better anchorage to the cellulose base retarding solvents can be used in moderatinon.

Polyester films

The high tear and impact strength of polyester film makes it particularly suitable for packaging both heavy and abrasive goods and its high heat resistance lends the film to boil-in-the-bag and retortable pouches. Only grades which are PVdC coated or have a special chemical coat can be heat sealed an therefore in the majority of applications lamination to polyethylene or foil and polyethylene is necessary.

For reverse printing and lamination uncoated polyester a vinyl ink must be used since other resin systems give poor bond strenghs either initially or after a period of time. It is especially important to select the pigments carefully for the vinyl carrier in order to obtain maximum flow and aid printability characteristics. Solvent retention can also be a problem especially with key tone/ester based laminating adhesives and alcohol soluble grades are therefore preferred as virtually no rewetting of the ink is then given.

On the rare occasions when inks are required for surface printing polyamide inks can be used for non-heat resistant applications. For heat resistant packs inks based on nitrocellulose modified with polyurethane and TAA, as for co-extruded polypropylene film, can be adopted.

For both surface and reverse printing of the PVdC-coated grades inks on CAP-acrylic systems can be used as previously described for PVdC-coated polypropylene films.

Red ink for reverse print and lamination on uncoated polyester film :

Barium 2B red toner (CI Pigment Red 48.1)	9.0
Vinyl chloride/vinyl acetate/vinyl alcohol co-polymer	10.0
Ethyl acetate	40.0
n-propyl acetate	40.0
Polyethylane wax	0.5
	100.0

Wall coverings

A variety of processes are used to print wall covering, with gravure, flexo and inks emboss predominating where surface printing once reigned supreme. Many manufactures use all three processes and it is not uncommon to see combinations of them used to print the same reel of wall covering.

A modern trend is for printers to carry the same range of inks for printing vinyl-coated papers and plain paper by both gravure and flexo. This is done to reduce the range if inks they have to stock. Normally the ink maker supplies a palette of colours along with reducing mediums, pearlescent bases and specials such as non-tarnish golds. Colour matching is carried out on site by the printer.

Inks for paper

Gravure inks for paper are normally expected to withstand the spongeability test without varnishing after embossing and the washability test after varnishing. As the base paper plays an important role in resistance to these tests, it is sometimes difficults to judge whether a failure is due to paper of ink.

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