EXECUTIVE SUMMARY

Photographic film consists of an emulsion of a light sensitive material, silver bromide in gelatin, coated onto a transparent and flexible support. When light strikes the silver halide grains, it prepares them to react with the chemical developer. The film is then developed in a developer, fixed and printed on a photographic paper.

There are two types of photographic films available for amateurs and professionals. Black-and-white films contain a single layer of the emulsion coated on to a support. This film registers the colours it is most sensitive to as dark areas, and the colours it is less sensitive to as light areas. Colour films consist of three basic layers of emulsions, with each layer being sensitive to a different optical primary. However the current films available contain as may as 17 layers, including the interlayers and couplers between the basic three layers, the thickness of the film being a few microns. In colour films, the orthochromatic films are sensitive to violet, blue and green. They can be developed under orange or red lights. panchromatic films are sensitive to all colours of light. They give the most natural reproduction and are to be developed in total darkness.

The science of photography makes use of the photochemical property of silver halide to form images and reused scenes. The alchemist Fabricius in 1556 observed that crystalline silver chloride becomes violet when exposed to sun light. In 1826, Josepeh Nie'phere Niepce, a French lithographer, made the first photograph with lithographic material instead of silver. He used a coating of white bitumen as peuter metal, which was transferred after exposure to light.

The first practical photographic process was invented and published by another French scenic painter, Louis Jacues Mande Daguerve, in 1839. He treated a silver plated sheet of copper with iodine vapour, exposed it, treated the plate with warmed mercury and fixed the image with sodium thiosulphate solution.

The Dagguerro type was unique and was impossible to multiply. In addition, the image was reversed left to right. In 1840, the Englishman, Flleurry Fox Talbot overcame this problem. In 1851, an English sculptor, Scott Archer, introduced the wet

collodion process. In this, a glass plate was coated with collodion (soluble gun cotton/nitrocellulose dissolved in a mixture of ether and alcohol) and potassium iodide was immersed in silver nitrate solution in dark and exposed in wet condition, developed immediately and fixed. But these plates were not successful for outdoor shooting as portable dark rooms were needed. With the invention of gelatin, most of the problems were solved in the mid 1870's. The invention of the dry plates carrying a silver halide emulsion in gelatin (1871) initiated manufacture of sensitized materials. Ready prepared emulsions were on sale by 1873 and coated plates by 1876.

With the introduction of the wet plate process, glass became the main support for negative materials. These plates, however, being fragile, were prone to breakages. This laid the foundation for flexible supports. Flexible film support based on celluloid, was invented by Alaxander Parkes in 1861. Ferrior of Paris, in 1880, made a combined film of gelatin and collodion, but the expansion of gelatin in the developing and fixing baths caused the collodion to crack. Later, films of gelatin emulsion coated on collodion, and hardened gelatin films, by Alfred Pumphrey in 1882 and films by Froedman, consisting a substratum of bicromated gelatin had been marked but found little demand due to high costs.

Celluloid was then suggested (in 1881-1883), but lack of processing know-how into thin films led to failure of this material. In 1888, John Carbutt introduced emulsion coated celluloid films. In 1898, Rev. Hannibal Godwin applied for a patent for his transparent roll film made of camphor and nitrocellulose. Before the patent could be granted, Eastman Kodak made roll films similar to Godwin's but they contained a non-curling layer. With the transparent roll film of Godwin and the popularisation of films by Eastmen, the modern era of photography had begun.

The cellulose nitrate which is similar to gun cotton is an inflammable compound. So the search for a safe support began. In 1900's, Eastman Kodak came out with non-flammable cellulose acetate based films and they are existent even today.

MANUFACTURE

Photographic film technically is a combination of silver halide emulsion and a flexible support. A normal photographic film consists of four layers. The top layer or supercoat of gelatin protects the emulsion from scratches and abrasion marks. The next layer is the emulsion layer, silver halide suspended in gelatin. The third layer is the subbing layer which promotes the adhesion of the emulsion to the film base. There is the support, backed by anticurling layer of gelatin containing a light absorbing dye to prevent halation in the back.

The overall manufacturing process of photographic film consists of preparation of the emulsion of silver nitrate, alkyl halide and gelatin, precipitation of the emulsion, washing, chemical and spectral sensitization and finally coating on to a support.

The emulsion is prepared by mixing silver nitrate in an alkaline silver bromide solution in the presence of a solution of gelatin. Double decomposition takes place and silver bromide which is insoluble, is precipitated. The silver bromide remains uniformly distributed throughout the gelatin. After the initial precipitation, the emulsion undergoes several after processes.

The first is ripening, which involves maintaining the emulsion at an elevated temperature for several hours, wherein the larger halide crystals grow at the cost of the smaller ones. After ripening, the emulsion is chilled to set it and is then passed through a perforated stainless steel plate to shred it. It is then washed to remove undesirable soluble compounds, particularly excess bromide and nitrates. A further heat treatment, known as after-ripening is given and it is at this stage that the sensitivity specks of silver sulphide are formed.

Before coating the emulsion on the support, it is doctored by the additions of substances to improve its physical and sensitometric properties. These substances include the very small amounts of sensitizing dyes necessary to give orthochromatic or panachromatic activity.

As important as the composition of the emulsion is its coating on to a base. The base is prepared by dissolving cellulose triacetate in a mixture of methylene chloride and alcohol, casting on a large heated chromium-faced drum which rotates, allowing the solvent to evaporate. The film becomes firm enough

to be stripped off in a continuous sheet. The base is then passed through a series of heated chambers to remove the remaining solvent. The base is then wound into rolls.

Another process of preparation of the base is melt extrusion of the polyester, polyethylene terephthalate through a slit dye and orientation of the film biaxially to improve the physical properties.

The emulsion is coated on the base at a temperature high enough to keep the gelatin as a solution. The material is then chilled to set the gelatin and it then passes through a drying track where clean air at carefully controlled temperature and humidity remove virtually all of the large amounts of water contained in the gel.

The conventional black and white photographic film consists of coating of emulsion on one side. The X-ray films are coated on both sides. Colour films consist of simultaneous coating of several layers on one side.

Structure and Status of Industry

Manufacture of photographic films and X-ray films in our country is 25 years old. Hindustan Photofilms Manufacturing Company (HPF) is the sole indigenous manufacturer of photographic and other photosensitive materials. HPF was started in 1961 in collaboration with M/s Bauchet of France and commercial production started in 1967.

There are a few others who are engaged in import of jombo rolls of photographic films (colour) and X-ray films, both for medical and industrial purposes, from M/s Fuji Photo Company (Japan), M/s Konica (Japan), M/s ORWO (Germany), M/s Agfa (Germany), and later converting, packing and marketing them. However Eastman Kodak of USA is marketing its products through its local agency.

Company/Product	LICENSED (Million sq.m.)	INSTALLED (Million sq.m.)
HPF		
Roll Film	1.010	1.134
X-ray Film	13.668	4.162
Indl. X-ray	0.750	0.250
Garware		
Indl. X-ray	3.000	0.050

The major units are:

PHOTOGRAPHIC FILMS

COMPANY	TRADE NAME
1. M/s Hindustan Photofilms Mfg. Co. Ltd., Ooty	INDU
2. M/s Jindal Photofilm, Delhi	SURERPLUS & FUJI
3. M/s Computer Graphics, Madras	KONICA
4. M/s India Photographic Co. Ltd., Bombay	KODAK
5. M/s India Cine Agencies, Madras	ORWO & MITSUBISHI

X-RAY FILMS

1. M/s Hindustan Photofilms Mfg. Co. Ltd., Ooty	INDU
2. M/s Garware Plastics & Polyester Ltd., Bombay	GARWARE
3. M/s Indian Thermoplastics Pvt. Ltd., Delhi	NIEU PLUS
4. M/s Choksi Bros., Bombay	LASER
5. M/s Agfa Gevaert India (Allied Photographer) Bombay	AGFA
6. M/s India Photographic Co. Ltd., Bombay	KODAK

7. M/s SNS Photo Company Ltd. SNS
8. M/s India Cine Agencies, Madras ORWO
9. M/s Yogi Industries (P) Ltd., Calcutta

Of all the above, HPF is engaged in the integrated production of both photographic (black and white) films and X-ray films. M/s Garware Plastics & Polyesters are operating a pilot plant to manufacture industrial X-ray films.

The performance of the indigenous manufacturer is satisfactory. The other units engaged in conversion are operating profitably.

The demand for photographic films is around 19.5 lakh sq. m./year. The demand for X-ray films is as given below:

		Growth rate
Medical X-ray	5 million sq. m.	4 - 6 %
Dental	0.005 "	8- 10 %

The indigenous manufacturer is the sole exporter of photo sensitive products to the developing and developed countries. In 1991, around Rs. 107 lakh worth films were exported by HPF, but subsequently, the export earnings have diminished.

There is no geographical pattern of setting up this industry as most of the units are scattered. As this industry needs a dust free environment and temperature control, all the units are equipped with air conditioners etc.

The black and white photographic films manufactured though in small quantities, are not accepted by the consumers. The consumers feel that the indigenous films have disadvantages of lack of paper adhesion between the film and the backing paper and variation of film from batch to batch. Thus, the consumers prefer imported films at a higher price.

The indigenous X-ray films are performing well. However, a common complaint is that there is a batch to batch variation in the film quality. On the other hand imported and converted film do not have this complaint.

The economics of scale of operation is poor because an economic size plant should be 40 million sq.m. capacity whereas the size of the indigenous plant is around 15 million sq.m. Moreover, the cost of indigenous production is high, due to the high cost of silver.

The initial technology for the manufacture of photographic and X-ray films was obtained from Bauchet of France in 1960. The initial equipment and the raw materials were imported. In 1975, technology for air knife coating of X-ray films was obtained from DuPont of USA. Collaboration was done with their East German based concern vebfilm Fabric for the roll films. In 1986, collaboration was forged with DuPont of USA for the conversion of Jumbo rolls of industrial X-ray films and to manufacture of polyester based X-ray film.

The exact details or the salient features of the technology used are not available. However, the pollutants are reported to be kept under minimum and a treatment plant is erected at the site at a cost of Rs. 30 lakhs.

Most of the raw materials like gelatin, silver nitrate etc. are procured from small scale industries and it is noteworthy that products with utmost purity are being supplied to the manufacturer.

Interaction with the user industry on the whole is satisfactory, except for a few problems.

The indigenous manufacturer is reported to be constantly modernising the plant with the latest equipments to improve the efficiency.

Indigenous films are quite competitive in the international market. However, due to the high cost difference of silver, the other international manufacturers are enjoying a large margin.

INTERNATIONAL SCENARIO

The following are the integrated manufacturers of photographic and X-ray films world wide.

COMPANY	COUNTRY	TRADE MARK
M/s Eastman Kodak Co.	USA	Kodak
M/s Fuji Photofilm Co.	Japan	Fuji
M/s Konishiroku Photo Industries Co. Ltd./		
M/s Konica Corpn.	Japan	Konica
M/s Mitsubishi	Japan	Mitsubishi
M/s Agfa Gevaert. AG	Germany	Agfa
M/s Veb Film Fabric Wolfen	Germany	Orwo
M/s 3 M	Italy	Scotch
M/s Ilford Photo Company	UK	Ilford
M/s Polaroid Corporation	USA	Polaroid

Besides the above major known units, the following are the other units reported to be involved in the manufacturing of these films.

RUSSIA

M/s Shostka
M/s Kujbishev
M/s Kasan
CHINA (trade names)
Era Color
Huanguang Color
Lucky Color
Shanghai Light Color

The technological details pertaining to the manufacturing, are regarded as a closely guarded secret.

The manufacture of photographic films and X-ray films is dependent on Research and Development. Every manufacturer is striving hard to come out with the best product and to have an edge over others. However, all their efforts are aimed at improving graininess and sharpness, which is dependent on the emulsion. The efforts are towards improvement of the crystals by increasing the surface area by which maximum light is absorbed. Though different names and procedures are given by these manufacturers, the principle remains the same. Kodak named it as T-grain, Fuji as Sigma crystal, Agfa as Twin Crystal and Ilford as Delta Crystals.

The other area where developmental activity is in progress is coupler technology for colour films. This relates to :

1. DIR Technology
2. DIAR
3. RIR
4. L-coupler
5. Automasking

DIR TECHNOLOGY

DIRs are development inhibitor releasing compounds which are used for edge enhancement, sharper looking images and higher colour saturation.

DIARS

These are improvements over DIRs and are specifically targeted development inhibitors that are released in one layer to react

with a different layer. The 'A' in DIAR stands for 'anchimeric' i.e., participating in the reaction rate of a neighbouring group. DIARs enhance colour fidelity and colour saturation.

3. RIR TECHNOLOGY

These are special DIAR couplers introduced by Fuji. They have a precursor in the initiating layer and the inhibitor coupler in the target layer, in other words, the coupler does not become a development inhibitor until it reaches the emulsion layer for which it is targeted. The advantage of this coupler is, as the precursor travels through the emulsions layers in which its actions are unwanted, it remains chemically inactive. In RIR technology, an additional fourth layer is incorporated by Fuji, which is blue-green-sensitive in addition to the time honoured tripack of blue, green and red recording layers.

4. L-COUPLER TECHNOLOGY

Latex bound coupler technology is responsible for the new standard of image sharpness and grain. This L-couplers enable high coupler concentration increase in density and extremely thin emulsion.

5. AUTOMASKING EMULSION TECHNOLOGY (AME TECHNOLOGY)

AME Technology is used for more precise separation and control of interlayer effects between the red, green and blue sensitive layers.

X-RAY FILMS

X-ray films which can be developed in day light and also laser films are reported to be latest in the advanced countries.

R&D EFFORTS, TECHNOLOGY ABSORPTION AND GAPS

There is no work going on in any of the national laboratories in this field. HPF's R&D is the only place where research is being carried out. The activities of this centre are:

1. Product/Process development/improvement.
2. Import substitution
3. Cost reduction
4. Adaptation of new technologies

All the products and formulations developed are inhouse only.

No sponsored projects are undertaken by this centre.

The major achievements are:

- modification of initial formulation
- reduction of silver content, the major raw material for these products.
- import substitution of active imported gelatin with indigenous one.
- development of various other chemicals like optical sensitizers, hardeners, antifoggants etc. for captive consumption.

INDIAN STANDARDS

There are some Indian standards for processing of photographic films and also for some chemicals used in development, fixing etc. A committee has been formed within the BIS which has formulated standards for the accessories and equipment used in the industry. Draft standards for unprocessed film and processed silver gelatin type black and white film are under formulation.

International standards, (ISO Standards) are available for almost all films, chemicals used in the industry. BIS is taking steps to formulate standards for X-ray films to be in line with ISO standards.

TESTING FACILITIES

There are no testing facilities available for the quality of these films. However testing facilities are available at HPF for monitoring quality of their products.

TECHNOLOGY ABSORPTION, ADAPTATION EFFORTS

HPF Efforts made at the companies are as given :

HPF has made the following efforts in this aspect.

1. Indigensiation of Process

The basic process for the emulsion preparation has been modified and new formulations have been made through continuous efforts of its R&D centre.

2. Reduction of Cost

Since silver constitutes the major raw material of the emulsion and also adds up to the value of the finished product, formulations have been developed at the R&D centre with reduced silver content without sacrificing quality.

Expansion

An additional coating plant at an investment of Rs. 2 crore was commissioned in 1985. This has increased the output of the medical X-ray films by another 1.8 millions sq.m.

A plant to manufacture polyester based X-ray films has been commissioned in collaboration with DuPont of USA at an investment of Rs. 290 crores. The production may start at any time this year. The capacity is 12 million sq. m.

IMPORT SUBSTITUTION

The imported raw materials used in all the products are reported to have been substituted with indigenous ones from 1980 onwards, resulting in substantial foreign exchange saving.

GARWARE PLASTICS & POLYESTER LTD.

The technology for manufacturing X-ray and graphic are film is reported to be indigenously developed by this unit. The equipment has been reported to be designed and fabricated indigenously. The raw materials are reported to be indigenous ones.

TECHNOLOGY GAPS

1. Manufacture of photographic colour negative film.
2. Manufacture of X-ray film which can be developed in day light.
3. Production of emulsions with fine grains.
4. Coating technology with greater speed.

Thrust Areas of Indigenous Technology

Indigenous Technology needs development with respect to colour negative film, as the technology for the same is not easily available for import. HPF with its vast experience and infra-structure can take up this task as any other industry to come up again has to start right from the scratch. Moreover basically this is a R&D based product which needs constant awareness regarding developments in other parts of the world. However, HPF and Garware may tie up with other recognised R&D laboratories for this endeavour.

CONCLUSIONS

Products of photographic films serve a wide variety of end-user markets and applications. In 1991 it was reported that out of the total world wide consumption of nearly 55 billion exposures, Japan consumes 24% of colour negative films, USA 24.1% and Europe 29%. The number of still photographic exposures are continuing to grow world wide at a rate of around 3 per cent.

The national demand of photographic films (colour) is around 1.65 million sq.m. per year. Black and white films have little demand in the country (about 0.29 million sq.m.). They are mainly used to cover functions, celebrities etc. apart from their use in passport size photgraphs.

The national consumption of X-ray films is about 5 million sq.m.

There is only one indigenous manufacturer (HPF) of black-and-white photographic films and x-ray films. However M/s Garware Plastics & Polyester have obtained license and are making X-ray films (polyester based).

There are about half a dozen industries converting the jumbo rolls of imported film (both photographic colour and X-ray film) into required sizes then packing and marketing.

The imported film has reportedly been offered to the importers at a comparatively cheaper rate as the business in India is small compared to the business worldwide.

HPF has absorbed the initial imported basic technology to a large extent and have even developed formulations based on their R&D expertise.

- As the emerging trend is towards use of polyester based X-ray films, a separate plant with capacity of 12 million sqm with the collaboration of DuPont of USA had been commissioned at a cost of around Rs. 290 crores, at HPF.

- Films, manufactured in India, are sold in the international market, despite the fact that the cost of production is high. The production cost is high because of the high cost of silver in the country.

- Colour negative films are not manufactured indigenoulsy.

- The quality of indigenous black-and-white photographic films is expressed to be of poorer quality as compared to the imported ones.

- The quality of X-ray film reportedly varies from batch to batch.

:OMMENDATIONS

- The quality of the indigenous black and white films needs to be improved mainly with respect to adhesion of backing paper etc. The manufacturers need to take necessary action.

- The quality of X-ray film needs to be monitored as there is variation from batch to batch. The indigenous manufaturers need take necessary corrective action.

- Formulation of standards for both X-ray films & photographic films need be completed on a priority basis by the BIS.

- As all manufactures and users do not have facilities for checking the quality of films, some common facility should be established. The possibilities of using the existing facilities at HPF and other such places should be explored to enable adequate quality testing.

- Quality parameters like contrast, latitutde, speed, colour sensitivity, gradation and other parameters need be set Methods for testing both imported and indigenously manufactured films in a stringent manner need be enforced.

- Green X-ray films should be used, instead of blue X-ray films, for the benefits of users, as green X-ray films reduce

exposure to x-rays in comparison to blue X-ray films. Knowledge about the properties of the different films should be widely circulated by the manufactures. Users should collect adequate information before opting for a particular colour/quality of film.

- Attempts to develop the technology for colour negative films need to be taken up on a priority basis by the industry. If need be, attempts to import the technology should also be made.

- The Indian manufacturers need accord more priority to R&D and should liaise with National. R&D laboratories and academic institutes to pursue targeted developmental goals.