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Measures to work from impact printing inks to work and the environment

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Abstract
Chemicals can be dangerous for the environment as a result of their production, processing and use. In the printing industry employed in the production, the most exposed to hazards of volatile organic compounds. The chemical substances can impair employees' health and pollute the environment. The most widespread chemical substances in printing presses are developers, fixers, solvents, paints, varnishes, adhesives and cleaners. Hazardous substances in the body can be entered: breathing, eating through food and drinks and contact with skin and eyes.
The chemical substances used for the printing of damage employees' health, and can have long lasting effects on the environment because they contain volatile organic compounds (VOC - Volatile Organic Compounds). Volatile compounds are the cause of various diseases such as cancer and mutagenic changes in reproduction. The volatile organic compounds include all organic compounds with a flash point in the range 50-260°C. VOC - (Volatile Organic Compounds) relates to the presence of volatile organic compounds in the air. Volatile compounds emitted into the atmosphere react with nitrogen oxides and ozone building other compounds that affect air pollution. VOC affects the quality of water and soil. Volatile organic compounds in the air represent 98% of total releases of toxic substances in the printing industry. Volatile organic compounds are present in all printing techniques: offset printing, intaglio printing, screen printing, pad printing, flexo printing and even with digital printing.

Keywords: printing inks, pigments, solvents, protection measures

1. Introduction
In the last three decades there has been an increasing global concern about the impact on human health which is attributable to environmental pollution, in particular, the global burden of disease. The World Health Organization (WHO) estimates that about a quarter of diseases facing humanity today that arise due to prolonged exposure to environmental pollution. Most of these diseases are related to the environment, it is not easy to detect and can be acquired during childhood and manifests itself later in adulthood. The greatest negative impact of printing ink by working and living environment are called. solvent inks - colors that have a high content of solvent (eg. ethyl benzene, ethylene glycol, glycol ether, toluene). Colours based on alcohol use various solvents are the major sources of pollution. However, printing inks based on alcohol due to volatility of these substances speeds up the printing process, extending the use of the printing form and improves ink transfer to the substrate compared to the alternative (ecological) colors. When printing color oil-based or alcohol need to install systems for reuse (recovery) solvent.
Another aspect of hazardous substances in the printing color is the content of heavy metals. By the mid-seventies, most produced colors contained metals, which are the maximum permissible concentration now required by law. Sellers have the responsibility of colors to indicate the toxicity of colors that sale. Indirectly, the reduction of harmful emissions by evaporation of solvent from the printing inks can be achieved through the following measures:
• the use of activated carbon adsorption and solvent removal from the air;
• using heat-set recuperator (compatible with most color flexo and gravure, but very energy demanding);
• using a catalytic oxidant, incinerators and other devices for purification, etc.
Most colors are usually recycled after use by mixing to obtain a black color. Colors can be recycled within the printer, when the special courts stirred for about 1/3 to 2/3 of waste paint and fresh paint gets black.

2. Basic Characteristics (Properties) Colour

Properties inks need to be adapted to different conditions of printing, various techniques of printing, printing speed and print media. The basic properties of printing inks are: consistency, cohesion, adhesion, a rainbow of colors, a brief struggle, stickiness, viscosity, flowability, tiskotropija, surface tension, the tone of the mass, under tone, tone and tinktorijalna peak power.

1. Konziszencija describes the general state of the color in the mass, and includes properties such as cohesion, adhesion, viscosity, flow characteristics, yield stress, surface tension and tiskotropiju. Consistency with high-quality color rose 3-4 days after making the color. If components of printing inks interact, the system is not stable and such color is not suitable for printing. The consistency of ink is changed by changing the temperature and a certain degree of mixing, and no changes can occur over time standing color. According consistency distinguish between two kinds of color: „ rare " and „ thick " the color or colors of light and heavy consistency. Printing Inks lake consistency are rare, fluid and is easy to use, while the ink heavy consistency of thick and pasty, and handling them is difficult.

2. The Adhesion of the attractive force between particles of different substances, and about her almost directly dependent adhesion. When we talk about the adhesion between the ink and the printed substrate, actually first think of „wetting'' color printing form before printing on the print medium. Ability „wetting'' specific color is determined by the strength of the forces between particles of color and material it is made of a printing form. The forces of adhesion must be sufficiently strong in order to be accepted by the color of the printing form, and then the whole transferred to the printed substrate. Color can be well transmitted to the printing form to the printed surface, and must not remain on the printing form or pull on the paper that is commonly used as the news media.

3. Cohesion is the force of attraction between particles of the same material. For color printing is the most important cohesion binders. We distinguish printing inks strong cohesion, printers are usually called „ long " color because in printing, or in the discharge of printing forms of printed substrates are stretched into long strands. Unlike them, „short'' colors are printing inks with low cohesion that is stretching the interrupt.

4. Rainbow Of colors in the printing process stretched into long strands. These colors are usually too sticky and cracking due to any cause dusting color. This dust falls on a beautiful print to print and Conference form, which ultimately results in smearing prints or poor quality printing. Long colors give a sharp image.

5. Brief color has little stickiness, it is mobile, well situated on the printed surface, has a good hiding during the press is free of dust. The bad feature of short color is what gives relatively neostar footprint, which means that not enough outlines the details. If the color is too short and poorly sticky residue lie in bojaniku and will be transmitted to the rollers razribavanje. Manufacturers of printing inks tend to formulate colors that are short and favorable viscosity, but also sticky enough to provide a high quality print.

6. Stickiness can be defined as the resistance of the color strength. Stickiness of color depends on its surface tension and its viscosity. Typo usually handy evaluate the stickiness of ink according to the length of thread, and so that the color put between your thumb and forefinger and seeks fingers apart. Sticky colors stretched into long threads, colors slight stickiness lepit will be little, and eventually made nor shall immediately terminate. Stickiness is too low to cause precipitation of paint colors in bojanik and filling the grid to form printing. Excessive stickiness of color causes bonding to form printing and pulling out, as this is related to unclean footprint Property stickiness is the result of the operation of cohesion and adhesion forces of matter from which the ink is formulated.

7. Viscosity, rheological properties of the paint. It is a phenomenon that occurs due to friction between the particles of color flowing, ie internal friction or friction. Viscosity is temperature dependent, does increase in temperature decreases the viscosity and the color becomes more fluid but this depends on the structure of substances or the composition of ink. The viscosity of a paint is doing by measuring the resistance passage metal plates certain weight through the color in a unit of time or resistance to rotation of the metal cylinder in color, dense colors. For rare color priručno used Ford cup or measure the flow volume of a particular color through the hole diameters defined in a unit of time or electronic viscometer immersed in bojanik.

8. Pour Paint, or fluidity size is inversely proportional to the dynamic viscosity. It is a property of matter that flows easily. Unlike viscosity, the flowability is proportional to the temperature increase. Paint with good flow properties, good will be placed according rollers dispense.

9. Thixotropy is desirable property of some colloidal solutions that exceed their suspension in pseudogel (fake gel) which is mixing destroys and turns into a liquid state. This phenomenon is characteristic for most of paste inks in which the long-standing gel creates a razribavanjem on the machine or mixing pseudogel is destroyed. The emergence tiskotropije explained as a consequence of the electric charge particles have turned into regular arrays or mats to form pseudogel, a stirring arrangement of such particles is disturbed and the color again becomes flowable.

10. Surface Tension is the emergence of tension on the surface of each liquid. A molecule inside the liquid is surrounded on all sides by neighboring molecules which interact to each other the same cohesion forces which keeps them in a state of equilibrium. On the molecules on the surface of the liquid acting on the one hand, the attractive forces of neighboring molecules, on the other hand adhesion molecule force of matter with which they are in contact. These two types of forces are in equilibrium on the surface molecules acting forces that are trying to drag them into the interior and thus reduce the overall surface of the liquid, resulting in the appearance of the surface tension or foaming.

11. Peak Tons is the color you see on the print immediately after the exit from the same printing unit. In many colors peak tone is changed by drying colors on the print. In general we can say that the colors are slightly lighter immediately after the print on the printed surface. For this reason, you should wait a few moments to print dry and only then judge the shades of the printed colors.

12. Under Tons is a color that can be seen on the print when it is removed from the light source. Different light sources emit different colors of light, which significantly influences the decision of the court on the printed colors and shades around the printed sheet. It is best to look footprint and make a judgment about the quality of multicolor reproduction in light that is closest to daylight.

13. Power Tinktorijalna the color intensity that depends on the participation of pigments in color. It can be said that has

greater power tints which has more pigment. But this statement is true only to a certain extent because too high content of color pigments can cause poor print. Clog the grid to form printing or embellishing print.

14. Tone Weight In the shade of the color you see when you open the packaging, packaging. This shade is different from the hue on the printout and in practice very often. Transparent colors show the greatest difference between tons in weight and tone printed. Opaque usually show almost the same tone in mass and in print.

3. Dyes for Offset Printing

The offset printing technique used to stain specific composition that is very complex. The reason for this complexity is the fact that during the printing dye must satisfy many requirements to be inflicted on the printed elements on the form, and transferred to the offset cylinder and finally to the printed surface. The offset dyes must be extremely viscous, must possess favorable stickiness, bounty, good dispersion, and must not tilt emulsifying and toning. Their dynamic viscosity does not exceed the limit of 40-100 Pa*s. Prints produced using offset technique is considered very high quality, and it is possible to reproduce the finest details. In its composition contains a dye: binder, pigment and various additives. The amount of fillers and additives in paints will have a direct impact on the consistency and the cost of dyes and print quality. It is therefore of great importance to prepare well before using dye. For good overlay printing elements, 5 dyes must be greater pigmentisanost (for better resistance to moisture).

The offset of dyes must be made of pigments with a high yield and high concentration. In addition, offset ink must not destroy offset rubber and cause it to swell. Color may not be too dilute, it may cause a poor acceptance of the paper. On the other hand it is known that pigments in the paint must be emulsified in order to achieve the balance water dyes. When we talk about the price, pigments and unite the most expensive component dyes. In order to reduce the price of the colorant is added to the cheaper filler that reduces the concentration of pigment. Such changes reduced the yield of tones, however it is still possible to get high quality print.

4. Pigments

The pigments are particles that give the color and opacity of the material in which they are dispersed. The structure and shape of the particles strongly depends on the crystallinity of the pigment. On the other hand, the particle size of the pigment strongly depend on their nature. Thus, the natural pigments they have a normal particle size of 20-50 microns and irregular structure, while the particles are synthetic pigments (e.g., synthetic iron oxide) is usually lower, but the regular structure. Mixing pigments of different particle size is undesirable because it can lead to inequalities colors in the resulting film.

During the process of obtaining the pigment particles build agglomerates, which is necessary to destroy during the dispersion of pigment in the medium to achieve uniform dispersion of pigment.

Regarding their structure, the pigments may be crystalline (arranged), an amorphous (disordered), or polymorphs (different crystal structures more) substances, and the color of the pigment depends on its structure. For practical reasons, the pigments are supplied in the form of aggregates or agglomerates. As the aggregates of pigment particles interconnected by touching the boundaries of crystals, their destruction is difficult, so their formation less desirable. In contrast to the aggregates, agglomerates are clusters of primary particles which easily may be destroyed during the dispersion of pigments. During the process of obtaining the pigment particles build agglomerates, which is necessary to destroy during the dispersion of pigment in the medium to achieve uniform dispersion of pigment.

Two types of pigments that are commonly applied in the preparation of painting colors are: inorganic and organic pigments.

4.1. Inorganic pigments

Inorganic pigments are inorganic materials which absorb radiation in the visible spectrum of light, whereby the effect of coloration occurs. In addition, these materials must be insoluble in the environment in which is dispersed in paint-making, must be resistant to agents which is exposed in the application (usually atmospheric conditions), which should have greater power of coverage, ie. to ensure the highest possible discoloration of the surface per unit mass of pigment and must be free of various impurities.

Inorganic pigments are chemically usually oxides, hydrates, silicates, sulfates, sulfides or carbonates of transition metals or of metalloids. Usually these are single-component particles with a clearly defined crystal structure, although there are so called. "Mixed" pigments, which are formed by mixing or comminution of different pigments or pigments with fillers in the dry state. This is an example of chrome yellow, formed by mixing chrome green and iron blue. However, a disadvantage of these pigments is that it can result in separation of the components during use.

In the case of pigments of substrate, one of the components is precipitated on the substrate a wet process, and then solidified during the drying or calcination. In this case, the formed connection preventing separation of the components during use.

The inorganic pigments possess a higher refractive index of light of the organic or impervious members, and transparent organic pigments build coatings.

4.2. Organic pigments

Unlike inorganic, organic pigments are frequently not found as such in nature. Therefore, the primary way of obtaining them by chemical synthesis. All organic pigments include carbon, and nitrogen as a heteroatom, and relatively low toxicity and environmental hazards. Raw materials for the preparation thereof are resin processed coal and various petroleum distillates. The traditional application of organic pigments in the industry for mass production of plastics, synthetic fibers and coatings for surface treatment of various materials.

The organic pigments can be classified into two main categories: azo (mono-, di-, tri- and polyazo) pigments and polycyclic pigments . Azo colorants are colored synthetic organic colors, which in their structure contain the azo group (-N = N-). Azo pigments mainly include yellow, orange, red, purple and brown colors.

Polycyclic pigments include:

- Phthalocyanine pigments,
- Hinakridonske pigments,
- Perilenske and perinonske pigments,
- Izoindolinonske and isoindoline pigments,
- Antrapirimidinske pigments,
- Diketopirolopirolske pigments.

4.3. The pigments in offset color

Pigment is one of the main components of dyes. The most important feature of pigments that set the tone colors. The inks meet three types of pigments: based on pure carbon, inorganic pigments and organic pigments. The structure generally is a crystalline pigment. High strength and provide color consistency and weight. Pigments have to be insoluble in the binder, but it should be well dispersed, and it is properly wetted. Today, the most commonly used synthetic pigments, only a few types of natural pigments convenient for customers in the printing industry. Dyes with these pigments are of adequate quality and provide good transfer from the printing form, the offset rubber blanket and the printing surface. In classical offset multicolor printing commonly used three pigments, which are: Cyan pigment based on copper (Pigment Blue 15 and copper phthalocyanine blue), magenta pigment (pigment or calcium 4B Pigment Red 57: 1). And a yellow pigment based on azo compounds (Pigment Yellow 13).

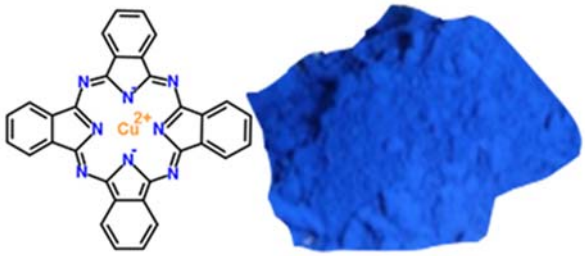

Fig 1: Structure of pigment Blue 15

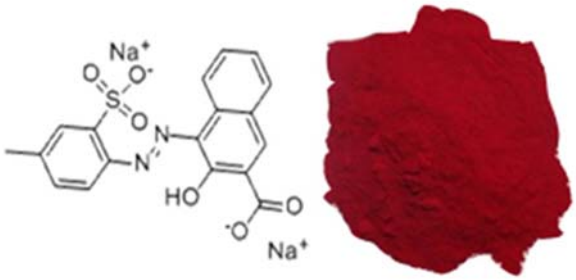

Fig 2: Structure of Red 57:1, pigment

Fig 3: Structure 13 Yellow pigment

The colors for offset printing these pigments must satisfy the following properties;

1) High tonal value - especially important property because of the small thickness. As the applied dyes 0.7-1.1 microns, the value of tons must be extremely high in order to achieve good optical properties of prints.

2) Resistance to light - the property is extremely important in the application of organic pigments under the influence of ultraviolet light fade.

3) Stability to chemicals - dyes in contact with bases, liquids and acids must not react and thus contaminate the graphic product.

5. Security and Safety at Work

The press, as well as any industrial process, requires special attention to be given to aspects that touch on health and safety in the workplace. Although many risks that existed when working with solvent-based inks, eliminated by switching to the use of UV products, are still necessary preventive health measures. Workers should be informed about health and safety risks involved and trained in the spirit of good industrial hygiene practice. Regular maintenance of all existing equipment, as well as the introduction of modifications in the printing process should be part of the overall effort to preserve the health and safety of staff at work. Good Manufacturing Practice means the safe handling and use of printing inks and proper equipment. It is essential that staff are informed about the possible harmful nature of printing inks and solvents. Knowledge of the process how to react in case of an accident minimizes health risks. The following recommendations can be considered good industry practice:

- in places where the handle color printing should not eat, drink or smoke;
- should be regularly cleaned with soap and water every gloves, hands and arms, as well as use hand creams that reduce skin irritation due to frequent washing;
- should be avoided touching equipment contaminated gloves or other parts of protective clothing, as transposed colors may later come into contact with unprotected skin;
- do not use solvents for washing and stripping of the skin, as it can reach penetration chemicals through the skin, increasing the risk of dermatitis;
- solvents can be used for cleaning and printing equipment, provided that workers wear protective clothing;
- do not store in the pockets of work wear cloths that are contaminated paints or solvents;
- printing color spill should be cleaned immediately and delete;
- the area where he spilled paint should be removed flames and all the vessels that cure;
- You must wear appropriate protective equipment during the cleaning process.

The ventilation system for the printing industry is very important. To provide a good general level of ventilation in the printing must be installed taller ceiling fan. The aim is to ensure the circulation of fresh air in the workspace, before the air is conducted from the printing press. Equipment for printing and drying should be deployed in accordance with roads svešeg air that is introduced into the workspace printing, while recirculating ventilation systems are not recommended.

5.1. Solvents and environmentalism

Legal restrictions in the use of organic solvents in the press stem from the fact that, when - during mixing, printing and curing - leads to the evaporation of solvents, volatile organic compounds (VOC - Volatile organic compounds) into the atmosphere. Sunlight then act as a catalyst in the photo-chemical reaction that converts the organic matter in smog. Smog has become a serious problem endangering the human environment, as well as a public health problem in many industrial cities in the world and, although some national regulations differ widely, reducing the emission of volatile solvents into the atmosphere and improving the work environment has become a very important factor in protecting the environment.

6. Experiment

6.1. Today's technology

Over the years, the reasons in favor of the use of UV inks are further reinforced the need for obtaining specialized colors for special applications. Today there are no more restrictions in terms of whether something can or can not be printed using UV inks. Continued progress in the technology of UV colors shown that many formulas UV inks outperform equivalent properties in solvent-based paints. Clients have recognized these benefits and many now require the detail and quality of finish that can be achieved using UV inks. In this way, the shift towards UV colors was a consequence of customer requirements.

The use of color in UV screen printing can achieve significantly higher productivity, as well as a significant reduction in production costs in the printing industry. It also shortens the turnaround time in accordance with the needs of today's market, seeking delivery by JIT ("Just-in-time") system. Continue the development of screen printing UV-based paint in recent years has also served as a catalyst for expanding the range of further advantages of this system, opening the door to new markets for sitoštampare. Obvious examples of this development is the introduction of new multi-colored liner machines for screen printing and drying systems that use low levels of energy (flash cure), which occurred as a result of the development and use of UV colors.

6.2. The elimination of IPA from the printing process

Today is the increasing pressure, the European Union, to perform printing without alcohol, regardless of print quality which is obtained by addition of IPA as a wetting agent. Law and consumer pressure to motivate printers that eliminate the IPA, thus protecting labor and the environment. Based solvents isopropyl alcohol used for washing printing presses in wetting agents, lose up to half its volume before starting their reaction. For example, 40-50% IPA participating in the systems for moistening evaporates from the very beginning of the process. Substances used in the printing industry as a substitution IPA have proved effective as wetting agents, but also more economical in their use. The elimination of IPA can be based on the following items:

- IPA is very flammable, its storage and use are subject to strict rules for storage, because the flash point (12o) below room temperature,
- IPA has a stated limit for occupational exposure if it is very high employee inhale vapors IPA,
- IPA is a volatile organic matter and completely evaporates into the atmosphere, a major limitations in terms of VOC compounds will be introduced because the law of the European Union aims to cleaner air and reduce pollution in the lower parts of the atmosphere, the printing industry will be forced to selectively reduce the use of VOC compounds ,
- Evaporation of IPA causes the more alcohol is added continuously wetting agents, so that the actual water consumption is greater than anticipated, the alcohol rate doubles the overall cost of a wetting agent, and is usually cost-effective elimination.

6.3. Measurement of VOC (Volatile Organic Compounds) gas chromatogram in the printing and analysis of the results obtained

By measurement of the concentration levels of VOC (Volatile Organic Compounds) on the ten selected measuring points were below the maximum allowable concentration, which indicates the absence of pollutants in dangerous quantities.

Table 1: Mean values of measured concentrations

Measuring place	Benzene [ppm]	Toluene [ppm]	Ethylbenzene [ppm]	Xylene [ppm]	IPA [ppm]	Acetone [ppm]
1.	0	0,153	0,285	0	53,768	0
2.	0	**0**	0	0	49,383	0
3.	0	0	0,624	0	67,638	0
4.	0	0,191	0,328	0	22,438	0
5.	0	0	0	0	18,269	0
6.	0	0	0	0	26,432	0
7.	0	0,172	0,428	0	61,257	0
8.	0	0	0	0	38,171	0
9.	0	0,231	0,176	0	28,556	0
10.	0	0	0,281	0	36,758	0

Table 1 shows the mean value of the concentration of volatile organic jedninjenja measured at ten measuring points in the field of printing. The measured concentrations do not exceed the MRL given components and are not harmful to human health and the environment. Isopropyl alcohol is present in the highest quantity in all measuring points, while xylene, benzene and acetone were not detected in the monitored measuring points.

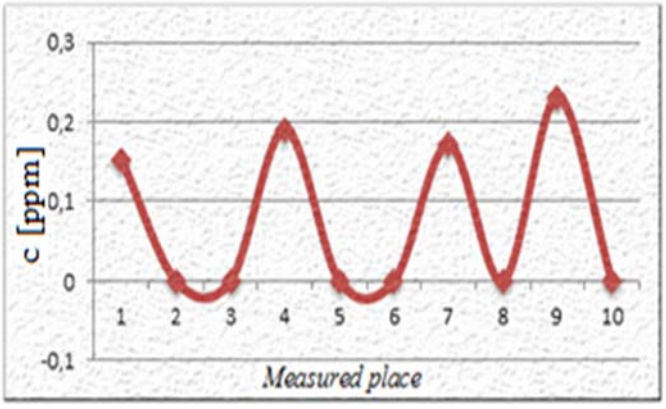

Fig 1: Measured concentrations of toluene [ppm]

Figure 1 shows the measured concentrations of toluene in the observed measuring points. Toluene was detected only at the measuring point. The measured concentration levels do not exceed the MRL for toluene in the workplace.

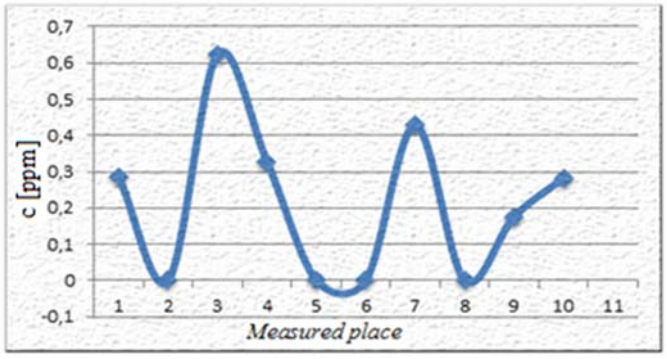

Figure 2. The concentrations of ethylbenzene [ppm]

Figure 2 presents the concentration of ethylbenzene. For measuring points recorded the presence of ethylbenzene. The measured concentration levels do not exceed the maximum allowable concentration for ethylbenzene.

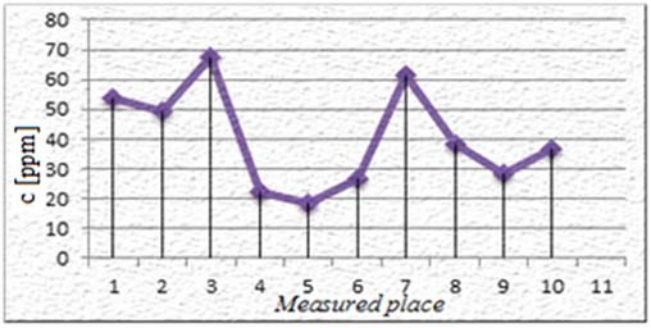

Fig 3: Measured concentrations of IPA [ppm]

The presence of isopropyl alcohol was detected in all tested measuring points and, in relation to other components VOC recorded IPA concentration levels are highest. The detected concentration of isopropyl alcohol levels shown in the graph third.

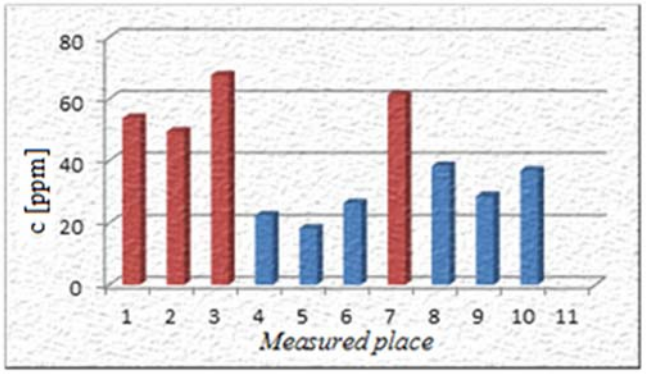

Fig 4: The maximum and minimum concentration of IPA

Figure 4 shows the maximum and minimum concentration of IPA measured at all measuring points. It can be concluded that the measuring points 1, 2, 3, and 7 the most burdened VOC compounds.

From Figure 4 it can be seen that the difference between the maximum and minimum concentration of isopropyl alcohol in the air at the individual measuring points are not great.

7. Conclusion

Adequate safeguards against the negative impact of printing ink can only be designed with a detailed knowledge of their hazardous properties, method of application, level, type and duration of exposure of workers and all other necessary information. The most desirable measure of safety at work from exposure to graphic colors and compounds that are liberated certainly the replacement of hazardous substances harmless or less harmful. In this sense, the use of environmentally friendly paint besides making a significant contribution to the protection of the environment, and improve the safety and health of employees, for the protection of life and working environment are inextricably linked.

Only small amounts of heavy metals are still present in some types of printing inks (eg , iron and manganese in the mineral pigments, cobalt as an agent for drying paint and copper in organic pigments, blue and green), which can quantitatively be tolerated in terms of safety and working environment.

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