

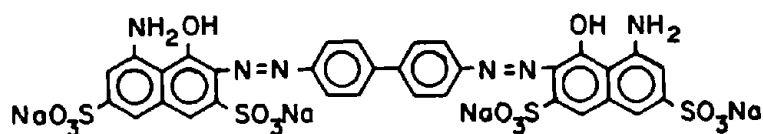
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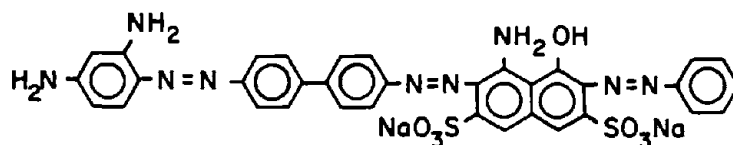
Current Intelligence Bulletin 24

April 17, 1978

DIRECT BLUE 6

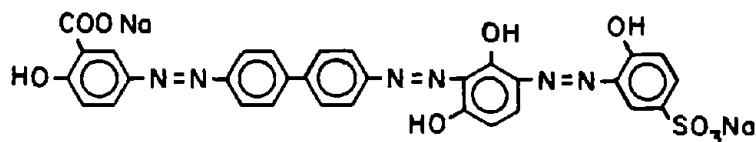


DIRECT BLACK 38



DIRECT BROWN 95

COPPER COMPLEX
DERIVED FROM



Benzidine Derived Dyes

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Center for Disease Control
National Institute for
Occupational Safety and Health

National Institutes of Health
National Cancer Institute

BIBLIOGRAPHIC INFORMATION

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PERFORMER: National Inst. for Occupational Safety and Health, Cincinnati, OH.
DHEW/PUB/NIOSH-78/148

Prepared in cooperation with National Cancer Inst., Bethesda, MD.

The National Institute for Occupational Safety and Health (NIOSH) recommends that three widely used benzidine-derived dyes, Direct Black 38, Direct Blue 6, and Direct Brown 95, be handled in the workplace as if they were human carcinogens. This recommendation is based primarily upon a preliminary analysis of National Cancer Institute (NCI) data from short-term feeding studies, and on early results from NIOSH field studies. Cancerous and precancerous liver conditions were found in rats, similar to the damage produced by known liver carcinogens. Degeneration of liver cells was found in mice. Although the dyes tested by NCI contained less than 4 ppm residual benzidine when fed to the test animals, greater quantities of benzidine were found in the urine of dosed rats and mice. Caution is also indicated by preliminary results from NIOSH field studies showing that humans working with these same dyes also excrete higher than expected levels of benzidine in their urine. Both laboratory and field studies indicate that these benzidine-derived dyes can be metabolized to benzidine which is present in the,...

KEYWORDS: *Environmental surveys, *Industrial medicine,
*Direct black 38, *Toxic substances,
*Occupational safety and health, *Direct blue 6,
*Direct brown 95.

Available from the National Technical Information Service, SPRINGFIELD, VA. 22161

PRICE CODE: PC A02/MF A01

The Current Intelligence Bulletin is the primary product of the Current Intelligence System. The purpose of the Current Intelligence System is to promptly review, evaluate, and supplement new information received by NIOSH on occupational hazards that are either unrecognized or are greater than generally known.

As warranted by this evaluation, the information is capsulized and disseminated to NIOSH staff, other government agencies, and the occupational health community, including labor, industry, academia, and public interest groups. With respect to currently known hazard information this system also serves to advise appropriate members of the above groups of recently acquired specific knowledge which may have an impact on their programs or perception of the hazard. Above all, the Current Intelligence System is designed to protect the health of American workers and to allow them to work in the safest possible environment.

FURTHER INFORMATION:

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SYNONYMS

Identifiers and Synonyms on Attached Sheets

DHEW (NIOSH) Publication No. 78-148

IDENTIFIERS AND SYNONYMS FOR DIRECT BLACK 38

Chemical Abstracts Service Registry Number 1937-37-7

NIOSH/RTECS Number JM71700

Chemical Formula $C_{34}H_{25}N_9O_7S_2Na_2$

Ahco Direct Black GX	Chloramine Black XO
Airedale Black ED	Chloramine Carbon Black S
Aizen Direct Deep Black EH	Chloramine Carbon Black SJ
Aizen Direct Deep Black GH	Chloramine Carbon Black SN
Aizen Direct Deep Black RH	Chlorazol Black E
Amanil Black GL	Chlorazol Black E (Biological Stain)
Amanil Black WD	Chlorazol Black EA
Apomine Black GX	Chlorazol Black EN
Atlantic Black BD	Chlorazol Burl Black E
Atlantic Black C	Chlorazol Leather Black ENP
Atlantic Black E	Chlorazol Silk Black G
Atlantic Black EA	Chrome Leather Black E
Atlantic Black GAC	Chrome Leather Black EC
Atlantic Black GG	Chrome Leather Black EM
Atlantic Black GXCW	Chrome Leather Black G
Atlantic Black GXOO	Chrome Leather Brilliant Black ER
Atlantic Black SD	Coir Deep Black C
Atul Direct Black E	Columbia Black EP
Azine Deep Black EW	Diacotton Deep Black
Azocard Black EW	Diacotton Deep Black RX
Azomine Black EWO	Diamine Deep Black EC
Belamine Black GX	Diamine Direct Black E
Bencidal Black E	Diaphtamine Black V
Benzanil Black E	Diazine Black E
Benzo Deep Black E	Diazine Direct Black E
Benzo Leather Black E	Diazine Direct Black G
Benzoform Black BCN-CF	Diazol Black 2V
Black 2EMBL	Diphenyl Deep Black G
Black 4EMBL	Direct Black Methyl
Brasilamina Black GN	Direct Black A
Brilliant Chrome Leather Black H	Direct Black BRN
C.I. 30235	Direct Black CX
C.I. Direct Black 38	Direct Black CXR
Calcomine Black	Direct Black E
Calcomine Black EXL	Direct Black EW
Carbide Black E	Direct Black EX
Chloramine Black C	Direct Black FR
Chloramine Black EC	Direct Black GAC
Chloramine Black ERT	Direct Black GW
Chloramine Black EX	Direct Black GX
Chloramine Black EXR	Direct Black GXR

Direct Black JET
Direct Black Meta
Direct Black Methyl
Direct Black N
Direct Black RX
Direct Black SD
Direct Black WS
Direct Black Z
Direct Black 3
Direct Black 38
Direct Deep Black E
Direct Deep Black E Extra
Direct Deep Black EA-CF
Direct Deep Black EAC
Direct Deep Black EW
Direct Deep Black EX
Enianil Black CN
Erie Black B
Erie Black BF
Erie Black GAC
Erie Black GXOO
Erie Black JET
Erie Black NUG
Erie Black RXOO
Erie Brilliant Black S
Erie Fibre Black VP
Fenamin Black E
Fibre Black VF
Fixanol Black E
Formaline Black C
Formic Black C
Formic Black CW
Formic Black EA
Formic Black MTG
Formic Black TG
Hispamin Black EF
Interchem Direct Black Z
Kayaku Direct Deep Black EX
Kayaku Direct Deep Black GX
Kayaku Direct Deep Black S
Kayaku Direct Leather Black EX
Kayaku Direct Special Black AAX
Lurazol Black BA
Meta Black
Mitsui Direct Black EX
Mitsui Direct Black GX

Nippon Deep Black
Nippon Deep Black GX
Paper Black BA
Paper Black T
Paper Deep Black C
Paramine Black B
Paramine Black E
Peeramine Black E
Peeramine Black GXOO
Phenamine Black BCN-CF
Phenamine Black CL
Phenamine Black E
Phenamine Black E 200
Pheno Black EP
Pheno Black SGN
Pontamine Black E
Pontamine Black EBN
Sandopel Black EX
Seristan Black B
Telon Fast Black E
Tetrazo Deep Black G
Tertrodirect Black E
Tetrodirect Black EFD
Union Black EM
Vondacel Black N

IDENTIFIERS AND SYNONYMS FOR DIRECT BLUE 6

Chemical Abstracts Service Registry Number 2602-46-2

NIOSH/RTECS Number QJ64000

Chemical Formula $C_{32}H_{20}O_{14}N_6S_4Na_4$

Airedale Blue 2BD	Enianil Blue 2BN
Aizen Direct Blue 2BH	Fenamin Blue 2B
Amanil Blue 2BX	Fixanol Blue 2B
Atlantic Blue 2B	Hispamin Blue 2B
Atul Direct Blue 2B	Indigo Blue 2B
Azocard Blue 2B	Kayaku Direct
Azomine Blue 2B	Kayaku Direct Blue BB
Belamine Blue 2B	Mitsui Direct Blue 2BN
Bencidal Blue 2B	Naphtamine Blue 2B
Benzanil Blue 2B	Niagara Blue 2B
Benzo Blue BBA-CF	Nippon Blue BB
Benzo Blue BBN-CF	Paramine Blue 2B
Benzo Blue GS	Phenamine Blue BB
Blue 2B	Pheno Blue 2B
Blue 2B Salt	Pontamine Blue BB
Brasilamina Blue 2B	Sodium Diphenyl-4,4'-Bis-Azo-2"-8"-Amino -1"-Naphthol-3",6"-Disulphonate
Calcomine Blue 2B	Tertrodirect Blue 2B
Chloramine Blue 2B.	Vondacel Blue 2B
Chlorazol Blue B	
Chlorazol Blue BP	
Chrome Leather Blue 2B	
CI 22610	
C.I. 22610	
C.I. Direct Blue 6	
C.I. Direct Blue 6, Tetrasodium Salt	
Cresotine Blue 2B	
Diacotton Blue BB	
Diamine Blue 2B	
Diamine Blue BB	
Diaphtamine Blue BB	
Diazine Blue 2B	
Diazol Blue 2B	
Diphenyl Blue 2B	
Diphenyl Blue KF	
Diphenyl Blue M2B	
Direct Blue A	
Direct Blue 2B	
Direct Blue 6	
Direct Blue BB	
Direct Blue GS	
Direct Blue K	
Direct Blue M2B	

IDENTIFIERS AND SYNONYMS FOR DIRECT BROWN 95

Chemical Abstracts Service Registry Number 16071-86-6

NIOSH/RTECS Number JM78780

Chemical Formula $C_{31}H_{20}N_6O_9SNa_2Cu$

Aizen Primula Brown BRLH	Hispaluz Brown BRL
Aizen Primula Brown PLH	KCA Light Fast Brown BR
Amanil Fast Brown BRL	Kayarus Supra Brown BRS
Amanil Supra Brown LBL	Paranol Fast Brown BRL
Atlantic Fast Brown BRL	Peeramine Fast Brown BRL
Atlantic Resin Fast Brown BRL	Pontamine Fast Brown BRL
Belamine Fast Brown BRLL	Pontamine Fast Brown NP
Benzanil Supra Brown BRLL	Pyrazol Fast Brown BRL
Benzanil Supra Brown BRLN	Pyrazoline Brown BRL
Brown 4EMBL	Saturn Brown LBR
C.I. 30145	Sirius Supra Brown BRL
C.I. Direct Brown	Sirius Supra Brown BRS
Calcodur Brown BRL	Solantine Brown BRL
Chloramine Fast Brown BRL	Solar Brown PL
Chloramine Fast Cutch Brown PL	Solex Brown R
Chlorantine Fast Brown BRLL	Solius Light Brown BRLL
Chrome Leather Brown BRLL	Solius Light Brown BRS
Chrome Leather Brown BRSL	Sumilight Supra Brown BRS
Cuprofix Brown GL	Suprazo Brown BRL
Derma Fast Brown W-GL	Suprexcel Brown BRL
Dermafix Brown PL	Tertrodirect Fast Brown BR
Dialuminous Brown BRS	Tetramine Fast Brown BRDN Extra
Diaphtamine Light Brown BRLL	Tetramine Fast Brown BRP
Diazine Fast Brown RSL	Tetramine Fast Brown BRS
Diazol Light Brown BRN	Triantine Brown BRS
Dicorel Brown LMR	Triantine Fast Brown OG
Diphenyl Fast Brown BRL	Triantine Fast Brown OR
Direct Brown 95	Triantine Light Brown BRS
Direct Brown BRL	Triantine Light Brown OG
Direct Fast Brown BRL	
Direct Fast Brown LMR	
Direct Light Brown BRS	
Direct Supra Light Brown ML	
Durazol Brown BR	
Durofast Brown BRL	
Eliamina Light Brown BRL	
Enianil Light Brown BRL	
Fastolite Brown BRL	
Fastusol Brown LBRSA	
Fastusol Brown LBRSN	
Fenaluz Brown BRL	
Helion Brown BRSL	

NIOSH/NCI JOINT CURRENT INTELLIGENCE BULLETIN

DIRECT BLACK 38, DIRECT BLUE 6, AND DIRECT BROWN 95 BENZIDINE-DERIVED DYES

April 18, 1978

The National Institute for Occupational Safety and Health (NIOSH) recommends that three widely used benzidine-derived dyes, Direct Black 38, Direct Blue 6, and Direct Brown 95, be handled in the workplace as if they were human carcinogens. This recommendation is based primarily upon a preliminary analysis of National Cancer Institute (NCI) data from short-term feeding studies, and on early results from NIOSH field studies. Cancerous and precancerous liver conditions were found in rats, similar to the damage produced by known liver carcinogens. Degeneration of liver cells was found in mice. Although the dyes tested by NCI contained less than 4 ppm residual benzidine when fed to the test animals, greater quantities of benzidine were found in the urine of dosed rats and mice. Caution is also indicated by preliminary results from NIOSH field studies showing that humans working with these same dyes also excrete higher than expected levels of benzidine in their urine. Both laboratory and field studies indicate that these benzidine-derived dyes can be metabolized to benzidine which is present in the urine of animals and humans.

Based on the data from the short-term study, NCI scientists believe a cancer-causing potential exists upon exposure to the benzidine-derived dyes, most likely through the mechanism of metabolic conversion of the dyes to benzidine in the animal system. This NIOSH/NCI Joint Bulletin summarizes the results of the NCI animal study, the NIOSH field studies, other pertinent data, their implication for occupational health, and suggested guidelines for minimizing employee exposure to the three dyes.

Potential Occupational Exposures

The National Occupational Hazard Survey (NOHS), conducted between 1972 and 1974 by the National Institute for Occupational Safety and Health, indicates that workers are occupationally exposed to Direct Black 38, Direct Blue 6, and Direct Brown 95 in a variety of industries including: paper and allied products, petroleum and related industries, rubber and plastic products, leather and leather products, instrumentation and measuring devices, and banking. In addition, the

textile industry accounts for a substantial occupational exposure. It is estimated that 25 percent of the benzidine-derived azo dyes are applied to textiles, 40 percent to paper, 15 percent to leather, and the remainder to other diverse applications. (1)

The Colour Index, (2) a reference by Great Britain's Society of Dyers and Colourists, reports the following uses for the three dyes:

- o Direct Black 38: Dyeing or staining of wool, silk, fibers for rope and matting, hogs hair, cellulose, acetate, nylon, and biological stains.
- o Direct Brown 95: Dyeing or staining silk, cotton, acetate, cellulose, wool, nylon, leather, paper, and certain plastics.
- o Direct Blue 6: Dyeing or staining silk, wool, cotton, nylon, leather, paper, biological stains and writing inks.

Historically, benzidine has been an important intermediate in dye production since its introduction to the dyestuff industry around 1890. (3,4) In 1948, production of benzidine-derived dyes was 35 million pounds which accounted for 25% of all domestic dyes manufactured and almost all of the direct class dyes. (5) Domestic production of direct benzidine-derived dyes has dropped to 11.4 million pounds in 1971. (6) Domestic production in 1978 should be limited to 12 benzidine dyes. The latest domestic production figures for Direct Black 38 show 7.3 million pounds in 1971, (6) down to 2.2 million pounds in 1975, (7) which rose to 3.76 million pounds in 1976. (8) Direct Brown 95 has shown an increased production to 600,000 pounds in 1976 which is up from 406,000 pounds in 1975 and 343,000 pounds in 1974. (8) Domestic production for Direct Blue 6 indicates that 327,000 pounds were produced in 1973, which is the last available figure for that dye. (9)

In the general population, unspecified exposure levels to the three dyes are thought to occur through the use of retail packaged dyes for home dyeing and for home and school use in art and craft projects such as tie-dyeing or batik. The Art Hazards Project of the Center for Occupational Hazards, New York City, has reported that package dyes sold in supermarkets, variety stores and hardware stores are combinations of direct, acid and basic dyes, and thus may contain benzidine-derived dye components. (10) Two of these dyes, Direct Black 38 and Direct Blue 6, have been used in hair dyes. (11)

NCI Dose-Ranging Feeding Study (11)

Ninety-day animal feeding tests have been completed by the National Cancer Institute for three widely-used dyes, Direct Black 38, Direct Blue 6, and Direct Brown 95. The first-phase tests are conducted routinely to establish dosage levels

in mice and rats for chemicals being screened for cancer-causing activity. The dose-ranging studies commonly precede standard bioassays--animal lifetime tests at dosages that do not shorten lifespans or impair growth.

All three of the dyes are benzidine-derived, having a unit of benzidine in their chemical structure. Benzidine is a known animal and human cancer-causing agent. (12) Residual free benzidine in the feed was below 4 parts per million (ppm).

A total of 120 rats and 120 mice were divided into groups of 10. One group of each sex and each species was reserved as undosed controls, while five groups of each sex and species received differing dosages of the dyes in feed. At the 4th and 12th week of the study, urine was collected from dosed rats and mice for benzidine analysis. After 91 days of feeding and one day of observation, the surviving animals were killed and their tissues examined.

After the 90-day trial, significant incidences of cancerous and precancerous changes in the liver were found in both male and female rats dosed with any of the three dyes, whereas, untreated control rats had no liver damage. The liver changes in dosed animals were similar to changes caused by benzidine.

In mice, all three dyes were found harmful to the liver, but no cancerous changes were found. This finding is compatible with the interpretation that the toxic effects may be related to benzidine, because benzidine is more likely to produce cancer in rats than in mice. No liver abnormalities or damage to any internal organs were found in the control animals of either species.

In addition, although the dyes were essentially benzidine-free when fed to the animals, substantial benzidine was found in the urine of dosed rats and mice, an indication that animal systems metabolize the dyes to benzidine.

The technical report "13-Week Subchronic Toxicity Studies -- Direct Blue 6, Direct Black 38, and Direct Brown 95 Dyes" is available from the Office of Cancer Communications, National Cancer Institute, Bethesda, Maryland 20014.

Other Laboratory Animal Studies

As an historical point, an early realization of the metabolism of azo compounds in mammals came as a result of feeding Orange I, an azo dye, to dogs in 1911. (13) An intermediate of the dye, sulfanilic acid, was identified in the urine demonstrating for the first time that azo compounds may be metabolized by reductive cleavage of the azo group. Since then it has been repeatedly demonstrated that the intestinal flora within animals and many animal hepatic enzyme systems are capable of splitting the azo bond. (14,15) The majority of this work was performed with azo dyes intended for food coloring.

Yoshida and Miyakawa found that when sulfonated benzidine azo dyes were injected into surgically removed mice intestines and then incubated, free benzidine was

later found. They also showed that Escherichia coli as well as soil bacteria were quite capable of reducing benzidine dyes when incubated at 37 C. (16)

Another study showed that rhesus monkeys, fed benzidine-derived dyes with no residual benzidine, excreted benzidine in their urine. The levels excreted were estimated as being almost as high as if an equal amount of pure benzidine, as found in the dye moiety, were fed instead to the monkeys. (17) These studies lead NIOSH to believe that when dyes of these types are ingested by man, they result in benzidine in the urine thus posing a potential carcinogenic hazard.

NIOSH Field Studies

Preliminary results from NIOSH studies indicate the presence of benzidine, or monacetylbenzidine (MAB), a metabolite of benzidine, in the urine of workers in four out of five industrial facilities in which urine samples were collected. The facilities surveyed to date include two benzidine dye manufacturers, two textile finishing companies and a leather tannery.

In one dye manufacturing plant, benzidine and MAB were found in all dye workers who worked solely with the finished dyes. Bulk benzidine-based dyes were quantitatively analyzed for residual free benzidine content which ranged from less than 1 to 19 ppm. It was conservatively estimated that about 20 times more benzidine and up to 200 times more MAB were present in the urine of these dye workers, than if they had been exposed only to the residual benzidine content in the dyes. The concentrations of benzidine found in the urine of these workers were significant fractions of those concentrations associated with a high incidence of bladder cancer as reported in the scientific literature. Among textile dyers included in the NIOSH study, four of ten had benzidine or MAB present in their urine and all had elevated aromatic amine levels. No benzidine or MAB was detected in urine samples collected at a leather tannery where good work practices were observed. While there was biological variability in body burden tolerance and differences in metabolism among those studied, it appears likely that work practices and personal hygiene played a major role in minimizing exposure. Analyses of data from these NIOSH studies are ongoing.

The relatively large particle size of the dry dye powders causes inhaled dyes to be deposited largely in the upper respiratory tract and then ingested. Prevention of worker inhalation or ingestion of these dyes would greatly reduce absorption into the body and subsequent benzidine exposure.

Epidemiological and Medical Studies -- Benzidine-Based Dyes

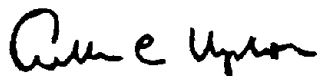
A strong association relating human exposure to benzidine-based dyes with the subsequent development of bladder tumors was presented after a case-control mortality study of 200 bladder cancer patients in Japan. (16) The patients were found to have been predominantly kimono painters and dyers. The kimono painters

had the habit of forming a point on their brushes by drawing the brush between their lips, which allowed for ingestion of the dyes.

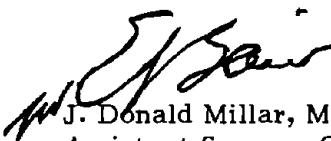
Several other case-control mortality studies indicate an increased risk of developing bladder cancer in the textile and leather industries, both large users of direct dyes. However, only a few references have been made concerning benzidine-derived dyestuffs.

In Russia, a medical study concerning the early detection of bladder tumors among textile dyers using benzidine-derived dyes found an unusual incidence of bladder lesions, some of which were suggested as being of a precancerous nature. The greatest number of such lesions were found in those workers with the highest potential exposure to these dyes.(18)

The National Institute for Occupational Safety and Health and the National Cancer Institute have jointly prepared this Bulletin to facilitate the rapid dissemination of our preliminary findings on three benzidine-derived dyes: Direct Black 38, Direct Blue 6, and Direct Brown 95. NIOSH recommends that these dyes be handled in the workplace as if they were human carcinogens and requests that producers, distributors, professional associations, and unions transmit the information in this Bulletin to their customers, employees, associates, and members.



Arthur C. Upton, M.D.
Director
National Cancer Institute



J. Donald Millar, M.D.
Assistant Surgeon General
Acting Director,
National Institute for Occupational
Safety and Health

NIOSH Action on Benzidine-Derived Dyes

1. The NIOSH Industrial Hygiene Section will shortly conduct a study in which workers who have had a one-day exposure to benzidine-based dyes are monitored over several days. This will hopefully confirm some assumptions on the excretion kinetics of such exposure and better establish the best time to monitor a worker's urine for benzidine.
2. The NIOSH Clinical and Biochemical Support Section has an interagency agreement with the National Center for Toxicological Research to conduct animal metabolism studies. Test animals will be fed Direct Black 38, Direct Blue 6 and Direct Brown 95. Metabolites will be identified in the urine and evaluated for mutagenic activity. Additional dyes made from 3,3-dimethylbenzidine, 3,3-dimethoxybenzidine, and 3,3-dichlorobenzidine will also be tested.

SUGGESTED GUIDELINES FOR MINIMIZING EMPLOYEE EXPOSURE TO
DIRECT BLACK 38, DIRECT BLUE 6, DIRECT BROWN 95
-- BENZIDINE-DERIVED DYES

NIOSH recommends that it would be prudent to handle Direct Black 38, Direct Blue 6, and Direct Brown 95 in the workplace as if they were human carcinogens. Exposure to Direct Black 38, Direct Blue 6, and Direct Brown 95 should be limited to as few employees as possible, while minimizing workplace exposure levels. The area in which they are used should be restricted to only those employees essential to the process or operation.

EXPOSURE MONITORING

Initial and routine employee exposure surveys should be made by competent industrial hygiene and engineering personnel. These surveys are necessary to determine the extent of employee exposure and to ensure that controls are effective.

The NIOSH Occupational Exposure Sampling Strategy Manual, NIOSH Publication #77-173, may be helpful in developing efficient programs to monitor employee exposures to Direct Black 38, Direct Blue 6, and Direct Brown 95. The manual discusses determination of the need for exposure measurements, selection of appropriate employees for exposure evaluation, and selection of sampling times.

Employee exposure measurements should consist of 8-hour TWA (time-weighted average) exposure estimates calculated from personal or breathing zone samples (air that would most nearly represent that inhaled by the employees). Area and source measurements may be useful to determine problem areas, processes, and operations.

MINIMIZING EMPLOYEE EXPOSURE

There are four basic methods of limiting employee exposure to Direct Black 38, Direct Blue 6, and Direct Brown 95. None of these is a simple industrial hygiene or management decision and careful planning and thought should be used prior to implementation of any of these.

- o Product Substitution

The substitution of an alternative material with a lower potential health and safety

risk is one method. However, extreme care must be used when selecting possible substitutes. Alternatives to Direct Black 38, Direct Blue 6, and Direct Brown 95 should be fully evaluated with regard to possible human effects. Unless the toxic effects of the alternative have been thoroughly evaluated, a seemingly safe replacement, possibly only after years of use, may be found to induce serious health effects.

o Contaminant Controls

The most effective control of Direct Black 38, Direct Blue 6, and Direct Brown 95, where feasible, is at the source of contamination by enclosure of the operation and/or local exhaust ventilation.

If feasible, the process or operation should be enclosed with a slight vacuum so that any leakage will result in the flow of air into the enclosure.

The next most effective means of control would be a well designed local exhaust ventilation system that physically encloses the process as much as possible, with sufficient capture velocity to keep the contaminant from entering the work atmosphere.

To ensure that ventilation equipment is working properly, effectiveness (e.g., air velocity, static pressure, or air volume) should be checked at least every three months. System effectiveness should be checked soon after any change in production, process, or control which might result in significant increases in airborne exposures to Direct Black 38, Direct Blue 6, and Direct Brown 95.

o Employee Isolation

A third alternative is the isolation of employees. It frequently involves the use of automated equipment operated by personnel observing from a closed control booth or room. The control room is maintained at a greater air pressure than that surrounding the process equipment so that air flow is out of, rather than into, the room. This type of control will not protect those employees that must do process checks, adjustments, maintenance, and related operations.

o Personal Protective Equipment

The least preferred method is the use of personal protective equipment. This equipment, which may include respirators, goggles, gloves, and other devices should not be used as the only means to prevent or minimize exposure during routine operations.

Exposure to Direct Black 38, Direct Blue 6, and Direct Brown 95 should not be controlled with the use of respirators except:

- During the time period necessary to install or implement engineering or work practice controls; or
- In work situations in which engineering and work practice controls are technically not feasible; or
- For maintenance; or
- For operations which require entry into tanks or closed vessels; or
- In emergencies.

Only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) should be used. Refer to NIOSH Certified Equipment, December 15, 1975, NIOSH publication #76-145 and Cumulative Supplement June 1977, NIOSH Certified Equipment, NIOSH publication #77-195. The use of faceseal coverlets or socks with any respirator voids NIOSH approvals.

Quantitative faceseal fit test equipment (such as sodium chloride, dioctyl phthalate, or equivalent) should be used. Refer to A guide to Industrial Respiratory Protection, NIOSH publication #76-189 for guidelines on appropriate respiratory protection programs.

In addition, proper maintenance procedures, good housekeeping in the work area and education of employees concerning the nature of the hazard, its control and personal hygiene are all aspects of a good control program.

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