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HEALTH PROBLEMS AT WELDING*

A survey is given on health problems at welding. Potential hazard from nitrous oxides, ozone, carbon monoxyde, fumes of lead, zinc and cadmium and the fumes containing iron oxides, amorphous silica and oxides of calcium and manganese are described. The irritative effect of fumes at arc welding with basic (low hydrogen) electrodes is believed to be due to the content of fluorine in the fumes. The maximum allowable concentration of arc welding fumes have been proposed to 20 mg/m³, at arc welding with basic electrodes 10 mg/m³. The welders' flash and its prevention are discussed. X-ray or radioactive isotopes used to control welds may also create a health hazard. It is pointed out that the most important accident risk at welding is the hazard of explosion at welding on drums, barrels etc. containing explosive or flamable material. The role of the Commission on Hygiene and Safety of the International Institute of Welding is described.

1. *Gases and Fumes at Arc Welding*

Gases and fumes at arc welding arise from the arc itself, from the welding rod and from the coating of the rods.

In the heat of the arc, nitrogen and oxygen of the surrounding air may, to some extent, combine to nitrous oxydes (NO, NO_2, N_2, N_2O_4). The formation of nitrous oxides at arc welding is, however, not very great, and will very seldom, even in confined spaces, give rise to hazardous concentrations.

During inert-gas metal arc welding, ozone may be formed, which will create a health hazard. The maximum allowable concentration of ozone in the air is 1 part per million. Usually, there will be no health hazard from ozone at inert-gas arc welding in rooms with normally goood ventilation. If welding is carried out in confined spaces, local exhaust ventilation or personal protective devices (filter masks or air-pressure masks) may be necessary. Chlorinated hydro-carbons should not be used as for instance in degreasing operations in rooms, where inert-gas arc welding is carried oud, as the vapors are quickly decomposed by the radiation from the arc. This seemed especially to be the

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case with trichlorethylene; non-toxic concentration of this vapor can be converted into toxic concentrations of noxious gases, mostly consisting of phosgene. Formation of nitrous oxides at inert-gas metal arc welding will under usual conditions not create any health hazard.

It has been discussed if carbon monoxide would be a health hazard at arc welding. According to recent Swedish studies, it seems that only under very special conditions, carbon monoxide may be formed to such an extent that it will give rise to a definite health hazard.

According to several studies on the composition of fumes, it has been found that the fumes consist mostly of iron oxides, to some extent of silica (amorpheous SiO_2) and oxides of calcium and manganese (see table 1). At arc welding with basic (low hydrogen) electrodes, the fumes will also contain up to 20% fluorine, half of it water-soluble (see table 2).

Table 1

Fumes at arc welding using some different types of electrodes

Types of electrodes	Fe_2O_3 %	SiO_2 %	TiO_2 %	MnO %
Common neutral	61,0	15,0	0,2	15,7
Organic rutile	54,8	22,7	3,4	6,7
Inorganic rutile	57,7	14,6	2,0	3,5
With acid coating	26,6	45,8	1,6	12,2
Approximate limits	27–76	10–46	<3	4–21

Table 2

Fumes at arc welding using different basic (low hydrogen) electrodes

Electrode no.	Fe_2O_3 %	SiO_2 %	TiO_2 %	MnO %	CaO %	F %
1	30,9	11,5	0,5	9,3	13,7	17,0
2	26,7	11,2	—	6,9	16,5	19,0
3	23,6	8,5	0,7	3,6	17,7	23,5
4	24,2	5,7	0,5	4,5	—	24,4
Approximate limits	20–35	6–13	<1	4–11	14–19	15–25

Arc welding of steel witl the usual coated welding rods except basic rods, will usually not give rise to any health hazard. 5 to 10% of arc welders, who have been welding in confined spaces for more than 10 years, will, according to experiences from many countries, show X-ray changes of the lungs similar to those of silicosis. These changes, however, are most probably due to inhaled iron oxide (siderosis) and these changes do not seem to affect the lung function or the working capacity. Especially in relation to the slow development of silicosis it must, however, be mentioned that we have not yet had experiences of the health problems at arc welding during enough long time. The fumes at arc welding may give rise to some slight irritation of the nose and throat, but this does not seem to give rise to any real disease of the bronchi or the lungs. The incidence of pneumonia among arc welders is not higher than among other workers, according to recent experiences from the United States.

The fumes at arc welding with basic (low hydrogen) electrodes, especially in confined spaces, will often cause some local irritation of throat and pharynx with cough and nausea, but do not seem to give rise to any serious diseases. This irritation is probably due to the content of fluorine in the fumes. No cases of chronic intoxication of fluorine have, however, been found among welders.

Manganese, which is known as a toxic substance, does, at usual arc welding, probably not occur in high enough concentration to give rise to intoxication, as no cases of manganese intoxication have been reported among welders.

Thus, the fumes at arc welding to not seem to create any serious health hazard. To get further experiences, it will, however, be of interest to study the X-ray changes of the lungs and to pay special attention to symptoms that may be related to chronic manganese intoxication. The local irritation of the upper respiratory tract arising from inhalation of fumes at arc welding with basic electrodes does not seem to give rise to any serious diseases, but in order to get further experiences it will be of value to pay attention to these symptoms in the future.

Even if fumes and gases at arc welding do not give rise to any serious health hazard, it will be of advantage to prevent, as far as possible, the workers from inhaling gases and fumes, especially at welding in confined spaces. Local exhaust ventilation that can be moved from one working place to another, will be of great value, especially at welding in confined spaces. In larger rooms, where arc welding is carried out, local exhaust ventilation is not necessary, but will however sometimes be of value to give greater comfort to the worker. According to recent studies on the composition of arc welding fumes, the maximum allowable concentration of arc welding fumes in the air 8 hours a day has been proposed to 20 milligram per cubic meter. With relation to the

fluorine content of fumes at arc welding with basic electrodes, the maximum allowable concentration has, in this case, been proposed to 10 milligram per cubic meter.

2. *Gases and Fumes at Gas Welding*

Intoxication from acetylene does not occur at gas welding, as the toxicity of this gas is very low. Hazards of explosion will occur already at a concentration of about 3% of acetylene in the air, but an anaesthetic effect of acetylene will arise at a concentration of about 20–30% of acetylene. It is thus obvious that apart from the explosion hazard, acetylene will not create a health problem at gas welding. However, impurities in acetylene as the very toxic arsine (AsH_3) and phosphine (PH_3) may create a health hazard, if the acetylene used is not purified. The incidence of such intoxications among welders seems, however, to be extremely low.

The most important health hazard at gas welding is related to formation of nitrous oxides in the welding flame arising from the small amount of nitrogen that may occur in the oxygen used and from nitrogen and oxygen in the surrounding air. The amount of nitrous oxydes formed will increase with the length of time of welding or cutting, and with the amount of acetylene used per hour (the size of the burner). More nitrous oxides are formed, if the welding flame is burning free than at welding or cutting. Dangerous concentrations may arise in confined spaces in a rather short time (10 to 20 minutes), especially if the welding flame is burning free.

Carbon monoxides may be formed, but under usual conditions, concentrations in the air will be low and will not give rise to any health hazard. At gas welding, the oxygen needed for complete oxidation of the acetylene used is taken partly from the oxygen used and partly from the oxygen in the surrounding air. In gas welding under water, however, the oxygen of the surrounding air will be missing, the oxidation of the acetylene will be incomplete, and give rise to the formation of carbon monoxide. Recent experiences in Sweden have shown that serious carbon monoxide intoxication may occur at gas welding under water.

Fumes at gas welding will mostly consist of iron oxide, but the amount of fumes are much less than at arc welding and will usually not give rise to any health hazard.

The most important health hazard at welding as a whole, is the formation of nitrous oxides at gas welding, and preventing measures,

especially at gas welding in confined spaces, will be local exhaust ventilation or personal protective devices as filter masks or, still better, masks provided with fresh air.

3. *Gases and fumes arising from coating or painting on the material to be welded*

At welding on coated or painted material, the substance in the coating or painting may be vaporised in the heat of the welding arc or flame and may give rise to gases and fumes. The practically most important and most common health hazard will arise at welding on iron and steel, painted with red lead. Chronic lead intoxication among welders, especially at ship-yards, has occurred in many countries, when the workers have inhaled lead fumes at welding or cutting of lead painted material.

Another health hazard, which, however, is not as serious as lead intoxication, may arise at welding on galvanated (zinc coated) sheets, where inhalation of the zinc oxide fumes may give rise to zinc fume fever. As it is well known, the symptoms of this disease will only last for one or two days and will not give rise to any later impairment of health.

Welding on cadmium coated material will give rise to the formation of cadmium fumes (boiling point of cadmium about 780° C), which may cause serious acute cadmium intoxication. The mortality of the acute intoxication may be about 15%, and it will thus be of importance to pay attention to this health hazard, although it occurs very seldom.

Welding or cutting of manganese steel alloys will give rise to formation of fumes with high content of manganese. So far, no cases of manganese intoxication have been reported, but in relation to the high concentration of manganese in the fumes and the experiences from other occupations than welding, where workers have been exposed to manganese fumes or dusts, it will be of importance to pay attention to this potential health hazard.

Health hazards arising from coating or painting on the welded material, will usually be related to lead, zinc, cadmium and perhaps manganese. The prevention of these health hazards will consist of thorough cleaning of the part to be welded, especially in confined spaces local exhaust ventilation, and personal protective measures as filter masks or masks provided with fresh air. In case of health hazard from lead fumes, regular health examinations will be of great value.

4. *Health risks from radiation*

Ultra-violet rays at arc welding will often cause acute conjunctivities (welders' flash). A short time after exposure, there will be pain in the eyes, the eye-lids will be swollen. The conjunctiva will show signs of acute inflammation. These symptoms will disappear after a few days, without leaving any damage to the eyes. Usual goggles will protect the eyes against exposure to ultra-violet rays, but for practical reasons, due to the high intesity of light from the welding arc, the welders always use very dark glasses. Glasses of different grades of light absorption can be recommended for different kinds of welding, as light gas welding, heavy gas welding, arc welding and inert-gas arc welding. There should, however, be sufficient choice of shades within the limits recommended to cover the welders' preferences. In some countries as Great Britain, recommendations exist on density of protective glasses to be used at different kinds of welding. It is important that the workers' eyes are also protected at the sides of the goggles, as very often welders' flash may arise from exposure from another weld than one's own. Welders' flash occurs almost exclusively at arc welding.

It has been discussed if exposure to infra-red rays at welding will cause any health hazard. So far, no eye disease caused by infra-red rays has been reported among welders. As it is well known that glass-blowers cataract will arise rather seldom and only after exposure of the eyes to infra-red rays during a very long time (20 to 30 years), it may be of interest to pay attention to this problem also in the future.

Burns of the face and of the hands may occur from exposure to rays and from sparks at welding. Personal protective measures as masks, shields and gloves will prevent this health hazard.

5. *Electric shock*

Severe electric shock occurs very seldom among welders, due to the low voltage normally used at arc welding (75 to 100 volts), and also due to the mostly well isolated welding equipment.

Humidity and heat may constitute a source of danger, as the skin of the welder is then wet from water or sweat. Welding inside containers may also be dangerous due to the possibility of having a large skin contact surface.

The welders should be well instructed how to avoid electric shock. Contact between the bare skin of the welder or any wet covering of his body (wet clothes) and the electrode or any metal part of electrode

holder should be carefully avoided. It is important from the safety point of view to use consistently electrode holders with well-insulated jaws, well-insulated cables and dry protective coverings on the hands and body. Insulation of the welder from ground is also useful. In very bad conditions the welding with D. C. (direct current) where possible should be considered, as the hazard from electric shock of D. S. is lower than of A. C. (alternating current) of the same voltage.

6. *Risks from X-rays and Gamma-rays*

During the last few years, X-rays and radioactive isotopes have been used, to an increasing extent, to control welds. The general effect on the human body from exposure to X-rays and Gamma-rays will be anaemia and leucopenia and the local effect ulceration and skin cancer. As these effects may arise usually after a very long time of exposure, it is important to have efficient preventive measures introduced from the beginning to protect the workers against the health risks from exposure to X-rays and Gamma-rays. The Commission on Hygiene and Safety of the International Institute of Welding made, at the meeting 1953, the following recommendations:

1. To eliminate risks to health, it is recommended that only properly trained personnel should be employed in radiographic processes or in handling radioactive material. Special training facilities should be provided for such personnel.
2. The doses of radiation received in a given time by each person engaged in radiographic work should be regularly checked (1). The interval between consecutive checks (films, personnel dosemetres, etc ...) should not exceed one week in respect of any person.
3. There should be proper medical supervision of all personnel and of the conditions under which work is carried out.
4. Personnel should take care never to expose themselves to the beam of radiation.
5. Gamma sources should not be brought from the store to the site until all other arrangements for the radiograph bave been completed, and the sources should be returned to the store as soon as possible after use.
6. All personnel should remain at a sufficient distance from the source of radiation (2). X-ray apparatus with remote control should be provided. Containers for radioactive sources should also be equipped with remote control devices for exposing or removing the source.
7. Suitable warnings and, if necessary, directions should be given to workers in the vicinity.
8. The exposure to radiations of any one person should, where practicable, be reduced to a minimum by alteration of duties (e. g. from operation room to dark room).

[1] The International Commission on Radiological Protection at its meeting in London in July 1950 recommended that the weekly permissible dose should be fixed at 300 milliröntgens measured in free air.

[2] The intensity of the rays varies inversely as the square of the distance from the source.

9. A fire-proof, burglar-proof safe or some other safeguard against unauthorized access and against danger of fire should be used for the storage of radioactive material.
10. Every container of radioactive material should be so marked as to indicate the nature and radioactive strength of the contents, and such containers should also be marked with a coloured hand to give warning of danger. These precautions may be supplemented as follows:

    Unless an exposure is made in a room which is locked, or in a place which is under constant guard, the container of the radioactive substance should be equipped with an automatic device to give the alarm if the container is removed or damaged.
11. Any new installation of radiographic equipment, or one which has been substantially altered or which requires fixed structural protection and is moved to a new site, should be planned and erected under the supervision of a competent person; before it is used a check should be made of the degree of radiation present in the vicinity of the equipment.
12. Any structure normally used for radiography should be periodically examined for defects or alterations which might permit the escape of radiation.

7. *Burns, explosions etc.*

There are certain accident risks that are related to welding. There may be an explosion hazard related to welding on drums, barrels, tanks or other containers which have contained explosive or flammable material or strong acids. These accidents do not seem to occur very often, but when they occur, they are often very serious. Many countries have issued special regulations to prevent accidents at welding on drums etc., considering cleaning of drums before welding, purging with inert gas or filling with water and inserting expansion pipes etc.

8. *International regulations and recommendations on preventive measures at welding*

The International Institute of Welding is an international organisation to promote the development of technique welding and to exchange experiences in this field. The national organisations participating are usually welding associations closely connected with engineering academies or technical universities. The work of this international organisation is carried out in 10 to 15 commissions, one of which is a Commission on Hygiene and Safety. This Commission collects experiences from different countries and has tried to issue short statements on health hazards and recommendations on their prevention. So far, the gases and fumes at gas welding and arc welding have been studied, as well as gases and fumes from welding on painted or coated material. Recommendations concerning prevention against exposure to

X-rays and Gamma-rays have been issued, and prevention against ultra-violet radiation and burns have been discussed. A booklet on health problems at welding and the prevention of health hazards is being prepared.

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Sadržaj

ZDRAVSTVENI PROBLEMI KOD SVARIVANJA*

Iznesen je pregled zdravstvenih problema kod svarivanja. Čini se, da plinovi i dim, koji nastaju kod lučnog svarivanja, ne predstavljaju ozbiljne zdravstvene probleme. Nitrozni plinovi stvaraju se samo u maloj mjeri, pa će vrlo rijetko, čak i u zatvorenim prostorima, dostići opasne koncentracije. Ozon, koji nastaje za vrijeme lučnog svarivanja upotrebom inertnog plina, može biti štetan po zdravlje, ali da se to dokaže, potrebna su dalja iskustva. Pod običnim uvjetima ugljični monoksid ne će biti opasan. Udisavanje dima, koji kod običnog lučnog svarivanja sadržava uglavnom željezne okside, amorfni silicij i kalcijeve i manganove okside, može, pogotovu ako se svarivanje vrši u zatvorenim prostorima, uzrokovati rentgenske promjene na plućima svarivača. Tu se, čini se, radi o siderozi nastaloj zbog udisavanja

* Predavanje održano u Institutu za medicinska istraživanja, Zagreb, 6. VII. 1954.

željeznog oksida, o promjeni, koja, čini se, ne oštećuje funkciju pluća niti smanjuje radnu sposobnost. Udisavanje dima kod lučnog svarivanja s bazičkim elektrodama (s niskim sadržajem vodika), naročito u zatvorenim prostorima, nadraživa ć e ponešto ždrijelo i grlo, ali, čini se, bez ozbiljnih oboljenja. To je djelovanje vjerojatno uzrokovano sadržajem fluora u dimu. Kako bi se spriječilo udisavanje plinova i dima, od velike će koristi biti lokalna ventilacija u obliku ekshaustora, naročito u zatvorenim prostorima. Predložena je kao maksimalno dopuštena koncentracija dima kod lučnog svarivanja 20 mg/m³, a kod lučnog svarivanja s bazičkim elektrodama 10 mg/m³.

Najvažnija opasnost po zdravlje kod plinskog svarivanja je udisavanje nitroznih plinova, koje može uzrokovati plućni edem.

Dim olova, cinka i kadmija može nastati kod svarivanja obloženog ili oličenog materijala i tako stvoriti opasnost po zdravlje.

Ultraljubičaste zrake kod lučnog svarivanja mogu uzrokovati akutnu upalu očnih spojnica. Čini se, međutim, da to zračenje ne uzrokuje trajnih oštećenja; zaštitne naočale će spriječiti tu opasnost.

Do teškog električkog šoka dolazi vrlo rijetko kod svarivača zbog toga, što se kod lučnog svarivanja obično radi s niskom voltažom, a osim toga je i svarivačka oprema dobra i izolirana.

Rentgenske zrake ili radioaktivni izotopi, koji se upotrebljavaju za kontrolu vara, mogu postati opasni. Zbog toga rukovanje radioaktivnim materijalom treba dopustiti samo dovoljno izučenom osoblju, a doze primljenog zračenja moraju se redovno kontrolirati. U tu svrhu će biti ponekad potreban i liječnički nadzor.

Najvažnija opasnost kod svarivanja je mogućnost eksplozije kod svarivanja na tankovima, bačvama i sličnim objektima, ako je u njima prethodno bilo eksplozivnog ili lako upaljivog materijala i jakih kiselina. Mnoge su zemlje izdale posebne pravilnike, kako bi spriječile takve nesretne slučajeve.

Međunarodni institut za svarivanje prati preko svoje Komisije za higijenu i sigurnost zdravstvene probleme kod svarivanja i izdaje kratka saopćenja o opasnostima po zdravlje kod svarivanja kao i upute za njihovo sprečavanje.

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