# OCCUPATIONAL HEALTH HAZARDS AND PREVENTIVE ASPECTS IN WELDING

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**SUMMARY**

Welding, although not an industry in the strict sense in which the term is used, is in fact an ubiquitous process for the application of welding, is now so widespread that there is no metal industry or branch of engineering, where welding is not used in one form or the other. Occupational health hazards in welding pertain to visual hazards, exposure to metal oxide fumes and other fumes generated as a result of high intensity arc. Exposure to non-ionization radiation like U-V rays and infrared rays are discussed with particular reference to aluminium welding. Incidence of approximately 1.2 percent of 'arc eyes' of all eye injuries in metal fabrication is reported. OH complaints among welders show high incidence (41.3%) of conjunctival involvement compared to controls (12.9%). No evidence of infrared cataract has been found among the 41 welders with over 10 years of welding exposure. Chronic lung changes in 41 welders engaged in arc welding work having more than 10 years of exposure and 19 healthy unexposed males as control group were taken for study on random basis. Minimal restrictive and obstruction disability was observed among smoker welders only compared to non-smoker group. A case report of metal fume fever' due to inhalation of copper fumes is described. Preventive measures towards visual hazards and control of fumes in welding environment are discussed in detail.

## INTRODUCTION

Welding, although not an industry in the strict sense in which the term is used, is in fact an ubiquitous process for the application of welding, is now so widespread that there is no metal industry or branch of engineering. Where welding is not used in one form or the other.Even joining togther of several metals and alloys which was considered impossible by forging etc., has been successfully done by modern welding techniques. As in many other spheres of human activity, there have been rapid and substantial technological developments in welding and allied processes in recent years and the progress continues apace. In the USA, it has been estimated that amount spent on welding industries (equipment and consumables) generates nearly 400 times its value in welded goods; apparently this implies that over one-third of the gross national products depends upon welding.

The new type of process, equipment and accessories employed, bring with them a variety of new hazards which call for increased attention to the occupational health and safety aspect of the process.

It is a common sight in metal engineering industries to observe a hooded man, braced upon a naked large steel shell several feet above the ground or crouched uncomfortably inside a shell, directing a stream of arc at a connection of metal joints; the arc fire burning at over 3000°C. As this man works, the intense flame he holds, melts the edges of two pieces of metal and a filler rod. The molten metal flows together and fuses the two pieces of metal casting into a single piece. When the metal cools, the bond is as strong as the original metal. This hooded man is a welder, an indispensable member of team that is building a modern industry.

### Environmental Health Hazard in Welding

The various health hazards in welding operations can be enumerated as under:

1. Radiation hazards which are essentially visual effects, including eye injuries.
2. Exposure to metal fumes and other fumes generated as a result of high

intensity arc - respiratory hazards.

3. Burn injuries due to molten metal.
4. Electric burns and explosive injuries.
5. Digestive disturbances.
6. Postaral fatigue.

**Visual Hazards**

Defective vision is common in industrial workers, particularly for close work. These defects are one of the most prolific causes of industrial fatigue with its sequence of discomfort, less end efficiency in production and accident liability.

The usual vision tests are unsatisfactory for detecting substandard visual functions, which can render the worker unsafe or inefficient. Various visual characteristics influence successful performance on certain jobs. For these visual functions tests have been devised which operate as a battery of tests (as in on Ortho-Rater) for rapidly selecting applicants acceptable for the jobs in question.

**Radiation Hazards**

Oxyacetylene, arc welding emits radiant energy which, if not absorbed by suitable means, affects the eyes adversely. The harmful radiations comprise light rays - the ultraviolet and infrared rays.

The intense arc light is sometimes thought to cause fatigue to the eyes inspite of adequate protection. Some welders complain of watering of the eyes and slight heaviness towards the end of the working shift but this may be attributed to the fumes rather than the intense light, or a combination of both the intense ultraviolet light hitting the unguarded eye can result in the condition of 'arc eye' or flash. The welder rarely gets a flash from his own welding arc, occasionally though it may result from failing to bring his head-shield down quickly before striking the arc; mostly he may get it from other workers working near him-specially if they are particularly close to him or if there are reflective surfaces, e.g., bright coloured walls or metal surfaces like aluminium, which reflect the light into his eyes.

It is unusual for any one wearing glasses to be affected. Table I shows the incidence of welder's arc eyes for a 5 year period (1980-84) in metal fabrication industry.

It is observed that welder's arc eyes comprised of 0.4 percent -1.4 percent of all industrial accidents. The high incidence of the arc eye among welders, have particularly been due to two or more welders, or a welder and a grinder or fabricator working in close proximity over a single large metal sheet. This is a very common situation in a metal fabrication industry and the incidence continues to remain high even though the welders continue to wear suitable goggles.

**Photophthalmia**

Industrial photophthalmia (Flash eye) is liable to occur in innumerable occupations, whenever insufficiently screened sources of light rich in short-waves are used. The most acute symptoms arise among ill protected workers engaged in oxy-acetylene or arc welding or in tending arc-furnaces. The

**Table 1 :** Showing Total No. of Accidents in metal Fabrication Industry.

| | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|
| 1. Grinding | 564 (8.1%) | 1128 (16.3%) | 817 (16.3%) | 618 (8.98%) | 469 (5.64%) |
| 2. Welding | 329 (4.7%) | 72 (1.0%) | 83 (1.1%) | 70 (0.92%) | 80 (0.96%) |
| 3. Flying Particles | 1012 (14.6%) | 828 (11.9%) | 1351 (18.6%) | 1365 (18.01%) | 1337 (16.8%) |
| 4. Chemical Injuries | 49 (0.7%) | 52 (0.8%) | 57 (0.8%) | 36 (0.47%) | 46 (0.55%) |
| 5. Arc Eyes | 110 (1.6%) | 96 (1.4%) | 78 (1.1%) | 141 (1.86%) | 146 (1.75%) |
| **Total** | **2064 (29.7%)** | **2176 (31.4%)** | **2386 (32.95%)** | **2293 (30.26%)** | **2224 (26.75%)** |
| 6. Total no of accidents | 6,944 | 6,940 | 7,259 | 7,756 | 8,311 |
| 7. Frequency Rate | 45.5 | 37.1 | 27.7 | 22.2 | 19.17 |
| 8. Severity Rate | 392.5 | 371.2 | 326.8 | 620.4 | 243.7 |

Frequency Rate : No. of Reportable accidents X 1 million Total No. of Man hours worked
Severity Rate : No. of man days lost X 1 million Total No. of Man hours worked
Reportable accident : Accident in which person has remained away from work for 2 days or more than 2 days (excluding day of accident)

acute symptoms of 'arc eye', which result from the emanation rich in ultraviolet light, first described by Defontaine (1887) and Candron (1888), are still of common occurrence and the literature has now become immense. This is, indeed, the commonest accident in many engineering shops (40%, Ricke, 1943).

The clinical picture of acute photophthalmia of industrial origin is characteristic. There is always a latent period the length of which varies with the intensity and duration of exposure; for ordinary exposure, it lasts for about 8 to 10 hours, so that the unpleasant effects usually start during the following evening or night. With extreme intensities of exposures, the latent period has been reduced to 30 minutes and it would seem never to have exceeded 24 hours, the factor of physiological repair apparently counter-acting the abilotic effects of radiation of weak intensity. The first symptom is a sensation of slight pricking as a foreign body in the eye, which in the mildest degrees of the trouble, is all that may develop. After moderately intense radiation, as in the usual doses accidentally received, this is followed by a considerable disturbance as if the eyes were full of sand, a sensation rapidly increasing to severe pain accompanied by extremely marked photophobia, profuse lacrimation occurring often in crises and blepharospasm, an hour or two later, ciliary neuralgia tends to develop.

The most distressing symptom is blepharospasm, which coming on as it usually does in the middle of the night, reduces the patient to a peculiarly miserable condition,the least attempt at movement or the incidence of light increases this reflex spasm and brings on an acute paroxysm of pain. On the whole, the objective signs lag behind the subjective symptoms. The eye becomes

**Table 2 :** Incidence of Arc Eyes among Aluminium Welders

| | Aluminium Welders | S.S.Welders |
|---|---|---|
| Initial three months : | 10 episodes in a month on an average | 3 episodes in a month |
| Subsequent three months: | 8 episodes in a month | 4 episodes in a month |

**Table 3 :** Ultraviolet Spectrum

| Air | | | | | Window Glass | | |
|---|---|---|---|---|---|---|---|
| Absorption - Ozone - | | | | | Transmits Germicidal Erythenal | | |
| 150 | 200 far | 250 | 280 | 300 | 315 | 350 | 400 |

**Table 4 :** Effects due to high Intensity Ultraviolet Visible and Infra-red Radiation

| Radiation | Wave Length | Adverse Biological Effects |
|---|---|---|
| UV - C | 200-280 | - Inflammation of cornea and slight burn |
| UV - B | 280-315 | - Arc flash and sun burn |
| UV - A | 315-400 | - Arc flash, sun burn, cataracts, skin cancer |
| Visible | 400-700 | - Petrochmecial or thermal retinal injury, thermal skin burns |
| IRA | 700-1400 | - Retinal burns, thermal & skin burns, cataracts |
| IRB | 1400-3000 | - Thermal skin burns |

**Table 5 :** Maximum Permissible U-V Exposure Duration for Skin and Cornea

| Process | Electrode gas | Welding Shielding current | (A) | Maximum time v/s. distance from Arc 1m | 10m | 30m |
|---|---|---|---|---|---|---|
| SMAW | E7010 | - | 200 DSRP | 6S | 10.4 min. | 1.6 hrs |
| GMAW | E 70 S-4 | CO2 | 200 DCRP | 13S | 21.7 min | 3.3 hrs |
| GTAW | EWth-2 | Avg. | 200 DCRP | 45 S | 1.4 hrs. | 11.1 hrs |

red and injected, exceptionally with chemosis, a spastic moisis develops, while on the surrounding area of the skin of the face there is some degree of erythema, occasionally with swelling and blistering. In the acute stage, the cornea shows irregularities of its reflex and if stained with fluorescin, will be found to be stippled; a diffuse slight corneal haze may be seen in the severe cases of industrial photophthalmia, while a dendrite of ulcer has been reported following exposure to welding arc (Sykowski, 1951). The acute symptoms last from 6-8 hours; and most of the discomfort disappears in 48 hours; with more severe exposure they may last for some days. A certain amount of injection and photophobia usually persists for sometime, and if there is already present a chronic injection in the conjunctival sac, it may be superadding itself, keep up inflammatory symptoms of greater or less severity. After severe exposures some headache and slight disturbances may persist for weeks.

Chronic photophthalmia, as is seen particularly in the inhabitants of snowbound regions and in welders, who are frequently exposed to sources of light, rich in shortwave U-V rays, is often accompanied by functional visual disturbances and increased sensitivity to light, as well as sight of chronic blepharo-conjuctivities.

A bright sheet of aluminium reflects 90 percent of the U-V energy with a wave length of 300nm, whereas a stainless steel reflects only about 30 percent. Therefore the incidence of arc eyes among Aluminium welders were observed to be atleast 2 to 3 times compared to S.S. Welders in our published study.

It is apparent from Table 2 that the welders engaged in Aluminium welding are more prone to effect of high intensity of U-V rays, emanating from Aluminium Welding.

Susceptibility to flash varies and according to ROSS(2), 50 percent of welders state that they have never had it at all, 20 percent have it less than once a year and 8 percent more than three times per year. It is rather difficult to define a safe exposure to U-V rays in a welding process, and according to Pattee(3) et al this depends on : (i) the distance of worker from the arc, (ii) the angle at which rays of U-V energy strike the welder's eye, (iii) radiation intensity and (iv) the type of eye protection used by the worker. Bates (4) had estimated that a safe exposure would be 20 seconds at 7 feet and 17 minutes at 50 feet.

The international commission on illumination (5) has classified the ultraviolet spectrum into three different wave length bands, 315-400 nm (nanometers), 280-315 nm, and 200-280 nm. These ranges are also referred to as near, mid range and far U-V wave-lengths resp. (Table 3). Wavelengths below 200nm are of little biological significance, since U-V radiation in this region is observed in very short path length in air, with associated production of ozone (6).

**Wave Length In MU or Nanometers.**

Recent studies by US Environmental Hygiene Agency (ACGIH) on biological effects of radiation are summarised in Table 4.

Table 5 gives the recommended time v/s distance from the arc for safe operating condition.

**Table 6 :** Incidence of Visual Complaints in Welders and Control Group

| Complaints | Welders | Control Group |
|---|---|---|
| 1. Headache | 33 (35.8%) | 1 |
| 2. Eye fatigue | 3 | Nil |
| 3. Blurring of vision | 22 (23.9%) | 2 |
| 4. Temporary loss of vision | 14 (15.2%) | Nil |
| 5. Photophobia | 14 (15.2%) | Nil |
| 6. Lachrymation | 56 (60.8%) | 2 |
| 7. Gritty feeling in the eye | 16 (17.4%) | 2 |
| 8. Itching and burning | 43 (46.7%) | 2 |
| 9. Diplopia | Nil | Nil |
| 10. Pain in the eye | 38 (41.3%) | 3 |

**Table 7 :** Results of Eye Examination

| Eye Condition | Welders | Control Group |
|---|---|---|
| 1. Conjuctivits | 38 (41.3%) | 4 (12.9%) |
| 2. Kerato Conjuctivitis | Nil | Nil |
| 3. Pterygium | 4 | Nil |
| 4. Incipient Cataract | 9 | Nil |
| 5. Oedema of lids | 14 (15.2%) | 2 |
| 6. Arcus sensils | 3 | 4 (12.9%) |
| 7. Trachoma | 4 | Nil |
| 8. Corneal Opacity | 14 (15.2%) | 8 (25.8%) |
| 9. Nystagmus | Nil | Nil |
| 10. Squint Divergent | Nil | Nil |
| 11. Squint Convergent | Nil | Nil |
| 12. Erosis | 2 | Nil |
| 13. Sty | Nil | 1 |

**Incidence of visual complaints among welders**

A study was undertaken by Panjwani & Bhar (7) to find out the visual complaints among 92 welders and the control group 31 workers, belonging to some Socio-economic group, working in the same shop floors. This group included grinders, slingers, crane operators, fabricators. Some of the observations are given in Table 6.

In the incidence of eye complaints among welders, lachrymation, itching, burning and pain in the eyes and frontal headaches were the major complaints, presumably due to exposure to high radiant energy in welding. However 24 cases (25%) had no complaints at the time of investigation, in contrast to 27 cases out of 31 cases (87%) among the control group.

In Table 7 majority of welders had conjuctivities, commonly known as 'arc eyes' associated with oedema oil lids, while 14 cases showed old healed corneal scarring. Incipient cataract was noticed in 9 cases. In the control group 8(25.8%) cases have corneal opacities which were noticed particularly among grinders. 4 cases had conjunctivities, while no case had incipient cataract.

**Action of the Lens: Infra Red Thermal Radiation Cataract**

Experimentally lenticular opacities are produced in rabbits after exposure to large doses of filtered infrared derived from carbon arc.

A punctate subcapsular opacity appears in the anterior cortex after an interval from a few minutes to two days depending upon the intensity of the doses, with greater intensities the anterior and posterior cortex both become cloudy leaving the nucleus clear; with still greater intensities the entire lens becomes turbid. When the radiation is not massive, the opacities appear earliest and most readily under the iris; If however, the dosage is less intense and particularly if it is repeated, a delayed opacity in the posterior cortex may appear after a considerabe interval (16-37days). Finally, if repeated subliminal doses are given Meesmann (1930) and Goldmann (1932) founded that a posterior cortical opacity alone develpoed after some months. This experimental finding bears a close relationship to the clinical occurrence of heat cataract in industrial workers.

The clinical occurrernce of heat cataract is rare. The thermal action of radiant energy upon the lens is important in the discussion of the occurrence of cataract in industries where the eyes are exposed to infra-red radiation such as welding. It is interesting that Vogt (1950) reported lens opacities resembling heat cataract in man following treatment with infra-red rays.

Mendonca (1966) has, however, reported large incidence of (14.3%) heat cataract in workers employed in glass industry. He has observed posterior polar cataract to varying degrees of cortical cataract to full nature cataract in these cases. Significant incidence was found among carriers and glass blowers, who are exposed to radiant heat and were not using any eye protective equipments.

**Prevention of Infra-red Radiation**

Too much light is emitted in welding and this has to be reduced to enable the operator to perform his task properly, the problem involves clear sight and therefore measures should be taken to permit satisfactory intensity for visual acuity and comfort of the operator. Filters to permit proper visibility are necessary and these are graded according to visual density. These specifications of filters have been discussed earlier. They should protect the operator from radiation and save the operator from cataract and injury to the interior of the eye and yet maintain good vision. When $CO_2$ and other gases are used, there is higher omission of infra-red radiation. Therefore an additional shield or goggles containing metallic oxides which absorb 90% heat radiation. Dark Green colour is more effective than dark blue colour. Crokkes' 217 glass (consisting of 96.8% fused sodaflux, 2.85% ferric oxide, 0.35% carbon) cuts off 96 percent heat radiation but transmits 40 percent light. Hence it is most satisfactory.

**Management of Welders' Arc Eyes**

The treatment of photophthalmia is essentially prophylactic, in the great majority of cases, it occurs as an accident or the result of carelessness in omitting to wear protective glasses on all occasions. When exposed, short-wave radiations may be expected. Since the liminal energy threshold is considerable, very short exposure to the sources in common use are harmless, but it is to be recommended that short exposures are additive within a period of 24 hours and are therefore cumulatively dangerous, a point easily overlooked. Widmark first showed in 1889 that the clinical symptoms were prevented by a plate of ordinary glass, 0.5 cm thick and for exposure of ordinary intensity and short duration, a pair of simple spectacles, affords sufficient protection. With severe or prolonged exposures, however, it is found that ordinary glass is not sufficiently protective.

Once the photophthalmia has developed, little can be done to reduce the distressing severity of symptoms. 2 percent Novocaine or 4 percent Xylocaine or other ocular anaesthetics

may be used to minimise pain and blepharospasm; they however, must be used sparingly, since the local anaesthetics delay heating of the corneal epithelium. Use of cold compresses, reduces the accompanying paroxysmal pain, especially if applied from the beginning. Usually, however, this does not by any means give complete relief, in such cases an effective measure is to bathe the eyes with cold astringent lotion or even to immerse the head in cold water, a procedure which gives great, although only temporary relief. The installation of adrenalin or its substitues may abort the symptoms in mild cases in the early stages; Atropine or homatropine may be comforting, particularly if miosis is extreme; analgesics and antibiotics should be used to preclude the onset of infection.

In the eye, Von Rom (1949) mooted the possibility of protection by sulphonamide derivative, which absorbs U-V radiation.

A typical formulation of 'eye drops' fo welders' arc eyes, can be dispensed in the clinic for ready use:

**Common Arc Eye Lotion**

| | |
|---|---|
| Zinc Sulphate | 0.25% |
| Boric Acid | 1% |
| Adernaline | 1 2000 |

**Prevention of arc eyes and safety measures**

In discussing prevention, it would be wrong to speak about only the protection of eyes in isolation, as it forms part and parcel of protection of worker from industrial hazards in general. The welding injuries to eye will register a sharp decline, if industrial health in general is given more importance at all levels. The safety and health objects and responsibilities should be clearly defined at the corporate level and systematic prevention techniques should be employed.

There should be a general statutory obligation for employers to consult with their workers on measures for promoting safety and health. Quite often, the employer's defence is that he has pointed out the benefits of safety goggles etc. to his workers, but they are reluctant to use them. But one should be reminded that if a person comes to work in an industry, leaving his home and hearth, gets mixed up in an entirely new society, changes his mode of living, adapts himself to his new environment, learns about a new job, a new and different type of dress, he can also get used to the use of safety gadgets. What is required is the regular emphasis with necessity. Safety dose not come by chance or accident, one has to work for it.

**Recommendations:**

- The solution to the problem of protection of the eyes of welders does not invariably lie in shielding his eyes. For electric welding, use of specified glass filters are an industrial requirement in most countries. These vary with the type of welding. The limits of transmission allowed in the various grades between light and heavy welding, recommended as per British and USA standards. Welders and their helpers should always use protective goggles, shields or helmets which are provided with appropriate glass filters.

  The recommended grades (shade, numbers) for electric welding are given in Table 8.

- Section 35 of Indian Factories Act, 1984, requires that effective screens or suitable goggles shall be provided for the protection of persons employed on or in the immediate vicinity of welding process. These rules should be strictly observed.

- Carrying out welding operations by submerged arc welding as far as possible and do away with the need for protective devices, as the arc is fully enclosed.

- An alternative method to eliminate the risk of arc eyes due to exposure is to use a 1 KW Iodine lamp to project a very powerful beam (luminance of 1600 cd/m2) to help the welder to pick out the place, he wants to strike through his goggles. Once the area is clearly seen the iodine lamp can be switched off.

- Use of splash gaurds and welding screen:

  Wherever feasible, welding operations and machines that give off sparks, intense light and splatter of hot objects, should be screened effectively. Such screens should preferably have a clearance of about 25cm. at the bottom to facilitate natural ventilation; the use of gaurds should be insisted upon by the supervisors.

- Workmen not actually engaged in welding should be provided with spectacles type goggles with tinted glasses.

**Table 8 :** The recommended grades (shade numbers) for electric welding (British Standards)

| Grade | Shade Number | Amp | Size of electrode |
|---|---|---|---|
| E.W. 1 | 8 & 9 | 100 – 300 | 16 – 12 S.W.G |
| E.W. 2 | 10 & 11 | Overe 300 | 10 – 4 S.W.G & 1/4 in |
| E.W. 3 | 12, 13 & 14 | Current | 1/4 in and over |

- Use of dual purpose welding goggles or face shield, consisting of 'filter' and a lens of shatter proof plain glass. They are meant to protect the eyes from injuries from chipping operations or from hot metal spatter after welding.
- Maintenance of protective appliances: Both goggles and face shields get smudged and facilities to clear them on the job should be available. Goggles worn continuously by one person should be claened and sterilized at frequent intervals. Particular attention is needed to ensure that visibility is not impaired by scratching or pitting. Face shields and goggles should be kept in suitable containers, e.g wall boxes or cupboards when not in use.
- A well maintained 'First aid box' facilities to take the affected workmen to a good opthalmic unit, in case of serious eye injury should be arranged.
- Pre-employment and periodic eye check-up : To detect early development of presbyopia and cataract and treatment of his refractive error, a drop in his visual acuity reduces his efficiency and increases his liability to accidents.
- Apart from eye protection, the welders should also wear leather or asbestos gloves and flame proof aprons made of leather, asbestos, or other suitable material for protection against radiated heat and sparks and clothing should be reasonabely free from oil or grease.

**Environmental Hazards of Welding Fumes**

The fumes evolved during different welding processes have been proved to be potential hazards for many years. The extent of hazards thus associated is dependent on the quality of material present in the gas/vapour medium. The other factors relating to welding fumes are the size of particles and injurious properties of these particles coming in contact with human system. The various effects of fumes due to suspended metallic, non-metallic and reaction products have been studied by a large number of researchers thruoghout the world in great details.

The welding fumes comprise of :

(a) Gases used or caused in welding process.

(b) Metal fumes arising from the vapourization of molten metals and other fumes originating from the electrode coating.

(c) Fumes arising from the evaporation of substances on the work piece

The air contaminants can therefore be divided into two main groups:

(i) Particular substances like dusts, fumes, smoke, etc.

(ii) Gaseous substances like gases and vapours.

The respiratory system of a welder is not infrequently exposed to both gases and particulate matter.

The degree of hazard to the welders due to contamination depend on the composition of the fumes and gases and their concentrations in the air which he is breathing.

The composition of the fumes and gases depends upon the process and the composition of the consumables and the material being welded, including any surface coating and dirt.

The concentration of the contamination depends on the amount of fumes produced, these depending in turn on the process; the type and size of the electrode; the duty cycle; the current: the dispersal of the fumes (that is the natural air movement or mechanical ventilation); how close the welder is to the arc; the configuration of the workpiece and the degree of confinement of the working space.

There are wide variations in concentrations across the rising cloud of particulate matter and gases, and these concentrations will also change with time, because of the intermittent nature of most welding processes.

**Metal Fume Fever**

A 32 year old welder had reported to the 'Plant Medical Centre', with a history of severe headache, cough, dryness of throat and general myalgia and shivering since previous night. When he reported for next morning shift, he complained of headache, body pain, fever, tightness in chest, profuse sweating and felt very thirsty. Clinical examination revealed congested throat, coated tongue, mild bronchospasm: the worker continued to have fever with chills and sweating during the next day, which ultimately subsided the following day. He was treated for an acute attack of 'Influenza' but a retrospective diagnosis of 'metal fume fever' due to inhalation of copper fumes was made after the analysis of copper fumes was known in his work place. The investigations into the working environment of the welder, a few days after the attack, revealed that he was engaged in welding of the peripheral ends of a number of 'U' 'tubes, inserted inside the U-shaped 'heat exchanger', with bare 'monel' electrode (nickel +copper alloy) wire at both the circular ends of the 'heat exchanger'. The welding is done over a block in an

atmosphere of argon. The operation is automatically controlled but this welder had to be in close proximity of the arc, with only a glass filter in front of the eyes, instead of regular head shield. It is quite apparent that this welder was inhailing the metal fumes emanating from the burning of the monel electrodes.

Various air samples from the welder's breathing zone were collected during monel welding operations. Nickel and Copper fumes were collected in diluted HCL by midget impinger. Nickel was analysed calorimetrically by dimethyl-gloyxime method and copper by diathizone method. The results of the air samples are given in Table 9

It may be seen from Table 9 that the airborne concentrations of nickel has been below the TLV of 1 mg/m3 as recommended by the American Conference of Government Industrial Hygienists, while in case of copper fumes, it has exceeded the limit of 0.1 mg/.m3 - this in all probability resulted in a solitary case of 'metal fume fever' due to copper fumes, in the welder.

**Welding fumes in Aluminium Welding**

A total of 12 welders engaged in aluminium welding were examined physically. Routine blood counts and chest X-Rays were taken. A detailed H/o present symptoms and past evidence of respiratory and eye complaints as recorded in the 'medical case records' were taken.

Various air samples for estimation of ozone and nitrous oxide from the welder's breathing zone were collected during aluminium welding. However, no samples of aluminium oxide were taken.

Pattern of symptoms among all the aluminium welders were: Frequent dry cough, throat irritation, chest pain, anorexia and epigastric discomfort. Ophthalmic symptoms revealed conjunctival irritation, lachrymation, photophobia.

It is seen from Table 10 that the air borne concentration of ozone has exceeded the TLV limit of 0.1ppm -in contrast to the concentration of nitrous oxide, which is within TLV limits.

The chest X-Ray pictures in 4 out of 12 welders showed reticular pattern, particularly over the mid zones there was no evidence of nodular formatrion. All the welders are non-smokers.

**Treatment of Metal Fume Fever**

There is no specific treatment for the uncomplicated metal fume fever attack. Bed rest and salicylates can be given in the more severe attacks (Anseline, 1972) along with antibiotics. Milk and antacid preparartion may be given for relief of nausea, heart bum and vomitting (Papp-8 1968). Corticosteriods have been recommended for metal fume fever caused by zinc fumes (Driesbach-9, 1969).

**Study of lung function test among welders**

In our study of lung function tests among welders (Panjwani, 10 1984), it was proposed to deal with (a) the pattern of lung disability (b) and the effects of smoking in arc welders.

A preliminary study of 41 workers engaged in arc welding work having more than 10 years of exposure and healthy un-exposed males as control group were taken into study on random basis.

They were interrogated in detail abuot the electrodes in use, smoking habits and respiratory symptoms with their relationship to work was noted. Detailed clinical examination, X-Ray chest in all were carried out and reviewed. Lung functions in the form of timed maximal expiratory spirograms were measured and corrected to BPTS.

All 50 workers were males with a mean age of 37 years, with range varying from 29 to 53 years, which was comparable with the control group. Out of these 41 workers, 18(14%) were smokers including 5 heavy smokers (over 20 a day) (12%), while in control group all were non-smokers.

Mean exposure period to welding fumes and gases was 16.3 yrs . Table 11 shows mean values of various readings of lung functions. As it is clear from the table, there is a gradual decline in lung functions from control gruop of heavy smokers. It shows somewhat higher incidence of minimal obstructive pulmonary impairment than restriction. Incidence of this obstructive pulmonary disablity was mainly in smokers and difference was not significant, if the welders did not smoke. Thus it appeared

**Table 9**

| Operation | Contaminant | Avg. Air borne Concern | TLV |
|---|---|---|---|
| Monel wire arc welding | Nickel | 0.2 mg/m3 | 1 mg/m3 |
| Monel wire arc welding | Copper | 0.8 mg/m3 | 0.1mg/m3 |

* The results are based on a single sample covering cycle of operation at the process was arranged for the study. The operation is carried out as and when required.

**Table 10 :** Results of Air Samples in Aluminium Welding

| Operation | Contaminant | Avg. Air borne concern | TLV |
|---|---|---|---|
| Al. welding | Nitroxide | 5 ppm | 5 ppm |
| Al. welding | Ozone | 0.15 ppm | 0.15 ppm |

**Table 11 :** Mean Lung Functions

| | No. | FVC OBS in ML | FVC OBS % FVC Pred | FEV in ML | FEV % PFV | FEF (MEFR) (200-1200) Lit/min | FMF (MMEFR) (25-75) Lit/Min |
|---|---|---|---|---|---|---|---|
| Control | 9 | 3300 | 97.10 | 2810 | 85.6 | 375 | 188.8 |
| Welders (NS) | 23 | 31.70 | 96.64 | 2460 | 77.8 | 202 | 149.4 |
| Welders (S) | | | | | | | |
| Mild | 6 | 2833 | 87.62 | 2266 | 75.5 | 230 | 151.6 |
| Moderate | 7 | 3642 | 109.00 | 2485 | 68.2 | 224 | 141.7 |
| Heavy | 5 | 2280 | 71.00 | 1700 | 74.5 | 198 | 150.2 |

Minimal PFT (OBST, REST) Disability ● Smoking welders show cumulative effect ● Heavy smokers show both Obst + Rest

that mal-effects of smoking and welding fumes of PFT might be cumulative and welding is not hazardous in lung function disability point of view inspite of long exposures. Some minimal restrictive disability was seen in heavy smokers, meaning that this group has high risk of lung fibrosis and hence need proper evaluation before employment.

**Control of Welding Fumes**

Wherever possible, welding operations should be carried on in a closed process like submerged arc welding ; if that is not possible, then an efficient local exhaust ventilation system must be provided at the welder's work place. A portable exhaust ventilation may also be used to remove the fumes at the sources, and this ventilation can be carried along with the work, form place to place. This is very convenient if the welding is done in confined or poorly ventilated places, such as tanks, boilers. Special attention to ventilation is essential in working with metal that has high zinc content, like galvanized pipes or if the steel contains cadmium, which is very toxic or if the flux contains fluorides.

Respirators should be worn by the operators, particularly if the exhaust blowers are not quite efficient or if for some reason, they cannot be used; some workers however, find the use of repirators as uncomfortable. It would be well, therefore, if talks could be given to the men and particularly to the foremen and the shop worker leaders, in order to obtain their intelligent co-operation in the use of their safety measures.

The recent development of a fully integrated 'welding rod smoke exhaust system', which is possible with the cored wire process, without disturbing the gas shield or the integrity of the weld, could prove to be a significant advance in protecting the welder from fume exposure. This type of rod reduces the quantity of fumes emitted at the arc.

Finally, little modern research has been carried out on the subject of the metal fume fever, possibly because of the short duration of the usual uncomplicated attack.

Further research could provide the answer to many of the enigmatic points and result in the better understanding of the causal mechanism which would, in turn, contribute to the preventiion of this usually short but unpleasant condition.

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