

# ENVIRONMENTAL & SAFETY ASPECTS OF WELDING IN 2000 AD

by  
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Presented at the Seminar : Welding Mechaneries, Accessories &  
Consumarables — Safety & Environment, Calcutta 26.6.96

## ABSTRACT

Welding is over two centuries old and in few years enters 2000 AD. All Technological Advancements have blessed this section of Engineering and presently more & more emphasis are given onto the Safety & Environmental Aspects to make Welding Truly "Eco-friendly". In the present article, the author has endeavoured to unveil the curtain over the great centre-stage - the subject covers Safety & Environmental Data related to Welding & Metal Joining have been discussed. Welding Fumes & its Extractions, Local Exhaust Systems, Medical & Health Hazards faced by the Welders, Occupational Hygienes in Welding - are other few subjects the author has touched upon.

## INTRODUCTION

Welding is all about joining two into one - may be metal or non-metal. The processes which are used to accomplish the joining give rise, alongwith other effects, some Safety & Environmental effects. And these, now-a-days, are vigourously receiving the attention of all with a desire to combat for a better safe welding/working environment.

Safety and Environmental considerations today tend to control, guide & develop any engineering process that affects both men and environment and welding is not out of the target. Reasonably, thus, worldwide attention of Environmentalists, Safety/Occupational Hygienists & Risk Management Experts are bringing out the subject to a new light and to place it on a new height. We may progress here to examine the correctness of this attention.

## Safety & Environmental Aspects of Welding : <sup>[1],[2]</sup>

Table I : may present the outline :

Welding & Metal Joining		
Safety Hazards	Environmental Hazards	
<ol style="list-style-type: none"> <li>1. Heat Burnt</li> <li>2. Fire Hazards</li> <li>3. Electric Shock</li> <li>4. Eye Damage</li> <li>5. Hearing Loss</li> <li>6. Health/other Hazards</li> <li>7. Spatters Hazards.</li> </ol>	<ol style="list-style-type: none"> <li>1. Spark Pollution</li> <li>2. Light Pollution</li> <li>3. Noise Pollution</li> <li>4. Radiation Pollution (for Laser etc.)</li> </ol>	<ol style="list-style-type: none"> <li>1. Welding Fume/ Gas Pollution</li> <li>2. Heat or Thermal Pollution</li> <li>3. Welding Testing Equipment Pollution (X-ray, Ultrasonic, Dye-Penetration)</li> <li>4. Welding Area/ Work Environment Pollution (with Dust/Aerosols/ Particulates)</li> </ol>
Affects Occupational Safety	Affects Human Eye/ Visions / Hearing	General Health/ Env. Pollution

## Health & Safety Regulation : <sup>[2]</sup>

Lie on Employers & Industry-Planners. Recent Researches are going on :

A) Offering Advance-Design Safety Equipment.

B) Imparting Personal Training to Welders on Personal Safety & Occupational Hygiens.

C) Deducing importance of Health Surveillance of Welders.

- D) Development of Environmental Release Estimate for Welding Operations.
- E) New Generation of Low-Fuming, Gas-shielded Flux Cored and Metal Cored Wires.
- F) Development of Eco-friendly Power Source as it has influence on particular fume generation & its toxic composition.

**Table II : Ten Simple Eco-Friendly Rules for Safety of Welders ;** <sup>[1], [2]</sup>

### 1. Personal Training

Welders should be trained/instructed in methods & steps of avoiding electric shock, eye injury and enhancing personal safety. It is very important, that one of the languages for all instructions be in his mother-tongue.

### 2. Personal Safety <sup>[2]</sup>

Welder should always wear (i) Shoes (Fire-resistant lagging high boots. Lower-cut shoes with unprotected tops shall never be used) & (ii) Goggles (iii) Gloves (iv) Flame-proof Aprons (against radiated heat & sparks) (v) use Head Cap or Gear or Helmet (with adjustable band to fit welder's head) and (vi) Shoulder covers made of leather/suitable other materials - during overhead welding or cutting operation. Self-ventilated, solar powered head gears are available in advanced countries.

For eye-protective goggles, material shall be heat-resisting, non-ignitable & impervious to the harmful ray. No metal frame, non metal rivets (metal being good conductor) be used for the goggles/glasses.

3. It shall be strictly prohibited to use any compressed gas or air to clean dust, dirt etc. of welder's cloths when those are being worn.
4. Walls of Welding Bay should be painted with a non-reflecting colour to prevent flickering reflections such as zinc-oxide or lamp black.
5. Loose connections of all welding/allied machines & proper Earthing (as per Electricity Rules, 1956) be checked. All electrodes shall be removed from holder when job is suspended & machines be off from power source/torch from gas supply for Arc Welding & Cutting, Electric Holders shall conform to IS : 2641-1964. Auto or Semi-Auto Resistance Welding Machines shall be equipped, as far as practicable, with gate guards or two handed tipped devices.
6. Fire and Heat-burn to be avoided. Noise Pollution from allied machines and surroundings to be reduced thereby allowing the welders to concentrate.

7. For welding in a confined space, use a Low Voltage safety device to limit the voltage available at the holder to approx. 25 V. For Manual Metal Arc Welding, Power source should function with a minimum no-load voltage (BS-638). Power source should have an internal or external hazard-reducing device to reduce no-load voltage.
8. **Oxygen shall never be used as substitute for compressed Air. Serious accident may happen.** Cylinders shall not be dropped. Hose shall be free from oily or greasy substances. Accidents due to tripping caused by welding hose lying on floor to be avoided. For welding of Oil Drums and Motor Car Petrol Tanks, they should be thoroughly dried, degreased, rinsed with hot water etc. before welding.
9. All welders should be thoroughly examined periodically, their medical history be monitored and nutritious foods or drinks (milk) etc. be given for long-term exposures.
10. Proper ventilation, local exhaust, fume extraction and good illumination level be maintained to improve overall and work zone environments. It is important to extract welding fumes before they reach breathing level of the welders.

## ENVIRONMENTAL ASPECTS

Environmental Protection in Welding should be more and more relevant in 2000 AD due to more popularisation of :

- Laser Welding / Cutting
- Plasma Welding / Cutting
- Alloy Metal Welding (Ni, Pb etc. contributing toxic metal fumes).
- Plastic Welding.
- Robotic Welding.
- Space-Tech. Welding.
- Development of Cold Welding (Multi-Metal, Germany).

## ENVIRONMENTAL ASSESSMENT

For welding fumes and gases it is of utmost importance to determine the level of exposures of the welders. Studies are conducted using (i) Personal Sampling Techniques (ii) Work Zone & Microclimate Study (iii) Medical Surveillance Study (short & long term for Chronic Diseases).

## ENVIRONMENTAL MONITORING

It's the key element in preventive measures. Welding Pollution Levels are highly variable depending on many factors, such as :

- Operating conditions of welders.
- Characteristics of work environment.
- Technology of welding process used.
- Geometric characteristics of welded parts.
- Ventilation, exhaust and aspiration systems (both at local level and generally in work environment).
- Exposure duration and concentration.

## GAS OR FUME GENERATION IN WELDING

Beside others, it depends mainly on :

**Table III : Average Gas & Fume Concentration in Typical Welding Process** <sup>(4)</sup>  
(Back Ground Measurement)

Welding Process	Gases (ppm)			Ozone	Fumes (mg/m <sup>3</sup> )		
	CO	CO <sub>2</sub>	Oxides		Fe	Cr	Mn
<b>Manual Metal Arc</b>							
a. Carbon Steel (Low H <sub>2</sub> Electrodes)	-	-	2.05	-	2.8	0.017	-
b. Mild Steel (Low H <sub>2</sub> Electrodes)	10	-	2.10	-	2.72	0.008	0.62
c. Low Alloy Steel	20	-	1.80	-	3.05	0.060	1.78
d. Stainless Steel (SS Electrodes)	20	-	1.90	-	3.01	0.053	1.08
<b>Submerged Arc Welding</b>							
a. Cast Iron	5	4	1.00	0.06	2.10	0.031	0.87
<b>CO<sub>2</sub> Welding</b>							
a. Mild Steel	5	7.6	1.18	0.04	1.10	-	0.23
<b>T J G</b>							
a. Mild Steel	-	-	2.18	0.07	1.76	-	0.58
<b>Plasma Arc Welding</b>							
a. Mild Steel (Stellite Power Spray)	-	-	2.00	0.05	2.10	0.001	-

- a. Angle of electrode holder with respect to the job.
- b. Proximity of electrode holder into the Job.
- c. Temperature of Welding/Pre-heating of the job.
- d. Shape of geometry of the Job.
- e. Type of electrodes and Flux covers.
- f. Current value in Amps.
- g. Welder's personal expertise and Job-training.

In **Table III** "Average Gas & Fume Concentrations in Typical Welding processes" have been presented based on Back-ground Measurement.

And in **Table IV** "Welding Fumes — Their Sources & Hazards" have been presented-mainly covering medical and health effects in general.

**OBSERVATIONS**

- a. Total Fume Concentrations are below the Threshold Limit Value (TLV's), excepting for Mn & Cr which exceeded (in two cases) the TLV'sy. However, exposures did not show any positive result in the welder's body fluids and usage of such electrodes is also limited.
- b. Numerous present day welding processes involve a great variety of physico-chemical reactions with emission of either particles (Fe, Cr, Mn, Si, Ni, Cu, Zn, Co, Pb, Cd, Mg. etc) or gases (Co, Ozone, Oxide of N<sub>2</sub> etc.)

**Table IV : Welding Fumes : Their Sources & Hazards**

Type of Fumes	Health Hazards and Risk alongwith affected Organs
Iron Oxides	Major Welding Fumes and Respiratory irritants. Long-term Exp. can cause Siderrosis (deposit of Iron Oxide on lungs) - visible on X-ray but believed to have no harmful consequences. Main affected parts : Nose, Throat, Lungs.
Copper	Causing 'Metal Fume fever' similar to Zinc & Galv. surfaces. Irritation of Nose, Throat and Nausea.
Fluorides	Found in many electrode fluxes and coatings. High conc. over long period causes Pulmonary Oedema and Bone damage. Eye, Nose & Throat irritation, Skin rashes, etc.
Cobalt	Some report : Respiratory diseases ranging from coughs and shortness of breath to permanent disability. Affects Nose, Throat, etc.
Cadmium Oxide	Short-term exp. in high conc. (0.5 mg/m <sup>3</sup> ) or more causes irritation of breathing passage-way and Pulmonary Oedema (fluid in lungs). At conc. of 50 mg/m <sup>3</sup> - reaction is fatal though delayed. Long-term low conc. exp. can lead to Emphysema, a disease which affects the ability of the lungs to transfer oxygen to blood stream and also damages Kidneys.
Lead	Welding of alloys containing lead or with lead based paint generated excessive conc. of Lead in fume. Symptoms : loss of appetite, a metallic taste in mouth, constipation, anxiety, muscle and joint pains and colic. Chronic exp. damages Blood forming processes, Nervous, Urinary and Reproducing systems while seveal Lead-poisoning may damage Central Nervous System and Kidneys, possibly causing Anaemia and Muscular paralysis.
Nickel	Nickel Exp. may follow Dermatitis and Respiratory Irritation. Welding Nickel Fume is generally of low conc. but caution be taken for St. or Alloys with high Nickel while welding.
Vanadium	Comes as component in some Electrode coatings, in steel and in some fuel oils. Affects Respiratory System. Produces Bronchities, Emphysema, Pulmonary Oedema or Pneumonia.

**Table IV Contd...**

Type of Fumes	Health Hazards and Risk alongwith affected Organs
Molybdenum	Long-term effects are not known yet but short-term exposure can cause eye, nose and throat irritation.
Magnesium	Welders exposed to magnesium oxide, though not usually seen in hazardous concentrations, may suffer from 'Fume Fever'.
Manganese	Found in many Electrodes and steels, Large-doses of Manganese poisoning (serious) may produce 'Pneumonia like disease' & small-doses of long-exposure may result in 'Nervous System Disorders'.

- c. Both Back-ground Monitoring and Personal Sampling of Welders are done at periodic intervals and all welders go for periodic medical check-up once in every 3 years.
- d. Lack of past data, trained manpowers in developing countries are bigger handicaps in carrying out Epidemiological studies.
- e. Long-term perspective studies are called for to arrive at a full-proof remedial action.

**RECENT ADVANCEMENTS IN WELDING FUME EXHAUST SYSTEMS**

**Old Expensive and not so reliable Fume Extraction Hoods** - now are replaced by a system which enables to exhaust the fumes directly at their source i.e. right above the arc. The efficient arrangement of the suction holes avoids any influence on the shielding gas atmosphere. It is therefore assumed that quality requirements with respect to weld seam are met.

**Work Stations, Lamina Flow Bench etc. (as per U.S. Federal Std. 209E)** : They will be in more and more uses. Enclosed Work station with HEPA Absolute Filters, Prefilters, Built-in Blowers etc. will enhance work environment by controlling welding fumes/gases at source. However, uses may be limited for precision light welding operations.

**Plastic Welding Fume Extraction<sup>[3]</sup>** : TWI of UK has carried out first hand studies, on behalf of Health and Safety Execution, UK on fumes involving substances given off by PVC, PA, PMMA, PC and PP materials during hot gas welding. It measured welder's personal exposures and found in all cases that these were very much lower than current Occupational Exposure Limits (OEL). Fume Sampling Techniques to monitor plastic fumes concentration levels during hot gas welding also developed in the process.

In addition, measurement of particles which can be inhaled was

carried out close to the welding operation. Modest concentrations were found for PVC and PP, while for remaining materials, concentrations were low.

The Second TWI investigation was made for CO<sub>2</sub> Laser cutting a range of Plastics including PVC, PC, PMMA, and Epoxy/Glass Fibre composites. Laser Cutting of all materials produced high concentration of particles which might be inhaled and all but epoxy/glass fibre composites produced high concentration of volatile substances, Results indicated there might be risk that welder engaged in laser cutting of plastics exposed to unacceptable levels of hazardous substances.<sup>[3]</sup>

**Modern Fume Removal System** : By some mechanically forced ventilation it produces current of fresh air in the immediate area. **Air Direction should be from welders face towards the workpiece.** This is best achieved by Localised Exhaust Ventilation using a suitably designed Hood nearest to the welding Area.

**WELDING HAZARDS AND MEDICAL EFFECTS**

**Chronic Diseases :**

Chronic Bronchities, Bronchial Asthma, Allergic Bronchities

**In One Study :**

It has been observed that 5.55% of ex-welders, who were smokers, have chronic Bronchities while only 2.08% of non-smoker

Table V

Welders	%	Prevalence of Respiratory Diseases	Reduction in FEV1/FVC% below 75%
Smoker	39.08	4.77%	1.83%
Non-Smoker	60.92	3.06%	1.88%

NOTE : For above Table V, Processes studied : Manual Metal Arc, Gas Metal Arc (CO<sub>2</sub>) & TIG & Materials covered : Carbon Steel, Alloy Steel, Stainless Steel.

ex-welders, who were non-smokers have it.

**Distribution of Respiratory Morbidity in Welders :**

Respiratory Morbidity is more for smoker welders and smoker ex-welders. As per one BHEL Trichi study ('85-89) covering a few hundreds of welders, the following observations were available;

Each welding technique and application produces a characteristic range of particulate composition and morphology.<sup>[4]</sup>

No significant differences were observed among welding processes or materials. Study were spread over 5 years.

Principal effects of welding fumes were found on small Airways or bronchisles. Remedy : Flow-volume cure and/or measures of Peripheral Airway Ventilation might be more justified for welders. Similar results were also marked from one old study on Danish Welders.

**In UK Control of substances Hazardous to Health Regulations : 1994**, would take care of similar Medical/Health Effects.<sup>[2],[3]</sup>

**Welding Toxic or Noxious Dusts or Particulates :**

In contact with Physiological fluids (saliva or mucose membrane) product poisonous solutions that are likely to cause acute intoxication or chronic poisoning.

**Weld Surface Finish & Industrial Hygiene :**

Weld surface finish plays vital role in Food processing Industry. Modern welding method and equipment are capable to produce welds with excellent surface finish. Corresponding Research on Bio-film Development proved that Bacterias common in the food industry were less likely to adhere to these welded surface than to the ground and polished weld and parent materials. Hence, costly practise of grinding and polishing of high quality welds for food processing industry may be avoided.

Development of Bio-film on different welded surface has been evolved (Robotics are used for Food Processing Industry). Surface features have direct influence on Bacterial attachment to and persistence on Stainless Steel by Plasma Arc Welding,

further improvement of surface finish is possible.

**Occupational Exposure Limit (OEL)**

Varies with nature of materials being welded.

Recommended OEL for plain Carbon or low Alloy Steel is quite high (5mf/M<sup>3</sup>) while OEL for St. St. Hard Facing Alloys, Nickel or Copper based Alloys is very low (0.2-0.5 Mf/M<sup>3</sup>).

**How Welding Fumes & Gases behave medically :**

Visible Fumes appearing during welding process consist of solid particles generated due to condensation of volatile molted substances. Larger particles settle as Dust - Fall but smaller particles (less than 0.1 µm in dia) remain in the air for a very long time and not be very easily visible. Such small particles are continuously irritant and can be a health hazard on prolonged exposure to welders. It is important to extract welding fume before it reaches breathing level of the welders. Other parts of it go in lungs and balance goes in lymphatic system causing serious health hazards depending on the nature of the particles.

Gases are present during welding either as a by-product or as a surplus shielding gas. These may be potentially toxic or asphyxiant; the latter occurring where a build-up of shielding gas in a confined space leads to shortage of air.

**TECHNOLOGICAL  
ADVANCEMENT TO OFFER  
"ECO-FRIENDLY" WELDING  
SAFETY AIDS AND  
EQUIPMENT :** [2,3,5,7,8]

**Welding Fume Extraction and  
Other Units :**

One U.K. firm is offering Welding Fume Extractors, Dust Extractors, Welding Curtains, Self-Retracting Hangers and Fully Adjustable Auto-darkening Welding Helmet (combining practicality and Ergonomic design).

As soon as the welding arc is struck, the lens of the Auto-Darkening Helmet changes from light to dark; the variable filter protecting against light, spark and noise. Electronic/Solar panel avoids the need for battery. Clear visibility, comfortable-wear and hands-free operation allow safe and efficient operation even for Plasma Cutting and TIG Welding.

**Welding Fume Eliminators :**

Fume Eliminators rapidly remove welding fumes and welding particulates, filter and clean them and blow clean air into the working area-to comply OSHA requirement. Other advantages : Welders may see better, work better and job quality improves, reducing welder's fatigue. Light-weight and carryalong type - these eliminate permanent venting system available with single or double hood with a down draft table<sup>[5]</sup>.

**Fresh-Air Respiratory System :**

Auto-Darkening Welding Helmet manufacturer has marketed new Respiratory system-available with both gas and particle filtration and a range of different Auto-darkening welding filters for eye-protection, Innovative features include : (i) electronic flow control system, which regulates the flow of air to the users and provide a constant supply independent of dust loading on filter; (ii) flow can be preset @ 160-200 l/min. Flow control over-comes the disadvantages of more conventional unregulated respirators which often have unpleasantly high flow rates when used with new filters (iii) a built in alarm gives warning of low battery condition or a low air flow associated with the need to change the filter (iv) further line enhancement of particulate filters can be achieved by fitting a prefilter, which removes larger particles from dirty air.

**New Range of Welding Fume  
Filter :**

Alongside sufficient extraction performance at source of fume it features an effective cleaning system. Extracted welding fume particles are deposited on the outside a concertina type filter cartridge cleanable by hand-held compressed Air-cleaning GUN. Designed for permanent and repeated uses.

**Hi-Tech Electrostatic In-Plant  
Pollution Control Device :**

To extract Welding Fumes, Smokes, Toxic Vapours. Available in 3000 m<sup>3</sup>/hr self-contained units to centralised 1,00,000 m<sup>3</sup>/hr. Units. Portable (smaller units) with flexible hoods are also available.

**Next Generation Welding  
Helmet :**

This waterproof, corrosion proof, translucent Helmets with Active Filter for ultimate comfort are now available.

**Fully Auto-Multishade**

**Welding Mask :**

These types of Mask are Solar Powered, auto - darkening from DIN 4 to multishade 10-12, thin (4 mm) and light-weight suitable for rough environment, waterproof, shock-resistant and fitted with fully auto switch.

**Gloves Designed for**

**Flexibility & Cut-Resistance :**

Comes in heavy and medium duty types. Made of high performance fibers to produce comfortable, flexible, cut-resistance gloves. Available with slip-proof polyurethane pattern, bonded to the surface.

**New Series of Welding  
Shields (Designed as Mig-It):**

This new series can be fitted to any Welding Torch. It deflects sparks and Spatters and protects Eyes from Arc-exposure. Available in range of lenses from 8 to 12 shade number.

**Protex Flash-back Arrester :**

These have been introduced to avoid Gas Cylinder explosion. During weld, due to defects in gas-torch, flashback occurs and hot flame spreading out at the speed of 10,000 km/hr. strikes Gas cylinder and explosion takes place. When this type of arrester is fitted with Gas torch, it will cut gas supply from cylinder and flame be arrested. Introduced in USA, 10-11 years back, it is now popular in Europe and other countries. Latest Nozzle-mixing technology virtually eliminates backfire possibilities as gases are mixed in the nozzle only. Light weight, ergonomic design : reduces welder's fatigue and increases efficiency. <sup>[7]</sup>

**Advanced-Designed Servo — Controlled Spot Welding Gun :**

Reduces weld spatters and time.

**Protective Aids for Welders :**

One of World's leading protective-aids, offers for welders-hearing protection, Eye-protection and Respirators. Earplugs are used widely for welding. Disposable Respirator range and IR/PC Eye-wear Range (using Bilsom's Revolutionary Light Absorbing, Light Protection Technology) - are other aids available.

**Ultrasonic Plastic Welding Machine :**

These are for performing various operations in plastic welding, riveting and spot welding. Suitable for Mass production, it is a clean

process and completely eliminates the necessity of adhesives and toxic solvent.<sup>[7]</sup>

**Torch Exchange System :**

Developed and used by IGM RoboterSysteme AG, Vienna, Austria : Useful for higher flexibility to suit multiple torch fitting requirement for different job environments.

**Anti-Spatter Spray for Welding:**

Is a non-flammable antispatter liquid suitable for all types of welding. Highly effective on MIG and TIG tips to prevent spatter build-up. It provides quick and easy means of anti-spatter spraying on to the work surface prior to welding. It eliminates the need of chiselling, wire brushing or grinding after welding.

**Eco-friendly Electrodes :**

Eco-friendly electrodes have been developed in India with German collaboration, Low-emission electrodes help control emission of poisonous gases during metal welding. New Rutile-coated electrode is believed to be suitable for deoxidising and refining the welded metal, unlike conventional electrodes which generate harmful gases.<sup>[8]</sup>

**Welding Safety Equipment :**

In India following equipment are also available (i) Air Stream Anti-Dust Helmet, (ii) Jupiter Powered Respirator (iii) Firefly Automatic Personal Distress Alarm, etc.

**Safe & Fuel-Efficient Cutting Torch :**

In early '95, the Nozzle Mix Technology was introduced in India, for Fuel Saving and Safe Cutting, which is widely employed in UK, USA, Japan, Australia and South East Asian Countries. Several Advantages : safe, enhances production, ensures smooth cuts and fuel saving.

In the torch, the explosive pre-mix of gases takes place only in the tip of the nozzle. Small amount of Oxygen and Acetylene or Oxygen and Propane enters the nozzle through separately drilled holes confining the mix to the tip of the nozzle. Experimental results reveal rise of 40% in cutting speed and 40% fuel saving.

**Disposable Welder's Respirators :**

Health and Safety Executives, UK, approve maintenance free disposable welder's. Respirator for protection against dusts and it meets BS 6016 Standard. It protects from Metal Fumes as well as Ozone generated by Carbon Arc. MIG/MAG and TIG. It replaced the older Rubber Cartridge type - as it is light weight, comfortable, low cost and requires no maintenance, cleaning or inventories of Spare parts. It provides welders to breathe, talk and can be worn with Goggles and Face shields without restricting vision.<sup>[3,6]</sup>



### Use of Shielding Gases :

Knowhow & supply of shielding Gases for high productivity (30%) and lower Welding Fume levels are available. Small quantity of Nitric Oxide is introduced into the arc region, which react with ozone-giving Oxygen and NO<sub>2</sub>. (less toxic gases than ozone).

### CONCLUSION

#### Environmental Comfort and its impact on Welding :

Environmental comfort is very important in welding field like others, for productivity factor. Any discomfort may lead to :

- Lower Efficiency.
- Permanent Fatigue

- Carelessness or in attentiveness.
- Accidents, Injury, Infirmity, or
- Other Occupational Diseases.

All these would result in social loss; social unrest and irritation; quality degradation; uncertainty of job-completion period and overall negative balance sheet on all counts.

It is, therefore, desirous that all attention should be given to Safety and Environment of Welding and thereby helping the growth of this branch of engineering in full by 2000 AD. Afterall, welding unites two (or more) into one and we have to safeguard that "union" for ever as "Eco-friendly safe end-product".

### REFERENCES

1. Encyclopaedia of Occupational Health & Safety, Vol.2, Int. Labour Office, Geneva.
2. Environmental Hazards in Welding & Metal Joining - By Anupam Haldar, National Seminar, IIW, Calcutta 1995.
3. TWI Connect, Issue No. 73, Jan'96, Cambridge, UK.
4. SOJOM-'91, Seminar Proceeding, IIW, Trichi.
5. Weldex News, Nov./Dec.'95, UK.
6. Joining and Materials, UK (Lesley Ashburner 3M Occup. Health & Env. Safety).
7. Industrial Products Finder, Sept.'95, Jan'95, Feb.'95, Jan'96, Bombay.
8. The Economic Times, May 17, '95, Oct. 20, '95, Calcutta.

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**Manufacturers of Quality Grade  
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HYDROCEL GRADE	TYPE OF ELECTRODES	PERCENTAGE OF HYDROCEL
HYD 006	E-6010 & E-6011	25 TO 40
HYD 006, ST 005, STY 005	E-6012 & E-6013	2 TO 5
HDY 006, ST 005, STY 005	E-6020 & E-7024	1 TO 5