Temperature changes in contact lenses in connection with radiation from welding arcs

by Lövsund P, Nilsson SEG, Lindh H, Öberg PÅ

Affiliation: Department of Ophthalmology, University Hospital, University of Linköping, S-581 85 Linköping, Sweden.

The following articles refer to this text: 1979;5(3):167-306; 1979;5(3):167-306

Key terms: contact lens; corneal damage; occupational safety; radiation; radiation hazard; soft contact lens; temperature; temperature change; welding; welding arc; worker safety

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/20120575
Temperature changes in contact lenses in connection with radiation from welding arcs

by PER LÖVSUND, M.Sc.E.E.,1 SVEN ERIK G. NILSSON, M.D., Ph.D.,2 HANS LINDH, O.O.,2 and P. ÅKE ÖBERG, Ph.D.1

LÖVSUND, P., NILSSON, S. E. G., LINDH, H. and ÖBERG, P. Å. Temperature changes in contact lenses in connection with radiation from welding arcs. Scand. j. work environ. & health 5 (1979) 271—279. Because of reports of risks associated with the use of contact lenses during exposure to welding arcs, the temperature changes in soft contact lenses were recorded in connection with certain types of welding [manual metal arc (MMA) welding, tungsten inert-gas (TIG) welding, and metal inert-gas (MIG) welding], both with free-hanging lenses and lenses applied to the eyes of anesthetized rabbits. A great increase in temperature was noted, especially with MMA welding. At a distance of 0.4 m the temperature of a lens on a rabbit eye rose from about 35 to 50°C within 6 min, whereas the air temperature only increased from 23 to 30°C. The increase was the greatest at the beginning of the welding period. Most of the lenses completely dried out during the experiment, and there would seem to be a potential risk that the lens would adhere to the cornea. One safety glass screen (DIN 10 A) proved effective in preventing the rise in temperature in contact lenses during MMA welding. Even though it is impossible to direct the eyes at the arc for a prolonged period of time, the use of contact lenses in connection with at least certain types of welding is not to be recommended without the use of a suitable safety glass screen (or safety glasses). With regard to the large number of particles in the welding environment, also a risk factor for contact lens wearers, it is doubtful whether even safety glasses or screens are satisfactory unless they fit closely.

Key words: corneal damage, radiation hazards, soft contact lenses, temperature changes, welding arcs, worker safety.

During recent years a number of contradictory reports have appeared on possible hazards associated with the wearing of contact lenses during welding. The original incident, which seems to have taken place at the Bethlehem Steel Corporation, U.S.A. (12), has been described in many journals (8, 9). It became known in Sweden in 1976 and attracted a great deal of attention. It involved a shipyard worker who was wearing contact lenses behind safety glasses and who was exposed to an arc flash in a breaker (440 V) when connecting a welding cable. When he later removed his lenses “large areas of dried cornea” came away with them. Apparently only the superficial epithelial layer was affected. The report resulted in the recommendation that contact lenses should not be worn,
even under safety glasses, in any place
where an arc flash may occur. According
to a report in The Welding Institute Re-
search Bulletin (8) this recommendation
was for a period also adopted by The
Royal Society for the Prevention of Ac-
cidents (RSPA), England. It later trans-
pired that the contact lenses in the case in
question had been worn for a continuous
period of 17—18 h, which alone was pre-
sumed to be enough to explain the drying
of the lenses and separation of the epi-
thelium when the lenses were removed
(8, 10, 11).

Novak and Saul (6) and Fox (1) report
apparently the same incident. Novak and
Saul maintain, as a principle, that contact
lenses are contraindicated in industrial
work. Fox is of the opinion that no one
working in connection with infrared, ul-
traviolet, or other radiation energy should
be allowed to wear contact lenses at work.

The National Society for the Prevention
of Blindness (NSPB) (13) asserts, partly
because welding arcs can cause contact
lenses to adhere to the cornea, that the
wearing of contact lenses in industrial
environments without the use of eye and
face shields fulfilling all the requirements
of the American standard ANSI Z87 should
never be allowed.

The question, "Is it dangerous for arc
welders to wear contact lenses?" was posed
in the British Medical Journal in 1974 (7).
The reply was that there is no risk if in-
dustrial goggles are worn, provided the
welder is an established wearer of contact
lenses. Nevertheless, the general advice is
given that contact lens wearers should "in
practice avoid exposure to atmospheric
pollution and arc flash hazards, and, where
laboratory and industrial environ-
ment cannot be made safe in these re-
spects, then contact lenses should not be
worn by employees."

In a recent article in RSPA's journal
Occupational Safety and Health (12) the
incident at Bethlehem Steel is dismissed
as an "industrial atrocity story." Dr. Smith
of the Employment Medical Advisory
Service is quoted as saying that "there is
no hazard" to welders from using contact
lenses. She claims that the greatest danger
is from "overwear," thermal effects of
such a degree as to damage the cornea
being extremely unlikely. RSPA's Senior
Technical Officer, John Hart, concludes
that "if a wearer of contact lenses did
sustain a flash burn he would have some
degree of ultraviolet keratoconjunctivitis,
and this might be further irritated by the
lens, but in such cases prompt removal of
the lenses and application of the normal
treatment for arc eye is all that is neces-
sary."

To our surprise we have been unable to
find reports of any experimental investiga-
tions on this important matter. In the
present study the temperature changes
that take place in contact lenses in con-
nection with welding were determined.
Comparisons are made between different
types of lenses and different welding
methods. The investigation covers free-
hanging lenses and lenses applied to the
eyes of anesthetized rabbits. In certain
cases a considerable rise in temperature
was noted. Concurrently with this work
we have carried out a study on the trans-
mittance and absorption properties of con-
tact lenses (5), from which it is clear that
the absorption is very great, especially in
the long-wave region of infrared and the
short-wave region of ultraviolet light. In
addition infrared heaters were tested for
possible effects on contact lenses (4).

MATERIAL AND METHODS

Temperature recording

Temperatures were measured with a cop-
per-constantan (T) thermocouple (High
Temperature Instruments Corporation,
U.S.A.), the tip of which was flattened to
a thickness of approximately 80 \( \mu \). The
temperature was read on a five-channel
digital temperature indicator (Doric,
U.S.A.) with a resolution of 0.1°C. Linear-
ization and compensation for the cold
junction are built into the instrument.

In a recent article in RSPA's journal
Occupational Safety and Health (12) the
incident at Bethlehem Steel is dismissed
as an "industrial atrocity story." Dr. Smith
of the Employment Medical Advisory
Service is quoted as saying that "there is
no hazard" to welders from using contact
lenses. She claims that the greatest danger
is from "overwear," thermal effects of
such a degree as to damage the cornea
being extremely unlikely. RSPA's Senior
Technical Officer, John Hart, concludes
that "if a wearer of contact lenses did
sustain a flash burn he would have some
degree of ultraviolet keratoconjunctivitis,
and this might be further irritated by the
lens, but in such cases prompt removal of
the lenses and application of the normal
treatment for arc eye is all that is neces-
sary."

To our surprise we have been unable to
find reports of any experimental investiga-
tions on this important matter. In the
present study the temperature changes
that take place in contact lenses in con-
nection with welding were determined.
Comparisons are made between different
types of lenses and different welding
methods. The investigation covers free-
hanging lenses and lenses applied to the
eyes of anesthetized rabbits. In certain
cases a considerable rise in temperature
was noted. Concurrently with this work
we have carried out a study on the trans-
mittance and absorption properties of con-
tact lenses (5), from which it is clear that
the absorption is very great, especially in
the long-wave region of infrared and the
short-wave region of ultraviolet light. In
addition infrared heaters were tested for
possible effects on contact lenses (4).

MATERIAL AND METHODS

Temperature recording

Temperatures were measured with a cop-
per-constantan (T) thermocouple (High
Temperature Instruments Corporation,
U.S.A.), the tip of which was flattened to
a thickness of approximately 80 \( \mu \). The
temperature was read on a five-channel
digital temperature indicator (Doric,
U.S.A.) with a resolution of 0.1°C. Linear-
ization and compensation for the cold
junction are built into the instrument.

In a recent article in RSPA's journal
Occupational Safety and Health (12) the
incident at Bethlehem Steel is dismissed
as an "industrial atrocity story." Dr. Smith
of the Employment Medical Advisory
Service is quoted as saying that "there is
no hazard" to welders from using contact
lenses. She claims that the greatest danger
is from "overwear," thermal effects of
such a degree as to damage the cornea
recording the lens was wet with physiological saline. Control experiments failed to demonstrate any false temperature increase from the absorption of infrared radiation by the naked thermocouple (4).

**Test program**

**Comparison between lenses of different manufacturers.** In a comparison of different manufacturers’ products, the temperature of certain lenses was recorded under radiation from one and the same welding apparatus, namely, the MAG ESAB LDA 275 (electrode 1 mm, shielding gas 20 % carbon dioxide and 80 % argon), current 250 A DC, iron being used as the welding material. The distance between the lens and arc was 0.3 m. All the lenses examined were HEMA-based soft lenses, as specified in table 1.

**Comparison between different welding methods.** For the comparison of the possible temperature-raising effects of different welding methods on contact lenses, the ideal approach would be to select methods that have emissions closely corresponding to the absorption of the contact lenses. Since, however, the availability of emission measurements over a sufficiently broad spectrum is very limited, we examined instead three common welding processes, namely, manual metal arc (MMA) welding, tungsten inert-gas (TIG) welding (two methods), and metal inert-gas (MIG) welding with an MAG apparatus. In these experiments a contact lens with a centrally applied thermocouple was allowed to hang free, the radiation from the welding process being directed towards the front of the lens. As can be seen from table 2, two comparable lenses were used, both HEMA-based, with a water content of 39 % and a center thickness of about 0.5 mm. A second thermocouple was placed in front of the lens to record the temperature of the immediately surrounding air. Welding was performed by an experienced worker, and the arc could therefore be kept fairly constant throughout the experiment. When an electrode was exhausted it was quickly re-

**Table 1.** Specifications of the compared contact lenses.

| Manufacturer | Diopter | Water content (%) | Approximate thickness of lens (wet) at the site of the thermocouple (mm) |
|--------------|---------|-------------------|--------------------------------------------------|
| Soflens +    | 17.50   | 39                | 0.5                                              |
| Hydron +     | 21.50   | 39                | 0.5                                              |
| Weicon +     | 15.00   | 39                | 0.6                                              |
| Scanlens +   | 24.00   | 85                | 0.8                                              |
| Scanlens -   | 5.50    | 85                | 0.2                                              |

**Table 2.** Experimental conditions used in the comparison between welding methods. (MMA = manual metal arc, TIG = tungsten inert-gas, MIG = metal inert-gas)

| Variable                  | MMA, ESAB KC 375 | TIG (1), AGA DA 35 | TIG (2), AGA DA 35 | MIG, MAG, ESAB LDA 275 |
|---------------------------|------------------|--------------------|--------------------|------------------------|
| Current                   | 275 A DC         | 110 A AC           | 110 A DC           | 175 A DC               |
| Distance between contact lens and arc | 0.3 m | 0.3 m | 0.3 m | 0.3 m |
| Material                  | Iron             | Aluminum           | Iron               | Iron                   |
| Electrode                 | 4 mm, high       | 2.2 mm             | 3.2 mm             | 0.8 mm                 |
| Shielding gas             | —                | Tungsten           | Tungsten           | —                      |
| Shielding gas efficiency  | —                | —                  | —                  | —                      |
| Contact lens              | Soflens + 17.50  | Soflens + 17.50    | Hydron + 22.50     | Hydron + 22.50         |
| Welding time              | 5 min            | 5 min              | 5 min              | 5 min                  |

273
placed, and welding proceeded after only a very brief interruption. The experimental conditions are summarized in table 2.

**Measurement of temperature in lenses applied to rabbit eyes.** Some cooling should normally result from the irrigation of the lens by tears, and the eyelid and bulb probably also assist in cooling. In order to achieve conditions as close as possible to “natural,” we also measured the temperature of lenses applied to rabbit eyes. Adult, pigmented rabbits were anesthetized with intravenous propanidid and pethidine, a method giving anesthesia without closure of the eyes and with apparently unaffected tear secretion.

Under these circumstances it proved difficult to retain the thermocouple in the lens. A double lens, the inner lens of which had radii of curvature equal to those of the cornea and the inner surface of the outer lens, was therefore used. The two lenses were glued together at the extreme periphery. The thermocouple, which had been bent to correspond with the curvature of the lenses, was introduced between the wet lenses, care being taken to avoid air bubbles. Before each exposure the lenses were rewet with physiological saline. A second thermocouple was placed in front of the lens to measure the air temperature. The rabbit was arranged so that the optical axis of the examined eye was directed towards the arc. The three types of lenses tested (HEMA lenses with a 39% water content) are specified in table 3.

In the rabbit experiments the MMA process (ESAB, KC 375), with a high efficiency 4-mm electrode (OK-FEMAX 3895), a welding current of 240 A DC, an eye-arc distance of 0.4 mm, and a welding time of 6.5 min, was used.

| Lens combination | Manufacturer and diopter | Approximate thickness of wet lens at the site of the thermocouple (mm) |
|------------------|--------------------------|---------------------------------------------------------------------|
| 1                | Hydron — 1.75            | 0.6                                                                |
|                  | Soflens + 3.50           |                                                                     |
| 2                | Weicon + 15.50          | 1.1                                                                |
|                  | Weicon + 15.50          |                                                                     |
| 3                | Hydron — 1.00           | 0.5                                                                |
|                  | Hydron — 1.50           |                                                                     |

Table 4. Increase in temperature (°C) in free-hanging, wet contact lenses: A comparison between different lenses.

| Type of lens | Soflens | Hydron | Weicon | Scanlens | Scanlens |
|--------------|---------|--------|--------|----------|----------|
| Lens temperature | + 17.50 | + 21.50 | + 15.00 | + 24.00 | — 5.50   |
| Initial      | 14      | 16     | 17     | 15       | 14       |
| Final        | 20      | 21     | 21     | 19       | 20       |
| Increase     | 16      | 13     | 14     | 12       | 10       |

Air temperature

| Initial | 17 | 17 | 18 | 17 | 18 |
| Final   | 20 | 21 | 21 | 19 | 20 |
| Increase| 3  | 4  | 3  | 2  | 2  |

Difference between final lens and air temperatures

| + 10 | + 8 | + 10 | + 8 | + 4 |