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EVALUATION OF PROPOSED ELECTROPLATED HGU-4/P FRAMES

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SUMMARY

A gold electroplated frame has been recommended to replace the standard gold-filled aviator frame. Since the proposed frame contains a nickel-silver based metal, the frame was evaluated under field and laboratory conditions at the U.S. Army Aeromedical Research Laboratory. Of the 18 subjects who wore the test frames for three months, one subject, an aviator, developed a mild dermatitis along the frontal and supraorbital portion of the face. Chemical analysis indicated "free" nickel in sufficient quantity to cause a reaction from nickel sensitive individuals. This study has shown that some skin reaction can be expected from a small percentage of wearers if the gold electroplated frame replaces the gold-filled frame.

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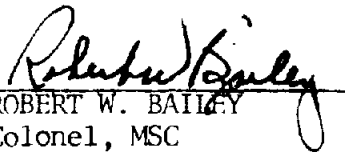

ROBERT W. BAILEY
Colonel, MSC
Commanding

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INTRODUCTION

Because of the considerable increase in the price of gold during the past several years, the manufacturers supplying the aviator gold-filled ophthalmic frame recently notified the Defense Personnel Support Center (DPSC) that fabrication of this frame was no longer cost-effective, and they were, therefore, unable to support the Army's requirements for these frames. As an alternative metal frame, the civilian manufacturers have recommended that the DPSC purchase an ophthalmic frame consisting of a nickel-silver base metal, plated with bright nickel, and overplated with gold. However, the Army dispensed nickel-containing frames in the 1940's and 1950's with the resulting experience of many soldiers reporting a dermatitis around the area of contact of the frames with the skin.

Nickel has been a well recognized source of metal contact dermatitis.^{1,2,3} The clinical picture is an eczematous dermatitis with pruritus, scaling and erythema progressing to lichenification. Common offending items containing nickel include rings, earrings, jewelry, spectacle frames, wrist watches, suspenders, and support garments.

Nickel sensitivity is considered more common in women than men. In the United Kingdom and Scandinavia, nickel is the most common cause of contact dermatitis in women.¹ Women, by their use of jewelry, do provide for greater exposure of nickel to skin contact than men. In men, nickel dermatitis occurs most commonly due to occupational exposure. In 60% of the cases, the eruption begins on the hands. Sensitization by wrist watches and spectacles is common.¹

Chrome plating has been used to decrease available surface nickel. Dermatitis has been produced by nickel "leaking out" through pores of the chromium plating.² Sweating has been implicated in the production of dermatitis as the sodium chloride may combine with nickel-silver to give silver chloride.² This process provides the basis for the finding of increasingly severe dermatitis in persons who perspire profusely.

The problem of nickel sensitivity should be considered in any patient with a metallic device or prosthesis externally or internally applied. Implanted stainless steel screws having 14% nickel have produced a severe dermatitis.⁴ A Wainwright stainless steel orthopedic plate containing 8 to 12% nickel and 17 to 20% chromium produced a dermatitis and "rejection" of the implant.⁵

Interestingly, a known nickel sensitive patient has received a Bjork-Shiley mitral valve prosthesis containing three grams of metal of which 10% is nickel without reaction after two years.⁶ It is

suggested that the small surface area, and thus less metal, may prevent difficulty due to constant wear; however, nickel may be delivered over a prolonged period.⁵

The use of nickel-gold alloys and nickel plated earrings following ear piercing has been documented as a cause of contact dermatitis.⁷

The presence of nickel in contact with the skin in amounts of 10 to 14% would indicate a strong possibility of allergic reaction in a sensitive individual. The plating specification for the U.S. Government HGU-4/P flying goggles provide a base metal of not less than 14% nickel silver, with nickel electroplate of not less than 50 millionths of an inch in thickness and overplated with a minimum of 60 millionths of an inch of 23K electrodeposit gold.⁸ Because of the possibility of contact dermatitis despite the buffer layer provided by the gold electrodeposit, the proposed frames were evaluated under field and laboratory conditions at the U.S. Army Aeromedical Research Laboratory.

METHODS

The sample frames used in this study were supplied through the Defense Personnel Support Center at the request of the American Optical Corporation. Of the twenty frames received from DPSC, eighteen pairs were used in the field study, one pair was retained for laboratory chemical analysis, and one pair was forwarded to the Medical Optical Laboratory, Fitzsimons Army Medical Center.

The subjects who volunteered to wear the test frames for the field study were selected as being reasonably representative of the potential user population. Table 1 shows the number of subjects within each of

	PRESCRIPTION LENSES	PLANO LENSES	
AVIATOR	4	3	7
TECHNICAL OBSERVER FLIGHT STATUS	5	2	7
NOT ON FLIGHT STATUS		4	4
	9	9	

Table 1. The number of subjects within each of the test groups.

the various groups. Included in the non-prescription, non-flight status group was one female and one black subject; all other subjects were white males. Before dispensing the test spectacles, each subject was individually briefed concerning the purposes of the study, the possible skin reactions to the frame, and what observations he or she should make periodically while wearing the test frame. Depending upon each subject's visual requirements, prescription lenses or plano tinted lenses were mounted into the frames. Each frame was adjusted to allow normal fitting characteristics, and the subjects were instructed to wear the test frames as they would normally wear their glasses.

After the subjects had worn the frames for approximately three months, they returned to the Laboratory to complete a questionnaire (appended). Each subject was examined by a flight surgeon as required, and the frames were examined by an optometrist for wear and durability.

Several of the frames were tested for the presence of "free" nickel with a 1% alcohol solution of dimethylglyoxime (DMG) with ammonia (furnished by Westwood Pharmaceuticals, Inc., Buffalo, New York). This precipitate test will detect the presence of "free" nickel in sufficient concentration (1:10,000) to produce dermatitis in nickel-sensitive individuals.

RESULTS

Clinical Evaluation

In our series of 18 subjects wearing the proposed HGU-4/P flying goggles, one subject, an aviator, developed a mild eczematous eruption of the frontal and supraorbital portion of the face. The area was erythematous with mild scaling. Pruritus was not described. The onset of the erythema was within two hours of wearing the frames and, reportedly, occurred each time the frame was worn while performing flying duties.

This aviator was emmetropic and usually wore his sunglasses only while flying. At the time of initial report of a dermatitis reaction, he had worn the standard issue gold-filled flying goggles for approximately seven years without experiencing any dermatitis from the frames. Subsequent to the test period, a trial of wearing the standard gold-filled frames with identical wearing conditions produced no reaction. Following this period, a second trial of prolonged (eight hours) wear of the test electroplated frames also failed to produce any reaction. However, several variations from the original wearing conditions should be emphasized. For this second trial, the sunglass lenses were removed

to facilitate indoor wear and the frames were considerably lighter which would affect the bearing areas on the face. Also, and probably of most significance, this second trial was conducted in an office area so that true cockpit conditions, including wear of the SPH-4 helmet with consequent perspiration, were not approximated. The possibility that the presence of perspiration contributed to the reaction was increased in that skin testing of this patient utilizing a "buffalo" nickel coin failed to present any reaction after 24 hours contact.

Frame Evaluation

Four frames were analyzed with the dimethylglyoxime spot test for the presence of "free" nickel. One of these frames had never been worn while the remaining three, including the pair resulting in dermatitis, had been worn for approximately three months. The frames were analyzed along the bridge, eyewire, and temple. All of the frames tested positive for the presence of "free" nickel in sufficient quantity to cause an allergic reaction from nickel-sensitive individuals. In addition, one standard gold-filled frame which had been worn previously was tested, and the results were negative for "free" nickel.

In general, the condition of the frames were as might be expected after three months wear. However, a significant percentage (39%) of them showed pitting and etching of the metal core underlying the clear plastic temple paddles. This might indicate a defect in the manufacturing process in which the seal around the plastic paddle temple cover was inadequate. Perspiration had probably been allowed to seep underneath the paddle and had pitted the metal core.

DISCUSSION

The results of this study provide evidence of "free" nickel arising from a nickel base of a known sensitizing concentration of not less than 14% as specified for the proposed HGU-4/P flying goggles. Chemical analysis has shown the potential for reaction, and field testing has developed one borderline positive dermatitis. The series of this study, although small, would indicate a 5% -6% incidence of nickel reaction.

The one dermatitis reaction was interesting in that the subject failed to develop similar or more pronounced symptoms with prolonged wear, and did not react to the "buffalo" nickel. However, as discussed earlier, the variations in the wearing conditions might explain the failure to develop symptoms with the longer wearing schedule. With the lenses removed, the frames were much lighter. Also, the frames

were worn only in an air-conditioned office. The hot and humid cockpit environment quite possibly causes sufficient perspiration to interact with the metal frame to result in the skin reaction.

The necessary restrictions imposed on this study must be recognized in considering the significance of these results. The sample size ($n = 18$) was quite small, and the test period only extended for three months. However, these restrictions, if anything, force a conservative estimate of the magnitude of the dermatitis problems to be expected if these frames are dispensed to military personnel. No attempt was made to screen the subjects for prior history of any dermatological conditions. When the study was terminated, three subjects reported that they had experienced a metal dermatitis previously, and none of these three evidenced any reaction to the test frames. However, these three subjects had only worn the frames in air-conditioned environments.

A problem that was not realistically addressed with this evaluation is the question of the durability of the gold electroplating. Since this study had to be completed within a relatively short time period, the frames were inspected after only three months use. Even after this short period, there was some evidence of rubbing along the inside of the temples and across the top of the eyewires with some of the frames. If a sufficient amount of the gold electroplating finish rubbed off to expose the nickel base, the dermatitis reactions might have been more frequently experienced.

RECOMMENDATIONS

1. Additional effort should be made to find a frame to replace the HGU-4/P flying goggles. Although the problems experienced during this evaluation were relatively minor, these results indicate that some reactions probably will be experienced by nickel-sensitive individuals. This is particularly so for those individuals working in warm environments, where perspiration might interact with the nickel-silver to increase the possibility and/or severity of reaction.
2. If an acceptable alternative frame cannot be found for the standard gold-filled frame, appropriate medical personnel (e.g. flight surgeons, eye clinics, dermatology clinics, etc.) should receive information concerning the potential skin reactions. In addition, a warning notice should be included with each pair of the gold electroplated frames issued to alert user personnel of the potential problems.
3. A sufficient supply of the standard gold-filled frames should be maintained for those personnel who might suffer from nickel dermatitis.

4. The U.S. Army Aeromedical Research Laboratory would encourage formation of a tri-service working group to develop a mutually acceptable alternative frame to replace the metal HGU-4/P flying goggles.

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AVIATION EYEGLASS FRAME STUDY

NAME	RANK	SSN
ORGANIZATION	RACE	HAIR COLOR

1. Issued: clear lens _____ sunglasses _____
2. Do you wear glasses full time? _____ part time? _____
How many hours/day? _____
3. Are you allergic to:

	Yes	No
a. Medication?	☐	☐
b. Any chemicals?	☐	☐
If so, list _____		
c. Any soaps or detergents?	☐	☐
If so, list _____		
d. Any type clothing or cloth?	☐	☐
If so, what type? _____		
4. Have you ever had a skin rash from your shoes? ☐ ☐
5. Have you ever developed a rash from your wrist watch band? ☐ ☐
6. Have you ever developed a rash from any metal in contact with your skin? ☐ ☐
7. Since wearing the experimental eyeglass frames, have you noted any rash or itching on or around the face?

a. Your nose?	☐	☐
b. Your eyebrows?	☐	☐

- c. Your hairline? ☐ ☐
8. Are the experimental eyeglass frames in your opinion
- Comfortable? ☐ ☐
- Provide good fit? ☐ ☐
9. Any comments?